The Model 3772/3771 CPC operates in single particle count mode up to 10^4 particles/cm^3. Rather than simply counting individual electrical pulses generated by light scattered from individual droplets, the CPC uses a continuous, live-time coincidence correction to improve counting accuracy at high particle concentrations. Coincidence occurs when the presence of one particle obscures the presence of another particle creating an undercounting error. "Live-Time Counting" is discussed later in Chapter 6. This option can be turned OFF by firmware command "SCC,0".

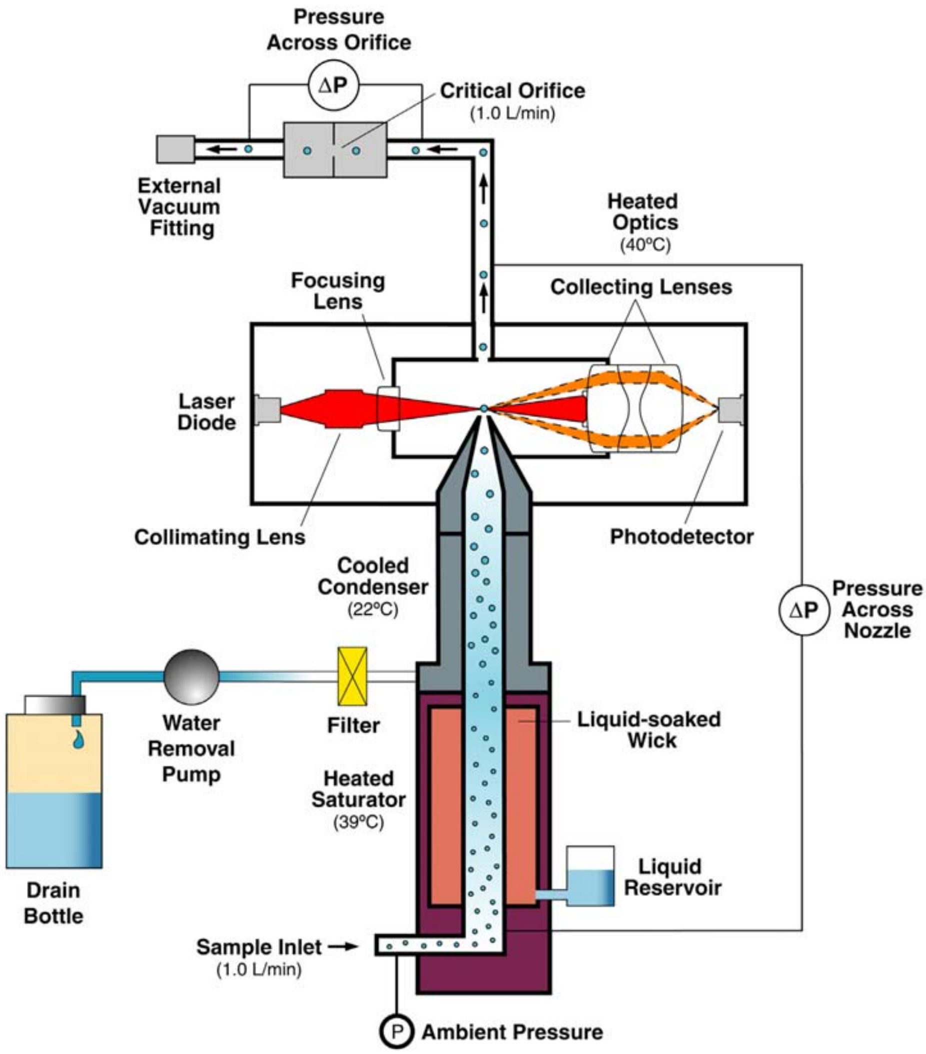


Figure 5-1
Flow Schematic of the Model 3772/3771 CPC

Critical Flow

To achieve the 1.0 L/min critical aerosol 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, assuring 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.

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

Values for pressures impacting CPC flow can be obtained using firmware commands for both 3772 and 3771 CPCs. They are also found on the Status menu on the front panel display for 3772. These pressures are identified as the Ambient pressure, the Orifice pressure, and the Nozzle pressure. The ambient pressure is typically the barometric pressure at the inlet. The orifice pressure is the differential pressure across the aerosol flow orifice. The nozzle pressure is the differential pressure across the nozzle. Figure 5-1 identifies the location of the pressure transducer sample ports.

To verify that critical pressure (therefore critical flow) is achieved under extremes in inlet resistance, determine the orifice upstream pressure from **(A – N)**. The downstream pressure is the upstream pressure minus the orifice differential pressure **(A – N – O)**.

Flow is critical if the following is true:

$$\frac{A - N - O}{A - N} \leq 0.528 \qquad (5\text{-}1)$$

Vacuum source, either a central building vacuum or a stand-alone vacuum source (e.g., TSI Model 3032 Vacuum Pump), should provide at least 60 kPa (18 in. Hg) vacuum and 1.0 L/min critical volumetric flow at the inlet of each CPC supported. The flow in the CPC is regulated by a critical orifice. Changes in the inlet pressure will not affect the flow rate through the instrument. A vacuum source that can provide a higher volumetric flow (e.g., TSI Model 3033 Vacuum Pump) is needed when running multiple CPCs.

Counting Efficiency and Response Time of the 3772/3771 CPC

The 3772/3771 CPC has a D_{50} of 10 nm. D_{50} is defined as the particle diameter at which 50% of particles are detected. The curve fit shown in Figure 5-2 is based on testing of three 3772/3771 CPCs 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 CPC readings to TSI Model 3068A Aerosol Electrometer readings.

Note the particle concentration measured by the CPC is the total number concentration of all particles that a CPC can detect. This measurement provides no size differentiation and it is not corrected using the CPC counting efficiency curve. When the 3772 CPC is used as part of a Scanning Mobility Particle Sizer (TSI Model 3936 SMPS), the counting efficiency curve is used to correct particle count data to provide particle size distribution.

The 3772/3771 CPC has a fast response time. T_{95}, defined as the time it takes for the CPC reading to reach 95% of a concentration step change, is about 3 sec for the 3772/3771 CPC. Figure 5-3 shows the response time curves. The curves are based on averaging of three CPCs.

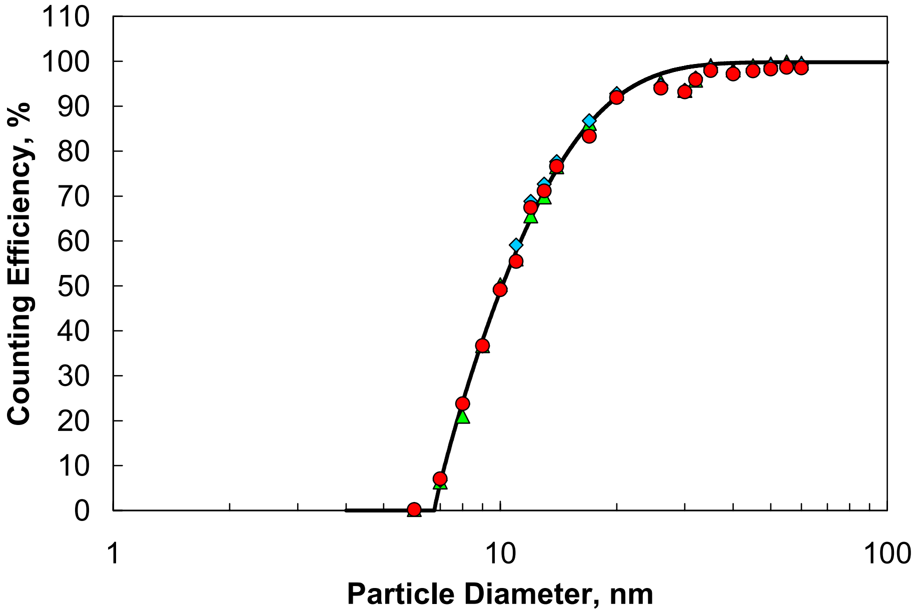


Figure 5-2
Counting Efficiency Curve of 3772/3771 CPC

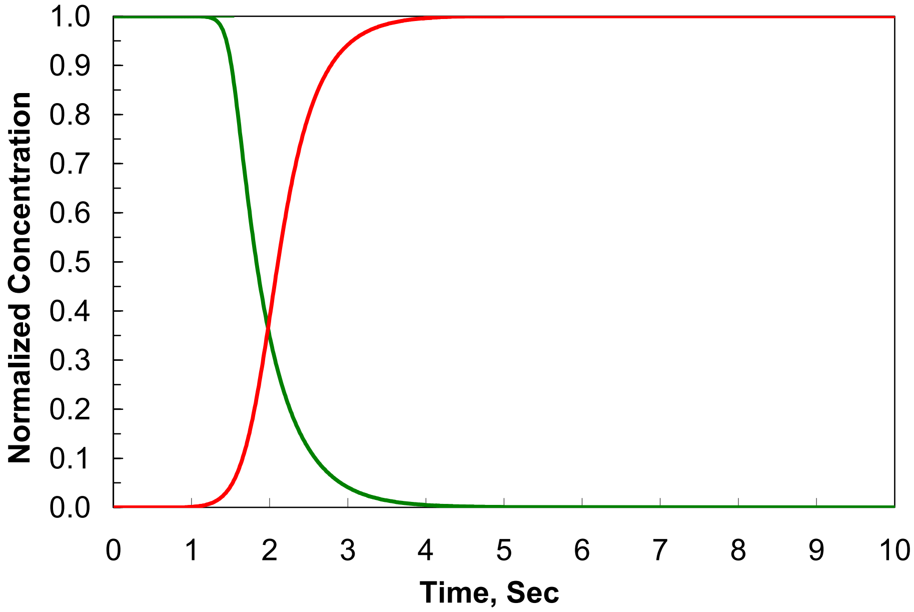


Figure 5-3
Response Time of 3772/3771 CPC

CHAPTER 6

Particle Counting

This chapter discusses specific aspects of particle counting and particle count measurements performed using the Model 3772/3771 Condensation Particle Counter (CPC).

The Model 3772 CPC has two modes for particle counting:

- Concentration mode, where data is presented as particle concentration in p/cc, updated each second on the display (the maximum time resolution is tenth of a second).
- Total Count Mode (Totalizer Mode), where total particle counts are accumulated and presented each second.

The Model 3771 CPC has the Concentration mode and is capable of Total Count Mode using the Aerosol Instrument Manager software. Concentration mode is commonly used for most applications. Total Count Mode is used at very low particle concentrations. Particles can be accumulated until a desired statistical accuracy is achieved. Refer to the section below discussing total count accuracy.

In the concentration mode, the CPC operates in the single count mode with continuous, live-time coincidence correction over the range between 0 and 10^4 particles per cubic centimeter.

Optical Detection

Submicrometer particles are drawn into the 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.

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

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

In total count mode (or totalizer mode), the accuracy of the concentration is increased by sampling for a longer period and counting more particles. The concentration is calculated by:

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

where
Q = Aerosol flow rate, nominally 1000 cm^3/min (16.7 cm^3/sec).
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 significantly impact the measured concentration.

The CPC 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 particles can't be counted during this time interval except the ones that are already in the viewing volume. The actual particle concentration therefore equals the number of counted particles divided by the live 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

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

This option can be turned off by firmware command “SCC,0”.

Coincidence Correction for Pulse Output

Live-time coincidence correction is not available if you are using the pulse output from the CPC which only provides raw counts of the particles. Concentration can be calculated using raw counts and the aerosol flow rate of the CPC. This concentration is only accurate for low particle concentrations when coincidence level is low, e.g., in clean air or after a filter. If the pulse output is used for higher concentration up to 10^4 particles/cm^3, the following calculation improves the accuracy of the particle concentration obtained from pulse output:

$$N_a = N_i \exp(N_a Q \tau_p)$$

where N_a = the actual concentration (particles/cm^3)
N_i = the indicated concentration (particles/cm^3)
Q = 16.67 cm^3/s
τ_p = 0.35 microsecond is the nominal effective time each particle resides in the viewing volume

The N_a in the exponent can be approximated by *Ni*.

Table 6-1 shows the calculated coincidence for several concentrations. Coincidence is 1-*Na*/*Ni*.

Table 6-1
Coincidence Levels Based on 0.35 µsec Pulse Width

Concentration Calculated (particles/cm^3)	Coincidence (%)
10	>.01
100	.06
1000	.59
5000	3.05
10000	6.4

Concentrations obtained from pulse width and coincidence-corrected with the above equation are slightly different from the live-time corrected concentrations on the front panel display. The former concentration is corrected based on nominal pulse width but the latter is corrected based on the actual pulse widths for particles. For concentrations above those in Table 6-1, contact TSI Incorporated for a more suitable particle counter.

C a u t i o n

At concentrations above 10,000, two exclamation marks appear at the sides of the concentration reading on the front panel of the 3772. If this occurs, the number of particles shown on the display could be lower than the actual concentration.

Particle Size Selector

The particle size selector (Model 376060 PSS) is an accessory (not included) to the Model 3772/3771 CPC to let you choose any of 11 cutoff sizes between 0.010 and 0.122 micrometer. The PSS uses a series of fine-mesh screens to remove small particles by diffusional capture. An additional set of diffusion screens (available separately, Model 376061) lets you select cutoff diameters up to 0.25 micrometer. The cutoff sizes listed below are calculated using efficiencies for 3772/3771 CPC and diffusion screens.

Diffusion screens	Particle size cut, µm (50%)
0	0.010
1	0.020
2	0.031
3	0.041
4	0.052
5	0.062
6	0.072
7	0.083
8	0.092
9	0.102
10	0.112
11	0.122

CHAPTER 7

Computer Interface and Commands

This chapter provides computer interface and communications information for the Model 3772/3771 Condensation Particle Counter (CPC). Information on the Flash Memory Card for the 3772 is also provided.

Computer Interface

This section includes descriptions on USB, Ethernet connections, RS-232, and the Flash Memory Card (3772 only).

USB

USB communications are provided with the 3772/3771 CPC, for use with the supplied Aerosol Instrument Manager® software. Simply connect the supplied USB cable to the instrument and computer having Windows®-based operating system and the Aerosol Instrument Manager software. Refer to the Aerosol Instrument Manager manual for specific system requirements, including operating system version.

Ethernet

The Ethernet port on the CPC can provide system status information over the internet and is updated every five seconds. Your web browser must support java plug-ins.

Network Setup

1. Connect the CPC to the network using an Ethernet cable and turn the instrument on.
2. On the computer that is connected to the same network using another Ethernet cable, run the device discovery program **Discovery.exe** found on the supplied Aerosol Instrument Manager Software CD or in the folder where the Aerosol Instrument Manager software is installed. This **Discovery.exe** program will find CPC devices on the network.

Note: *This program will only find CPCs that are on the same subnet. Example: If the computer is at IP address 10.1.3.1, the device discovery program will find all CPCs on 10.1.3.x. Also, if the Windows® firewall is enabled (on by default in service pack 2), the device discovery will not find any CPCs. Once the IP address is known, you can access the CPC from another subnet.*

3. Select the device and choose **Configure network settings**.

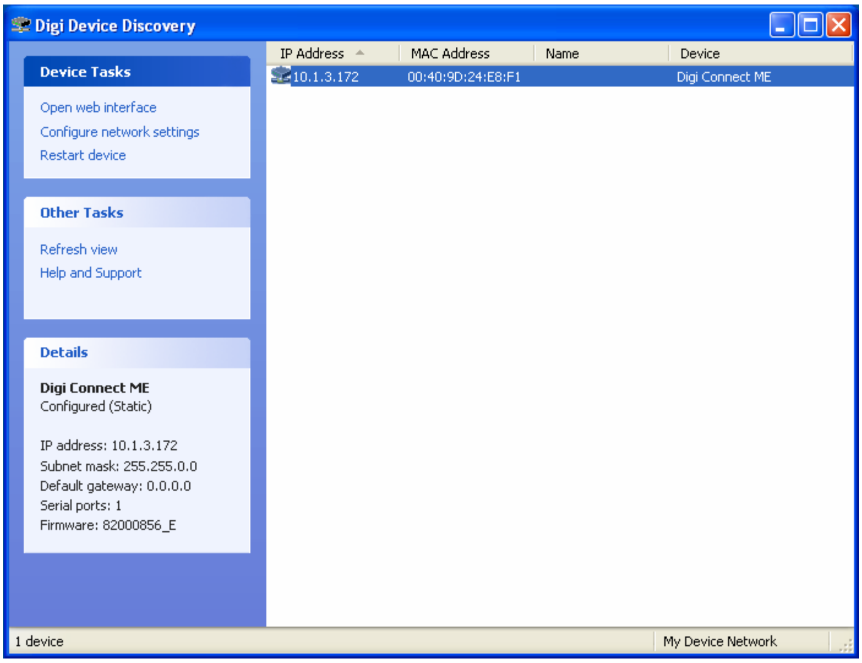


Figure 7-1
Digi Device Discovery Screen

4. Talk with your network administrator to verify the correct network settings this device should operate at. If needed, the MAC address can be located on the back of the instrument or in this pop-up window. Fill in the appropriate information and click **Save**.

®Windows is a registered trademark of Microsoft Corporation.

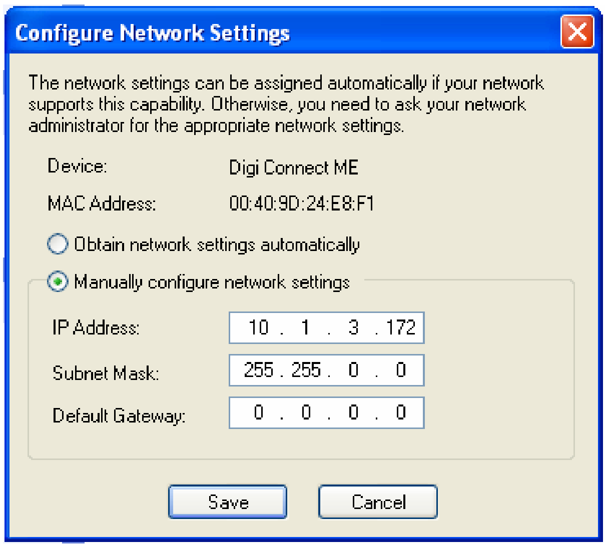


Figure 7-2
Configure Network Settings Screen

5. Close the device discovery program and restart the CPC. It takes about a minute for the Ethernet to initialize.

6. If the CPC is in the same subnet as the computer, start the device discovery program **Discovery.exe** and click on **Open web interface**. The username and password are "**tsicpc**" as shown below in Figure 7-3. If the CPC is not in the same subnet as the computer, type in the IP address in your web browser. Work with your network administrator to make sure the IP address is accessible from the network your computer is in.

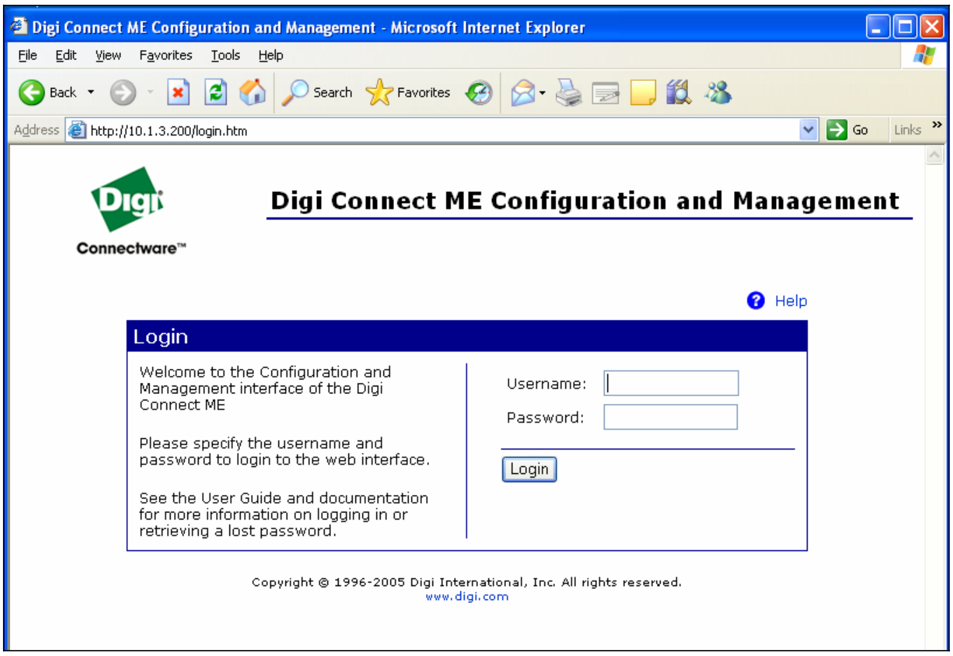


Figure 7-3
Digi Connect ME Configuration and Management Screen

7. From the web interface of the device discovery program or the web browser, you can monitor the status of the CPC.

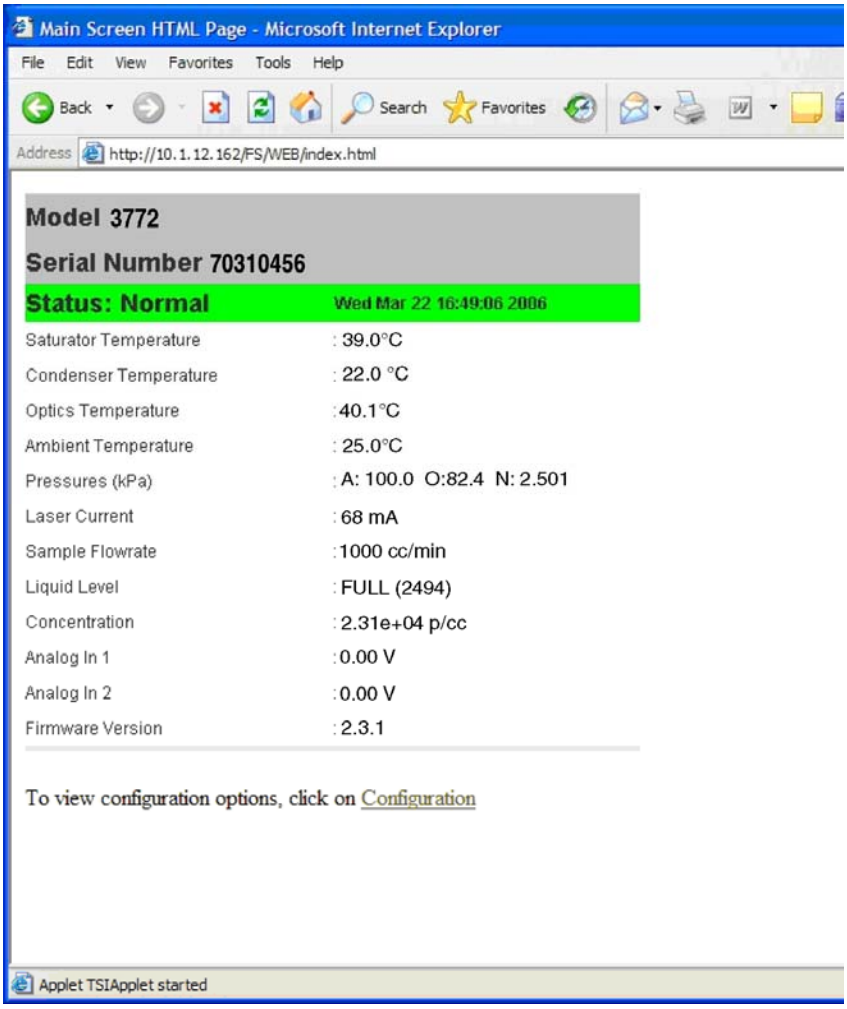


Figure 7-4
Main Screen HTML Page

Flash Memory Card Specification (3772 only)

A file is created on the Flash Memory Card when the Data Logging option is turned ON from the front panel of the 3772. Each file will contain one hour of data, unless if the run is stopped early with the STOP option. See Chapter 4.

Each file has this format:

LINE 1: "TSI CPC DATA VERSION 1"
LINE 2: start time of this file (the first number is the total number of seconds elapsed from midnight Jan. 1, 1970)
LINE 3: data average interval in seconds

LINE 4: Instrument model number, firmware version number, instrument serial number (result of the "RV" command)
LINE 5: first data set
LINE 6: second data set
LINE X: last data set

The data sets are defined as counts, concentration, analog input 1, analog input 2, status. These data sets are saved every average interval so if the average interval was one minute, the counts would be total counts (coincidence-corrected) over the last minute, etc. Instrument operates in normal condition if the status bit shows zero. A nonzero status indicates that some operating parameters deviate from normal conditions. See RIE command in Appendix B.

Every time a user begins a new run, a unique file will be created with the date and time as the file name.

Www_Mmm_dd_hh_mm_ss_yyyy

Where Www is the weekday, Mmm the month in letters, dd the day of the month, hh_mm_ss the time, and yyyy the year.

Disclaimer: Due to the fact that the FAT file systems are by design not power fail-safe, if power is lost, part or all of the file system may be lost.

Note: *Keep the amount of data stored in the flash memory card under 64 MB to avoid long overhead time before generating a new data file each hour in the card.*

C a u t i o n

Remove the flash memory card following the correct procedures:

1. Use *Safely Remove Hardware* option in Windows to disconnect the card reader from the computer—stop USB Mass Storage Device.
2. After *the* message *Safe To Remove Hardware: The "USB Mass Storage Device" device can now be safely removed from the system* appears, physically remove the flash memory card from the card reader.

Failure to follow these procedures may result in failure to log data with the flash memory card.

RS-232 Serial Communications

The communications ports are configured at the factory to work with RS-232-type devices. RS-232 is a popular communications standard supported by many mainframe computers and most personal computers. The Model 3772/3771 CPC has two 9-pin, D-type subminiature connectors on the back panel labeled Serial 1 and Serial 2. Figure 7-5 shows the connector pins on the serial ports; Table 7-1 lists the signal connections.

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

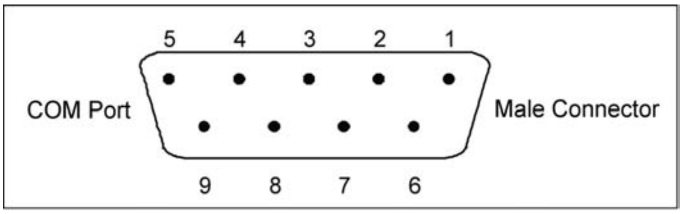


Figure 7-5
RS-232 Connector Pin Designations

Table 7-1
Signal Connections for RS-232 Configurations

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

An external computer is connected to Serial 1 for basic instrument communications and when Aerosol Instrument Manager software is used. Serial 2 is used for attaching another instrument. Read and write commands are sent and received from Serial 2 by the computer connected to Serial 1. Serial 1 and Serial 2 can have different baud rates and communications protocols. Normally, only Serial 1 is used.

Commands

All commands and responses, unless specified as binary-encoded, are sent or received as ASCII characters. All messages are terminated with a <CR> (0x0D) character. All linefeeds (0x0A) characters are ignored and none are transmitted. Commands are case insensitive. Backspace character (0x08) will delete previous characters in buffer.

In this specification, values enclosed by “<>” indicate ASCII characters/values sent/received. For example, <,> indicates the comma was sent or received via the communications channel.

Integers are 32-bit values. Floating point are IEEE() 32-bit values. Integer and floating point values are ‘C’ string compatible ASCII-encoded. For example, an integer value of

<11011100101110101001100001110110> binary, would be sent as <3703216246>.

When char, integer or hex-decimal data is sent with more than one digit, leading zeros should always be left off. If the value of the data is zero, then one zero must be sent. An exception is the value zero in real format, it should be sent as 00000E0.

The firmware commands are divided into the following categories:

- READ Commands
- SET Commands
- MISC (MISCELLANEOUS) Commands
- HELP Commands

READ commands are used to read parameter from the instrument (flow rates, pressures, temperatures, etc.). READ commands can be identified by a leading "R".

SET commands set an internal parameter to the value(s) supplied with the command. Supplied parameters are always delimited by a “<,>”. SET commands can be identified by a leading "S". The instrument will reply to all set commands with the string “OK” <CR>.

MISC (MISCELLANEOUS) commands will be used for calibration and SMPS mostly.

HELP commands. A list of firmware commands are accessible using the HELP command sent to Serial 1 of the CPC. The firmware commands are also listed in Appendix B. The commands can be used to read CPC data, instrument statuses, set instrument operating parameters, and send and receive data from another instrument attached to the Serial 2 port.

The instrument will reply with a serial string of "ERROR", if a command was not understood.

To use the HELP commands and the firmware commands, a program capable of sending and receiving ASCII text commands can be used. A terminal program such as “HyperTerminal” (supplied with Windows®) is appropriate.

Connect to Serial 1 of the Model 3772/3771 CPC and perform the following steps:

1. Open the HyperTerminal program by selecting: **Start | Programs | Accessories | Communications | HyperTerminal**.
2. Enter a name for the connection, for example, TSI-3772.

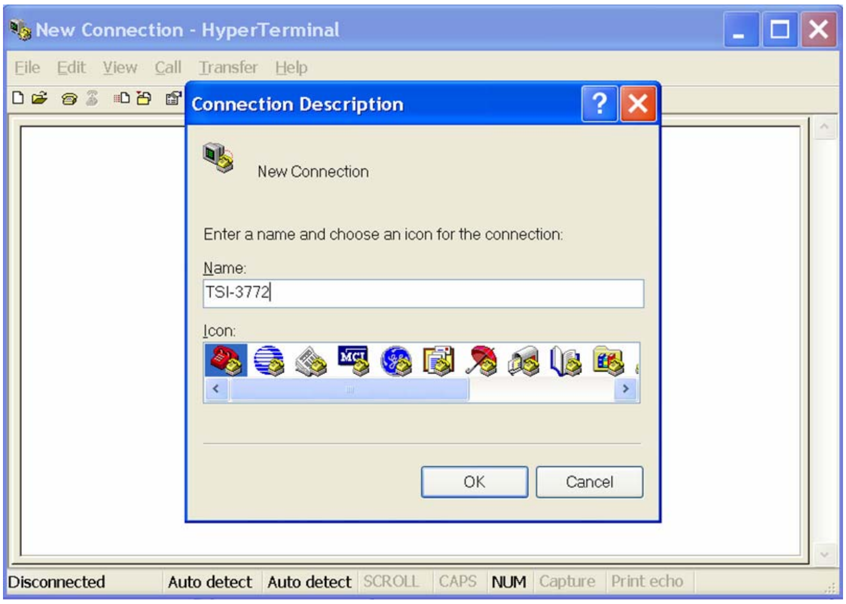


Figure 7-6
Connection Description Screen

3. Enter the communications (COM) port.

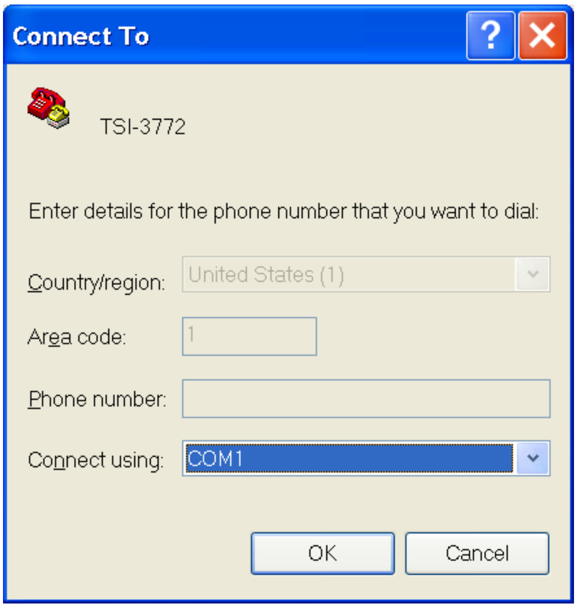


Figure 7-7
Connect To Dialog Box

4. Enter the port settings described below and click **OK**.

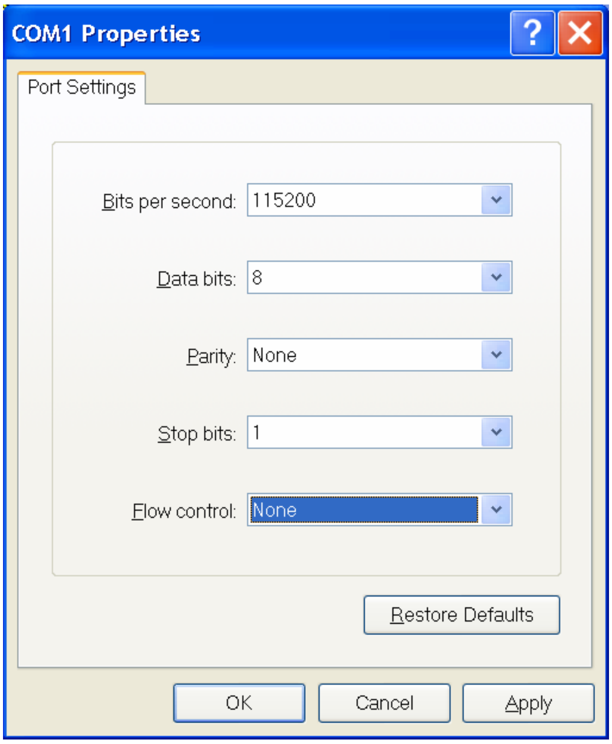


Figure 7-8
Port Settings Dialog Box

5. Under the settings tab, pick the **ASCII Setup** button and check the boxes shown below.

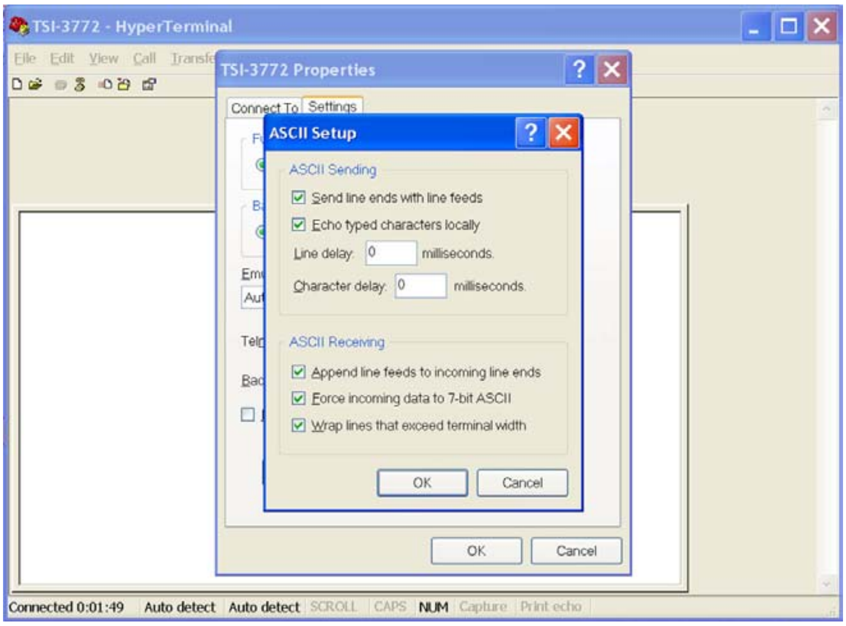


Figure 7-9
ASCII Setup Dialog Box

6. Now select **File|Save As** and save the file to the desktop for easy access.
7. Close the program and start it again from the desktop. It should automatically open a connection to the instrument.
8. Type in firmware commands to communicate with the CPC. A list of firmware commands can be obtained using the HELP commands or from Appendix B. To obtain the list from HELP command, select **Transfer|Capture Text**..and then **HELP ALL** in the terminal window lets you capture all the help commands to a text file for easy reference.

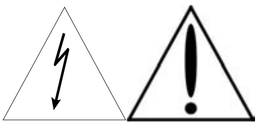
CHAPTER 8

Maintenance and Service

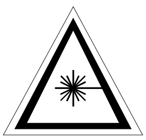
This chapter is written for a service technician with skills in both electronics and mechanics. Static preventative measures should be observed when handling any printed circuit board connectors.

Regular maintenance of the Model 3772/3771 Condensation Particle Counter (CPC) will help ensure years of useful operation. The frequency of service depends on the frequency of use and the cleanliness of the air measured. This section describes how to check and service some components of the CPC.

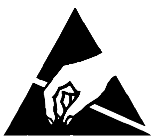
You are encouraged to call TSI for assistance in performing special maintenance. It may also be helpful to have the technician, tools, and the CPC close to the telephone when discussing the problem with a TSI technician. Refer to this chapter for directions on contacting a technical resource at TSI.



W A R N I N G
Procedures described below may require removal of the instrument cover. The instrument must be unplugged prior to service to prevent possible electrical shock hazard.



W A R N I N G
Unplug the instrument prior to removing the cover to avoid potential of exposure to laser radiation.



C a u t i o n

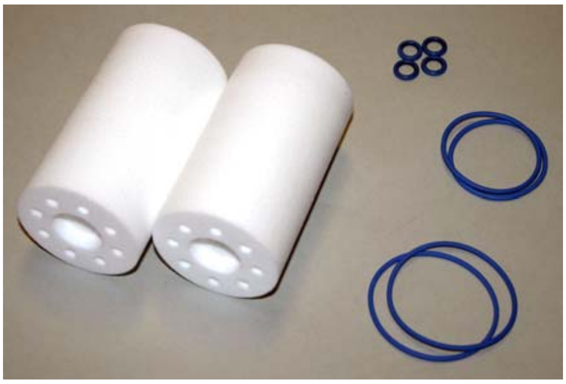
Whenever performing service on internal components avoid damage to the CPC circuitry by not stressing internal wiring, through bumping, snagging or pulling. Also use electrostatic discharge (ESD) precautions:

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

Replacement Parts Kits

In addition to replacement parts found in your supplied accessory kit, replacement items are also available from TSI to keep your CPC operating for many years. Parts are available in kits listed below. Please contact your TSI representative for details and purchase of these items.

Table 8-1
3772/3771 CPC Maintenance and Replacement Kits

TSI Part No.		Name	Description
1031513		Replacement Filter Kit, CPC 3772 and 3771	Kit of all filters used within the CPC.
1031514		Replacement saturator wick kit, CPC 3772 and 3771	Two (2) replacement wicks and O-rings for the removable saturator base.
1031515		Maintenance Kit Model, CPC 3772 and 3771.	All items listed above.

TSI Part No.		Name	Description
1031548		Fill/Drain Bottle Kit, CPC 3772 and 3771	Fill and drain bottles, bracket, vacuum drain cap, tubing and fittings.
1031492		Kit, Charcoal Filter, large, CPC	Five (5) large charcoal filters used to remove butanol from exhaust (~ten-day effectiveness for each filter).
1031493		Kit, Charcoal Filter, small, CPC	Five (5) small charcoal filters used to remove butanol from exhaust (~two-day effectiveness for each filter).

Draining Butanol from the Butanol Reservoir

Butanol must be drained from the butanol reservoir prior to removing the saturator base and wick from the bottom of the CPC. To drain the butanol reservoir:

1. Connect butanol drain bottle (from the accessories) to the drain fitting on the back of the CPC using the mating quick-connect fitting.
2. Place the drain bottle on the floor.
3. The Drain can be initiated by using the "SDRAIN" firmware command on 3771 or by using the User Settings menu on the 3772. Detailed instructions for initiating the manual Drain for the 3772 are provided in Chapter 4.
4. The butanol drain valve will open. Often there is not a significant column of liquid in the butanol drain line to initiate flow from the butanol reservoir. Tipping the instrument toward the drain port and squeezing the butanol drain bottle will sometimes help start flow. When releasing the squeezed drain bottle, plug the hole on the bottle cap to create a vacuum and to initiate draining.
5. A special vacuum drain bottle cap is provided in the accessory kit to facilitate butanol draining using a vacuum source. Figure 8-1 shows the special cap, which consists of a vacuum port and a Balston filter. The Balston filter provides a bypass flow path. Connect the external vacuum source to the vacuum port. Connect the drain line to the Drain port on the CPC. When drain valve is open and vacuum is applied, the vacuum helps to pull excess butanol from the internal butanol reservoir and the wick. Exhaust from the external vacuum source contains butanol vapor and must be directed away from work spaces.
6. The butanol reservoir in the 3772 and 3771 CPCs is much smaller than the reservoir in predecessor models 3010, 3760, or 3762. The total volume drained from the reservoir and tubing is typically less than 7 ml. During draining, Auto-Fill is automatically turned off.

Figure 8-1
Vacuum Drain Cap Assembly

Note: *When draining is stopped, the Auto-Fill must be turned on again by selecting this option from the User Settings menu for 3772 or through "SFill" firmware command for 3772 and 3771. Restarting the CPC can also turn Auto-Fill on.*

Caution
Whenever the instrument is turned on, the Auto-Fill is activated. Do **not** run the instrument with the saturator base and wick removed to prevent spilling butanol from the butanol reservoir.

Changing the Filters

The CPCs use three liquid filters. The liquid filters are for butanol fill, butanol drain, and the water removal system. The filter in the water removal system is called Micro-pump filter. These filters may require replacement at intervals that depend on usage. As a general estimate the butanol fill filter needs to be replaced after every 2000 hours of usage, while the other two are replaced only as needed. Replacement filters are supplied in the accessory kit and are available from TSI as maintenance kits. Refer to the earlier section Replacement Parts Kits.

Butanol Fill and Drain Filters

The butanol fill filter is found in the fill line leading from the butanol fill bottle to the fill solenoid valve. The butanol drain filter is found in the line between the reservoir and the drain solenoid valve (Figure 8-2).

1. Read warnings and cautions at the beginning of this chapter.
2. Unplug the instrument and lift off the cover by first removing the cover screws.
3. Find the filter shown in Figure 8-2.
4. Remove the tubing from the barbed fittings at the back and front of the filter.
5. Replace the filter with the 73 µm filter (P/N 1602088) found in the accessory kit. This filter has no preferred direction.

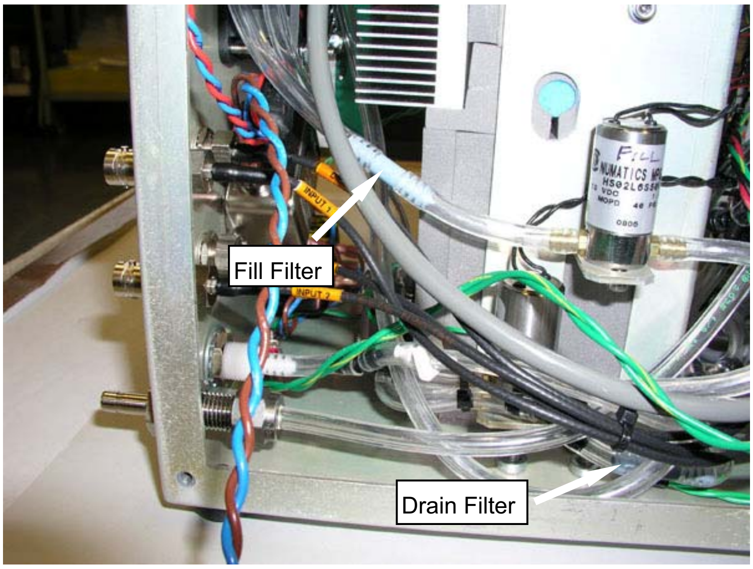


Figure 8-2
Replacing the Butanol Fill and Drain Filters

Micro Pump Filter

The Micro-pump is used to remove condensed water vapor before it contaminates butanol in the saturator. The micro-pump filter protects the pump from contamination which could impede its performance. This filter should generally be replaced only if it becomes blocked. A blocked micro-pump filter prevents condensate from being extracted.

When using the water removal feature it is advisable to check the drain tubing to the drain bottle to verify liquid movement. The liquid column will pulse a small amount toward the drain bottle, approximately once per second as the micro-pump actuates. If no pulsing occurs, first verify that the water removal feature is on (see User Settings in Chapter 4). If the feature is on and no liquid flows in the liquid column, the micro-pump filter needs to be changed.

1. Read the warnings and cautions at the beginning of this chapter.
2. Unplug the instrument and lift off the cover by first removing the cover screws.
3. Find the filter shown in Figure 8-3.
4. Remove the tubing from the barbed fittings at the back and front of the filter.
5. Replace the filter with the 25 µm filter (P/N 1500192) found in the accessory kit. This filter has no preferred direction.

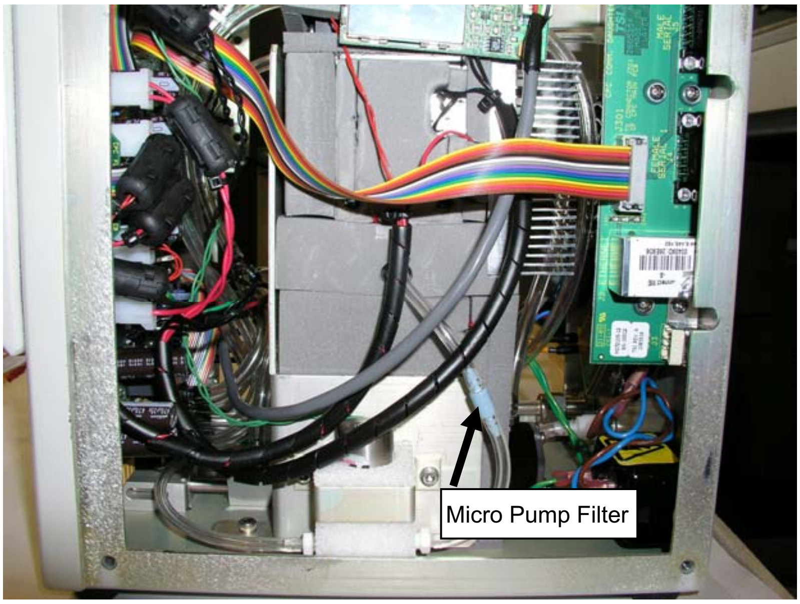


Figure 8-3
Replacing the Micro Pump Filter

Removing and Installing the Saturator Wick

Saturator wick can be removed to facilitate drying prior to shipping the instrument. It is no longer necessary to wait overnight to let the saturator wick dry out as for the predecessor Model 3760, 3762, or 3010 CPC.

Caution
Removing the saturator wick will cause butanol (butyl-alcohol) vapors to diffuse into the work space. Wick replacement operations must be performed in a well ventilated area, ideally under a fume hood. If unfamiliar with butanol, refer to the Chemical Safety information at the front of this manual.

Caution
Whenever the instrument is turned on, the Auto-Fill is activated. Do *not* run the instrument with the saturator assembly removed to prevent spilling butanol from the butanol reservoir.

Tools Needed

6” plastic bag with seal, Phillips-head screwdriver, and paper towels. Refer to figures that follow.

To remove and reinstall the saturator wick, follow the instructions below.

1. Find a plastic bag with seal, suitable to hold the 3” × 1.75” saturator wick. The 6” × 6” sealable plastic bag (P/N 1380024) included in the accessory kit can be used for this purpose. The wick will likely be wet with butanol when removed and needs to be placed in the bag immediately to reduce release of butanol vapors.
2. Connect the Drain Bottle to the drain port at the back of the instrument.
3. Initiate the Manual Drain option as described in “Draining Butanol from the Butanol Reservoir” section.
4. Once drained, turn the CPC off and remove the vacuum source from the external vacuum port.
5. Remove the inlet screw indicated in Figure 8-4 on the front panel and pull out the inlet tube. The inlet tube will not pull all the way out. It will stop when it has cleared the saturator block, approximately half an inch.

Figure 8-4
Inlet Tube

6. To access the saturator base on the bottom panel, tilt the CPC on its side so it is lying on the table. Place paper towels on the table under the saturator base to absorb any butanol that spills out. Do ***not*** turn it upside down.
7. Remove the three screws which hold the base in the saturator block as shown in Figure 8-5. Release the handle in the base by loosening the thumbscrew.

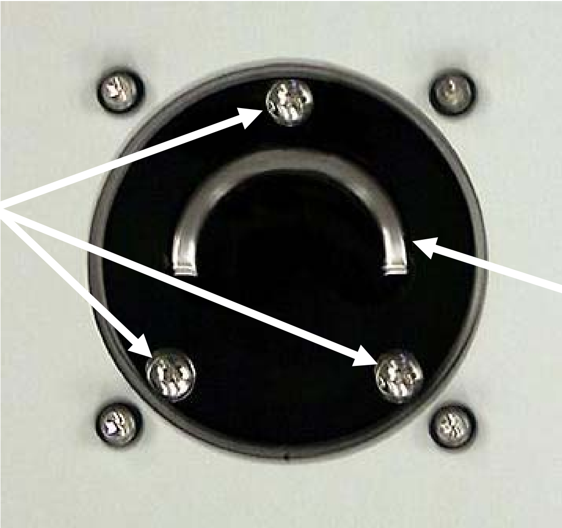


Figure 8-5
Wick Removal

8. Using the saturator handle, pull the saturator base straight out. The wick is attached and will be removed with the base. It will be snug but **avoid using a twisting motion**.

9. Remove the 2-inch screw securing the wick to the base as indicated in Figure 8-6. Pull the wick straight off the base. **Avoid using a twisting motion** because the wick is keyed onto the base with dowel pins and the soft wick material can rip.

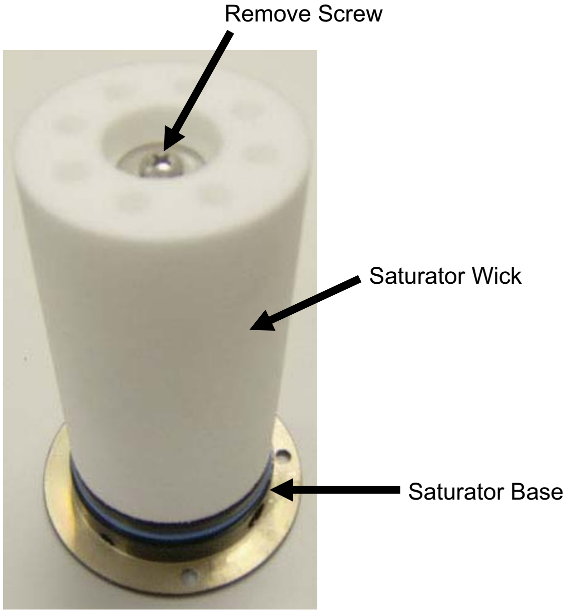


Figure 8-6
Removing the Wick from the Saturator Base

10. Place the wick in the plastic bag and seal the bag. Replace the saturator base in the CPC prior to shipping. This will prevent the aerosol path from becoming contaminated. Resecure the inlet tube. The wick can be dried by putting it in a vacuum for three hours. However, it is not necessary to dry the wick before putting it back into the saturator block after the shipment.

11. To install a wick back into the CPC, confirm that four O-rings on the saturator base are in place and undamaged. Replacement O-rings are provided in the accessory kit if an O-ring on the saturator base becomes lost or damaged. Figure 8-7 shows the two outer O-rings (P/N 2501172, 2501569) and Figure 8-8 shows the two inner O-rings (P/N 2500021).

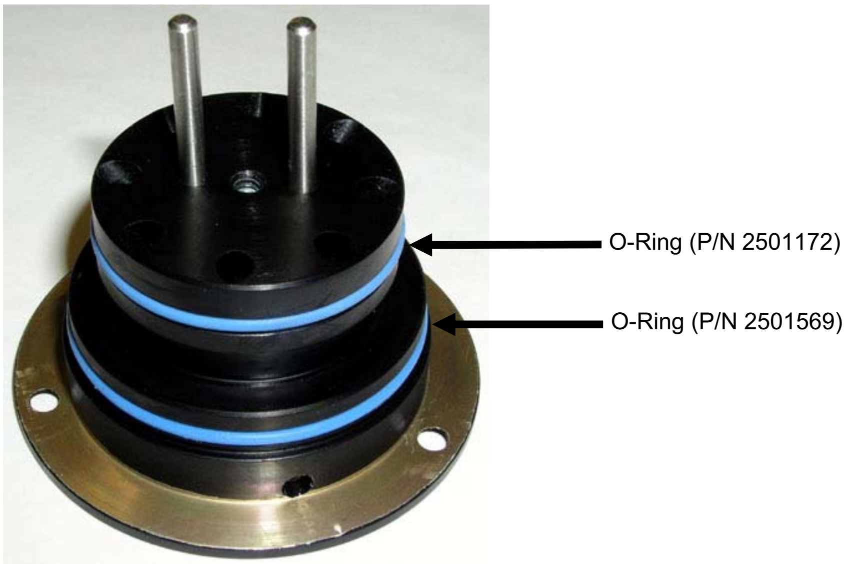


Figure 8-7
O-Rings on Saturator Base (P/N 2501172 and 2501569)

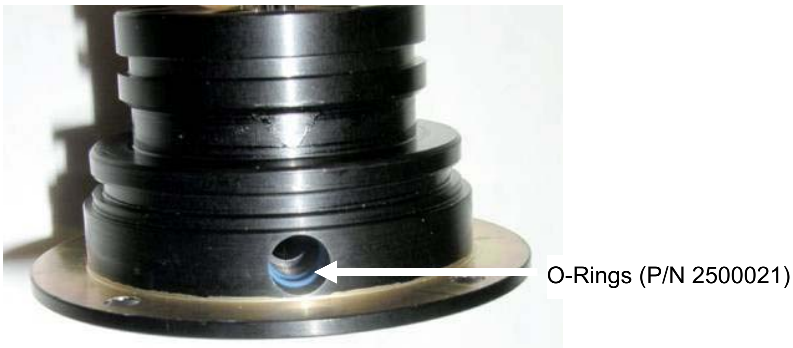


Figure 8-8
O-Rings on Saturator Base (P/N 2500021)

12. Slide the wick back onto the saturator base using the two dowel pins to key it. This will keep the holes aligned as the wick is replaced in the CPC. Replace the 2-inch screw and washer.

13. Keep the CPC turned off and the vacuum supply disconnected from the external vacuum port on the back panel. Tilt the CPC on its side to access the bottom panel. The CPC can lie flat on its side but do ***not*** turn it upside down.

14. Reinsert the wick and base and secure to CPC using the three screws indicated in Figure 8-5. In case the wick does not insert easily, follow these tips:

    i. If the CPC has recently been turned off, the saturator may still be warm. Let the saturator cool down to room temperature before inserting the wick.

    ii. Apply Krytox O-ring grease (accessory kit) to the bottom O-ring only. Do ***not*** use silicon-based O-ring grease.

15. Reinsert the inlet tube and secure the sleeve with the screw indicated in Figure 8-4.

16. Turn on the instrument and use the Auto-Fill option to refill the reservoir with butanol. See "User Settings" in Chapter 4.

Verifying Flow Rate

To measure the instrument sample flow rate, connect a low pressure-drop flowmeter to the CPC inlet. A bubble flowmeter or a thermal flowmeter works best. A TSI mass flowmeter also works because it is corrected for atmospheric pressure to give volumetric flow. The flow rate should be 1.0 L/min (0.035 cfm) ±5 percent. If the flow rate is too low, the orifice or nozzle may be plugged, the vacuum may be less than 18 inches of mercury, or the pressure drop of the test flowmeter may be too high. A clogged orifice or nozzle can be further verified by the pressure drop across the orifice or nozzle which can be read on the front panel display for the 3772 or through serial command for both 3772 and 3771. If you suspect a clogged orifice or nozzle, contact TSI for instructions.

Calibration

Aside from the optics alignment, the initial factory checkout of the electronics, and the periodic flow verification, the CPC requires no calibration. The flow is controlled by a critical orifice, and thus, no adjustments are needed. The minimum detectable particle size is controlled by the supersaturation ratio of the fluid vapor in the condenser. Since the fluid droplets grow to nearly the same size, there is no particle size discrimination by electrical pulse-height. Finally, the CPC is a single-particle counter, there is no photometric calibration for concentration.

Correcting Flooded Optics

Due to the nature of the reservoir in the CPC, the inlet tube must not be plugged for more than a couple seconds when the instrument is in operation. In addition, the instrument should not be tilted more than 10º when it is in operation. In these events the vacuum flow can draw fluid from the reservoir through the entire flow path, including the optics.

Usually the first sign of flooding is the particle concentration decreases or changes erratically. In addition, the vacuum may have trouble functioning, you may see fluid in the vacuum lines, or you may hear a slurping sound coming from the CPC.

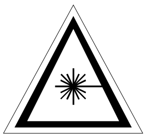
If you suspect the CPC is flooded, shut off the vacuum pump or disconnect the vacuum system. Follow these steps to dry out the instrument:

1. Drain the reservoir following the steps in the "Draining Butanol from the Butanol Reservoir" section in this chapter.
3. Remove the cover from the CPC.
4. Inspect all tubing to make sure that no fluid is in the lines. If there is, **remove the tubing** and blow out any fluid with clean, compressed air. Tubing needs to be removed prior to cleaning to avoid other parts, e.g., pressure transducer, that could be damaged by compressed air.
7. With fill bottle disconnected, run the CPC for 48 hours with vacuum to thoroughly dry out the optics.
8. Refill the CPC with clean working fluid.
9. While sampling room air, use an oscilloscope to check the pulse height of the analog pulses from the CPC. See the "Viewing Analog Pulses" procedure next in this chapter.
10. If the pulse height is not within a normal range, the CPC should be returned to TSI to have the optics cleaned. Refer to "Returning the CPC for Service" later in this chapter for directions on returning the CPC to TSI.

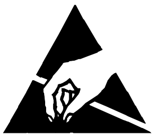
Viewing Analog Pulses

You may want to observe the pulse shape of droplets passing through the CPC optics by looking at the electronic signal produced in the photodetector. This signal is produced when detecting scattered light from the droplets passing through the laser beam. In general, the pulses will be fairly uniform in shape and size regardless of the initial size of the particles detected.

Notes:
- ❑ *Viewing analog pulses should only be attempted by someone who is familiar with the operation of the CPC and who is technically qualified.*
- ❑ *When removing the cover of the CPC, observe the laser warning label on the inside of 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.



C a u t i o n
Whenever performing service on internal components avoid damage to the CPC 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

Using an oscilloscope, observe the analog electrical pulses from the photodetector by following these steps:

1. Remove power from the CPC.

2. Remove the CPC cover.

3. Connect a “SMC Plug to BNC male” cable (not included) from J101 on the detector board to an oscilloscope as shown in Figure 8-9. The oscilloscope should be 50-ohm terminated. When viewing the signal on the scope, the signal height should be scaled down by a factor of 10. For a typical pulse of 3 volts, the scope will read only 300 mV.

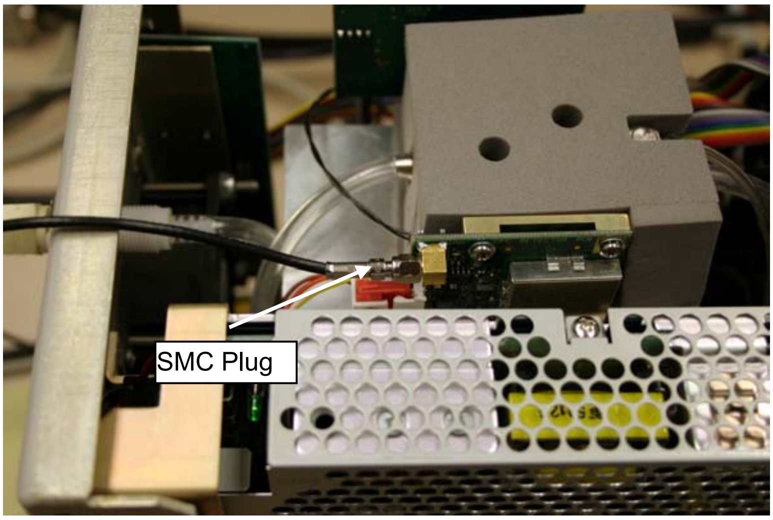


Figure 8-9
Connecting SMC Plug to Detector Board

4. Apply power to the CPC.

   A typical analog pulse trace for 3772/3771 CPC is shown in Figure 8-10. The minimum pulse amplitude is about 1 volt (100 mV on the oscilloscope) and the pulse width is about 0.30 microseconds. The pulse amplitude may range as high as 3.5 volts (350 mV on the oscilloscope).

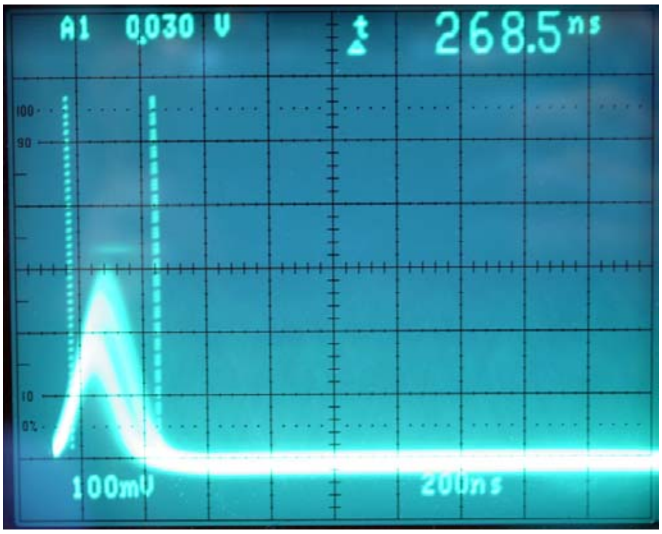


Figure 8-10
Typical Analog Pulse Trace

False Count Check

If you find that the CPC is continually counting a lot of particles even with a high efficiency (HEPA or ULPA) filter on the inlet, the CPC may have developed a leak or the aerosol flow path may have become contaminated with butanol.

To eliminate the possibility of butanol contamination, follow the directions for "Correcting Flooded Optics" in this chapter. If the false count problem continues, it is most likely due to a leak. If the wick has recently been replaced, confirm that the aerosol inlet is secured on the front panel.

If the false count problem continues, return the CPC to TSI for service.

Error Messages and Troubleshooting

The table below provides basic information on the errors generated by the Model 3772/3771 CPC, and suggestions for corrective action.

When an error occurs, the status LED on the front panel of the CPC turns off. Status parameters can provide information for troubleshooting the error. On the 3772/3771, the RIE firmware command will list instrument errors. On the 3772, in addition, refer to the Status Screen for status errors (see Figure 4-8). An exclamation mark will appear next to the parameter which is out of range. For both CPCs, refer to the table below to help identify the problem.

When called upon to remove the cover for service in the troubleshooting table, follow instructions below:

1. Read warnings and cautions at the beginning of this chapter.
2. Unplug the instrument and remove the instrument cover screws before lifting off the cover.

Table 8-2
Troubleshooting

Problem	Description	Problems/Suggestions
Concentration out of range	Concentration is higher than 10^4 particles/cm^3	Concentration entering the CPC is too high. Dilute the aerosol before it enters the CPC.
Saturator temp out of range	Saturator temperature out of range ~±0.5 degrees C.	Warm up is not complete, instrument is operating in an environment outside its specified operating range (10 to 35°C), or instrument was removed recently from a temperature extreme. Place instrument in an appropriate environment, allow temperature to stabilize.
Condenser temp out of range	Condenser temperature out of range ~±0.5 degrees C.	Warm up is not complete, instrument is operating in an environment outside its specified operating range (10 to 35°C), instrument was removed recently from a temperature extreme, or fan flow is impaired. Place instrument in an appropriate environment, allow temperature to stabilize. Clean or replace fan filter, remove object blocking fan flow
Optics temp out of range	Optics temperature out of range ±2 degrees C.	Warm up is not complete, instrument is operating in an environment outside its specified operating range (10 to 35°C), or instrument was removed recently from a temperature extreme. Place instrument in an appropriate environment, allow temperature to stabilize.

Problem	Description	Problems/Suggestions
Nozzle or orifice pressure getting near to out of range; aerosol flow rate getting near to out of range – Indicated by a '?' instead of a '!' on the display.	The orifice and/or nozzle flow is getting close to being out of range. This uses tighter criteria than the "Nozzle or orifice pressure out of range" condition described in the next row, so it is a warning and not an error.	Apply sufficient external vacuum. Contact a TSI service technician.
Nozzle or orifice pressure out of range; aerosol flow rate is out of range	Orifice pressure is <10 or >90 kPa; Nozzle pressure is <1 or >6 kPa.	Apply sufficient external vacuum. Contact a TSI service technician.
Flooded instrument	Butanol liquid is present in the instrument optics causing a variety of problems including erratic or very low concentration readings and/or changes in transducer pressure measurements.	Although the 3772 and 3771 CPCs have been designed to resist flooding, it can occur if the instrument is shipped without properly drying or removing a wet wick. Flooding can also occur if the inlet is blocked or the instrument is tipped during operation. Once the instrument cover is removed, evidence of flooding is seen by examining tubing for the presence of liquid. Start by looking at tubing connected to the pressure transducers. Carefully remove and dry out wet tubing then replace. ***Note:*** *Don't dry the tubing in place to avoid damaging other parts in the CPC.* If flooding has occurred, it will be necessary to dry the optics block.* Begin by draining the butanol and removing the wick as described earlier. Replace the saturator base without replacing the wick. Turn the instrument on and make sure the external vacuum is on and the fill bottle is disconnected. Allow the instrument to operate for at least 20 hours. Refer to "Correcting Flooded Optics" for detailed instructions.
Status: Laser power low	Detector in the laser indicates low laser power.	Contact a TSI service technician.
Status: Liquid level low	Liquid level sensor in the reservoir does not detect the presence of butanol.	Verify that no liquid is present in the reservoir by taking off the cover of the CPC and looking through the reservoir window. If it is difficult to identify the liquid level, using a flash light and tipping the CPC a couple degrees are helpful. If no liquid level line is seen, check carefully to confirm that it is not overfilled, indicating a problem in the butanol level detection circuitry. Add butanol to the fill bottle and connect the bottle at the quick connect fitting. Make sure the Auto Fill Enable is selected ON in the User Settings menu (Figure 4-6). Watch the reservoir to confirm that it fills then stops. If filling does not occur, the fill filter may need to be replaced. Refer to "Changing the Filters" presented earlier.

*Flooding can contaminate the lens surfaces in the optics block reducing signal strength and instrument sensitivity. Lens cleaning is performed at the factory if flooding occurs. A noticeable change in instrument performance characteristics (e.g., lowered detected concentration) can indicate the need to return the instrument to TSI for maintenance.

Technical Contacts

- ❑ If you have any difficulty installing the CPC, or if you have technical or application questions about this instrument, contact an applications engineer at TSI Incorporated, (651) 490-2811.
- ❑ If the CPC 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 001 (651) 490-2811
E-mail: technical.service@tsi.com
Website: http://service.tsi.com

Returning the CPC for Service

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

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

TSI recommends that you keep the original packaging (carton and foam inserts) of the CPC for use whenever the CPC 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 drain and dry the CPC before shipping. See "Moving and Shipping the CPC" in Chapter 4 for detailed instructions.

If you no longer have the original packing material, first protect the CPC 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 CPC. The packaging material must be sufficient to completely protect the integrity of the CPC when dropped from a height of 30 inches (76 cm).

APPENDIX A

Specifications

Table A-1 contains the specifications for the Model 3772/3771 Condensation Particle Counter (CPC). These specifications are subject to change without notice.

Table A-1
Model 3772/3771 CPC Specifications

Particle size range	
Min. detectable particle (D_{50})...	10.0 nm, verified with DMA-classified sucrose particles
Max. detectable particle	>3 µm
Particle concentration range.....	0 to 1×10^4 particles/cm^3, single particle counting with continuous, live-time coincidence correction that can be turned off
Particle concentration accuracy	±10% at <1×10^4 particles/cm^3
Response time.........................	≅3.0 sec to 95% in response to concentration step change
Aerosol flow rate	1000 ± 50 cm^3/min
Flow source...........................	External vacuum
Flow control	Volumetric flow control of aerosol flow by internal critical orifice; Differential pressure across critical orifice is monitored.
Operating temperatures	
Saturator	39°C ±0.2°C
Condenser	22°C ±0.2°C
Optics	40°C ±0.2°C
False background counts	<0.001 particle/cm^3, based on 12-hr average
Aerosol medium	Recommended for use with air; safe for use with inert gases such as nitrogen, argon, and helium (performance specifications are for air)
Environmental operating conditions	Indoor use Altitude up to 2000 m (6500 ft) Inlet pressure 75 to 105 kPa (0.75 to 1.05 atm) Operating temperature range 10 to 35°C Safe temperature range 5 to 40°C Storage temperature range -20 to 50°C. Ambient humidity 0–90% RH noncondensing Pollution degree II Overvoltage category II

Table A-1
Model 3772/3771 CPC Specifications

Condensing liquid	
Working fluid	Reagent-grade n-butyl alcohol (butanol, not included)
Filling system	Electronic liquid-level sensor initiates automatic filling as needed, requires connection to fill bottle
Water removal	All condensate is collected and removed automatically by a constant-flow-rate micropump, may be switched on for use in humid environments
Communications	
Protocol	Command set based on ASCII characters
Interface	USB, type B connector, USB 2.0 compatible at 12 MB
	RS-232, 9-pin, “D” subminiature connector, pinouts compatible with standard IBM-style serial cables and interfaces
	Ethernet, 8-wire RJ-45 jack, 10/100 BASE-T, TCP/IP
Data logging and storage (3772)	SD/MMC flash memory card (3772 only)
Averaging interval	1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, or 60 seconds (set from front panel of 3772), software provides more averaging options
Inputs	
Analog	Two BNC connectors, 0 to 10 volts (data recording for external sensors)
Outputs	
Digital display	Concentration, time and total counts, status (temperatures, pressures, laser power, liquid level, etc.), and user settings
Analog	BNC connector, 0 to 10 volts, user-selectable function output (linear concentration, also DMA voltage control for 3772, DMA voltage control function is not available for Model 3771 CPC)
Pulse	BNC connector, TTL level pulse, 50-ohm termination, nominally 350 nanoseconds wide
Software	Aerosol Instrument Manager® software (USB and RS-232 compatible)
Physical features	
3772 front panel	LCD display, aerosol inlet, LED particle indicator light, LED status indicator light, six-button keypad, flash memory card slot
3771 front panel	Aerosol inlet, LED particle indicator light, LED status indicator light.
Back panel	Power connector, USB, Ethernet, two 9-pin D-sub serial connectors, two BNC inputs, two BNC outputs, fan, butanol-fill connector, butanol-drain connector, external vacuum port, fill bottle and bracket
Dimensions (HWD) (nominal)	26 cm × 18 cm × 25 cm (10 in. × 7 in. × 10 in.), not including fill bottle and bracket
Weight	5.5 kg (12 lbs)

Table A-1
Model 3772/3771 CPC Specifications

Power requirements	100–240 VAC, 50/60 Hz., 210 W maximum
Fuse	4.0A FB/250V (internal—not replaceable by operator)

APPENDIX B

Firmware Commands

The firmware commands are be divided into the following categories:

- READ Commands
- SET Commands
- MISC (MISCELLANEOUS) Commands
- HELP Commands

READ commands are used to read parameter from the instrument (flow rates, temperatures, etc.). READ commands can be identified by a leading "R".

SET commands 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**>. Also, if no parameter is supplied, the command will return the current set value.

MISC (MISCLLANEOUS) commands will be used for calibration and SMPS mostly.

HELP commands. Type "HELP" in a HyperTerminal window or a similar program and it will explain how to use it. All the command descriptions that follow can be obtained using the help command.

The instrument will reply with a serial string of "ERROR", if a command was not understood.

READ Commands

RFV Read the firmware version number

Returns: A string in the format of X.X.X where X are numbers from 0–9

Example: 2.3.1

RSF Read the aerosol flow rate in cc/min

Returns: A floating point number from 0.0 to 9999.9

Example: 1000

RIF Read the inlet flow rate setting in liters per minute

Returns: A floating point number from 0.0 to 9999.9

Example: 1.0

RTS Read the saturator temperature in degrees Celsius

Returns: A floating point number from 0.0 to 50.0

Example: 39.0

RTC Read the condenser temperature in degrees Celsius

Returns: A floating point number from 0.0 to 50.0

Example: 22.0

RTO Read the optics temperature in degrees Celsius

Returns: A floating point number from 0.0 to 50.0

Example: 40.0

RTA Read the cabinet temperature in degrees Celsius

Returns A floating point number from 0.0 to 50.0

Example 23.8

RCT Read the current time

Returns: Www Mmm dd hh:mm:ss yyyy
where
Www is the weekday
Mmm is the month in letters
dd is the day of the month
hh:mm:ss is the time
yyyy is the year

Example: Mon Jun 11 11:05:08 2006

RIE Read the instrument errors

Returns: 16-bit integer in hexadecimal format.
The parameter is in error if the bit is set.
Bit 0x0001 => Saturator Temp
Bit 0x0002 => Condenser Temp
Bit 0x0004 => Optics Temp
Bit 0x0008 => Inlet Flow Rate
Bit 0x0010 => Aerosol Flow Rate
Bit 0x0020 => Laser Power
Bit 0x0040 => Liquid Level
Bit 0x0080 => Concentration
Bit 0x0100 => Unused
Bit 0x0200 => Unused
Bit 0x0400 => Unused
Bit 0x0800 => Unused
Bit 0x1000 => Unused
Bit 0x2000 => Unused
Bit 0x4000 => Unused
Bit 0x8000 => Unused

RPA Read the absolute pressure transducer in kPa

Returns: A floating point number from 15.0 to 115.0

Example: 100.1

RPO Read the orifice pressure transducer. Units are in kPa

Returns: A floating point number from 0.0 to 99.9

Example: 82.4

RPN Read the nozzle pressure transducer. Units are in kPa

Returns: A floating point number from 0.000 to 10.000

Example: 2.50

RSN Read the serial number

Returns: A string of up to 20 characters

Example: 70514396

RAI Read the analog input voltages

Returns: X,Y where X is analog input 1 and Y is analog input 2.
X and Y are floating point numbers from 0.00 to 10.00

Example: 5.22,3.65

RALL Read a set of current values

Returns Concentration, instrument errors, saturation temp, cond temp, optics temp, cabinet temp, ambient pressure, orifice press, nozzle press, laser current, liquid level

RLP Reads the laser current in milliamps

Returns: An integer from 0 to 150

Example: 70

RLL Reads the liquid level

Returns: FULL or NOTFULL and the corresponding ADC reading. The ADC reading is an integer from 0 to 4095

Example: FULL (2471)

RMN Read the model number

Returns: 3771,3772,3775,3776,3790 or 100

Example: 3772

R0 Legacy command to read the liquid level

Returns: FULL or NOTFULL

R1 Legacy command to read the condenser temperature in degrees Celsius

R2 Legacy command to read the saturator temperature in degrees Celsius

R3 Legacy command to read the optics temperature in degrees Celsius

R5 Legacy command to read the instrument status.

Returns: READY or NOTREADY

RD Legacy command to read the concentration in p/cc

RV Read the version string.

Returns: Model 377x Ver B.B.B S/N AAAAAAAA

SET Commands

SAV Set analog output full scale voltage

Params
1 => 0 - 1 Volt
2 => 0 - 2 Volt
3 => 0 - 5 Volt
4 => 0 - 10 Volt

Example SAV,4 (A full scale concentration will equal 10V)

SSTART Start a new sample

Params
0 – Stop
1 - Start, data type 1
2 - Start, data type 2

Example SSTART,1 (Starts new sample)

Unit returns once/sec

Data Type 1:

UX,D,D,D,D,D,D,D,D,D,D,C,C,C,C,C,C,C,C,C,C,AN1,AN2,RIE

UX => elapsed time(sec), integer

D => tenth sec corrected counts, integer

C => tenth sec concentration, float

AN1 => analog input 1, float

AN2 => analog input 2, float

RIE => See help cmd for RIE

Data Type 2, 3776:

UX,C,C,C,C,C,C,C,C,C,C,R,R,R,R,R,R,R,R,R,R,F,F,F,F,F,F,F,F,F,F,T,T,T,T,T,T,T,T,T,T

UX => elapsed time(sec), integer

C => tenth sec concentration, float

R => tenth sec raw counts, integer

F => flowrate(cc/0.1sec), float

T => tenth sec deadtime(sec), float

Data Type 2, 3771/72/75:

UX,C,C,C,C,C,C,C,C,C,C,R,R,R,R,R,R,R,R,R,R,F,DTC,T,T,T,T,T,T,T,T,T,T

UX => elapsed time(sec), integer

C => tenth sec concentration, float

R => tenth sec raw counts, integer

F => flowrate(cc/sec), float

DTC => deadtime correction, float

T => tenth sec deadtime(sec), float

SCM	Set the operating mode		
	Params:	0 => Concentration 1 => Totalizer 2 => SMPS	
	Example:	SCM,0 (sets operating mode to concentration)	
STS	Set saturator temperature		
	Params:	c => 0.0–50.0	
	Example:	STS,39.0 (changes the saturator set point to 39.0 degrees C)	
STC	Set condenser temperature		
	Params:	c => 0.0–50.0	
	Example:	STC,22.0 (changes the condenser set point to 22.0 degrees C)	
STO	Set optics temperature		
	Params:	c => 0.0–50.0	
	Example:	STO,40.0 (changes the optics set point to 40.0 degrees C)	
SAWR	Set the auto water removal function on/off		
	Params:	0–Off 1–On	
	Example:	SAWR,1 (turns on water removal)	
SVO	Set analog output voltage		
	Params:	v => 0.000–10.000	
	Example:	SVO,4.482 (sets the output voltage at 4.482 volts)	
SAO	Set analog output voltage proportional to concentration. The analog output is 0 to 10V.		
	Params:	0 => Off 1 => 1E1 2 => 1E2 3 => 1E3 4 => 1E4 5 => 1E5 (CPC100 only)	
	Example:	SAO,4 (A concentration reading of 1E4 will equal 10V)	

SCOM Setup auxiliary comport

Params: Port => 1,2,3
Baud =>
2400,4800,9600,14400,19200,28800,38400,
57600,115200
Bits => 5,6,7,8
Parity => E, O, N
Stop => 1, 1.5, 2

Example: SCOM,2,9600,7,E,1 (Set 2nd serial port to 9600, 7 bits, Even Parity, 1 Stop bit

SHOUR Set the Real Time Clock Hours (24 hour mode)

Params: hour => 0–23

Example: SHOUR,13 (sets the hour to 13)

SMINUTE Set the Real Time Clock Minutes

Params: min => 0–59

Example: SMINUTE,45 (sets minutes to 45)

SSECOND Set the Real Time Clock Seconds

Params: sec => 0–59

Example: SSECOND,0 (sets seconds to zero)

SYEAR Set the Real Time Clock Year

Params: year => 0–99

Example: SYEAR,6 (sets the year to 2006)

SDAY Set the Real Time Clock Day of the Month

Params: day => 1–31

Example: SDAY,23 (sets the day to the 23rd of the month)

SMONTH Set the Real Time Clock current Month

Params: month => 1–12

Example: SMONTH,2 (sets the month to February)

SFILL Turn on/off auto fill

Params: 0 => Off
1 => On

Example: SFILL,1 (turns on auto fill)

SDRAIN Turn drain on/off (3771 only)

Params: 0 => Off
1 => On

Example: SDRAIN,1 (turns drain on)

SCC Turn coincidence correction on/off

Params: 0 => Off
1 => On

Example: SCC,1 (turns coincidence correction on)

MISC (MISCELLANEOUS) Commands

ZB Begin SMPS scan based on the ZT, ZV and ZU parameters (except 3771)

ZE End SMPS scan (except 3771)

ZT Set the scan time in tenth second increments (except 3771)

Params: delay => 0–255 (0–25.5 seconds)
up => 10–6000 (1–600 seconds)
down => 10–6000 (1–600 seconds)

Example: ZT0,600,100

Note: *This command does not need a comma separating the first parameter from the command*

ZU Scan using up direction instead of down (except 3771)

ZV Set the scan voltages (except 3771)

Params: start => 10–10000 Volts
end => 10–10000 Volts

Example: ZV10,10000

Note: *This command does not need a comma separating the first parameter from the command*

COM2 Data after the ":" will be transmitted to serial port 2

Example: COM2:RFV ("RFV" will be transmitted to com port 2)

D	Legacy command to read accumulative time (sec) and accumulative counts since the last time this command was sent.
DEL	Delete Flash File, path\filename (except 3771)
FORMAT	Format the flash drive. This will also erase all the data stored on the drive (except 3771).
DIR	Read the flash card directory (except 3771)
CD	Change the active flash card directory (except 3771)

HELP Commands

Help,Read

Help,Set

Help,Misc

Help,x where x=Command Name

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

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

Caldow, R.C., M.R. Palmer, and F.R. Quant
”Performance of the TSI Model 3010 Condensation Particle Counter,” paper presented at the *American Association for Aerosol Research Conference*, San Francisco, California, October 1992. (TSI paper A83)[*]*

[*]Paper refers to TSI Model 3010 CPC, a predecessor of the Model 3772

Fink, M.A., R.C. Caldow, H.S. Han, E.M. Johnson, S.J. Olson, and M.A. Woessner
”Characterization of New Butanol-based Condensation Particle Counters,” poster #8PC1, *American Association for Aerosol Research Conference*, Austin, Texas, October 2005

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

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

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

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

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

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.

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

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 Q, H.S. Han, S.W. Kerrigan, and E.M. Johnson
"Characterization of Two New Butanol-based Condensation Particle Counters." Poster #IPC17 at 2005 AAAR, Austin, Texas, October 2005.

Shi Q, H.S. Han, S.W. Kerrigan, and E.M. Johnson
"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

Index

I–J

K

L

M

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 3772/3771 Condensation Particle Counter__ P/N 1980529 Rev C

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 ______________________________ ______________________________

TSI Incorporated
Headquarters—Tel: *+1 651 490 2811* ***Toll Free:*** *1 800 874 2811* ***E-mail:*** *particle@tsi.com*
UK ***Tel:*** *+44 1494 459200* ***E-mail:*** *tsiuk@tsi.com* ***France*** ***Tel:*** *+33 491 95 21 90* ***E-mail:*** *tsifrance@tsi.com*
Germany ***Tel:*** *+49 241 523030* ***E-mail:*** *tsigmbh@tsi.com* ***Sweden*** ***Tel:*** *+46 8 595 13230* ***E-mail:*** *tsiab@tsi.com*
India ***Tel:*** *+91 80 41132470* ***E-mail:*** *tsi-india@tsi.com* ***China*** ***Tel:*** *+86 10 8260 1595* ***E-mail:*** *tsibeijing@tsi.com*

For current information
www.tsi.com

P/N 1980529 Rev. C