

Model 2400 Model 2408 Laser Particle Counter

Operating Guide



Major revisions of this manual are 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" at the back of this manual. Pacific Scientific Instruments is not liable for personal, property, or financial damages resulting out of the use of this product or the material contained in this manual.

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Safety

Safety Considerations

Warnings and cautions are used throughout this manual. Familiarize yourself with the meaning of a warning and a caution before operating the particle counter. A warning appears before the procedure or step to which it applies. A caution appears in the narrow column and next to the step to which it applies. Take extreme care when doing any procedures preceded by or containing a warning.

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 or possibly death. A WARNING appears directly above the step to which it applies. Do not proceed beyond a WARNING until the indicated conditions are fully understood and met.

CAUTION

A CAUTION indicates a hazard for the particle counter. It calls attention to a procedure which, if not correctly performed or adhered to, could result in damage to the counter. A CAUTION appears in the column to the left or right of the step to which it applies. Do not proceed beyond a CAUTION symbol until the indicated conditions are fully understood and met.

Note

A Note highlights an important operating procedure or other important information not involving safety of equipment or personnel.

Additional safety information is contained in the "Particle Counters For Air" manual.

There are several classifications of Warnings defined as follows:

- Laser — pertaining to exposure to visible or invisible laser radiation
- Electrical and Electrostatic — pertaining to electrical shock and to static hazards

Laser Safety Information

This Model 2400 / 2408 particle counter contains a laser-based sensor that 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. The manual contains no procedures for service of internal parts within this unit. Service should be performed only by factory-authorized personnel.


The particle counter has 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".

WARNING

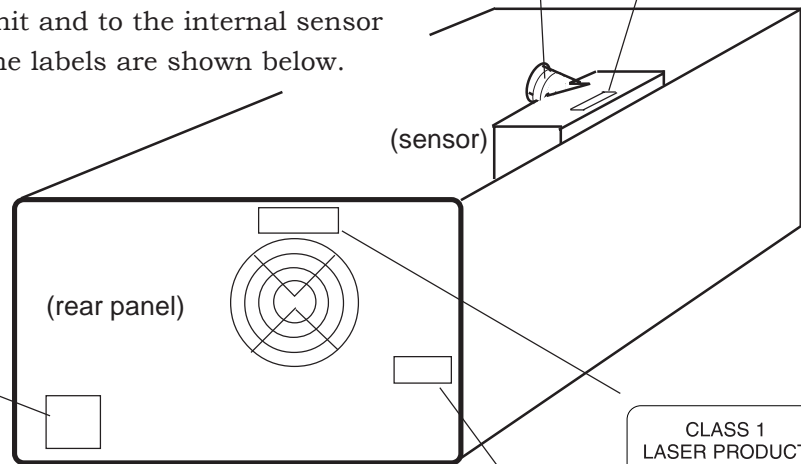
The use of controls, adjustments, or performance of procedures other than those specified within this manual may result in exposure to invisible (infrared) radiation that can quickly cause blindness.

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

MODEL	2408-1-115-1
P/N	2082784-01
MFG DT	APRIL 1997
S/N	970230248
OPTION	
VOLTS	115V~1A. 50/60HZ
SIZES	0.5µM
FLOW	1 CFM



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



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

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



**CLASS 1
LASER PRODUCT**
IEC 825-1 1993



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

Additional safety information is contained in the "Particle Counters For Air" manual you also received. For further technical assistance, contact our Customer Service Department at the location shown on the back cover of this manual.

Safety

Electrical Safety Information

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 power supply inside the unit for your awareness. Reproductions of the label is shown below:

**DANGER
HIGH VOLTAGE**

Electrostatic Safety Information

Electrostatic discharge (ESD) can damage or destroy electronic components. Therefore, all work inside the particle counter should be done at a static-safe work station. A static-safe work station can be created by doing the following:

- 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.

This operating guide describes how to use the Model 2400/2408 Particle Counter. Together, this operating guide and the “Particle Counters for Air” manual provide complete operating, application, and maintenance information for the particle counter. Any changes of instrument operation due to design changes are covered at the back of this guide.

The 2400/2408 can be ordered with two, four, five, or six particle-size ranges and a built-in printer (standard configuration). It meets requirements for a light scattering automatic particle counter as described in Japanese Industrial Standard JIS B 9921. A microprocessor controls all instrument functions. Count data is displayed as cumulative count or differential count. A model 2408 counter, for example, could have 0.5 micron sensitivity and six particle size ranges of 0.5, 1, 2, 3, 5, 10 microns. A model 2400 counter could have 0.3 micron sensitivity and six particle size ranges of 0.3, 0.5, 1, 3, 5, 10 microns.

The counter uses a laser-diode light source and collection optics for particle detection. Particles scatter light from the laser diode. Collection optics focus the light onto a photo diode that converts the bursts of light into electrical pulses. The pulse height is proportional to particle size. Pulses are counted and their amplitude is measured for particle sizing. Results are displayed as particle counts in the specified size range.



Figure 1. The 2408 Laser Particle Counter

Unpacking and Initial Inspection

The particle counter is thoroughly inspected and tested at the factory and is ready for use upon receipt. When received, inspect the shipping carton for damage. If the carton is damaged, notify the carrier and save the carton for carrier inspection. Inspect the counter for broken parts, scratches, dents, or other damage.

Introduction

Note:
Model 2400/2408 counters also support the 16-port Model 2431 manifold which is no longer manufactured.

Options

One of the two following options (*not both*) is available when you order your counter. The manifold is standard if no option is specified. The "configuration" feature can be installed at time of order or any time thereafter if you return your counter to the factory. See back cover of this manual for address and telephone number.

Manifold—The Model 2432 manifold (32 location) with controller allows the 2400/2408 to sample many different locations. The manifold routes the sample from each location to the 2400/2408 for analysis, one location at a time. This option and the "configuration" option are not both available simultaneously.

"Configuration"—The configuration capabilities option (see Generating a Configuration on following pages) allows the user to program up to 10 sets of count parameters (period, hold time, count alarm limit, etc.) in advance for quick setting of parameters. This option and the "manifold" option are not both available simultaneously.

Accessories

You can order several accessories to tailor the counter to your needs. These accessories can be either ordered from the factory during the week from 8:00 a.m. to 5:00 p.m. PST or from your local agent.

High Pressure Diffuser—connects to the sensor inlet tube. Permits direct sampling of pressurized air and nitrogen at pressures from 30 to 150 psi (2 to 10 Bar).

RH/Temp Probe—plugs into the counter rear panel. The probe monitors relative humidity (10% to 90%) and temperature (0 to 100 °F or -17 to +38°C). The results are displayed and printed.

Air Velocity Probe—plugs into the counter rear panel. The probe monitors air velocity from 10 to 200 feet/minute (3 to 60 meters/minute). The particle counter displays the reading of the probe.

Isokinetic Probe (provided with counter)—for use in unidirectional air flow to maximize correlation between counts and actual particle-size distribution. Can also be hand-held for spot location particle counting.

Purge Filter—attaches to sensor inlet; keeps external particles from contaminating sensor while purging sensor of internal particles.

Carrying Case—protects the counter during shipment and storage.

PortAll Software—when installed, automatically retrieves and stores count data from the rotating buffer of both airborne and liquid particle counters. PortAll does not work when the "Configuration" option is installed.

Your particle counter is ready to use directly out of the shipping carton. You may want to take a sample count prior to setting up the programmable functions. To count particles, proceed as follows:




WARNING

Do not attempt to sample reactive gases (such as hydrogen or oxygen) with the particle counter. Reactive gases create an explosion hazard in the counter. Contact the factory for more information.

1. Locate counter in a clean environment.
2. Plug ac power cord into facility power outlet; plug other end of cord into rear panel connector marked AC INPUT.
3. Remove red protective cap from the inlet tube (on top of counter). If using the isokinetic probe provided, install probe by connecting probe tubing to counter inlet tube.

WARNING

Exposure to infrared radiation may cause eye injury. Do not look into counter inlet tube while counter is on.

4. Set  on rear panel to 1 (on).
5. To start counting particles, press  key. The number on the display is the number of particles being counted. Check that the indicated flow rate is nominal. The flow is always in cfm unless "Concentration Mode or "ISO 14644 Calculations" is selected. To adjust airflow, see "Adjusting Airflow" on pages that follow.
6. Press  to stop counting. The total number of particles counted during the "run" time will be displayed.
7. (Optional) You may want to read "Front Panel Overview" on the next page to learn about the keys and displays that run your counter.

Using the Counter for the First Time

CAUTION

To prevent sensor damage, water, solvents, or other liquids of any type should never be put into the sensor via the inlet tube.

Never operate the counter with the inlet tube capped or plugged as damage can occur to the internal pump.

Front Panel Overview

Each front-panel key has a specific function. The keys are grouped into operating functions such as display field, modes, display/program, and printer. Some keys are used in conjunction with others. Some keys select the desired mode while others select functions to be set such as count alarm limits, particle size range, time, date, etc. In this subsection, you will learn the function of front-panel keys and displays of each group.

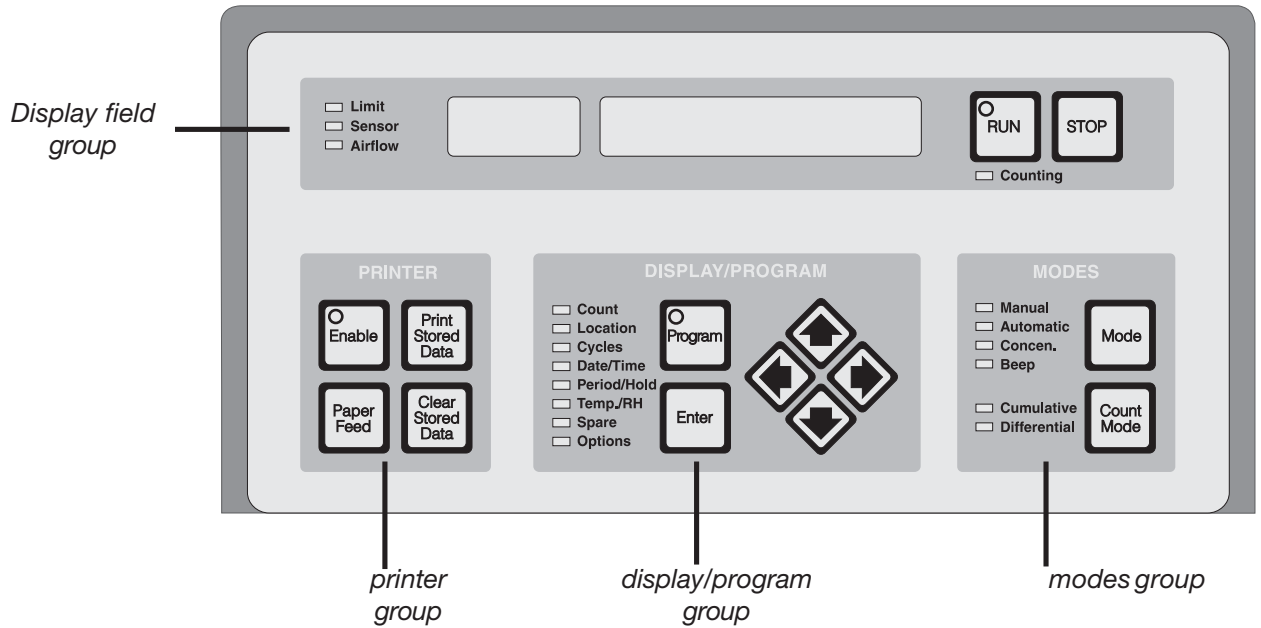


Figure 2. Front Panel Keys and Indicator Lights

Display Field Group



Starts the count cycle.



Stops the count cycle. (Infinite hold time when stopped.)



When on, indicates the counter is counting.



(Seven Digit Display) Displays total particle count, time-of-day, date, etc.



(Three Digit Display) Displays particle size range selected.



When flashing, indicates the programmed count and/or analog alarm limit has been surpassed.




When flashing, indicates either a failure of the laser diode electronics or contamination in the sensor.





When flashing, indicates airflow through sensor is high or low.

MODES Group



- 

Selects one of four operating modes: Manual, Auto, Concen. (concentration), or Beep.
- Manual

When on and  is pressed, the counter will count for one count cycle then turn off.
- Automatic

When on and  is pressed, the counter will repeat count and hold cycles for the programmed number of count cycles and then pump will turn off.
- Concen.

When on, the counter will calculate particle concentration in counts/ft³ (or counts/1000 liter) of air; display is updated once each second; the counter runs for programmed number of count cycles. The concentration value is saved as stored data.
- Beep



When on, the counter will give one beep when count alarm limit is reached, then beep once for every multiple of the limit; the counter runs until  is pressed.
- 



Selects differential or cumulative count mode for display.
- Cumulative

When on, the count readout being displayed is the total count of all particles of the size channel selected and larger.
- Differential

When on, the count readout being displayed is the count of particles only in the size channel selected.

DISPLAY/PROGRAM Group

-  or 

Selects what will be displayed in the seven-digit display: Count, Location, Cycles, Date/Time, Period/Hold, Temp./RH, Spare, or Options. Temp./RH will not come on if probe is not connected. Spare (containing air velocity probe information) will not come on if probe is not connected.
-  or 


Steps through or toggles between choices when a program has more than one selection (e.g., Count, Date/Time, and Options). Also changes digit value when in Program status.

Front Panel Overview



For entering the programming mode to set a limit (e.g., alarm limit), change a number (e.g., number of cycles to be taken), change date/time, or change an option; also displays the alarm limits of the selected size. The appropriate indicator light must be on to make a change within the program functions (description of indicators given below).



Saves to memory the new limit set during programming (see description of  above); exits program mode.



When on, indicates the particle size range is being displayed. This light must be on to program the count alarm limit of the displayed size range. When blinking, indicates a count alarm limit has been exceeded.



When on, indicates the location assigned to a test run is being displayed. This light must be on to select a new location.



When on, indicates the programmed number of count cycles to be taken is being displayed. This light must be on to program a new number of count cycles.



When on, indicates date or time of day is being displayed. This light must be on to change either function.



When on, indicates either the sample period or hold time is being displayed. This light must be on to program period or hold time.



When on, indicates current temperature or relative humidity is being displayed. This light must be on to program alarm limits; will not come on if environmental probe is not connected. When blinking, indicates the probe alarm limit has been exceeded.



When on, indicates air velocity is being displayed. This light must be on to program air velocity alarm limits; will not come on if probe is not connected. When blinking, indicates the probe alarm limit has been exceeded.



When on, indicates one of the available options is being displayed: **AFb** - turns audio feedback (beeper) on or off; **FLO** - gives flowrate through the counter; **bd** - selects baud rate; **UOL** - selectable units of volume between cu. ft. (CF) or liters (L)

Front Panel Overview

when in Concen. mode or when printing ISO 14644 calculations; **Prn** - selectable between:

ALL - when printer enabled, prints results
14644-1 - calculates and prints stored data as ISO 14644 calculations

ALr - prints results only if a count or analog alarm occurs.

PRINTER Group



Enables printer to print results of the choice selected in Options. The LED is a reminder the printer is enabled.



When printer is enabled, will print all the count cycles stored in the rotating buffer. Contents remain in the buffer.



When momentarily pressed, gives number of count cycles presently stored in the rotating buffer. When held down for more than two seconds, clears rotating buffer of its contents.





When printer is enabled, will advance paper.


Setting and Changing Functions

Note

For basic operation of the particle counter, refer to "Using the Counter for the First Time" on earlier pages.

To turn off the alarm, enter a limit value of 0 (zero) for all particle size ranges. To silence the alarm, press any key except  or . To hear one beep when the count limit is reached and at each multiple thereafter, select the beep mode.

Note

For any of the following programming functions, if the counter is in the run mode when it is turned on, press .

Operating functions of the counter (count alarm limits, period and hold times, etc.) are changed using front panel keys. You can also change some set-up functions (environmental probe limits, baud rate, etc.) via the front panel.
















Reference is made in the following procedures to digits of the front panel display. Refer to the following example for more digit information:

Procedures below provide step-by-step instructions to change all programmable functions.

Count (Alarm Limits)

An audible count alarm can be set to occur when the count exceeds any number. The range is from zero (turns alarm off) up to 9,999,999. Each particle size range may have a different count alarm limit. The alarm will sound as soon as any count alarm limit is exceeded. Set count alarm limits as follows:

1. Turn counter on; press .
2. Press  or  until Count  is on. Press  or  until size range of the limits to be changed appears.
3. Press  (program LED comes on); the current count alarm limit will be displayed and the smallest digit of the alarm limit will blink.
4. Press  or . The smallest digit of alarm limit will blink. Press  until digit requiring change is blinking.
5. Press  (or ) once to increment (or decrement) digit to the next value. To scroll, press and hold either arrow key.
6. To change another digit, press  then repeat step 5 above.
7. Press  to save changes and exit programming mode (Program LED is off).
8. To change count alarm limits for another particle size range, press  until desired size range is displayed then repeat steps 3 through 7 above.











Location (Number)

Any number from zero to 999 can be assigned to a location. You can assign a different number each time you change locations. The number will appear on the printout and as part of the stored data.

During remote operation, this number is also used as the device










Setting and Changing Functions

number (from 0 to 63). Refer to “Serial Port Protocol and Commands” for more information. Change location number as follows:






1. Press  or  until Location  is on. Current location number will appear on the readout display.
2. Press  (“ones” digit will blink) then press  (or ) once to increment (or decrement) digit to the next value. To scroll, press and hold either arrow key.
3. To change “tens” or “hundreds” digit, press  then press  to increment number. To scroll, press and hold  key.
4. Press  to save changes and exit programming mode (Program LED is off).








(Number of Count) Cycles

The number of count cycles is the number of times the counter will count then hold, count then hold, etc., before stopping. Up to 999 cycles can be made while in the Automatic mode. To repeat count cycles indefinitely, set the number to zero. Change the number of count cycles as follows:


1. Press  or  until Cycles  is on. The current number of count cycles programmed will appear on the readout display.
2. Press  (“ones” digit will blink) then press  (or ) to increment (or decrement) the number to the next value. To scroll, press and hold either arrow key.
3. To change “tens” or “hundreds” digit, press  then press  to increment number. To scroll, press and hold either key.
4. Press  to save changes and exit programming mode.

Date/Time




These parameters can be displayed while in either the run or stop mode by pressing  or  until the Date/Time  comes on then by pressing  or  to switch between date and time. To change date or time-of-day, perform the following steps:

1. Turn counter on; press .
2. Press  or  until Date/Time  is on. Current date will be displayed. The MMDDYY numerical format is used.
3. Press ; the month digits will blink. To advance to week or day digits, press .
4. To increment (or decrement) digits to the next value, press  (or


Note











Press  to start a new count cycle; display automatically goes to count and displays the last size selected.

Setting and Changing Functions

5. To change additional digits, press  and repeat step 4 above.
6. Press  to save changes and exit programming mode (Program LED is off).
7. To change time of day, press  then repeat steps 3 through 6 above for hours, minutes, and seconds.










Period/Hold (Time)

The period (sample time) is the length of time you want to sample air. Period can be set to any value from 0 (zero) up to (but not including) 24 hours. Hold time is the length of time between samples and can be set to any value from 1 second up to (but not including) 24 hours. If the period is set to 0 (zero), the counter will count indefinitely or until  is pressed. In the Manual mode the counter counts for the period (sample time) then stops. In the Automatic mode, the sample and hold cycles repeat for the number of times programmed under Cycles. The final count value will be displayed during the hold time. Change period or hold time as follows:

1. Turn counter on; press .
2. Press  or  until Period/Hold  is on. Existing period will be displayed in hours, minutes, and seconds. To change hold time, press  then go to step 3. To change period, go to step 3.
3. Press ; seconds digits will blink. To advance to minutes or hours digits, press .
4. To increment digits to the next value, press  once. To scroll, press and hold either arrow key.
5. To change additional digits, press  and repeat step 4, otherwise press  to save changes and exit programming mode (Program LED is off).

Turning Beeper On or Off (AFb)

The audible feedback system (beeper) can be turned on or off except for an environmental probe alarm. Turn beeper on or off as follows:










1. Press  or  until Options  is on then press  or  until **AFb** is displayed. The current status (on or off) of the beeper will appear on the readout display.
2. Press  (the status will blink) then press  or  to change to either OFF or ON.
3. Press  to save changes and exit programming mode (Program LED is off).

Setting and Changing Functions

Volume Units (UOL) for Concentration Mode and ISO 14644 Calculations










The concentration mode provides an estimation of the counts per cubic foot (CF) or counts per cubic meter (1 cubic meter = 1000 L).

Change from one set of units to another as follows:

1. Press  or  until Options  is on then press  or  until **UOL** is displayed. The current units (CF or 1000 L) will appear on the readout display.
2. Press  (existing units will blink) then press  or  to toggle to other choice.
3. Press  to save changes and exit programming mode (Program LED is off).







Baud Rate (bd)

The baud rate may be set to either 300, 1200, 2400, or 9600. Set baud rate as follows:

1. Press  or  until Options  is on then press  or  until **bd** is displayed. The current baud rate will appear on the readout display.
2. Press  (existing baud rate will blink) then press  or  to cycle through selections; stop when your choice is displayed.
3. Press  to save selection and exit programming mode (Program LED is off).

Adjusting Airflow (FLO)

Nominal airflow through the sensor is 1 (one) cfm. Airflow is monitored and adjusted during a count cycle only. Adjust airflow as follows:

1. Press  until Options  is on then press  or  until **FLO** is displayed.
2. Press  to start a count cycle. After airflow readout has stabilized, turn AIRFLOW ADJUST knob on rear panel for a reading of 1.00. Turning knob clockwise increases airflow.
3. Press  to stop the count cycle.

Note

You may want to set a period (sample time) of three minutes or more to give ample time for airflow adjustment.


Using Special Features

Note

One cfm means one cubic foot of air passes through the sensor in one minute.

After each second, the oldest period's count is deleted from the average and the newest is calculated into the average and the new result is displayed.





Note

The counter will count in this mode until  is pressed.

Your counter offers several special features for sampling air. The following procedures give detailed instructions for using these features.





Concentration (Concen.) Mode

This mode gives a quick (within seconds) calculation of the particle concentration. The mode averages the number of particles counted in one-second samples to give the calculation of count-per-cubic-foot (or count-per-cubic meter = 1000 L) of air. The displayed count is updated every second. Counting continues for the period and number of samples programmed in "Period/Hold" procedure. There is no computer serial interface capabilities while in this mode. If printer is enabled, concentration mode results are printed at the end of each count cycle. Results are also stored in memory and can be printed out at a later time.

1. Turn counter on; press .
2. Press  until Concen.  is on.
3. Select units (ft./min. or meters/min.) required for the concentration reading. Refer to "Volume Units (UOL) for Concentration Mode and ISO 14644 Calculations" procedure in this section to determine units currently programmed or to change units.
4. To start counting, press .






Audible (Beep) Mode

The beep mode changes the count alarm feature to a single audible sound (beep) once each time the count alarm limit is reached and then once again for every count multiple of the count limit. A beep will sound for each particle size range count limit. In order to focus attention on one particle size range, we suggest you set a limit for only the size range of interest and set the remaining ranges to zero (no alarm). The beep mode limits and count alarm limits are one and the same.

1. Press  until Beep  is on.
2. The count number that was set in the "Count Alarm Limits" procedure will be the number that applies also for the beep mode. To change when the audible sound occurs, perform "Setting Count (Alarm Limits)" procedure.
3. To begin sampling, press . Sampling will continue until  is pressed.

Count Cycles Average Calculations

Your counter will automatically calculate and print out the results of the average of the counts taken in up to 999 count cycles. To use this averaging feature, perform the following steps:

1. Position the counter at the sample location; turn power on.
2. Press the  key until Automatic  is on.
3. Set the sample Period and Hold functions to the desired duration; set the number of Cycles to be taken (procedures located elsewhere in manual).
4. Choose "14644-1" from "Prn" (Options) using "Selecting Printer Function" procedure on following pages.
5. From the printer control keys, press  then press . The counter will run for the number of cycles you programmed, print the results of each cycle, and stop.
6. Press  key. The counter will print the averages of each particle size range for the number of cycles you programmed in step 3 above. These averages represent particles/cubic foot.
7. If more than one location is to be sampled, perform "ISO 14644 Calculations" procedure.

Using Special Features


Note

The averages will be calculated and displayed in particles per cubic foot.

The average value includes only the last sample run, not buffer contents from previous runs.

Using Special Features

CAUTION

Make sure you no longer need the stored data before you press and hold down  key.


Note

In the ISO 14644 calculations, a period of 60 seconds must be selected so that at a nominal flow rate of 1 cu. ft./min, a total volume of 1.000 cu. ft will be sampled. The count is calculated on one cubic foot of sampled air.

Note

Number of count cycles must be 1 (one) or greater. If set to 0 (zero) or manual, ISO 14644 calculations will not be made.







Note

If you want to retake the samples at the same location, press  again. The data from the retaken sample will then be used in the calculations.

ISO 14644 Calculations

Your counter will automatically calculate the statistical data required for compliance with ISO 14644. This selection is made as one of the print modes when setting Options. Calculations are made on the last data stored at each location (up to 400 samples). Sampling must take place at two or more locations for calculations to be made. When all locations have been sampled, the printer prints the mean of averages, standard deviation, standard error, and upper 95% confidence limit. The upper confidence limit is only calculated for nine or fewer locations.

To use ISO 14644 calculations feature, perform the following steps:

1. Position the counter at the first sample location; turn power on.
2. To keep from using previous data in the calculations, clear stored data by pressing and holding .
3. If you are taking temperature, relative humidity, or air velocity readings at location 1, position the probes now.
4. Set "Location" to 1 using "Location (Number)" procedure.
5. Set number of cycles to be taken at each location using "Number of Count Cycles" procedure; set sample time of each cycle to one minute (hold time, your choice) using "Period/Hold (Time)" procedure.
6. Set mode to "Automatic" or "Concentration" (not "Manual") then press . The Counting  will come on while samples are being taken. Verify flow rate is 1 cfm as described on earlier pages. The counter will stop when samples are complete.
7. Turn the counter off then move counter to the next location.
8. Set "Location" to 2 then press . Samples will be taken at location 2.
9. Repeat steps 5 and 6 above for the remaining locations.
10. Decide if calculations are to be in cubic feet (CF) or cubic meters (1000 L) then make selection using Volume Units (UOL) for Concentration Mode and ISO 14644 Calculations.
11. Choose "14644-1" from "Prn" (Options) using "Selection Printer Function" procedure on following pages.
12. From the printer control keys, press  then press . The average particles per unit volume at each location will be printed out, followed by ISO 14644 calculations of all locations. The following is a typical printout of three samples taken at two locations.

Using Special Features

```

ISO 14644 STATISTICS
AVERAGE PARTICLES /CUBIC FOOT

LOCATION 001,09:45:39 MAY 7, 99
CYCLES = 003,VOL = 1.000 CU FT
TEMP. = 71.3 F      RH = 29.5%
SIZE  CUMULATIVE  DIFFERENTIAL
0.5µ   3256.3      2634.7
1.0µ   621.7       361.3
2.0µ   260.3       58.3
3.0µ   202.0       31.7
5.0µ   170.3       22.3
10.µ   148.0       148.0

LOCATION 001,09:45:39 MAY 7, 93
CYCLES = 003,VOL = 1.000 CU FT
TEMP. = 71.3 F      RH = 29.5%
SIZE  CUMULATIVE  DIFFERENTIAL
0.5µ   4478.7      3954.3
1.0µ   524.3       435.0
2.0µ   89.3        43.0
3.0µ   46.3        18.7
5.0µ   27.7        9.3
10.µ   18.3        18.3

      MEAN OF THE AVERAGES
SIZE  CUMULATIVE  DIFFERENTIAL
0.5µ   3867.5      3294.5
1.0µ   573.0       398.2
2.0µ   174.8       50.7
3.0µ   124.2       25.2
5.0µ   99.0        15.8
10.µ   83.2        83.2

SIZE  STD DEV  STD ERR  95% UCL
0.5µ   864.3   611.2   7724.0
1.0µ   68.8    48.7    880.1
2.0µ   120.9   85.5    714.3
3.0µ   110.1   77.8    615.3
5.0µ   100.9   71.3    549.1
10.µ   91.7    64.8    492.3
    
```

} average of the three count cycles

Note

In the ISO 14644 calculations, a period of 60 seconds must be selected so that at a nominal flow rate of 1 cu. ft./min, a total volume of 1.000 cu. ft will be sampled. The count is calculated on one cubic foot of sampled air.

Figure 3. Typical ISO 14644 Printout

Generating a Configuration


If you ordered your counter with the "configuration" capabilities option, you can program a "configuration" that stores in memory count cycle information. The information is stored at a location number so that when the location is selected, the period, hold time, count alarm limit, and number of cycles will be automatically performed during a run cycle. Up to 10 different configurations can be generated. Any configuration can be stored in one or more of the 1000 location slots available.

Using Special Features

Note

To abort a change, press  again. To save a change, press .
































Note

If "Loc" appears in the 3-digit display, presently programmed parameters (count alarm limit, etc.) will be used when  is pressed. If "Loc" appears in the 7-digit display, test parameters have been assigned to this location.

Note

The default configuration (C 1 on the 3-digit display) will be used for all locations during count runs that have not been specifically programmed as described in this procedure.

To generate, apply, review, or delete a configuration, perform the following steps:



1. Decide on the "configuration" you want then set the configuration (count alarm limit, period/hold time, number of cycles) using procedures found elsewhere in this section.
2. Press  or  until Options  is on then press  or  until **CFg** (configuration) is displayed.
3. Press  (a configuration number will blink) then press  or  to select the configuration number (any number from 1 to 10) that will be assigned to contain your "configuration" (as set in step 1).
4. Press  to enter into memory the assigned number and to exit the programming mode (Program LED will go off).
5. To apply this configuration (or any other programmed configuration) to a location number, press  or  until Location  is on. The current location number (7-digit display) and the present configuration in this location (3-digit display) will be displayed. If "Loc" appears in 3-digit display, no configurations have yet been assigned.
6. Press  then select the desired location number.
7. Press  until configuration number in the 3-digit display blinks then press  or  to step through the ten configuration numbers until configuration number you want to apply is displayed.
8. Press  to configure the selected location and to exit the programming mode. A configuration must be programmed (using step 3 above) before a location can be programmed (see note to right).
9. To see what configuration is in a location, press  or  until Location  is on, press , then press ,  and ,  to step through locations. The assigned configuration number will be given in the 3-digit display. Press  again when finished.
10. To print out a copy of how many and what configurations have been used, and the parameters of each configuration, repeat step 2 above then press .
11. To delete a stored configuration, repeat step 2 then press , and with  or , select desired configuration number to be deleted (number will blink); press . Verify deletion by printing the configuration (repeat step 10).

Using the Printer

The particle counter can be ordered with or without a printer. If ordered without a printer, a rear-panel connector is installed for use with an external (Centronics parallel-interface) printer. When enabled, the printer will print all count data as well as date, time, location, etc., automatically as a test run is completed. Sample time (period) of each test run must be greater than eleven seconds for the printer to be able to respond. All test run data is stored in a rotating buffer and can be printed out at any time. To print results, you must choose one of the “printer selections” (described below) and “enable” the printer. Operating the printer is described in these subsections:

- Loading Printer Paper
- Selecting Printer Function
- Printing ISO 14644 Calculations
- Clearing Data Stored in Rotating Buffer
- Interpreting the Printout
- Setting up an External Printer

Loading Printer Paper

1. Open paper cover then remove any remaining paper from last roll by snipping paper at spool and pressing  until printer is empty.
2. Trim end of new roll to a clean, arrow-shaped edge.
3. Place paper roll in paper tray so that paper feeds toward print mechanism from bottom of roll.
4. Insert tip of paper into slot in feed mechanism (above the bottom of the paper tray) so that when  is pressed, paper will be pulled through printer; close paper cover.

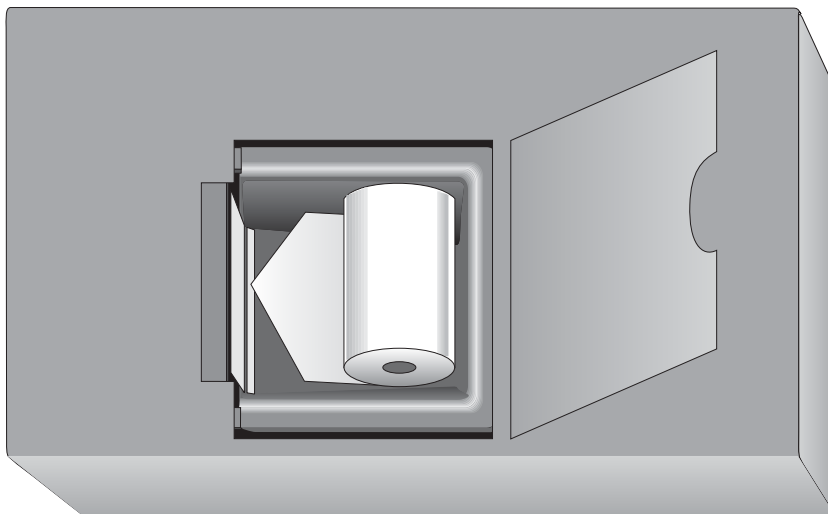


Figure 4. Loading Printer Paper in the Counter

CAUTION

The printer should not be operated without paper as damage may occur to the print head. If the particle counter must be operated without paper in the printer, be sure printer is not “enabled”.

Do not pull paper from printer in opposite direction of normal feed. This will damage printer.


Paper used in this printer is temperature-sensitive on one side and thus must go into the printer as explained in the instructions.










Note

Leave natural “curl” in paper so that paper tracks properly through mechanism.

Using the Printer

Selecting Printer Function

The print function currently selected is displayed when Option is on and Prn appears on the 3-digit display. The three selections available are: 1) print "ALL" - prints results after completion of each count cycle (if cycle is greater than eleven seconds), 2) print "Alr" - prints results only when a count alarm limit has been exceeded, 3) print "14644-1" - prints ISO 14644 calculations. The first two options, when selected, occur during particle counting. The third option, when selected, occurs after count cycles at at least two locations are completed and when  is pressed. For any of the selections to work, the printer Enable LED must be on. Choose desired print selection as follows:

1. Press  or  until Options  is on.
2. Press  or  until Prn is displayed. The current status ("ALL", "14644-1", or "Alr") will appear on the readout display.
3. Press  (current status will blink) then press  or  to step through the three choices ("ALL", "14644-1", or "Alr").
4. Press  to save your choice and exit the programming mode (Program LED is off).

Printing ISO 14644 Calculations

Your counter will automatically calculate the statistical data required for compliance with ISO 14644 after sampling particles at two or more locations. The printer will print the mean of averages, standard deviation, standard error, and upper 95% confidence limit by simply enabling the printer then selecting "14644-1" from the print mode of the Options program. Refer to "ISO 14644 Calculations" in Using Special Features section for step-by-step instructions for taking samples and printing results.

Interpreting the Printout

The printer will print the particle size ranges and cumulative and differential counts for each range. It also prints environmental probe values if external probes are connected to the counter. Date, time, location, period and number of cycles are always added to each printout. If there is an alarm during a sample run, the printout will show what type of alarm occurred.

A typical printout when  has been pressed will look similar to this:


```

PRINTING 002 RECORD(S)

***** COUNT ALARM *****
***** ANALOG ALARM *****
LOCATION 001, 17:45:39 MAY 9, 93
CYCLES = 002, PERIOD 00:00:30
TEMP. = 75.3 F RH = 29.0%
SIZE CUMULATIVE DIFFERENTIAL
0.5µ 21205 12150
1.0µ 9055 6398
2.0µ 2657 2263
3.0µ 394 253
5.0µ 141 100
10.µ 41 41

***** COUNT ALARM *****
LOCATION 001, 17:46:16 MAY 9, 93
CYCLES = 002, PERIOD 00:00:30
TEMP. = 71.3 F RH = 29.5%
SIZE CUMULATIVE DIFFERENTIAL
0.3µ 21934 12578
0.5µ 9356 6625
1.0µ 2731 2301
3.0µ 430 264
5.0µ 166 122
10.µ 44 44
    
```

Figure 5. Typical Printer Printout

In this example, two runs (cycles) were stored in the rotating buffer. The count of 21205 for size .5 micron is the cumulative (total) count. The differential count of 12150 is for the .5 micron range only (.50 through .99 micron) at location 001. The words COUNT ALARM above the count cycle data means the count exceeded the programmed alarm limit for that cycle at one of the six particle sizes. ANALOG ALARM means either the temperature or relative humidity reading exceeded the programmed limits during both count cycles. PRINTING 002 RECORD(S) appears at the top of the printout only when  has been selected.

Using the Printer

CAUTION

Make sure you no longer need the stored data before you press and hold down

 key.



CAUTION

Before performing this procedure, load paper into external printer; refer to printer instruction manual. Operating printer without paper may damage the print head.

If an external printer is being used, the counter must be turned off before printer is connected. Connecting the printer while the counter is on may damage the counter.

Clearing Data Stored in Rotating Buffer

Count data taken while in the manual and automatic modes are stored in the counter's rotating buffer. Up to 400 data records can be stored in the buffer. At that time the oldest record is removed to make room for the newest record. Printing count data does not remove records from the buffer. To clear all data records from the rotating buffer, perform the following steps:


1. Momentarily press . The number of sample runs currently stored in the buffer will appear on the readout display.
2. Press and hold down  for two seconds or longer; the display will go to 0, meaning no sample runs remain in the rotating buffer.

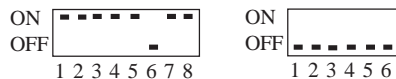
Setting up an External Printer

An external printer is considered an option because output to the external printer requires installation of a Centronics parallel interface connector at the time the counter is built.


Over the years, several external printers have been available as options from the factory. The Model DPU-414 is the latest printer available and supercedes the DPU-411.

If you ordered the external printer option (no built-in printer), connect the printer as follows:

1. Set  to 0 (off).
2. Turn power off to printer.
3. If using a DPU-411 printer, verify switches on bottom of printer are set for parallel format. They should be set as follows:




If using the DPU-414 printer, DIP switch settings are made in software. Set the DIP switch for a parallel format by following the procedure in the printer's Operation Manual.

4. Connect ribbon cable between the printer and the connector marked PRINTER on rear panel of counter.
5. Set  to 1 (on); set printer power switch to on.
6. Make printer selection changes, if desired, as described in "Selecting Printer Function" on earlier pages.

Using Accessories

Accessories can be ordered from the factory at any time. Those accessories requiring additional discussion are the two environmental probes currently available.

Environmental Probes




The particle counter has rear-panel connectors for two environmental probes: RH/temp probe for monitoring relative humidity and temperature and an air velocity probe for monitoring air velocity. When a probe is connected to the counter, the front panel will display the probe reading when the appropriate “DISPLAY” is selected with the arrow keys. (Air velocity can be monitored when the Spare  is on.)




When the printer is enabled, the probe readings present during each count cycle will automatically be printed with the count results. Otherwise, readings can be printed at a later time. Alarm limits can be set for each probe so that if either a high or low limit is exceeded, the Limit light will come on. A light will blink adjacent to the label of the probe in alarm if that probe's reading is being displayed. Refer to the “Probe Alarm Limits” earlier in this manual for setting alarm limits.

The following tips should be noted during use of the RH/temp or air velocity probe:

- Never touch the sensing element of the probe; it is very fragile. Sensing elements should not be exposed to caustic vapors (e.g., acetone, Freon, and RTV).
- Keep the RH/temp probe away from exhaust fans for more accurate measurements of temperature.
- For accurate measurements of relative humidity, allow probe to stabilize several minutes; take samples in still air.
- When taking air velocity measurements, make sure the white sensing element is fully exposed to the direction of airflow.

Setting Temp/RH Probe Alarm Limits

Temperature and relative humidity can be displayed while in either the run or stop mode by pressing  or  until Temp/RH  is on. Program the probe high- and low-alarm limits or change from °F to °C or from °C to °F as follows:

1. Turn counter off. Connect RH/temp probe to the counter rear-panel connector marked RH/TEMP then turn counter on.
2. To read temperature or relative humidity, press  until Temp/RH  is on. Current temperature will be displayed. Press  for relative humidity reading.
3. To change the high-alarm limit or to change readout to °F or °C,














Note

Alarm limits for relative humidity and temperature can only be displayed or programmed when the probe is connected to the counter.




To silence the alarm, press any front-panel key *except*  or .












To turn off the alarm, enter both an upper and lower limit value of 0 (zero).

Using Accessories

- press  then press  until the digit you want to change is blinking.
4. To increment digit to the next value, press  or  once. To scroll, press and hold down either arrow key.
 5. To change other digits, press  and repeat step 4.
 6. To set low-alarm limit, press  until “HI” blinks then press ; “LO” will blink. Press  to select digit to be changed then repeat steps 4 and 5 above.
 7. Press  to save changes and exit programming mode (Program LED is off).
 8. To set relative humidity alarm limits, while RH/Temp  is on press  (current relative humidity reading will be displayed) then press . Using  select digit to be changed, then repeat steps 4 through 7 above.

Setting Air Velocity Probe Alarm Limits

When air velocity probe is connected, air velocity can be displayed while in either the run or stop mode by pressing  or  until Spare  is on. Program the probe high- and low-alarm limits or change readout units to ft./min. or meters/min. as follows:

1. Turn counter off. Connect air velocity probe to the counter rear-panel connector marked AIR VELOCITY then turn counter on.
2. To read air velocity, press  until Spare  is on. If a decimal point is in the three-digit readout, results are in meters/minute, otherwise results are feet/minute.
3. To change the high-alarm limit or to change readout to ft./min or meters/min, press . “HI” will be blinking. Then press  until the display you want to change is blinking. A blinking “-” means readout is in meters/min; blinking “F” is ft./min.
4. To increment digits to the next value, press  or  once. To scroll, press and hold down either arrow key.
5. To change other digits, press  and repeat step 4.
6. To set low-alarm limit, press  until “HI” is again blinking, then press ; “LO” will blink. Select digit to be changed using  then repeat steps 4 and 5 above.
7. Press  to save changes and exit programming mode (Program LED is off).

Serial Port Protocol and Commands

This section describes operating the particle counter with a computer. Your counter has been set up for both serial-type data communications capabilities: 1) RS-232 serial interface circuitry provides asynchronous communications between the counter and computer, or 2) RS-485 serial network circuitry provides asynchronous communications between up to 64 counters and a controlling computer.

Software is available from the factory that will provide a variety of features including controlling your counter from a computer; uploading count data into the PC; sort, normalize, and calculate count data for cleanroom classification. For additional information about software, contact the factory. Also, the “Particle Counters for Air” manual you received with your counter will provide more detail information on this subject.

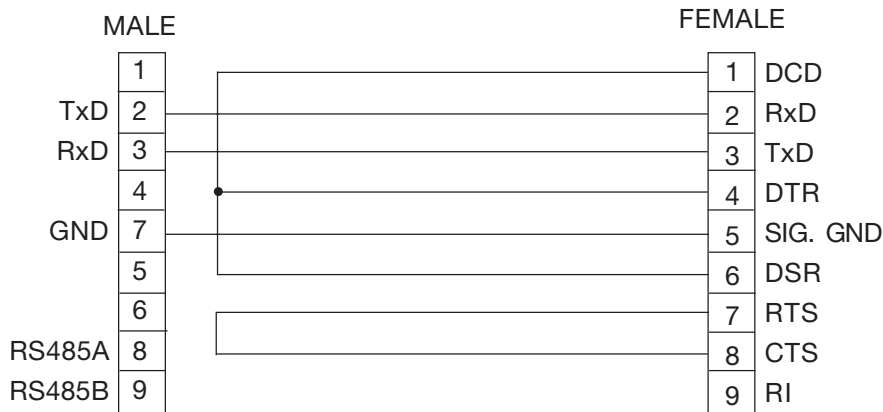
Serial Cables

All counters are connected to a computer with a serial cable. If you purchased PortAll software, you will also receive an adapter you can use with a standard 9 pin-to-9 pin serial cable. The cabling diagram below is provided for those who wish to make their own custom-length cable.

Connector for Counter

Connector for PC

CAUTION



To avoid internal circuit board damage, configure the cable as shown in figure 6. The figure shows wiring for a nine-pin connector on the computer. If your computer is a 25-pin type, use a 25-pin to nine-pin adapter cable. Both cables are available from your local distributor or Pacific Scientific Instruments.

Figure 6. Serial Cable

Serial Port Protocol and Commands

Communication Protocol

The counter has the following fixed parity and protocol:

- Eight (8) data bits
- One (1) stop bit
- No parity

The device number (select code) and baud rate are selected from the front panel of the counter. Make these selections as described in “Location (Number)” and “Baud Rate (bd)”, respectively, covered earlier in this manual.

Commands

The following ASCII commands described below are supported by your particle counter:

"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 (quick 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 and control the count cycle based on the front-panel setting for period (sample time).

"e" Stop Counting—The counter will immediately stop counting without waiting for an even second boundary.

"C" Clear Buffer—The rotating buffer will be erased.

"E" Send EPROM Revision—The counter will send the EPROM number (e.g. E2082179-1A Note: your EPROM number or letter may not match the letter shown in this manual).

"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.

"T" Identify Model—The counter will send a four character model number (e.g. 2408).

"A" Send Record—The next 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.

If no count cycles have been completed since the counter was turned on, then a “#” will be sent. The record can not be sent until the current count cycle is complete.

"R" Resend Record—The last record sent will be resent. Records sent prior to the last record have been permanently erased.

Serial Port Protocol and Commands

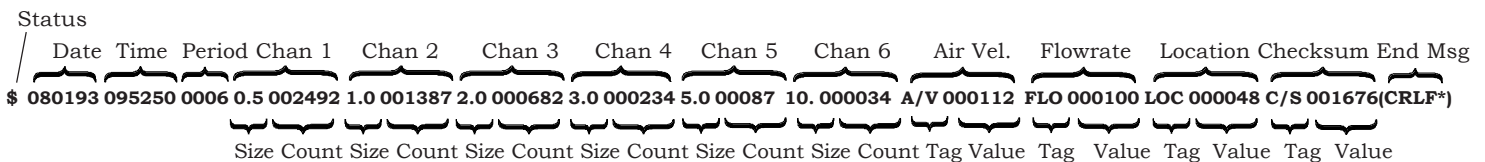
CAUTION

Do not use the Universal Select command when more than one counter is on the same serial port because more than one counter will respond at the same time, causing communication problems.

- "h" **Standby Mode**—The counter will enter a mode that turns off the air pump and shuts down the sensor to conserve power and reduce equipment wear.
- "g" **Active Mode**—The counter will enter a mode that prepares it for counting. The air pump will turn on to purge the air path.
- "l" **Local Mode**—(for factory test purposes) The counter will be set to off-line.
- "U" **Universal Select**—The counter will respond to all commands after receiving this command, regardless of which select code is programmed into the counter.
- "128-191" **Counter Select**—The counter will respond to all subsequent commands when a number is sent that matches its select code. The counter is deselected, or 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.
- "192-255" **Device Select**—When the counter is sent a number that matches a device number, the counter will select the manifold station (192 selects station 1). The station is deselected by selecting another station.

Data

Each counter, regardless of model version, 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. The following is an example to show the serial communications format of a six-channel counter with an air velocity probe:



*CRLF is the carriage return and line feed command

Figure 7. Typical Data Record

Refer to the "Particle Counters for Air" manual for a detailed explanation of the data record.

Technical Data

Specifications

Number of Size Ranges	2, 4, 5, or 6 (selected at time of order)
Particle Size Ranges	
Model 2400	0.3, 0.5 microns (2 ranges) 0.3, 0.5, 1, 5 microns (4 ranges) 0.3, 0.5, 1, 5, 10 microns (5 ranges) 0.3, 0.5, 1, 3, 5, 10 microns (6 ranges)
Model 2408	0.5, 0.5 microns (2 ranges) 0.5, 1, 5, 10 microns (4 ranges) 0.5, 1, 2, 5, 10 microns (5 ranges) 0.5, 1, 2, 3, 5, 10 microns (6 ranges)
Sample Flow Rate	1 cfm
Coincidence Loss	Less than 5% at 400,000 particles/cu. ft.
Counting Efficiency*	50% for 0.50 micron and 1 cfm
Minimum Counts Ratio*	2:1
Light Source	Laser diode (30,000 hours MTTF)
Count Display	7-digit LED
Maximum Count Displayed	9,999,999
Sample/Hold Times	1 second to 24 hours
Count Alarms	1 to 9,999,999 counts
Data Storage	400 samples, rotating buffer
Count Cycles	up to 999 while in Automatic mode
Locations	up to 999, number appears on printout
Output	RS-232C/RS-485 for computer
Sensor Type	70°-angle, laser diode
Pump Type	air vacuum, 1 cfm
Size	11.2" wide x 6.0" high x 18.0" deep (28.5 x 15.3 x 45.7 cm)
Weight	24 lbs. (11 kg.)
Power (specify),	150 watts, 100, 115, or 230 vac ±10% 50 - 60 Hz
Environment (Operating):	
Temperature	12 to 29°C (55 to 84°F), typical
Humidity	10 to 85% relative, non-condensing
Environment (Storage):	
Temperature	-40 to 50°C (-40 to 122°F)
Humidity	Up to 98% relative, non-condensing

* Overall particle counter performance exceeds Japanese Industrial Standard JIS B 9921

Component Location

The following drawing can be used to help locate and identify components on your counter that are referenced in this operating guide or the “Particle Counters for Air” manual.

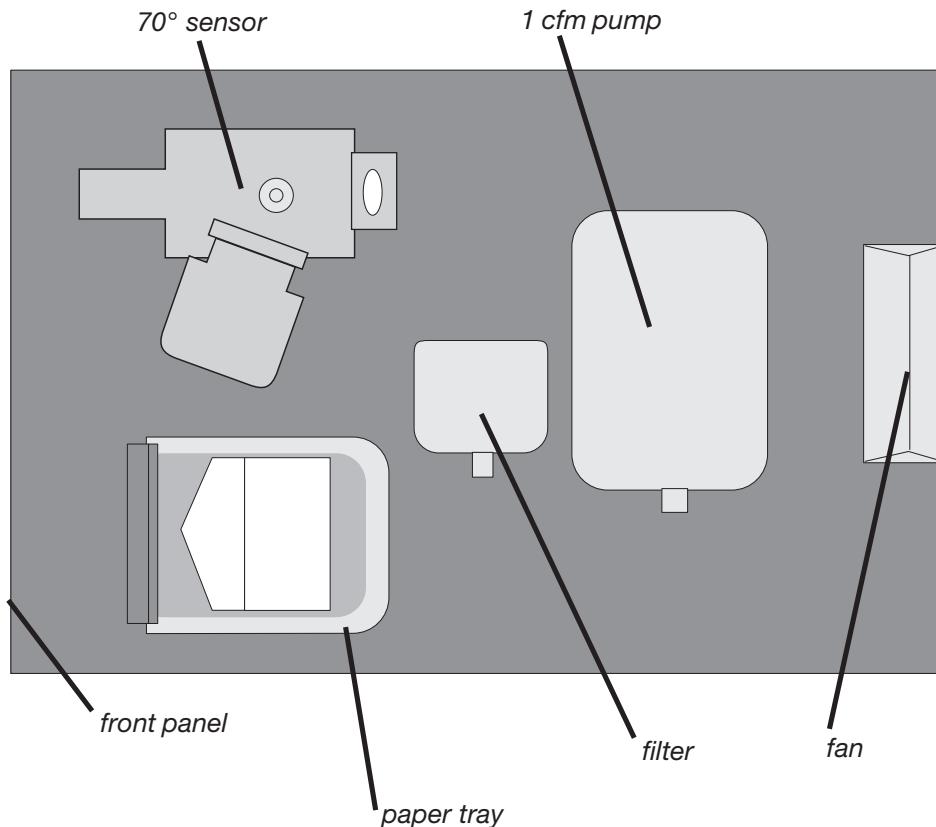


Figure 8. Layout of Major Components

Technical Data

CAUTION

All stored sample data will be cleared when the counter is reset. All functions you have programmed (time and date, count alarm limits, etc.) will also be cleared and reset to the factory default settings.







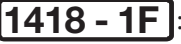

Note

If the results in step 2 do not occur, disconnect any external equipment (RH/ temp probe, external printer if applicable) and repeat this procedure. Reconnect one piece of equipment and repeat procedure to determine if external equipment is the source of the problem.

Technical Data

Resetting Counter Options

This procedure clears the counter memory and restarts its micro-processor. Reset the counter as follows:

1. Set  to 0 (off).
2. Press and hold  then turn power on. A beep will sound. Release . The front panel displays should be as follows:
Manual : on, Cumulative : on,
 : shows default values have been reloaded ;
gives your EPROM part number and revision level (Note: this part number is for the manifold option; your revision number or letter may not match the number (letter) shown in this manual).
3. Press  then reenter programmed functions.

Manual Backdating

Several additions and changes to the 2400/2408 particle counter brought about revision level changes to the manual. These changes are summarized below:

to Rev. D:

Incorporated the 2400 and 2408 into one manual and replaced Fed Std 209E with ISO 14644

to REV. C:

- 1) removed all references to 0.3 micron particle size range, as this size is no longer offered in the Model 2408 (0.5 micron is the smallest size range available).
- 2) reworded Options to clarify that the manifold option is standard if no option is specified.
- 3) reworded introduction to the Serial Port Protocol section.
- 4) modified Serial Cable figure to reflect the more common 9-pin configuration of a computer.
- 5) deleted the "A" as a prefix to the model number for consistency purposes within the product line.

to REV. B:

- 1) a "count cycles average" feature automatically calculates and prints out results of the average of counts taken. Up to 999 count cycles can be programmed.
- 2) a "configurations" feature has been added that when programmed into the particle counter and then selected, the period, hold time, count alarm limit, and number of cycles will be automatically performed during a run cycle. Up to 10 different configurations can be generated. Refer to "Generating a Configuration" for a step-by-step procedure. Particle counters with the "configurations" feature will

display the EPROM number: **dEF** : **2179 - 1R**. Otherwise,

dEF **1145 - 16** will be displayed for older units (Note: your revision level letter may not match the letter shown in this manual).

3) all references to data storage in the rotating buffer changed from 500 to 400 samples, as firmware was changed to make room for storage of the "configuration" information.

4) testing was performed on the 2400/2408 counter for conformance to electromagnetic compatibility (a requirement for European customers). A "Declaration of Conformity" certificate stating what requirements were met to achieve this goal appears at the back of this manual.

