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Model 7650
Condensation Particle Counter
Instruction Manual

Particle Measuring Systems
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Boulder, Colorado 80301
(303) 443-7100

P/N 1930090

The following is a manual history of the Model 7650 Condensation Particle Counter. P/N 1930090.

Revision	Date
Final	January 1997

In January 1997, the manual was first printed.

This section gives instructions to promote safe and proper operation of the Model 7650 Condensation Particle Counter (CPC), samples of warnings found in this manual, and labels attached to the instrument.

Laser Safety

The Model 7650 Condensation Particle Counter is a Class 1 laser-based instrument. During normal operation, you will not be exposed to laser radiation. However, you must take certain precautions or you may expose yourself to hazardous radiation in the form of intense, focused invisible light. Exposure to this light can cause blindness.

Take these precautions:

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



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

Chemical Safety

The Model 7650 CPC uses reagent grade n-butyl alcohol (butanol) as a working fluid. Butanol is flammable. Butanol is also toxic if inhaled. Refer to a Material Safety Data Sheet for butanol and take these precautions:

- Use butanol only in a well-ventilated area.
- Butanol vapor is identified by its characteristically strong odor and can easily be detected. If you smell butanol and develop a headache, or feel faint or nauseous, leave the area at once. Ventilate the area before returning.



Caution

Butanol is flammable. Butanol is also potentially toxic if inhaled. Use butanol only in a well-ventilated area. If you smell butanol and develop a headache, or feel faint or nauseous, leave the area at once. Ventilate the area before returning.



WARNING

Although the CPC is appropriate for monitoring inert process gases such as nitrogen or argon, it should not be used with corrosive, toxic, or other hazardous gases such as hydrogen or oxygen. Using the CPC with hazardous gases may cause injury to personnel and damage to equipment.

Description of Safety Labels

This section acquaints you with the advisory and identification labels on the instrument and used in this manual to reinforce the safety features built into the design of the instrument.

Caution



Caution

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

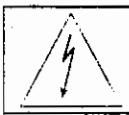
Warning



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

Caution or Warning Symbols

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

	Warns you that uninsulated voltage within the instrument may have sufficient magnitude to cause electric shock. Therefore, it is dangerous to make any contact with any part inside the instrument.
	Warns you that the instrument contains a laser and that important information about its safe operation and maintenance is included. Therefore, you should read the manual carefully to avoid any exposure to hazardous laser radiation.
	Warns you that the instrument is susceptible to electro-static dissipation (ESD) and 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 CPC housing and to the heatsink and optics on the inside of the instrument.

Figure 1 shows the internal and external labels for the Model 7650 CPC.

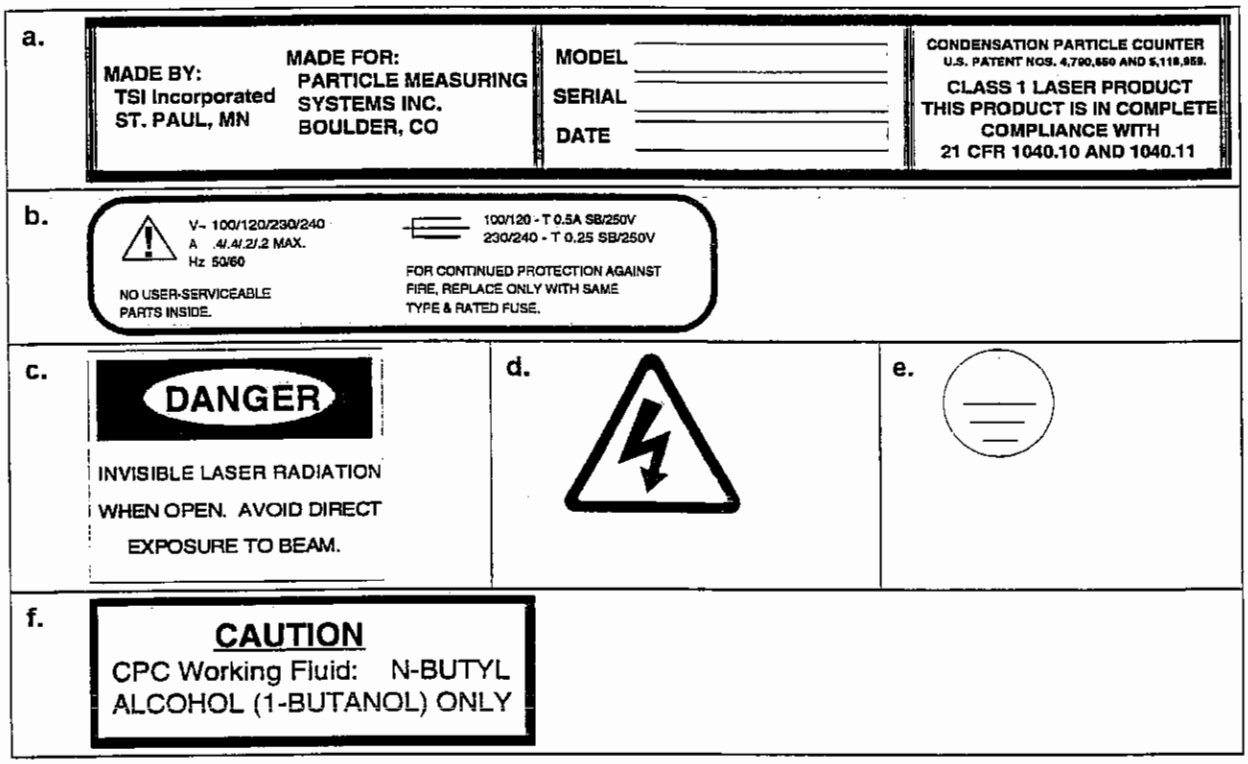


Figure 1. Advisory Labels: *a* Identification Label (on heatsink); *b* Power Requirements Label (on heatsink); *c* Warning Label (on the optics housing); *d* Electrical Shock Hazard; *e* Electrical Ground. *f* Working Fluid (on top of CPC)

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Particle Measuring Systems, Inc. is a team of creative people who are leaders in the design and manufacture of microcontamination-detection instruments. At PMS we seek to support our valued customers by doing our job right the first time, by providing state-of-the-art products that conform to accepted specifications and standards, and by delivering our products within the committed time schedule. We rely upon our vendors for their products to conform to their specifications and invite them to join us in the commitment we have to all our customers.

Our quality policy is: to continuously strive to meet or exceed the needs and expectations of our customers, and to pursue improvement on a continuous basis throughout our company in order to produce instruments of exceptional quality while reducing production costs.

At PMS, quality is our culture.

The Model 7650 Condensation Particle Counter, is manufactured by TSI Incorporated, St. Paul, Minnesota, for Particle Measuring Systems, Incorporated, Boulder, Colorado.

Reusing and Recycling



As part of our effort to have a minimal negative impact on the communities in which our products are manufactured and used:

- ❑ This manual uses recycled paper.
- ❑ Shrink-wrapping, which is difficult to recycle, has been reduced to the manual's outer binder.
- ❑ This manual has been shipped, along with the instrument, in a reusable carton.

The CPC, when combined with a suitable vacuum pump, can be used as a stand-alone sensor or can be connected directly to a computer or to a data acquisition system.

Model 7650 CPC features include:

- A sampling flowrate of 0.1 cfm (2.8 lpm)
- Back inlet with male 4 VCR cajon fitting
- An internal microprocessor to allow direct communications with other systems
- An LCD display indicating particle concentration in particles/ft^3 or in cumulative number of particles counted over a fixed time period
- An automatic daily working-fluid fill system. Reservoir capacity that allows the instrument to run up to four days between refills.
- Three communication modes: RS-485 Computer interface mode for multi-instrument network (polled data output only); RS-232 two-way communications (polled and unpolled data output) and RS-232 Local Printer Output Mode (unpolled data output). Also, 4–20 mAmp concentration output data with two range selections, and BNC 6.4 µsec pulse for each particle counted, compatible with Model 7130 Remote Processor and Model 7110 Multiplexer/Processor.
- Data written to memory with a queue size of 20 samples.
- Front panel and computer interface entry of Date, Time, Sampling Period, Number of Samples, Location, and Concentration Averaging Time.

Refer to Appendix A, "Specifications" for Model 7650 CPC operating specifications.

How it Works

The Model 7650 CPC measures the number concentration of individual particles that are 0.14 µm in diameter and larger. The particles are detected by condensing alcohol vapor onto the particles, causing them to grow into droplets. These particles, in droplet form, are easily counted by a simple optical particle detector (Figure 1-2).

Product Overview

This chapter contains an introduction to the Model 7650 Condensation Particle Counter (CPC) and a brief explanation of how the CPC operates.

Product Description

The Model 7650 CPC, shown in Figure 1-1, is a compact, single-particle counting instrument used for process gas monitoring requiring detection of particles 0.14 µm in diameter and larger. This model's performance is *not* within the Federal Standard 209E Figure D.1 "Envelope of acceptability for the counting efficiency of a DPC used to verify the U descriptor." The detection efficiency is more sensitive than required by FS-209E.

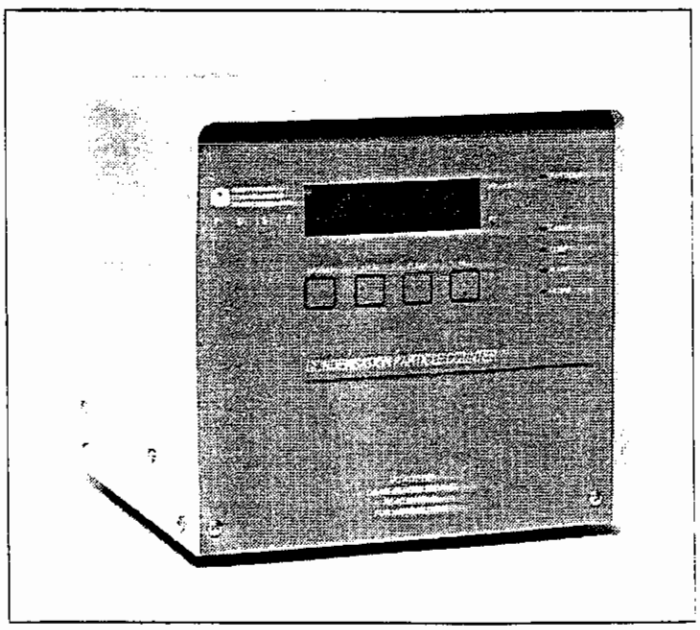


Figure 1-1. PMS Model 7650 Condensation Particle Counter

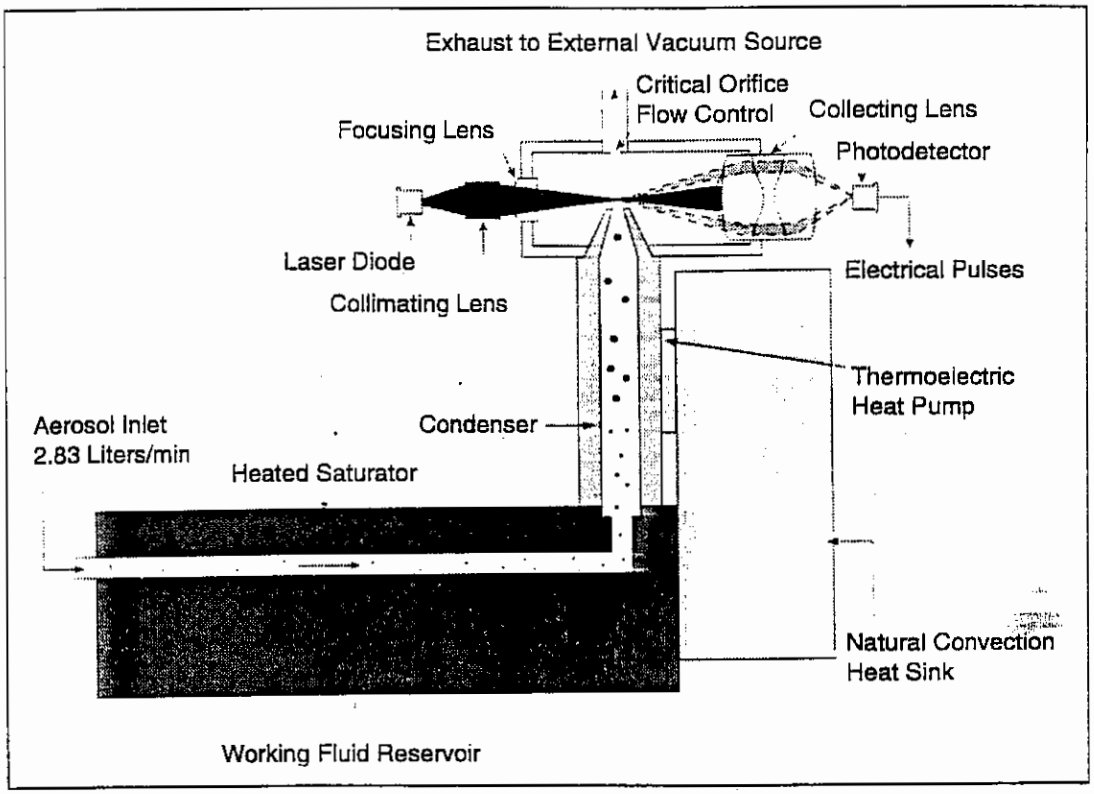


Figure 1-2. Model 7650 CPC Flow Schematic

A heatsink, which makes up the entire back panel of the CPC, dissipates heat by natural convection. A cabinet purge airflow (1.0 lpm) helps to cool the electronics within the cabinet and creates a slight negative pressure within the instrument. Particles that may be generated inside the cabinet are quickly carried out through the vacuum line and do not contaminate the surrounding area.

See Appendix B for a detailed theory of operation for the CPC.

Unpacking

Use the information in this chapter to unpack the Model 7650 Condensation Particle Counter (CPC).

Packing List

Table 2-1 shows the packing list for the CPC.

Table 2-1. CPC Packing List

Qty.	Description	Part No.
1	Model 7650 Condensation Particle Counter	
1	12-foot 9-pin (M/F) interface cable	962002
1	Cable adapter 25-pin (F) to 9-pin (M)	962003
1	Power-cable, 110-120 V *or*	1303053
	220-240 V	1303075
1	AQ Filter Assembly	1035643
1	Fill bottle assembly (tested)	1035749
	Butyl tubing, 3 ft	3900030
	Barb fitting, quick disconnect	1611174
1	Drain bottle assembly (tested)	1035591
	Butyl tubing, 7 ft	3900030
	Barb fitting, quick disconnect	1611174
1	Instruction manual	1930090

Table 2-2 shows optional RS-232 Printer and RS-232 Computer Interface, not included with CPC.

Table 2-2. Optional RS-232 Printer and RS-232 Computer Interface

Qty.	Description	Part No.
1	Thermal Printer, Seiko DPU-411-040 Type 21BU with 8K of memory	PR33
1	7625/7650 Printer Cable, DP-9 to DP-25, 5 ft. (RS-232 Output Communication Only)	CD1996
1	RS-485 to RS-232 Converter	90451064
1	Power Supply for converter	MI 209-1
1	RS-485 Converter to Node - Device Cable, DP-25 to DP-9, 10 ft	CD1053
1	IBM 25 Pin COM1/COM2 to RS-485 Converter Cable, DP-25 to DP-25, 1 ft	CD1055

For two-way RS-232 communications need: converter, power supply, CD1053, and CD1055.

For output to PR33 printer can either use: cable CD1996, output RS-232 communications only; or converter, power supply, CD1053, and CD1055.

Note: *Due to shipping regulations on flammable materials, n-butyl alcohol (butanol) is not supplied with the CPC. Butanol may be purchased from scientific chemical-supply houses. Use reagent grade n-butyl alcohol.*

Unpacking Instructions

The Condensation Particle Counter comes fully assembled with protective coverings on the sampling and vacuum inlets and electrical connections.

To avoid contaminating the instrument or the environment the CPC is monitoring, do *not* remove the protective covers until you are ready to install the instrument.

If anything is missing or appears to be damaged, contact your PMS representative. See "Product Support" at the end of this manual for PMS contacts.

Controls, Indicators, and Connectors

Use the information in this chapter to familiarize yourself with the location and function of controls, indicators, and connectors on the Model 7650 Condensation Particle Counter (CPC).

This chapter is organized into three sections: general overview; front panel display, controls and indicators; and back panel connectors and switches.

Front Panel

Figure 3-1 shows the front panel of the CPC. The front panel includes an LCD display, control buttons, particle and status indicator lights, a liquid level window, and a sampling inlet. Each area is labeled for easy reference.

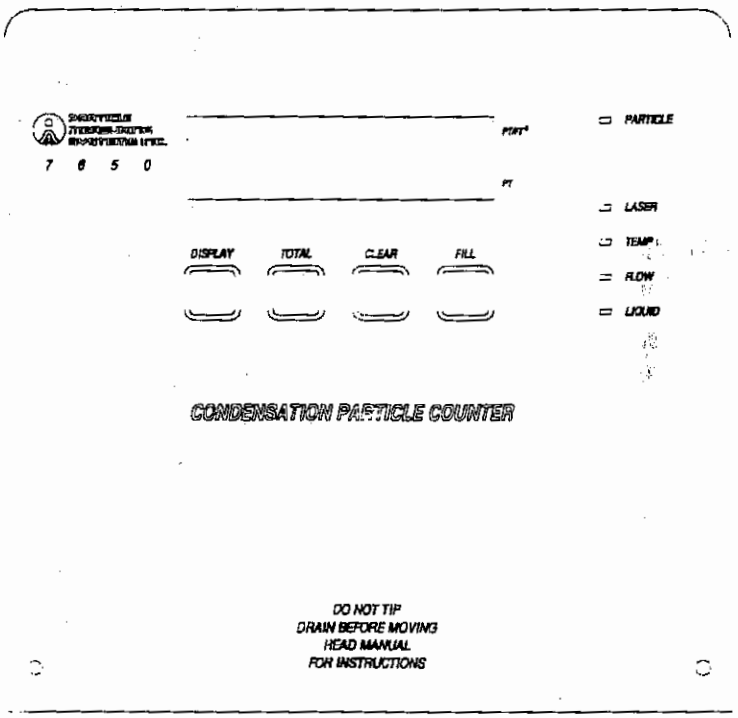


Figure 3-1. CPC Front Panel

General Overview

The Model 7650 CPC has three operating modes: RS-485 Computer Interface Mode; RS-232 Two-Way Computer Interface Mode; and RS-232 Local Printer Output mode. Each operating mode is slightly different. The RS-485 Computer Interface Mode is for multi-instrument networks, where the instrument is controlled by the network host computer. RS-232 Two-Way Computer Interface Mode is for small mutli-instrument networks and local, single instrument sampling. RS-232 Local Printer Output mode is for stand-alone control and report output to an external RS-232 printer. The RS-232 Two-Way and RS-232 Local Printer Output modes require optional equipment not included with the Model 7650, see page 2-1 for optional equipment list. The factory default of the Model 7650 is in the RS-232 Local Printer Output mode. This allows you to operate the CPC without any optional equipment or computer.

LCD Display

The front panel has a 5-digit liquid crystal display (LCD) as shown in Figure 3-2. Using the **DISPLAY** control button, the LCD will scroll through three displays, particles/ft^3 (PT/FT^3), total particle count in the sampling period (PT), and time remaining in the sampling period (seconds). A horizontal bar is displayed next to the appropriate unit (PT/FT^3), or (PT). In the time remaining display mode no horizontal bar is displayed. In each mode the display is updated every second. The horizontal bar will flash when the CPC is sampling. At the end of the sampling period the horizontal bar stops flashing, the display will hold the sampling period data for 5 seconds. When in the concentration display mode, the 5-second data is the total concentration for the sampling period. total counts divided by total volume of sampled air in cubic feet. Concentration data can be averaged over a user selectable range, 1 to 999 seconds long. The averaged concentration is a sliding window that is updated every second. See Chapter 5, "Using the CPC Controls," on changing the averaging period. When at the end of the countdown mode, no horizontal bar displayed, the display will change to the total number of particles counted for 5 seconds and then the display will return to the countdown mode of the next sampling period.



Figure 3-2. LCD Display

Control Buttons

Four control buttons control the LCD display and the fill mode of the CPC. Each button is described below. Operating control buttons with a description of the concentration and totalizer modes is described in Chapter 5.

DISPLAY	**DISPLAY** controls the display screen. Press **DISPLAY** to toggle between three modes: concentration (PT/FT^3), total (PT), time remaining in sampling period (seconds), or count up time if sampling period interval is unlimited. Holding the **DISPLAY** button down for 5 seconds will activate the Front Panel Set-up mode. Activating the set-up mode will terminate a sample. When in the Front Panel Set-up mode, the **DISPLAY** button is used to toggle through the digits. The flashing digit is the one that can be changed. Push **DISPLAY** to scroll to the next digit. The Front Panel Set-up mode can be active in all of the Communication Modes, RS-485, RS -232 Two-Way, RS-232 Local Printer Output Mode.
TOTAL	Press **TOTAL** to start and stop the sampling period. In the Front Panel Set-up mode, the **TOTAL** button will scroll through the flashing digit values each time this switch is pushed. In RS-485 and RS-232 Two-Way operating mode, the sampling period start/stop is controlled by the host computer. Therefore, **TOTAL** button does not function.
CLEAR	Press **CLEAR** to end the current sampling period and start the next sampling period. In the Front Panel Set-up mode the **CLEAR** button will increment to the next screen. After the Location variable is displayed, pushing the **CLEAR** button will exit the Front Panel Set-up mode. In RS-485 and RS-232 Two-Way operating mode, the **CLEAR** button does not function.
FILL	Press **FILL** to manually begin filling the CPC reservoir. The **FILL** button is active in all three communication modes.

Indicator Lights

Four green status lights on the right-hand side of the CPC front panel monitor these instrument parameters: laser, temperature, flow and liquid. An amber status light monitors the presence of particles.

Note: *Also refer to "Warm-Up Mode" in Chapter 5 and "Identifying Problems" in Chapter 7 for more information on the indicator lights.*

PARTICLE	**PARTICLE** indicates the presence of particles in the viewing volume of the instrument. When the concentration sampled by the instrument is approximately below 1.5E4 particle/ft^3, **PARTICLE** blinks once for each particle detected by the instrument. When the concentration is higher, **PARTICLE** is continuously lit.
LASER	**LASER** lights when power is supplied to the CPC and the laser is operating within a set power range. **LASER** should always light under normal operation.
TEMP	**TEMP** indicates the status of the temperature difference between the saturator and condenser sections of the CPC. When power is applied to the CPC, **TEMP** flashes until the operating temperature is reached.
FLOW	**FLOW** indicates there is sufficient vacuum supplied to the critical orifice to produce a correct flow at the inlet. This status light indicates vacuum presence rather than precise flow. As long as there is sufficient vacuum supplied to the instrument, the critical orifice will provide accurate flow control (within 10 percent).
LIQUID	The **LIQUID** comes on after a fill procedure has completely filled the reservoir. The **LIQUID** will stay on for 24 hours after the fill. The **LIQUID** will stop glowing after 24 hours, but there should be enough working fluid in the receiver to keep the CPC working for four days. Power cycling, complete fill, and computer reset CSR resets the fill timer to 24 hours. If the CPC is not full after a power cycle or reset, then the CPC will initiate a fill sequence.

Back Panel

Figure 3-3 shows the back panel of the CPC. Back panel features include the COM ports (A & B), BNC output (C), liquid fill connector (D), DIP switches (E), fuse panel (F), power cord inlet (G), vacuum connector (H), liquid drain connector (I), liquid level window (J), and sampling inlet (K).

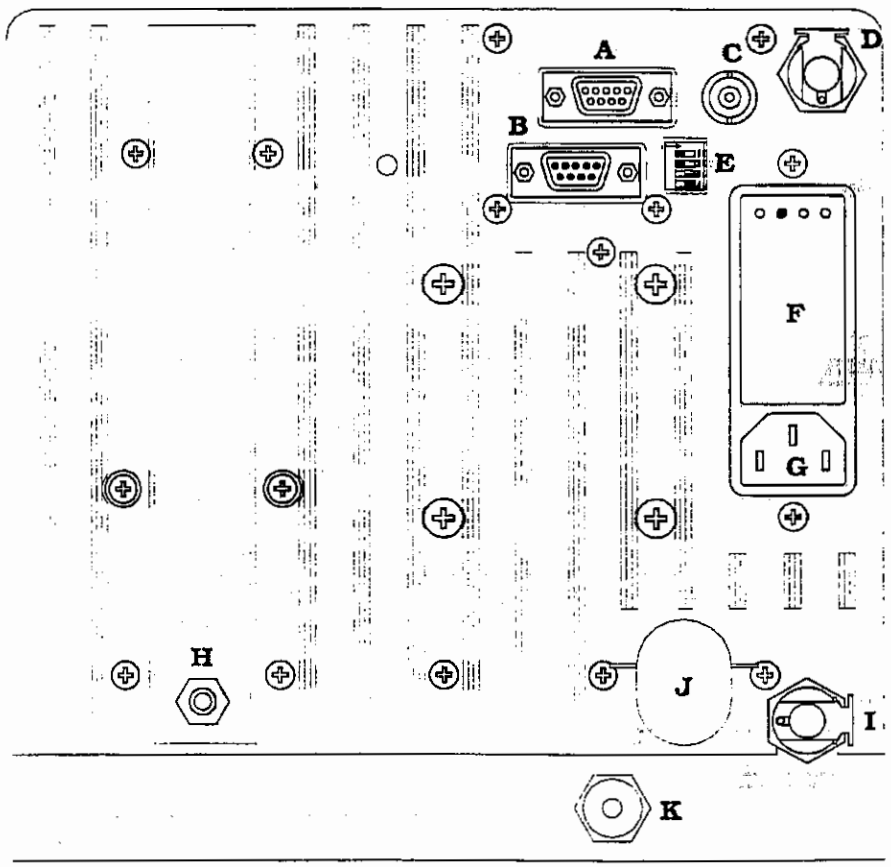


Figure 3-3. CPC Back Panel

Descriptions of the back panel features follow.

COM Ports (A) and (B)

Two COM ports are on the heatsink for RS-485 and 4-20 mA. The upper port (COM port A) is a 9-socket, female, D-type subminiature that supports RS-485 and 4-20 mA communications. The lower port (COM port B) is a 9-pin, male, D-type, subminiature that supports RS-485 and RS-232 Local Printer Output mode.

Note: *See Appendix C for a description of the computer interface hardware as well as a software program you can modify for your use.*

BNC Output (C)

The BNC output is a square 6.4 µs wide, 15 volt high pulse with one pulse per particle count.

Liquid Supply Connector (D)

The liquid supply connector is a quick-disconnect, shut-off connection. Use the liquid supply connector with the liquid fill bottle. Refer to the "Filling the CPC Reservoir " section in Chapter 5 for more information.

DIP Switches (E)

The DIP switch array has four switches numbered 1 to 4. The switch functions are listed in Table 3-1 below.

Table 3-1. The DIP Settings are "Hot", Settings Will Change When the Switch Position is Changed

Switch	OFF	ON
DP1 Auto Fill	Off Factory default	Auto refill every 24 hours
DP2 Sampling Period	600 second, (nominal 1 cfm) Default Number of Samples = ∞ Factory default	No Limit Default Number of Samples = 1
DP3 4-20 mAmp range	4 mAmp = 0#/ft^3 20 mAmp =10K#/ft^3	4 mAMp = 0#/ft^3 20 mAmp=1M#/ft^3 (max. of CPC) Factory default
DP4 Communication type	RS-485	RS-232 Two way and RS-232 Local Printer Output Mode Factory default: Local Printer Output Mode.

Refer to Chapter 4. "Setting DIP Switches." for directions on setting the first bank of DIP switches.

Fuse Panel (F)

The fuse panel allows access to the voltage selector card and the fuses. For more information on the card and the fuses. refer to "Checking the Line Voltage Configuration" in Chapter 4.

Power Cord Inlet (G)

The power cord inlet is the receptacle for the AC power cord that is supplied with the CPC.

Vacuum Connector (H)

The vacuum connector, a ¼-inch male Swagelok® connector, connects an external vacuum source to the CPC. Refer to Chapter 4, "Connecting the Vacuum Source," for directions on connecting a vacuum to the CPC.

Liquid Drain Connector (I)

The liquid drain connector is a quick-disconnect, shut-off connection for the liquid drain bottle. Refer to the "Draining the CPC Reservoir" procedure, Chapter 7, for directions on connecting the drain bottle to the liquid drain connector.

Liquid Level Window (J)

The liquid level window shows the amount of n-butyl alcohol (butanol) available in the CPC reservoir. Butanol is necessary to operate the CPC and should be in the reservoir at all times, except when moving the instrument.

For directions on filling the CPC reservoir, see "Filling the CPC Reservoir" in Chapter 5.

Sampling Inlet (K)

The sampling inlet is a Cajon® male 4 VCR®. The sampling inlet can be attached to a variety of fittings to allow sampling from many tubing configurations.

®Swagelok is a registered trademark of the Crawford Filling Co., Solon, Ohio.

®Cajon is a registered trademark of Cajon Company, 9760 Shepard Road, Macedonia, Ohio 44056.

®VCR is a registered trademark of the Cajon Company.

Setting Up the Condensation Particle Counter

Use the information in this chapter to properly set up the Model 7650 Condensation Particle Counter (CPC).

This chapter contains these procedures:

- ❑ Positioning the CPC
- ❑ Checking the line voltage configuration, and if needed, changing the fuses
- ❑ Setting DIP switches
- ❑ Connecting the vacuum source

Positioning the CPC

The Model 7650 CPC should be positioned right-side up as shown in Figure 4-1.

1. Place the CPC on a level surface.

   Note: *Position the CPC so the appliance coupler is easily accessible.*

2. Ensure the heatsink on the back panel of the CPC is exposed to cooling, ambient air.
3. Remove the protective caps from the sampling inlet and exit flow ports (front and back panels).



Caution

To avoid damage to the CPC, provide adequate ventilation for the back panel. If you have any questions about the temperature requirements for this instrument, see Appendix A, "Specifications."

If the CPC has n-butyl alcohol (butanol) in the reservoir, be very careful when moving the CPC. The CPC can be moved on a benchtop if there is no vacuum applied and if you keep the CPC upright. If you decide to move the CPC from one location to another, use the "Draining the CPC Reservoir" procedure in Chapter 7.

Note: *The filling process generates false particle counts, data collected during the filling process should be discarded. It is recommended to fill the CPC on a known schedule during non-critical sampling time so that data collected during the fill process can be discarded. If monitoring a process that is longer than one day and less than four days long, then set the AUTO FILL switch to Off.*

Sampling Period

Use switch 2 to set the power up default sampling period length. The Sampling period length and number of samples can be changed using the Front Panel Set-up, RS-485, and RS-232 Two-Way communications. Programmed settings will be lost when the power is removed from the CPC.

4–20 mAmp Output Range

Switch 3 sets the span of the 4-20 Amp output. For clean areas, the lower range of 20 mAmp =10 K particles/ft^3 can be used.

Communication Type

There are three communication types, RS-485, RS-232 Two-way, and RS-232 Local Mode Printer Output. The RS-485 mode is compatible with the standard PMS RS-485 Protocol. The RS-232 Two-way mode uses the same commands as the RS-485 mode, but the CPC address and checksum features are removed. In all three modes, data is stored in a 20-sample queue. An external signal converter is required to convert the electrical signals from RS-485 to RS-232, see page 2-1 for optional equipment list. The RS-232 Local Printer Output Mode allows the Model 7650 CPC to be used as a stand-alone instrument with data printed out on an external printer. A special cable is required to connect the CPC to the printer, or the RS-485 to RS-232 signal converter can be used. See Appendix C for communication details.

BNC Connector

The BNC output is a digital signal that sends a 15-volt, 6.4 µs wide, pulse for each particle detected by the instrument. The digital pulse is derived from the raw photodetected pulse and, therefore, the pulse width will vary slightly with the size of the detected pulse.

2. Lift off the cover of the fuse and voltage module cover on the back panel of the Model 7650 using a small-blade screwdriver or similar tool (Figure 4-2). Set aside the cover/fuse block assembly.

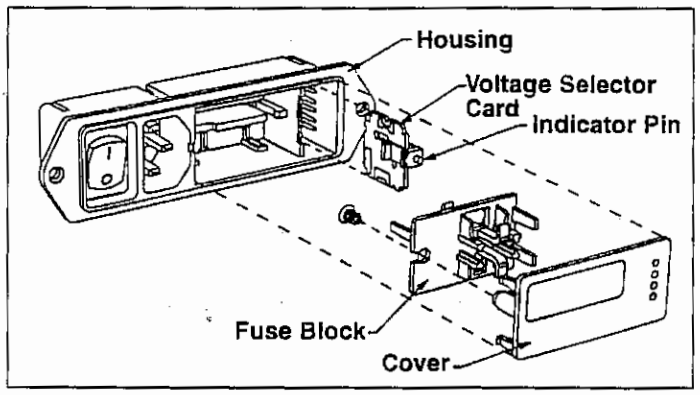


Figure 4-2. Power Entry, Fuse, and Voltage Module

3. Grasp the indicator pin and pull the voltage-selector card straight out of the housing (Figure 4-2).
4. Orient the selector card so that the desired voltage is readable at the bottom.
5. Orient the indicator pin so that it points up when the desired voltage is readable at the bottom. When the pin is fixed and in place, rotate the card 90° clockwise (Figure 4-3).

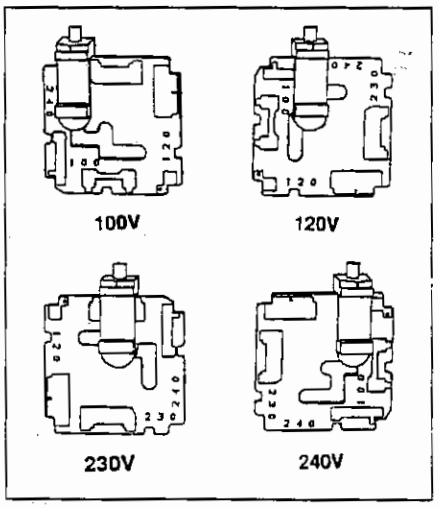


Figure 4-3. Orientation of the Voltage Selector Card

6. Insert the voltage-selector card into the housing, making sure the edge containing the desired voltage is inserted first and the printed side of the card faces the IEC (power cord) connector.
7. Replace the cover, making sure that the indicator pin shows the desired voltage.

Changing the Fuse

1. Disconnect the power from the Model 7650 and remove the line cord.
2. Lift off the power-entry module on the back panel of the Model 7650 using a small-blade screwdriver or similar tool (Figure 4-2).
3. Replace the fuses. Make sure the Fuse(s) are the proper size and rating for the line voltage you are using. The Fusing label is located just above the power entry module on the back panel of the Model 7650.

Note: *Two European-style 5 × 20 mm fuses are required in the European-Fusing arrangement (Figure 4-5).*

4. Replace the power-entry module cover.

Changing Between European and American-Style Fuses

Before installing the Model 7650, make sure the fuse is compatible with your site. The Model 7650 works with both North American and European-style fuses. The 100/120-volt model comes with the North American-style fuse and the 230/240-volt model is equipped with the European-style fuse. If you need to change the fuse from North American (Figure 4-4) to the European-style (Figure 4-5),or vice versa, follow these steps:

1. Disconnect the power from the Model 7650 and remove the line cord.
2. Lift off the power-entry module on the back panel of the Model 7650 cover using a small-blade screwdriver or similar tool.

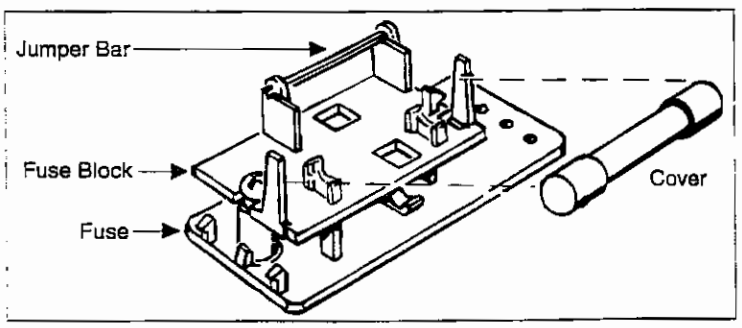


Figure 4-4. North American–Fusing Arrangement

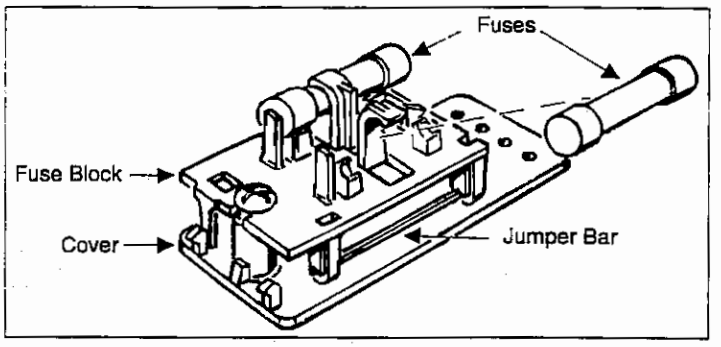


Figure 4-5. European–Fusing Arrangement:

3. Loosen the screw on the fuse block two turns.
4. Remove the fuse block (Figure 4-6) by sliding it up and away from the screw. Lift the block from the pedestal.

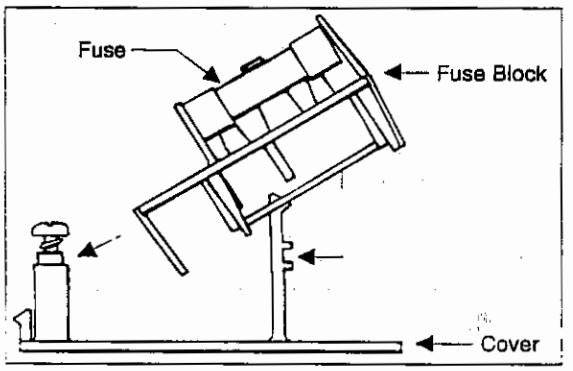


Figure 4-6. Fuse Block/Cover Assembly

5. Change the fuses:

Note: *Two European 5 × 20 mm fuses are required in the European-Fusing Arrangement.*

Invert the fuse block and slide it back onto the screw and the pedestal.

6. Tighten the screw and replace the power-entry module cover. The fuse(s) that enters the housing first is the active one.

Setting DIP Switches

This section shows you how to set DIP switches for the CPC. The first bank of DIP switches, located on the CPC back panel, configures the CPC to match the application with which it is used.

This section explains the DIP switch setting for the CPC. The DIP switch settings are used to set default parameters on power up.

Table 4-1 gives a quick reference and functions for the DIP switches.

Table 4-1
The DIP Settings are "Hot", Settings Will Change When the Switch Position is Changed

Switch	OFF	ON
DP1 Auto Fill	Off Factory default	Auto refill every 24 hours
DP2 Sampling Period	600 second, (nominal 1 cfm) Number of Samples = ∞ Factory default	No Time Limit Number of Samples = 1
DP3 4-20 mAmp Output Range	4 mAmp = 0 particles/ft^3 20 mAmp =10 K particles/ft^3	4 mAMp = 0 particles/ft^3 20 mAmp=1 Mparticles/ft^3 (max. of CPC) Factory default
DP4 Communication Type	RS-485	RS-232 Two way and RS-232 Local Printer Output Mode Factory default: Local Printer Output Mode.

Auto Fill

If switch 1 is disabled, the CPC reservoir only fills when power is supplied to the CPC, when the FILL button is pushed, or with a computer command. The CPC does not have a low liquid level sensor, only a high/full level sensor. A 24-hour count down timer is used to initiate a fill when switch 1 is on. This timer is reset at the end of a fill cycle. Fill cycles are started by: CFILL RS-232 and RS-485 commands; manual FILL pushbutton on the power front panel; power cycling of the CPC. The CPC can run for four days between fills.

For RS-485 computer monitoring systems, the AUTOFILL should be off and CFILL should be sent once per day at a non-critical monitoring time. Filling will cause false counts, this period should be flagged as bad data.

Note: *The filling process generates false particle counts, data collected during the filling process should be discarded. It is recommended to fill the CPC on a known schedule during non-critical sampling time so that data collected during the fill process can be discarded. If monitoring a process that is longer than one day and less than four days long, then set the AUTO FILL switch to Off.*

Sampling Period

Use switch 2 to set the power up default sampling period length. The Sampling period length and number of samples can be changed using the Front Panel Set-up, RS-485, and RS-232 Two-Way communications. Programmed settings will be lost when the power is removed from the CPC.

4–20 mAmp Output Range

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Communication Type

There are three communication types, RS-485, RS-232 Two-way, and RS-232 Local Mode Printer Output. The RS-485 mode is compatible with the standard PMS RS-485 Protocol. The RS-232 Two-way mode uses the same commands as the RS-485 mode, but the CPC address and checksum features are removed. In all three modes, data is stored in a 20-sample queue. An external signal converter is required to convert the electrical signals from RS-485 to RS-232, see page 2-1 for optional equipment list. The RS-232 Local Printer Output Mode allows the Model 7650 CPC to be used as a stand-alone instrument with data printed out on an external printer. A special cable is required to connect the CPC to the printer, or the RS-485 to RS-232 signal converter can be used. See Appendix C for communication details.

BNC Connector

The BNC output is a digital signal that sends a 15-volt, 6.4 µs wide, pulse for each particle detected by the instrument. The digital pulse is derived from the raw photodetected pulse and, therefore, the pulse width will vary slightly with the size of the detected pulse.

Connecting the Vacuum Source

The CPC flow, controlled by a critical orifice inside the instrument, requires an external vacuum source. You can use a central building vacuum or a stand-alone vacuum pump.

Connect vacuum tubing between the vacuum source and the vacuum connector on the CPC back panel (see Figure 4-1). Flexible 12-mm (½-inch) OD and 6-mm (¼-inch) ID tubing is recommended.

The CPC requires a minimum vacuum pressure of 18 inches (460 mm) of mercury at a total flowrate of 0.13 cfm (3.8 lpm).

Note: *Only 0.1 cfm (2.8 lpm) make up the sample flowstream. The remaining airflow is purge air to remove heat and particles from the cabinet.*

The flow in the CPC is regulated by a critical orifice. Changes in the inlet pressure will affect the flowrate through the instrument.

Although the orifice should not be affected by overpressure, the saturation rate of the fluid may be affected at higher inlet pressures. Therefore, operate the CPC with an inlet pressure of ±1 inch water (0.25 kPA) compared to ambient pressure. Inlet pressures out of this range can generate false particle counts, and may cause flooding of the optics with working fluid.

Operating the Condensation Particle Counter

This chapter contains the following operating information and procedures for the Model 7650 Condensation Particle Counter (CPC):

- ❑ Operating precautions
- ❑ Supplying and removing power
- ❑ Warm-up mode
- ❑ Filling the CPC with butanol
- ❑ Using the CPC controls

Note: *Before supplying power to the CPC, set up the instrument using information in Chapter 4.*

Operating Precautions

Read the following before applying power to the CPC:

- ❑ Review the operating specifications for the CPC in Appendix A.
- ❑ Do not operate the CPC outside the range of 10°C to 35°C. If the CPC is operated outside this range, the displayed concentration may be inaccurate.
- ❑ If the CPC reservoir contains butanol, be very careful when moving the CPC. The CPC can be moved on a benchtop if there is no vacuum applied and if you keep the CPC upright. If you need to drain the reservoir, use the "Draining the CPC Reservoir" procedure in Chapter 7.



WARNING

Although the CPC is appropriate for monitoring inert process gases such as nitrogen or argon, it should not be used with corrosive, toxic, or other hazardous gases such as hydrogen or oxygen. Using the CPC with hazardous gases may cause injury to personnel and damage to equipment.

Supplying Power and Removing Power

Supply power to the CPC by plugging the AC power cord into the power cord inlet on the back panel and then into an AC source. Make certain the power cord is plugged into a grounded power outlet. Disconnecting the power will reset many of the operating variables to their default values. The date, time, sampling period, operating mode, and fill time will be reset. Remove power from the CPC by unplugging the power cord from the AC source.

Warm-up Mode

When power is supplied to the CPC, the green status lights (**Laser**, **Temp**, **Flow**, and **Liquid**) light or flash.

On power-up, the CPC enters a warm-up mode to bring the condenser and saturator temperatures within the correct operating conditions. This is indicated by a blinking **Temp** indicator light. The warm-up period ends when the difference between the saturator and condenser temperatures and the laser power have reached normal operating levels.

Notes:

- *The CPC may take up to 30 minutes to warm to normal operating temperatures.*
- *Particle counts taken by the CPC are not accurate until the **Laser**, **Temp**, and **Flow** green indicator lights are lit and non-blinking.*

Normal Operation

Under most circumstances, you can determine if the CPC is operating normally by observing the LCD display and indicator lights (**Laser**, **Temp**, **Flow** and **Liquid**) on the front panel:

- On power up, a blinking light indicates the designated parameter is moving towards a normal condition.
- A lit and non-blinking light indicates the designated parameter is within normal operating range.
- An unlit **Laser**, **Temp**, or **Flow** light indicates the designated parameter outside normal operating range. If the **Liquid** light is unlit but other statu lights are lit, the CPC should operate provided there is fluid visible in the Liquid Level window.

If you suspect the CPC is not operating normally, see "Troubleshooting" in Chapter 7.

Filling the CPC Reservoir

The CPC reservoir can be filled using four different methods:

- ❑ Automatically, when power is supplied to the CPC
- ❑ Manually, by pressing the **Fill** control button on the CPC front panel
- ❑ Automatically, using the Auto Fill DIP switch
- ❑ Automatically, using a command signal from a computer.

This section includes a procedure for connecting a fill bottle, information on the automatic fill process when power is supplied to the CPC, and a procedure using the **Fill** button to fill the CPC reservoir. See Chapter 4, "Setting DIP Switches" for information on using the Auto Fill DIP switch; see Appendix C for information on sending a command signal from a computer.

The CPC uses reagent-grade n-butyl alcohol (butanol) as a working fluid. Refer to a Material Safety Data Sheet for butanol and the Safety section at the front of this manual for more information on handling butanol.



Caution

Butanol is flammable. It is also potentially toxic if inhaled. Use butanol only in a well-ventilated area. If you smell butanol and develop a headache, or feel faint or nauseous, leave the area at once. Ventilate the area before returning.

Connecting the Fill Bottle

Use this procedure to connect the fill bottle to the CPC so the CPC reservoir will fill automatically when power is supplied to the instrument.

1. Pour the fluid into the fill bottle to at least one-half full. Because of the shut-off fittings, the liquid will not flow into the CPC until the connections are made and the CPC is switched on.

   Note: *The fill bottle cap has a small hole in it that acts as an air vent.*

2. Connect the fill bottle fitting to the CPC mating fitting as shown in Figure 5-1.

3. Set or hold the bottle as high above the CPC as you can to allow liquid to flow into the CPC. The fluid drain connector has a check valve that only allows flow out of the instrument. This prevents accidental overfilling of the CPC by attaching the fill bottle to the wrong connector.

   Note: *If the CPC optics become flooded during operation, or cannot fill, see the "Correcting Flooded Optics" procedure in Chapter 7.*

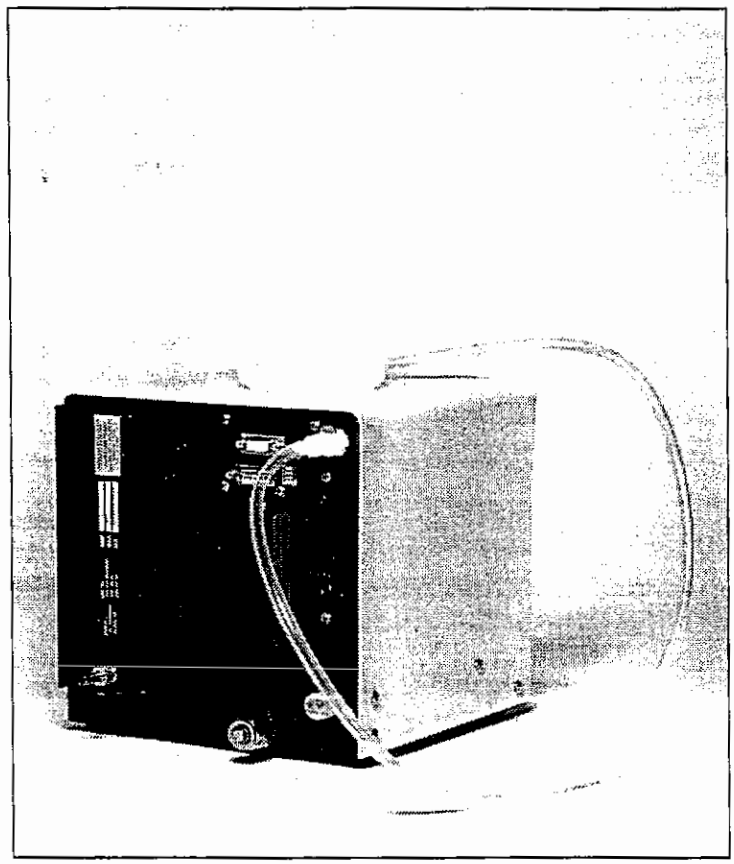


Figure 5-1. Fill Bottle Connection to the CPC

Automatic Fill Process

Approximately 20 seconds after power is supplied to the CPC, the internal microprocessor checks to see if the fluid reservoir is full (flashing **Liquid** indicator light). If the reservoir is not full, the fill solenoid valve opens allowing fluid to fill the reservoir. Within eight minutes, the reservoir level should rise and stop close to the top of the window. You can check this by observing the Liquid Level window on the front of the CPC. The **Liquid** status light should stay steadily lit for 24 hours. If the reservoir is not filled within eight minutes, the **Fill Status** and **Fill Valid** computer command variables are set to 2. See Appendix C for all computer commands.

Note: *The fluid is gravity-fed, so if the bottle is not raised very high above the CPC, you may have to press the **Fill** button to completely fill the reservoir. Filling can be done when the CPC is connected to the vacuum source.*

Pressing the Fill Button

Using the **Fill** button, fill the CPC reservoir after power is supplied:

1. Connect the fill bottle (containing butanol) to the fill fitting on the back of the instrument.
2. Push the **Fill** button. After a 3-second period, the CPC reservoir begins to fill. The **Liquid** status light blinks until the reservoir is full.

   Note: *If you push the **Fill** button again, the valve closes, the fill process stops, and the **Liquid** status light goes out.*
3. Check the liquid level window to see the level is rising.
4. If the **Liquid** status light goes out, the reservoir did not completely fill in the given cycle period. Repeat steps 2 and 3 until the **Liquid** status light stays illuminated.
5. Disconnect the bottle.

Maintaining Liquid in the Reservoir

A full reservoir contains enough butanol for the CPC to run continuously for four days. If you are running the CPC continuously, make sure the working fluid in the reservoir is replenished every four days.

It is not usually necessary to leave the bottle connected to the instrument unless you are using the DIP switch or computer command to automatically fill the reservoir on a daily basis (see "Setting DIP Switches" in Chapter 4).

Fluid helps prevent air from leaking into the sample airstream from the reservoir and generating stray particle counts. It is better to keep some fluid in the CPC reservoir at all times than to allow the reservoir to dry out between refills. However, the filling process itself is likely to generate some particle counts.

Draining the Reservoir

Butanol has a tendency to absorb water over time when it is exposed to humid conditions, so you should drain the CPC reservoir on a weekly or as-needed basis. You should also drain the reservoir if you are moving the CPC from one location to another. Use the "Draining the CPC Reservoir" procedure in Chapter 7.

Using the CPC Controls

This section gives information of the different operating modes.

Power Up

When the CPC is powered up, the front panel LCD will display several screens of information for approximately 20 seconds.

Table 5-1. Power Up LCD Information Screens

CPC LCD Display on Power Up	Description of Screen
7650	Model number
Sn####	Serial Number of CPC
C####	Year of last Calibration date
C__##	Month of last Calibration date
C__ ##	Day of last Calibration date
V _#. ##	Version of EPROM operating code
Add##	Address of CPC for RS-485 node, default is last two digits of serial number
Lo###	Location of CPC, user inputted value.
232	Computer interface protocol, set to RS-232. If in RS-485 displa is 485.
8.88.8.8=	LCD display test

If all of the operating variable LEDs are on, Laser. Temp, Flow, Liquid leve the LCD will display particle concentration data.

Power interruption and a computer reset CSR command change many of the operating variables to the default values. There is *no* battery backup for the clock. The DIP switches on the heatsink control the operating variables. See Table 3-1 for switch settings.

Front Panel Set-up Mode

The current date, time, sampling period length, number of samples, and location can be entered through the Front Panel or through the RS-485 and RS-232 Two-way communication modes. By holding down the **DISPLAY** button on the front panel for five seconds will activate the front panel set-up mode. Activating the set-up mode will terminate a sample. The digit that can be changed is flashing. Push the **DISPLAY** button to scroll to the next digit location. Use the **TOTAL** button to scroll through the digit values. Use the **CLEAR** button to save and increment to the next screen. After the location value has been enter pushing the **CLEAR** button will exit the Front Panel Set-up mode.

Table 5-2. Front Panel Set-up Mode Information Screens

CPC LCD Display in Front Panel Set-Up mode	Description of Screen
y.####	Year (default = 1996)
_.__ ##	Month (default = 01)
d.__ ##	Day (default = 01)
h.__ ##	Hour (default = 00)
_.__ ##	Minute (default = 01)
S.####	Sample period length in seconds 000 = ∞ (136 years)
n._ ###	Number of Samples 000 = continuous sampling, 001 = one sample, up to 999
A._###	Averaging Concentration Time Period. Average time period for front panel LCD and 4–20 mAmp output concentration data (default = 1 second).
L. _###	Location. User inputted value 000 to 999 (not the same as the RS-485 address)

Communication Modes RS-232; RS-232 Local Printer Output; RS-485

There are three communication types, RS-485, RS-232 Two-way, and RS-232 Local Printer Output mode. The RS-485 mode is compatible with the standard PMS RS-485 Protocol. The RS-232 Two-way mode uses the same commands as the RS-485 mode, but the CPC address and checksum features are removed. In all three modes, data is stored in a 20-sample queue. An external signal converter is required to convert the electrical signals from RS-485 to RS-232, see page 2-1 for optional equipment list. The RS-232 Local Printer Output Mode allows the Model 7650 CPC to be used as a stand-alone instrument with data printed out on an external printer. A special cable is required to connect the CPC to the printer, or the RS-485 to RS-232 signal converter can be used. See Appendix C for computer command details. The table below shows which feature/ items function in each mode.

Table 5-3. Communication Modes Functions

Feature/ Item	RS-485 Mode	RS-232 Two-way Mode with Optional External Signal Converter	RS-232 Local Printer Output Mode. Unpolled, CSU Command
COM Port on CPC	COM Port A or B.	COM Port A or B.	COM Port B, Pins 7 and 1, or Com Port A or B with external signal converter.
DISPLAY Button	Scroll between PT/FT^3, PT, Time in seconds remaining in sampling period. Does *not* effect data during sampling period.		
TOTAL Button	Does *not* function in this mode. Use CSS command to start sampling, CTS to stop.	Does *not* function in this mode. Use CSS command to start sampling, CTS to stop.	Starts/Stops Sampling, data printed out. Use CSU command, cycle DIP switch 4 to ON, CRS command to activate this mode.
CLEAR Button	Does *not* function in this mode.	Does *not* function in this mode.	Ends current sample, data printer out. Starts next sample if Number of Samples is greater than 1.
FILL Button	Starts fill process, does *not* terminate current sample, Fill Valid flag in data report set to 1.	Starts fill process, does *not* terminate current sample, Fill Valid flag in data report set to 1.	Starts fill process, terminates current sample, data printed out. When fill finished, will start sampling if Number of Samples greater than 1.

RS-232 Local Printer Output

An RS-232 printer can be attached to COM Port B (Pin 7 Xmt, Pin 1 Gnd) or, to COM Port A or B using the external RS-485 to RS-232 signal converter. The PMS PR33 thermal printer, or Seiko DPU-411-040 Type 21BU with 8K of memory operating in condensed mode can be used. See page 2-1 for the optional equipment list. The banner will be printed out on startup of the CPC, when DIP switch 4 is set to ON, or exiting the Front Panel Set-up mode. Attach the printer cables and turn on the printer before powering up the CPC to get the initial banner. No banner is printer out if the CPC is in the RS-485 mode.

Example of printout for Local Printer Output Mode.

```
PMS Model 7650 CPC
Version #.## yyyy/mm/dd
Last Calib. yyyy/mm/dd
Location: ###
Date: yyyy/mm/dd

Start Time: hh:mm:ss
Counts   Period(sec)   Status Check
#####      ####          OK
#####      ####          LASER (Laser level below specification)
#####      ####          TEMP (Temp level below specification)
#####      ####          FLOW (Flow level below specification)
#####      ####          LIQUID (Liquid level below specification)
#####      ####          LASER TEMP FLOW LIQUID (All below spec.)
Start Time: hh:mm:ss (Time stamp every sixth report)
#####      ####          OK
.
.
.
```

Status Check

At the beginning of the sampling period the status of the operating variables, Laser, saturator–condenser differential Temperature, Flow, and working fluid Liquid level are checked. If any variable is not within specification, the sample will not start until the error is corrected. During the sampling period, the status variables are checked. If all variables are within operating specifications, the Status Check will be OK. If there is a problem during the sampling period, the current sample will end, particle counts, sample time length in seconds, and which variable that was out of specification will be printed. If the Number of Samples was set to a number greater than 1, the next sample will automatically start after the error is corrected.

After power-up, the CPC requires the reservoir to be full. If there is some working fluid in the reservoir, visible level in window, the CPC can start sampling after the **FILL** button is pushed. Pushing the **FILL** button will reset the fill timer to 24 hours. Make sure there is enough working fluid in the reservoir to last long enough for your sampling needs; if not, fill.

4–20 mAmp Output Concentration

Concentration data in particles/ft^3 is continuously available on 4–20 mAmp Output interface. Output range is set by DIP switch 3.

Switch 3: OFF 20 mAmp =10 K particles/ft^3
ON 20 mAmp =1 M particles/ft^3

The concentration data is updated every second. Concentration data can be averaged with a sliding window averaging time period. Using the CAC computer command on the front panel setup, the averaging period can be set from 1 to 999 seconds (default is 1 second). The LCD displayed concentration data matches the 4–20 mAmp data output. With air flowrate of 0.1 cfm, averaging time of 1 second, and 1 particle per second, the displayed concentration is 600 PT/FT^3.

A long averaging period smoothes out the large changes in the displayed and outputted concentration values.

At the end of a sampling period the front panel LCD concentration display will hold for five seconds the concentration for the period. This concentration can be different than the continuous averaged value. The five-second display for the sampling period is not outputted on the 4–20 mAmp.

4–20 mAmp Connection

To connect to the 4–20 mAmp, an external DC supply between +12 to +36 volts is required.

Use the top DB-9 connector located on the heatsink. Pin 6 is Vcc, the external voltage input. The 4–20 mAmp signal is on Pin 8 and signal ground is Pin 9, which is independent of the CPC chassis ground. Pin 7, +15 VDC can be connected to Pin 6 to power the 4–20 output. If this is done, connect Pin 9 to the DB-9 shield for ground.

The 4–20 mAmp data is updated every second and corresponds to the front panel display when in concentration display. A sliding averaging window time period can be used to average the data. The time period can be between 1 to 999 seconds long. Use the front panel set-up mode or CAC computer command to change the averaging period time. The default period is one second.

Application Information

This chapter contains special application information for the Model 7650 Condensation Particle Counter (CPC) and consists of these topics:

- ❑ Using the CPC to monitor clean air and gas
- ❑ Viewing analog pulses with an oscilloscope.

Clean Air/Gas Monitoring

The CPC is ideal for measuring very low particle concentrations. Since the particle-pulse amplitude is relatively high, there is little chance of falsely triggering on electrical noise when no particles are present. The count accuracy is limited only by the accuracy of the flowrate. To reduce false counts, keep the CPC inlet pressure ±1 in. H_2O. Compare to ambient.

In addition, the CPC is well suited for placement in very clean areas. The CPC has no pump or fan to produce contaminating particles and the hot electrical components are purged with air evacuated from the cabinet to prevent contamination of surrounding areas.



WARNING

Although the CPC is appropriate for monitoring inert process gases such as nitrogen or argon, it should not be used with corrosive, toxic, or other hazardous gases such as hydrogen or oxygen. Using the CPC with hazardous gases may cause injury to personnel and damage to equipment.

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.*



WARNING

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



Caution

To avoid damage to the CPC circuitry, use electrostatic discharge (ESD) precautions when removing the cover of the CPC:

- 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 housing.
3. Using Figure 6-1 as a reference, connect the ground lead of an oscilloscope to test point 1 (TP1) on the main PC board (attached to the front panel) and the main lead of the oscilloscope to test point 6 (TP6).

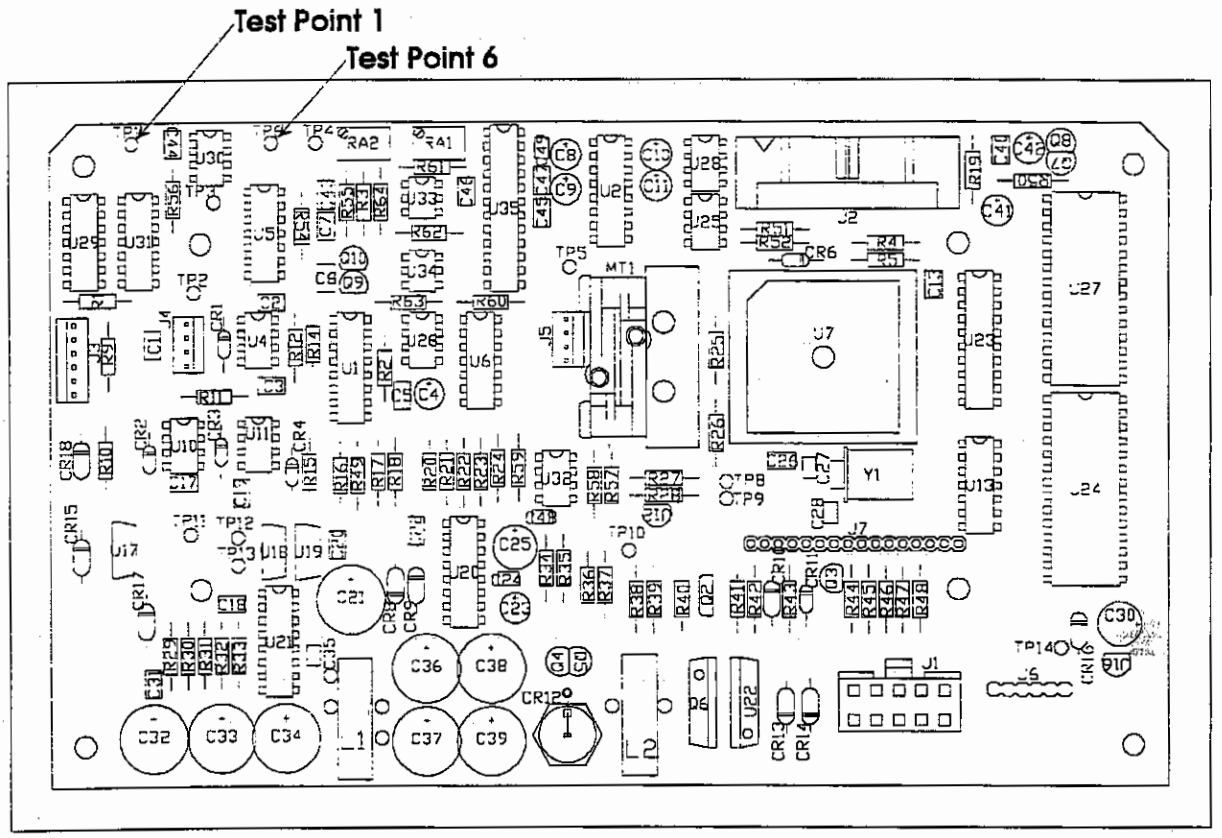


Figure 6-1. Test Points 1 and 6

4. Apply power to the CPC.

The minimum pulse amplitude is about 500 millivolts and the pulse width is about 0.5 microseconds (Figure 6-2). The pulse amplitude may range as high as 1 volt. The electrical noise level is about 10 millivolts, giving an overall signal-to-noise ratio of better than 20:1.

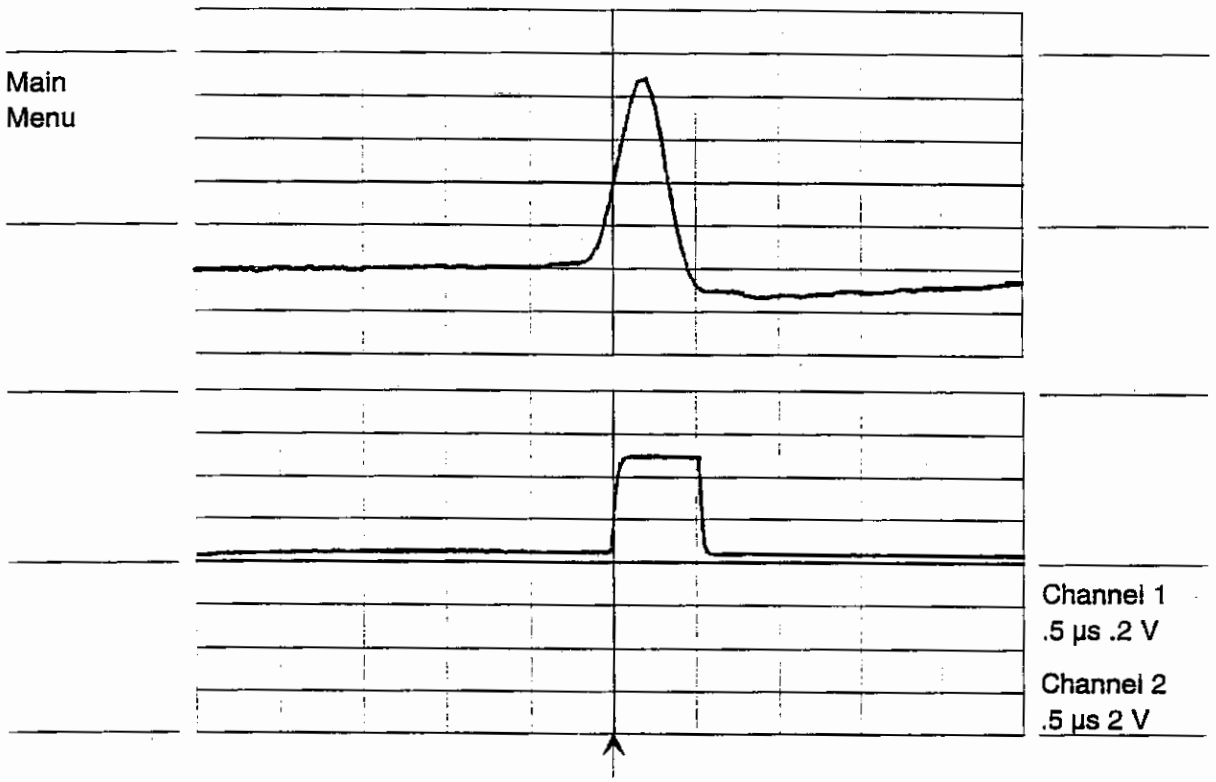


Figure 6-2. Typical Analog Digital Pulse Trace

Maintenance and Troubleshooting

This chapter gives routine and special maintenance procedures, and ways to troubleshoot the Model 7650 Condensation Particle Counter (CPC).

Routine Maintenance

Periodic maintenance on the CPC is necessary to ensure its accuracy. Table 7-1 below lists the procedures and time intervals for recommended maintenance. Most of the procedures follow, in detail.

Table 7-1. Maintenance Schedule

Task	Time Period	Reference
Calibration	not needed	This chapter
Filling the reservoir w/ butanol	4 days/or manually	Chapter 5
Draining the reservoir	weekly/as needed	This chapter
Checking flowrate	6 months/as needed	This chapter
Changing filters	12 months	This chapter
Leak checking	12 months	This chapter
Checking concentration accuracy	12 months	Call PMS
Cleaning optics	12 months	Call PMS

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, since the CPC is a single-particle counter, there is no photometric calibration for concentration.

Draining the CPC Reservoir

Butanol has a tendency to absorb water over time when it is exposed to humid conditions so you should drain the CPC reservoir completely and refill with fresh butanol on a weekly basis or as needed by your application.

If you plan to leave the CPC power off for more than a few days, drain the working fluid from the CPC. The CPC should be drained if you are moving the instrument from one location to another. Also, you should dry the saturator block if you are shipping the instrument.

Follow these four steps to drain butanol:

1. Disconnect power and vacuum source.
2. Connect the drain bottle connector to the liquid drain connector on the back panel of the CPC (Figure 3-3).
3. Loosen the cap on the drain-bottle and hold the bottle below the instrument.
4. Tip the CPC toward the connector to drain the last drops. Even after draining by gravity, keep in mind that a lot of fluid will remain soaked in the porous saturator block.

Note: *To refill the CPC reservoir, use the "Filling the CPC with Butanol" procedure in Chapter 5.*



Caution
Before shipping the CPC, the saturator block and reservoir must be completely dried. This prevents fluid from passing from the saturator into the optics and damaging the CPC.

Drying the Saturator Block

The saturator block and reservoir should be dried if the CPC is shipped to another location. You can use a simple method, which takes from 12 to 24 hours, or you can use a faster but more complicated method, which takes approximately one hour.

Twelve-Hour Method

You can dry the saturator block by draining the liquid from the CPC reservoir and then running the CPC normally with dry air going through the instrument for 12 to 24 hours.

One-Hour Method

To dry the saturator block, follow these seven steps:

1. Remove the CPC cover by unscrewing the two screws on each side of the instrument.
2. Seal off the vacuum exit tube on the CPC back panel.
3. Using Figure 7-1 as a reference, remove the purge air tube from the CPC. Disconnect the pressure tap, which is connected directly to the optics, at the pressure sensor. Reconnect the end to the fitting that was connected to the purge-air inlet on the heatsink.

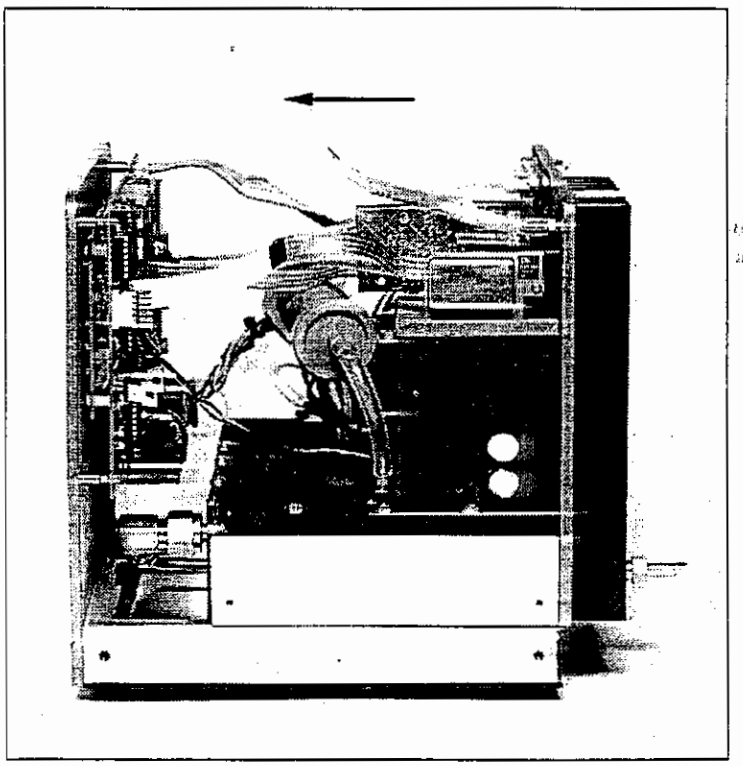


Figure 7-1. Inside View of the CPC-Purge Air Inlet and Filter

4. Attach the connector on the drain bottle to the connector on the CPC and loosen the cap on the bottle so that air can easily escape. *Slightly* tilt the CPC so that the drain connector is lower than the rest of reservoir.
5. Use a clean (filtered), dry compressed air-source to *carefully* introduce a slight pressure (approximately 34 kPa, 5 psig) into the CPC inlet. The pressure forces the liquid out of the saturator block and out through the drain.

6. Vent the air from the drain tube into a hood or other ventilator.
7. Allow the drying air to run for an hour before shipping the CPC.

Note: *Running the air for two or more hours dries the saturator completely.*

Verifying Flowrate

To measure the instrument sample flowrate, connect a low-pressure-drop flowmeter to the CPC inlet. A bubble flowmeter or thermal flowmeter works best. A mass flowmeter should be corrected for atmospheric pressure to give volumetric flow.

The flowrate should be 2.8 lpm (0.10 cfm) ±10 percent. If the flowrate 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. If you suspect a clogged orifice or nozzle, contact PMS for instructions.

Changing Filters

The CPC has three filters that should be replaced periodically: the fluid line filter, the purge air filter, and the reservoir vent filter.

Use the information in Table 7-2 to order replacement filters. Procedures for replacing or cleaning the filters follow.

Table 7-2. Replacement Filters

Filter	PMS Part Number	Other Source
Fluid line filter	P/N 1602028	None
Purge air filter	P/N 1602059	None
Reservoir venter filter assembly, AQ filter, and tubing	P/N 1035749	Balston Inc., Lexington, MA, U.S.A., 1-800-343-3048, P/N DFU-9922-11-AQ
AQ filter only	P/N 1602174	



Caution

To avoid damage to the CPC circuitry, use electrostatic discharge (ESD precautions when removing the cover of the CPC:

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

Fluid Line Filter

The fluid line filter is shown in Figure 7-2. The fluid line filter is located in the fill line of the CPC between the fill connector and the fill solenoid valve. This filter protects the valve from debris that may enter from a dirty fill bottle and prevent the valve from closing properly. The filter is easily replaced by following the six steps below:

1. Unplug the CPC.
2. Remove the cover from the instrument.
3. Locate the in-line filter, between the fill connector and the solenoid valve (the side closest to the AC line connector) and make a note of the direction of the arrow on the side of the filter.
4. Remove the filter by pulling the flexible tubing from either end of the filter.
5. Replace the filter with a new one, making sure the direction of the arrow on the side of the filter matches the direction of the old filter.
6. Replace the cover on the instrument.

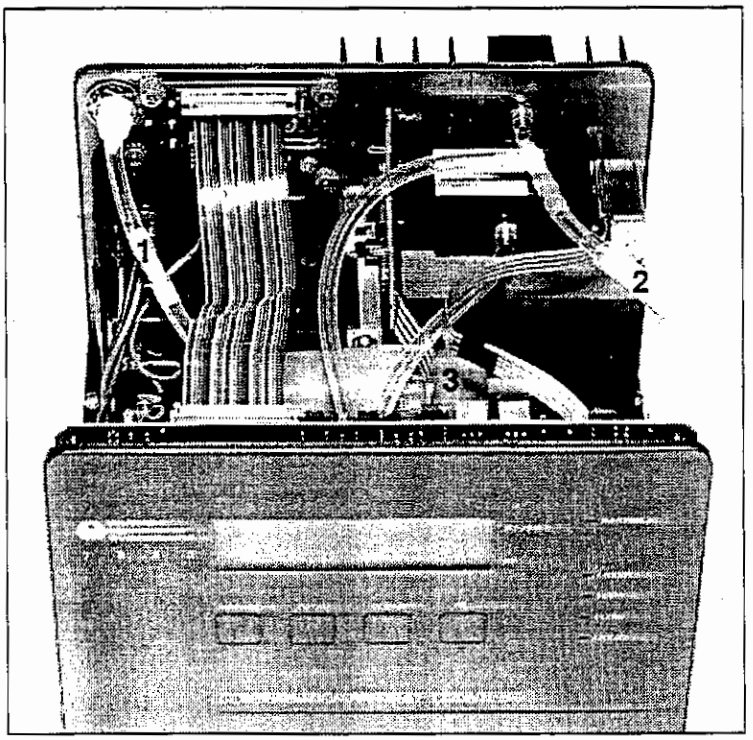


Figure 7-2. Location of Filters: 1 Fluid Line Filter, 2 Purge Air Filter, 3 Reservoir Vent Filter.

Purge Air Filter

The purge air filter is shown in Figures 7-1 and Figure 7-2. This filter protects the critical orifice used to control the flow of purge air from the cabinet. The filter is replaced by following the six steps below:

1. Unplug the CPC.
2. Remove the cover from the instrument.
3. Locate the white, porous, plastic filter attached to tubing near the top of the instrument .
4. Remove the filter by pulling the flexible tubing from the bottom of the filter.
5. Replace the filter.
6. Replace the cover on the instrument.

Reservoir Vent Filter

The reservoir vent filter is shown in Figure 7-2. The reservoir vent filter allows air to enter the reservoir as fluid is displaced in the reservoir. Very slow filling of the reservoir can be caused because the filter is wet with working fluid.

Replace the reservoir vent filter by performing these steps:

1. Unplug the CPC.
2. Remove the cover from the instrument.
3. Locate the blue capsule filter near the center of the instrument, close to the reservoir and make a note of the direction of the arrow on the side of the filter.
4. Remove the filter by pulling the flexible tubing from either end of the filter.
5. Replace the filter with a new one, making sure the direction of the arrow on the side of the filter matches the direction on the old filter.
6. Reattach all tubing and wiring connectors to the main board. Replace the two screws fastening the front panel to the reservoir.
7. Replace the cover on the instrument.

Checking for Leaks

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, it is likely that the CPC has developed a leak.

To check the CPC for leaks, follow these steps:

1. Unplug the counter and drain any remaining fluid from the reservoir. Dry out the reservoir using the "Draining the CPC Reservoir" procedure in this chapter.
2. Remove the top cover by withdrawing the four screws (two on each side) fastening the cover.
3. Remove the purge air filter shown in Figures 7-1 and 7-2 and plug the tubing so that it is leak tight.
4. Use a cover or plug to seal the vacuum connection on the back of the instrument.
5. Using Figure 7-3 as a reference, connect a vacuum gauge, valve, and vacuum pump to the inlet connector on the CPC. Use the inlet connector, rather than the outlet, to reduce the chance of contaminating the optics.

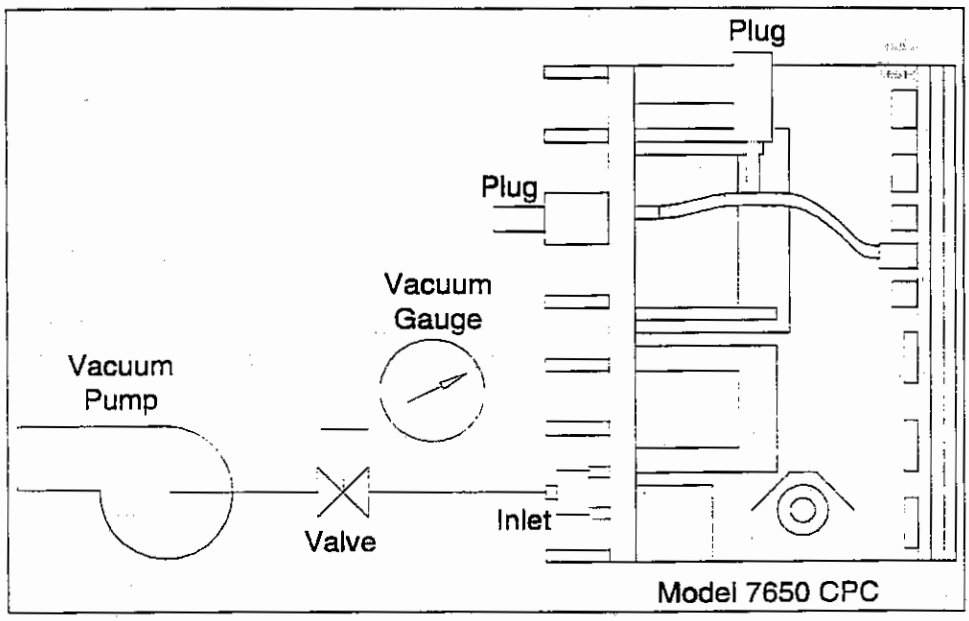


Figure 7-3. Overhead View of the Vacuum Pump Connection

6. Draw at least 650 mmHg (348 in H_2O) of vacuum through the instrument and close the valve. Shut off the vacuum source.
7. Check that the counter loses no more than 1 mmHg (0.54 in H_2O) vacuum in 5 minutes according to the gauge.

8. If you find that the CPC leaks, tighten all fittings and screws and repeat the vacuum test.
9. To locate a small leak, do the following:
   a. Replace the vacuum source with a compressed air source.
   b. Introduce approximately 70 kPa (10 psig) of air into the CPC.
   c. Search for leaks by squirting a soap-and-water solution around fittings, O-ring seals, and other possible leak locations, taking care not to wet the electronics in the process. A leak shows up as numerous small bubbles in the soapy water.
   d. Repair the leak and retest with the vacuum leak test (steps 1-7).
   e. Dry any remaining soap and water from the CPC before plugging it into a power source.

Special Maintenance

Upgrading the EPROM and Correcting Flooded Optics are two special maintenance procedures. These procedures are not considered routine and should only be attempted by someone who is familiar with the operation of the CPC and who is technically qualified.

You are encouraged to call PMS for assistance in performing special maintenance. It may also be helpful to have the technician, tools and the instrument close to the telephone when discussing the problem with a PMS technician.



WARNING

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

Upgrading the EPROM

The EPROM is an electronic chip that contains a firmware program to control all functions of the microprocessor. From time to time, PMS may develop an updated EPROM with new features to enhance the performance of your instrument.

Refer to Figure 7-4 and the following instructions to install a new EPROM.



Caution

To avoid damage to the CPC circuitry, use electrostatic discharge (ESD) precautions when removing the cover of the CPC:

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

Tools Needed

You need a chip extractor (part number 3012038), a Phillips-head screwdriver. a grounded, static-discharging wriststrap, and an antistatic mat.

1. Remove power from the CPC and from any instruments connected to the CPC.
2. Remove the CPC top cover by removing the four screws (two on each side) fastening the cover.
3. Using the chip extractor, remove the old EPROM from its socket (Figure 7-4). Be very careful not to apply too much pressure.

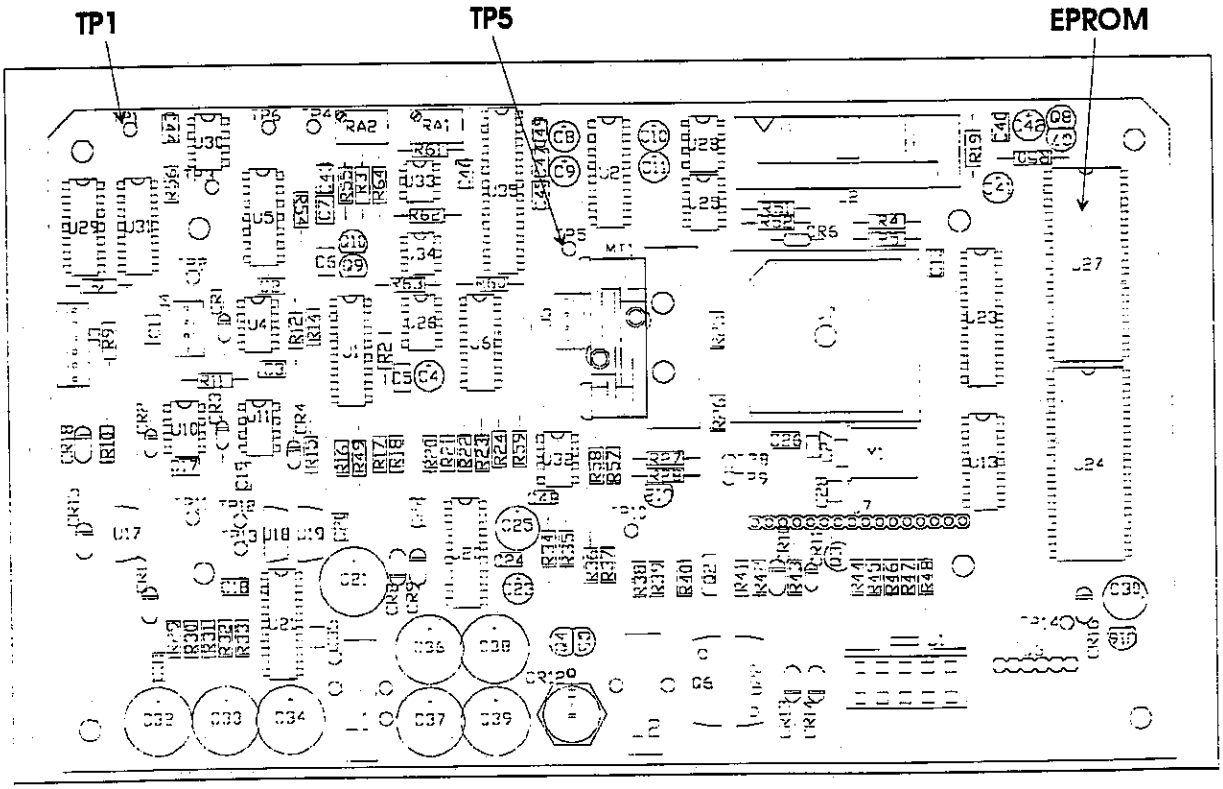


Figure 7-4. EPROM Location on the Main PC Board

4. Remove the updated version of the EPROM from its static protective wrapper.
5. Align the chip in the socket. making sure the clipped corner of the chip matches the clipped corner of the socket as shown in Figure 7-4. Apply pressure to the center of the chip until it snaps down into the socket. Press *firmly* to make sure it is seated properly.
6. Replace the cover on the CPC.
7. Apply power to the 7650 CPC and make sure the LEDs function properly.
8. If the CPC does not function properly, remove power from the CPC and make sure the EPROM is positioned correctly and seated snugly. If the CPC still does not function properly, contact a PMS representative for assistance.

Correcting Flooded Optics and Reservoir Vent Filter

Due to the nature of the reservoir in the CPC, the instrument must not be tilted when it is in operation. If the CPC is bumped or tilted when running, the vacuum flow can draw fluid from the reservoir thorough the entire flow path, including the optics and reservoir vent filter.

Usually the first sign of flooding is the **Flow** light going out or flashing 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. Unplug the CPC and drain any remaining fluid from the reservoir. Dry out the reservoir using the "Draining the CPC Reservoir" in this chapter.
2. Connect a vacuum source to the CPC and tilt the instrument on its back. This will allow any remaining fluid inside the optics chamber to be drawn out. Roll the CPC from side to side until no fluid can be heard or seen in the vacuum line.
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.
5. Disconnect the reservoir vent (blue capsule) filter from the tubing. Blow through this gently with low pressure compressed air. If any fluid comes out of the filter, or there seems to be a blockage in the filter, it is probably wet and should be replaced. See Table 7-2.
6. Connect the good filter in line with the tubing.

7. 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 in Chapter 6.
10. If the pulse height is not within a normal range, the CPC should be returned to PMS to have the optics cleaned. Refer to "Product Support," at the end of the manual for PMS contacts.

Troubleshooting

Use the information in this section to identify problems.

Under most circumstances, you can determine if the CPC is acting normally by observing the LCD display and status LEDs (**Laser**, **Temp**, **Flow** and **Liquid**) on the front panel:

- On power up, a blinking status light indicates that the designated parameter is moving towards a normal condition.
- A lit but non-blinking status light indicates the designated parameter is within normal operating range.
- An unlit **Laser**, **Temp**, or **Flow** status light indicates the designated parameter is outside normal operating range. If the **Liquid** light is unlit but other status lights are lit, the CPC should operate provided there is fluid visible in the Liquid Level window.

Identifying Problems

Use the information in Table 7-3 to identify possible problems with the CPC.

Table 7-3. Problem Symptoms

Symptom	Possible Problem
The **Laser** LED does not light.	Indicates either a lack of power to the CPC or the laser is not working. If other status lights (**Temp**, **Flow**, and **Liquid**) light, the laser is not operating. Using the information in "Product Support," contact PMS.
The **Temp** LED does not light.	Indicates a circuitry problem, possibly a failed saturator or condenser thermistor. Using the information in "Product Support," contact PMS.
The **Flow** LED goes out or flashes erratically.	The vacuum supply to the CPC may be too low or off, or fluid from the reservoir may have flooded the CPC optics. Check the vacuum supply and refer to "Connecting the Vacuum Source" in Chapter 4, then see "Correcting Flooded Optics" in this chapter.
The **Liquid** LED flashes for 15 seconds after starting a fill process, but then turns off without filling.	Indicates a circuitry problem, possibly a failed Liquid Level sensor. Using the information in "Product Support," Contact PMS.
The vacuum pump is not functioning correctly or you see fluid in the vacuum lines.	Fluid from the reservoir may have flooded the CPC optics. See "Correcting Flooded Optics" in this chapter.

Solving CPC Processor Problems

The built-in CPC processor is capable of detecting some failures of components within the device but solving processor failures generally requires the advice of a PMS technician. "Product Support" gives information you need to contact technical personnel at PMS

Specifications

The following specifications—which are subject to change—describe the most important data of the major components.

Table A-1. Model 7650 CPC Operating Specifications

Sample flowrate	2.8 L/min (0.10 cfm) ±10% nitrogen
Sample inlet pressure	±0.25 kPa (1 in. water)
Inlet	4 Cajon® VCR® male fitting
Outlet (total) flowrate	3.8 SL/min (0.20 cfm) flowrate varies
Vacuum source	450 mm (18 in.) Hg minimum
Particle size range:	
minimum detectable particle	50% of particles, 14 nm NaCl particles in dry nitrogen, other gases 50% point changes
maximum detectable particle	>3 µm
Particle concentration range:	up to 1,667 particles/sec. 10^6 particles/ft^3
Background count:	<0.2 particle/ft^3
Working fluid	Reagent-grade n-butyl alcohol, $CH_3 (CH_2)_3 OH$
Reservoir capacity	350 ml (4-day supply at 22 C)
Light source	50 mW, 780 nm laser diode
Signal-to-noise ratio	20:1 minimum
Response time	<5 sec for 95% response to step change
Digital output, square pulse:	15 V, 6.4 µs
Communications I/O	RS-232 to printer. RS-232 Two-way with external signal converter, RS-485, 4–20 mA
Power	100/120/230/240 VAC @ 50/60 Hz, 25W maximum
Fuse requirements	100/120V ~ T .5A SB/250V 230/240V ~ T .75A SB/250V
Size (LWH)	26.7 by 21.6 by 21.6 cm (10.5 by 8.5 by 8.5 in)
Weight	6.5 kg (14.3 lbs)
Environmental conditions	Indoor use Altitude up to 2000 m (6500 ft) Ambient temperature range 10 to 35°C Ambient humidity 0–90% RH noncondensing Overvoltage category II Pollution degree II

*All specifications are subject to change without notice.

Theory of Operation

The counter acts very much like an optical particle counter. However, the particles are first enlarged by a condensing vapor to form easily detected droplets. The science behind the counter, therefore, is focused on how to condense the vapor onto the particles. Portions of the following discussion are taken from a paper by Keady et al. [1986].

When the vapor surrounding particles reaches a certain degree of supersaturation, the vapor begins to condense onto the particles. This is called *heterogeneous* condensation. If supersaturation becomes high enough, condensation can take place even if no particles are present. This is called *homogeneous nucleation* or *self-nucleation* whereby molecules of the vapor form clusters due to the natural motion of the gas and attractive Van der Waals forces to form nucleation sites.

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:

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:

$$\text{Saturation Ratio} = \frac{P}{P_s} = \exp\frac{4gM}{rRTd}$$

where g = surface tension of the condensing fluid
M = molecular weight of the condensing fluid
r = 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 round liquid surface, such as the surface of a droplet, the actual saturation vapor pressure is greater. In other words, 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. Smaller liquid particles will evaporate and larger particles 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.

If the saturation ratio is controlled to a level below the critical saturation ratio—the point at which homogeneous nucleation takes place—condensation will not take place in a particle-free environment.

The lower size sensitivity of the counter is determined by the operating saturation ratio. For the CPC this ratio is several hundred percent, whereas in the atmosphere, this ratio is only a few percent for water.

Instrument Design

The basic instrument consists of two major subsystems: the sensor and the microprocessor-based signal-processing electronics.

Sensor

The sensor itself is made up of a reservoir, saturator, condenser, and optical detector. The reservoir holds enough liquid to run the sensor continuously for four days. The inlet flow enters the saturator section where it passes through a heated, liquid-soaked porous plastic block. The block continually draws liquid from the reservoir. It is constructed of an electrically conductive material to prevent a build up of charge that could cause particle losses to the walls. The liquid evaporates and saturates the aerosol stream with vapor.

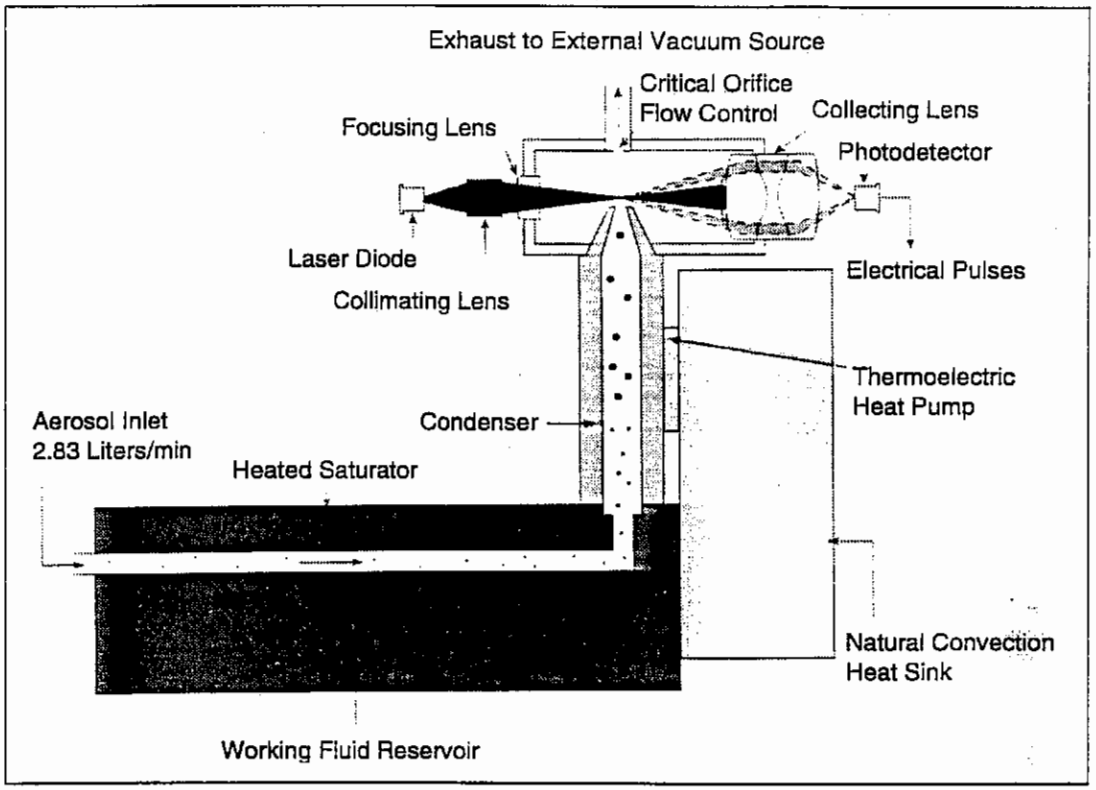


Figure B-1. Model 7650 CPC Flow Schematic

The aerosol next enters the condenser where it is cooled using a thermoelectric device outside the condenser. The vapor cools, becomes supersaturated, and begins to condense on the particle nuclei carried in the aerosol stream to form larger droplets. The droplets pass from the condenser tube through a nozzle into the optical detector. Liquid that condenses on the walls of the condenser tube runs back down into the saturator and is absorbed into the saturator block for reuse.

The sensor's focusing optics consist of a laser diode, collimating lens, and cylindrical lens. This combination forms a horizontal ribbon of laser light above the aerosol exit nozzle. The collecting optics incorporate a pair of aspheric lenses that collect forward-scattered light onto a low-noise photodiode. The main beam is blocked by a light-stop in the center of the first aspheric lens. The surface temperature of the optics housing is maintained, by mechanical contact with the heatsink, at or above the saturator temperature to avoid condensation on the lens surfaces.

Microprocessor

The counter incorporates an Intel 80C552 microprocessor to control all its functions. The processor has 256 bytes of on-board RAM and uses a 256K byte EPROM for program memory. The microprocessor utilizes built-in analog to digital converters to monitor temperatures, voltages, and pressure drop of the CPC. Counters within the microprocessor keep track of the particle pulses detected by the photodetector. The display, pushbutton, and RS-232/485 communications are also controlled by the microprocessor.

Communication Protocol

The Model 7650 CPC supports the Particle Measuring Systems serial communication protocol.

Serial Transmission Parameters RS-485 and RS-232

Baud Rate:	9600
Parity:	None
Bits:	8
Stop Bits:	1

Operation

The following is a presentation of typical command sequences that are to be processed in order to perform specific operations. The operations may be one-time command sequences (i.e., instrument initialization) or command sequences that need to be performed repeatedly (i.e., polling for data). A detailed explanation of each command is contained in the protocol section.

Instrument Initialization

The following command sequence is typical during initialization or re-initialization of the instrument.

CSR CDT 1996/12/16 12:13:00

This sequence performs a software reset and sets the current date/time into the instrument.

Table C-2. Computer Interface Commands for RS-485 and RS-232 with External Signal Converter (*continued*)

Computer Command	CPC Response and Function
CVER	RVER MN#### SN#### VR##.# ##/##/## LC##/##/## TD### MN#### Model Number of CPC, 7650 SN#### Serial Number of CPC VR##.# ##/##/## Firmware version and date LC##/##/## Last Calibration date TD### Temperature difference set point between the saturator and condenser, in °C*0.1. Model 7650 set point is 190, 19°C.
CFILL	RFILL FS# FS - Fill Status (0-Not Filling, fill valve closed; 1 - Filling, fill valve open, void data, contains false counts; 2 - Time out error, fill not complete in 8 minutes).
CFT	RFT FT##### FT - Fill Timer. Time remaining in seconds, maximum of 86,400 seconds, 24 hours.

Note: *Each device will respond with the STX character of a response within a device specific time, approximately 4 seconds or less, if no response is received within this time, a time-out fault condition should be assumed by the host computer.*

Data Port Pin Assignments

Note: *All signal functions are denoted as seen from the CPC (i.e. Transmit data means the Model 7650 CPC transmits the data).*

Table C-3. RS-485 IN with a DB-9 (top DB-9 connector on heatsink) Connector (sockets)

Pin #	Function
1	No connection
2	RS-485 Transmit data +
3	RS-485 Transmit data –
4	RS-485 Receive data +
5	RS-485 Receive data –
6	Vcc 4-20 mA external power
7	+15 VDC +12 to +36 volts
8	4-20 mA current
9	4-20 mA independent ground
	Shield connected to chassis ground

Protocol

The general communication procedure in the protocol has what is called a command/response sequence. For each command directed to a Model 7650 CPC, there is a response generated by the Model 7650 CPC. The format of the response is dependent on the particular command. (See "Protocol Commands" for a complete listing of the Model 7650 CPC commands.) These commands and responses are formatted and packeted to ensure error free communication. The packet begins with a STX (start of transmission) and ends with a ETX (end of transmission).

The process of building a packet can be divided into three logical steps shown below:

Step One

The address of the instrument is added to the beginning of the data, and a checksum is added to the end of the data. This produces the following unformatted data structure.

ADDRESS HIGH BYTE | ADDRESS LOW BYTE | FIRST DATA BYTE | SECOND DATA BYTE | ... | LAST DATA BYTE | CHECKSUM HIGH BYTE | CHECKSUM LOW BYTE

Note: *| is used to improve readability and does not exist in the actual data packet.*

CHECKSUM is a 16-bit unsigned integer sum of the unformatted data including the address with the carry bit ignored if an overflow occurs during the calculation. The STX and ETX are not included in the check sum.

Step Two

To minimize the difficulties when the network includes devices such as modems. Only visible ASCII characters (32–126), with the exception of the packet delimiting STX and ETX, are transmitted on the network. The nonvisible characters and non-ASCII characters are run through the conversion formula shown below before they are transmitted. The STX and ETX are used as delimiters of the packet and are not visible characters but do not cause problems as the NUL. DEL and other 8-bit data characters can.



Table C-1. ASCII Characters Transmitted on Network

Value of Byte		Character(s) Transmitted (i.e. byte 1 then byte 2)
byte	$<20_{hex}$	$7B_{hex}$ then (byte + 20_{hex})
$7B_{hex}$	<=byte $<80_{hex}$	$7C_{hex}$ then (byte – $5B_{hex}$)
80_{hex}	<=byte $<CO_{hex}$	$7D_{hex}$ then (byte – 60_{hex})
CO_{hex}	<=byte	$7E_{hex}$ then (byte – AO_{hex})
otherwise		byte

The following is an example of what a typical command and response packet should look like at this point in the formatting and packetting process.

Note this particular Model 7650 CPC has an address of 1.

Address 1
ASCII { {!
Hex 7B207B21

Command CQC
Response RQC 10 1 (ten samples in queue, still sampling)

Command transmitted to Model 7650 CPC:

ASCII { {!CQC{ -8
Hex 7B207B214351437B207E38

Response transmitted by the Model 7650 CPC:

ASCII { {!RQC 10 1{!}Y
Hex 7B207B215251432031D3020317B217D59

Step Three

Preface the ASCII packet formed in the second step with an ASCII STX character and terminate it with an ASCII ETX character (STX = 2, ETX = 3).

RS-485 and RS-232 Command Set

Table C-2 lists the protocol commands with their response and purpose (note commands are not case sensitive). Commands that are sent without the variable, return the current variable value. You need to have a space between the command and the variable.

Table C-2. Computer Interface Commands for RS-485 and RS-232 with External Signal Converter

Computer Command	CPC Response and Function
CADDRESS ## (##=00-99) RS-485 Address	RADDRESS ## (##=00-99) Address of CPC on RS-485 network. Default is ##, last two digits of serial number. RS-232 Not required, can be set in this mode.
CSR Reset	RSR Software Reset. The command stops the hardware watchdog timer causing a system reset. When the next command is issued to the CPC, it will respond with an RSR. All programmed variables will be reset to the defaults set on the back panel DIP switches.
CDT yyyy/mm/dd hh:mm:ss Date and Time set	RDT yyyy/mm/dd hh:mm:ss Date and Time. Sets date and time on the CPC. Send in 24-hour time, use leading zeros to fill field, if required. Responds, without leading zeros to fill field. If the instrument is sampling when this command is issued, the sampling period will end and the CPC will stop sampling. Must be set before CPC will return data. Default is 1996/01/01 00:00:00
CSI #### (seconds 0000- 9999) Sampling interval period	RSI #### (seconds 0000 - 9999) If back panel DIP switch 2 is OFF, default sampling period will be 600 seconds on power up or after CSR, reset. If DIP switch 2 is ON, No Limit, on power up or after CSR, reset, the sampling interval must be set before CPC will return data. No limit = 0000 seconds
CNS ### Number of continuous sampling period	RSN ### (000 = infinite number of continuous samples - 999) Number of continuous samples. In the RS-232 Local Printer Output mode, if the CLEAR button is pushed, it will terminate the current sample, and start the next sampling period. Pushing the TOTAL button will end all sampling.

(continued)

Table C-2. Computer Interface Commands for RS-485 and RS-232 with External Signal Converter (*continued*)

Computer Command	CPC Response and Function
CSS Start sampling, polled data Data written to queue, must poll queue to retrieve data.	RSS # (0 - Not sampling, need to set data/time or sampling interval; 1- sampling. started.) Continuous sampling will occur, data will be sent into the queue. Newest records will be sent to the highest possible location on the queue. The oldest record in the queue is on top. Maximum queue size is 20. When the queue is full, the oldest record will be automatically deleted when a new record is added. Default 000 seconds.
CSU Start Sampling, Unpolled data transmitted out and written to queue after end of each sample. Only functions when DIP switch 4 is ON, RS-232 mode. This is the RS-232 Local Printer Output mode.	RSU # (0 - Not sampling, need to set data/time, sampling interval, or in RS-485 mode; 1- sampling. started.) Continuous sampling will occur, data will be sent out on COM port, and to queue. Newest records will be sent to the highest possible location on the queue. The oldest record in the queue is on top. Maximum queue size is 20. When the queue is full, the oldest record will be automatically deleted when a new record is added. Default 000 seconds.
CTS End sampling period	RTS Ends sampling period before the end of the specified period length.
CLO ### Location of CPC	RLO ### User definable location ID, will appear on attached printer printout in RS-232 mode. Default location is 001.
CPQ Pop Queue	RPQ # (0 - If there is no data report available; 1 - If queue is decremented by one.) Cause the report currently on the top of the transmission queue to be discarded. Oldest record is on top of the queue, record number 1. This command does *not* disturb the sampling process. The Model 7650 has a queue size of 20 sample reports. When the queue is full, the oldest record will be automatically deleted when a new record is added.
CQC Queue Count of reports	RQC ## # (##= Number of complete sample reports, -1 - Need initialization, or not warmed up; 0 - No reports, 1 to 20 - Number of complete reports; #=0 Not sampling, #=1 Running a sample) Returns the number of sample reports in the queue.

(continued)

Table C-2. Computer Interface Commands for RS-485 and RS-232 with External Signal Converter (*continued*)

Computer Command	CPC Response and Function
CTD Transmit Data report Values during sampling period	RTD yyyy/mm/dd hh:mm:ss CN ##### SP #### FV # FI # LV # TA ### TV # LO ### RND responds if there is no data to report. yyyy/mm/dd hh:mm:ss Time that sampling period began, in 24-hour time. CN##### Count Number, particle counts. SP#### Sampling Period length in seconds. FV# Fill Valid (0 - CPC not filling during sampling period, 1 - Filling during sampling period. data can contain false particle counts during fills, 2 - Time out error, fill not completed within 8 minutes. FI# Flow Indicator valid during period (0 - Flowrate low, requires a stronger vacuum level. 1 - Flow within range. The flowrate is within range when the vacuum level across the flow control critical orifice is approx. 16 in. Hg. This value corresponds approx. to the lower limit of a sample flowrate of 0.1 ±0.01 cfm) LV Laser status Valid (0 - Laser not continuously working during sampling period, requires service, 1 - Laser working during sampling period) TA### Temperature Average difference between the saturator and condenser during the sampling period, in °C*0.1. TV# Temperature difference Valid during the sampling period (0 - Temperature difference out of range, 1 - Temperature difference within range) LO### (000 -999) Location of CPC. set by user.

(continued)

Table C-2. Computer Interface Commands for RS-485 and RS-232 with External Signal Converter (*continued*)

Computer Command	CPC Response and Function
CSTATUS Instantaneous, current values	RSTATUS FL # FS # FW # LS # SW #### TC ### TS ### TP ### WC #### FL# Fluid Level (0 - not full, 1 - full) FS# FW# Flow indicator status (0 - Flowrate low, requires a stronger vacuum level. 1 - Flow within range. The flowrate is within range when the vacuum level across the flow control critical orifice is approx. 16 in. Hg. This value corresponds approx. to the lower limit of a sample flowrate of 0.1 ±0.01 cfm). LS# Laser Status (0 - Laser not working, requires service, 1 - Laser working). SW#### Switch setting on heatsink DIP switches. DIP1 - Autofill (0 OFF, 1 ON) Default 0 DIP2 - Sampling period (0 OFF - 600 seconds, Number of Samples = ∞; 1 ON - No Time Limit, Number of Samples 1) Default 0 DIP3 - 4-20 mAmp range (0 OFF - 10K#/ft^3, 1 ON - 1M#/ft^3) Default 1 DIP4 - RS-485/RS-232 (0 OFF - RS-485, 1 ON - RS-232) Default 1 Default response is: SW0011 TC### Temperature of Condenser °C *0.1. Current reading, can be below 0°C. TS### Temperature of Saturator °C *0.1. Current reading. TP### TED (ThermoElectric Device) Power 0 to 255 bit value. WC#### Warm-up clock, seconds since power up, or RESET that the CPC requires to get to operating temperature. A long warm-up time indicates CPC needs service. Time of warm-up good/bad TBD.
CAC### Average concentration time period	RAC ### (seconds, 1 to 999). Averaging time period for front panel. LCD display and 4–20 mA output concentration data. Default 1 second, 1 particle/second = 600#/ft^3.

(continued)

Table C-2. Computer Interface Commands for RS-485 and RS-232 with External Signal Converter (*continued*)

Computer Command	CPC Response and Function
CVER	RVER MN#### SN#### VR##.# ##/##/## LC##/##/## TD### MN#### Model Number of CPC, 7650 SN#### Serial Number of CPC VR##.# ##/##/## Firmware version and date LC##/##/## Last Calibration date TD### Temperature difference set point between the saturator and condenser, in °C*0.1. Model 7650 set point is 190, 19°C.
CFILL	RFILL FS# FS - Fill Status (0-Not Filling, fill valve closed; 1 - Filling, fill valve open, void data, contains false counts; 2 - Time out error, fill not complete in 8 minutes).
CFT	RFT FT##### FT - Fill Timer. Time remaining in seconds, maximum of 86,400 seconds, 24 hours.

Note: *Each device will respond with the STX character of a response within a device specific time, approximately 4 seconds or less, if no response is received within this time, a time-out fault condition should be assumed by the host computer.*

Data Port Pin Assignments

Note: *All signal functions are denoted as seen from the CPC (i.e. Transmit data means the Model 7650 CPC transmits the data).*

Table C-3. RS-485 IN with a DB-9 (top DB-9 connector on heatsink) Connector (sockets)

Pin #	Function
1	No connection
2	RS-485 Transmit data +
3	RS-485 Transmit data –
4	RS-485 Receive data +
5	RS-485 Receive data –
6	Vcc 4-20 mA external power
7	+15 VDC +12 to +36 volts
8	4-20 mA current
9	4-20 mA independent ground
	Shield connected to chassis ground

Table C-4. RS-485 OUT with a DB-9 (bottom DB-9 on heatsink) Connector (pins)

Pin #	Function
1	GND
2	Transmit data +
3	Transmit data –
4	Receive data +
5	Receive data –
6	no connection
7	Do not use
8	no connection
9	no connection

CPC RS-232 Cable

Table C-5 below lists the RS-232 Local Printer Output mode (one-way output) with a DB-9 connector (pins).

Table C-5. RS-485 with a DB-9 (bottom DB-9 connector) Connector (pins)

Pin #	Function
1	GND
2	Do not use
3	Do not use
4	Do not use
5	Do not use
6	no connection
7	XMT
8	no connection
9	no connection

4

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