Particle Counters For Air

Application and Maintenance Information

PACIFIC SCIENTIFIC INSTRUMENTS

Note:
This manual is a general tutorial and reference for all of the particle counters listed on the following page. Your particular model of counter may vary slightly from the counters described in this manual.

Particle Counters Covered by This Manual*

Model	Sensor	Power Source
227, 228, 229	Laser Diode	Battery/AC
237	Laser Diode	Battery/AC
237D	Laser Diode	External DC
237H	1-port HeNe	Battery/AC
A2100	3-port HeNe	AC
A2200	1-port HeNe	AC
A2400, A2408	Laser Diode	AC
A2813, 2815	Laser Diode	AC
A 2913, 2915	Laser Diode	AC
A3100, 3300	Laser Diode	Battery/AC
R4000, R4300	3-port HeNe	AC
R4700, R4800, R4900 Series	Laser Diode	External DC
R5700, R5800, R5900 Series	Laser Diode	External DC
R8700, R8800, R8900 Series	Diode Pumped Solid State Laser	External DC

*Some models previously covered in this manual are no longer in production and are thus not listed in this table. Some information on these models, however, is included in "Manual Backdating" in Appendix A.

Major revisions of this manual will be indicated by a new revision level. Minor corrections or additions may be made at any time without changing the revision level. Changes made to this manual causing the new revision are documented under "Manual Backdating" in Appendix A of this manual. Met One is not liable for personal, property, or financial damages resulting out of the use of this product or the material contained in this manual.

Published May, 1992; revised April 2000

Note

Shipping the counter out of the U.S.A. may require an export license. Contact the factory for more information.

Published by

Pacific Scientific Instruments

FAX ..... (541) 479-3057

Phone..... (541) 479-1248

www.pacsciinst.com

Manual PN: 701078 REV: C

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How to Use This Manual

Since this manual contains information on a wide variety of counters, reference to counter specifications was necessary. You must therefore know your counter's sensitivity, flow rate, light source, and power source to determine which information applies to your counter. These specifications are given on the data sheet and in the operating guide for your counter.

Manual Conventions

Safety notes headed by WARNING and CAUTION are used throughout this manual. Learn the meaning of each before operating the particle counter. A warning appears before the procedure or step to which it applies. A caution appears in the margin next to the procedure or step to which it applies. Take extreme care when doing any procedures preceded by or containing a warning. A warning indicates a hazard for you. It calls attention to a procedure which, if not correctly performed or adhered to, could result in injury. Do not proceed beyond a warning until the indicated conditions are fully understood and met.
There are several classifications of warnings defined as follows:

- Gases—pertaining to toxic fumes and flammable materials
- Laser—pertaining to exposure to visible or invisible laser radiation
- Electrical and Electrostatic—pertaining to shock hazards

Gaseous Safety

Several precautions should be considered when handling certain types of gases and gases under pressure. Take extreme care when doing any procedures containing or preceded by a warning.

WARNING

DO NOT attempt to sample reactive gases, such as hydrogen and oxygen, with the particle counter. Reactive gases create an explosion hazard in the counter. Contact the factory for more information.

WARNING

DO NOT sample any pressurized gases without using a pressure-reduction device (e.g., a high-pressure diffuser). All counters are designed to operate at atmospheric pressure.

CAUTION

DO NOT attempt to sample any gas or air that is not dry. Any moisture droplets will be detected as particles. Damage to the sensor will also occur.

Safety

MODEL A2408-1-115-1
P/N 2082784-01
MFG DT APRIL 1997
S/N 970230248
OPTION
VOLTS 115V~1A. 50/60HZ
SIZES 0.3µM
FLOW 1 CFM

THIS PRODUCT COMPLIES WITH
21 CFR. CHAPTER 1, SUBCHAPTER J

Unit Identification Label located on outside of counter

Declaration of Conformity (International)

CLASS 1
LASER PRODUCT
IEC 825-1 1993

Class 1 Label – located next to identification Label

-WARNING-
DO NOT RETURN THIS UNIT FOR REPAIR OR CALIBRATION IF IT CONTAINS ANIMAL BY-PRODCUTS, TOXIC OR RADIOACTIVE MATERIALS. REF: OSHA HAZARD COMMUNICATION STD. 29 CFR SECTION 1910.1200

Material Warning Label
Located near Identification Label

-WARNING-
DO NOT OPERATE UNIT WITHOUT ISOKINETIC PROBE ATTACHED
IEC 825-1 1993

Sampling Warning Label
Located near inlet nozzle

Laser Safety

The particle counter is a Class 1 product (as defined by 21 CFR, Subchapter J, of the Health and Safety Act of 1968) when used under normal operation and maintenance. Service procedures on the sensor can result in exposure to either visible or invisible radiation, depending on the type of sensor you have. Only factory-authorized personnel should perform Service on the counter.
For those particle counters that have been evaluated and tested in accordance with EN 61010-1:1993, "Safety Requirements for Electrical Equipment For Measurement, Control, and Laboratory Use" and IEC 825-1:1993, "Safety of Laser Products", a Declaration of Conformity certificate will appear in the manual and a **CC** decal will be placed on the instrument.

WARNING

The use of controls, adjustments, or performance of procedures other than those specified within this manual may result in exposure to visible or invisible (infrared) radiation that can quickly cause blindness.

Several labels are attached to the unit and to the internal sensor for your awareness. Reproductions of the labels are shown to the left and below.

–WARNING–
INVISIBLE LASER RADIATION WHEN OPEN
AVOID EXPOSURE TO BEAM
780 - 820nM 50mW
CLASS 3B LASER
IEC 825-1 1993

DANGER
LASER RADIATION
WHEN OPEN

Laser Sensor Warning Labels

WARNING
VISIBLE LASER RADIATION WHEN OPEN
DO NOT STARE INTO BEAM OR VIEW
DIRECTLY WITH OPTICAL INSTRUMENTS.
HELIUM-NEON LASER
5mW MAX OUTPUT AT 632.8nm
CLASS 3A LASER PRODUCT
IEC 825-1 1993

DANGER
INVISIBLE LASER RADIATION
WHEN OPEN—AVOID DIRECT
EXPOSURE TO BEAM

DANGER
VISIBLE LASER RADIATION
WHEN OPEN—AVOID DIRECT
EXPOSURE TO BEAM

Safety

Electrical and Electrostatic Safety

Potential shock hazard exists as soon as a cover is removed from a particle counter. Extreme care should be used whenever a cover is removed.

WARNING

Failure to disconnect electrical power cord before removing instrument covers can result in severe electrical shock.

The label pertaining to shock safety is attached to the unit for your awareness. Reproductions of the label is shown below:

High Voltage warning label
located near HeNe laser power

Electrostatic discharge (ESD) can damage or destroy electronic components in the counter. Therefore, all service or maintenance work should be done at a static-safe workstation. A static-safe workstation can be created as follows:

- ❑ Use a grounded conductive table mat and resistor-isolated wrist-strap combination
- ❑ Earth-ground all test instruments to prevent a buildup of static charge.

WARNING

Using a wrist strap without an isolation resistor will increase the severity of an electrical shock.

CAUTION

The laser driver board, mounted on the laser-diode sensor inside the counter, contains wire leads from an extremely static-sensitive laser diode. Do not touch the laser driver board or any attached cables unless you are ESD protected.

Battery Safety Information

An explosion can occur if the internal battery is incorrectly replaced. The following label appears on the battery for your safety.

WARNING
DANGER OF EXPLOSION IF BATTERY IS INCORRECTLY REPLACED
REPLACE ONLY WITH THE SAME OR EQUIVALENT TYPE RECOMMENDED BY THE MANUFACTURER, DISPOSE OF BATTERIES ACCORDING TO MANUFACTURER'S INSTRUCTIONS.

1 Understanding Particle Counters

This section introduces you to particle counters, with a generalized description of the following subjects:

- ❑ How a Particle Counter Works
- ❑ Features of Particle Counters
- ❑ Options, Accessories, and Connectors
- ❑ Glossary of Particle Counting Terms

How a Particle Counter Works

Overview

Airborne particle counters measure airborne particles in a number of size ranges and display the number of particles in each range. All counters have the same basic components of sensor, vacuum source (for sample flow) and counting electronics. Display and operator interface are available on most counters. Refer to Figure1.
The vacuum pump pulls the sample through the sensor where any particles present are detected. The counting electronics collect, report and store the information for use by the operator.
Peripheral devices can be used for other ancillary functions and will be discussed on the following pages.

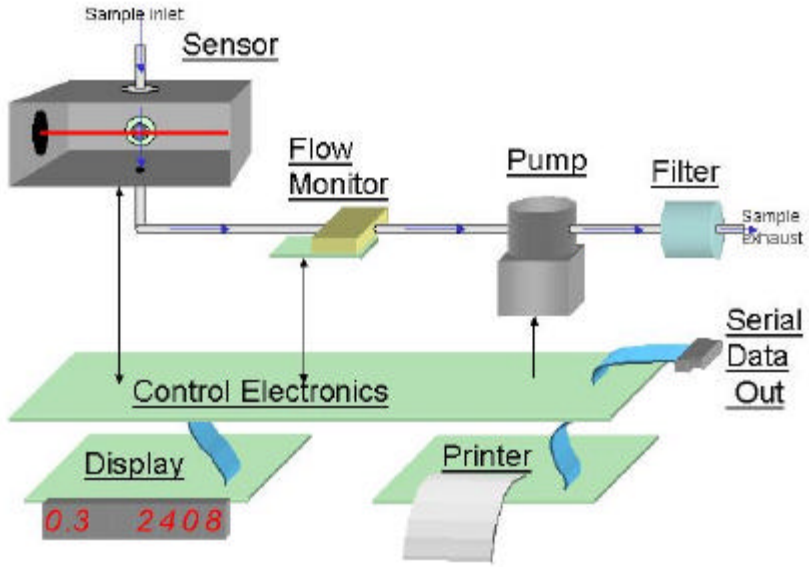


Figure 1

Sensors

The most important part of a particle counter is its sensor. Airborne sensors use light scattering and collection to detect particles. The sensor contains a light source (a HeNe laser or a laser diode) that illuminates an area called the view volume with intense light. Particles in the sample pass through the view volume and scatter the laser light, which is then collected and focused onto a photodiode. The intensity of scattered light is a function of the size of the particle. The photo diode detects and converts the light signal to electrical pulses, the height of which is directly proportional to the particle size.

How a Particle Counter Works

Pacific Scientific Instruments airborne counters use one of two types of lasers. The HeNe plasma tube laser is used when high sensitivity is required. The laser diode-based sensor is used in less sensitive applications. Diode Lasers are smaller, lighter, and more rugged.

Open-Cavity Helium-Neon (HeNe) Laser Sensor

Particle counters with HeNe sensors will detect smaller size particles than laser diode sensors.
Two variations of HeNe sensor are presently in use. The first is a single-port sensor for those requiring sensitivity down to the 0.16 micron range at a flow rate of 1.0 cubic foot/minute (cfm). This single-port sensor also exists in a small version at 0.1 cfm that provides the greater sensitivity of a HeNe (0.1 micron) as well as the portability of a battery-operated counter.
The second variation of HeNe sensors is the three-port sensor that has one input and three separate view volumes in which particles are detected. The sample flow moves at a lower velocity through the three view volumes than the same volume of air through one view volume. This provides for more accurate electronic signal processing which results in a better signal-to-noise ratio and detection of smaller particles (0.1 micron at 1 cfm).

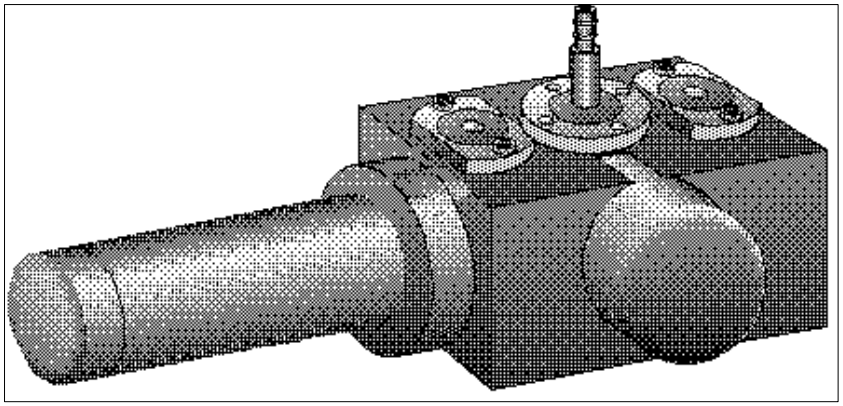


Figure 3: Single-Port HeNe Sensor

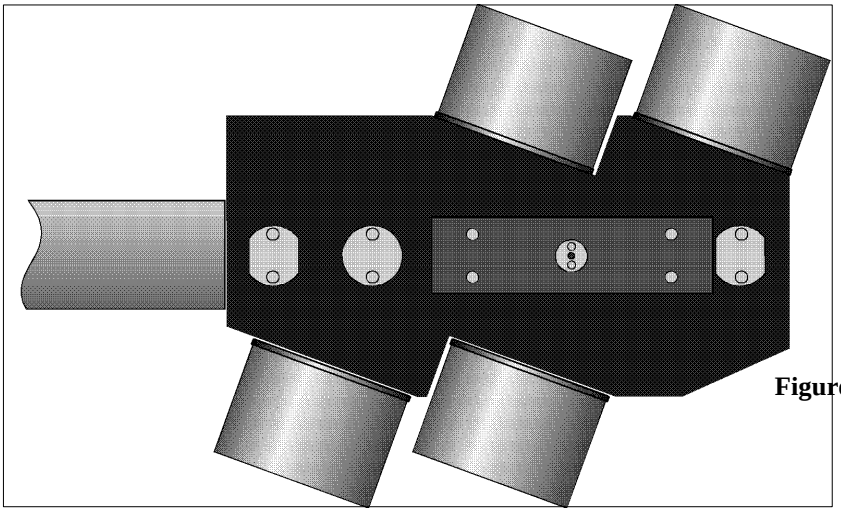
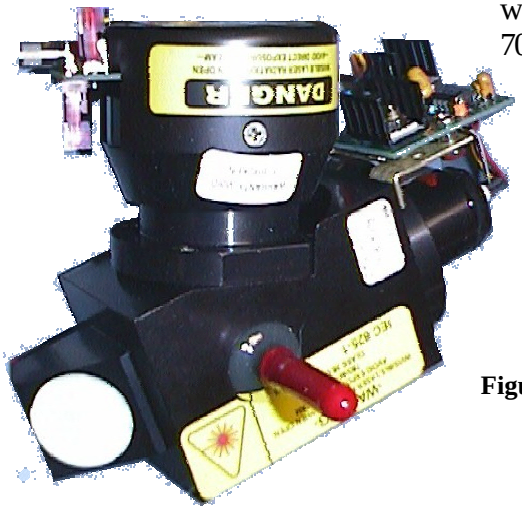


Figure 2: Three-Port HeNe Sensor

How a Particle Counter Works

Laser-Diode Sensor
These sensors are much smaller in size than the open-cavity laser sensors and are used in portable counters. The smaller sensors also require less power, and can be battery-operated. The following laser diode-based sensors are presently used:

- ❑ The “Mini-sensor” is a 90° (right-angle) version for use in smaller counters typically operating at 0.1 cfm flow rate
- ❑ The Standard laser diode sensor is used in some battery-operated counters as well as in AC powered units. These sensors offer about the same sensitivity as the "mini-sensors" and are available with flow rates of 1 cfm and 0.1 cfm. This sensor is configured at 70° for optimum operation at 1.0 cfm.



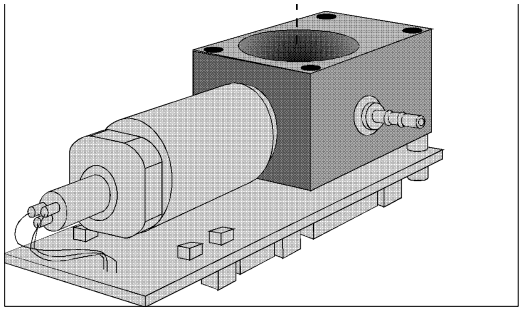


Figure 4: Laser Diode Sensors

Diode Pumped Solid State Lasers
DPSSL sensors provide the high optical power and greater sensitivity associated with HeNe sensors, but operates on low voltage DC power as found in the laser diode sensors. They are capable of sensing 0.1 micron particles.

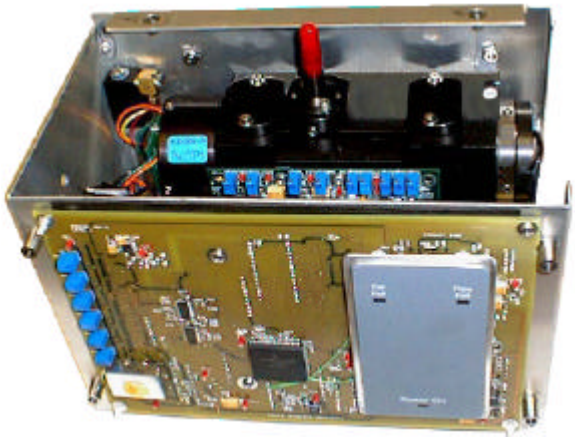


Figure 5: Diode Pumped Solid State Laser (DPSSL)

How a Particle Counter Works

Electronics

The pulses are counted and measured by electronics on a circuit board containing **counting operations** circuitry, which use comparators to measure pulse height and sort the signals into channels according to size, while counting circuits count the pulses in each channel. The results indicate the particle counts for each size channel. Any calculations required by the operator are performed and the data is available to the **I/O** circuits for the display on the front panel, printer or other peripheral devices. The firmware that controls counter operations is stored in a read-only memory (EPROM) chip. The counting operations circuitry can also process external analog signals from environmental probes when used.

Additional circuitry provides **device controls** for the sample flow, printer, and external accessories.

Power regulation and distribution circuits control the proper levels and internal application of DC voltages.

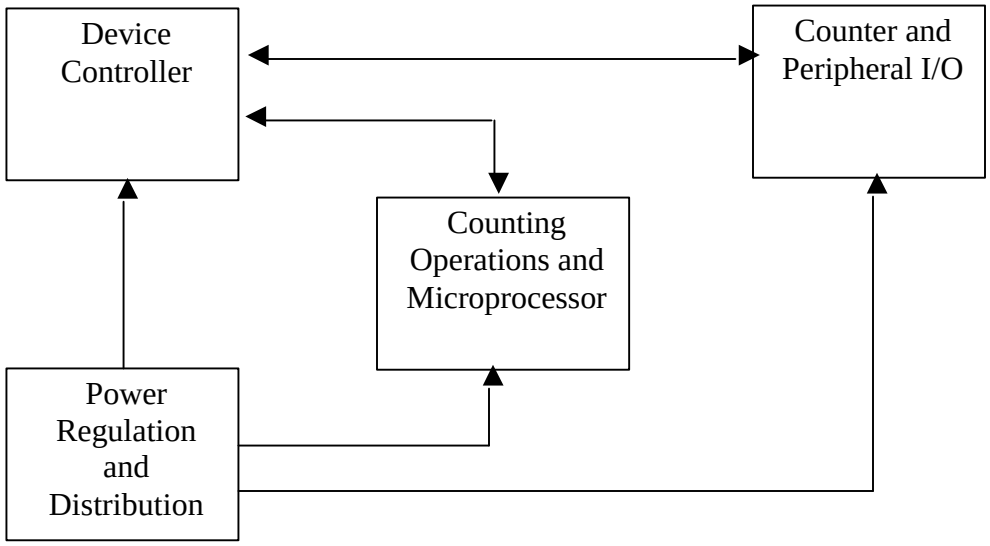


Figure 5: Counting Electronics Block Diagram

How a Particle Counter Works

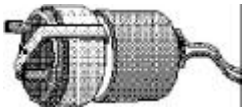
Sample Flow Control

For those counters equipped with an internal pump, sample flow control is achieved by operating a vacuum pump under control of the counting electronics and using a flow meter to monitor for the correct flow rate. Automatic or manual controls are then employed to correct any unacceptable variations. Remote sensor systems make use of external pumps to provide vacuum.

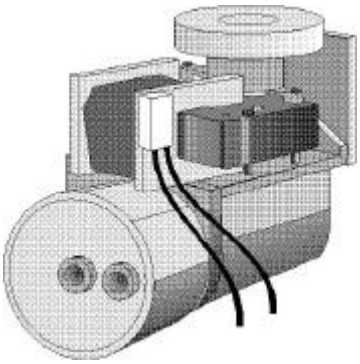
The larger particle counters operate at a nominal flow rate of 1.0 cfm (or 28.3 liters/min) through the sensor. Certification of industrial cleanrooms is best done with an instrument of this type although Federal Standard 209-Series calculations allow 1.0 or 0.1 sampling rates. Refer to the latest revision of Federal Cleanroom Regulations. Flow rates of 0.1 cfm and 0.01 cfm are also available for high particle concentrations and for applications requiring a low flow rate (e.g., from a disk drive) or high sensitivity.

Many battery-operated counters operate at flow rates of 0.1 cfm, although recent technology has allowed the larger portables to achieve 1.0 cfm.

Pumps

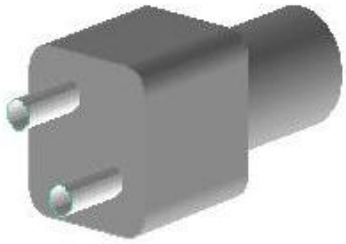


0.1 cfm, DC power

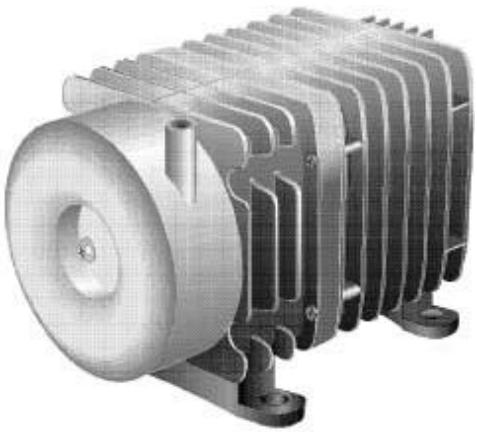


0.1 cfm, AC power

Note:
To determine what type pump is in your counter refer to “Specifications” in the Operating Guide.



1.0 cfm, DC power



1.0 cfm, AC power

Figure 6: Vacuum Pumps

Features

Counting Modes

A variety of modes are offered to provide quick answers to measurement questions or allow unattended operation. The usefulness of auto, cumulative, differential, rate, average, beep, or 209-series/ISO 14644-1 modes depends on the counter's flow rate and the task being performed: determining particle concentration, performing Fed-Std-209/ISO 14644-1 measurements, finding a faulty filter, or monitoring for short-term "bursts" of particles. The count mode determines how many air samples are taken and how the count data is displayed.

Automatic

Repeats count and hold cycles for the programmed number of count cycles or until stopped. This mode allows continuous, unattended monitoring, and count data records held in memory may be printed later.

Manual

Counts for one count cycle then stops; infinite hold time.

Cumulative

Displays the total particle count for a selected size and larger. This is useful in determining the total particle level. Cumulative counts are required in Fed-Std-209 or ISO14644-1 documents.

Differential

Displays the number of particles of the selected size, up to but not including the next larger size only. This is useful for comparing the distribution of particles by size range, which can assist in finding sources of particle contamination.

Concentration (sometimes labeled "Rate")

Gives an estimation of the particle concentration (particles/ft^3 or particles /M^3). The mode uses the particle count in a selectable 1- to 10-second period to extrapolate a count per-cubic-foot or liter, updated every second or every six, seconds. Rate mode is ideal in the battery-operated counters for quick walk-through status checks of a cleanroom. It may also be used to see a full sample would be beyond the concentration limits of the counter.

Average

Gives the average, minimum, and maximum count of a size range for a selected number of count cycles. This mode is useful for establishing a "baseline" count level.

Note:
Not all particle counters include all of these modes. Refer to the Operating Guide for the modes included in your counter.

Features

Beep

Beep mode can give one beep for counts that exceed a given limit, or multiples of that unit, programmable down to a single count. It is useful for locating leaks in filter banks, but if particle concentration is too high, the discrete beeps will blend into a continuous tone. Limits should be set to useful levels in areas with high particle concentrations.

Fed Std 209E

Available on many 1.0 cfm counters, this mode automatically calculates the statistical data required for compliance with Fed-Std-209E documentation: average count by location, mean of the average counts, standard deviation, standard error; and the 95% upper confidence limit, which defines the cleanroom class. For example, a clean room with 10 particles at the upper confidence limit would be a Class 10 cleanroom.

Printers

A printout of particle counting results can be used as a record whenever documentation of room cleanliness is required, as in Fed-Std-209E certification. A permanent record is also handy when tracking the particle concentration trend of a workstation or location. Built-in and external thermal printers used with most particle counters require a standard thermal paper that is heat-sensitive only on one side. A non-shedding, fibreless thermal synthetic paper is also available that is guaranteed to not contaminate a room with particles and is approved for use in class 10 cleanrooms. Built in printers may be disabled by the operator so that stored data records can be printed later if desired. External printers provide the same printouts as a built in printer, but connect by means of a cable to the counter rear panel.

Accessories

Additional accessories can be simply connected to the counter. Options are additional features that are installed at customer request. All options are factory installed because they are an integral part of the particle counter.

Isokinetic Probes

The purpose of the Isokinetic probe is to gather a representative sample of the area being tested. Its dimensions are based on the volume of the sampled air through the particle counter and the velocity of the sample air approaching the probe. The use of the probe is critical when used in a laminar flow air stream. For turbulent or non-laminar flows, use of an isokinetic probe is optional. As shown in figure 7, particles

can be missed when traveling in a typical 100 feet per minute laminar flow air stream. When used with manifold systems in turbulent or laminar flow air, the Isokinetic probe provides a superior method to terminate sample tubing.

Accessories

Excerpt from Federal Standard 209E, Appendix C, Section C30:

"When particles are sampled from a flowing air stream, a difference between the air velocity in the stream and the air velocity entering the probe inlet can cause a change in concentration because of particle inertia. When these velocities are the same, the sampling is Isokinetic; otherwise, the sampling is anisokinetic".

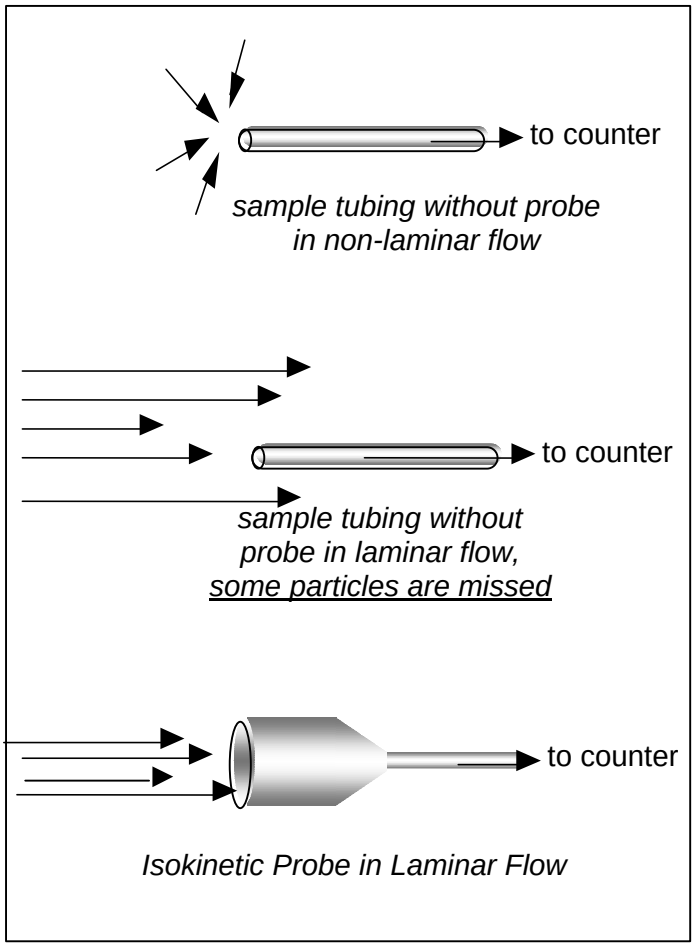


Figure 7 Isokinetic Probe Function

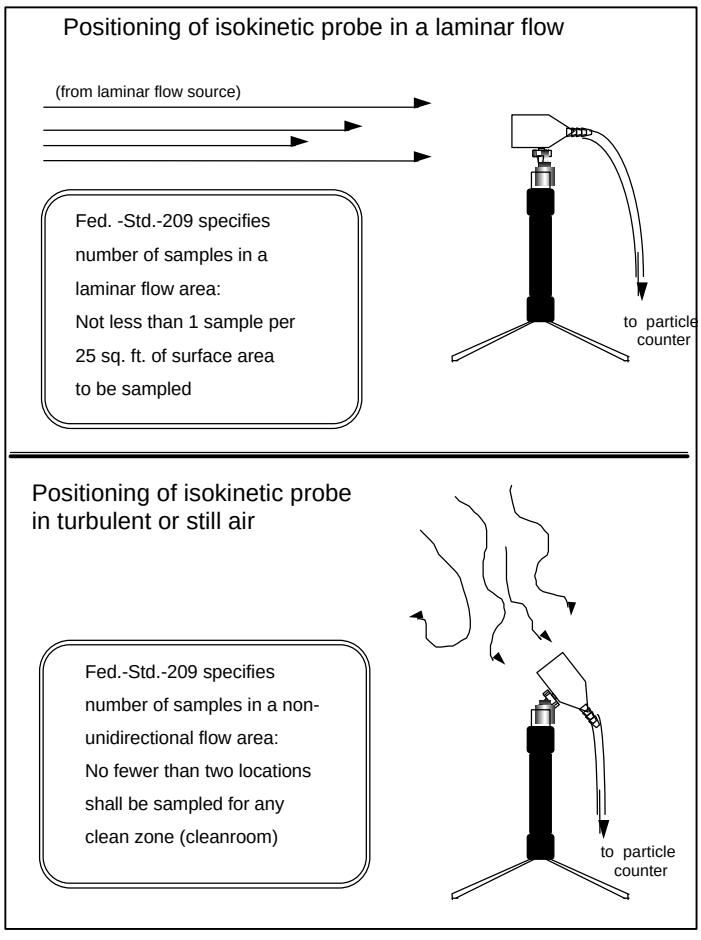
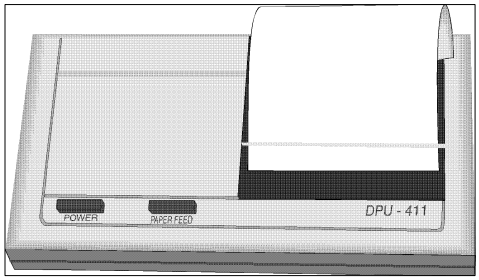


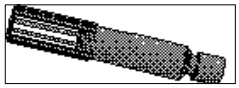
Figure 8 Isokinetic Probe Positioning

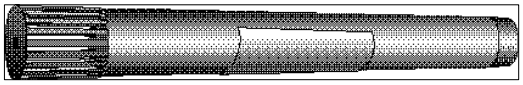
Accessories



Printer

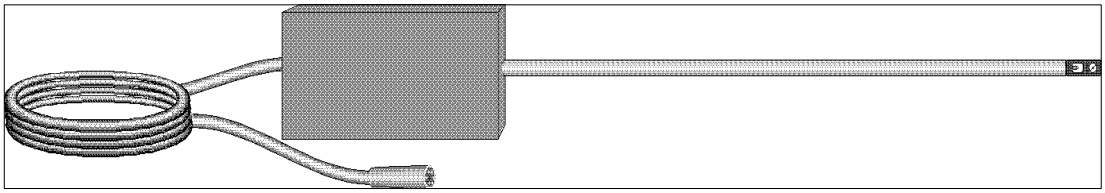
Provides same printouts as built-in printer. Plugs into the counter rear panel.





RH/Temp Probe

Plugs into the counter rear panel (top panel on hand-held models). This probe monitors relative humidity (10 to 90%) and temperature (specify 0 to 100°F, or -18 to 38°C). Particle counter displays the reading of the probe

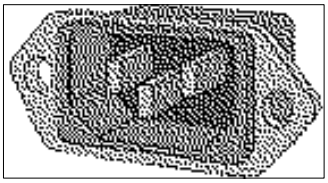


Air Velocity Probe

Plugs into the counter rear panel. This probe monitors air velocity (available in several ranges and in U.S. or metric readouts - contact factory). The particle counter displays the reading of the probe.

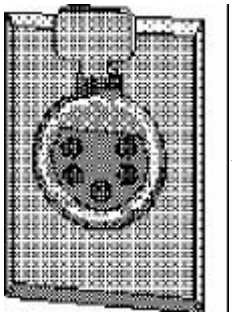
Rear-Panel Connectors

Each rear-panel connector is used as an interface to external equipment or to facility power. The connector is identified by the name above or below the connector. If the name happens to become worn off the panel you can use these figures for identification.



AC power input

DC power input

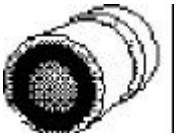


Air Velocity Probe

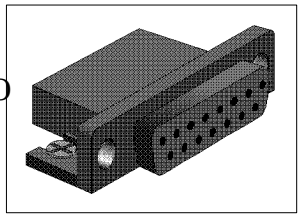
RH/Temperature Probe

Parallel Printer

Filter Probe option



Computer System I/O
15 pin, remotes only



Analog Input

Serial Output - 9 pins

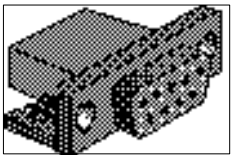


Figure 9 Rear Panel Connectors

> Note
> Some of the connectors shown here do not appear on all models, depending on option availability. Refer to your particle counter data sheet for a list of options and accessories.

Glossary of Particle Counting Terms

The following terms are used throughout the particle counting industry when measurements are being discussed. Definitions containing the word “particle” are based on spherical polystyrene particles.

Accuracy
The difference between true size and the measured size. It is the correctness of the size measurement; expressed as a percentage. 100% is perfect accuracy.

Audible alarm limit
The programmed value at which an audible alarm will sound.

Battery life
The length of operating time that a battery operated particle counter can be used continuously.

Cleanroom class (Federal Standard 209E)
The maximum number of allowable 0.5 micron particles and greater per cubic foot of sampled air. For example, in a Class 100 cleanroom, a maximum of 100 particles of 0.5 micron and larger are allowed per cubic foot of air.

Coincidence error
The error introduced when particle concentration becomes so great that two or more particles are in the sensor view volume at the same time, causing two particles to be detected as one.

Concentration
The number of particles per volumetric unit (cubic foot, cubic meter, or liter).

Concentration mode
Gives a quick (within seconds) approximation of the concentration of particles in a volume of air.

Count displayed
Indicates number of particles counted—up to 9,999,999 on some counters.

Counting efficiency
For a typical single size particle distribution, (see distribution) the percentage of particles counted, where 50% describes counting those particles of the nominal size and larger, disregarding those smaller than the nominal size.

Cumulative count
The total count for the selected size range and all larger sizes.

Data storage
The number of sample data records that can be stored in the counter’s rotating-type serial buffer.

Glossary of Particle Counting Terms

Differential count
The count for the selected size range only.

Distribution
For a given sample of a single size of particle, the variance in actual size compared to nominal size. Typically a standard bell shaped (gaussian) curve.

False count rate
The counts reported using perfectly clean air (Zero count).

Flow rate
The rate at which air is pulled through the sensor by the pump. Typically expressed in cubic ft./min (cfm) or Cubic Meters/min (M^3/min.

Hold time
The programmed length of time between sample cycles (from 1 second up to 24 hours).

ISO Class
A cleanliness class rating from 1 through 9, established by ISO standard 14644-1to define the number of particles in one cubic meter

Isokinetic probe
A shaped collection tube connected to the sensor inlet to minimize turbulence and optimize particle collection.

Light source
Type of illumination used in the view volume where particles are detected (i.e. laser diode, HeNe laser).

Noise
Unwanted pulses or disturbances in a signal, not produced by a particle in the view volume of the sensor.

Operating environment
The temperature and humidity range at which you can safely operate the counter—normally 55 to 84 °F and 0 to 85% relative humidity.

Outputs
Depending on the counter, parallel printer interface (built-in or external), RS-232C or RS-485 interfaces for serial communications with a computer.

Particle size range
That range of particle sizes for which counts are accumulated. Sometimes called channel or bin.

Precision
Is the “repeatability” of the size measurement from particle to particle in the same measurement. It is expressed as the standard deviation of repeated measurements of the same size PSL spheres.

Glossary of Particle Counting Terms

PSL
As in PSL spheres; NIST-traceable polystyrene particle standard.

Reproducibility
The extent to which a counter will give the same sizing and counting response to the same diameter PSL spheres over a long period of use (also called repeatability or calibration stability).

Resolution
The ability to discriminate between variations in particle size. Also referred to as “relative precision,” “relative standard deviation,” and “coefficient of variation.” Resolution is expressed as the ratio of the true size to the standard deviation in the measured size. Smaller resolution numbers indicate better resolution and particle sizing accuracy.

Sample time (or Period)
The programmed length of time for each sampling cycle.

Sensitivity
The smallest size particle a counter can detect at a specified counting efficiency, e.g., 0.3 micron at 50% counting efficiency.

Signal
The electronic output of a sensor, wherein a pulse represents particles. Particle size is deduced from the pulse amplitude.

Signal-to-noise ratio
The ratio of the particle signal size to the “background noise” signal size. A high signal-to-noise ratio implies low false count rate.

Size ranges (or channels)
(see Particle Size Ranges)

209E calculations
Calculated statistical data required for compliance with Fed-Std-209E: average count by location, mean of the average counts, standard deviation, standard error, and 95% upper confidence limit.

Best Practices

Particle counters are reliable during normal use. The mechanical and electrical parts of the counter are rugged enough to sustain routine operation for extended periods. As a result, most problems with the counter are due to misuse or a lack of normal maintenance.

This section describes the particle counter's intended use, common operating mistakes, and the best operating and maintenance practices. Understanding these subjects will help you get many years of trouble-free service from the counter. The following topics are discussed:

- Counting Environments—discusses common problems when using the counter in controlled (clean) and uncontrolled (greater than class 100,000) environments.
- Operating Mistakes—gives examples of common operator errors that may damage the particle counter or degrade its performance.
- Best Practices—describes some simple operating steps and maintenance procedures that will ensure the best particle counter performance.
- Maintenance Schedule—gives a schedule of when maintenance procedures should be performed.

Note

In this section, the assumption is made you know how to operate your particle counter. If not, please read the Operating Guide for your counter before proceeding.

Counting Environments

Particle counters are used to measure the amount of airborne particles in two types of environments: controlled and uncontrolled. Controlled environments are Class 100,000 or cleaner cleanrooms (as defined by Federal Standard 209). Cleanrooms control airborne contamination and are used by industry to build sensitive products, such as integrated circuits and pharmaceuticals.

Uncontrolled environments are any environments that do not meet the criteria for Class 100,000 cleanrooms. Examples are areas under construction, offices or areas exposed to outdoor air. When used in uncontrolled environments, the counter may require special maintenance to prevent measurement problems.

Caution

Particle counters that have 0.1 micron sensitivity should not be used in greater than class 1000 cleanrooms without special precautions to prevent sensor contamination. Contact Technical Support for specific instructions before using a 0.1 micron counter in this environment.

Controlled Environment

The most common problem in this environment is an incorrect sampling technique, resulting in a sample of the wrong air, or something other than air.

An example of sampling the wrong air is sampling air from the counter exhaust or cooling fan. Even if the counter is used in a unidirectional airflow zone, contaminants blown by the cooling fan may affect the sample air. Proper placement of the sample probe will prevent this sort of error, or an external HEPA filter is available that filters all air leaving the counter. If sampling in a vertical unidirectional flow zone, take the sample above the counter.

Caution

Sampling liquids will damage the counter. This damage requires factory repair. For more information, refer to “Sampling Errors” in this section.

Accidentally sampling liquids is another common problem where the sample area is subject to aseptic washdowns without removing the installed particle counter. The counter is often used to automatically monitor a cleanroom and because the counter monitors automatically, it can easily be forgotten. Thus, the counter is left on during the aseptic washing, and it pulls liquid into the sensor. Turn the counter off during this washing and cap the sensor inlet. Ensure that the caps are removed before operations begin again.

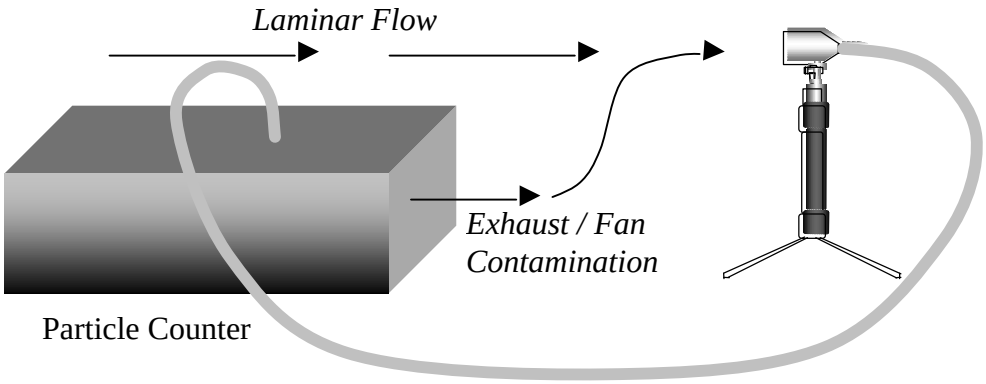
In other settings, reservoirs of liquid are stored or used in the sample area. The probe should be kept at least 12 inches from any liquid. The suction at the open end of the probe is strong, and liquid can be quickly pulled into the probe if it is inadvertently placed too near an open container.

Uncontrolled Environment

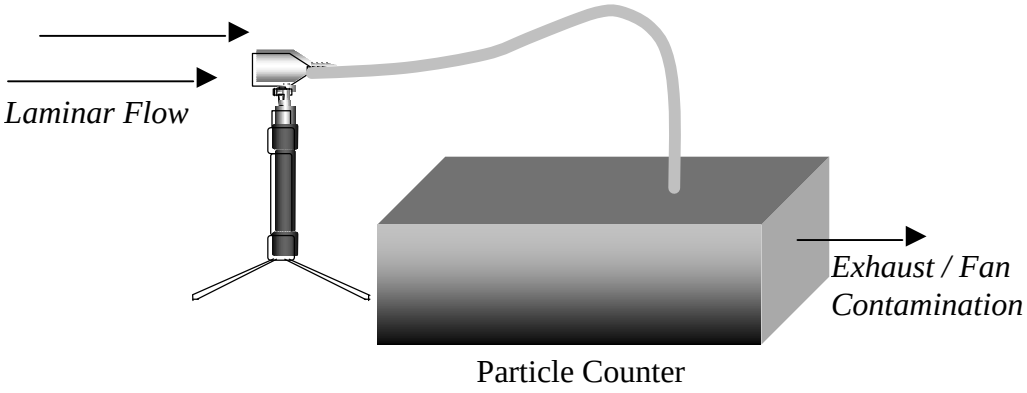
The most common problem in this environment is the uncontrolled nature of the environment. This environment may contain excessive contaminants such as airborne particles or airborne lint and dust. Contaminants can lodge in the sensor inlet tube, inhibiting flow or coming loose later and erroneously raising the particle count. Contaminants in the sensor inlet tube can be minimized by frequently purging the counter’s sensor. Purging is a process that draws clean air

through the sensor, blowing out contaminants that may have accumulated. Purging is described later in this section.

Counting Environments



Poor placement



Good placement

Figure 1 Isokinetic Probe placement

Operating Mistakes

Sampling Errors

As a general guideline, keep the input nozzle at least twelve inches from loose materials, dust, sprays, etc., and avoid the following:

- ❑ Powdered materials will coat the sensor and cause false readings or counter failures.
- ❑ Liquids coat the sensor and ruin its calibration. Sometimes liquids are suspended in air in the form of oil droplets, which will stick to the internal optics of the sensor.
- ❑ Vapors from drying adhesives or other chemicals may permanently coat the sensor optics or other internal parts.
- ❑ Smoke of any kind contaminates the sensor.
- ❑ Corrosives may be suspended in vaporous form and will quickly cause permanent damage to optics or electronics

Restricting Sample-Air Flow

A common operator mistake is using the airflow control valve to turn off the sample flow, instead of putting the counter in the Stop mode. The airflow valve is intended to compensate for minor variations in airflow resistance. Using the airflow valve to completely shut off the pump strains the pump and will result in early pump failure.
When operating a 1.0 cfm counter, restricting the inside diameter of the intake tubing to less than ¼ of an inch will increase pump wear. Custom-designed isokinetic probes and intake tubing should have a minimum intake diameter of ¼-inch. Never kink the inlet tubing or cap the isokinetic probe or sample air inlet tube when the counter pump is on. Counters operating at 0.1cfm may use smaller tubing with an inside diameter of ? inch.

Restricting Cooling Air

The larger particle counters contain a cooling fan on the rear panel. If the rear panel is blocked in any way, the inside of the counter can get too hot, causing the counter to malfunction. Usually this malfunction can be fixed by moving the counter away from the wall and resetting the counter as described in its operating guide, but occasionally the counter becomes permanently damaged.

If cabinet installation is necessary, you must vent the cooling fan air out of the cabinet through a straight hose or tube of four-inch or 10 cM diameter. The tube cannot be blocked or filtered in any way. The cabinet must also be vented to allow air intake and prevent a vacuum from developing.

Best Practices

Developing a few good habits and doing some regular maintenance can prevent most problems with particle measurements. The following steps are for general use. For specific instructions, refer to the particle counter’s operating guide.

Proper Operation

1. Turn the counter on.
2. Verify counter is not in the run mode (not counting particles).
3. Verify the counter's Sensor alarm or Cal Fail indicator is off. This indicates the internal sensor is operating normally. If no alarms are indicated, you are ready to take samples. If an alarm is displayed, measurements may be invalid.
4. Ensure the sample inlet is uncapped, and the appropriate sample accessories are attached.
5. Press RUN.
6. If your counter has the capability to display the airflow rate ("FLO"), check the airflow rate and adjust as necessary. If not within ±5% of the nominal flow rate, an alarm may be present and the particle count measurements will be misleading. If the airflow will not adjust correctly, contact Technical Support.
7. Verify the alarm limits are set correctly for your measurement.
8. When sampling is complete, verify there are no alarms. If an alarm (other than a limit alarm) has occurred, measurements may not be accurate. Contact Technical Support for assistance.
9. Press STOP.
10. Turn the counter off.
11. Turning the counter off during particle counting can cause a power surge when the counter is turned back on, which may cause the counter’s internal processor to lock up. When this happens, some or all front-panel controls may not function. This problem can be fixed by resetting the counter according to instructions in the Operating Guide.
12. In portable units, leave the counter plugged in whenever possible, to preserve the charge of the internal batteries. The batteries provide power to run the counter. Other internal batteries also maintain counter memory, which stores all the program settings and count data.

Zero Counting, Purging

Zero counting verifies that particles have not contaminated the counter, causing high particle counts. Purging is an extension of zero counting, running as long as necessary to achieve zero count results, often for 24 hours. How frequently you should zero count the counter depends on your environment, but it is generally done prior to a test, to ensure a proper baseline reference for the counter. During zero

Best Practices

counting, the counter samples air through an absolute filter. The filter blocks external particles so that only particles inside the sensor are counted. Don't expect a count of zero immediately; most counters trap a few particles in the inlet tube or other internal areas during operation, especially if exposed to high concentrations.
Perform zero counting as follows:

1. Attach a standard purge filter assembly to the sensor inlet tube.
2. For counters with no built-in printer, turn the counter off and connect the external printer. Turn the counter on.
3. Set particle counter for one minute samples spaced five seconds apart.
4. Begin zero count procedure by starting the count cycle.

When the count is zero, and no alarms are on, the counter is functioning correctly. If you do not get a count of zero after nine or ten samples, the sensor should be purged overnight. Purging is a process for removing contaminants such as particles, lint, or dust from the sensor. Allow the counter to operate for 24 hours with the filter attached. You may want to disable the printer to save paper. If purging fails to solve the problem, refer to sensor cleaning techniques on the following pages.

Internal Chassis Cleaning and Filter Inspection

Many large counters contain a cooling fan to keep the 1 cfm air pumps cool. If the counter is operated in an uncontrolled environment, the fan may pull contaminants into the chassis. This internal cleaning procedure uses compressed nitrogen to blow contaminants from the chassis. When you should clean the chassis depends on how you use the counter. For an internal cleaning schedule, refer to "Maintenance Schedules" in this section.

The large counters can also be ordered with an external HEPA (High Efficiency Particulate Air) filter. This filter virtually eliminates all particles from escaping to the atmosphere. Some filters come with a standard built-in ULPA (Ultra Pure Particulate Air) filter.

Best Practices

WARNING

Failure to unplug counter and then touching internal parts can result in severe electrical shock.

Cleaning Procedure

1. Turn off counter, then unplug.
2. Remove top cover.
3. Cap sensor inlet tube.
4. Using clean compressed air or nitrogen, at less than 25 lbs/square inch, blow contaminants and dust from counter chassis.
5. Clean printer with compressed nitrogen. Gently remove any foreign objects.
6. Check all tubing for cracks, kinks, or loose fittings. Replace tubing as required.
7. Observe outlet filter(s). It should be white or gray (except for some large counters which have a long black carbon filter).
8. Check filter in air vacuum pumps as described in "Pump Filter Inspection" procedure in Section 3.
9. If your counter is equipped with an external HEPA filter (built-in ULPA filter in some counters), visually inspect the filter for damage such as cracks or holes. Replace filter if damaged. To test for filter "leaks", place counter in a unidirectional flow zone with an isokinetic probe and use your counter to test for particles.

CAUTION

Do not put any lubricants or cleaners on printer guide-rod or cam. Damage to printer may result.

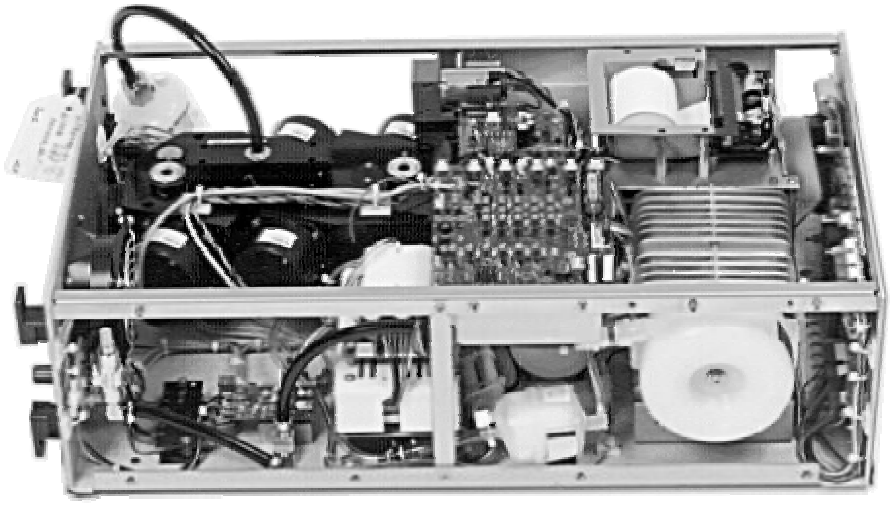


Figure 2 Internal chassis of typical large counter

Routine Maintenance

Refer to the Maintenance Schedule below for a schedule of maintenance procedures described in this section. The table assumes daily use of the particle counter and indicates that as the operating environment becomes less controlled, the need for maintenance increases.

The maintenance procedures should also be done under the following conditions:

- ❑ When you move the counter from a less controlled to a more controlled environment, do zero counting. This will ensure that contaminants from the less controlled environment are not affecting the sensor and giving unusually high readings.
- ❑ When you move the counter from a class 100,000 (class 1000 for 0.1 micron units) or worse environment to a cleaner environment and your counter is equipped with a cooling fan, do an internal cleaning. This will control the possibility of contaminating the cleaner environment.
- ❑ If a sensor alarm occurs, the sensor may be contaminated. Purge the particle counter as explained in this section. If the sensor alarm still comes on, contact Customer Service for assistance.
- ❑ The factory puts a tag on the top cover after every calibration. This tag shows the last date of factory calibration, and when the next calibration is due. This calibration is the same as a primary calibration as defined in Federal Standard 209.
- ❑ Sensor cleaning when the sensor alarm appears or the counter will not zero count.

CAUTION

Counters with 0.1 micron size range were designed for particle sampling in class 1000 or better cleanrooms, thus could be damaged if used in a less controlled environment.

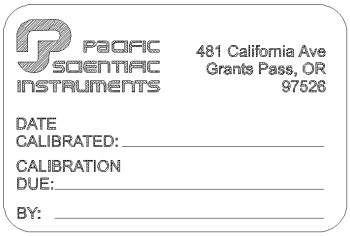
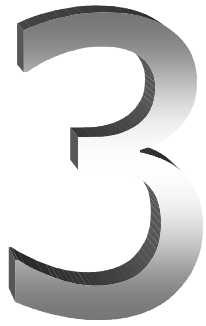


Figure 3 Calibration tag

Factory calibration is available with 48-hour turn-around time, provided no repairs are needed. If you are going to return the counter to the factory for any reason, refer to "Returning the Counter" in Chapter 3. Routine maintenance actions are outlined in the table below. Corrective actions are described in chapter 3

Cleanroom class ®	10	100	1000	10,000	100,000	Uncontrolled
Action –						
Purge/zero count	Each use	Each use	Each use	Each use	Each use	Each use
Chassis cleaning	As Req'd	As Req'd	As Req'd	As Req'd	As Req'd	Weekly
Calibration/ Factory service	Yearly	Yearly	Yearly	Yearly	Yearly	Yearly

Table 1 Routine Maintenance schedule



General Maintenance

This section describes general troubleshooting and repairs that can be performed by the user, even those without a technical background. This section discusses the following:

- Checking the Basics— a few simple checks that verify the source of the problem.
- Symptoms and Solutions— the most common symptoms of counter trouble and procedures for diagnosing the cause of the problem.
- Pump Maintenance – Procedures for users to perform maintenance and minor repairs on the air pump on their own site.
- Sensor cleaning procedures – Maintenance that a skilled user can perform to solve common sensor problems.
- Returning the Counter — instructions for returning the counter for factory authorized service.

Checking the Basics

Note:
Resetting the counter (as described in the operating guide for that counter) is a valuable technique that can solve many problems caused by a temporary microprocessor malfunction.

Many problems can be solved by rechecking what was being done when the problem occurred. Taking a few minutes to make a few simple checks may eliminate the need to send your particle counter to be repaired. Make the following checks whenever you think a problem exists:

- ***Is the counter plugged into the proper power source?***
  AC operated counters that are shipped internationally may be configured for other voltages. If your counter is battery operated, The AC/DC adapter used to recharge the batteries must be the one that came with the counter, or a replacement from the factory. Voltages and polarity vary widely among different manufacturers and the wrong adapter can damage your counter. Battery operated counters are also equipped with a Low Battery indicator. Recharge the battery in accordance with the Operation Guide for your counter.
- ***Is the protective cap still on the sensor inlet?***
  Operating the counter when plugged will damage the pump.
- ***Are the sample probes and tubing properly connected at all points?***
  The zero/purge filter should be removed prior to sampling and replaced with the appropriate tubing and probe. Ensure there are no kinks, leaks or blockages in the tubing.
- ***Is the airflow rate indicator within the allowed limits?***
  An incorrect flow rate will give misleading particle measurements.
- ***Are any alarm indicators on?***
  If alarms occur, the sensor may be contaminated or damaged. Contact Technical Support for assistance at 1-800-866-7889.
- ***Is the counter "locked up" so that some or all of the functions are failing?***
  The Real Time Clock, which keeps the time of day, is crucial to counter operations. If the seconds portion of the time display is not counting, reset the counter as directed in the operating guide.

The possible causes in the following tables are given in the order of highest probability. The solutions are given in the order you should do them for the best repair. Other helpful information can be found in checkout, replacement, and cleaning procedures which appear after the tables.

If use of the tables and associated test procedures does not find and fix the problem, you should contact the factory. If the problem cannot be resolved over the phone, you may have to return the counter for testing and repair. Refer to “Returning the Counter” in this section.

Replacing Fuses

Changing Fuses

If your counter uses fuses (either one or two), they will be mounted on the rear panel for easy access. If your counter will not turn on after replacing fuses, contact the factory.

Failure to disconnect electrical power cord could result in electrical shock.

Twist-Lock

1. Turn counter off and, if applicable, disconnect AC power cord.
2. Turn twist-lock cap counterclockwise then remove cap from chassis.
3. Pull old fuse from cap; insert new fuse.
4. Reinstall fuse holder with new fuse; rotate clockwise.
5. Reconnect AC power cord (if applicable).

Flush-Mount

1. Turn counter off and, if applicable, disconnect AC power cord.
2. Insert tip of flat-blade screwdriver into notch located directly above on/off switch; twist screwdriver gently to open fuse door.
3. Insert screwdriver at tip of arrow of fuse holder; gently pry fuse holder out.
4. Remove old fuse and insert new fuse in holder; press into place by rocking fuse holder slightly to the right.
5. Close fuse door.

Some of the procedures in this section require you to remove the counter covers, exposing internal parts. Failure to follow instructions while power is on may cause electrical shocks.

Symptoms and Solutions

Note:
The laser driver and photo amplifier boards are part of the sensor and are not repairable or replaceable. The sensor is factory aligned in conjunction with these two boards as a complete unit and thus must be replaced as a unit at the factory.

General Problems

Symptom	Possible Causes	Solution
Inoperative, no lights	Not turned on	Turn power switch on
	Unplugged	Verify power socket has power. Plug power cord in.
	Blown fuse	Replace fuse, refer to "Changing Fuses" in this section
	Low Battery Charge	Verify proper AC Adapter, Plug in adapter and charge for 16 hours
Abnormal display	Internal processor malfunction	Reset counter, refer to "Resetting the Counter" in the Operating Guide
	Circuit failure	Return counter to factory for service
Sensor alarm light is on	Particle concentration too high, Sensor saturated	Purge counter and zero count; refer to "Zero Counting Purging" in Chapter 2
	Sensor optics are dirty	Clean sensor; refer to" Sensor Cleaning" in Chapter 3
	Laser diode or associated circuitry failed	Return counter to factory for service
Counter seems to be counting too high or too low	Sensor contamination	Purge counter and zero count; refer to "Zero Counting Purging" in Chapter 2
	Counter out of calibration	Return to factory for service
Counter does not retain settings when off or unplugged	Internal battery is dead	Replace Internal battery

Battery Problems (portables)

Symptom	Possible Causes	Solutions
Two short beeps at power turn on, no other operation.	Extremely low battery	Recharge battery according to Operating Guide
	Faulty battery	Replace battery; call Technical Support if you need assistance

Symptoms and Solutions

Airflow Problems

Symptom	Possible Causes	Solutions
No airflow, air pump not running (should be audible)	Counter not in RUN or OPERATE mode	Press RUN key
	Low battery charge (portable models)	Charge battery
	Air pump or circuitry failure	Return counter to factory for repair
No or low airflow readout, pump can be heard	Restricted air intake	Disconnect tubing to sensor inlet tube. If airflow returns to normal, problem is a restriction in external tubing
	Airflow adjustment not properly set	Adjust airflow control
	Airflow cannot be set	Check for plugged air filter or improper "O" ring seating in pump; check internal tubing for kinks or leaks; replace diaphragm, refer to "Pump Filter Inspection" in this section
	Possible flow meter problem or pump failure	Check airflow adjustment; refer to "Airflow Adjustments" in Section 2

Alarm Problems

Symptom	Possible Causes	Solutions
Counter does not alarm	Alarm limit not exceeded	Check alarm limit settings
Audible alarm sounds but count alarm indicator not on	Count alarm indicator defective	Return counter to factory for repair
Count alarm indicator on but audible alarm does not sound	Audible alarm not enabled	Enable audible alarm, if desired
	Faulty components on circuit board	Return counter to factory for repair

Symptoms and Solutions

Printer Problems		
Symptom	Possible Causes	Solutions
Paper does not come out of printer	Out of paper	Add new roll of paper; refer to Operating Guide
	Paper jammed	Snip off paper at roll then carefully pull paper from printer in SAME DIRECTION of feed. Refeed paper
Paper feeds, but no images are printed	Thermal paper is installed upside down	Snip off paper and press paper feed button until printer empties. Turn paper roll over so that paper feeds from bottom of roll
	Non-thermal paper	Add new roll of paper; refer to Operating Guide
	Bad cable between Controller PCBA and printer PCBA	Check cabling and connections
	Printer or counter damaged by making connections with power on.	Return to factory for service.
Printer prints only upper or lower half of characters	Dirt on print head	Snip off paper at roll ; press paper feed to empty printer. Clean print head with alcohol and brush.
	Roller gears damaged by pulling paper out of printer backwards	Gears should move platen bar towards head during print and retract it during feed. If not working, contact Customer Service
Printer inoperative, does not respond to paper feed button	Printer not enabled	Press printer Enable key
	Bad ribbon cable between printer head and printer PCBA or between printer PCBA and controller PCBA	Check printer cables and connections
	Dirt in printer jamming print head and worm gear	Turn power off and try to move worm gear to move print head away from dirt; clean gear with alcohol
	Printer circuits or motor failure	Replace printer
External battery operated printer goes off-line during printing	Low battery	Charge battery according to printer manual

Pump Maintenance

Three types of pumps are covered in this section: carbon vane pump, air vacuum pump, or diaphragm pump. Some maintenance may be performed on each type in the field.

- ❑ Carbon vane pumps used in DC or battery powered hand held and portable counters require very little maintenance. The carbon vanes rarely break, but the pump may occasionally need to be adjusted for peak flow.
- ❑ 1.0 cfm vacuum pumps are used in larger AC operated counters, and the internal intake filter requires occasional cleaning.
- ❑ The 0.1 cfm diaphragm pump is used in CNC's and is optional in some other models. The diaphragms may be replaced in the field.
- ❑ Roots Pump used in battery operated 1.0 cfm counters

Pump Removal and Installation

1. Turn counter off and unplug.
2. Remove top cover and bottom cover.
3. Remove tubing from pump assembly fittings.
4. Cut cable ties and free pump wiring from attachments, unplug pump assembly

Remove the pump according to the following procedure.

5. *Small pumps*: Pull pump assembly from snap-type holder.
6. *Air vacuum pumps*: From bottom side of chassis remove four screws securing pump mounting bracket to bottom chassis; remove pump and mounting bracket.
7. Reassemble in reverse order

Note
Before removing tubing, label tubing/fitting combinations for ease of reassembly.

Note
Check all tubing for kinks, cracks, loose fittings, or blockage. Replace tubing if necessary.

Do not use a ball-type rotameter to monitor airflow. This type of meter affects measurement accuracy because lifting the ball loads the airflow circuit.

Pump Maintenance

1.0 cfm Pump Filter Inspection and Replacement

If your particle counter is to be used in extremely dusty or dirty environments, clean or replace the intake air filter element periodically. Frequency of cleaning depends on the environment and running time of counter. Clean or replace element as follows:

1. Turn counter off and unplug. Remove cover.
2. Remove screw holding white air filter cover to pump body; pull air filter cover away from pump body in order to access filter.
3. Gently pull filter from filter cover and inspect for dirt or debris.
4. If filter is dirty, replace with a new filter or wash existing filter with detergent and rinse with clean water. Allow filter to air dry.
5. Insert new (or clean) filter in cover.
6. Check that "O" ring is in position on mounting flange of pump then place the cover on pump noting orientation of cover. Attach air filter cover to pump then install cover on counter.

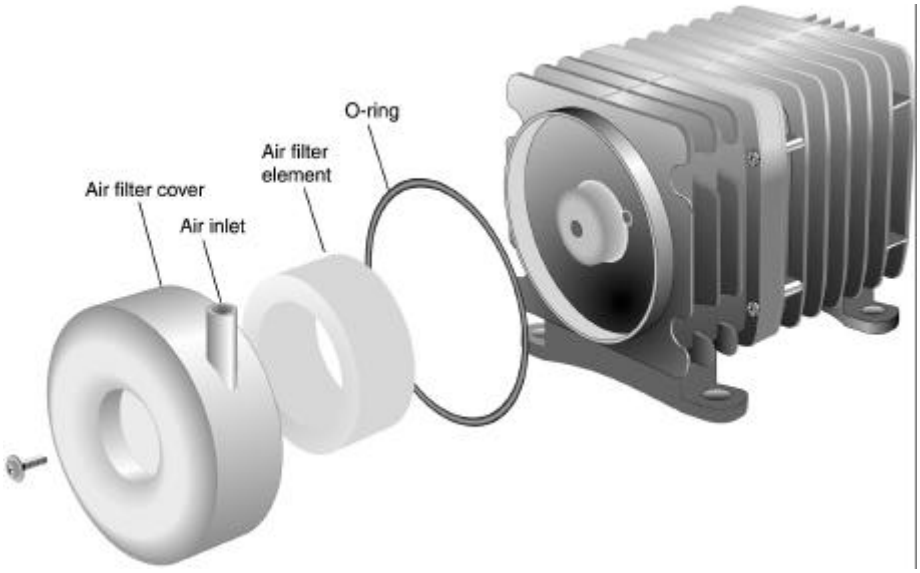


Figure 1 1.0 cfm AC Powered Pump Maintenance

Pump Maintenance

0.1 cfm Pump Airflow Adjustments

The following procedures apply to 0.1 cfm air pumps used in all battery-operated particle counters. There are two parts to the adjustment. The first part applies to all counters and maximizes air pump output at minimum noise level. The second part is an adjustment that varies depending on your type of sensor. It provides the correct flow rate through the sensor

Maximizing Pump Output

1. Remove top cover of counter.
2. Connect flowmeter gauge to sensor inlet tube.
3. Turn counter power on then start a count cycle.
4. Disconnect tubing between pump and exhaust filter; verify airflow increase is less than 10%. If greater than 10%, replace filter.
5. Loosen pump set screw at end of c-clamp just enough to turn pump body. Turn pump body for maximum flow rate on flowmeter gauge while maintaining minimum pump noise. Retighten setscrew.

Adjusting for Correct Flow Rate (90° Mini-Sensors)

Turn setscrew for a flowmeter gauge reading of 0.1 cfm (access to set screw on some units is through hole in rear panel; for other units, separate two halves and locate adjusting screw in tubing line between sensor and pump).
Turn power off, remove flowmeter gauge, and then install top cover.

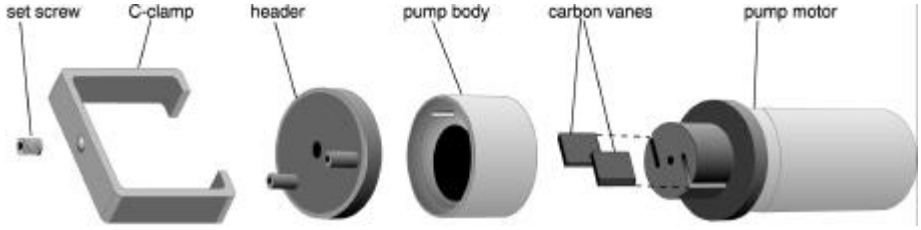


Figure 2 0.1 cfm DC powered Pump Maintenance

Pump Maintenance

0.1 cfm Diaphragm Pump

As the diaphragm pump wears with use, either or both internal diaphragms can become brittle, stretched, or develop holes, which will cause the pump to not maintain 0.1 cfm adjustment. Replace both diaphragms as follows:

1. Remove air pump per “Pump Removal and Installation” in this section.
2. On some configurations you may have to remove the barb fitting to gain access to all four screws. Remove four screws holding diaphragm housing to pump assembly then remove housing.
3. Remove screw holding plastic protective cover to pump assembly, and then remove cover.
4. Rotate pump shaft until diaphragm is in relaxed position.
5. Unscrew diaphragm; retain any shim washers.
6. Put shim washers (if any) over fastening screw on new diaphragm then screw new diaphragm in place.
7. Separate two parts of diaphragm housing.
8. Insert new flapper valve between two parts of diaphragm housing so that cutout portions of flapper valve are centered on the two O-rings. Verify alignment marks on side of housing are in line.
9. Place diaphragm housing on pump assembly so that alignment marks are nearest to coil windings; fasten with four screws. Reinstall pump and tubing.

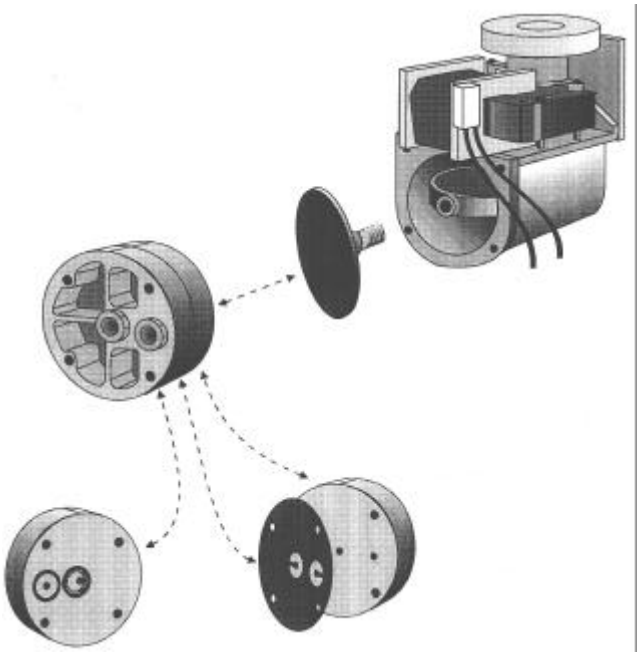


Figure 3 0.1cfm AC Powered Pump Maintenance

Sensor Maintenance

All particle counters accumulate contaminants within the sensor, where they build up on the internal optics and other surfaces, and can eventually cause a sensor failure alarm to occur. These surfaces can often be purged clean by drawing clean air through the sensor. Before performing cleaning procedures, perform a purge and zero count as described in chapter 2.

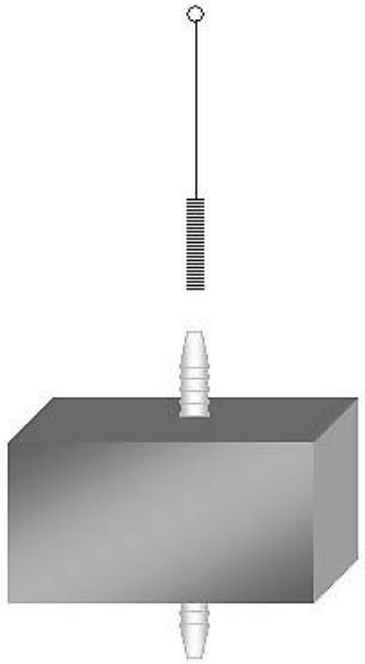
When you should clean the sensor depends on where and how you use the counter. Do not clean the sensor unless you have tried the purging procedure and only if a distinct sensor problem exists, such as zero count failure or a sensor failure alarm. The sensor does not need annual cleaning.

Caution

Do not use this procedure on the 3-port HeNe sensors as damage can occur to the sensor.

The first place to clean if sensor problems exist is the inlet nozzle. Carefully examine the inlet under a strong light and remove any visible obstructions by pulling them out with tweezers. If no visible obstructions are present, perform the following:

1. Turn particle counter on and begin a run cycle so that air is flowing through the counter.
2. Slowly insert brush into sensor inlet tube until it stops. Rotate brush clockwise and counterclockwise while moving brush up and down several times. Remove brush from cell; stop count cycle.
3. Attach the purge filter and run the counter to obtain a zero count. If the counter will not zero, proceed to the applicable sensor cleaning procedure that follows.



Laser-diode-type sensors and mini-sensors must be removed from the particle counter for cleaning. The sensor is generally mounted to a cover or an internal bracket with four screws, which protrude through the counter chassis and thread into the sensor. If you cannot figure out how to loosen and remove the entire sensor assembly from the counter, you are advised to return the counter to the factory for sensor cleaning. Sensor cleaning requires good mechanical skills and must be performed carefully. If the sensor is not reassembled correctly after cleaning, then the counter calibration will be altered and count accuracy will be adversely affected.

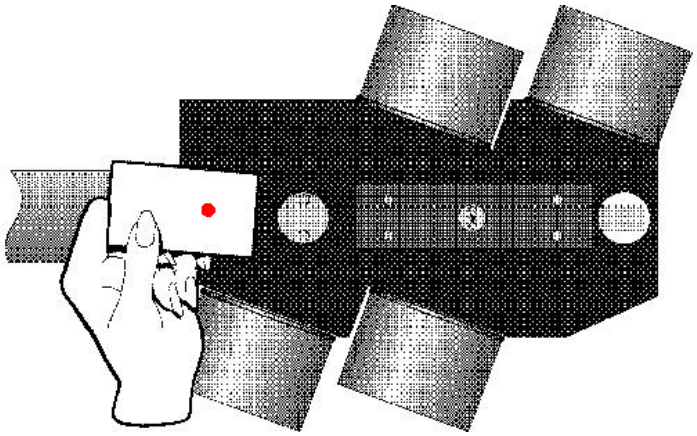
HeNe Cleaning Procedure

Warning

Maintenance procedures on the sensor can result in exposure to either visible or invisible radiation, depending on the type of sensor you have. The use of controls, adjustments, or performance of procedures other than those specified within this manual may result in exposure to visible or invisible (infrared) radiation that can quickly cause blindness.

Laser Safety

1. In a clean room or under a clean hood,
2. Remove top cover from particle counter.
3. Locate sensor Assembly

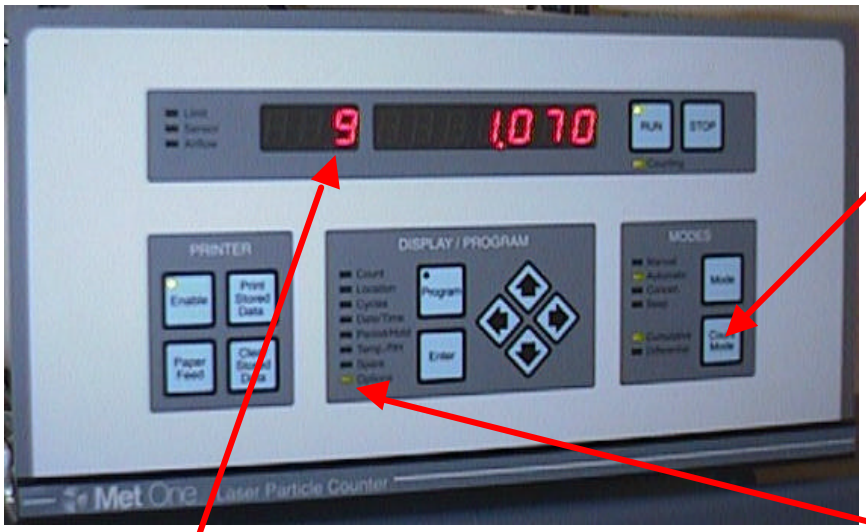


4. Place a small white paper over the Brewster's window opening and turn on counter. If there is an intense red dot shining through the paper, turn counter off and scrub Brewster's window surface with acetone and a swab. Turn counter on and make sure the red dot is gone. If not, return the counter to the factory.

HeNe Cleaning Procedure

Monitor the Calibration Voltage (or resistance indication on older models) as shown below. Calibration Voltage for a clean sensor should be about 1.0 VDC

Viewing Calibration Voltage



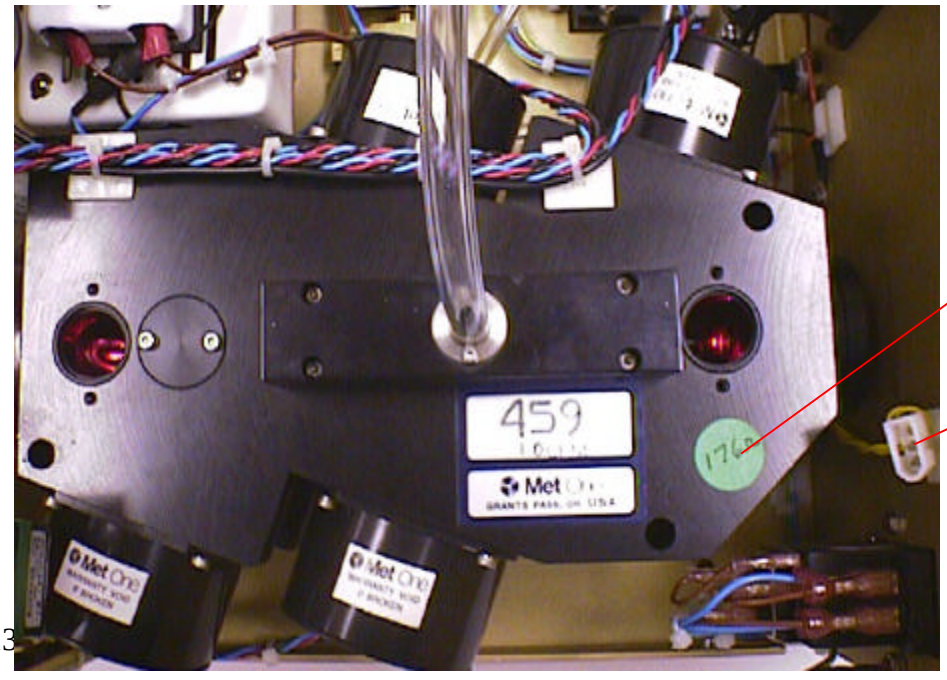
1. With power off, press and hold Count Mode kev

2. Turn counter on (Rear panel)

3. Use up or down arrow keys to select Options display

4. Use left or right arrow keys to select Option 9

Sensor Resistance Measurement

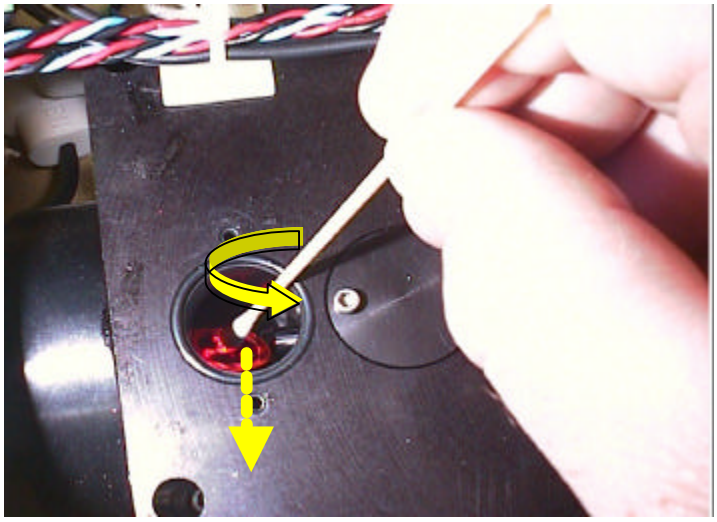


Desired Resistance Reading

Resistance Test Connector

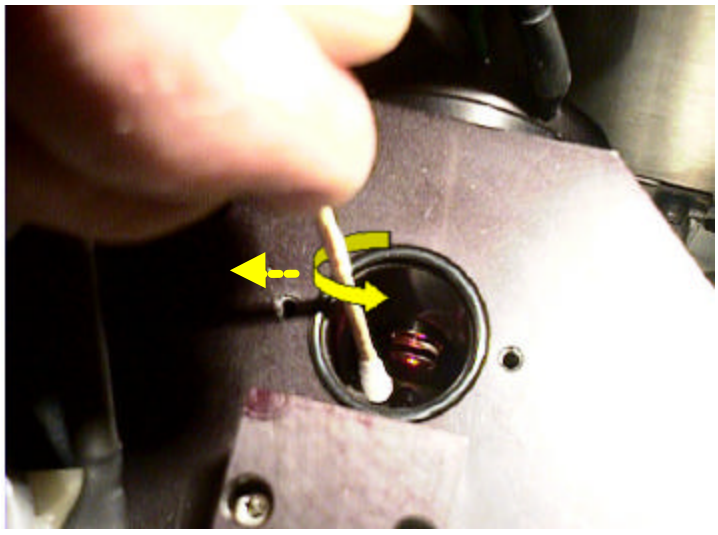
HeNe Cleaning Procedure

Brewster Window Cleaning Technique



1. Wet a cotton swab with a generous amount of reagent grade acetone and scrub window
2. Wet a fresh swab with a very slight amount of reagent grade acetone and make a single swipe across the window
3. Repeat using a clean swab each time until you achieve the optimum cal voltage or resistance.

Laser Mirror Cleaning Technique



1. Wet a cotton swab with a generous amount of reagent grade acetone and scrub mirror
2. Wet a fresh swab with a very slight amount of reagent grade acetone and make a single swipe across the mirror
3. Repeat using a clean swab each time until you achieve the optimum cal voltage or resistance.

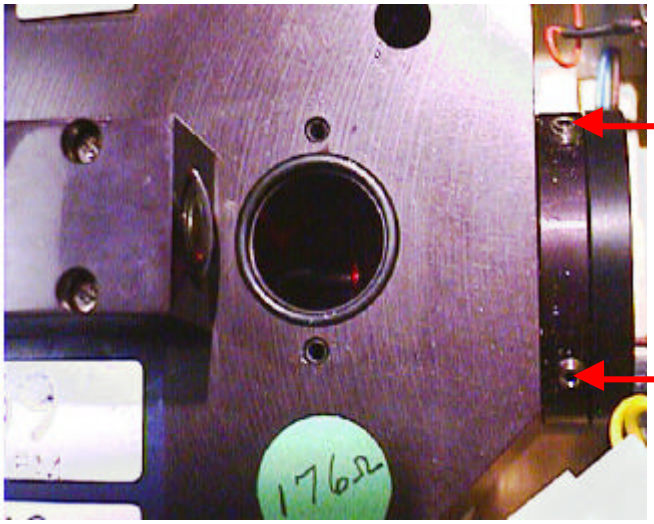
HeNe Cleaning Procedure

X-Y Axis Adjustment

If you are unable to achieve the desired resistance or voltage values using the cleaning procedure, you can adjust the X-Y alignment as follows:

Using a 3/32 or 5/64 inch hex wrench (*depending on sensor vintage*), adjust X axis **very slightly** in either direction and monitor voltage or resistance for optimum value. Repeat this process for the Y-axis as well.

CAUTION: If you adjust either axis too far, the laser will stop lasing and the entire unit will need to be returned to the factory for re-alignment.



X-Axis

Y-Axis

Laser Diode Sensor Cleaning

CAUTION

Take care in noting orientation of collection lens assembly before removing from housing. The assembly must be reinstalled correctly for proper operation.

CAUTION

Do not remove the "Warranty Void if Broken" stickers that cover the setscrews located on several sensor assemblies. Any movement of lenses in the collection lens housing will damage critical focus parameters, ruining sensor calibration.

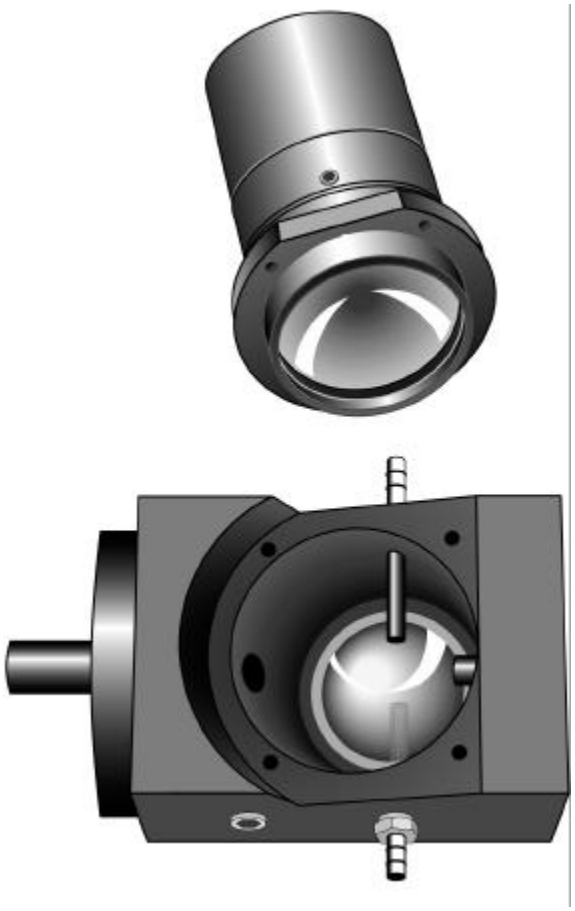
Never put fluids into the sensor inlet fitting. Fluids will damage the sensor.

Cleaning 70° Laser Diode Sensors

WARNING

On AC-powered counters, removing covers before turning power off creates a risk of severe electrical shock. Removing collection lens assembly before turning power off can quickly cause blindness.

1. Turn counter power off then remove sensor from counter chassis.
2. Using ball driver, remove four Allen-head screws securing collection lens assembly to main optics housing.
3. Carefully remove collection lens assembly from main optics housing noting position of assembly in housing.
4. While holding collection lens assembly, clean exposed lens with medical-grade cotton applicator wetted with reagent-grade alcohol.
5. Clean reflector located inside optics housing with another applicator wetted with alcohol.
6. Slide lens assembly into main optics housing and attach with four Allen screws.
7. Install sensor in counter.



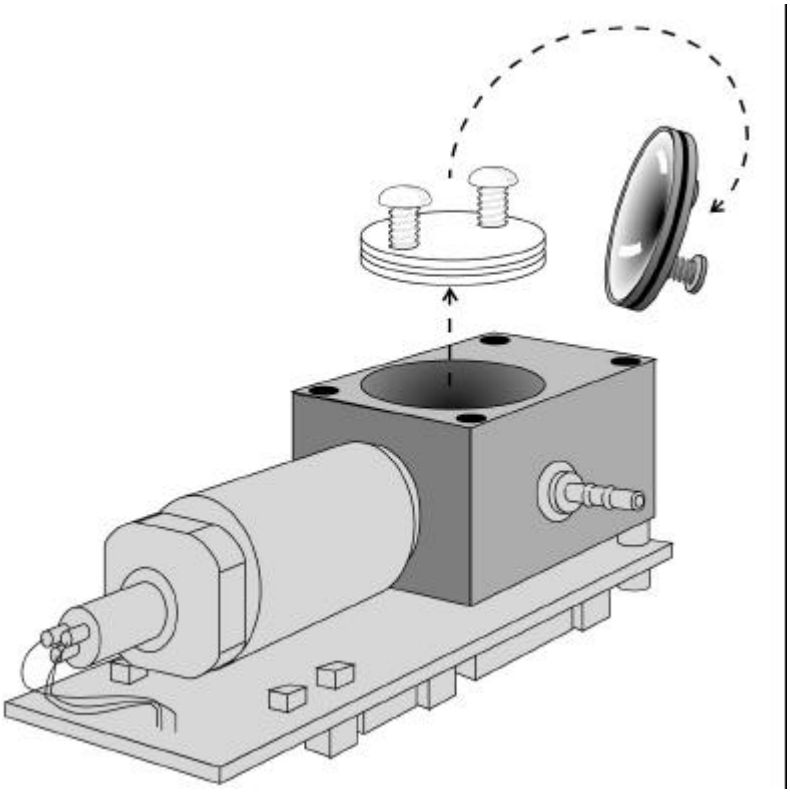
Laser Diode Sensor Cleaning

Cleaning Laser-Diode 90° Mini-Sensors

WARNING

Removing collection lens assembly before turning power off can quickly cause blindness.

1. Turn counter power off then remove sensor from counter chassis.
2. Screw in two 2-56×3/4-inch machine screws into holes in the sensor reflector.
3. Using the two screws as handles, pull reflector outward while twisting slightly.
4. Clean the reflector with medical-grade cotton applicator wetted with reagent-grade alcohol. Clean the lens located inside the housing with another applicator wetted with alcohol.
5. Insert reflector into sensor housing with a slight twisting motion until reflector bottoms out. Remove two 2-56×3/4-inch screws.
6. Re-install sensor by following in reverse order steps 1 through 3 above; attach two connectors to main board. Be sure to place nylon washers between sensor and chassis.



Caution

Take care not to touch the laser driver board; the laser diode is extremely static sensitive.

Make sure when installing sensor into the counter, the nylon washers are placed between sensor and chassis.

Returning Counters For Service

Pacific Scientific Instruments has complete technical facilities for complete testing and troubleshooting of your particle counter. Due to the unique interaction between the particle detecting sensor and the electronics that convert detected particle pulses to a displayed count, special troubleshooting techniques are often required.

Preventive maintenance through periodic cleaning and servicing is recommended to keep problems to a minimum. For recommended frequency of maintenance, see the Maintenance Schedule table in Chapter 2. All types of servicing including calibration are available at the factory, as well as Service Contract Agreements that provide for annual cleaning and calibration of your particle counter at a fixed price. Contact our Technical Support department for additional information.

If the counter is to be returned to the factory or a field service center for service or calibration, you must obtain a Return Authorization number. Contact Customer Service for a return number. Place the return number on all shipping documentation and purchase orders.

After receipt of the number, follow these shipping instructions:

1. Use the original container and packing materials whenever possible.
2. If the original container and packing materials are not available, wrap the unit in “bubble pack” plastic; surround with shock-absorbent material and place in a double-wall carton.
3. Seal container or carton securely. Mark “Fragile” and write Return Authorization number in any unmarked corner.
4. Ship the counter to the address shown below or to the designated Service Center address you are given when you call for an RA number.

Pacific Scientific Instruments
481 California Avenue
Grants Pass, OR 97526

Phone: 541-479-1248
Toll Free: 800-866-7889
Fax: 541-474-7414
On-line: www.pacsciinst.com

Remote Operation

This chapter describes particle counter operation using a computer to control the count cycles and then read and process the data. To do this the computer must have an asynchronous serial port and both computer and counter must have the correct serial cable and have compatible communication modes and baud rates.

You can also use a computer to control more than one particle counter. To do this, proper interconnections must be made and correct select codes must be set. Refer to “Multiple Counter Installation” on following pages. A command and data syntax list provides the counter control commands and expected responses from the counter.

The following sections provide the technical information that is required for Remote Operation:

- Preparing for Remote Operation—describes setting up the counter and hardware for remote operation.
- Communication syntax—lists the counter commands and describes the command and data responses.

Note
In this section, assumption is made that you understand front-panel operation of the counter, operation of your computer, and serial data buses.

Preparing For Remote Operation

Note:
When the serial cable is attached between the counter and computer, and Remote Mode has been selected on the counter (some counters receive a “device select” code from the computer to initialize remote mode), normal front panel operation is not possible. To restore front-panel operation, turn the counter off, remove the serial cable and turn the counter on (on some counters you must also select local mode).

Note:
The most common counter settings are 9600, N, 8, 1:

9600 Baud Rate
No parity
8 Data bits
1 Stop Bit

Set the counter for computer operation using following procedure:

1. Verify the serial cable is compatible with all equipment. Refer to the Operating Guide you received with your counter for a serial cable diagram.
2. Set the counter communication mode and baud rate to match the computer. Refer to the Operating Guide for instructions.
3. If you are using multiple counters, assign a device number (or location number) to each counter as described in the Operating Guide.
4. For single counter systems, connect the computer serial port and counter “SERIAL I/O” port together with appropriate serial cable.
5. For multiple counter applications, set a different counter select code for each counter (refer to Operating Guide) then connect the counters per the instructions given in “Multiple Counter Installation” below.

Multiple Counter Installation

All counters feature serial RS-485 data communication for multiple counter operation. RS-485 serial network circuitry provides asynchronous communications between up to 32 counters and a controlling computer. The host computer controls activity on the serial link using protocol that is compatible with systems supplied by Pacific Scientific Instruments. Since RS-485-type shielded, twisted-pair cable is used, only one station can transmit at a time. This is accomplished when the computer sends a select code to make one counter actively communicate. It is a requirement of the system that each station have a unique select code. These select codes (known by different names in different instruments: counter select number, unit ID number, device number, location number) must be set during the installation. Refer to your particle counter Operating Guide for entering the select code. A remote counter will echo the valid select character, while no response indicates an invalid select character. The echo is delayed 20 milliseconds to allow the computer time to return to receive state. Once a station is made active, half duplex communication begins between the host and the counter, whereby the computer may download the counter’s data or initiate a change to the operating state. An active counter will remain active until the computer de-activates it by sending a select code not addressing the current active station. Several methods are available for connecting ("daisy-chaining") multiple counters together. If the application calls for remote counter(s) in different rooms, wall plates can be used for interconnection. For connecting counters together in the same room, an RS-485 network adapter can be used that plugs directly into the

Preparing For Remote Operation

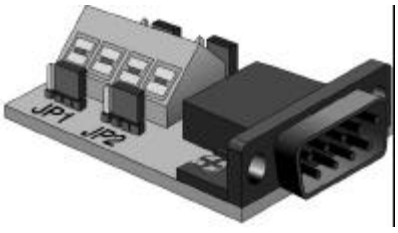
serial connector on the counter. Either method allows for access to each counter by "daisy-chaining" from one counter to the next.

Hardware Setup Using Wall Plates
Wall plates are available in several configurations (dash numbers). The connector in the wall plate can be a 9-pin type or 15-pin type with a vacuum quick-disconnect fitting. To accommodate multiple counter (RS-485) networking, you may need some of the following equipment:

- ❑ RS-232/RS-485 converter — changes typical RS-232 serial output of computers to RS-485 for networking purposes
- ❑ Termination module — as a network termination circuit
- ❑ Wire, shielded, twisted pair (e.g., Belden PN 9841) — for wiring between wall plate (or RS-485 adapter) and RS-232/RS-485 converter
- ❑ Power source — for use with counters without built-in power supply
- ❑ Wall plate or RS-485 adapter — for connecting counter to computer

Prepare for multiple counter operation by performing the steps below and by using figure 4-2 on following page:

1. Place counters in desired locations.
2. If using wall plates, verify the number of pins in the wall plate connector matches the number in your counter's serial port then install plates at the counter locations using standard construction methods.
3. Connect shielded, twisted-pair cable to male plug of the RS-232/RS-485 converter as shown in figure 4-2.
4. Connect other end of twisted-pair cable in step 3 to first wall plate and then to remaining wall plates (up to a total of 32). Install a termination module to the *last* wall plate between pin 6 and 8 of DB-15 connector (pins 8 and 9 if a DB-9 connector).
5. If your counter does not have a built-in power supply, connect shielded twisted-pair cable from de-energized power source to each wall plate as shown in figure 4-2.
6. Prepare braided shield of both twisted pair of wires (signal and power) at each wall plate and attach to pin 13 of DB-15 connector (pin 7 if a DB-9 connector).
7. Connect counter to wall plate using a signal cable.



RS-485 Network Adapter

DB9 wall plate

DB15 wall plate

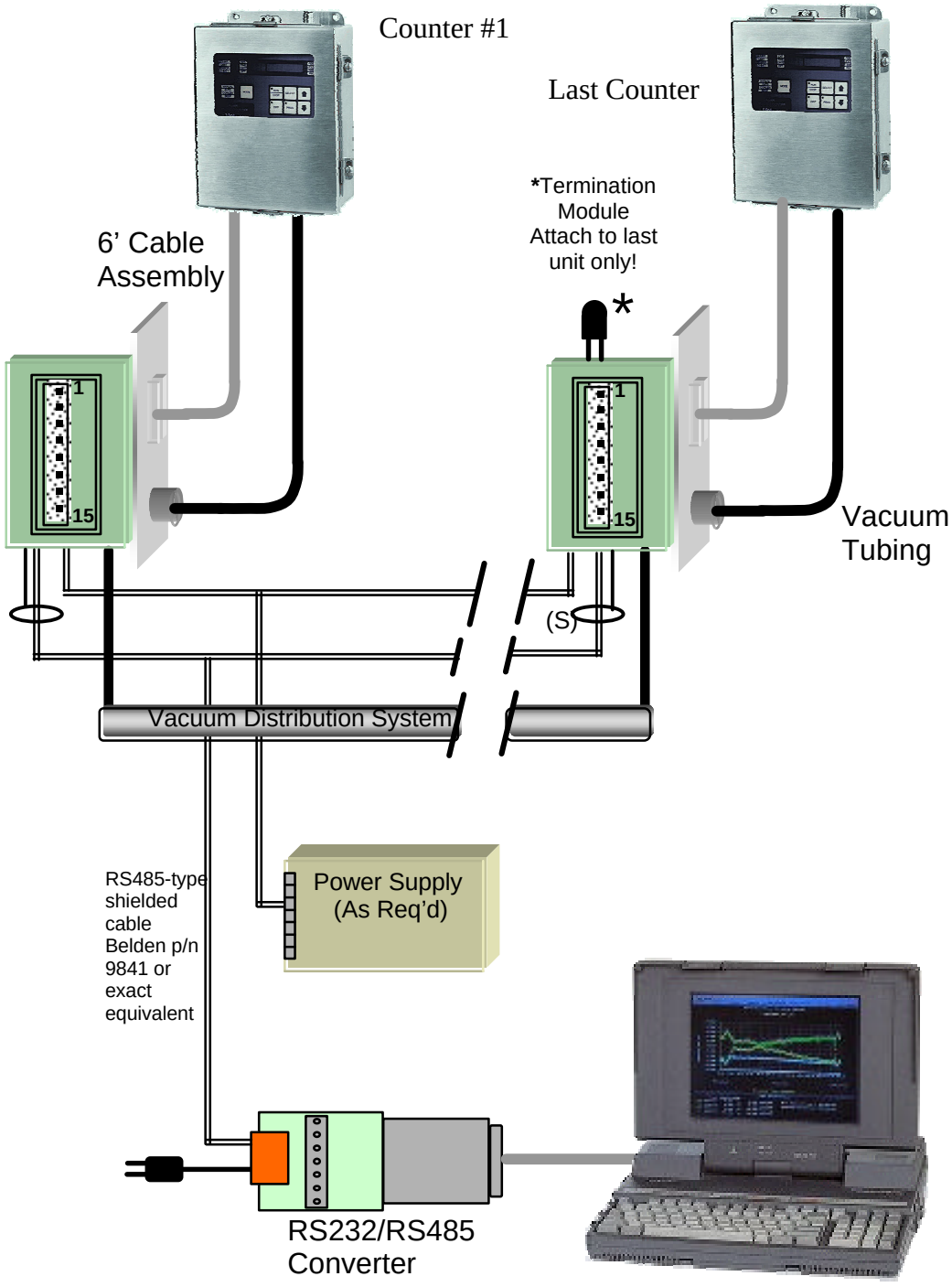
Remote Operation Setup

DB9 Wall Plate Pinout

1	DC Common
2	RS232
3	RS232
4	RS232
5	RS232
6	+5VDC
7	Shield Gnd
8	RS485A
9	RS485B

DB 15 Wall Plate connector Pinout:

1	DC common
2	n/c
3	n/c
4	n/c
5	n/c
6	RS485A
7	n/c
8	RS485B
9	(reserved)
10	(reserved)
11	(reserved)
12	(reserved)
13	Ground
14	(reserved)
15	+V Power



Communication Syntax

Command and Data Syntax

The counter responds to ASCII commands and sends a data record that varies in length based on content. The command and data syntax is defined below.
The following ASCII commands are supported by your counter and are case-sensitive (lowercase letter is a different command from an uppercase letter).

REQUEST FOR DATA Commands:
"**A**" **Send Buffered Record**—The next data record in the rotating buffer will be sent. When the rotating buffer is empty, a “#” will be sent. Each record is erased from the buffer as it is sent. A record of the most recent count cycle will always be sent first. If no count cycles have been completed since the counter was turned on, then a "#" will be sent. The record cannot be sent until the current count cycle is complete.
"**B**" **Send Current Record**—The data record of the most recent sample period will be sent. Thereafter, if no new sample period has been completed, a “#” character will be sent. The rotating buffer is unaffected.
"**C**" **Clear Buffer**—Contents of the rotating buffer will be erased.
"**D**" **Number of Records**—The counter will send the number of records in the rotating buffer terminated by a carriage return and line feed. The number of records returned is varying length, no leading zeros, and has no limit. If no data records are available, a “0” will be returned (D0<cr><lf>).
"**E**" **EPROM Revision**—The counter will send the EPROM number and latest revision. The format field lengths can vary, and is terminated by a carriage return and line feed.
"**H**" **Hold Time**—When an upper case “H” followed by a carriage return and line feed are sent, the counter will display the current Hold Time terminated by a "carriage return" plus "line feed" (<cr><lf>). Hold time will be in a format of HHMMSS (hours, min., sec.). To program hold time, enter upper case "H" followed by only relevant time information. Use the form of HHMMSS (hours, min., sec.), terminated by (<cr><lf>). Do not enter leading zeros.
"**L**" **Sample Period**—When an upper case “L” followed by a carriage return and line feed are sent, the counter will display the current Sample Period terminated by a carriage return line feed (<cr><lf>). Sample period will be in a format of HHMMSS (hours, min., sec.). To program sample period, enter upper case "L" followed by only relevant time information. Use the form of HHMMSS (hours, min., sec.), terminated by (<cr><lf>). Do not enter leading zeros.

Communication Syntax

"**M**" **Mode Request**—The counter will send its present mode. If counting, a “C” will be sent. If holding, an “H” will be sent. If stopped, an “S” will be sent.
"**R**" **Retransmit Record**—The last record sent will be retransmitted. The buffer will not be cleared. If there is no record to retransmit, a # following the echoed command will be sent.
"**T**" **Identify Model**—The counter will send an alphanumeric data string name label terminated by a carriage return and line feed. The “Name Label” field can vary in length.
"**U**" **Universal Device Select**—The counter will be placed in the "remote" mode, and will respond to all commands after receiving this command, regardless of which select code is programmed into the counter.
"**V**" **Protocol Version**—The counter will send an alpha data string terminated by a carriage return and line feed. The “Protocol Version” field will contain FX (enhanced Standard FIX Protocol).

ACTION Commands:
"**128-191**" **Device Select**—The counter will respond to all subsequent commands when a number is sent that matches its select code. The counter is deselected (made unresponsive to computer commands) by selecting another counter, i.e. sending a number between 128 (corresponding to Loc = 0) and 191 (corresponding to Loc = 63) that does not equal the counter’s select code. To send a number, press and hold <Alt> key then enter number.
"**a**" **Auto**—When the “d” command is used, the counter will count in the auto mode.
"**b**" **Manual**—When the “d” command is used, the counter will count in the manual mode.
"**c**" **Start Counting** (computer controlled)—The counter will begin counting without waiting for an even second boundary (immediate start). Counting will continue until stopped by the computer. The count cycle should be controlled by the computer.
"**d**" **Start Counting** (counter controlled)—The counter will begin counting on an even second boundary (using internal clock; not in the middle of a second) and control the count cycle based on the front-panel setting for the period (sample time).
"**e**" **Stop Counting**—The counter will immediately stop counting without waiting for an even second boundary.
"**g**" **Active Mode**—This device will enter a mode that prepares it for counting. For example, the air pump will turn on to purge the air path, and the sensor's laser will turn on.
"**h**" **Standby Mode**—The device will enter a mode that will turn off air pumps and shut down laser sensors to conserve power or reduce equipment wear, if applicable. Only this command can turn off the pump and laser.

Communication Syntax

UNIVERSAL ACTION Commands:
"**ua**" **Universal Auto Sample Mode**—Puts the counter(s) in the "Auto" count mode. When the "ud" command is used, the device(s) will count in the auto mode. Auto mode causes the device(s) to continuously cycle through their own Sample and Hold period settings. This command is not echoed.
"**ub**" **Universal Manual Sample Mode**—Places the counter(s) in the "Manual" count mode. When the "ud" command is used, the device(s) will count in the manual mode. Manual mode causes the device(s) to cycle through their own Sample period once. This command is not echoed.
"**uC**" **Universal Clear Buffer**—The contents of the buffer will be erased. This command is not echoed.
"**uc**" **Universal Auto Sample Mode**—The counter(s) will start counting in either pre-selected counting mode (Auto, Manual). This command is not echoed. The device will start counting without waiting for an even second boundary (quick start). Counting will continue until stopped by the computer. The count cycle the computer will control time.
"**ud**" **Universal Start Count**—The counter(s) will start counting in either of the two preselected counting modes (Auto or Manual). This command is not echoed.
"**ue**" **Universal Stop Count**—The counter(s) will stop counting and will build a data record. This command is not echoed.
"**ug**" **Universal Active Mode**—The counter(s) will enter a mode that prepares it for counting. For example, the air pump will turn on to purge the air path, and sensor's laser will turn on. This command is not echoed.
"**uh**" **Universal Standby Mode**—The counter(s) will enter a mode that will turn off air pumps and shut down laser sensors to conserve power or reduce equipment wear, if applicable. Only this command can turn off the pump and laser. This command is not echoed.

Command Responses

The counter will respond to all commands and select codes by sending the command character back to the computer. If the counter does not recognize a command, it will send a "?" character back to the computer. If the computer is asking for a record from an empty buffer, the counter will send a "#" character. If the computer is asking for a record that has already been sent, the counter will send a "#" character unless the computer uses the Re-transmit Record command.
If the counter's serial communication mode sets parity and there is a parity or framing error, the counter will not send any command characters back to the computer.

Communication Syntax

Data

Each counter can send a record of its data. The data record is a string of ASCII characters where the position in the string identifies the character's meaning. The length of the string changes with the amount of data points available from the counter. Each data point is preceded by a three-character tag that identifies the type of data that follows in the next six data characters. In the following example, the bold characters comprise a data record and the non-bold words describe the meaning of the characters. The following is an example to show the serial communications format:

> Note:
> The number of environmental sensors connected to your particle counter and number of particle size ranges in your counter will determine the number of data points that appear in the data record.

$ 081792 083916 0130 0.3 006351 0.5 000034 0.7 000021
Status Date Time Period tag- data tag-data tag–data

1.0 000015 2.0 000007 5.0 000002 TMP 000741 R/H 000563 FLO 000100
tag- data tag-data tag–data tag- data tag-data tag–data

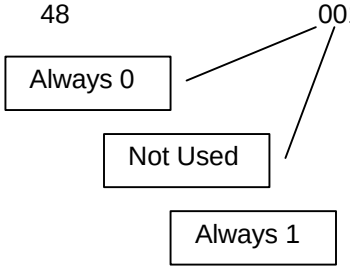
LOC 000022 C/S 00144B (CRLF*)
Location # checksum end

Status: When translated to a binary byte, this character will indicate the status of the counter. As shown in the table on the next page, the ASCII character "$" has a decimal value of 36, which when converted to a binary byte, sets the third and sixth (always 1) bits. Bit 0 is considered the first bit. The ASCII character "$" translates to a status byte that is indicating a "Count Alarm" (see shaded line in table).

> Note:
> In this example, ASCII character "$" translates to a status of "count alarm". If an ASCII character appears in your data record string that is not shown here, contact the factory for updated information.

ASCII Character	Meaning	Decimal Equivalent	Binary Equivalent (bit 76543210)
(blank space)	no alarms	32	00100000
!	calibrate failure	33	00100001
"	low battery*	34	00100010
#	cal. fail, low batt.*	35	00100011
$	**alarm/count alarm**	**36**	**00100100**
%	cal. fail and alarm	37	00100101
&	low batt.* and alarm	38	00100110
'	cal. fail, low batt.*, and alarm	39	00100111
(	manifold home error (if manifold is an option)	40	00101000
0	analog alarm (on some later models)	48	00110000

* = portable units



Communication Syntax

Date: Date information is carried in the 3rd through 8th characters of the record. The second character is always a space (separates the status character from the date characters. The date is arranged as MMDDYY (Month Day Year). In the example on the previous page, the date is August 17, 1992. This is the day the counter collected data in the record.

Time: Time information is carried in the 10th through the 15th characters of the record. The 9th character is always a space, to separate the date from the time. The time is arranged as HHMMSS (Hours Minutes Seconds) military time. In the example, the time is 8:39 AM and 16 seconds.

Period: The period is the sample time, or the length of counting time. Period information is carried in the 17th through 20th characters. The 16th character is always a space, to separate the time from the period. The period is presented in minutes and seconds. In the example above the period was 0130 or 1 minute and 30 seconds. When the period is controlled by the computer (c command), the period characters will be zeros. When the period (sample time) is controlled by the counter (d command), the period characters will represent the sample time.

Tags:

The tags contain three characters that identify the type of data that will follow. If the data is a particle count, the tag will indicate the particle size. In the example, the first two tags indicate that particle count data follows for the 0.3 and 0.5 micron particle size ranges. If the data is relative humidity or temperature readings, the tag will indicate this with the appropriate characters. For example, the seventh tag indicates temperature data will follow and the eighth tag indicates that relative humidity data will follow.

Data: These elements contain data from the different counter channels and sensors. Each data value is six characters long and is preceded by a 3-character tag that identifies the type of data that follow. The tags and data are each preceded by a space character for separation. Up to 11 data elements can appear in the data record depending on the number of particle size ranges (up to six) and how many environmental sensors are connected to the counter. The data record will be in the following units of measure:

Particle Counts	Counts
Temperature	°F (or optional °C)
Relative Humidity	%
Air Velocity	f/m (or mm/sec) (does not apply to all counters)
Flow Rate	% of nominal (does not apply to all counters)
Differential Press.	Inches of H_2O (does not apply to all counters)

Communication Syntax

Location: Gives manifold station number to which the count data applies (does not apply to all counters).
Checksum: Always the last data element in the record, the sum of the ASCII value of each character in the data string. Used for testing accuracy of the data transmission.
End of Message: The end of message characters will immediately follow the last tag/data element with no separating space. The “end of message” characters are a carriage return and line feed.

Appendix A
Manual Backdating

This section contains Manual Backdating information that highlights the changes that have been made to the original Particle Counters for Air manual. The changes listed below cover procedures or pictures of obsolete counters or subassemblies and are for historical purposes only. Changes came about due to overall improvements to the airborne particle counter line. The data contained herein should provide you with helpful information if you have an older-version airborne particle counter. The changes to the original manual are summarized below:

- Carbon-vane pumps — tells how to replace the vanes in 1 cfm and 2 cfm pumps
- Sensors — shows some of the older sensors
- Cleaning the sensor — shows access when cleaning older sensors (procedures remain the same)
- Inside chassis cleaning — tells how to clean older chassis
- RS-232 to RS-485 converter — shows older configuration

Obsolete Pumps

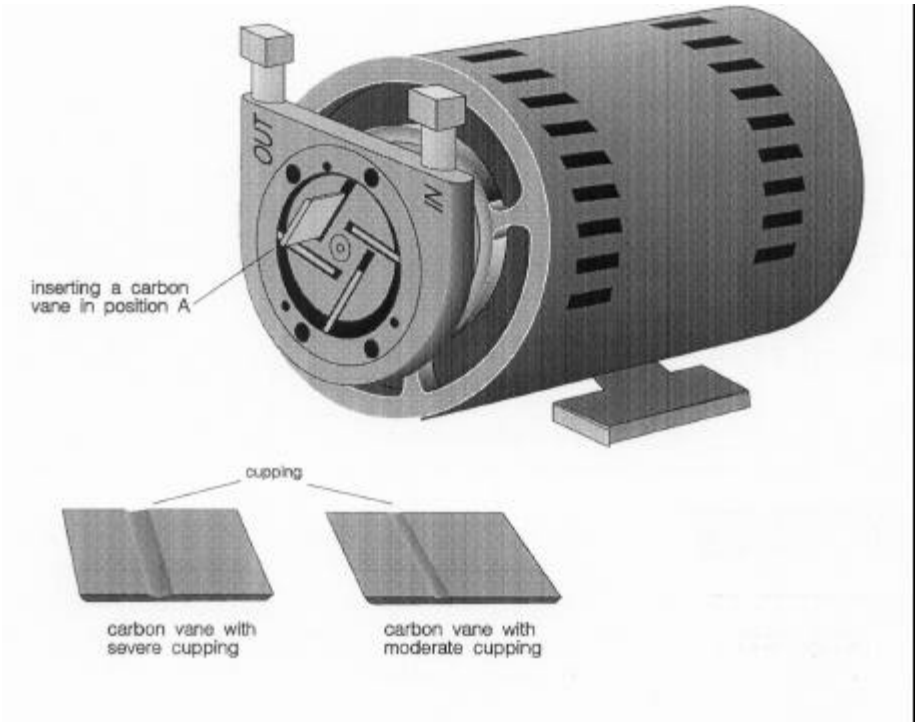
Pump Vane Inspection

(Carbon Vane Types)

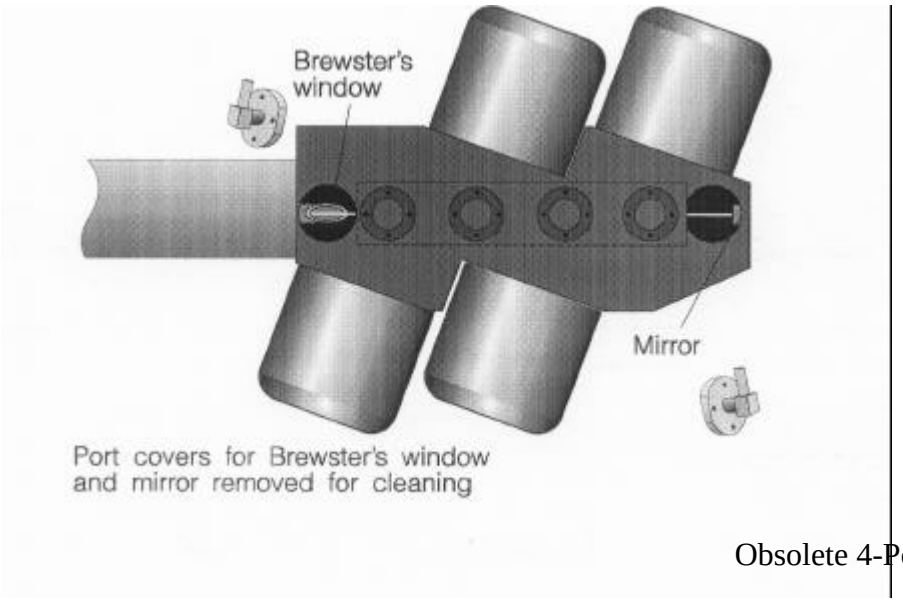
Inspecting the pump vanes protects against vane breakage due to excessive wear. A broken or loose pump vane can lodge in the motor causing the motor to seize and halting particle counting operations. Sometimes the fuse will also blow. Inspect (and replace if necessary) pump vanes as follows:

1. Remove air pump.
2. Turn metal outlet tubing (including bottle filter) counterclockwise until pump end plate can be removed.
3. Unscrew Allen screws; remove end plate and carbon disk.
4. Without removing vanes, inspect for less than 1/4-inch clearance with vane in position A.
5. While carefully noting orientation within slots, remove vanes from slots.
6. Check vanes for “cupping” (wear marks on sides of vane). If vanes show signs of cupping or have more than 1/4-inch clearance (step 4), install new vanes.
7. If vanes are still good, replace them in exactly the same orientation. Then replace carbon disk and end plate.
8. Reposition metal outlet tubing and bottle filter. Reinstall pump and tubing.

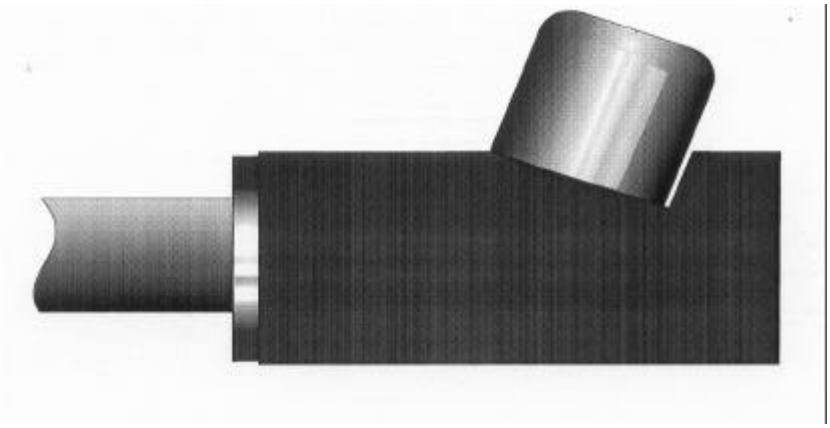
1 and 2 cfm models
Carbon-vane 115V/220V, 2.4 amps (2 cfm); 1.4 amps (1 cfm) Front- or rear-panel adjustable flow rate.



Obsolete HeNe Laser Sensors

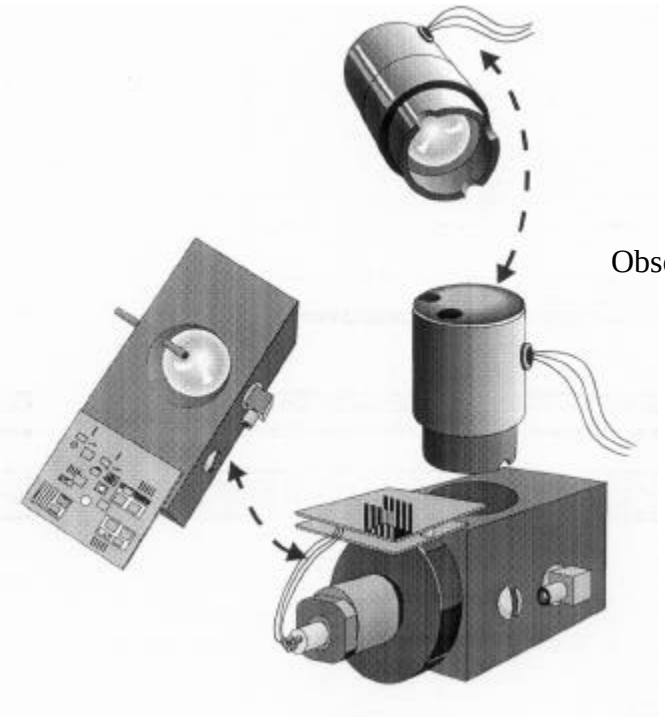


Obsolete 4-Port HeNe Sensor

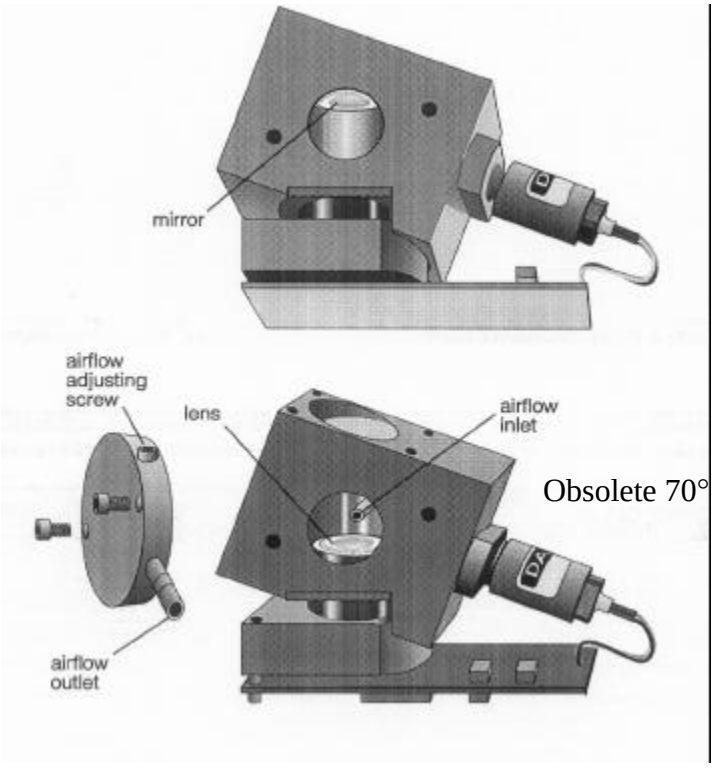


Obsolete Single Port HeNe Sensor

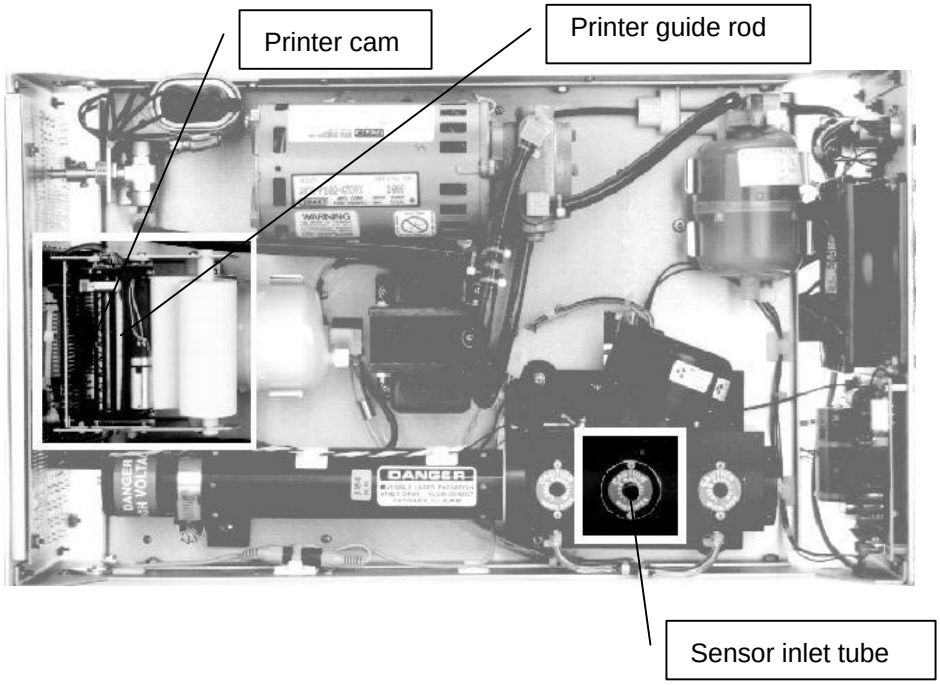
Obsolete Laser Diode Sensors



Obsolete 90° Sensor



Obsolete 70° mini sensor



CAUTION

Do not put any lubricants or cleaners on printer guide-rod or cam. Damage to printer may result.

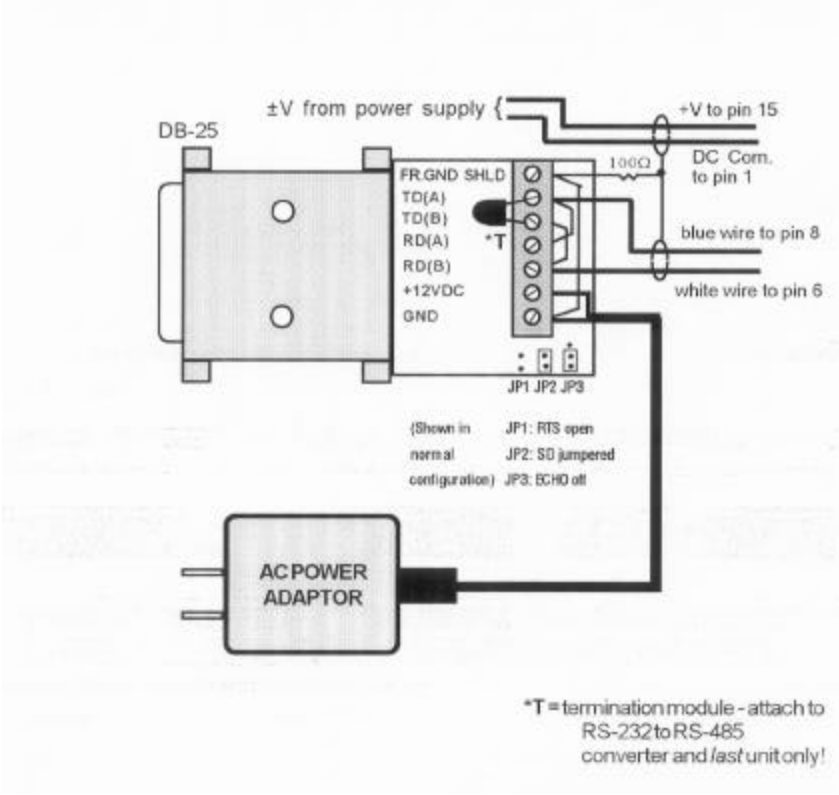
WARNING

Failure to unplug counter and then touching internal parts can result in severe electrical shock.

Internal Chassis Cleaning of Older Units

1. Turn counter off then unplug counter.
2. Remove top cover. The cover is attached with screws on each side of counter.
3. Cap sensor inlet tube(s). Using compressed nitrogen, at less than 25 lbs/square inch, blow contaminants and dust from counter. Clean both top and bottom of chassis.
4. Clean printer with compressed nitrogen. Gently remove any strings.
5. Check all tubing for cracks, kinks, or loose fittings. Replace tubing as required.
6. Observe outlet filter(s). It should be white or gray (except for the large 0.1 micron units which have a long black carbon filter).
7. Check filter in air vacuum pumps as described in "Pump Filter Inspection" procedure in Section 3.
8. If your counter is equipped with an external HEPA filter (built-in ULPA filter in some counters), visually inspect the filter for damage such as cracks or holes. Replace filter if damaged. To test for filter "leaks", place counter in a unidirectional flow zone then with isokinetic probe, use your counter to test for particles.

Original RS-232 to RS-485 Converter



Second Generation RS-232 to RS-485 Converter