EPC™
ENVIRONMENTAL PARTICLE COUNTER™ MONITOR
MODEL 3783

OPERATION AND SERVICE MANUAL

P/N 6003653, REVISION E
SEPTEMBER 2015

START SEEING THE BENEFITS OF REGISTERING TODAY!

Thank you for your TSI instrument purchase. Occasionally, TSI releases information on software updates, product enhancements and new products. By registering your instrument, TSI will be able to send this important information to you.

http://register.tsi.com

As part of the registration process, you will be asked for your comments on TSI products and services. TSI's customer feedback program gives customers like you a way to tell us how we are doing.

UNDERSTANDING, ACCELERATED

TSI Incorporated - Visit our website **www.tsi.com** for more information.

USA	**Tel:** +1 800 874 2811	**India**	**Tel:** +91 80 67877200
UK	**Tel:** +44 149 4 459200	**China**	**Tel:** +86 10 8219 7688
France	**Tel:** +33 1 41 19 21 99	**Singapore**	**Tel:** +65 6595 6388
Germany	**Tel:** +49 241 523030		

Printed in U.S.A.

EPC™

ENVIRONMENTAL PARTICLE COUNTER™ MONITOR

MODEL 3783

OPERATION AND SERVICE MANUAL

Manual History

The following is a history of the Model 3783 EPC™ Environmental Particle Counter™ Monitor Operation and Service Manual (Part Number 6003653).

Revision	Date
A	April 2010
B	March 2011
C	October 2011
D	January 2013
E	September 2015

Warranty

Part Number	6003653 / Revision E / September 2015
Copyright	©TSI Incorporated / 2013-2015 / All rights reserved.
Address	TSI Incorporated / 500 Cardigan Road / Shoreview, MN 55126 / USA
Fax No.	651-490-3824
E-mail Address	particle@tsi.com

Limitation of Warranty and Liability
(effective February 2015)

(For country-specific terms and conditions outside of the USA, please visit www.tsi.com.)

Seller warrants the goods, excluding software, sold hereunder, under normal use and service as described in the operator's manual, to be free from defects in workmanship and material for twelve (12) months, or if less, the length of time specified in the operator's manual, from the date of shipment to the customer. **If tap water or a working fluid other than distilled (<6 ppm) or HPLC water is used in this instrument, the warranty will no longer be valid.** This warranty period is inclusive of any statutory warranty. This limited warranty is subject to the following exclusions and exceptions:

a. Hot-wire or hot-film sensors used with research anemometers, and certain other components when indicated in specifications, are warranted for 90 days from the date of shipment;
b. Pumps are warranted for hours of operation as set forth in product or operator's manuals;
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;
d. Seller does not provide any warranty on finished goods manufactured by others or on any fuses, batteries or other consumable materials. Only the original manufacturer's warranty applies;
e. This warranty does not cover calibration requirements, and seller warrants only that the instrument or product is properly calibrated at the time of its manufacture. Instruments returned for calibration are not covered by this warranty;
f. This warranty is **VOID** if the instrument is opened by anyone other than a factory authorized service center with the one exception where requirements set forth in the manual allow an operator to replace consumables or perform recommended cleaning;
g. This warranty is **VOID** if the product has been misused, neglected, subjected to accidental or intentional damage, or is not properly installed, maintained, or cleaned according to the requirements of the manual. Unless specifically authorized in a separate writing by Seller, Seller makes no warranty with respect to, and shall have no liability in connection with, goods which are incorporated into other products or equipment, or which are modified by any person other than Seller.

The foregoing is **IN LIEU OF** all other warranties and is subject to the **LIMITATIONS** stated herein. **NO OTHER EXPRESS OR IMPLIED WARRANTY OF FITNESS FOR PARTICULAR PURPOSE OR MERCHANTABILITY IS MADE**. **WITH RESPECT TO SELLER'S BREACH OF THE IMPLIED WARRANTY AGAINST INFRINGEMENT, SAID WARRANTY IS LIMITED TO CLAIMS OF DIRECT INFRINGEMENT AND EXCLUDES CLAIMS OF CONTRIBUTORY OR INDUCED INFRINGEMENTS. BUYER'S EXCLUSIVE REMEDY SHALL BE THE RETURN OF THE PURCHASE PRICE DISCOUNTED FOR REASONABLE WEAR AND TEAR OR AT SELLER'S OPTION REPLACEMENT OF THE GOODS WITH NON-INFRINGING GOODS.**

TO THE EXTENT PERMITTED BY LAW, THE EXCLUSIVE REMEDY OF THE USER OR BUYER, AND THE LIMIT OF SELLER'S LIABILITY FOR ANY AND ALL LOSSES, INJURIES, OR DAMAGES CONCERNING THE GOODS (INCLUDING CLAIMS BASED ON CONTRACT, NEGLIGENCE, TORT, STRICT LIABILITY OR OTHERWISE) SHALL BE THE RETURN OF GOODS TO SELLER AND THE REFUND OF THE PURCHASE PRICE, OR, AT THE OPTION OF SELLER, THE REPAIR OR REPLACEMENT OF THE GOODS. IN THE CASE OF SOFTWARE, SELLER WILL REPAIR OR REPLACE DEFECTIVE SOFTWARE OR IF UNABLE TO DO SO, WILL REFUND THE PURCHASE PRICE OF THE SOFTWARE. IN NO EVENT SHALL SELLER BE LIABLE FOR LOST PROFITS, BUSINESS INTERRUPTION, OR ANY SPECIAL, INDIRECT, CONSEQUENTIAL OR INCIDENTAL DAMAGES. SELLER SHALL NOT BE RESPONSIBLE FOR INSTALLATION, DISMANTLING OR REINSTALLATION COSTS OR CHARGES. No Action, regardless of form, may be brought against Seller more than 12 months after a cause of action has accrued. The goods returned under warranty to Seller's factory shall be at Buyer's risk of loss, and will be returned, if at all, at Seller's risk of loss.

Buyer and all users are deemed to have accepted this LIMITATION OF WARRANTY AND LIABILITY, which contains the complete and exclusive limited warranty of Seller. This LIMITATION OF WARRANTY AND LIABILITY may not be amended, modified or its terms waived, except by writing signed by an Officer of Seller.

Service Policy

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

Trademarks

TSI logo, Scanning Mobility Particle Sizer, SMPS. EPC, and Environmental Particle Counter are trademarks of TSI Incorporated. TSI and Aerosol Instrument Manager is a registered trademark of TSI Incorporated.
Microsoft and Windows are registered trademarks of Microsoft Corporation.
IBM is a registered trademark of International Business Machines Corporation in the United States, other countries, or both.
Swagelok is a registered trademark of Swagelok Company.

Safety

This chapter provides instructions to promote safe handling and correct operation of the Model 3783 EPC™ Environmental Particle Counter™ Monitor.

There are limited user-serviceable parts inside the particle counter. All repair and maintenance should be done by qualified, trained technicians. All maintenance and repair information in this manual is included for use by a qualified, trained technician.

W A R N I N G

Unsafe use of this instrument can occur if it not used in a manner described within this manual. Failure to follow all of the procedures described in this manual can result in serious injury to you or cause irrevocable damage to the instrument.

Laser Safety

The Model 3783 EPC™ monitor is a Class I laser-based instrument. During normal operation, you will not be exposed to laser radiation. To avoid exposing yourself at any time to hazardous radiation in the form of intense, focused visible light (exposure to this light can cause blindness), take these precautions:

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

W A R N I N G

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

Description of Safety Labels

This information explains the advisory and identification labels used on the instrument and in this manual to reinforce the safety features built into the instrument.

Caution

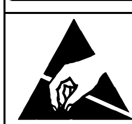
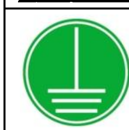
C a u t i o n
Caution means ***be careful.*** If you do not follow the procedures described in this manual you may damage the instrument or you may have to begin again. Caution also indicates important information about the operation and maintenance of this instrument.

Warning

W A R N I N G
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.

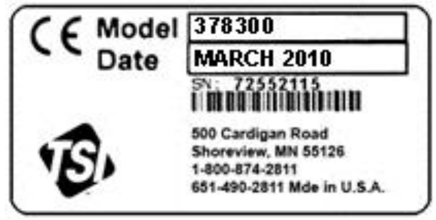
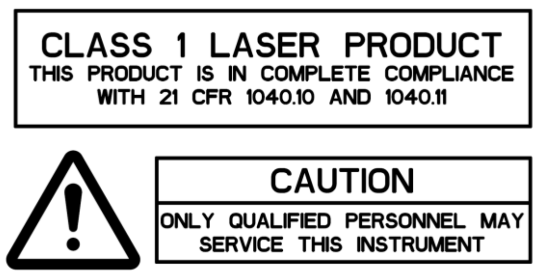
Caution or Warning Symbols

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

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

Labels

Advisory labels and identification labels are attached to the outside of the EPC™ monitor housing and to the optics on the inside of the instrument. Labels for the EPC™ monitor are described below:

Serial Number Label—displayed on the back panel.	
Laser safety warning label—displayed inside the Model 3783 near the laser diode assembly.	
High Voltage warning label—displayed inside the Model 3783.	
Class 1 Laser certification and identification label—displayed on the back panel. When operated according to the manufacturer's instruction, this device is a Class I laser product as defined by U.S. Department of Health and Human Services standards under the Radiation Control for Health and Safety Act of 1968.	
TSI Service Label—displayed on the back panel.	

(This page intentionally left blank)

Contents

Figures

Tables

About This Manual

Purpose

This is an operation and service manual for the Model 3783 EPC™ Environmental Particle Counter™ monitor.

Organization

The following information is a guide to the organization of this manual.

- **Chapter 1: Product Overview**
  Contains an introduction to the Model 3783, a list of features, and a brief description of how the instrument works.
- **Chapter 2: Unpacking and Setting Up the Model 3783**
  Contains a packing list and the step-by-step procedures for installing the Model 3783.
- **Chapter 3: Moving and Shipping the Model 3783**
  Describes how to prepare the Model 3783 for moving and shipping.
- **Chapter 4: Instrument Description**
  Describes features and controls that run the Model 3783, including the components on the front-panel, back-panel, and inside the instrument. It also covers the basic functions of the instrument.
- **Chapter 5: Instrument Operation**
  Describes the operation of the Model 3783.
- **Chapter 6: Technical Description**
  Describes the principle of operation, theory, and performance of the Model 3783.
- **Chapter 7: Particle Counting**
  Contains information about the particle counting modes.
- **Chapter 8: Computer Interface, Commands, and Data Collection**
  Describes the computer interface, commands and data collection.
- **Chapter 9: Maintenance, Service, and Troubleshooting**
  Describes the recommended practices for routine maintenance and service, as well as important troubleshooting procedures.
- **Appendix A: Specifications**
  Contains the specifications of the Model 3783.
- **Appendix B: Firmware Commands**
  Lists all the serial commands for communications between the Model 3783 and the computer.

- **Appendix C: References**
  Contains a list of the references that have been used within the text of the manual as well as a general list of references pertaining to condensation nucleus counters.

Related Product Literature

- ***Model 3007 Condensation Particle Counter Operation and Service Manual*** (part number 1930035) TSI Incorporated
- ***Model 3772/3771 Condensation Particle Counter Operation and Service Manual*** (part number 1980529) TSI Incorporated
- ***Model 3775 Condensation Particle Counter Operation and Service Manual*** (part number 1980527) TSI Incorporated
- ***Model 3781 Water-based Condensation Particle Counter Operation and Service Manual*** (part number 1930111) 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
- ***Aerosol Instrument Manager® Software for CPC and EAD Instruction Manual*** *(part number 1930062) TSI Incorporated*

  This manual contains operating instructions for Aerosol Instrument Manager® Software for CPC and EAD, a software program that monitors, calculates, and displays particle concentration data collected by a CPC or an EAD.

Submitting Comments

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

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

TSI Incorporated
Particle Instruments
500 Cardigan Road
Shoreview, MN 55126
Fax: (651) 490-3824
E-mail Address: particle@tsi.com

(This page intentionally left blank)

CHAPTER 1

Product Overview

This chapter contains an introduction to the Model 3783 EPC™ Environmental Particle Counter™ monitor and provides a brief explanation of how the instrument operates.

Product Description

The Model 3783 EPC™ monitor is a continuous laminar flow condensation particle counter that uses water as its working fluid. The Model 3783 provides rapid, high-precision measurement of the numbers of ultrafine (down to 7 nm) airborne particles. The instrument delivers robust field performance in both pristine and heavily polluted areas and can be used for a variety of applications including ambient monitoring and research, indoor air quality investigations, atmospheric and climate research, and health effects studies. TSI recommends annual maintenance and calibration for the Model 3783 EPC™ monitor.

Features of the Model 3783 EPC™ monitor include:

- 6-inch color touch screen with a graphical interface displaying particle concentration, total counts, and a plot of concentration vs. time.
- 7-nm detection.
- Single-particle counting to 10^6 particles/cm^3.
- Continuous, live-time, electronic processing for maximum accuracy.
- Adjustable inlet flow (3.0 or 0.6 L/min), inlet location (front or back), and water supply connection (front or back).
- Flexible data acquisition options including USB stick, Ethernet, USB port, and RS-232 port.
- Advanced instrument diagnostics including a novel pulse height analyzer to monitor super-saturation state, wick health, and instrument status.
- Newly designed air flow, wicking, and water handling systems.
- Option to mount in a rack with included hardware.

Figure 1-1
Model 3783 Environmental Particle Counter™ Monitor

How it Works

The Model 3783 Environmental Particle Counter monitor is designed to measure the concentration of airborne particles. The EPC™ monitor draws in an air sample and counts the number of particles in that sample to provide a particle concentration value that is displayed as the number of particles detected per cubic centimeter of sampled air.

The EPC™ monitor utilizes a patented* laminar-flow, water-based condensation growth technique. Particles which are too small (nanometer scale) to scatter enough light to be detected by conventional optics are grown to a larger size by condensing water on them. In this instrument, an air sample is continuously drawn through the inlet via an external pump and a portion of the flow is sent to the exhaust as transport flow. The stream of aerosol particles is uninterrupted and follows a laminar flow path from the sample inlet to the optical detector.

*US Patent No. 6,712,881, Aerosol Dynamics Inc., Drs. Susanne V. Hering and Mark Stolzenburg.

The Model 3783 EPC™ monitor particle counting process is as follows:

- The aerosol enters the sample inlet.
- In the conditioner, the aerosol sample stream is saturated with water vapor and then temperature-equilibrated.
- The sample passes to a growth tube where the wetted walls (composed of a porous medium) are heated to raise the vapor pressure. The high diffusivity of the water vapor allows the vapor to reach the center of the sample stream at a faster rate than the thermal diffusivity of the vapor can equilibrate to the higher temperatures near the walls—creating a supersaturated condition along the radius of the flow stream. These unstable conditions facilitate water condensation on the sample particles.
- Particles that are larger than the detection limit of the EPC™ monitor's minimum critical particle size act as condensation nuclei as they pass up the growth tube.
- The enlarged particles are passed through a laser beam and create a large light pulse. Every particle pulse event is detected and counted. In this technique, particle concentration is measured by counting **each** particle in the air stream.

Figure 1-2 illustrates the flow system of the Model 3783 EPC™ monitor.

Acknowledgement

The continuous, laminar-flow, and environmentally-friendly principle on which this product is based is patented technology licensed from Aerosol Dynamics Inc. of Berkeley, CA (U.S. Patent 6,712,881). We give our thanks to Susanne V. Hering PhD and Mark R. Stolzenburg PhD for their invention, their clever insights to this unique technology, their numerical models, and the gracious feedback they have provided during the development of this product.

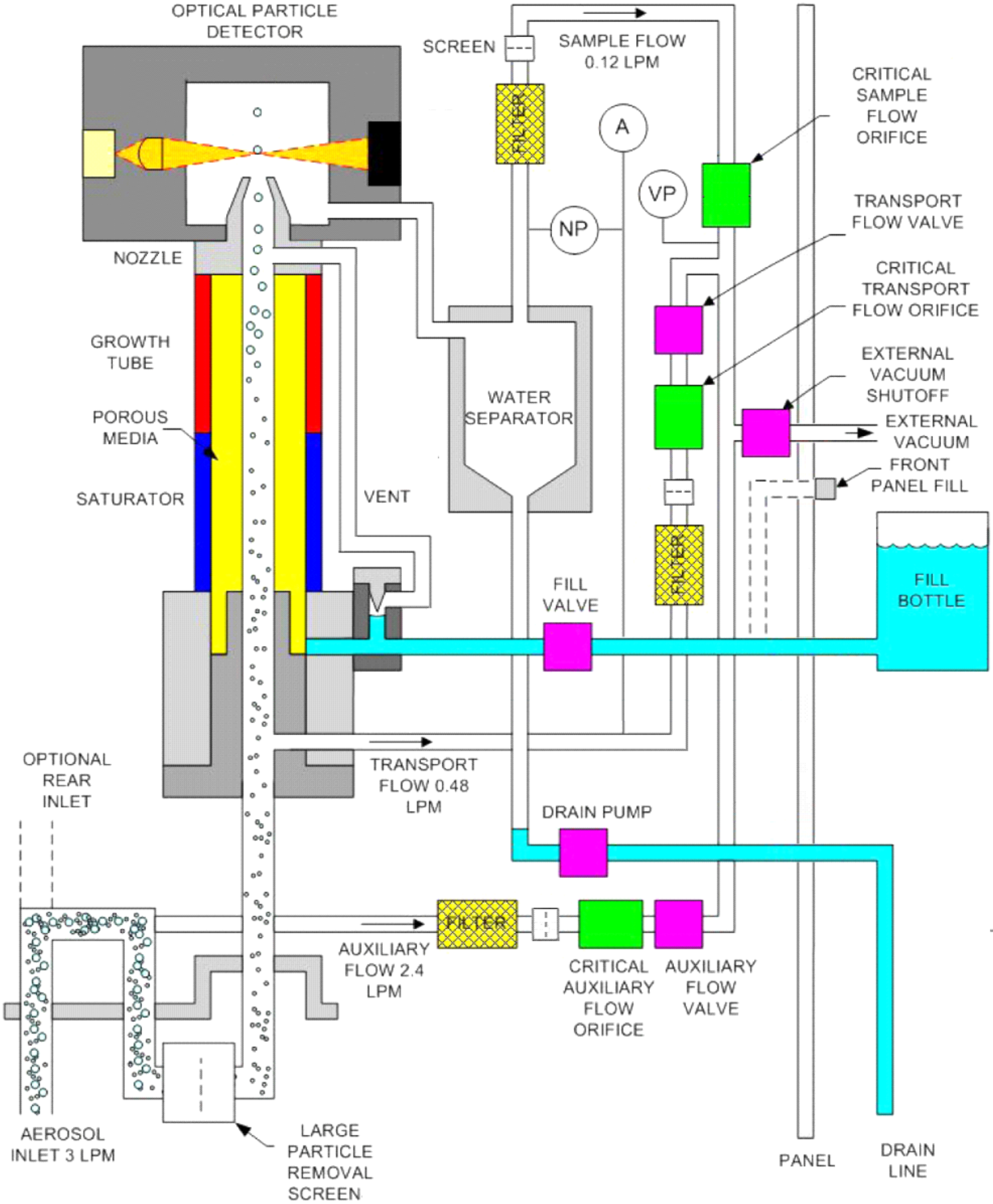


Figure 1-2
Model 3783 Environmental Particle Counter™ Monitor Flow System Schematic

CHAPTER 2

Unpacking and Setting up the Model 3783

Use the information in this chapter to unpack and set up the Model 3783 EPC™ Environmental Particle Counter™ monitor.

Packing List

The packing list described in Table 2-1 shows the components shipped with the Model 3783.

Table 2-1
Model 3783 EPC™ Monitor Packing List

Qty.	Part Number/ Model Number	Description
1	378300	Model 3783 Environmental Particle Counter Monitor
1	6003653	Model 3783 Operation and Service Manual
1	6003948	Model 3783 Quick Start Guide
1	N/A	Power cable
1	1183015	2x Rack-mount brackets with 4x mounting screws (10-32 x ½ inch) and USB adapter cable.
1	1183021	Water supply bottle
1	1183022	Water drain bottle
1	N/A	Vacuum pump tubing
1	1183019	Inlet screen assembly
1	1183020	Inlet cap
1	N/A	Calibration Certificate
1	1303740	Computer cable, USB A to B
1	962002	RS-232 Serial cable
1	390065	Aerosol Instrument Manager® Software
1	1183001	Maintenance Kit (for details see Table 2-2 below)

Note: *Some items above and those for future maintenance are available for purchase as kits from TSI. A complete list of replacement parts is included in the Maintenance section in Chapter 9.*

Table 2-2
Model 3783 EPC™ Monitor Maintenance Kit

Qty.	Part Number	Description
1	1183004	CFO CTO Filter: Replacement filter for Critical Sample Flow Orifice and Critical Transport Flow Orifice
1	1183005	CAO Filter: Replacement filter for Critical Auxiliary Flow Orifice
1	1183006	Critical Sample Flow Orifice 3783 (CFO): Replacement Critical Sample Flow Orifice (.005 inch)
1	1183007	Critical Transport Flow Orifice 3783 (CTO): Replacement Critical Transport Flow Orifice (.0095 inch)
1	1183008	Critical Auxiliary Flow Orifice 3783 (CAO): Replacement Critical Auxiliary Flow Orifice (.0225 inch)
1	1183002	3783 Wick Cartridge
12	1183024	Wick 3783: Replacement wicks (set of 12)
1	N/A	Three-foot length of 1/8 inch tubing

Unpacking

Carefully unpack the Model 3783 EPC™ monitor from the shipping container. Use the Packing List in Table 2-1 to verify that there are no missing components.

Save the original shipping container to be used for future shipping.

If anything is missing, or appears to be damaged, contact your TSI representative or TSI Customer Service using one of the following methods:

Telephone: 1-800-874-2811 (within the US)
001-651-490-2811 (outside the US)
E-mail: technicalservice@tsi.com.

See Chapter 9 for instructions on how to return the instrument to TSI.

Caution

The Model 3783 Environmental Particle Counter monitor operates using distilled (<6 ppm) or HPLC water as a working fluid. Do **not** tip the instrument more than 10 degrees during normal operation. Perform the procedures described in Chapter 3 before moving or shipping the instrument.

Do **not**:

- Ship an “undried” instrument.
- Transport an “undried” instrument over long distances.
- Subject an “undried” instrument to freezing temperatures.

Any of the above actions can result in the flooding of the optical system, performance degradation, and possible damage to the instrument. Such neglect is not covered under the manufacturer’s warranty.

Installation

I M P O R T A N T

The wick used in the 3783 must be changed every 4 weeks (800 hours), and distilled (<6 ppm) or HPLC water must be used as the water source. Follow the instructions in Chapter 9 for wick replacement.

This section contains instructions for installing the Model 3783 Environmental Particle Counter™ monitor. Follow the instructions in the order given.

The installation procedures, described on the following pages, include the following:

- Removing protective caps.
- Connecting the water supply.
- Connecting the water exhaust tube.
- Connecting the aerosol supply.
- Installing the Model 3783 in a rack (if desired).
- Connecting the USB cable.
- Connecting the power and warming up the Model 3783.

Equipment

You will need the following equipment to install the EPC™ monitor:

- Vacuum capable of 6 SL/min at 400 mbar absolute pressure.
- 9/16 inch wrench.
- 7/64 inch hex driver.
- ¼-inch, thick-walled, plastic tubing.
- Water supply.

Note: *Use either distilled (<6 ppm) or HPLC water. Do **not** use tap water.*

Remove Protective Caps

After unpacking the EPC™ monitor, remove the protective caps from the **AEROSOL INLET**s on the front and back panels of the instrument and from the **PUMP EXHAUST**. Then remove the covers from the BNC connectors.

Connecting the Water Supply

The Model 3783 uses a gravity-fed water fill system.

***Note**: To prevent the water from draining back into the bottle during operation, the bottle must always be placed at a higher level than the instrument.*

To connect the water supply, follow these instructions:

1. Using a 7/64 inch hex driver, mount the water supply bottle bracket to the front or back of the particle counter using the provided bottle bracket mounting screws. The figure below shows the bracket mounted on the back.

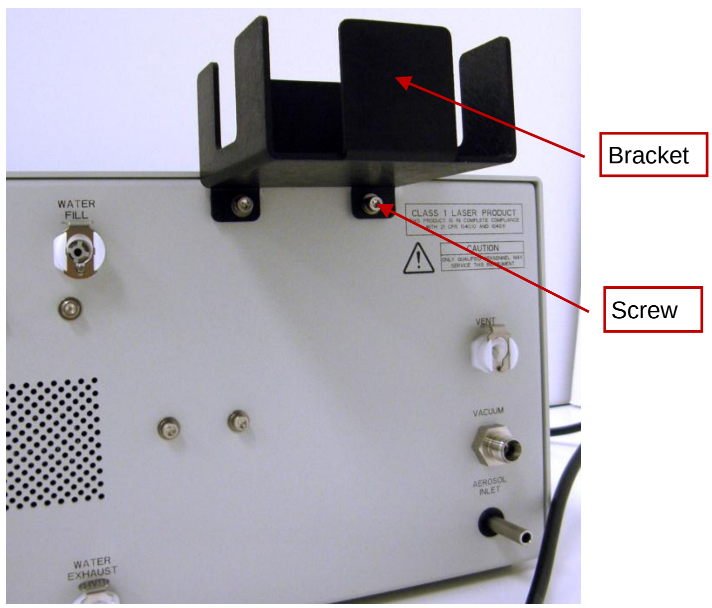


Figure 2-1
Connecting the Water Supply

2. Fill the water supply bottle with either distilled (<6 ppm) or HPLC water and place the bottle in the bracket.

   ***Note**: A filled water supply bottle will typically allow the EPC™ monitor to operate for more than the 4-weeks wick replacement interval. If water is added between the wick change, it is recommended that the water be added to the bottle without disconnecting it from the EPC™ monitor to avoid adding any bubbles into the the water supply line.*

3. Push the connector on the water supply bottle tubing into the **WATER FILL** fitting on either the front or back of the instrument (figure below shows the back).

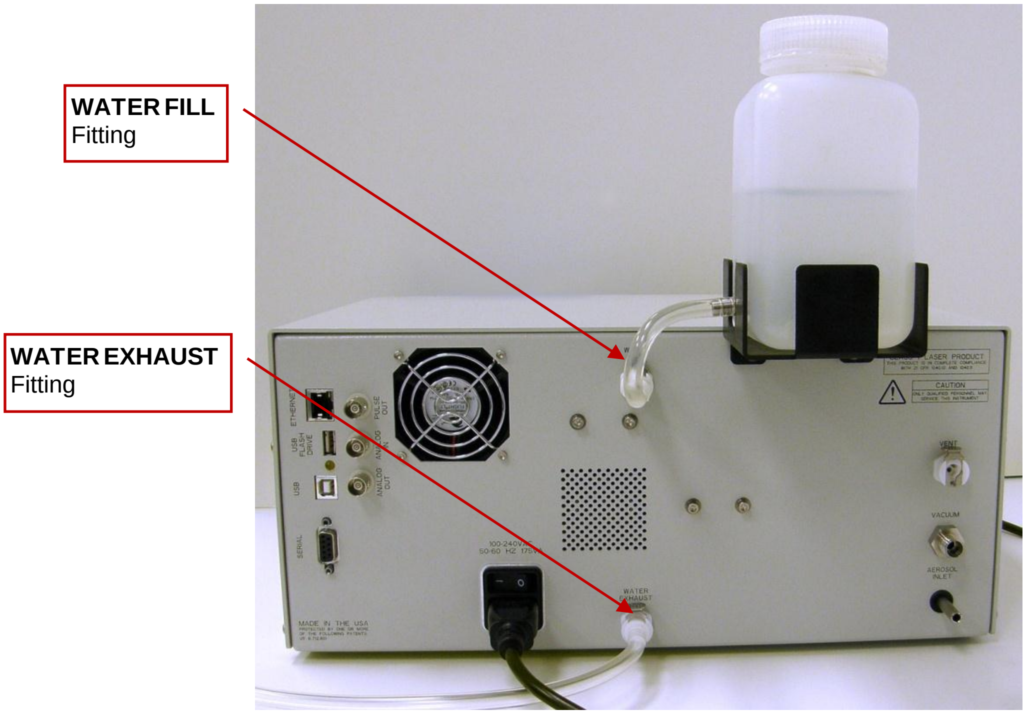


Figure 2-2
Water Fill and Water Exhaust Fittings

Connecting the Water Exhaust Tube

The waste water should pass into a suitable drain such as a floor drain or a vented container. To connect the drain tube, follow these instructions:

1. Push the connector on the supplied length of drain tubing into the **WATER EXHAUST** fitting on the back panel.
2. Place the other end of the drain tube in a vented container or over a floor drain.

Connecting the Aerosol Supply

The Model 3783 allows you to conduct aerosol sampling from either the front or the back of the instrument. To run the instrument effectively, you need an external vacuum capable of drawing 6 SLPM at 400 mbar absolute pressure.

Sampling options include the following:

- Ambient sampling using the inlet screen assembly (provided with the counter) connected to the Model 3783 inlet. The inlet screen assembly prevents large matter (such as insects and dirt) from entering the instrument.

  Note*: If you are sampling from the back of the instrument, you must use the inlet screen assembly and the flow rate must be 3 L/min when using the inlet screen.*

- Using a sampling system connected directly to the aerosol inlet.
- Environmental monitoring using tubing connected directly to the aerosol inlet.

I M P O R T A N T

The gauge pressure of the sampled aerosol must be within +4/-20 in. H_20 pressure relative to the ambient pressure. Pressures outside of this range will result in water-handling failures.

To set up the aerosol supply, follow these instructions:

1. Decide whether you will sample from the front or the back of the instrument.
2. Place the aerosol sample inlet cap over the sample port that you will not be using.

3. Determine your sampling method. The instrument is shipped with the inlet screen assembly in place, but if it has been removed and you wish to use it, you must reconnect it to the Model 3783 inlet. If you are not using the inlet screen, connect the aerosol sample line to the aerosol inlet.

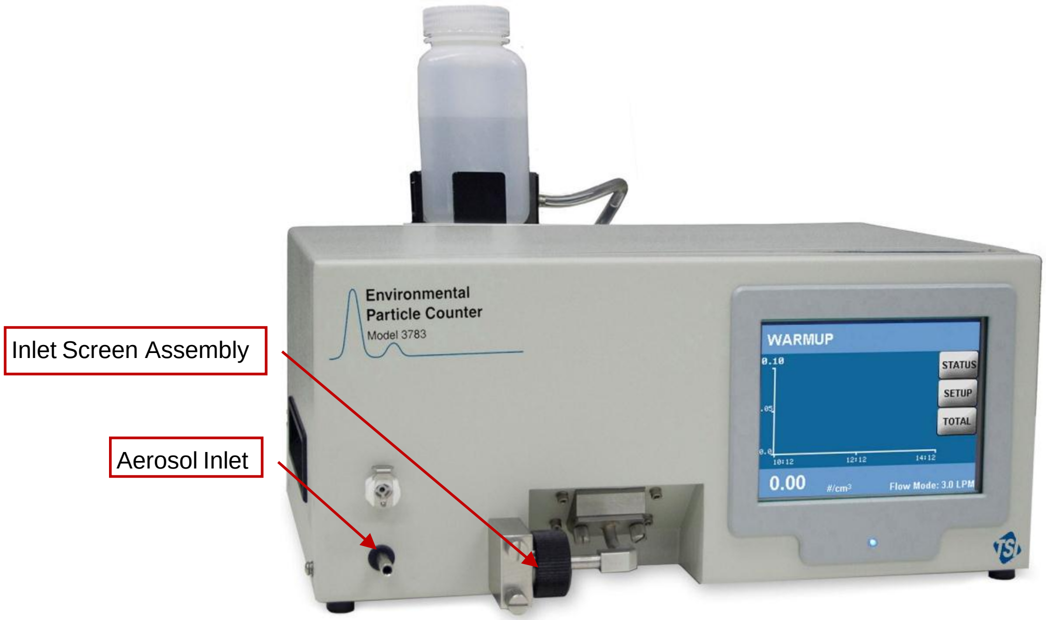


Figure 2-3
Connecting the Aerosol Supply

4. If you are using the inlet screen assembly and it needs to be connected, line up the two captive screws with the corresponding holes on the front panel. The elbow tube should line up with the sampling inlet.

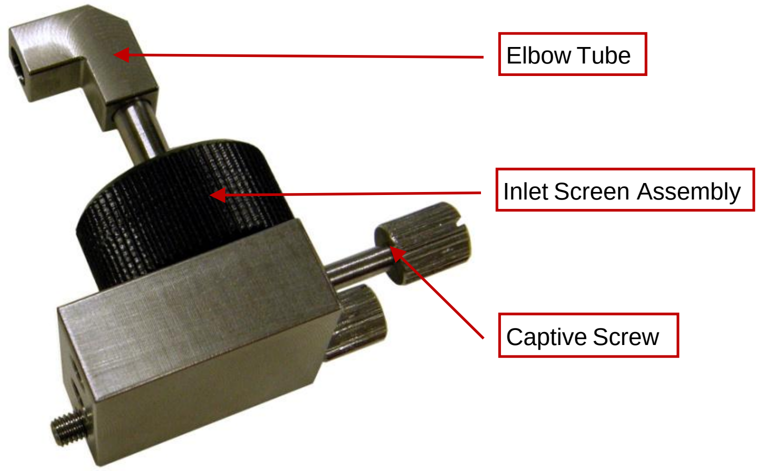


Figure 2-4
Connecting the Aerosol Supply to Inlet Screen Assembly

5. Turn the captive screws to secure the inlet screen assembly in place.

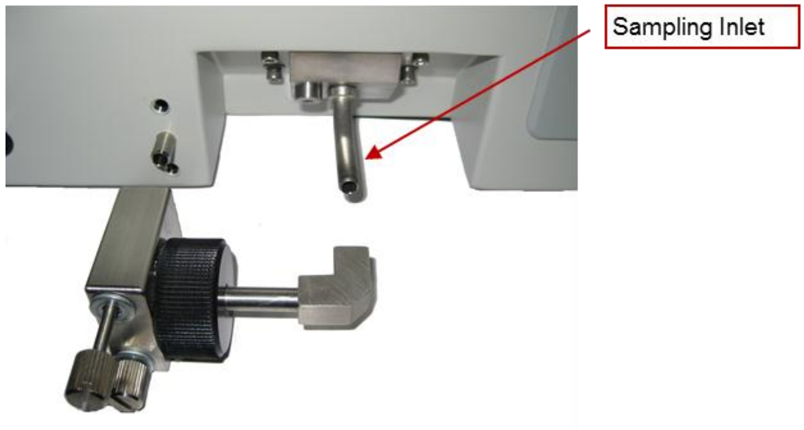


Figure 2-5
Securing Inlet Screen Assembly in Place

6. If you have not already done so, remove the protective cap from the **VACUUM** inlet on the back panel.

7. Connect an external vacuum source to the **VACUUM** inlet using the vacuum tubing provided with the instrument, and a 9/16-inch wrench to tighten the Swagelok® fitting.

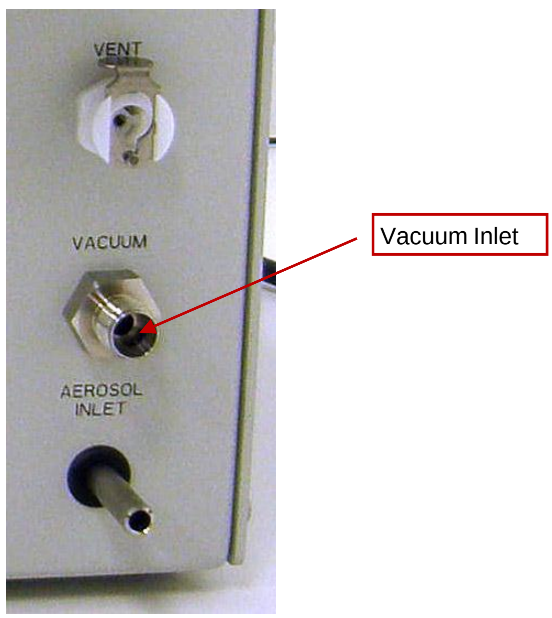


Figure 2-6
Connecting External Vacuum Source

Swagelok is a registered trademark of Swagelok Company.

Installing the Model 3783 in a Rack

Before you can install the Model 3783 Environmental Particle Counter™ monitor in a rack, you must attach the rack-mount brackets. To attach the rack-mount brackets, follow these instructions:

1. Using a 1/8-inch hex driver and the mounting screws provided with the particle counter, attach the rack-mount brackets to the front sides of the instrument.

   Note *The bracket with the USB port should be attached to the front right of the instrument.*

Figure 2-7
Installing Model 3783 in a Rack

2. Place the Environment Particle Counter in the rack.

W A R N I N G
When mounting the instrument in a rack location be certain that the back panel power on/off switch is accessible or that a readily accessible means of disconnecting power is provided.

Connecting the USB Cable

Connect the provided USB cable to the USB connector on the back panel of the Model 3783. If you have placed the counter in a rack, you can use an extension cord to connect the port at the back of the instrument to the port on the rack-mount handle to give you easy access to the USB port.

Connecting the Power and Warming up the Model 3783

After you connect the power, the warm-up process takes approximately 20 minutes.

Follow these instructions to connect the power and warm up the Model 3783:

1. Plug the power cord provided with the Model 3783 into the power connector (100 to 240 VAC 50/60 Hz 175 VA) on the back panel.
2. Plug the cord into an earth-grounded AC power source (100 to 240 VAC, 50 to 60 Hz, 0.6 A).

W A R N I N G
Connection to an improperly grounded electrical source may cause a severe shock hazard—ensure that the ground is secure.

3. Turn on the instrument. The Home screen appears on the display and reads **Warmup**. During the warm-up process, status messages are displayed at the top left of the home screen.

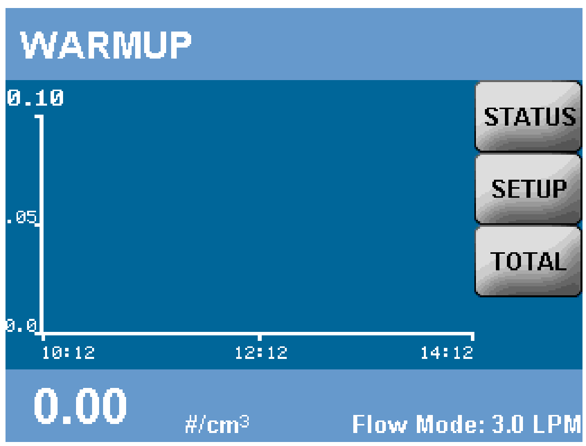


Figure 2-8
Warm-up Screen

4. When the warm-up is complete, if all conditions for operation are in place, the display reads **Ready**. If you do not see the Ready message, check the settings.

CHAPTER 3

Moving and Shipping the Model 3783

Use the information in this chapter to prepare the Model 3783 EPC™ Environmental Particle Counter™ monitor for moving or shipping.

Caution

The Model 3783 operates using water as a working fluid. Do **not** tip the instrument more than 10 degrees during normal operation or you may flood the optical system.

Do **not**:

- Ship an "undried" instrument.
- Transport an "undried" instrument over long distances.
- Subject an "undried" instrument to freezing temperatures.

Any of the above actions can result in the flooding of the optical system, performance degradation, and possible damage to the instrument. Such neglect is not covered under the manufacturer's warranty.

Moving the Model 3783 Short Distances

You can successfully transport the EPC™ monitor short distances from one lab to another, or even a short drive in a vehicle, without draining it first. However, do *not* tip the instrument >45°and do *not* subject it to prolonged freezing temperatures.

Preparing the Model 3783 for Shipping and Storage

To prepare the EPC™ monitor for shipping, follow these instructions:

1. Disconnect the water bottle, empty it, and then reconnect it.
2. If you have not already done so, turn on the particle counter and allow it to warm up (the display screen reads **Ready** when the warm-up is complete and all the settings are correct).
3. Disconnect any connections to the aerosol inlet.
4. Allow the instrument to operate for at least one hour with the water source disconnected.
5. Disconnect the drain tube from the **WATER EXHAUST** outlet.
6. Turn off the power.

7. With the inlet screen assembly securely in place, carefully place the instrument in the original packing materials. (Detailed instructions for attaching the inlet screen assembly are given in Chapter 2, "Connecting the Aerosol Supply".)

The EPC™ monitor is now ready for shipping or storage.

CHAPTER 4

Instrument Description

Use the information in this chapter to become familiar with the location and function of controls, indicators, and connectors on the Model 3783 EPC™ Environmental Particle Counter™ monitor.

Front Panel

The main components of the front panel are shown in the figure below.

Figure 4-1
Model 3783 Environmental Particle Counter™ Monitor Front Panel

Display

The QVGA color LCD display provides continuous, real-time display of sample data as well as user menus and status information. Press the display "buttons" to move from one screen to another or to record settings.

Status Indicators

Status indicators display at the top of the home screen. The indicators are as follows:

Status Indicator	Description
Low Water	Water level is low
Warmup	Instrument is warming up
Laser Fault	Laser fault
Inlet Pressure Fault	Inlet pressure is too high/low
Vacuum Fault	Vacuum pressure is too high/low
Nozzle Fault	Plugged nozzle or wet sample flow filter
Absolute Pressure Fault	Barometric pressure is out of range
Optics Temp Fault	Optics temperature is out of range
Growth Tube Temp Fault	Growth Tube temperature is out of range
Conditioner Temp Fault	Conditioner temperature is out of range
Separator Temp Fault	Water Separator temperature is out of range
Pulse Height Fault	Low particle pulse height
Ready	Warm-up process has finished and the instrument is ready for use

Note*: The fault indicators on the front-panel display are a warning that there is a problem with the instrument. However, only one indicator can display at a time. Check the Status screen for more details about potential problems.*

Indicator Light

The blue indicator light flashes once for each particle detected. At particle concentrations >100 particles/cm^3, the flashing becomes a continuous glow.

Back Panel

The main components of the back panel are shown in the figure below. Components include power and data connections, analog input/output connections, and water and sample inlets/outlets.

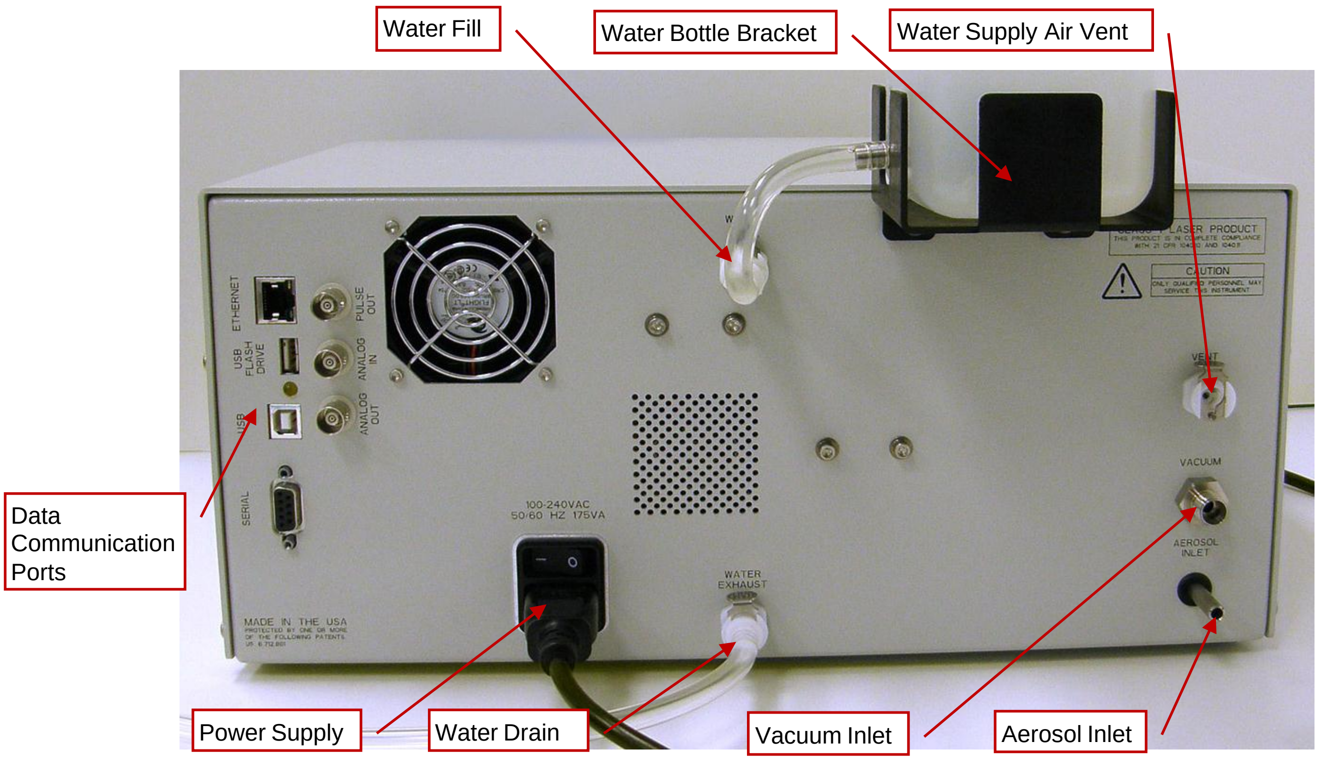


Figure 4-2
Model 3783 Environmental Particle Counter™ Monitor Back Panel

Internal Instrument Components

Internal components are described in this section and identified in the photos below.

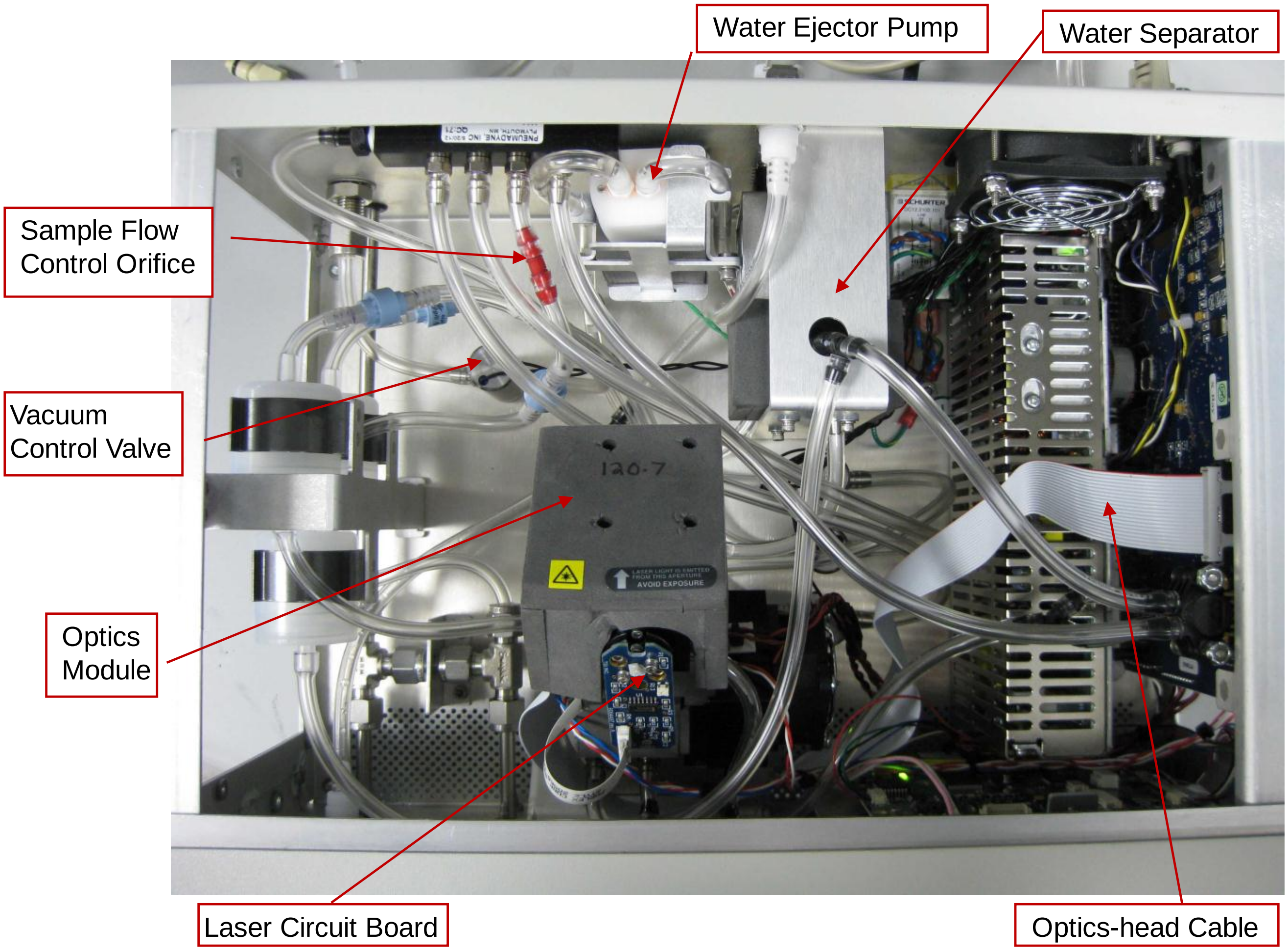


Figure 4-3
Model 3783 Environmental Particle Counter™ Monitor Internal Components (bottom is instrument front)

Optics Module

The optics module detects particle droplets from the growth tube. The optics module contains a laser, photodetector, and the optics, as well as the detector and optics circuit boards.

Vacuum Supply

An external vacuum supply enables all the flows. The internal vacuum control valve (controlled by parameters available on the **SETUP** screen) is an electronic valve used to turn on/off the vacuum from the external source.

Water System

The water separator removes water from the vapor stream coming from the optics head. This prevents water from condensing and blocking the flow orifices. Water from the separator is pumped out by the water ejector pump.

The instrument flow orifices operate under critical pressure with flow determined by the orifice diameter. Each orifice is protected by a glass fiber filter followed by a separate inline screen to remove contamination which can result from an accidental flooding event.

Fans

Two internal fans cool the instrument; one cools the internal electronics and one dissipates the heat generated during cooling of the condenser.

Circuit Boards

The EPC™ monitor contains the following circuit boards:

- Main board
- Laser board
- Detector board

The main circuit board controls all the primary functions. Feedback circuits on the main electronics board control the internal temperatures (displayed on the Status screen).

Internal Clock

The clock used in the EPC™ monitor is a Quartz crystal component embedded in the microprocessor. The accuracy is on the order of about a second per day, but time drift during long periods of data logging is possible. If a higher level of time accuracy is needed, one of the following options should be implemented:

1. Use Aerosol Instrument Manager® software as the data collection tool. The software can be configured to synchronize the 3783 with the computer clock once per day.
2. Send a serial command to the instrument once per day to reset the 3783 clock to synchronize with the data collection tool.
3. If collecting data via the USB stick, reset the clock on the instrument as needed.

Data Communication Ports

USB Communication Port

The EPC™ monitor provides a USB port for use with the TSI Aerosol Instrument Manager® software included with the instrument. When USB communications are used with the software, the computer automatically recognizes the Environmental Particle Counter™ Monitor as a TSI instrument. Additional information on USB communications can be found in the Aerosol Instrument Manager® software manual.

RS-232 Serial Connections

The EPC™ monitor provides one standard, 9-pin RS-232 serial port that allows communication between a computer and the particle counter. Serial commands are sent to and from the computer to monitor instrument status information, to retrieve and monitor data, and to provide a variety of control functions such as turning the pump on and off. Aerosol Instrument Manager® software may be used with the Serial or USB connections. More information can be found in the Computer Interface section of Chapter 8.

Analog Input

The EPC™ monitor can monitor the analog voltage from an external source via the analog input BNC connector on the back panel (labeled Analog Input). The input voltage range for these ports is 0 to 10 V. Analog voltages can be displayed together with concentration data on the display screen and can be saved to the removable Flash Drive or a computer. Voltages from connected pressure, flow, or temperature transducers can be correlated to particle concentration in real time.

Amplification must be supplied by the user to bring low voltage signals to the appropriate 0 to 10 V range for best resolution.

DMA/Analog Out and Pulse Out

During normal operation of the Model 3783 EPC™ monitor, the Analog Out port provides an analog 0 to 10 V signal proportional (linear or log) to particle concentration. This particle concentration is corrected for coincidence and tracks the displayed concentration.

Pulse Out provides a 5-volt (50-ohm termination) digital pulse for each particle detected. This enables you to use your own counting electronics hardware and provides a particle trigger for special applications. The width of the pulse depends on both the shape of the photo detector pulse and the trigger-level of the pulse threshold. To provide accurate pulse counts, *use a counter that is capable of counting pulses with a width of 50 nanoseconds or less*.

Particle concentrations that have been calculated based on the particle counts from the counting electronics hardware are *not live-time corrected* for particle coincidence. Thus, when particle concentration is high, the concentration provided by this output might be lower than the displayed concentration. Appropriate coincidence correction should be applied when pulse output is used for high concentration measurements.

The pulse output is a way to get raw particle count information. This information is also available through serial command. Using the **SM** or **SSTART,3** command, described in Appendix B, you can read raw, uncorrected, particle counts. TSI recommends using the serial interfaces for raw counts rather than the pulse output because then all the information used to calculate the corrected concentration is communicated and there are no issues with the counter's ability to accurately count the pulses.

Ethernet Communication Port

Instrument status, including particle concentration, of the EPC™ monitor can be monitored remotely from a local area network or over the internet using the Ethernet communication port.

(This page is intentionally left blank)

CHAPTER 5

Instrument Operation

This chapter describes the basic operation of the Model 3783 EPC™ Environmental Particle Counter™ monitor and describes how to use the controls, indicators, and connectors found on the front and back panels.

Operating Precautions

Read the following before applying power to the particle counter:

- Review the operating specifications for the Model 3783 EPC™ monitor described in Appendix A.
- Do ***not*** operate the Model 3783 at temperatures outside the range of 10°C to 35°C. If the particle counter is operated outside this range, the displayed concentration may be inaccurate.

WARNING

The Model 3783 should not be used with hazardous gases such as hydrogen or oxygen. Using the particle counter with hazardous gases may cause injury to personnel and damage to equipment.

Recommended Operation Procedures

Outdoor Operation Procedures

When sampling outdoor aerosol, follow these recommendations:

- Place the EPC™ monitor in a conditioned enclosure to ensure that it is operating within temperature and humidity specifications.
- If the EPC™ monitor is placed in an environment with temperatures lower than the ambient temperature, consider heating the sample line to reduce condensation.
- If you are not using a sampling system, use a cyclone with a cut size no greater than 3 µm on the particle counter inlet.
- Ensure that the pressure differential at the inlet is not greater than 2.5 kPa (10 inches of H_2O). If you are using a cyclone, do not exceed the inlet pressure drop of 2.5 kPa.
- Follow the startup advice contained in the Quick Start Guide (shipped with the instrument).

Standard Operation Procedures

Perform these standard procedures every 4 weeks (800 hours):

- Replace the wick.
- Check the flow using a volumetric flowmeter.
- Fill the water bottle with 1 liter of distilled (<6 ppm) or HPLC water. **Do not use tap water.**
- Verify that the inlet pressure is in the correct operating range relative to the ambient pressure:
  - Check the inlet pressure value on the status screen then disconnect the aerosol inlet and check the value again. The pressure drop caused by an inlet any restriction should not exceed 250 mbars (25 kPa).

    or
  - Check inlet pressure on the status screen then turn the instrument vacuum off and check the pressure again. The pressure drop caused by an inlet restriction should not exceed 250 mbars (25 kPa).
  - The inlet pressure should not exceed the ambient pressure as this will inhibit water flow to replenish the wick.
- Check the status screen to make sure the parameters are still accurate.
- Check the inlet screen and remove any debris collected there.
- Check the time and date on the Flash Drive.

Perform these standard procedures annually:

- Replace the filters.
- Perform a Zero check by placing a HEPA filter on the EPC™ monitor inlet and ensuring that particle concentration is >0.01 particles/cm^3.

Note: *Detailed information about these procedures can be found in the Maintenance section of Chapter 9.*

Warm-up

When you have successfully made all the connections described in the Installation section of Chapter 2, and turned on the power, the Home screen appears on the display and reads **Warmup**. When the warm-up process is complete, and the optics and growth tube temperatures are within two degrees of their standard operating temperatures, the display reads **Ready**. Use the menus to do the following:

- Turn flow on and off.
- Set the date and time.
- Set sampling parameters.
- Check flow.
- Collect Data.
- Set the network and data collection options.

Display/User Settings

Read this section for details of the screens, how to make selections, and how to change options.

HOME Screen

The Home screen displays a real-time sample graph of the concentration in particles/cm^3, the **STATUS** of the instrument, and the **SETUP** and **TOTAL** options. You can return to the Home screen from any other screen by pressing **HOME**.

The following screens are accessible from the home screen and are described on the following pages:

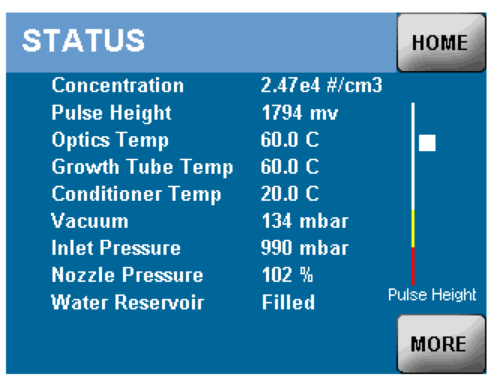
- **STATUS**
- **SETUP**
- **TOTAL**

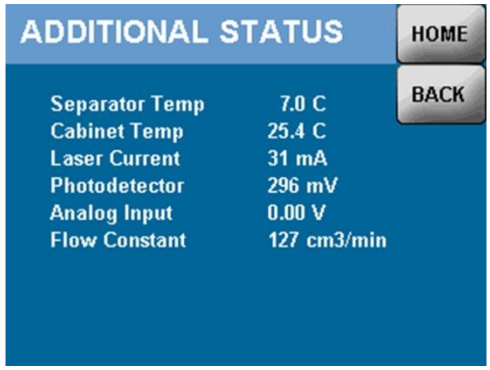
STATUS Screens

The two **STATUS** screens display a variety of real-time readings to give you an instant view of the operational status of the instrument. The following status colors are significant:

- Red indicates a parameter that is “out of range.”
- Yellow indicates something “in process.”
- White indicates “normal” conditions.

Press **MORE** on the first Status screen to see the **ADDITIONAL STATUS** settings. The photos below show the **STATUS** and **ADDITIONAL STATUS** screens.





The Status screens display the following information:

Status	Description
Concentration	Represented in particles/cm^3
Pulse Height	The signal height in mV. The pulse height varies with particle concentration and is useful for indicating problems with the wick.
Optics Temp	Temperature of the Optics in degrees Celsius. A normal Optics temperature is 60°C.
Growth Tube Temp	Temperature of the Growth Tube in degrees Celsius. A normal Growth Tube temperature is 60°C.
Conditioner Temp	Temperature of the Conditioner in degrees Celsius. A normal Conditioner temperature is 20°C.
Vacuum	The vacuum pressure in mbars (must be less than half of the inlet pressure).
Inlet Pressure	The atmospheric pressure in mbars. This parameter is preset and can be used to indicate a blockage.
Nozzle Pressure	The pressure difference upstream and downstream of the optics assembly. Should be 100% - a 10% drop in nozzle pressure indicates a nozzle clog.
GT Reservoir	Indicates whether the growth tube reservoir is Filled/Not Filled/Filling.
Cond Reservoir	Indicates whether the conditioner reservoir is Filled/Not Filled/Filling.
Separator Temp	Temperature of the Separator in degrees Celsius. A normal Separator temperature is 7°C.
Cabinet Temp	Temperature inside the Model 3783 cabinet.
Laser Current	The operating current of the laser in mA.
Photodetector	Indicates photodetector voltage in mV.
Analog Input	Displays the voltage of the analog input.

Status	Description
Flow Constant	Represented in particles/cm^3. Compensates for any variations in orifice diameter.

SETUP Screens

HOME | SETUP

Pressing the **SETUP** button on the home screen takes you to the **SETUP** screen where you can set the following operating parameters:

Parameter	Description
SAMPLE TIME	Select a sample time for updating the display graph. Choices are 1 sec, 2 sec, 3 sec, 4 sec, 5 sec, 6 sec, 10 sec, 12 sec, 15 sec, 20 sec, 30 sec, 60 sec.
VACUUM	Turn the vacuum valve on/off.
INLET FLOW	Set the inlet flow. Choices are 3 L/min (total flow), 0.12 L/min (transport flow), and 0.6 L/min (auxiliary flow).
SET TIME	Set the time for the internal, real-time clock used for data logging purposes.
MORE	Takes you to the **NETWORK SETUP** screen.
NETWORK SET UP	Set up network connections including **NETWORK, ADDRESS, MASK**, and **GATEWAY**.
MORE	Takes you to the **ADDITIONAL SETUP** screen.
ADDITIONAL SETUP	Specify the **ANALOG OUTPUT** and **LOGGING** time.
ANALOG OUTPUT	Set an analog voltage range for the output.
LOGGING	Choose intervals for logging data.

The following pages contain descriptions of the **SETUP** options.

SAMPLE TIME

SETUP | SAMPLE TIME

Select a sample time in seconds for the on-screen graph. Press the **SAMPLE TIME** button to scroll through the settings. Sample Time choices are 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, and 60 seconds. If you intend to gather data for long periods of time, use the longer sample times to reduce the number of data files.

VACUUM

SETUP | VACUUM

Select one of the following vacuum settings:

Vacuum Setting	Description
ON AFTER WARMUP	Turns on the vacuum. Message displays during the warm-up process.
ON	Turns on the vacuum valve. Message only displays when warm-up is complete.
OFF	Turns off the vacuum valve.

***Note**: You can toggle between the **ON** and **OFF** settings.*

INLET MODE

SETUP | INLET MODE

Set the inlet flow in liters per minute. Press the **INLET MODE** button to scroll through the settings. Inlet flow choices are:

Inlet Mode Setting	Description
3 L/min	When the inlet flow is set to 3 L/min, the flow through the screen assembly is 0.6 L/min and the auxiliary flow is 2.4 L/min.
0.12 L/min	When the inlet flow is set to 0.12 L/min, the transport flow is off and the flow through the screen assembly matches the inlet flow. ***Note**: The Model 3783 samples 0.12 L/min independent of the **INLET MODE** setting.*
0.6 L/min	The transport flow rate through the screen assembly.

SET TIME

SETUP | SET TIME
Select the date (year, month, and day) and time (hour, minute, and second) for data collection.

To set the date and time, follow these instructions:

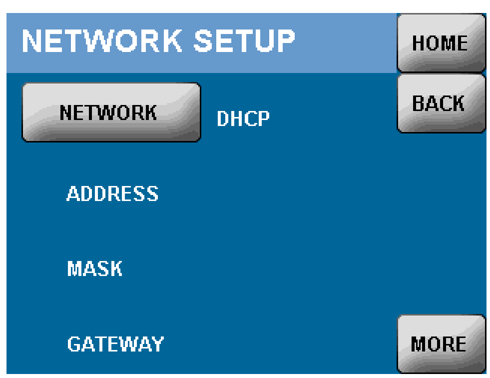
1. Touch the screen option you wish to change. In the photo below, the Year is active (indicated by the line below the number) and ready to be changed.

2. Use the ▲▼ arrows to scroll through the different settings.
3. Touch **BACK** to return to the previous screen when you have made your choices.

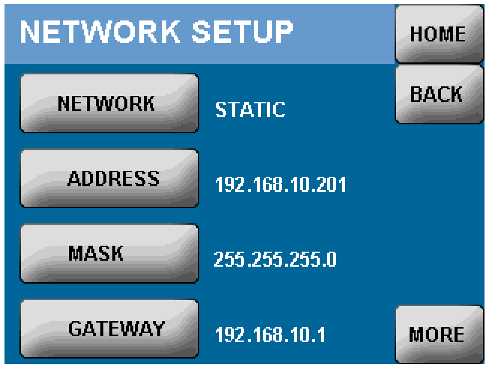
NETWORK

SETUP | NETWORK SETUP | NETWORK
Specify the network settings. The **NETWORK** button toggles between the settings **STATIC** and **DHCP** (shown below).

Note: *If the network settings have been selected, they are displayed, otherwise they are blank.*



On this screen, only the network setting has been specified.

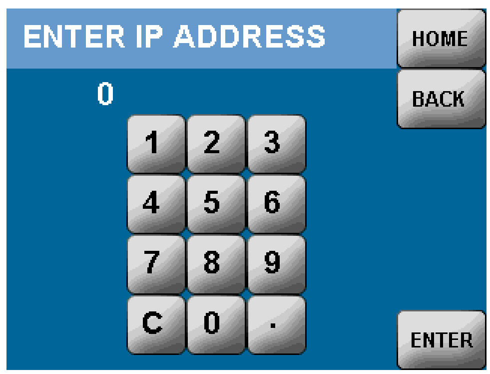


On this screen all network settings have been specified.

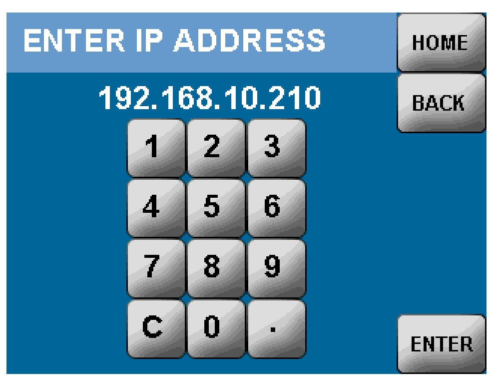
ADDRESS

SETUP | NETWORK SETUP | ADDRESS
Specify an IP address for your network. To set the IP Address, follow these instructions:

1. Press the numbers on the on-screen keypad.



2. When you have selected all the numbers, press **ENTER**. The IP Address is now recorded and displayed on the screen.



3. Press **BACK** to return to the Network setup screen where the IP address is now displayed.

MASK

SETUP | NETWORK SETUP | MASK
Specify the network mask.

***Note**: The Mask must match the size of your network. A typical setting is 255,255,255.0 for a small network.*

To set the Mask, follow the instructions for using the onscreen keypad to set the IP Address.

GATEWAY

SETUP | NETWORK SETUP | GATEWAY
Specify the network gateway device. To specify the Gateway, follow the instructions for using the onscreen keypad to set the IP Address.

ANALOG OUTPUT

SETUP | NETWORK SETUP | MORE | ADDITIONAL SETUP | ANALOG OUTPUT
Set the function of the analog output. Press the button to scroll through the options. Settings are 1.00, 100, 1000, 1.0 E^4, 1.0 E^5, 1.0 E^6, 1.0 E^7#/cm^3 FS, LOG OUTPUT (Logarithmic output) and **STATUS OUTPUT** (where a normal Status Output is 0. Abnormal output is 5V).

LOGGING

SETUP | NETWORK SETUP | MORE | ADDITIONAL SETUP | LOGGING
Choose intervals for logging data to the Flash Memory Card. Logging options are either one hour, or one day. Press the button to toggle between the options.

(continued on next page)

TOTAL Screen

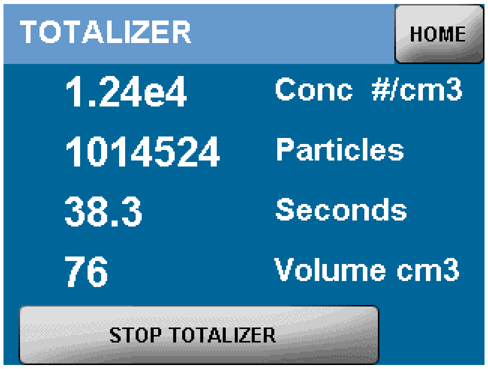
Pressing the **TOTAL** button on the home screen takes you to the **TOTALIZER** screen. The screen displays the following information:

- Current particle concentration in #/cm^3.
- Number of accumulated particles.
- Sample time in seconds.
- Volume based on flow rate and sample time.

This option is useful for manually measuring concentration over a period of time.

There is a toggle button at the bottom of the screen. When you choose **TOTAL** from the Home screen, the toggle button displays **CLEAR TOTALIZER**. When you press **CLEAR TOTALIZER**, the button displays **START TOTALIZER**.

Note: *If you go to another screen on the display, the* ***TOTALIZER*** *continues to run. It can only be stopped by pressing* ***STOP TOTALIZER****.*



CHAPTER 6

Technical Description

The Model 3783 is a continuous-flow, water-based, condensation particle counter that detects particles down to <7 nm at a sample flow rate of 0.12 L/min. This section describes the function of the particle counter, its subsystems and its components. A discussion of operation theory and history is given first.

Theory

The Model 3783 acts very much like an optical particle counter. However, the particles are first enlarged by a condensing vapor to form easily detectable droplets. Portions of the following discussion (focusing on how to condense the vapor onto the particles) are taken from a paper by Keady, et al. [1986].

In *heterogeneous* condensation, the vapor surrounding particles reaches a certain degree of supersaturation and begins to condense onto the particles. In *homogeneous nucleation* (*self-nucleation),* supersaturation is so high that condensation can take place even if no particles are present because molecules of the vapor form clusters (nucleation sites) due to the natural motion of the gas and attractive van der Waals forces. The Model 3783 operates below the supersaturation ratio to avoid homogenous nucleation.

The degree of supersaturation is measured as a saturation ratio (P/P_s), which is defined as the actual vapor partial-pressure divided by the saturation vapor pressure for a given temperature:

$$\text{supersaturation} = \frac{P}{P_s}$$

For a given saturation ratio, the vapor can condense onto particles only if they are large enough. The minimum particle size capable of acting as a condensation nucleus is called the *Kelvin diameter* and is evaluated from the following relationship:

$$\text{saturation ratio} = \frac{P}{P_s} = \exp\frac{(4\gamma M)}{\rho RTd}$$

where γ = surface tension of the condensing fluid
M = molecular weight of the condensing fluid
ρ = density of the condensing fluid
R = universal gas constant
T = absolute temperature
d = Kelvin diameter

The higher the saturation ratio, the smaller the Kelvin diameter.

The saturation vapor pressure P_s is defined for a flat liquid surface. For a curved liquid surface, such as the surface of a droplet, the actual saturation vapor pressure is greater. The smaller the droplet, the easier it is for the vapor molecules to escape the liquid surface. The Kelvin diameter defines the critical equilibrium diameter at which a pure droplet is stable (there is neither condensation nor evaporation). Liquid particles with diameters smaller than the critical equilibrium diameter will evaporate and larger particles will grow even larger by condensation. The larger particle will grow until the vapor is depleted, causing the saturation ratio to fall until it is in equilibrium with the particle droplet. The lower size sensitivity of the counter is determined by the operating saturation ratio.

History

In 1979, TSI introduced the world's first single-particle-counting condensation particle counter. The Model 3020 was a continuous-flow, diffusional, alcohol-based, thermal-cooling CPC (Bricard et al. [1976], Sinclair and Hoopes [1975], Agarwal and Sem [1980]). In an alcohol based CPC the air sample is saturated with alcohol vapor when it passes over a heated pool of liquid alcohol. The vapor-saturated air stream flows into a cold condenser tube where the air is cooled by thermal diffusion. The alcohol condenses onto the particles and the droplets grow to approximately 3 to 5 micrometers. The droplets are then counted by a single-particle-counting optical detector.

The Models 3010, 3025 and 3022 were butanol based CPCs introduced in late 80s and were replaced by Model 3771, 3772, 3775 and 3776 in 2005. A hand-held, battery powered isopropyl alcohol CPC (Model 3007) was introduced in2004.

Continuous-flow, diffusional, water-based CPCs (WCPCs) were developed between 2003 and 2006 (TSI Model 3781, 3785, and 3786 WCPCs). Using a patented technology from Aerosol Dynamic Inc., (U.S. Patent No. 6,712,881), an aerosol sample is drawn continuously through a cooled conditioner into a heated condenser. In the condenser, water vapor diffuses to the centerline faster than heat is transferred from the warm walls, producing supersaturated conditions for water vapor condensing onto the particles.

In 2010, the Model 3783 was developed specifically for measuring high concentrations in single-count mode for environmental monitoring. Also in 2010, the Model 3785 was replaced by the Model 3787, and the 3786 was replaced by the Model 3788. These new instruments have significant improvements to increase reliability and add features.

Models 3772, 3775, 3776, 3785, and 3786 can be used as components of Scanning Mobility Particle Sizer™ (SMPS™) Spectrometers (TSI Model 3936). The SMPS™ spectrometer provides high-resolution submicron-aerosol size-distribution measurements.

Design of the Model 3783

Submicrometer particles are drawn into the particle counter and enlarged by condensation of a supersaturated vapor into droplets that measure several micrometers in diameter. The droplets pass through a lighted viewing volume where they scatter light. The scattered-light pulses are collected by a photodetector and converted into electrical pulses. The electrical pulses are then counted and their rate (live-time corrected) is a measure of particle concentration.

The basic instrument consists of three major subsystems: the sensor, the microprocessor-based signal-processing electronics, and the flow system. The sensor and the flow system are described below.

Sensor

The sensor contains a conditioner, a growth tube, and an optical detector (shown schematically in Figure 1-2). The sensor grows the sampled aerosol particles into larger droplets that are detected optically.

The sample flow is cooled with a thermoelectric device in the conditioner. The vapor passes into the growth tube where it becomes supersaturated and condenses onto the aerosol particles (acting as condensation nuclei) to form larger droplets. The droplets pass through a nozzle into the optical detector.

The sensor's optical detector is comprised of a laser diode, collimating lens, cylindrical lens, elliptical mirror, and photodiode detector. The laser and collimating lens form a horizontal ribbon of laser light above the aerosol exit nozzle. The collection mirror focuses the light scattered by the droplets at a 90° angle (side scatter) onto a low-noise photodiode. The main beam is blocked by a light-stop in the back of the sensing chamber. A reference photodiode is used to maintain constant laser power output. The surface temperature of the optics housing is maintained at a higher level than the growth tube to avoid condensation on the optical surfaces.

The Model 3783 operates in single particle count mode up to 10^6 particles/cm^3. Rather than simply counting individual electrical pulses generated by light scattered from individual droplets, the Model 3783 uses a continuous, live-time correction to improve counting accuracy at high particle concentrations. Live-time correction occurs when the presence of one particle obscures the presence of another particle creating an undercounting error that results in dead time.

Pulse Height

The Model 3783 contains an electronic sub-system for monitoring the amplitude (voltage height) of the particle pulse generated by the optical detector. The actual amplitude of the pulse does not affect the particle counting performance as long as it is large enough to intercept the preset discriminator threshold. Typical pulse amplitudes (1 to 2 volts) are 10 to 40 times higher than the discriminator level which is typically 20 times higher than the RMS noise level of the photo-detector electronics. This large magnitude of ‘signal-to-noise’ margin provides robustness in performance in the optical detection of droplets.

Under normal operating conditions, the pulse amplitude decreases with increasing particle concentration. As particle concentration increases, depletion effects within the growth tube cause the nucleated droplets to grow to smaller sizes than they would at lower particle concentrations.

Note*: The droplet size has been reduced in this instrument compared to those of previous generations - reducing the variation in pulse amplitude with respect to particle concentration to about 2:1 over the concentration range of the instrument.*

Changes in optical alignment, laser power, operating temperatures, flow rates, presence of water, or optical cleanliness can all reduce pulse amplitude, therefore the pulse amplitude indicates the “health” of the WCPC. A peak-sense and hold circuit within the Model 3783 measures the pulse amplitude of 50 particles/sec. The average pulse amplitude is displayed both numerically and in a bar graph on the Status screen, and is also included in the data retrieved from the digital interfaces. The limitation of the Pulse Height indication is that is requires the presence of at least 50 particle pulses/sec to provide information. The Pulse Height fault status indication is displayed for particle concentrations over 1000 #/cm^3 with a pulse height of less than 350 mV. When measuring very low concentrations (<10 #/cm^3) the Pulse Height fault may be displayed even though the correct particle concentration is provided.

Flow System

Refer to Figure 1-2 while reviewing the instrument flow information.

The Model 3783 relies on an external vacuum supply to maintain constant flows through three critical orifices.

Orifice	Description
0.12 L/min aerosol sample flow mode	Carries the aerosol to be sampled. This is **not** user-selectable.
3.0 L/min auxiliary flow mode	A user-selectable flow rate providing a higher flow rate for use with sampling systems. ***Note***: *2.4 L/min auxiliary flow is removed to leave a transport flow of 0.6 L/min.*
0.6 L/min transport flow mode	A user-selectable flow rate used to reduce particle losses. ***Note***: *0.48 L/min transport flow is removed to leave a sample flow of 0.12 L/min.*

The flow rate through the sensor is always 0.12 L/min, independent of the inlet flow rate setting. Problems with the aerosol flow can be detected by monitoring the pressure drop across the nozzle and verifying that the critical orifice pressure is maintained.

Critical Flow

To achieve the 0.12 L/min sample flow through the sensor, an orifice is used (operated at the *critical pressure ratio*) to provide a *critical flow*. Critical flow is very stable and is a constant *volumetric* flow, ensuring accurate concentration measurements despite varied inlet pressure.

The critical pressure ratio is found by dividing the absolute pressure downstream of the orifice P_D, by the absolute pressure upstream of the orifice P_U. This ratio must be below 0.528 for air.

$$\text{Critical pressure} = \frac{P_D}{P_U} \leq 0.528$$

The following pressure values are displayed on the Status screen and can affect the EPC™ monitor flow.

Pressure Value	Description
Vacuum	The vacuum pressure
Inlet Pressure	The inlet pressure.
Nozzle Pressure	The differential pressure across the sensor flow orifice

Temperature Control

The temperatures of the conditioner, growth tube, and optics are nominally maintained at 20°C, 60°C, and 60°C, respectively, with specified ambient temperatures in the operating range of 10 to 40°C. Temperatures are controlled through feedback circuits on the main electronics board and are displayed on the Status screen on the front-panel display.

Note: *For ambient temperatures outside the instrument operating range, the instrument temperature performance may not be maintained. Moderate increases in conditioner temperature will raise* D_{50} *a small amount.*

Vacuum Supply

The external vacuum supply must be sufficient to maintain the sample flow at 0.12 L/min along with the auxiliary and transports flows. The recommended supply is 4 SLPM at 400 mbar absolute pressure.

Inlet Pressure Measurement

With an adequate vacuum supply, the EPC™ monitor can operate at inlet pressures in the range of 75 to 105 kPa. The inlet pressure is measured by an absolute pressure sensor and is equal to the barometric pressure if no inlet restriction is present.

The Inlet Pressure reading is displayed on the Status screen on the front-panel display.

Water Removal System

The EPC™ monitor has a water separator and ejection system to remove water from the vapor stream exiting the optics assembly. The water separator condenses the water vapor and then the collected water is ejected through the **WATER EXHAUST** port on the back panel and away from the internal flow control orifices. A drain tube or bottle is provided to allow the small amount of expelled water to be directed away from the instrument to a suitable drain.

Counting Efficiency and Response Time of the Model 3783

The Model 3783 EPC™ monitor has a lower detection curve with a D_{50} of 7 nm. D_{50} is defined as the particle diameter at which 50% of particles are detected. The curve fit shown in Figure 6-1 is based on testing of three Environmental Particle Counter™ monitors using sucrose particles generated by TSI Model 3480 Electrospray Aerosol Generator and size-classified with TSI Model 3080 Electrostatic Classifier and Model 3085 Nano Differential Mobility Analyzer (DMA). The counting efficiency is calculated by comparing the Model 3783 readings to TSI Model 3068A Aerosol Electrometer readings.

The particle concentration measured by the particle counter is the total number concentration of all particles that the Model 3783 can detect. This measurement provides no size differentiation and it is not corrected using the Model 3783 counting efficiency curve.

The EPC™ monitor has a fast response time. T_{95}, defined as the time it takes for the Environmental Particle Counter™ monitor reading to reach 95% of a concentration step change, is < 1.0 sec. Figure 6-2 shows the response time curves, based on the average of three Environmental Particle Counter™ monitors.

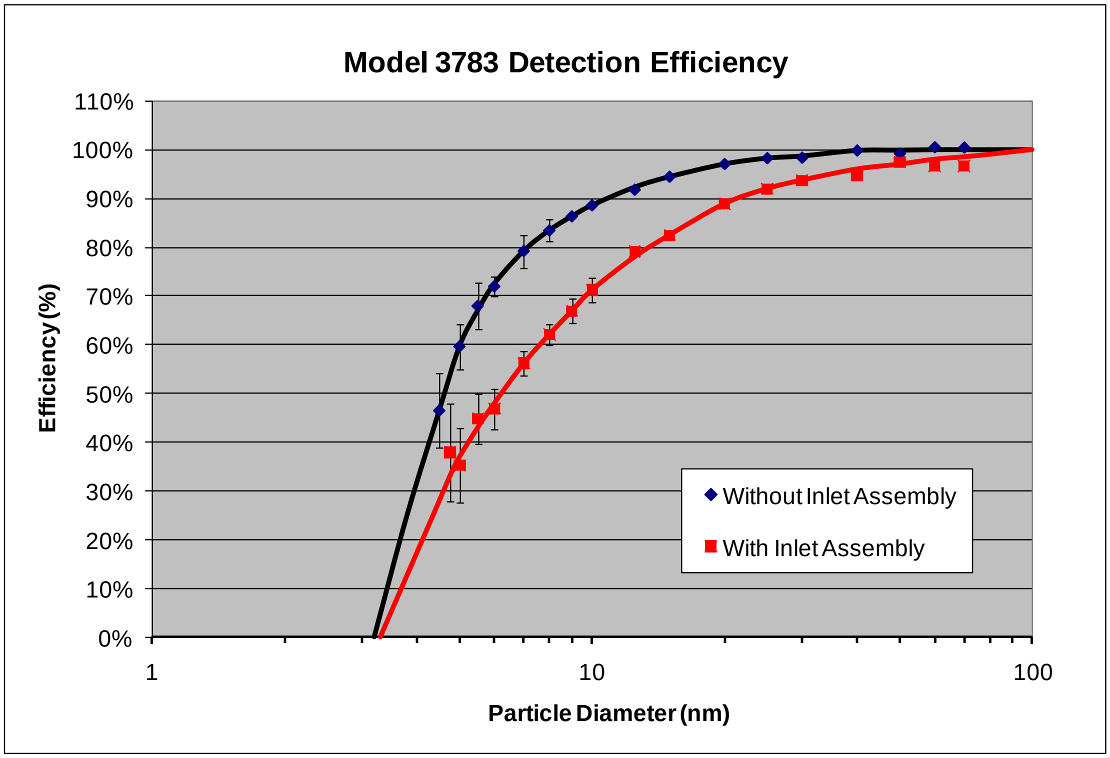


Figure 6-1
Counting Efficiency Curve of Model 3783

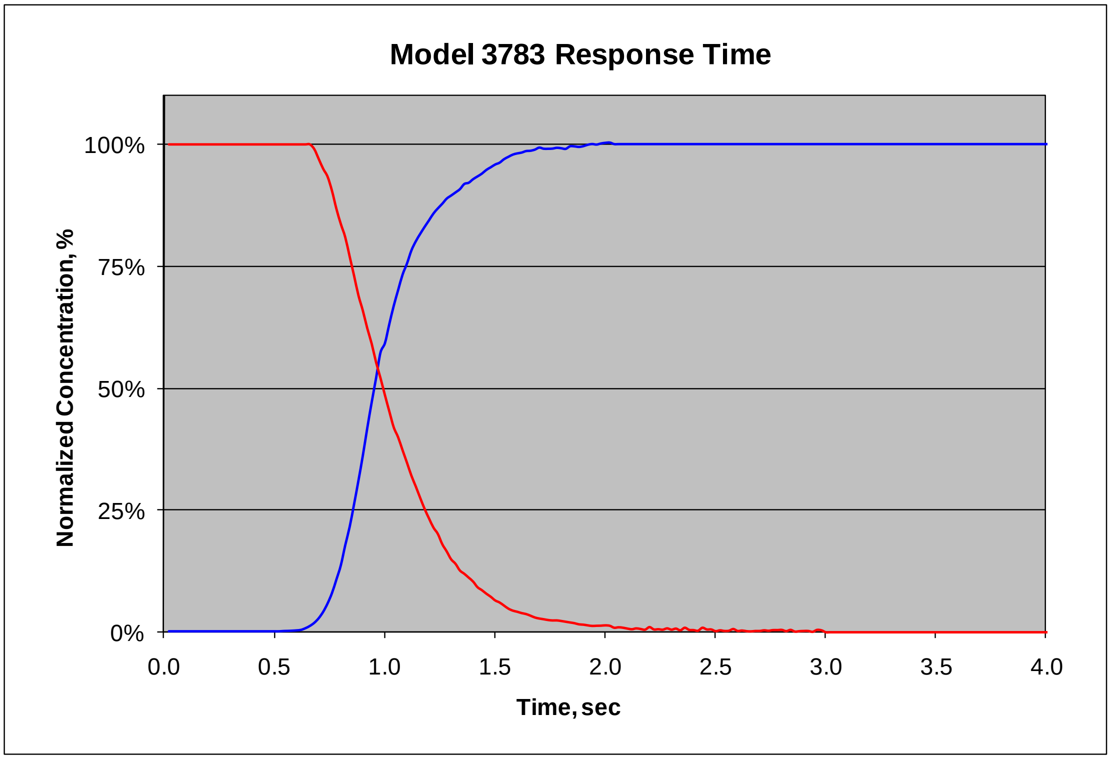


Figure 6-2
Response Time of Model 3783

CHAPTER 7
Particle Counting

This chapter discusses particle counting and particle count measurements performed using the Model 3783 EPC™ Environmental Particle Counter™ monitor.

The EPC™ monitor has two modes for particle counting:

- Concentration mode, where data is presented as particle concentration in particles/cm^3, updated each second on the display (the maximum time resolution is one second).
- Totalizer mode, where total particle counts are accumulated and presented each second.

Concentration mode is commonly used for most applications and for averaging over a period of time. Totalizer mode is used at very low particle concentrations and includes live-time corrections. Particles can be accumulated until a desired statistical accuracy is achieved.

In the concentration mode, the EPC™ monitor operates in the single count mode with continuous, live-time correction over the range between 0 and 1×10^6 particles/cm^3.

The instrument can display up to 10^6 particles/cm^3. The Model 3783 must be calibrated against a concentration reference (e.g., an aerosol electrometer or another Environmental Particle Counter™ monitor with a dilution bridge with a known dilution ratio) in the range from 3×10^5 to 10^6 particles/cm^3 in order to provide a single dead-time correction calibration (DTC) factor.

Total Count Accuracy

At very low concentrations, the accuracy of the measurement in the single-particle-counting mode is limited by statistical error. If the total number of particles counted in each time interval is very small, the uncertainty in the count is large. The relative statistical error of the count σ_r is related to the total count n by

$$\sigma_r = \sqrt{n}.$$

In totalizer mode, the accuracy of the concentration is increased by sampling for a longer period and counting more particles. The concentration is displayed on the front panel in totalizer mode and is calculated by:

$$\text{concentration} = \frac{\text{total counts}}{\text{volume of aerosol flow in the sensor}} = \frac{n}{Q \times t}$$

where

Q = Sample flow rate ration. It is very close to its nominal value of 0.12 L/min.

t = sample time in sec.

Live-Time Counting

Coincidence occurs when more than one particle occupies the optical sensing region simultaneously. The optical detector cannot discriminate between the particles and multiple particles are counted as a single particle. At higher particle concentrations, particle coincidence begins to have a significant impact on the measured concentration.

The EPC™ monitor corrects for coincidence continuously with the instrument electronics performing a “live-time” correction.

Live-time refers to the time between electrical pulses. This is the total measurement time interval minus the time during which the counter is disabled with one or multiple particles in the optical sensing volume (the dead time). The dead time should not be included in the sample time since only the particles already in the viewing column can be counted. The actual particle concentration therefore equals the number of counted particles divided by the live-time (actual sample time) and the aerosol flow rate.

To measure live-time, a high-speed clock and accumulator are used. The accumulator adds up the live time and the counter adds up pulse counts. The particle concentration is then calculated by

$$C_a = \frac{\text{number of counted particles}}{\text{accumulated live-time}} \times \frac{1}{\text{aerosol flowrate}}$$

Note: *At concentrations > 10^6 particles/cm^3, the status reads **Over Range**. If this occurs, the Model 3783 is outside of the concentration operating range and the number of particles shown on the display could be lower than the actual concentration.*

Concentration Measurement

The EPC™ monitor can report particle concentration values in the following ways:

- On the front-panel display.
- On the Totalizer display.
- Using the data communications ports.

Particle concentration is presented as particles per cubic centimeter (p/cm^3). The following parameters are important for calculating particle concentration:

- The number of particle pulses counted (measured internally by the Model 3783).
- The sample time (measured internally by the Model 3783).
- The sample flow rate (always assumed to be 0.120 L/min, or (120 cm^3/min).

The basic calculation for the number of particles per volume of air is:

$$Concentration = \frac{N}{Q \times t}$$

where:

Concentration is the particle concentration in #/cm^3
N is the number of particle counted
t is the sample time (corrected for dead-time)
Q is the sample flow rate in cm^3/second

The number of particles in the measured sample is one of the limiting factors of how low a particle concentration can be precisely determined. To calculate low particle concentrations, the Totalizer uses the elapsed time as the sample time in the above calculation.

The formula for this statistical precision is:

$$\sigma_N = \frac{\sqrt{N}}{N} \times 100\%$$

where:

σ_N is the relative standard deviation in percent
N is the number of particle counts in the sample

For a sample of 10,000 particles, the statistical precision is 1% (greater accuracy than that of the instrument). At 100 particles, the statistical uncertainty increases to 10% and becomes a significant factor in determining the aerosol concentration. The Totalizer allows for increased statistical precision at low particle concentrations through the use of longer sample times.

When a particle enters the optical viewing volume and is being detected, no other particles can be counted. As the particle concentration increases, the amount of time blocked by the presence of particles becomes significant. If the particle concentration were computed using elapsed time, the value would be under-reported, therefore the actual sample time needs to be corrected for this blocked or dead time.

To adjust for this particle “coincidence” effect, the Model 3783 measures the “dead time” resulting from the presence of particles in the viewing volume and subtracts it from the sample time. This sample ‘live-time’ value is used in place of the elapsed sample time for the concentration calculations for the primary display when not using the Totalizer.

At very high concentrations, the dead-time value grows and the adjustment becomes large. Single particle events may not even be detected since particles are nearly continually in the measurement viewing volume and the accuracy of the ‘live-time’ measurement begins to diminish. When the measured ‘live-time’ value drops below 40% of elapsed (real time), the display will show an “OVER” annotation indicating that the measured concentration exceeds its specified operating range. When the ‘live-time’ value drops below 10% of elapse time, the display will show a concentration of $9.99e^5$ particles/cm^3 indicating an extreme overload condition.

During operation, the EPC™ monitor collects single particle counts and dead-time corrected sample time every tenth of a second. The concentration value reported on the front-panel display is updated each second. It uses data collected over the previous second of elapsed time to calculate concentration. If the concentration is <20.0 particles/cm^3, a 6-second running average of particle count data is used to calculate the displayed value. A single particle counted during this six-second sample is displayed as 0.03 particles/cm^3 which is the minimum value that can be displayed (other than 0.00) without using the Totalizer. Concentration data is also available from the data communications ports and it is ‘aggregated’ or summed from each tenth-second measurement with programmable sample periods from 0.1 second to 3600 seconds.

Totalizer Mode

The Totalizer mode counts the number of particles in a given time period. This mode is used primarily to improve counting resolution at very low particle concentrations, but it can also be used to take an average over a user-specified time period.

The time, number of counts, accumulated sample volume, and particle concentration are shown on the display. The time is the actual sample time and is shorter than the elapsed time (beginning when the Totalizer is started).

The Totalizer automatically stops when 3600 seconds of sample time have been accumulated.

CHAPTER 8

Computer Interface, Commands, and Data Collection

This chapter provides information about the computer interface, communications information, and data collection for the Model 3783 EPC™ Environmental Particle Counter™ monitor. Information about using a Flash Drive is also provided.

Computer Interface

The Model 3783 EPC™ monitor provides four interfaces to allow for flexible data collection and instrument control. This section of the manual includes information about the following data interfaces:

- Ethernet
- Flash Drive
- USB
- RS-232 (Serial)

Although four interfaces are provided, you can only use one at a time. The Serial and USB data interfaces share a common communications channel to the EPC™ monitor microcontroller. Data input to the EPC™ monitor from the Serial interface is exclusive from input via the USB interface. Communications can be received from the Serial interface until a connection is linked to the USB port. When the link is established, communications can be received via the USB port but not from the Serial port. When the USB link is terminated, the Serial port can be used.

Ethernet

The Ethernet port on the EPC™ Monitor can provide system status information or instrument control over a network. In the instructions below, the client is used. Please note that Telnet feature is not included with Windows Vista® or Windows 7 operating system and must it must be enabled to be used.

To enable Telnet in Windows 7 operating system, follow these instructions:

1. From the **Start** menu, choose **Control Panel** and then choose **Programs and Features**.
2. Choose **Turn Windows features on or off**.

3. Choose **Telnet Client** and then click **OK**. A dialog box appears confirming the installation of new features.

To monitor system status using the Telnet client, follow these instructions:

1. Insert an Ethernet cable into the Ethernet port on the back panel of the 3783 and connect the cable to your network or a personal computer.
2. On the 3783 home screen, choose **SETUP** then choose **MORE** to view the **NETWORK SETUP** screen.
3. On the **NETWORK SETUP** screen, choose **ADDRESS** and enter a static IP address for this unit that is available on your network. Alternately choose **NETWORK** and select **DHCP**. If your network has a DHCP server, a dynamic address will be selected for you in a few seconds.
4. If you are using a personal computer, from the **Start** menu, choose **Run** then type the command **telnet xx.xx.xx.xx** where **xx.xx.xx.xx** is the IP address determined in step 3.
5. A console screen appears which allows direct entry of firmware of commands.

To test communication between the personal computer (or your network) and the N-WCPC, follow these instructions:

1. From the Start menu, choose **Run**, type **cmd** and press **Enter**.
2. In the resulting window type **ping xx.xx.xx.xx** where **xx.xx.xx.xx** is the IP address determined in step 3 above.
3. The response shows the response from the instrument if the network connection is valid as shown in the figure below.

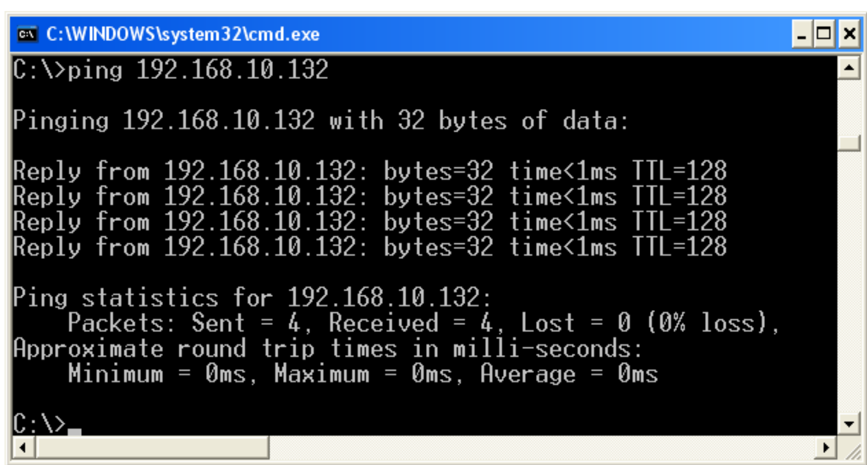


Figure 8-1
Screen Showing Valid Network Connection

Flash Drives

The Model 3783 can store particle concentration data and analog input data to a flash drive inserted into the USB slot.

***Note**: Flash drives >16 Gigabytes may not be recognized.*

To insert a Flash drive, follow these instructions:

1. Plug the Flash drive into the USB Flash Drive port on the back panel of the EPC™ monitor.

   ***Note**: If the Model 3783 is mounted in a rack, you can use the alternative USB port on the rack-mount bracket by running an extension cable from the USB port on the back panel to the USB port on the front.*

2. Check the Home screen. You should see a **START** button displayed beneath the other home screen buttons. If you do not see this button, check that your Flash drive is inserted correctly. You should also see a status message beneath the button. This message reads **Mem Stick** until you begin data collection.

3. Press **START**. The status message changes to **Logging** and the button displays **STOP**. When you press **START**, a directory named **3783** is created on the Flash drive. The data files created within that directory contain either one hour or one day of data (depending upon the **SAMPLE TIME** you chose on the **SETUP** screen), unless you press STOP to discontinue the data logging.

   ***Notes**: Data records written to the flash drive are also echoed out of the Ethernet interface on the Telnet socket. This allows redundant external data collection to be performed with the Ethernet connection while data is being collected by the flash drive.*

   *The **SAMPLE TIME** cannot be changed while data is being logged. You must stop logging data first.*

4. Press **STOP** to discontinue data logging at any time.

   ***Note**: Do **not** remove the Flash drive while logging data.*
   *Do **not** restart data logging or go beyond 99 files. If you do, data files may be overwritten.*

5. Remove the Flash drive and connect it to a computer to download the data.

Flash Memory Data Files

The data is stored in files with the "dat" extension and a new file is created either every day or every hour (depending upon the Logging selection you have made). If you stop data collection at any time, the current data file is saved even if it contains less than one hour/day of data. These data files can be imported to Aerosol Instrument Manager® software.

Every time a new run is started, a unique file is created. Each data file has the following format:

Filename	yymmddxx, where yy is the year (no leading zero), mm is the month (1-12), dd is the day of the month, and xx is a sequence number for the day (01-99). Example: 12110601.DAT where 12 is the Year, 11 is the month, 06 is the day, 01 is the file number and .DAT is the extension.
LINE 1	“TSI CPC DATA VERSION 3”
LINE 2	Time stamp for the file: yy/mm/dd,hh:mm:ss where yy is the year, mm is the month, dd is the day of the month, hh is the hours, mm the minutes, and ss the seconds
LINE 3	Data average period (sample time intervals) in seconds.
LINE 4	Dead-time correction factor, flow calibration constant (mL/min).
LINE 5	Instrument model number, firmware version number, serial number
LINE 6	Header descriptions.
LINE 7	First data record.
LINE 8	Second data record.
LINE X	Last data record.

Example of data record:

```
TSI CPC DATA VERSION 3
1268228469,2012/3/10,13:41:09
60
1.00,120
Model 3783 Ver 1.00 S/N 123456
"Date","Time","Concentration","Count"," Live-
Time","Blank","Abs Press"," Analog In","Pulse Height"," Pulse
STD","Status Flags"
2012/3/10,13:41:57,2.15e4,2522183,58.62,,970,0.00,567,600,0
2012/3/10,13:41:57,2.32e4,2719488,58.51,,970,0.00,607,595,0
2012/3/10,13:42:57,2.15e4,2530791,58.62,,970,0.00,587,609,0
2012/3/10,13:43:57,2.13e4,2505886,58.63,,970,0.00,581,615,0
```

Data fields include:

- Date
- Time
- Particle Concentration (#/cm^3)
- Raw Particle Counts
- Live-time (seconds)
- Comma (reserved field)
- Absoluter Pressure (mbars)
- Analog Input (V)
- Pulse Height average (mV)
- Pulse Height Standard Deviation
- Status flags.

Select the Sample Time (the period over which data is collected and reported) from one of the following choices: 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, or 60 seconds. Data is collected internally 10 times/second and is averaged over the selected sample time. The average is displayed on the graph and can be saved to the flash drive. Data is saved to the flash drive every 10 seconds, or at the rate of the data averaging period if it is longer than 10 seconds. The data averaging period is the same as the Sample Time setting. Once the data is being logged to the Flash drive, the Sample Time setting cannot be changed.

IMPORTANT

If power is lost at any time, the instrument should continue data logging when the power is returned. The data files created will have the extension **.rdt** so that the previous files are not overwritten.

USB

USB communications are provided with the Model 3783 EPC™ monitor for use with the supplied Aerosol Instrument Manager® software. USB driver software must be installed on the host computer. For Windows® operating systems the drivers may be downloaded from the USB chip manufacturer's site at: http://www.ftdichip.com/Drivers/VCP.htm

To install the USB driver, follow these instructions:

1. Find the appropriate driver for the host computer's operating system.
2. Download the driver to the host computer.
3. Extract (unzip) the driver to a blank folder.
4. Connect the computer to the Model 3783 USB port.
5. Follow the **Add New Hardware** wizard steps and browse to the folder containing the extracted driver. If the wizard does not start, use the Add Hardware function on the Control Panel.

When the USB driver is loaded, the operating system recognizes the Model 3783 as a new serial device. In Microsoft® Windows® operating system this is a new port (such as COM2 or COM6). If it is not obvious which COM port is being used, you can check in the computer's Device Manager. To check which COM port is being used, follow these instructions:

1. Open the **Control Panel** and choose **System**.
2. In the **System Properties** dialog box, choose the **Hardware** tab and then click **Device Manager**.
3. In the **Device Manager** dialog box, click the **+** sign next to **Ports (COM & LPT)**. The USB Serial Port indicates in parenthesis which COM port is being used.

Connect the supplied USB cable to the Model 3783 USB port and a computer running the Windows®-based operating system and the Aerosol Instrument Manager® software. In the Aerosol Instrument Manager® software, double-click the correct COM port and the data is displayed in real time (depending upon the sample time you have selected).

Refer to the Aerosol Instrument Manager® software manual for specific system requirements, including operating system version.

RS-232 Serial Communications

The communications port is configured at the factory to work with RS-232-type devices. RS-232 is a popular communications standard supported by many computers. The Model 3783 has one 9-pin, D-type subminiature connector on the back panel (labeled Serial). Table 8-1 lists the signal connections.

Note: *This pin configuration is compatible with standard IBM® PC serial cables.*

Table 8-1
Signal Connections for RS-232 Configurations

Pin Number	RS-232 Signal
2	RXD (Input to Model 3783)
3	TXD (Output from Model 3783)
5	GND

An external computer can be connected to the Serial or USB ports for basic instrument communications and when Aerosol Instrument Manager® software is used.

IBM is a registered trademark of International Business Machines Corporation in the United States, other countries, or both.

Communications Parameters

All serial communications with the Model 3783 EPC™ monitor are accomplished using the following communications parameters:

- Baud Rate: 115,200
- Bits/Character: 8
- Stop bits: 1
- Parity: None

All data communications are performed through ASCII-based character codes.

All multi-field responses are comma separated values (CSV).

All input commands and output responses are terminated with a carriage return.

All input line feeds are ignored.

Terminal Communications

When you have made a Serial or USB connection between the EPC™ monitor and host computer, you can use Aerosol Instrument Manager® software or a terminal emulation program to communicate with the Model 3783. You can choose from the following terminal emulation programs:

- Tera Term—a free terminal emulator for Microsoft Windows® operating systems.
- HyperTerminal—included with most Microsoft Windows® operating systems.

You should set up the terminal emulation software so that incoming carriage returns are translated into carriage return line feed sequences and therefore do not overwrite the previous line of data. Also, consider enabling local echoing of characters so that data typed on the keyboard is displayed on the screen.

When the terminal emulation software is connected and running, if you press the **Enter** key you will see an **ERROR** response from the Model 3783 in the terminal emulation software. This is because, although the Model 3783 and computer are communicating, the command is not understood. You can ignore this error message – it is only used for testing the connectivity. When data is being reported to the screen of the terminal emulation software, you can either, cut and paste the data into a file, or use the software's data logging capabilities to capture data. Data in the comma-delimited format can be imported into programs such as Microsoft Excel® spreadsheet software for analysis and graphing.

Appendix B, "Firmware Commands" describes the commands that control the operation and data reporting options for the Model 3783 Environmental Particle Counter™ monitor.

Aerosol Instrument Manager® Software

Aerosol Instrument Manager® software is supplied with the Model 3783. This program provides many useful data acquisition, display, processing and download functions used in particle measurement. Review the supplied Aerosol Instrument Manager® software manual for complete information on software functions.

Commands

It is important to note the following information about the commands and responses:

- Unless specified as binary-encoded, all commands and responses are sent or received as ASCII characters.
- All messages are terminated with a <CR> (0x0D) character.
- All linefeed (0x0A) characters are ignored and none are transmitted.
- Commands are case insensitive. The backspace character (0x08) deletes previous characters in buffer.
- Values enclosed by “<>” indicate ASCII characters/values sent/received. For example, <,> indicates the comma was sent or received via the communications channel.

The firmware commands are divided into the categories described below.

Commands	Description
READ	Used to read parameters from the instrument (such as flow rate, pressure, temperature, etc.). **READ** commands can be identified by a leading "R".
SET	Set an internal parameter to the value(s) supplied with the command (supplied parameters are always delimited by a comma). **SET** commands can be identified by a leading "S". The instrument will reply to all **SET** commands with the string "OK"<CR>.

***Note**: When the instrument does not understand a command, it replies with the string "ERROR".*

To use the read and set commands, a program capable of sending and receiving ASCII text commands can be used. A terminal program such as HyperTerm (supplied with Windows® XP operating system) is appropriate. To use Hyperterm, follow the instructions below for Windows® XP operating system. Other OS versions may require that you download a terminal program such as TeraTerm, but the steps are similar.

1. Connect to Serial 1 of the Model 3783 EPC™ monitor.
2. Open the HyperTerminal program by selecting: **Start | Programs | Accessories | Communications | HyperTerminal**.
3. Enter a name for the connection, for example, TSI-3783.

4. Enter the communications (COM) port.
5. Enter the following port settings and click **OK**:
   Bits per second: 115200
   Data bits: 8
   Parity: None
   Stop bits: 1
   Flow control: None**.**
6. Under the settings tab, pick the **ASCII Setup** button and check the following boxes:
   ☐ Send line ends with the feeds
   ☐ Echo typed characters locally
   ☐ Append line feeds to incoming line ends
   ☐ Wrap lines that exceed terminal widths
7. From the **File** menu choose **Save As** and save the file to the desktop for easy access.
8. Close the program and start it again from the desktop. It should automatically open a connection to the instrument.
9. Type in firmware commands to communicate with the EPC™ monitor. A list of firmware commands can be obtained using the **HELP** command or from Appendix B.

   To obtain the list from the **HELP** command, select **Transfer | Capture Text**. **HELP ALL** in the terminal window lets you capture all the help commands to a text file for easy reference.

(This page intentionally left blank)

CHAPTER 9

Maintenance, Service, and Troubleshooting

This chapter describes recommended maintenance procedures and is intended to be used by a service technician with skills in both electronics and mechanics. Static preventative measures should be observed when handling any printed circuit board connectors.

Regular maintenance of the Model 3783 Environmental Particle Counter™ monitor will help ensure years of useful operation, however the frequency of service depends upon the frequency of use and the cleanliness of the air measured. TSI recommends annual maintenance and calibration for the Model 3783 EPC™ monitor.

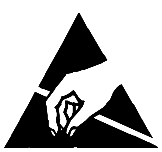
If you need to contact TSI for assistance, please have the EPC™ monitor close to the telephone when discussing the problem with a TSI technician.


WARNING

Procedures described on the following pages may require removal of the instrument cover. The instrument must be unplugged prior to service to prevent possible electrical shock hazard**.**

WARNING

Unplug the instrument prior to removing the cover to avoid potential of exposure to laser radiation.



Caution

Whenever performing service on internal components avoid damage to the Model 3783 circuitry by not stressing internal wiring, through bumping, snagging or pulling. Also use electrostatic discharge (ESD) precautions:

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

Removing the Cover

When removing the EPC™ monitor cover to perform service or maintenance, follow the instructions below:

1. Read the warnings and cautions at the beginning of this chapter.
2. Unplug the instrument and remove the instrument cover by loosening the eight side panel screws.
3. Lift the cover up.

Replacement Parts Kits

In addition to replacement parts found in your supplied accessory kit, additional replacement items are available from TSI to keep your Model 3783 EPC™ monitor operating for many years. Parts are available in kits listed below in Table 9-1. Please contact your TSI representative for details and purchase of these items.

Table 9-1
Model 3783 Maintenance and Replacement Kits

TSI Part No.	Name	Description
1183001	3783 Maintenance Kit	See Table 2-2 in Chapter 2 for details.
1183002	3783 Wick Cartridge	Replacement Wick Cartridge
1183024	Wick 3783	Replacement Wicks (set of 12)
1183004	CFO CTO Filter	Replacement Filter for Critical Sample Flow Orifice and Critical Transport Flow Orifice
1183005	CAO Filter	Replacement filter for Critical Auxiliary Flow Orifice
1183006	Critical Sample Flow Orifice 3783 (CFO)	Replacement Critical Sample Flow Orifice (.005 inch)
1183007	Critical Transport Flow Orifice 3783 (CTO)	Replacement Critical Transport Flow Orifice (.0095 inch)
1183008	Critical Auxiliary Flow Orifice 3783 (CAO)	Replacement Critical Auxiliary Flow Orifice (.0225 inch)
1183009	200 µm Screen	Replacement 200 µm Screen (0.75 inch)
1183010	Water Separator Assembly	Replacement Water Separator with Bracket
1183011	Ejection Pump Assembly	Replacement Ejection Pump with Bracket
1183012	O-ring Inlet	Replacement Inlet O-ring 11
1183013	Optics Cable	Replacement Main Board-Optics Cable
1183014	Optics Assembly	Replacement Optics Assembly

Removing and Installing the Wick

The wick should be replaced every 4 weeks (800 hours). To replace a wick, follow these instructions:

1. Find your replacement (spare) wick cartridge in your replacement parts kit. Unscrew the top of the wick cartridge and insert a new, dry replacement wick.

Figure 9-1
Loading New Wick into Spare Wick Cartridge

2. With the EPC™ monitor powered on, disconnect the water supply.
3. Loosen the thumb screws holding the inlet screen assembly in place and pull off the assembly.

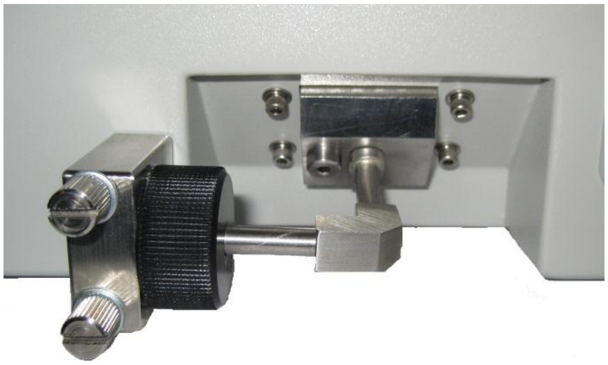


Figure 9-2
Removing Inlet Screen Assembly

4. Loosen the sampling inlet jack-screw using the supplied 1/8” Hex ball driver, and slowly turn the screw. As the jack screw is turned, the nozzle and wick cartridge will gradually be pushed out of the instrument. Grasp the sampling inlet and carefully pull it from the instrument.

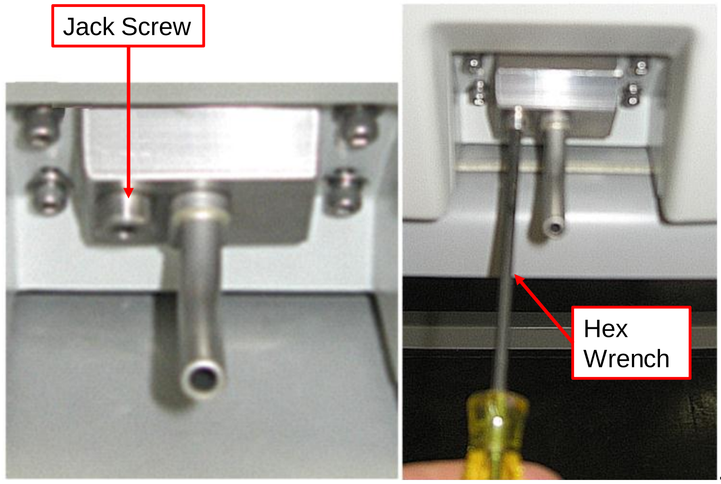


Figure 9-3
Sampling Inlet Jack Screw. Removal with hex wrench.

5. Insert spare wick cartridge loaded with a new wick into the inlet assembly. Wick inserted in Step 1.

N o t e

It is important that the flow path through the wick is uniform and clear of obstruction. Visually inspect the flow channel through the cartridge before installing it on the inlet nozzle assembly to ensure that the wick is not twisted and provides a uniform flow path.

6. Reinstall the sampling inlet assembly and the inlet screen assembly.
7. Allow removed wick to dry inside removed wick cartridge
8. Once the old wick is dry, unscrew the end of the wick cartridge and carefully remove the old wick.

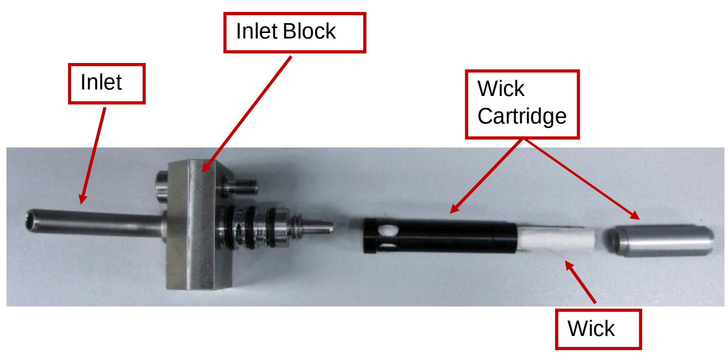


Figure 9-4
Removing Wick

9. For the next required wick replacement, discard the used wick, and insert a new wick into the wick cartridge. Keep this assembly handy.

Changing the Filters

The Model 3783 EPC™ monitor contains three filters. The filters should be replaced as part of the annual service.

To replace a filter, follow these instructions:

1. Turn off the power to the EPC™ monitor.
2. Remove the instrument cover.
3. Remove the filter from the filter clip.

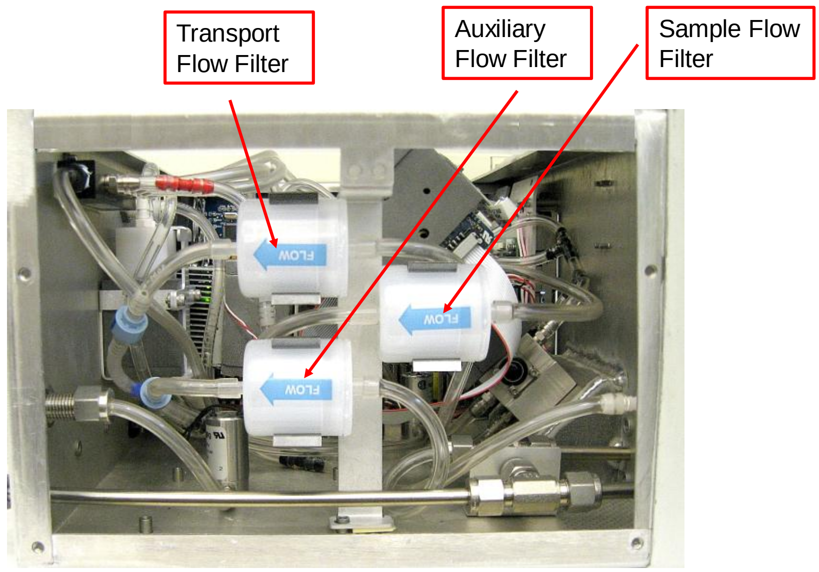


Figure 9-5
Location of Filters

4. Noting the direction of flow, push the ends (easier than pulling) of the tubing off both ends of the filter (Figure 9-6).
5. Attach the tubing to a new filter making sure the flow direction matches that of the filter you removed.
6. Remove the filter inline filter screen.
7. Push the filter into the filter clip.
8. Replace the instrument cover.

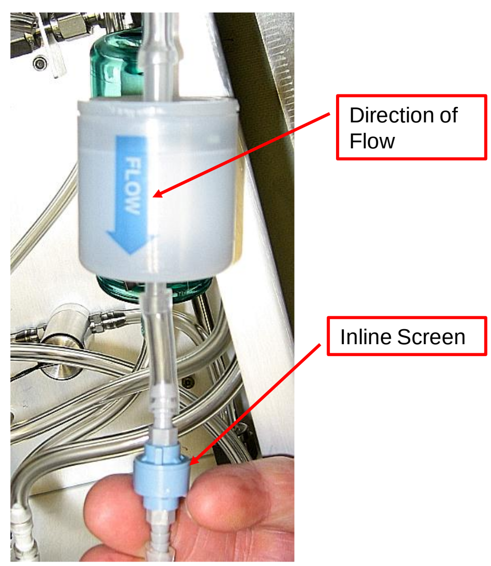


Figure 9-6
Changing Filter

Aerosol Flow Checks

The correct aerosol sample flow rate is essential in the determining of aerosol concentration. For this reason, it is important to periodically verify the sample flow rate. This is especially important after changing the wick or other activity which may result in the contamination of the optics nozzle or orifice (filter change).

To verify aerosol sample flow rate, follow the instructions presented in this section.

The flow schematic below shows the auxiliary, transport and sample flows through the Model 3783 EPC™ monitor.

Note*: Check each flow after every wick change.*

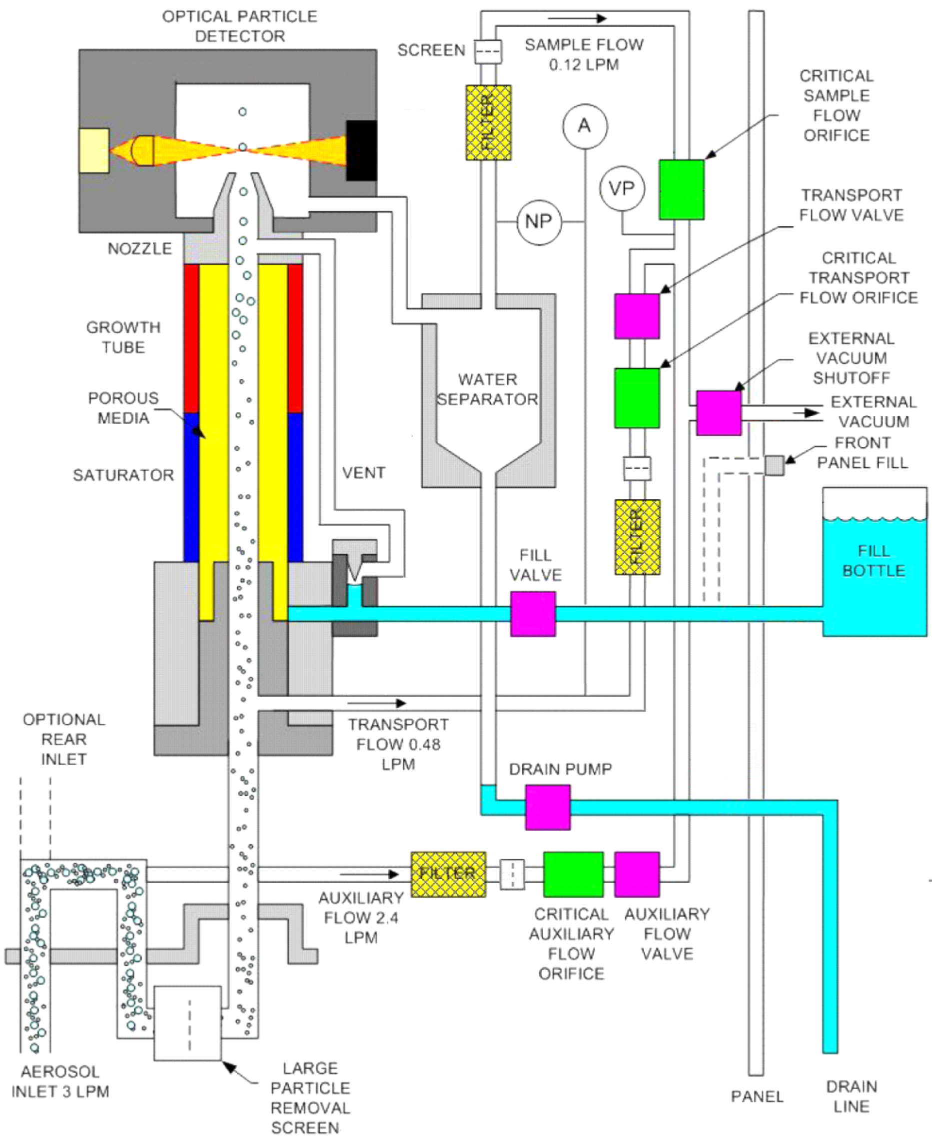


Figure 9-7
Model 3783 Flow Schematic

The instructions below describe the procedure for checking the aerosol flow. Use a similar procedure to check the auxiliary and transport flows.

To check the aerosol sample flow, follow these instructions:

1. With the instrument powered on, press **SETUP** on the Home screen, then press **INLET FLOW**.
2. Select 0.12 L/min as the setting. This value is nominal for the aerosol sample flow. Your actual inlet flow value may be slightly different, and depends on characteristics of the critical sample flow orifice. The actual flow for your orifice is displayed as an instrument Flow Constant status value on the **ADDITIONAL STATUS** screen.
3. Attach an accurate external flow meter such as a bubble meter, or Gilibrator (brand), to either the Model 3783 sample inlet or the aerosol inlet and measure the inlet flow.

Figure 9-8
External Flow Meter Attached to Model 3783 Aerosol Inlet

4. From the **HOME** screen, select **STATUS, MORE, ADDITIONAL STATUS.** Observe the Flow Constant value. This is the aerosol sample flow for the installed orifice.
5. Verify that the measured flow corresponds with the observed Flow Constant within ±5%, and also add in any uncertainty in the flow measurement resulting from errors in the accuracy of your flow meter. If the measured flow still does not compare with the Flow Constant when the tolerance errors are considered, refer to the Troubleshooting section of this chapter.

Cleaning the Water Bottle

To prevent bacterial growth and potential contamination of the Model 3783, clean the water bottle after every use. To clean the water bottle, follow these instructions:

1. Disconnect the water fill tubing from the **WATER FILL**.
2. Empty the water bottle.
3. Wash the water bottle with a mild detergent.
4. Thoroughly rinse out the water bottle.

Inspecting and Cleaning the Fans

The fans should not require much maintenance, but it is beneficial to perform a visual inspection at intervals to check for dust build up. If any of the fans are dusty, blow them clean with compressed air.

Clean/Replace the Orifices

The Model 3783 has three orifices:

- Total flow orifice (0.12 L/min)
- Transport flow orifice (0.6 L/min)
- Auxiliary flow orifice (3 L/min)

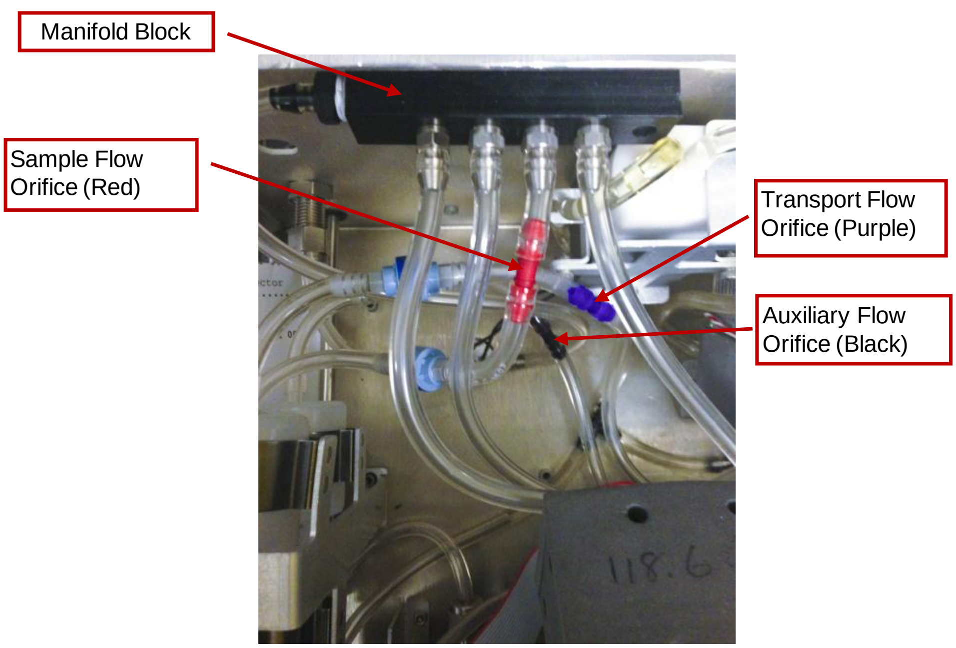


Figure 9-9
Cleaning/Replacing Orifices

To clean or replace an orifice, follow these instructions:

1. Turn off the power to the Model 3783.
2. Remove the instrument cover.

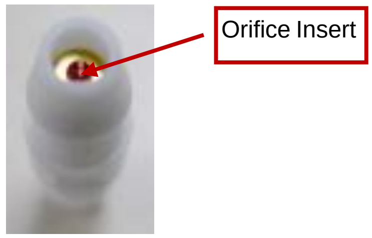


Figure 9-10
Orifice Insert

3. Grasp the tubing on either side of the orifice and pull firmly to detach the tubing from the orifice.
4. Using a microscope, inspect the orifice. If debris is present, soak the orifice in isopropyl alcohol for 20 minutes.

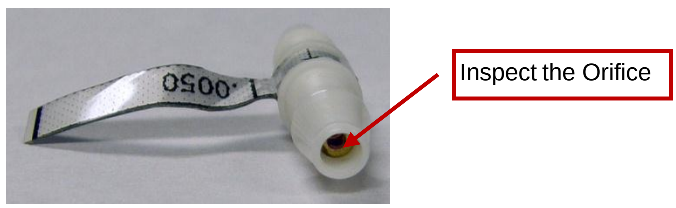


Figure 9-11
Inspect Orifice

5. Using compressed air at <60 psi, blow out the orifice and then re-inspect under the microscope.
6. If the orifice is clean, replace it in the instrument making sure that the orifice insert is positioned closest to the manifold block.
7. If the orifice is not clean, replace it with a new one. ***Note****: replacement orifices are supplied by TSI Inc.*
8. Replace the instrument cover.

Inspect Liquid Lines

Inspect the water filling lines that flow from the fill connectors located on the front and back panels to the fill valve. Also inspect the water line from the fill valve to the EPC™ monitor engine. Check for cracks, damage, loose fit, or signs of leaking. Replace as necessary with tubing supplied in the maintenance kit that comes with the instrument. Replacement of liquid flow lines is part of the TSI factory annual service.

Status Messages

Status messages display at the top of the Home screen. The messages are described below.

Status Message	Indicator Description
Low Water	Water level is low
Warmup	Instrument is warming up
Laser Fault	Laser malfunction
Inlet Pressure Fault	Inlet pressure is too high/low
Vacuum Fault	Vacuum pressure is too high/low
Nozzle Fault	Flow obstruction exists
Absolute Pressure Fault	Barometric pressure is outside the operating range
Optics Temp Fault	Optics temperature is out of range
Growth Tube Temp Fault	Growth Tube temperature is out of range
Conditioner Temp Fault	Conditioner temperature is out of range
Separator Temp Fault	Separator temperature is out of range
Pulse Height Fault	Low pulse height
Ready	Warm-up process has finished and the Model 3783 is ready for use.
Fault	Unspecified fault (not covered by any of the specific indicators)

Note: *The messages are a warning that there is a problem with the instrument, but only one message can display at a time. Check the Status screen for more details about potential problems.*

Troubleshooting

The **STATUS** screen displays the status of the operating parts in live-time. The table below provides basic information about some status messages and suggestions for corrective action.

Table 9-2
Troubleshooting

Problem	Cause	Suggestions
Nozzle fault indicated on the Home screen and low Nozzle Pressure (<50%) indicated on the Status screen.	Low sample flow. Likely causes:	Verify 0.12 L/min inlet flow as described in the Flow Checks section of this chapter. If flow is OK, check for the presence of water in the Pressure Transducer sample lines.
	There is an obstruction in the Sample Flow Orifice.	The Sample Orifice is likely clogged or dirty and needs cleaning or replacement.
	The Sample Flow Filter is wet. This may result after a flooding incident, or result from poor performance of the Water Separator.	Replace the Sample filter if it appears wet. A wet filter may indicate flooding or poor performance of the Water Separator. The problem may be seen as presence of water in the tubing immediately upstream of the filter. Replace the Sample Filter. Also mark flow direction with a marker and remove the filter Screen found downstream of the Sample Filter. Use compressed air to blow back through the Screen to remove trapped material. Replace the Screen in its original orientation as indicated by the mark.
	Water present in the pressure transducer sample lines.	Poor performance of the Water Separator may result if the instrument is operated outside its temperature and humidity specification range.
Nozzle fault indicated on the Home screen and high Nozzle Pressure (>300%) indicated on the Status screen.	The pressure over the nozzle is high indicating that the nozzle may be plugged or the path ahead of the nozzle is obstructed. Obstruction may be due to an improperly installed, twisted wick or the presence of excess water.	Verify 0.12 L/min inlet flow as described in the Flow Checks section of this chapter. Disconnect the water bottle and remove the inlet block and wick assembly as described earlier in this chapter. If the Nozzle Pressure % remains high, the nozzle is plugged. The nozzle is not user serviceable, contact TSI. If the Nozzle Pressure % drops to near 100% after wick assembly removal, a restriction in the wick cartridge is indicated. Unscrew the wick cartridge from the inlet block and the growth tube from the conditioner. Look through the wick tube to verify an open path. If there is no clear path, (e.g. the wick is twisted causing a blockage), refer to the manual section on replacing the wick. If there appears to be excessive water dripping from the instrument after inlet removal, flooding may have occurred. Disconnect the water fill bottle at the quick disconnect and allow the instrument to run for a few hours without the wick cartridge installed. This will dry the instrument.

Problem	Cause	Suggestions
Home screen displays Inlet Pressure Fault. Status Screen displays a low inlet pressure reading (in red).	There is an obstruction in the aerosol or Model 3783 inlet.	1. Check that there are no kinks in the sample tubing leading to the inlet. 2. Check the inlet screen assembly for obstructions. 3. Remove the inlet screen assembly. 4. Remove the elbow joint.  5. Unscrew the black cap. 6. Remove the screen assembly. ***Note**: Do **not** lose the O-ring.*  7. Blow the screen with compressed air. 8. Reassemble the inlet screen assembly. 9. Replace the inlet screen assembly.
“Temperatures out of range” error messages are displayed for the Water Separator, Optics, Growth Tube or Conditioner. Status screen shows readings in red.	The instrument was flooded. Environmental temperature or humidity is too high or too low. ***Note**: If the instrument was flooded, you will see water in the tubing and high nozzle pressure readings.*	In the event of flooding: 1. Disconnect the water bottle from the **WATER INLET/DRAIN**. 2. Run the instrument for 6 to 8 hours to dry it out. 3. When the flow returns to normal, the instrument is dry. 4. Reconnect the water bottle. If concentrations do not return to normal, return the instrument to TSI Inc., for repair.
Status screen indicates Water Reservoir Not Filled.	There is no water in the reservoir. The water bottle may not be connected. The water bottle may be empty, or the water bottle has been placed below the level of the instrument.	Check that the water bottle is filled and connected correctly. Make sure that the bottle is placed at a higher level than the instrument to provide for the gravity flow fill mechanism. If the problem persists, return the instrument to TSI Inc., for repair.

Problem	Cause	Suggestions
Status screen Pulse Height indicator is too low (in the red area).	There is no or very low (<10 #/cm^3) particle concentration. At higher concentrations, this indicates a dry wick, optical alignment problems, dirty optics, or flooded optics.	If the suspected concentration is above 100 #/cm^3 then replace the wick and make sure water is connected to the instrument. If all other status indicators are normal, the optics module must be replaced. Return the instrument to TSI Inc. for replacement of the optics module by a qualified service technician.
The real-time clock does not maintain time when the instrument is turned off. The time is not maintained correctly.	The clock battery needs replacing.	Replace the clock battery located on the main electronics board with a BR1225 Panasonic or equivalent.

Technical Contacts

- If you have any difficulty installing the Model 3783, or if you have technical or application questions about this instrument, contact an applications engineer at TSI Incorporated, (651) 490-2811 or contact particle@tsi.com.

- If the Model 3783 fails, or if you are returning it for service, visit our website at http://rma.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: particle@tsi.com

TSI GmbH
Neuköllner Strasse 4
52068 Aachen
GERMANY

Telephone: +49 241-52303-0
Fax: +49 241-52303-49
E-mail: tsigmbh@tsi.com
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
Fax: +44 (0) 149 4 459700
E-mail: tsiuk@tsi.com
Web: www.tsiinc.co.uk

Returning the Model 3783 for Service

Before returning the Model 3783 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. When you call, have the following information ready for the Customer Service representative:

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

TSI recommends that you keep the original packaging of the Model 3783 for use whenever the instrument is shipped, including when it is returned to TSI for service. Always seal off the sampling inlet to prevent debris from entering the instrument and dry the Model 3783 before shipping. If you no longer have the original packing material, first protect the Model 3783 by placing it inside a plastic bag. Then package the unit with at least 5" (13 cm) of shock absorbing/packaging material around all six sides of the Model 3783.

See Moving and shipping in Chapter 3 for detailed instructions.

APPENDIX A

Specifications

Table A-1 contains the operating specifications for the Model 3783 Environmental Particle Counter™ monitor. These specifications are subject to change without notice.

Table A-1
Model 3783 Environmental Particle Counter™ Monitor Specifications

Particle Size Range	
Min detectable particle (D_{50})	7 nm (verified with DMA-classified sucrose)
Max detectable particle	>3 µm
Particle Concentration Range	
Single Particle Counting	0 to 10^6 particles/cm^3, with continuous live-time coincidence correction
Particle Concentration Accuracy	
Measurement Accuracy	±10% at 10^6 particles/cm^3
Response Time (T95)	
High flow mode(3 L/min)	<3 sec to 95% in response to concentration step change
Low flow mode (0.6 L/min)	<5 sec to 95% in response to concentration step change
Flow	
High-flow inlet	3 ±0.3 L/min
Low-flow inlet	0.6 ± 0.06 L/min
Aerosol flow rate	120 ±12 cm^3/min
False Background Counts	
False background counts	<0.01 particles/ cm^3, one hour average
Aerosol Medium	
Aerosol medium	Air only
Environmental Operating Conditions	
Ambient temp range	10 to 38°C (50 to 100.4°F)
Ambient humidity range	0 to 90% non-condensing
Inlet Pressure Operation	
Inlet pressure operation (absolute)	50 to 110 KPa (0. to 1.1 atm)
Inlet pressure gauge	1 to -5 kPa (-20 inch H_20)
Water System	
Condensing liquid	Water
Water system	External 1 liter bottle for up to 4 weeks of operation.
Water consumption	~250 ml/week
Vacuum	
Vacuum	External vacuum pump not included in instrument accessories

Communications	
Protocol	ASCII command set
Interfaces	
RS-232	9-pin, D-Sub connector
USB	Type B connector, USB 2.0 compatible at 12 MB
Ethernet	8-wire RJ-45 jack, 10/100 BASE-T, TCP/IP
Data Logging	
Data logging	USB Flash drive
Averaging interval	Data averaging interval of 1-3600s 1,2,4,5,6,10,12,15,20,30 or 60s software provides more avg options.
Outputs	
Digital display	9-inch QVGA color touch screen with graphical interface. Graph of conc vs. time, concentration, time and total counts, and status
Analog output	BNC connector, 0 to 10V proportional to concentration, or 0 to 7V in LOG concentration mode.
Digital output	Data download using USB or RS-232 serial interface
Software	
Software	TSI Aerosol Instrument Manager® software included
Calibration	
Calibration	Recommended annually
Power	
Requirements	100 to 240 VAC, 50/60 HZ, 335 W max
Physical Features	
Front panel	Display, sample inlet, LED particle indicator
Back panel	Power connector, USB, Ethernet, RS-232, BNC output, fan, water fill connector, pump exhaust port, fill bottle and bracket
HxDxW	8 x 19 x 12 inch
Weight	9.9 Kg (22 lbs)

APPENDIX B

Firmware Commands

The firmware commands are divided into the categories described below.

Commands	Description
READ	Used to read parameters from the instrument (such as flow rate, pressure, temperature, etc.). **READ** commands can be identified by a leading "R".
SET	Set an internal parameter to the value(s) supplied with the command (supplied parameters are always delimited by a comma). **SET** commands can be identified by a leading "S". The instrument will reply to all **SET** commands with the string "OK"<CR>.

Note*: When the instrument does not understand a command, it replies with the string "ERROR".*

Table B-1 is a quick reference of all the firmware commands. More detailed information about each command can be found on the following pages.

Note*: The commands are not case sensitive.*

Table B-1
Model 3783 Firmware Commands

Command	Explanation
Read Commands	
RAI	**R**ead **A**nalog **I**nput **V**oltage
RALL	**R**ead Operating Condition
RCT	**R**ead **C**urrent **T**ime
RD	**R**ead **D**isplayed **C**oncentration
RIE	**R**ead **I**nstrument **E**rrors
RIF	**R**ead **I**nlet **F**low Rate
RIS	**R**ead **I**nstrument **S**tatus
RL	**R**ead **L**aser Current
RLL	**R**eads **L**iquid **L**evel
RPA	**R**ead **A**bsolute **P**ressure
RPN	**R**ead **N**ozzle **P**ressure
RPV	**R**ead **V**acuum **P**ressure
RRD	**R**ead **D**ata **R**ecord
RRS	**R**ead **S**tatus **R**ecord
RTA	**R**ead **C**abinet **T**emperature
RTC	**R**ead **C**onditioner **T**emperature

Command	Explanation
Read Commands	
RTG	**R**ead **G**rowth **T**ube **T**emperature
RTO	**R**ead **O**ptics **T**emperature
RV	**R**ead **V**ersion
Set Commands	
SM	**S**et **M**ode **x**=mode **t**=sample time in tenth of second
SA	**S**et **A**uxiliary Flow
SFC	**S**et **F**low Rate **C**alibration Constant
SP	**S**et **P**ump On/Off
SR	**S**et **R**eal Time Clock
SSTART	**S**tart a New **S**ample
ST	**S**et **T**ransport Flow On/Off
SW	**S**et **W**ater Separator Temperature Control On/Off
SWS	**S**et **W**ater Separator Temperature **S**et Point

READ Commands

Read Commands are used to display specific data values. The values, associated parameters, responses returned by the Model 3783, and examples are given on the following pages.

RAI – Read Analog Input Voltage

RAI reads the analog input voltage in V.

RAI		
Command	RAI	
Response	X	X = analog input ZZAs (a floating point number from 0.00 to 10.00)
Example		
Command	RAI	Read Analog Input Voltage
Response	5.22	Voltage = 5.22 V

RALL – Read Operating Condition

RALL reads the Model 3783 EPC™ monitor's operating condition, calibration parameters, and diagnostic parameters.

RALL		
Command	RALL	
Response	X	X = a list of operating condition, calibration parameters, and diagnostic parameters (see below)
Example		
Command	RALL	Read Analog Input Voltage
Response		

```
Model 3783 Ver 1.01 S/N 83031002
ROM Checksum,                          356E
Service Date Cal_Reminder Num          0101-30,0101-30,6
On time Las time,                      497:10,389:30
Laser SP mA,                           750,0
Detect Offset Thrsh HV Photo,          3700,125,1000,0
Ejection Rate,                         60
Cap Flow SP Offset Value,              2500,3,5
Nozzle SP Offset Val Flow,             254,128,121,0
ABS Raw Mbar Inlet_Cap,                3267,991,0
Deadtime  Corr   Val%,                 117,84
Inlet SP Temp Drive Cal,               100,221,0,221
Optics SP Temp Drive,                  600,509,1023
GT SP Temp Drive,                      600,512,1023
Cond SP Temp Drive Zero Current(ma),200,200,103,134,59
Sep SP Temp Drive Zero Current(ma), 200,200,66
Fill Cond_Thresh GT_Thresh,            850,700
Analog Output DAC Span Offset,         217950,1291
Analog Input ADC Span Offset,          9801,100
Cabinet SP Temp(bits) Temp,            1722,1722,25.0
Particle Conc,                         0.00
Pulse Height Threshold,                150
Network Setting (DHCP State),          STATIC
MAC Address,                           0:55:3:4:F3:DA
IP Address,                            192.168.20.201
Subnet Mask,                           255.255.255.0
Gateway Address,                       192.168.20.1
```

RCT – Read Current Time

RCT reads the current time.

RCT		
Command	RCT	
Response	yyyy/mm/dd,hh:mm:ss	yyyy = year mm = month (1 – 12) dd = day (1 – 31) hh:mm:ss = time (hours, minutes, seconds)
Example		
Command	RCT	Read Current Time
Response	2012/12/18,20:22:19	Year = 2012 Month = December Day = 18 Hour = 8 pm Minutes = 22 Seconds = 19

RD – Read Displayed Concentration

RD is a legacy command that reads the displayed concentration in particles/cm^3.

RD		
Command	RD	
Response	x	X = #/cm^3, floating point number (0.00 – $1.00e^6$)
Example		
Command	RD	Read Displayed Concentration
Response	$3.16e^4$	

RIE – Read Instrument Errors

RIE reads the instrument errors (displayed as a 16-bit integer in hexadecimal format). The number may be a combination of the values of more than one flag.

RIE		
Command	RIE	
Response	Bit 0 x XXXX	Bit = Hexadecimal character A-F. When the bit is set, the parameter is in error. XXXX = 4-digit number 0x0001 = Conditioner Temperature 0x0002 = Growth Tube Temperature 0x0004 = Optics Temperature 0x0008 = Vacuum Level 0x0020 = Laser Status 0x0040 = Water Level 0x0080 = Concentration Over-range 0x0100 = Pulse Height Fault 0x0200 = Absolute Pressure 0x0400 = Nozzle Pressure 0x0800 = Water Separator Temperature 0x1000 = Warmup 0x2000 = Reserved 0x4000 = Service Reminder 0x8000 = Reserved
Example		
Command	RIE	Read Instrument Errors
Response	C00	Water Separator Temperature and Nozzle Pressure faults (Nozzle Pressure = hexadecimal 4. Water Separator = hexadecimal 8. Added together they make hexadecimal C.)

***Note**: Hexadecimal is a numerical system using a base of 16. The symbols 0-9 represent the values zero to nine, and the letters A-F represent the values ten to sixteen. It is a useful "shorthand" for computer engineering because each hexadecimal digit represents four binary digits.*

RIF – Read Aerosol Flow Rate

RIF reads the inlet flow rate in liters per minute (L/min).

RIF		
Command	RIF	
Response	X	X = Floating point number either 0.12, 0.6, or 3.0
Example		
Command	RIF	Read Inlet Flow Rate
Response	0.3	3.0 L/min

RIS – Read Instrument Status

RIS reads the instrument status (displayed as 13 comma-separated fields).

RIS		
Command	RIS	
Response	X	X = 1-13 1 = Concentration (#/cm^3) 2 = Livetime (%) 3 = Not used in Model 3783 4 = Inlet Pressure (mBar) 5 = Nozzle Pressure (%) 6 = Inlet Flow Mode (0.12, 0.6, 3.0) 7 = Analog Input Voltage (mV) 8 = Pulse Height (mV) 9 = Optics Temp (°C) 10 = Growth Tube Temp (°C) 11 = Conditioner Temp (°C) 12 = Water Separator Temp (°C) 13 = Water Reservoir (Filled/Not Filled, 0/1)
Example		
Command	RIS	Read Instrument Errors
Response	0.00, 100, blank 1002, 100, 0.12, 0.00, 0, 60.0, 60.0, 20.0, 7.0, 0	Particle Concentration Livetime Not used in Model 3783 Inlet Pressure Nozzle Pressure Inlet Flow Mode Analog Input Voltage Pulse Height Optics Temp Growth Tube Temp Conditioner Temp Water Separator Temp Water Reservoir (Filled)

RL – Read Laser Current

RL reads laser current in mA.

RL		
Command	RL	
Response	X	X = 0 - 50
Example		
Command	RL	Read Inlet Flow Rate
Response	30	30 mA

RLL – Read Liquid Level

RLL reads the liquid level.

RLL		
Command	RLL	
Response	FULL/NOTFULL X	X = ADC reading from 0 to 4095
Example		
Command	RLL	Read Liquid Level
Response	FULL (2471)	FULL – water level ADC - 2471

RPA – Read Absolute Pressure Transducer

RPA reads the absolute pressure transducer in mbars.

RPA		
Command	RPA	
Response	X	X = A floating point number from 150 to 1150
Example		
Command	RPA	Read Absolute Pressure
Response	1001	

RPN – Read Nozzle Pressure Transducer

RPN reads the nozzle pressure transducer in percent.

RPN		
Command	RPN	
Response	X	X = A floating point number from 0 to 2050
Example		
Command	RPN	Read Nozzle Pressure
Response	100	

RPV – Read Vacuum Pressure

RPV reads the vacuum pressure transducer in mbars.

RPV		
Command	RPV	
Response	X	X = A floating point number from 0 to 1150
Example		
Command	RPV	Read Vacuum Pressure
Response	408	

RRD – Read Data Record

RRD returns the current data values in the “D” record format. Data records are collected according to the time period you have specified for the data collection interval.

RRD		
Command	RRD	
Response	D record (see below)	
	D	Record identifier
	Date	Date in yyyy/mm/dd format
	Time	Time in hh:mm:ss format
	Flags	Status Flags (see information in RIE command description)
	Conc	Aggregated concentration calculated by dividing the accumulated aggregate counts by the live-time of the sample flow rate (2 cm^3/sec). The aggregated counts and live-times are accumulated each 1/10th second interval. The overflow flag is set when the concentration value exceeds the maximum specified concentration.
	AT	Elapsed sample time 0.1 sec resolution (0.1 to 3600)
	LT	Live time 0.001 sec resolution (0.001 to 3600)
	CNT	Accumulated particle counts
	Photo	Average photodetector value in mV
	Reserved	Blank reserved space
	PH	Average pulse height in mV
	PSTD	Pulse height standard deviation

Example D Record:
D,2012/11/2,08:01:21,0,1.04e4,6.0,4.4,769424,140,,0,0

Record Type	Date	Time	Flags	Conc	AT	LT	CNT	Photo	PH	PSTD
D	2012/11/2	08:01:21	0	1.04e4	6.0	4.4	769424	140	0	0

RRS – Read Status Record

RRS returns the current raw analog values in “S” record format for diagnostic use.

RRS		
Command	RRS	
Response	S record (see below)	
	S	Record identifier
	AP	Absolute pressure in mbars
	ST	Conditioner Temperature in degrees Celsius
	GT	Growth Tube temperature in degrees Celsius
	OT	Optics temperature in degrees Celsius
	WT	Water Separator temperature in degrees Celsius
	FL	Sample flow rate in cm^3/min

Example S Record:
S,1003,20.0,60.0,60.0,7.0,124.0

Record Type	AP	ST	GT	OT	WT	FL
S	1003	20.0	60.0	60.0	7.0	124.0

RTA – Read Cabinet Temperature

RTA reads the cabinet (ambient) temperature in degrees Celsius.

RTA		
Command	RTA	
Response	X	X = A floating point number from 0.0 to 60.0
Example		
Command	RTA	Read Cabinet Temperature
Response	23.8	23.8 °C

RTC – Read Condenser Temperature

RTC reads the conditioner temperature in degrees Celsius.

RTC		
Command	RTC	
Response	X	X = Floating point number from 0.0 to 50.9
Example		
Command	RTC	Read Conditioner Temperature
Response	20.0	20.0°C

RTG – Read Growth Tube Temperature

RTG reads the Growth Tube temperature in degrees Celsius.

RTG		
Command	RTG	
Response	X	X = Floating point number from 0.0 to 80.0
Example		
Command	RTG	Read Growth Tube Temperature
Response	60.0	60.0°C

RTO – Read Optics Temperature

RTC reads the optics temperature in degrees Celsius.

RTO		
Command	RTO	
Response	X	X = Floating point number from 0.0 to 80.0
Example		
Command	RTO	Read Optics Temperature
Response	60.0	10.0°C

RV – Read Firmware Version Number

RV returns the instrument model number, firmware version number, and serial number.

RV		
Command	RV	
Response	Model 3783 Ver v.vv S/N nnnn	v.vv = ranges from 0.01 to 9.99 (3 digits) nnnn ranges from 100-99999999)
Example		
Command	RV	Read Version Number
Response	Model 3783 Ver 1.00 S/N 1004	Model 3783 = Model # Ver 1.00 = Version # S/N 1004 = Serial Number

SET Commands

Set commands are used to set instrument parameters and data collection modes. You will use the **Set Mode** (SM) command to control data collection.

SM – Set Mode

SM is used to set the data collection mode and the sample interval. At the end of each sample interval, the data is reported and, if in a continuous mode, the data is cleared internally and the next sample is started. The four available modes are shown in the list below.

0	Idle. No data collection.
1	Continuously collects data and reports data (“D” record) at end of every sample interval.
2	Continuously collects data and reports data (“S” record) at end of every sample interval.
3	Continuously collects data and reports data (“D” record) at end of every sample interval. Concatenates “S” record to the “D” record.

SM		
Command	SM,n,tttt	n = mode (0,1,2,3) ttttt – sample interval
Response	OK	Response issued after parameters changed.
Example		
Command	SM,1,60	Continuous data collection (response mode 1) at 6-second sample intervals.
Response	OK	
Command	SM	Parameters not changed.
Response	1,60	Continuous data collection (response mode 1) at 6-second sample intervals.

***Note**: To stop data collection, enter SM,0 in the Firmware Command field.*

SA – Set Auxiliary Flow Valve

SA is used to turn the auxiliary flow valve on or off. When the Model 3783 is powered off, the setting is saved (it does not revert to the default).

SA		
Command	SA,x	x = 0 turns valve off x = 1 turns valve on
Response	OK	Response issued after parameters changed.
Example		
Command	SA,0	Turns the valve off.
Response	OK	
Command	SA	
Response	0	Parameter not changed – current setting displayed on record.

SFC – Set Flow Rate Calibration Constant

SFC is used to set the flow rate calibration constant or to return the value of the current setting if no parameter is supplied. When the Model 3783 is powered off, the setting is saved (it does not revert to the default).

SFC		
Command	SFC,ccccc	cccc = 1000-1400
Response	OK	Response issued after parameters changed.
Example		
Command	SFC,1205	Changes the flow rate constant to 120.5 cm^3/min.
Response	OK	
Command	SFC	
Response	1205	Parameter not changed. Current setting displayed on record.

SP – Set Pump Vacuum

SP is used to turn the pump vacuum on or off. The default setting at power-up is On. When the Model 3783 is powered off, the setting is saved (it does not revert to the default).

SP		
Command	SP,x	x = 0 turns vacuum off x = 1 turns vacuum on
Response	OK	Response issued after parameters changed.
Example		
Command	SP,0	Turns the vacuum off.
Response	OK	
Command	SP	
Response	0	Parameter not changed – current setting displayed on record.

SR – Set Real-time Clock

SR is used to set the clock. When the Model 3783 is powered off, the setting is saved (it does not revert to the default).

SR		
Command	SR,yy,mm,dd,hh,mm,ss	yy = year (2 or 4 digits) mm = month (1-12) dd = day (1-31) hh = hour (0-23) mm = minutes (0-59) ss = seconds (0-59) Note: mm and ss are 0 if not included.
Response	OK	Response issued after parameters changed.
Example		
Command	SR,12,5,6,15,34	Clock is set to May 6, 2012, 3:34 pm
Response	OK	
Command	SR	
Response	09,5,6,15,34	Parameter not changed – current setting displayed on record.

SSTART – Starts a New Sample

SSTART is used to start a new sample routine.

SSTART		
Command	SSTART,x	X = 0,1,2,3 0 = Stop 1 = Start data type 1 (not used) 2 = Start data type 2 (not used) 3 = Start s new sample
Response	OK	Response issued after parameters changed.
Example		
Command	SSTART,0	Stops sample.
Response	OK	
Command	SSTART,3	Starts new sample.
Response	OK	
Command	SSTART	
Response	3	Parameter not changed – current setting displayed on record. U records are displayed when the **SSTART,3** command is entered. The records are returned once per second (see below).
	U	Record type
	X	Elapsed time in seconds (integer)
	C	Concentration in 1/10th second intervals (float)
	R	Raw counts in 1/10th second intervals (integer)
	X	No value represented between commas for the Model 3783
	T	Live time in 1/10th seconds (float)
	D	DTC value (float)
	P	Absolute pressure in millibars (integer)
	AN	Analog input
	HM	Pulse height mean in millivolts (integer)
	HS	Pulse standard deviation in millivolts (integer)
	IS	Instrument status (use RIE command to see a list of statuses)

Example U record:
UX,C,C,C,C,C,C,C,C,C,C,R,R,R,R,R,R,R,R,R,R,,T,T,T,T,T,T,T,T,T,T,D,P,
AN,HM,HS,IS

```
U1,2.13e3,1.97e3,2.18e3,2.24e3,2.34e3,2.29e3,2.26e3,2.31e3,
2.35e3,2.17e3,466,430,475,489,510,500,493,505,512,474,,,,,,,,
,,,0.099,0.099,0.099,0.099,0.099,0.099,0.099,0.099,0.099,0.09
9,1.17,990,0.000,1179,421,0
U2…
```

ST – Set Transport Flow

ST is used to turn the transport flow on or off. The default setting at power-up is On. When the Model 3783 is powered off, the setting is saved (it does not revert to the default).

ST		
Command	ST,x	x = 0 turns flow off x = 1 turns flow on
Response	OK	Response issued after parameters changed.
Example		
Command	ST,0	Turns the flow off.
Response	OK	
Command	ST	
Response	0	Parameter not changed – current setting displayed on record.

DATA Reporting Records

The Model 3783 displays data in real time on the front panel display. You can also collect data records over time. Data records include the following:

D Records	Used for data collection
S Records	Used for data collection
U records	Used by Aerosol Instrument Manager® software

D Record

D records contain the following information:

D	Record identifier
Date	Date in yyyy/mm/dd format
Time	Time in hh:mm:ss format
Flags	Status Flags (see information in RIE command description)
Conc	Aggregated concentration calculated by dividing the accumulated aggregate counts by the live-time of the sample flow rate (2 cm^3/sec). The aggregated counts and live-times are accumulated each 1/10th second interval. The overflow flag is set when the concentration value exceeds the maximum specified concentration.
AT	Elapsed sample time 0.1 sec resolution (0.1 to 3600)
LT	Live time 0.001 sec resolution (0.001 to 3600)
CNT	Accumulated particle counts
Photo	Average photo-detector value in mV
Reserved	Blank reserved space
PH	Average pulse height in mV
PSTD	Pulse height standard deviation

Example D Record:
D,2012/11/2,08:01:21,0,1.04e4,6.0,4.4,769424,140,,0,0

Record Type	Date	Time	Flags	Conc	AT	LT	CNT	Photo	Res	PH	PSTD
D	2012/11/2	08:01:21	0	1.04e4	6.0	4.4	769424	140		0	0

S Record (Status)

S records are displayed on the Text tab when you enter the command RRS in the Firmware Command field. They display status information.

S	Status record identifier
Pinlet	Inlet pressure in millibars
Pvac	Vacuum pressure in millibars
Tcond	Temperature of the conditioner in °C
Tgrowth	Growth tube temperature in °C
Toptics	Optics temperature in °C
Tsep	Water separator temperature in °C
Tinlet	Inlet temperature in °C

Example S Record:
S,990,282,20.0,59.9,60.0,20.0,23.2

Record Type	Pinlet	Pvac	Tcond	Tgrowth	Toptics	Tsep	Tinlet
S	990	282	20.0	59.9	60.0	20.0	23.2

(continued on next page)

U Record

U records are displayed when the **SSTART,3** command is entered. The records are returned once per second. They contain the following information:

U	Record type
X	Elapsed time in seconds (integer)
Ci	Concentration in 1/10th second intervals (float)
Ri	Raw counts in 1/10th second intervals (integer)
X	No value represented between commas for the Model 3783
Ti	Live time in 1/10th seconds (float)
D	DTC value (float)
P	Absolute pressure in millibars (integer)
AN	Analog input
HM	Pulse height mean in millivolts (integer)
HS	Pulse standard deviation in millivolts (integer)
IS	Instrument status (use RIE command to see a list of statuses)

Example U record:
UX,C,C,C,C,C,C,C,C,C,C,R,R,R,R,R,R,R,R,R,R,,T,T,T,T,T,T,T,T,T,T,D,P,AN,HM,HS,IS

```
U1,2.13e3,1.97e3,2.18e3,2.24e3,2.34e3,2.29e3,2.26e3,2.31e3,
2.35e3,2.17e3,466,430,475,489,510,500,493,505,512,474,,,,,,,,
,,,0.099,0.099,0.099,0.099,0.099,0.099,0.099,0.099,0.099,0.09
9,1.17,990,0.000,1179,421,0
```

APPENDIX C
References

The following sources have been used in the text of this manual.

Agarwal, J.K. and G.J. Sem [1980]
"Continuous Flow Single-Particle-Counting Condensation Nuclei Counter"
J. Aerosol Sci., Vol. **11**, No. 4, pp. 343–357

Aitken, J. [1888]
"On the Number of Dust Particles in the Atmosphere"
Proc. Royal Soc. Edinburgh, **35**

Aitken, J. [1890-1891]
"On a Simple Pocket Dust Counter"
Proc. Royal Soc. Edinburgh, Vol. XVIII

Allen, J; Cubison, M.; Hering, S.; Ogren, J.; Jimenez, J-L; Carlo, P.; Goldstein, A.; Millet, D. [2005]
"Observation of Biogenic Nucleation Events at Low Tide in Nova Scotia, Canada".
Presentation, 24th Annual AAAR Conference, Austin TX,
October 17-21, 2005

Arhami, Mohhammad; Polidori, Andrea; Delfino, Ralph J.; Siousta, Constantinos, [2006]
"Indoor/Outdoor Relationships, Trends and Carbonaceous Content of Fine Particulate Matter during the CHAPS study"
2006 International Aerosol Conference, St. Paul, MN,
September 10–15, 2006

Attoui, MB; de la Mora, J. Fernadez [2005]
"On the Detection Limit of Hydrophilic Particles by a Water CPC,"
Presentation,
2005 European Aerosol Conference, Ghent, Belgium,
August 28–September 2, 2005

Berndt, Torsten; Böge; Stratmann, Frank, [2006]
"Formation of atmospheric H_2SO_4/H_20 particles in the absence of organics"
2006 International Aerosol Conference, St. Paul, MN,
September 10–15, 2006

Birmili, Wolfran; Mordas, Genrik; Petäjä, Tuuka,; Aalto, Pasi P.; Riipinen, Ilona; Grönholm, Tiia; Hämeri, Kaarle; Kulmala, Markku [2006]
"Activation properties of atmospheric nano-particles in the size range of 3 to 10 nanometers: contrasts between urban and rural observations"
2006 International Aerosol Conference, St. Paul, MN,
September 10–15, 2006

Bischof, O.F; Zerrath, A.F. [2005]
"Measurements of Urban Aerosol in a Light Industrial Area – Physical Properties, Including Particle Size, Number, and Diameter Concentrations". Poster
24th Annual American Association for Aerosol Research Conference, Austin, Texas, October 17–21, 2005

Biswas, Subhasis; Fine, Philip M.; Geller, Michael D.; Hering, Susanne V.; Sioutas, Constantinos [2005]
"Performance Evaluation of a Recently Developed Water-Based Condensation Particle Counter,"
Aerosol Science & Technology, **39**(5):419-427

Bradbury, N.E. and H.J. Meuron [1938]
'The Diurnal Variation of Atmospheric Condensation Nuclei"
Terr. Magn., **43**, pp. 231–240

Bricard, J., P. Delattre, G. Madelaine, and M. Pourprix [1976]
"Detection of Ultrafine Particles by Means of a Continuous Flux Condensation Nucleus Counter"
in *Fine Particles*, B.Y.H. Liu, ed., Academic Press, New York, pp. 565-580

Caldow, R. and P.B. Keady [1990]
"Performance of an Ultrafine Condensation Particle Counter."
Aerosols Science, Industry, Health and Environment - Proceedings of the 3rd International Aerosol Conference, Kyoto Japan, (S. Masuda and K. Takahashi, ed.) 1, 503-506

Eiguren-Fernandez, A; Zhu, Y.; Miguel, A.; Hinds, W.; Hering, S.; Nazaroff, W. [2005]
"In-Cabin and Outdoor Nanoparticles, and Ultrafine Particles II: Collocated Number Concentration Measurements on Los Angeles Roadways".
Presentation, 24th Annual AAAR Conference, Austin TX, October 17-21, 2005

Erickson, Kathy; Liu, Wei; Osmondson, Brian; Oberreit, Derek R.; Schiesher, Nathaniel; Quant, Frederick [2006]
"Performance Characterization of a Compact Water-Based Condensation Particle Counter (TSI Model 3781)"
International Aerosol Conference 2006, St. Paul, MN, USA, September 10–15, 2006

Filimundi, E.; Bischof, O.F.; Bennett, I.P. [2005]
"Measurement of nucleation mode particles using an ultrafine water-based condensation particle counter".
Presentation, Le 21ème Congrès Français sur les Aérosols (CFA 2005). ASFERA, Paris, France, December 14–15, 2005

Hering, S., Keady, P.B.; Stolzenburg, M.R.; Fernandez, A.E.; Miguel, A. H.; Quant, F.R.; Obereit, D.R. [2005]
“Response of Water-Based Condensation Particle Counters to Ambient and Vehicular Particulate Matter"
Presentation, 2005 European Aerosol Conference, Ghent, Belgium, August 28–September 2, 2005

Hering, Susanne V.; Lewis, Gregory S.; Quant, Fred R.; Oberreit, Derek R. [2006]
“A Micro-Environmental, Water-Based, Condensation Particle Counter”
Poster
2006 International Aerosol Conference, St. Paul, MN,
September 10–15, 2006

Hering, Susanne V., Olga Hogrefe, G. Garland Lala and Kenneth L Demerjian [2004]
“Field Evaluation of a Laminar-Flow, Water-Based Condensation Particle Counter,” Poster
American Association for Aerosol Research 2004 Annual Conference, Atlanta, GA, October 4–8, 2004

Hering, Susanne V., Stolzenurg, Mark R. [2005]
“A Method for Particle Size Amplification by Water Condensation in a Laminar, Thermally-Diffusive Flow.”
Aerosol Science & Technology, **39**(5):428-436

Hering, Susanne V.; Stolzenburg, Mark R.; Quant, Frederick R.; Keady, Patricia B.; Oberreit, Derek [2005]
“A Fast-Response, Nanaoparticle Water-Based Condensation Counter.”
Presentation, the Particulate Matter Supersite program and Related Studies, An International Specialty Conference sponsored by the American Association for Aerosol Research, Atlanta, GA,
February 7–11, 2005

Hering, Susanne V; Stolzenburg, Mark R. [2004]
“Continuous, laminar flow water-based particle condensation device and method”
US Patent # 6,712,881, March 30, 2004

Hering, Susanne V.; Stolzenurg, Mark R.; Quant, Frederick R.; Oberreit, Derek; Keady, Patricia B. [2005]
“A Laminar-Flow, Water-Based Condensation Particle Counter (WCPC).”
Aerosol Science & Technology, **39**(7):659-672

Hering, S., M.R. Stolzenburg, F.R. Quant, D.R. Oberreit, and P.B. Keady [2005]
“A Nano-Particle, Water-Based Condensation Particle Counter",
Presentation,
24th Annual AAAR Conference, Austin TX, October 17-21, 2005

Hering, Susanne V.; Stolzenurg, Mark R.; Quant, Frederick R.; Oberreit, Derek [2004]
"A Laminar-Flow, Water-Based Condensation Particle Counter," Presentation
American Association for Aerosol Research 2004 Annual Conference, Atlanta, GA, October 4–8, 2004

Hering, Susanne V., Stolzenburg, Mark R.; Quant, Frederick R.; Oberreit, Derek [2003]
"A Continuous, Laminar Flow, Water-based Condensation Particle Counter," Poster
American Association for Aerosol Research 2003 Annual Conference, Anaheim, CA, October 2003

Hering, S. V.; Quant, F. R. [2005]
"Two New Water-Based Condensation Particle Counters."
Presentation, American Geophysical Union, Fall Meeting, San Francisco, CA, December 5 – 9, 2005

Hermann, M., Wehner, B., Bischof, O., Han, H.-S., Krinke, T., Liu, W., Zerrath, A., and Wiedensohler, A. [2007]
"Particle Counting Efficiencies of New TSI Condensation Particle Counters"
Journal of Aerosol Science, **38**:674-682

Hirschl, Rhonda S.; Lee, Shan-Hu [2006]
"Aerosol Nucleation Rates of Sulfuric Acid and Water Measured Under Atmospheric Conditions"
2006 International Aerosol Conference, St. Paul, MN, September 10 – 15, 2006

Hogan, A.W. [1979]
"Aerosol Detection by Condensation Nucleus Counting Techniques"
in *Aerosol Measurement*, D.A. Lundgren, ed., Univ. Presses of Florida, Gainesville, Florida, pp. 497–514

Iida, Kenjiro; Stolzenburg, Mark R.; McMurry, Peter H.; Smith, James N.; Quant, Frederick R.; Oberreit, Derek R; Keady, Patricia B.; Eiguren-Fernandez, Arantza; Lewis, Gregory S.; Kreisberg, Nathan M.; Hering, Susanne V. {2008}
"An Ultrafine, Water-Based Condensation Particle Counter and its Evaluation under Field Conditions"
Aerosol Science and Technology, **42**:862-871

Iida, Kenjiro; Stolzenburg, Mark; McMurry, Peter H.; Dunn, Matthew; Smith, James; Eisele, Fred; Keady, Pat [2006]
"Identifying the Contribution of Ion Induced Nucleation from Measurements of Charge Distributions and Aerosol Size Distributions"
2006 International Aerosol Conference, St. Paul, MN,
September 10 – 15, 2006

Jeong, Cheol-Heon; Evans, Greg J. [2006]
"Intercomparison of the Performance of a Fast Mobility Particle Sizer and an Ultrafine Water-based Condensation Particle Counter for Measuring Particle Number and Size Distributions in the Atmosphere"
2006 International Aerosol Conference, St. Paul, MN,
September 10 – 15, 2006

Keady, P.B., F.R. Quant and G.J. Sem [1986]
"'A Condensation Nucleus Counter for Clean Rooms"
Proc. Institute of Environmental Sci., Annual Technical Mtg, pp. 445-451

Keady, P.B., F.R. Quant and G.J. Sem [1988]
Two New Condensation Particle Counters: Design and Performance
Presented as a poster at the AAAR Annual Meeting, Chapel Hill, NC, U.S.A.

Keady, P.B., V.L. Denler, G.J. Sem [1988]
A Condensation Nucleus Counter Designed for Ultrafine Particle Detection Above 3-nm Diameter,
Presented at the 12th International Conference on Atmospheric Aerosols and Nucleation, Vienna, Austria.

Keston, J., Reineking, A. and J. Porstendorfer (1991)
"Calibration of a TSI Model 3025 Ultrafine Condensation Particle Counter."
Aerosol Science and Technology, **15**, 107-111, 1991 (TSI paper A77).

Kousaka, Y. T. Nida, K. Okuyama and H., Tanaka [1982]
"'Development of a Mixing-Type Condensation Nucleus Counter"
J. Aerosol Sci., Vol. **13**, No. 3, pp. 231–240

Kulmala, M., Mordas, G., Petjäjä, T., Grönholm, T., Aalto, P.P., Vehkamäki, H., Hienola, A.I., Herrmann, E., Sipilä, M., Riipinen, I., Manninen, H.E. Hämeri, K., Stratmann, F., Biulder, M., Winkler, P.M., Birmili, W., and Waner, P.E. [2007]
"The Condensation Particle Counter Battery (CPCB): A New Tool to Investigate the Activation Properties of Nanoparticles,"
Journal of Aerosol Science, **38**:289-304.

Kulmala, Markku; Mordas, Genrik; Petäjä, Tuuka,; Grönholm, Tiia; Aalto, Pasi P. Vehkamäki, Hanna; Gaman, Anca; Herrmann, Erik; Sipilä, Mikko; Riipinen, Ilona; Hämeri, Kaarle; Birmili, Wolfran; Wagner, Paul E. [2006]
"Estimation of composition of growing aerosol particles using a condensation particle counter battery"
2006 International Aerosol Conference, St. Paul, MN,
September 10 – 15, 2006

Liu, B.Y.H. and D.Y.H. Pui [1974]
"A Submicron Aerosol Standard and the Primary Absolute Calibration of the Condensation Nucleus Counter"
J. Coll. Int. Sci., Vol. **47**, pp. 155–171

Liu, W, Kaufman, Stan L.; Sem, Gil J.; Quant, Fred R. [2004]
"Material Effects on Threshold Counting Efficiency of TSI Model 3785 Water-based Condensation Particle Counter," Poster
American Association for Aerosol Research 2004 Annual Conference, Atlanta, GA, October 2004

Liu, Wei; Kaufman, Stanley L.; Osmondson, Brian L.; Sem, Gilmore J.; Quant, Frederick R.; Oberreit, Derek R. [2006]
"Water-based Condensation Particle Counters for Environmental Monitoring of Ultrafine Particles"
Journal of Air and Waste Management Association, **56**(4):444-455

Miguel, Antonio H.; Eiguren-Fernandez, Arantzazu; Zhu, Yifang, [2005]
"In-Cabin Commuter Exposure to Ultrafine and Nanoparticles in Los Angeles Roads and Freeways: Measurements with a New Water-Based Condensation Particle Counter" Presentation
The Particulate Matter Supersite program and Related Studies, An International Specialty Conference sponsored by the American Association for Aerosol Research, Atlanta, GA, February 2005

Miguel, A.; Zhu, Y; Eiguren-Fernandez A.; Hinds, W.; Hering, S.; Nazaroff, W. [2005]
"In-Cabin and Outdoor Nanoparticles, and Ultrafine Particles I: Size Distribution Measurements on Los Angeles Roadways". Presentation
24th Annual AAAR Conference, Austin TX, October 17-21, 2005

Miller, S.W. and B.A. Bodhaine [1982]
"Supersaturation and Expansion Ratios in Condensation Nucleus Counters: an Historical Perspective"
J. Aerosol Sci., Vol. **13**, No. 6, pp. 481–490

Mordas, G.; Kulmala, M.; Petäjä, T.; Hämeri, K. [2006]
"Calibration of the Ultra-fine Water-based Condensation Particle Counter TSI3786
2006 International Aerosol Conference, St. Paul, MN, September 10 – 15, 2006

Mordas, G., Manninen, H.E., and Petaja T. [2008]
"On Operation of the Ultra-fine Water-based CPC TSI3786 and Camparison with other TSI Models (TSI3776, TSI3772, TSI3025, TSI3010, TSI3007)"
Aerosol Science and Technology, **42**:152-158

Nolan, P.J. and L.W. Pollack [1946]
"The Calibration of a Photoelectric Nucleus Counter"
Proc. Royal Irish Acad., **A9**, pp. 9–31

Nolan, P.J. [1972]
"The Photoelectric Nucleus Counter"
Sci. Proc. Royal Dublin Soc., Series A, Vol. **4**, pp. 161–180

Petäjä, T.; Mordas, G.; Manninen, H.; Aalto, P. P.; Hämeri, K.; Kulmala, M. [2006]
"Detection Efficiency of a Water-Based TSI Condensation Particle Counter 3785"
Aerosol Science & Technology, **40**(12):1090-1097

Polidori, Andrea; Arhamik, Mohammad; Sioutas, Constantino; Singh, Manisha [2006]
"Indoor and Outdoor Measurements of the Surface Area of Particles Deposited in the Human Lungs Using the TSI Model 3550 Nanoparticle Surface Area Monitor"
2006 International Aerosol Conference, St. Paul, MN,
September 10 – 15, 2006

Pollak, L.W. and A.L. Metnieks [1959]
"New Calibration of Photoelectric Nucleus Counters"
Geofis. Pura Appl., Vol. **43**, pp. 285–301

Quant, F. R., R. Caldow, G.J. Sem, T.J. Addison [1992]
"Performance of Condensation Particle Counters with Three Continuous-Flow Designs," presented as a poster paper at the European Aerosol Conference, Oxford England, Sept. 7-11, 1992.

Quant, Frederick R.; Oberreit, Derek; Stolzenburg. Mark R. [2004]
"Increasing the Single Particle Counting Range of a Condensation Particle Counter," Poster
American Association for Aerosol Research 2004 Annual Conference, Atlanta, GA, October 2004

Rich, T.A. [1955]
"A Photoelectric Nucleus Counter with Size Discrimination"
Geofis. Pura Appl., Vol. **31**, pp. 60–65

Rogers, David C.' Herring, Susanne; Stolzenburg, Mark R.; Oberreit, Derek; Quant, Fred [2006]
"Airborne Tests of a New Low-Pressure Water-Based CN Instrument"
2006 International Aerosol Conference, St. Paul, MN,
September 10 – 15, 2006

Scheibel, H.G., and J. Porstendorfer [1983]
"Generation of Monodisperse Ag- and BaCl- Aerosols with Particle Diameters Between 2 and 300 nm. *Journal of Aerosol Science*, **14**, 113-126

Schlichting [1955]
Boundary Layer Theory, 6th ed., McGraw-Hill, New York

Sem, G.J.
“Design and Performance Characteristics of Three Continuous-Flow Condensation Particle Counters: a Summary.” *Atmospheric Research* **62**: 267-294, 2002

Sem, G.J., J.K. Agarwal and C.E. McManus [1980]
“New Automated Diffusion Battery/Condensation Nucleus Counter Submicron Sizing System: Description and Comparison with an Electrical Aerosol Analyzer”
Proc. 2nd Symp. Advances in Particulate Sampling and Measurement, U.S. Environ. Protection Agency, Research Triangle Park, North Carolina

Shi, Qian; Han, Hee-Siew; Kerrigan, Steve W.; Fink, Melissa; Caldow, Rob; Liu, Wei [2006]
“Particle Number Concentration and Size Distribution Measurements of Ambient Aerosol in Minnesota with New TSI Condensation Particle Counters”
2006 International Aerosol Conference, St. Paul, MN,
September 10–15, 2006

Shi, Q, H.S. Han, S.W. Kerrigan, and E.M. Johnson [2005]
“Characterization of Two New Butanol-based Condensation Particle Counters.”
Poster #IPC17, American Association for Aerosol Research annual conference, Austin, Texas, October 2005.

Shi, Q, H.S. Han, S.W. Kerrigan, and E.M. Johnson [2005]
“Characterization of A New Butanol-based Ultrafine Condensation Particle Counter,”
Oral presentation #086 at European Aerosol Conference 2005, Ghent, Belgium.

Sinclair, D. and G.S. Hoopes [1975]
“A Continuous Flow Nucleus Counter”
J. Aerosol Sci., Vol. **6**, pp. 1–7

Stolzenburg, M.R., and P. H. McMurry [1991]
“An Ultrafine Aerosol Condensation Nucleus Counter.” *Aerosol Science and Technology,* **14**, 48-65, 1991 (TSI paper A82)

Stolzenburg, M.R. [1988]
“An Ultrafine Aerosol Size Distribution Measuring System”
Ph.D. Thesis, University of Minnesota, Minneapolis, Minnesota, July

Stolzenburg, Mark R.; Iida, Kenjiro; McMurry, Peter H.; Smith, James N.; Keady, Patricia B.; Hering, Susanne, V. [2006]
“Field Evaluation of a Water-Based Ultrafine Condensation Particle Counter” Poster
2006 International Aerosol Conference, St. Paul, MN
September 10–15, 2006

Thomas, Rick; Nemitx, Eiko; House, Emily; Hallquist, Mattias; Coe, Hugh [2006]
“Speciated Aerosol Fluxes above an Urban Canopy: Measurements during the GÖTE-2005 Campaign”
2006 International Aerosol Conference, St. Paul, MN,
September 10–15, 2006

Tsang, Hamilton C.; Ma, Roger; Miguel, Antonio H. [2006]
“Number Concentration Measurements Using a Water-Based CPC in Hong Kong Under Heavy Traffic Conditions”
2006 International Aerosol Conference, St. Paul, MN,
September 10–15, 2006

Tuomenoja, Henna; Lamminen, Erkki; Nieminen, Elina; Ukkonen, Ari [2006]
“Real-time Number Size Distribution Measurement, and Density Estimation of Indoor Air Particles Using an ELPI and a CPC”
2006 International Aerosol Conference, St. Paul, MN,
September 10–15, 2006

Westerdahl, Dane; Fruin, Scott; Marshall, Julian; Fine, Phillip M.; Singh, Manisha [2006]
“Coarse, Fine and Ultrafine Particles in Jakarta, Indonesia”
2006 International Aerosol Conference, St. Paul, MN,
September 10–15, 2006

Wu, Yun; Hu, Weiwei; Chalmers, Jeffrey; Wyslouzil, Barbara [2006]
“Electrohydrodynamic Spraying of Lipid Nanoparticles for Drug Delivery”
2006 International Aerosol Conference, St. Paul, MN,
September 10–15, 2006

Zerrath, Axel F.; Bischof, Oliver F. [2005]
“Urban Aerosol in a Light Industrial Area—Particle Size Distribution and Number Concentration Measurements In the Submicron Range”
European Aerosol Conference 2005, Ghent-Belgium,
August 28–September 2, 2005

(This page intentionally left blank)

Index

T

U

V

W–X

Y

Z

Reader's Comments Sheet

Please help us improve our manuals by completing and returning this questionnaire to the address listed in the "About This Manual" section. Feel free to attach a separate sheet of comments.

Manual Title Model 3783 EPC™ Environmental Particle Counter™ Monitor P/N 6003653

1. Was the manual easy to understand and use?

   ☐ Yes ☐ No

   Please identify any problem area(s) ______________________________

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

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

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

   Comments: ______________________________

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

5. Rate your level of experience with the product:

   ☐ Beginning ☐ Intermediate ☐ Expert

6. Please provide us with the following information:

   Name ______________ Address ______________

   Title ______________

   Company ______________

UNDERSTANDING, ACCELERATED

TSI Incorporated – Visit our website **www.tsi.com** for more information.

USA	**Tel:** +1 800 874 2811	**India**	**Tel:** +91 80 67877200
UK	**Tel:** +44 149 4 459200	**China**	**Tel:** +86 10 8219 7688
France	**Tel:** +33 1 41 19 21 99	**Singapore**	**Tel:** +65 6595 6388
Germany	**Tel:** +49 241 523030		

P/N 6003653 Rev E Printed in U.S.A.