



# INSTRUCTION MANUAL

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SPECTREX SUPERCOUNT™ SOFTWARE  
FOR WINDOWS®  
REV 8.3B  
FOR USE WITH PC-2200



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


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# Seven Simple steps to running a sample on the Spectrex PC-2200 Laser Particle Counter with Supercount for Windows Software

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**...after the system has been made operational**

1. Turn on the PC-2000, computer and monitor.
2. With mouse, click on SPECTREX LPC icon.
3. Place sample onto **V Block** on the PC-2200.
4. Click on  to select **settings**.
5. Press spacebar or click on **GO** icon on monitor to start count.
6. Click on  to select output options.
7. Click on  to print results.

**For a computer running Windows 95, 98 or 2000, the system should have at least 32 MB Ram and 800 x 600 monitor resolution.**

**IMPORTANT**

### **If dilution is necessary**

Any sample with counts greater than 800–1000 per cc should be diluted to avoid coincident counts. It is important to always have as clean a diluent/suspension medium as possible. It should not have more than 30-40 particles greater than 1 $\mu$ m per cc. A good source of particle-free water is the distilled water available at supermarkets. However, this varies widely in quality from batch to batch and should be filtered through a 0.2 $\mu$ m filter if counts greater than 30-40/cc are obtained. For hydraulic oils, high quality, particle-free hexane is available from EM Science, 111 Woodcrest Road, Cherry Hill, New Jersey 08034. Particle-free 5605 hydraulic oil is available from Fluid Technologies, Stillwater, Oklahoma (Phone 405-624-0400).

Particle-free limonene is available from Oil Analysis Labs, Spokane WA. (Phone 509-535-9791).

Before unpacking and installing the National A-D data acquisition board (see Spectrex parts list) refer to the manuals supplied with your computer and install the main system components per their instructions. Then familiarize yourself with its operation before attempting to use the computer in conjunction with the LPC.

**Note: Before removing or installing any A-D cards, make sure the computer is turned off - preferably unplugged from its wall socket.**

### **DRIVER installation and set-up**

1. Turn on computer
2. Load Spectrex CD and let boot up.
3. The NIDAQ installation will automatically start. If it does not automatically start, navigate to the CD drive and double click on setup.exe. Notice that if you are running Windows 2000, you may be asked to reboot your computer at this time. If so, re-insert the CD to initiate the install again after system comes back up.
4. Choose "Install NIDAQ/NI-SWITCH" from the menu. Only traditional NIDAQ is necessary to install. Deselect all other drives.
5. Proceed through the NIDAQ installation wizard. After installation is complete, you will be prompted to reboot your system.
6. Shut your system completely down.
7. Install the E-Series A-D Board in your computer.
8. Turn your computer back on.
9. Start the National Software by:
  - For Windows XP users, choose Start/All Programs/National Instruments/Masurement & Automation.

- For Windows ME, NT4 and 2000 users, choose Start/Programs/National Instruments/Measurement & Automation.
10. From the National Instruments Measurement and Automation Explorer, Click on the Plus sign to the left of the label "**Devices and Interfaces**" to expand the tree.
  11. From within "Devices and Interfaces", click on the Plus sign to the left of the label "**Traditional NI-DAQ Devices**".
  12. Click on the Label under Traditional NI-DAQ Devices that corresponds to the specific board you have installed. For example, if you have a PCI-6024E board, you would click on the label PCI-6024E.
  13. Choose the button labeled "Properties" near the top of the Application window. (Or, right click on the board label and choose properties from the context menu)
  14. From the Configuration Device Dialog, choose the **AI** tab.
  15. Verify that the **Polarity/Range** setting is set to "**-10.0V - +10.0V**".
  16. Verify that **Mode** is set to "**Referenced Single Ended**".
  17. Click "OK" to save settings.
  18. Close the Measurement and Automation Explorer Application.

## **SPECTREX installation and set-up**

1. Select windows "Start" button on toolbar.
2. Select "Run" then "Browse" and locate the CD and select "InstallSuperCount.exe", open, and OK.
3. Follow the instructions and the Spectrex software will be installed.
4. Load Spectrex Software, select "Utilities" then "Counter Signal Calibration" and go to section B "Set up - Instrument and Computer interface calibration.

1. Click on **Utilities** and then on **Counter Signal Calibration**.
2. Ignore the warning sign as you will now be setting up the calibration parameters for your particular computer. Click on **Yes**.
3. The **Card Calibration Parameter Values** window will appear at the bottom right side of screen.
4. Click on **Pre-gain Slide** which can be moved from left to right with the mouse. Set the number to the right of the slide to the pre-gain value on the front page of the Calibration Report for your LPC.
5. Repeat this for the Voltage Reference **Vref** and **Offset**.
6. Click on **Exit/Save** and you are now in calibration.

The Spectrex Laser Particle Counter (referred to throughout this manual as LPC) determines the number and size distribution of particles in a liquid suspension. The system currently handles particle sizes ranging from 1  $\mu\text{m}$  to 100  $\mu\text{m}$  in diameter. It accomplishes this by analyzing the forward scattering interference patterns created by illuminating the particles with a beam of monochromatic light. This is called Fraunhofer diffraction. The characteristics and amplitudes of these patterns are analyzed in real time to determine both the number and size of the particles creating these patterns.

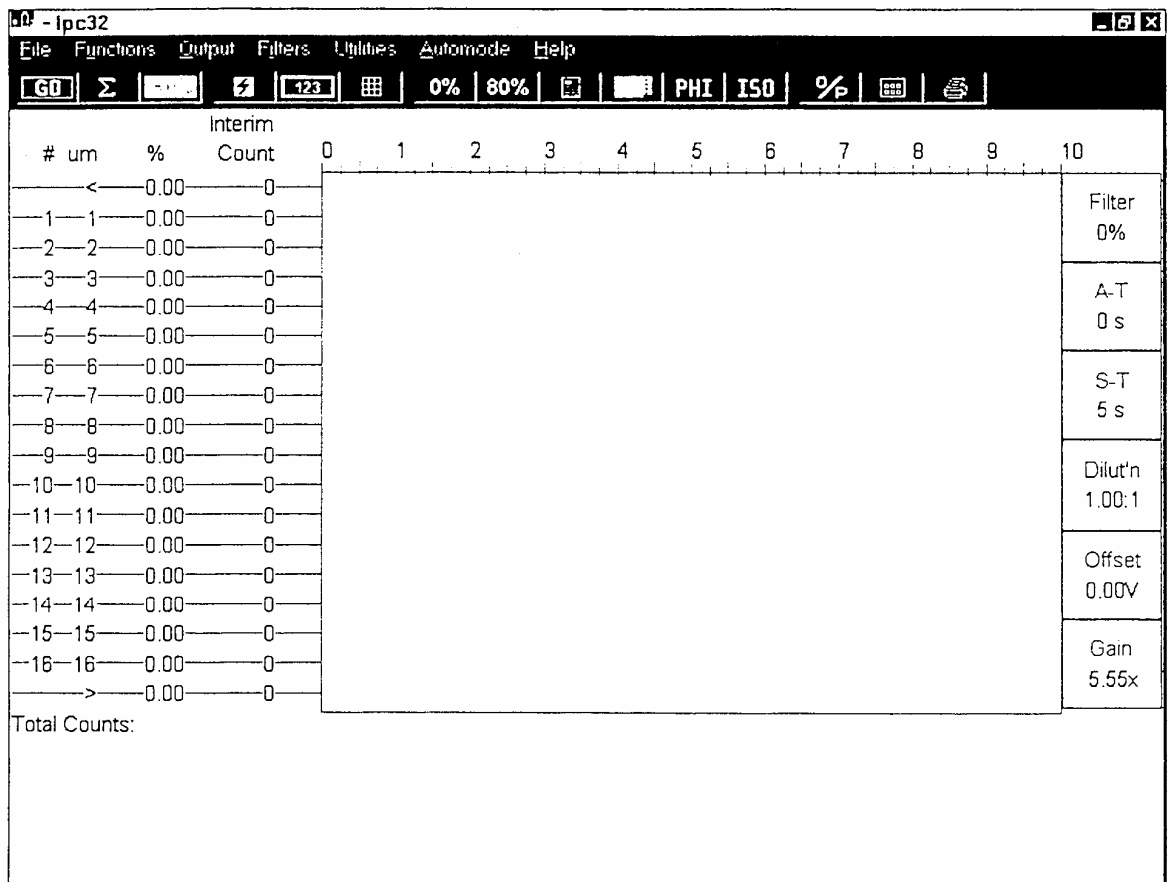
Two groups of 16 size ranges are available: the **F0 filter** sizes particles from 1  $\mu\text{m}$  to 16  $\mu\text{m}$  in size, and **F80 filter** sizes from 17  $\mu\text{m}$  to 100  $\mu\text{m}$ . The F0 and F80 refer to the amount of effective illuminating beam attenuation used to size particles in the two size ranges. Since larger particles reflect more light, either the illumination source or the detector signal must be attenuated when measuring them to ensure that the resulting amplitude signal remains within the operational range of the detector amplifiers.

While the LPC is analyzing a sample, it updates an onscreen histogram in real time as the system detects each new particle. By the end of the sampling interval, this histogram provides a graphic representation of the relative number of particles detected in each size range.

The LPC can also present the data comprising the histogram in tabular form, providing precise numerical quantities and other information not present on the histogram. The tabular data may (at option of the user) include any or all of the following:

1. The percentage of the total sample population which falls into each size range.
2. The percentage of the sample's total surface area represented by particles in each of the size ranges.
3. The percentage of the sample's total mass represented by particles in each of the size ranges.
4. The concentration (in parts per million) of particles in each size range.

The summary data, which appears after the histogram, includes additional information such as the mean particle size, the standard deviation of same, the total number of particles detected per unit volume, the dilution factor used, etc.



The icons through which full operation is conducted are arrayed in a horizontal line above the histogram of the introductory screen. They are each described, if you direct the pointer onto it, by a balloon.

## Reading from left to right...



### **Start sample counting (1-16 µm range).**

Starts a count in the lower (1-16 µm) range.



range

### **Start count, integrate mode (1-100 µm range).**

Starts a count of both the lower range (1-16 µm) and the higher (17-100 µm).



### **Stop current run now.**

This will permit stopping a sample run at any time.



### **Clear. Delete previous run.**

This clears the screen and all data for the next run.



### **Counter Settings.**

These settings establish count time, dilution factor, etc. and will be described later. (Page 11).



### **Load filter.**

This selects the **filter file** required for any specific sample. F0/F80 for normal use, F11/F81 for small vial use and F30/F83 for hydraulic oils.



### **Load F0 file (1/16 µm range).**

This provides quick access to this file.



### **Load F80 file (1-16 µm range).**

This provides quick access to this file.



### **Report.** View listing of numbered counts.

After a sample run has been completed this displays a listing of the percentages, etc. in each size bin.



**Return to histogram display, if you are in listing mode.**

Self-evident.



**PHI standard classification (cumulative plot used by sedimentologists).**



**ISO standard classification (graph) used mainly for hydraulic oils. This displays the standard ISO graph and computes ISO code for the sample.**



**Comment/Print out options.**

See later description (page 18).



and

Dilution calculator. This provides a quick and easy way to calculate

enter **dilution factor** when a sample has to be diluted.



Print

## **Use of Keystroke Commands (as the alternative to the mouse)**

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The following key commands are provided:

Key Location	Action
Space Bar	Start count as <b>Go</b> .
I	Start integrate count.
C	Clear screen.
Exit	Return to histogram from any

of the put-down windows.

123 Counter Settings – more detailed description

C

## IMPORTANT

The *Settings* window provides the following functions:  
(Use the Tab Key to step down)

1. Dilution Factor

Any number up to 999,999 can be entered. This number will be automatically entered by using Dilution Calculation Icon.

2. Pause in Integrate

This on/off option provides a pause between F0 and F80 counting in **integrate mode** to count rapidly settling larger particles. It provides time for stirring or bottle inversion.

3. Time To Sample

Any number up to 9,999 can be entered.

Note: this is the time in seconds for the computer to sample. The LPC takes approximately 16 seconds to take a scan and will recycle as long as the computer is collecting data.

4. Volume Exponent

This selects the power to which the particle size radius is raised when calculating % volume. The user can enter a value between 2 and 3. (Spectrex recommends 1.75).

5. Standards

See pages 14 and 27.

6. Autoscaling

This will automatically set the scale of the histogram for the time set (3 above).

7. Include Underflow

This is for counting particles in the 0.5 – 1.0 $\mu$ m range. It should only be used for clean samples, with total counts less than 300 $>$ 1 $\mu$ m. The threshold knob should then be set to 6

8. Specific Gravity (of the particles)

This permits accurate, automatic calculation of the Mass/Bin and Total Suspended Solids.

9. Max Scale Value

This sets the Histogram Scale.

10. Minimum Size allowed

This is left at 0 unless, for hydraulic oils, if 5  $\mu\text{m}$  is the smallest size required and then it is set at 5.

11. Maximum Size allowed

This is normally left at 99.

12. Data File Subdirectory

Leave this with the word DATA entered.

13. OK.

When the correct numbers have been entered, click on this button.

## Dilution Calculator (more detailed description)

Tab down:

1. Enter dilution volume (usually 100 ml).
2. Enter sample volume (default value: 1 ml).
3. Click on **Calculate**. Dilution Factor will appear.
4. Click on **Use Value**. Correct Dilution Factor will appear in window and Dilution Window will disappear.
5. **Exit** permits exiting window without calculation being made.

## Navigating menus in the Laser Particle Counter

The main menus are accessible through the icons displayed above the histogram on the screen after booting up the software. Both a mouse and keyboard can be used to operate menus.

The LPC supports two principal groupings of size ranges which are referred to as **filter files**. A grouping of size ranges is simply a group of 16 contiguous size ranges (size ranges are also called “bins”). For example, the “F0 filter” includes the following 16 bins: 1/2  $\mu\text{m}$ , 2/3  $\mu\text{m}$ , 3-4 $\mu\text{m}$ , 4-5 $\mu\text{m}$ , 5-6 $\mu\text{m}$ , 6-7 $\mu\text{m}$ , 7-8 $\mu\text{m}$ , 8-9 $\mu\text{m}$ , 9-10 $\mu\text{m}$ , 10-11 $\mu\text{m}$ , 11-12 $\mu\text{m}$ , 12-13 $\mu\text{m}$ , 13-14 $\mu\text{m}$ , 14-15 $\mu\text{m}$ , 15-16 $\mu\text{m}$  and 16-17 $\mu\text{m}$ . As you can see, the ranges are contiguous (each picks up where the preceding one left off). This group of bins is collectively referred to as the “F0 filter.”

The second size grouping is the “F80 filter” which contains the following bins: 17-22 $\mu\text{m}$ , 22-27 $\mu\text{m}$ , 27-32 $\mu\text{m}$ , 32-37 $\mu\text{m}$ , 37-42 $\mu\text{m}$ , 42-47 $\mu\text{m}$ , 47-52 $\mu\text{m}$ , 52-57 $\mu\text{m}$ , 57-62 $\mu\text{m}$ , 62-67 $\mu\text{m}$ , 67-72 $\mu\text{m}$ , 72-77 $\mu\text{m}$ , 77-82 $\mu\text{m}$ , 82-87 $\mu\text{m}$ , 87-92 $\mu\text{m}$  and 92 $\mu\text{m}$ -100 $\mu\text{m}$ .

Each filter file also has a bin for particles which are either too large or too small to be classified. These are called the **underflow** and **overflow** bins.

### Sampling using a single filter file

In many cases it is sufficient to sample a suspension using only one of the two “filter files” (F0: 1-16 $\mu\text{m}$ , F80: 17-97 $\mu\text{m}$ ). To do this, select the desired filter file by clicking on the “load filter” icon. (More on menus in the program later.) Whenever you take a sample, the LPC assumes that you wish to use whichever filter file is currently loaded. The current filter file selection is displayed in the “Filter” box on the right edge of the Particle Counter screen.

### “Integrated” mode

This uses BOTH size ranges for the same sample. The LPC will sample particles using either one or both of the filter files. In situations requiring size data extending beyond the range of a single filter file, both filter files must be applied to the same sample. For example, if the sizes of interest ranged from 10µm - 50µm, then neither the F0 nor the F80 filter file could handle the entire size range alone. Since the F0 only covers sizes from 1-16µm and F80 only covers 17-92µm, it is clear that both filter files must be used. When a suspension is analyzed using both filter files, the sample is said to be “**integrated.**” In “integrated” mode, the results of a F0 particle count and of an F80 particle count are integrated into a single histogram and report. Such an analysis will display the results in 32 bins instead of the usual 16 (along with the omnipresent overflow and underflow bins). This mode is useful to produce a complete “workup” on a given suspension.

**Standards:** (See page 27 for complete listing of standards and their sizing ranges)

Universally accepted size range groupings: A sizing standard is simply a universally recognized set of specified size ranges. The LPC sizes particles into very narrow size groupings (e.g. the F0 filter has 16 separate size groups: 1-1.99µm, 2-2.99µm, 3-3.99µm, etc.) Standards, on the other hand, have fewer groupings each of which covers a wider range of sizes. For example, in the “Phi” standard, particle sizes are grouped as follows:

Phi #	Size range (µm)
10	1-2
9	2-4
8	4-8
7	8-16
6	16-32
5	32-64
4	64-128

As you can see, there are fewer groups (a mere 7 instead of the 32). However, some of the groups cover much wider ranges than any range found in an individual filter file (group #6 alone covers a size span of 16µm). The size ranges of this standard (2-128µm) require the sample to be analyzed using both the F0 filter file (1-16µm) and the F80 filter (17-100µm).

As you may have guessed, standards can only be applied to integrated samples since they require the size ranges appearing in both the F0 and F80 filter files. There are several such universal particle sizing standards. The standards supported by the LPC are: Phi, ISO, NAS 1638, SAE and NSF (the exact specifications of each standard appear in Appendix A).

## **Reports available from “normal” and “integrated” samples**

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When analyzing a sample using only one filter file, the only report available is the 16-channel report. The results of an integrated sample, however, can be reported in BOTH the 32–channel format (specific counts/percentages of every size bin in F0 and F80) AND by the size groupings of the current standard (6-7 channels worth of results, depending on which standard you are using). When the results are reported “by standard,” all of the particle counts and densities observed in a sample are reported with respect to the standard’s size ranges.

## **ISO standard plot option**

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A special sizing standard is the ISO standard. It is special because when it is applied to an integrated sample, you have the option of producing an ISO plot.

This plot depicts the concentration of particles in each of the size ranges in the ISO standard on a log scale. In addition to the size densities, the graph computes the ISO cleanliness class of the sample based on the observed number of particles greater than 5µm and 15µm particles per ml. This is particularly handy in situations where hydraulic oils are being analyzed since many installations require that such oil be replaced when the number of particles in suspension exceeds a set amount.

## **Functions above icons (from left to right)**

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### **a. File**

**New (Clear) Histogram.** This clears previous run in preparation for next run. It is quicker to use.

**Open Histogram File.** This gives access to any previously stored histogram file. Click on **Open**.

**Save Histogram File.** Enter file name and click on **Save**.

**Save Histogram as.** Same as **Save File** above.

**Print Histogram print-out.** However, it is quicker to click on icon.

**Print Preview.** Previews what will be printed. The Page 1 of 2 will be displayed. Click

on **Next page** to view page 2.

**Previous Page** brings you back to page 1.

**Two Page** displays both pages.

**Zoom In** and **Zoom Out** are self explanatory.

## b. Functions

These functions are all available elsewhere.

**Clear Counter.** Clears histogram.

**Filter Select.** Gives access to all the filter files.

**Update filter file.** Permits changing filter parameters.

**Normal Sample.** Same as Icon **GO**.

**Integrated Sample.** Same as  $\Sigma$

**Settings.** Same as 123

**Setting Scan.**

**Stop.** (Sampling or graph)

## c. Output

**Log Plot.** Output scale will be logarithmic.

**Review Report.** Displays the numbers listings of previous run.

**Save Report to File.** Same as **Save Histogram**, but it is a **prn** file. It can be read by

Excel and put into graphical format. However the data will be lost to the Spectrex software so you should save it as a **hst** file first.

**Output Options.** Same as icon O/P

**ISO Standard Graph.** Displays the standard ISO graph and computes the ISO code

for a sample. Same as icon ISO.

**Cumulative Graph.** Same as Phi.

**Parameter Listing.** Displays the filter parameters for the filter files in use and can be

printed out at this stage.

## d. Filters

This accesses the filter files. See **Navigating menus** section of manual.

**Load Filter File.** Loads a filter file of your choice. Enter file number in **file name** space and click on **Open**.

**Save Filter File.** Provides availability of saving and loading a new filter file generated

by the LPC user.

**Load 0% Filter.** Loads of 0% Filter-the most commonly used one.

**Show filter File Parameters.** Shows linearization values etc. You can print these from here.

**Load 80% Filter.** Loads 80% Filter-sizing 16-100 $\mu$ m.

**Edit Filter Parameters.** Provides ability to create and change linearization values,

offset and ADC gain. They define how a histogram matches the actual size of particles in a standard. These numbers should not be changed unless instructed by Spectrex.

## e. Utilities

**Stopwatch.** A window will be displayed. **Start, Stop, Reset** and **Done** are self

evident. This is useful to check the time the LPC takes to count a sample. Push the count button on the LPC while clicking on **Start**.

**Cycle Timer.** Gives the elapsed cycle time for the computer to complete one complete count cycle. This is set at Spectrex and should not be changed.

**Background Calibration.** This function is useful to check the consistency of a standard or sample. It is also titled **Background/Threshold Utility**. For more details see **Background Threshold Utility** section of manual (Page 16).

**Dilution Factor Calculator.** See pages 6 and 30.

**Counter Signal Calibration.** See Appendix F.

Note: Do not change these values unless specifically directed to do so.

### Filter File Maintenance

Each filter file is actually a collection of parameters. These parameters include:

1. The “Linearization” parameters for each channel.
2. The lowest size of particle in each channel.
3. The analog to digital converter gain parameter and offset settings to be used.
4. The integration link file for this filter.

### What is a Linearization Parameter?

To understand what the linearization parameters and channel labels are, a couple of concepts need to be understood. The size of a given particle is determined by measuring the maximum amplitude of its interference pattern. In general, bigger particles produce higher Maximum Signal Amplitudes (MSAs) than smaller particles do. The MSA is just the highest voltage level seen in a given particle’s interference pattern (light intensities of the interference patterns are converted to voltage levels). The “voltage levels” are digitized into integers from 0 to 225.

Unfortunately, the exact relationship between a particle’s MSA and its size is anything but linear. That is the problem the linearization parameter table is designed to remedy. The linearization parameters are simply the MSAs of particles of 18 different sizes. For instance, in the F0 filter file, the particles sizes are 1 $\mu$ m, 2 $\mu$ m, 3 $\mu$ m... In the F0 filter file Spectrex would need to know the MSA of 1 $\mu$ m particles, 2 $\mu$ m particles, 3 $\mu$ m particles, etc. all the way up to that of 16 $\mu$ m particles. With this information we can take any observed MSA and look it up on our list to determine what the particles’ size must be. To go from the abstract to the concrete, some the actual MSA’s for the F0 filter are listed below:

Size ( $\mu\text{m}$ )	MSA (0.255)
< 1 $\mu\text{m}$	14
1	18
2	24
3	32
4	42
5	54

If our system detected a particle whose MSA was 26, we could determine its size just by looking on the table above. (26 falls between the 24 MSA of a 2  $\mu\text{m}$  particle and the 32 MSA of a 3  $\mu\text{m}$  particle). Since this value exceeds the MSA of a 2  $\mu\text{m}$  but not that of a 3  $\mu\text{m}$  particle, this particle must belong in the 3  $\mu\text{m}$  bin. Note that the values on the table define the maximum value permissible to be included in a certain bin, so values from 14 are in the “< 1  $\mu\text{m}$ ” bin, values from 15-18 are in the “1  $\mu\text{m}$  bin” and so on.

There are two special entries on this table that need further explanation: the first and the last. The first entry is the maximum underflow value. Any signal with an MSA up to and including 14 in this case, is deemed to be “underflow” which means that its size is some unknown value less than 1  $\mu\text{m}$ . The other special case is the last entry, which is ignored! Any particle with an MSA greater than the value for channel 16 is deemed to be “overflow”.

Now that you are an expert in MSAs, the following explanation will make a lot more sense. A filter file is primarily a collection of the MSAs of 17 particle sizes (underflow up to the 16<sup>th</sup> size designation). These MSAs are collectively referred to as “linearization parameters”. They make the non-linear relationship between MSA and the particle size “linear” by specifying MSA ranges for each particle size range. Fortunately, Spectrex Corporation has already figured out the MSAs for you, but if you want to mess with them at least you know how the game is played!

The threshold knob on the front of your LPC sets the counter's trigger threshold. This "trigger" threshold is simply the DC voltage level just high enough to include the signal of the smallest particle of interest. For example, if your counter's circuitry were such that the signal from a 1 $\mu$ m particle went from 0 up to 0.63v, then you would want the counter to increment each time the signal moved above that level since that would indicate that another particle had drifted through the beam. The proper "trigger" threshold would be a hair below 0.63v.

### Finding the Background

The first step in setting the background level is to determine the setting, which will exclude the counter's noise such as dust floating through the beam, amplifier noise, etc. The Find Background function does this. The procedure to find the background is as follows:

1. Clear the stage (remove any bottles from the counter) and close the light tight cover.
2. With **Main Menu** on screen, click on **Utilities** and select **Background Calibration**.
3. Select **Find Background**, then **Review Parameters**.
4. Indicate the number of sample counts you intend to take. We recommend 10. Enter background setting of 4 and hit **OK**. The Window will close and you will be returned to the **Find Background** Window.
5. Set the threshold knob to 4.
6. Select **Take counts**. The computer will open a new window with a prompt **OK** to begin sampling. While the LPC is counting, the computer will indicate the number of counts taken, the current average, and the total number of events for any completed counts.
7. If the average counts are greater than 10, increase the threshold knob setting to 5 and repeat steps 3-6 above. Continue until the average is less than 10 counts. Normally, the background threshold setting should not be greater than 8. Call Spectrex if it is. **The Threshold should never be set to below 4 on the dial. Normally it is set at 4.**

### Checking a Standard Bottle

Whenever the counter hardware is moved, the optical alignment needs to be checked. To do this, you first determine the background threshold level as described above. You then use the **Standard Bottle** function within **the Background threshold utility**. To check a standard bottle, enter the number of counts you wish to take. Indicate the background, which standard you wish to check and the count to expect (the count is written on the label on each standard). The procedure to check a standard bottle is as follows:

1. Place the desired standard bottle on the stage.
2. Select **Standard bottle**, then **Review Parameters**.
3. Indicate the number of counts (Samples) you intend to take. Then enter the background setting (normally on 4) for the standard bottle and the expected count from the front of the bottle. Click on **OK** after the expected count from the front of the bottle. Clicking on **OK** after last entry will close the **window** and you will be returned to the previous window.
4. Select **Take Counts**. The computer will open a new window with a prompt to set the threshold knob on the front of the LPC to a new setting (usually 10). Clicking on **OK** will start the LPC counting (only do this after resetting the knob). While the LPC is counting, the computer will indicate the number of counts taking the current average, and the expected value, as well as the totals for any completed counts.
5. If after the computer has finished taking the specified number of counts, the average sample deviates from the expected count by more than plusminus 15%, the LPC may need an optical re-alignment or electronic **gain** correction. Check all three bottles before jumping to any rash decisions however.

## Checking a Custom Bottle

This function is essentially the same as the Standard Bottle function. The difference is that it is intended to operate on any bottle with particles of any size within the basic capability of the instrument. The procedure to check a custom bottle is as follows:

1. Place the desired custom bottle on the stage.
2. Select **Custom Bottle**, then **Review Parameters**.

3. Indicate the number of counts (samples) you intend to take. Then enter the background setting of the particle size of interest and the expected count from the front of the bottle. Clicking **OK** after the last entry will close the **Window** and you will be returned to the previous window.
4. Select "Take counts". The computer will open a new window with a prompt to set the threshold knob on the front of the LPC to a new setting. Clicking "OK" will start the LPC counting (only do this after resetting the knob). While the LPC is counting, the computer will indicate the number of counts taking the current average, and expected value, as well as the totals for any completed counts.
5. After the computer has finished taking the specified number of counts, the average sizes will be computed and displayed.

## Counter Signal Calibration

See Appendix F, page 38

This sets the Card Calibration Parameter Values.

**Important.** Please do NOT change these values. They have been preset by Spectrex for your particular particle LPC.

The LPC can present the results of a sampling in several ways. In addition to the basic screen display, the LPC also produces reports containing the precise numerical counts observed in a sample. These reports can be sent to the printer, disk, or may be previewed on the screen in test format. When the output is sent to the printer, you may choose to include a comment which appears at the top of each printout. This comment, which typically is used to commit the particulars of a sample to hardcopy, consists of 8 lines of text, each line containing 60 characters. The output Function Menu itself lets you do the following: specify where the output should be sent and select which columns should be included in the report.

### Detailed Explanation of Out-Put Printout

#### A. Title

(Report Comment)

Identification and description of sample.

#### B. Histogram Showing Size Distribution

**Bin Number** Left hand vertical column indicates bin or channel number, normally 32 bins are used.

**Particle size range** Moving from left to right: the next vertical column shows the particle sizes from 1 to 100 micrometers (symbol  $\mu\text{m}$ ). Note:  $1\mu\text{m}$  is equivalent to one thousandth of a millimeter or one millionth of a meter. The human eye is able to see down to about  $50\mu\text{m}$ , while the Spectrex Instrument can count and size down to  $1\mu\text{m}$ .

**Particle size in %** Next column is the percentage distribution over the complete size range.

**Count Column** (Interim, for 16 bin) (total, for 32 bin).  
For 16 bin mode, these numbers are only indirectly related to the absolute number of particles in each bin and depend

on time of count. For 32 bin mode, they are the absolute counts, the same as C3.

<b>Bar Graph</b>	This gives a quick visual indication of the size distribution.
<b>“Histogram”</b>	The scale at the top can be changed as necessary.
<b>Filter Box</b>	(The topmost of six rectangles to the right of Bar Graph). F0 is used for clear water samples. F30 is used for opaque hydraulic oil samples. F11 is used for the small vial attachment.
<b>A-T</b>	This is the actual number of seconds it took to collect the sample.
<b>S-T</b>	This is the number of seconds SET on the computer to take the sample.
<b>Dilution</b>	If the sample has to be diluted, this is the amount of dilution needed.
<b>Offset and Gain</b>	These are constant presets in the computer to ensure that the sized particles are entered in the right bins.

### C. Listings

These are the vertical columns of numbers immediately under the Histogram (for 16 bin o/p) or on page 2 (for 32 bin o/p)

<b>Bin Number</b>	As explained above in B.
<b>Size</b>	As explained above in B.
<b>Total Counts per cc each the</b>	This column lists the absolute number of particles in bin and indicates the dilution factor. If there is a “0” in the sub 1 $\mu\text{m}$ category this does not mean that there are not any submicron particles present. Unless specifically requested we usually size from 1 $\mu\text{m}$ upward as there is a slightly indeterminate factor below that size, while we are sure that all 1 $\mu\text{m}$ particles are counted.
<b>Counts Percent</b>	As explained in B.
<b>Surface Area %</b>	The computer rearranges the distribution by Surface Area.

The Surface Area is derived by multiplying counts percent by the “square” of the diameter.

**Volume Percent** This is calculated using the “cube” of the diameter. You will notice that the percentage distribution is heavily weighted toward the larger particle range. A “volume calculation” in Settings mode permits calculating the power from 2 (square) to 3 (cube).

**Mass Per Bin** (in parts per million)  
The Volume Percent is multiplied by the specific gravity to derive the weight of the particles in each size range. The total of this column gives the total suspended solids in parts per million or milligrams per liter. (see E-2 below).

#### D. Standard Classification

This is usually in “Phi” categories, used by sedimentologists, geologists and water engineers. It is a relisting of C above in reduced number of channels. Other “Standard” listings, for hydraulic oils, are ISO, NAS and SAE and NSF for filtration testing. If you would prefer one of these three rather than “Phi,” specify in “Settings” mode.

#### E. Totals

Here we list

**Total number of particles in the sample.** This is the total of C3 above.

**Total number suspended solids.** This is a sum of the listing C7 and is both in parts per million and in milligrams per liter.

**Dilution Factor.** This is an indication of how much dilution was necessary to get the required results.

**Specific Gravity.** This important aspect of the sample is entered into the computer before the sample is run and is used to calculate the mass per bin (C7) and total suspended Solids (E2).

**Mean Size and Standard Deviation** are computed from total counts per cc C3.

**Date and Time** at which the sample was running is a valuable reference for the future.

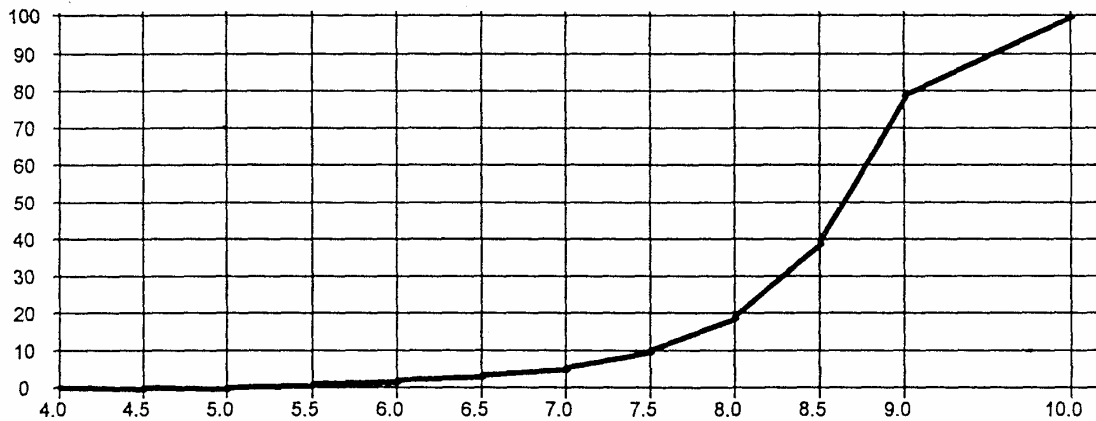
**Phi Sizing – for SEDIMENTOLOGY**

**Phi**

Phi #	Size Range (µm)
10	1-2
9	2-4
8	4-8
7	8-16
6	16-32
5	32-64
4	64-128

Cumulative %  
of sample

Phi size vs. Cumulative percentage of sample counts



Phi	Cumul%	Phi	Cumul%	Phi size			
4.0	0.43	7.0	5.34	Phi (5%)	6.9	Median	8.63661
4.5	0.43	7.5	10.26	Phi (16%)	0	Mean	8.57434
5.0	0.43	8.0	19.02	Phi (25%)	7.8	Dispersion	0.792296
5.5	1.28	8.5	39.32	Phi (50%)	3	Skewness	2.84736
6.0	2.35	9.0	78.42	Phi (75%)	8.1	Kurtosis	1.45323
6.5	3.63	10.0	100.00	Phi (84%)	5		
				Phi (95%)	8.6		
					4		

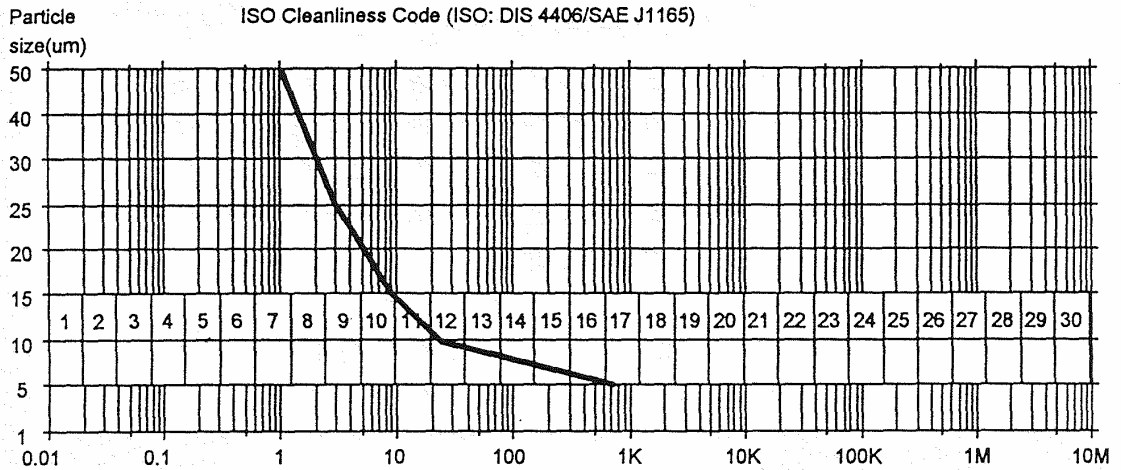
8.9  
6  
9.2  
6  
9.7  
7

Typical Print-out for sediments, Classification, cumulative.

## Oil Standards

### ISO

Group #	Size Range (µm)
1	>5
2	>10
3	>15
4	>25
5	>50



Number of particles/ml greater than indicated size

>Size	Number/ml
5 µm	723
10 µm	23
15 µm	9

25 $\mu\text{m}$	3
50 $\mu\text{m}$	1
ISO Code	17/10

Demo Printout for ISO Display typical for hydraulic oils

### NSF

Group #	Size Range ( $\mu\text{m}$ )
1	>1
2	1-5
3	5-15
4	15-30
5	30-50
6	50-100

### NAS 1638

Group #	Size Range ( $\mu\text{m}$ )
1	<5
2	5-15
3	15-25
4	25-50
5	50-100
6	$\geq$ 100

### SAE 749D

Group #	Size Range ( $\mu\text{m}$ )
1	<5
2	5-10
3	10-25
4	25-50
5	>50

### GB

<b>Group #</b>	<b>Size Range (µm)</b>
1	<5
2	5-15
3	16-25
4	26-50
5	50-100
6	>100

Hydraulic Oils Program

Appendix  
**B**

## Introduction

Our earlier model ILI-1000 LPC used a Helium Neon Laser and was more sensitive to red oils than the PC-2000, which uses a Laser Diode.

An AC-Fine Test Dust Standard in 5606 hydraulic oil is available from Spectrex. The optional Opacity Meter will indicate its opacity, which should not exceed 10%. The ILI-1000 would indicate 30% opacity. That is why the filter file for hydraulic oils is called F30. It should still be used with the PC-2000 as its parameters have been corrected.

Samples should be diluted until the Opacity Meter indicates not more than 10% opacity and the dilution factor entered via the Settings icon.

## Step-by-Step Instructions for Oils

### Step 1

Using the Opacity Meter, ensure that the opacity of sample is 10% or less.

### Step 2

With a sample "histogram" displayed on the screen, open the "Function" menu. Change the Filter Setting Number from F0 to F30.

### Step 3

Click onto the "Settings" menu, and enter the dilution ratio. Also, while in this menu, select which of the standards (ISO, SAE, or NAS) you prefer. You can also set the specific gravity, etc.

**Important.** Also set *Minimum Size Allowed* to 5.

Note: The SAE method of oil classification divides the particle range over 5  $\mu\text{m}$  dia. Into the following categories 5-10  $\mu\text{m}$ , 10-25  $\mu\text{m}$ , 25-50 $\mu\text{m}$ , 50-100 $\mu\text{m}$  and >100 $\mu\text{m}$ . The computer will automatically grade your sample into these categories and give it a “class” number. **Refer to Appendix A.**

#### **Step 4**

Click the  $\Sigma$  icon. This commands the computer to automatically collect counts in the lower range (F30) 5-16 $\mu\text{m}$ , then the higher range (F83) 17-100 $\mu\text{m}$  and finally integrates these into one continuous 32 channel listing.

#### **Step 5**

To view data, generate hard copy or a data file, click “O/P” for “Output Options” with “Histogram” on the screen, and follow standard procedure.

#### **Important (for SAE and NAS standards)**

If total counts per 100 cc are greater than 100,000 then there are coincident counts. The number of particles per ml are so high that the laser has begun to strike two (or more) particles at the same time, making them look like one larger one. It is important in this case to dilute your sample so that the number on the front of the LPC is less than 1000. (The number of total counts greater than 5 mm dia on the computer print-out would be less than 100,000 per 100 cc). Use the dilution techniques outlined in the introduction to this appendix.

## **Calibration**

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Besides the standard Red, White and Green capped calibration bottles, Spectrex can provide, upon request, a bottle of red 5606 oil containing AC Fine Test Dust obtained from Fluid Technologies, Stillwater, Oklahoma, and thus a primary standard. It has a Yellow Cap. This bottle contains a known number of particles per cc greater than 5  $\mu\text{m}$ . This number is recorded on the label on the bottle. To provide long term stability, the airspace in the bottle contains inert argon gas. Fluid Technologies guarantees its standard for one year. We suggest you purchase a new standard (\$250) from Spectrex at the end of each year.

#### **Step 1**

Shake the bottle for 15 seconds and put it into an ultrasonic bath for 15 seconds to remove air bubbles. As you have a built-in magnetic stirrer, a stir bar will have been installed in the bottle to keep larger particles in suspension.

**Step 2**

Carefully wipe the bottle with a clean, lint free, oil free cloth and place it in the V-Slot on the stage of the LPC. Visually check that there are no dust particles or other blemishes on the area where the laser beam enters the bottle. The red circle drawn by the laser should be faint.

**Step 3**

Set the “Threshold” knob on the LPC to approximately 25-30 (to get the correct count on the standard bottle).

**Step 4**

Run a count. The histogram on the computer screen will “grow” and the LPC display will show rapidly changing (increasing) counts.

**Step 5**

When counting has stopped, the final number should match the number on the bottle plus or minus 15%. If it is beyond this range, adjust the threshold knob on the LPC to zero it in.

Check that the resulting print-out looks like this:

Bin	Size	Total Counts/cc	Counts percent	Surface area %	Volume percent	Mass/bin ppm
1	>5	258	99.61%	100.00%	100.00%	2.20
2	>10	41	15.83%	61.85%	94.49%	2.08
3	>15	24	9.27%	46.41%	84.18%	1.85
4	>15	3	1.16%	10.15%	37.67%	0.83
	>50	1	0.39%	0.00%	0.00%	0.00

ISO Class: 15/12  
 Total Counts: 258/cc  
 Total suspended solids: 2.20ppm (mg/liter)  
 Spec. gravity: 1.00  
 Mean size: 7.05 um

Standard deviation: 4.19 um

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## Instructions for use of the Magnetic Stirrer Attachment for the Spectrex PC-2000 Laser Particle Counter

This attachment is a standard attachment and is helpful in keeping larger particles in suspension. It should always be used for hydraulic oils.

The Magnetic Stirrer is fitted underneath the glass plate in the Stage area, and so positioned that it is centered under a sample bottle or beaker when it is positioned in the "V" slot.

The Stirrer Motor automatically starts rotating when the LPC is turned one, so there is no need for a separate On/Off switch. All that is needed is a stir-bar to be dropped into the sample.

### Step 1

We recommend a stir-bar approximately 1" long and 3/8" in diameter. It should be carefully cleaned before using to avoid contaminating the sample. (One is included with your equipment).

### Step 2

With the stir-bar in the sample, place the sample in position on the LPC. The bar will rotate at approximately 2 cycles a second, giving a gentle, even, agitating movement.

**Note:** If magnetically attracted particles are to be counted, a special u-metal plate is available from Spectrex to deactivate the magnetic stirrer.

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## Instructions for “Auto-Averaging” Software Feature for the Spectrex PC-2000 Laser Particle Counter

### Introduction

This software revision greatly improves the accuracy and reproducibility of the data collected with the Spectrex LPC System.

The system both counts and sizes the particles in the sample liquid. The counts are automatically taken from the LPC display while the size distribution is the accumulation of counts displayed on the histogram over a set-time. The new software permits maximum data collection of both functions by “auto-averaging” and increasing sampling time.

A. The Procedure is very simple:

1. With the histogram displayed on the computer screen click the **Setting’ icon.**
2. Move cursor down to **Time to Sample.**
3. Enter number of seconds required to get good, statistically representative results. This becomes the **Set Time.** (60 seconds would be typical).
4. Click on **OK.**
5. Start particle count by either hitting the space bar or clicking on/or **GO.**

B. What will happen:

The histogram will grow until the A-T box (Actual Time) number coincides with that in the S-T box (Set Time). Meanwhile the LPC will take a series of counts, as many as will fit into the time envelope defined by S-T and will display an average on output.

**Example:** If S-T is 60 seconds and the LPC takes 17 seconds to perform one count cycle, then it will make a series of 3 count cycles while the computer is accumulating 60 seconds worth of sizing data.

$$17 \times 3 = 51 \quad (\text{well below the S-T of } 60)$$

The more time the LPC can cycle its counts and the longer the “Set Time” is, the more accurate the results will be.

### **Taking an extreme**

You can make “Set Time” be up to 9,999 seconds. Thus the particle cycles 9,999 = 588 times in this period and average the results.

### **Working backward**

If you wanted to average 5 counts on the LPC, multiply the number of seconds taken for one count by 5 and add an extra 5 seconds for safety. Thus  $(5 \times 17) + 5 = 90$  seconds. Of course, if you use the “Integrate” mode the total time will be double this as the higher size range (F80 or F83) will repeat the 5 cycles. Thus the final decision as to how long to count is a compromise between “limited time” and “required accuracy.”

It is important that the diluent used should have as low a particle count as possible. The “Dilution Calculation” program provided in the Windows® Software is a great help in entering the correct dilution factor in the settings window. However this does not correct for pre-existing counts in the diluent. If these are ignored they can cause considerable error.

### Example

If the diluent has 40 particles greater than 1 mm and the dilution factor is 1,000 then the final count is  $40 \times 1,000 = 40,000$  (too high). If the final count on the particle counter is 800 so that the final absolute count is  $800 \times 1,000 = 800,000$ , then this 40,000 is relatively insignificant (5%). However if the final count on the particle counter is only 400, then the final absolute count is 400,000 and 40,000 is a very significant factor (10%).

On the other hand, if the diluent has only 10 particles per cc, then for a final count of 400,000 the extra 10,000 particles added by the diluent is only 2.5%.

### Summarizing

1. Keep diluent count as low as possible, (30/cc or less), the lower the better.
2. Add sample so that the final count on the particle counter is **at least** 20 times the diluent count.
3. Always ensure that the final count does not exceed 800-1,000 to avoid coincident counts.

This is accessed through the Utilities Window.

### Warning

If Spectrex supplies a computer with your particle counter, **do not change** these values unless specifically directed to do so by Spectrex. If you proceed from here the **Card Calibration Parameter Values** window appears.

This contains three **slide** controls:

- a) Pre-Gain
- b) Voltage Reference
- c) Offset

Each can be adjusted by clicking on the slider and moving it to left or right. The values to the right of each **slide** define the sizing capability of the software.

**Important:** Make a note of these values before changing them.

### Note

For customers who buy the particle counter and software, installing it on their own computer, then these values must be set by the end user as they are individually customized to her/her particle counter.

From time to time you will want to check to see if you have the latest, updated Spectrex software. We provide an automatic update procedure, which is easy to connect to. On the CD-Rom provided will be an icon named **Spectrex Software Update Utility**. Double clicking will lead to a window – **Software Update Utility**.

Click onto **Update Software** and you will be automatically connected to your server, and the latest update transferred to your computer.