Spraytec

user manual

MALVERN
INSTRUMENTS

Spraytec User Manual

MAN0368 Issue 3.0 May 2007

Head office:

Malvern Instruments Ltd.
Enigma Business Park,
Grovewood Road,
Malvern,
Worcestershire WR14 1XZ
United Kingdom.

Tel + [44] (0)1684-892456
Fax + [44] (0)1684-892789

Printed in England

Table of Contents

Part 1 - Operator's Guide

Introduction to this manual

What is the Spraytec?

The Spraytec hardware

The Spraytec software

Measurement tutorial

Interpreting the results

Using measurement files

Basic maintenance

Part 2 - Supervisor's Guide

Security

Advanced Features

SOP Management

Part 3 - Appendices

Health and safety

Specification

Site requirements

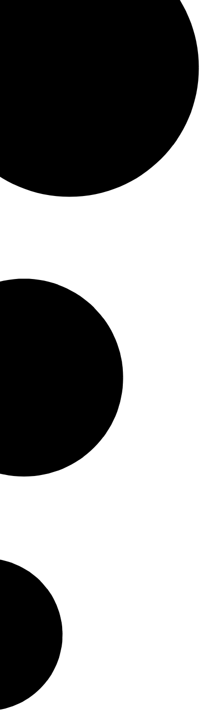
Unpacking instructions

Installation

Regulatory statements

Index

Part 1 -
Operator's Guide



1

Introduction to this manual

Introduction

This manual covers the operation and maintenance of the Spraytec system. In simple terms the Spraytec measures the size distribution of particles in sprays. It uses a software package for control, measurement and analysis, presenting the data according to the user's needs.

The aims of this manual are to:

- Explain what the Spraytec is, how it works and the parameters it measures.
- Explain in simple terms how the instrument analyses sprays.
- Describe the Spraytec hardware and software components.
- Explain how to use the instrument to make a measurement.
- Explain how to interpret the result data, how to print data and how to export it to other applications.
- Identify the user maintenance and troubleshooting procedures.
- Provide detailed information on advanced areas like alarms and triggers.
- Show supervisors how to configure security.

How to use this manual

Users **must read** the Health and Safety information in **Appendix A** before operating the instrument. The information given in this appendix applies to the Spraytec instrument itself, as well as accessories used with it.

We recommend reading this manual fully before starting the first measurement. Those who are more familiar with laser diffraction as applied to sprays can jump straight to **Chapter 5** which is a practical tutorial on making measurements.

The manual is divided into the following three sections.

Part 1 - Operator's guide

The Operator's guide contains all the information required by an operator using the Spraytec. Topics covered are:

- What the Spraytec does.
- The Spraytec hardware and software components.
- A tutorial – describes how to create three types of **Standard Operating Procedure** (**SOP**) and make a measurement.
- How to interpret the results.
- How to print results and export information for use elsewhere.
- Basic maintenance and troubleshooting procedures.

Part 2 - Supervisor's guide

The Supervisor's guide concentrates on administration and the more advanced Spraytec features. Topics covered are:

- Security – explains how to set up administrators, users and user groups.
- Advanced features – describes triggers, alarms, spray profiles, etc. in detail.
- SOP management – describes how to edit and delete SOPs and also how to set up SOP templates.

The supervisor should also read Part 1 - Operator's guide.

Part 3 - Appendices

Appendix A contains essential Health and Safety information which all users must read. **Appendices B** and **C** give the specification and site requirements. The other appendices contain supplementary information not necessary for the general operation of the system.

Access to the instrument

This manual refers to the various people who will have access to the instrument, as follows.

Malvern personnel

Malvern personnel (service engineers, representatives, etc.) have full access to the instrument and are the only people authorised to perform all service procedures that may require the removal of the covers.

Warning!
Removal of the covers by unauthorised personnel will invalidate the warranty of the instrument.

Supervisor

The supervisor is the person responsible for the management and safety of the instrument and its operation. The supervisor is responsible for training the operators. The supervisor can perform all user maintenance routines identified in **Chapter 8**.

Operator

An operator is a person trained in the use of the system. The operator can perform all user maintenance routines identified in **Chapter 8**.

Warning!
Under no circumstances should a supervisor or operator remove the main cover of the instrument. Failure to follow these guidelines could result in exposure to hazardous voltages.

Assumed information

This section presents general information.

Naming convention

The Spraytec is referred to either in full as "the Spraytec" or as "the instrument". The combination of the Spraytec instrument, the computer and the Spraytec software is referred to as "the system".

Menu commands

Menu commands in the Spraytec software are always shown in bold text and shown in the form:

main menu-menu item-submenu item

As an example, the command **Tools-Options-Serial Port** refers to selecting the **Serial Port** option of the **Options** command in the **Tools** menu.

Where to get help

Manual and online help

The primary sources of information on the Spraytec system are this manual and the software's online help. This manual gives an overview of the system as a whole, while the online help gives detailed information on the Spraytec software. Each dialogue in the Spraytec software has a **Help** button giving information on its use.

Accessories manual

The **Spraytec Accessories User Manual** provides details on the use, functions and maintenance of the following options/accessories:

- **Spraytec NSS** – the actuator support system.
- **Air Purge** – used to keep the instrument windows clear of spray.
- **Extractor system** – used to draw spray through the measurement zone.
- **Inhalation Cell** – allows measurements to be made in an enclosed cell where the flow rate can be fixed and closely controlled.
- **Wet Dispersion Unit** – used for particle-in-liquid particle sizing. This allows characterisation of wet dispersions as well as sprays.
- **Aerosol Adapter** – used for positioning aerosol sprays accurately.

As further accessories become available the manual will be expanded to cover these.

Help desk

All queries regarding the system should initially be directed to the local Malvern representative. Please quote the following information:

- The model and serial number of the instrument (located on the back of the Receiver module). This is also available from the software when an instrument is connected.
- The Spraytec software version (to find this, select **Help-About** in the software).

Contact the United Kingdom help desk if the local Malvern representative is not available. Its direct line is +44 (0) 1684 891800.

Note
This help line is primarily English speaking.

Remote support

Malvern Instruments offers a remote support service, delivered by an Internet connection. Benefits include fast and efficient fault diagnosis, reducing downtime and costs.

Online user training is also available, plus software updates. A high speed Internet connection is recommended for making use of this facility.

Malvern Website - www.Malvern.com

The Malvern website offers a comprehensive range of particle characterisation resources for use by customers 24 hours a day, seven days a week.

Resources include software downloads, frequently asked questions, a knowledge base and application notes, plus information on other particle characterisation solutions that Malvern Instruments can provide.

What is the Spraytec?

Introduction

This chapter describes the full process of making a measurement, explaining at each stage how the Spraytec works. It begins with a summary of what the Spraytec does, then covers the following:

- Preparing the spray and the instrument.
- Designing a **Standard Operating Procedure** (**SOP**).
- Capturing the scattering pattern – the principles of Spraytec operation.
- Calculating the particle size.
- Displaying results – the importance of volume-based results and how parameters are derived.
- Experiments, records and files – explains the meaning of these terms in this manual and the Spraytec software.

The Spraytec summarised

The Spraytec instrument measures the size of particles in a spray. Specifically, it measures the distribution of different sizes within a spray. The measurement process involves the following steps:

1. A spray is prepared and delivered using an appropriate spray delivery device or accessory.
2. The spray is delivered between the two functional modules of the instrument, the Transmitter and Receiver modules.
3. The Transmitter uses a He-Ne (Helium-Neon) laser to produce a laser beam that passes through the spray delivered to the measurement zone.
4. Detecting optics in the Receiver module detect the light diffraction pattern produced by the spray, converting the light detected into electrical signals. The signals are processed by analogue and digital electronics boards, and passed to the analysis software.
5. The light diffraction pattern is analysed using an appropriate scattering model to calculate the spray size distribution.
6. The software displays the results in a number of forms, including histograms, result-under plot and result-over plot, etc.
7. The user further processes the data as required, re-analysing records, averaging records, comparing sprays using overlays, etc.
8. Saved data is exported as required for use and further analysis elsewhere.

The use of **Standard Operating Procedures** (**SOPs**) ensures that results are as objective and reproducible as possible.

Preparing the spray

This involves:

- Priming the device, in some instances.
- Positioning the spray, taking into account the distance to the measurement zone, the working range and the risk of contaminating the optics.
- Considering whether extraction is needed to draw the spray through the measurement zone.
- For sprays like nasal sprays, setting actuation parameters to control the atomisation process.
- Taking account of ambient conditions, for example direct sunlight.

Designing an SOP

There are two ways to make a measurement; manually or using a Standard Operating Procedure (SOP). An SOP is like a template that defines a set of measurement parameters and settings. Advantages of using SOPs are:

- It ensures that measurements made on similar sprays are made in a consistent way, essential in Quality Control environments. SOPs can be created or modified as required.
- SOPs are ideal for measuring the same spray in slightly different ways. Instead of setting up sets of largely identical parameters each time, the user copies an existing SOP and just changes the required parameters. This reduces the risk of making errors in the settings.
- An SOP can be created centrally and then distributed to all Spraytec users within an organisation. Anyone can create an SOP but typically it is the responsibility of the system administrator.

Default SOP templates are provided for continuous sprays, rapid mode measurements and nasal sprays. Initially it may be best to use one of these, then refine it later as experience grows. The user can design templates as extra defaults.

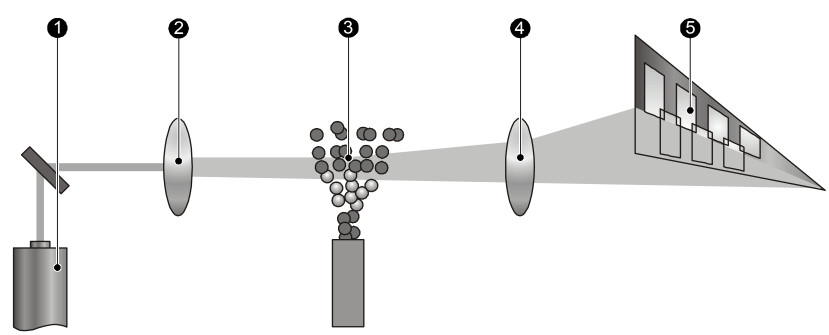
The software can be used to create an SOP without an instrument connected. The software can be installed on a remote computer and SOPs created and edited before they are tested on an instrument.

Capturing the scattering pattern

This section describes the principles of the Spraytec's operation.

Fundamentals

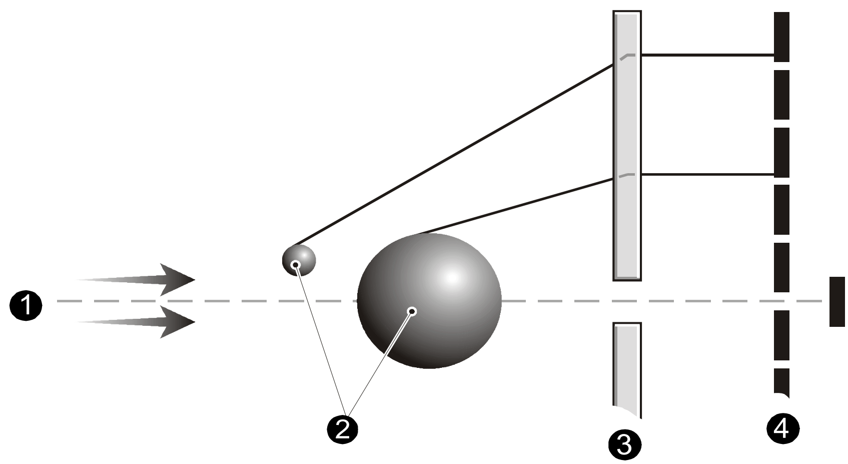
The fundamentals of Spraytec spray measurement are shown in this diagram:



ill 7424

The process is:

1. Light from the laser ① is scattered by the spray droplets ③.
2. The laser beam is expanded by the collimating optics ② to provide a wide parallel beam.
3. The scattered light is focused by a focusing lens ④ in a Fourier arrangement and picked up by the detector array ⑤.
4. Unscattered light is focused by the focusing lens ④, so that it passes through the pinhole at the centre of the detector array. This is measured by the beam power detector (detector 0) to give the light transmission.
5. The angle at which a particle diffracts light is inversely proportional to its size. The detector array is made up of over 30 individual detectors, each of which collects the light scattered by a particular range of angles. There is a data channel for each of these. Measuring the angle of diffraction determines the size of the particle, as shown in the following diagram.

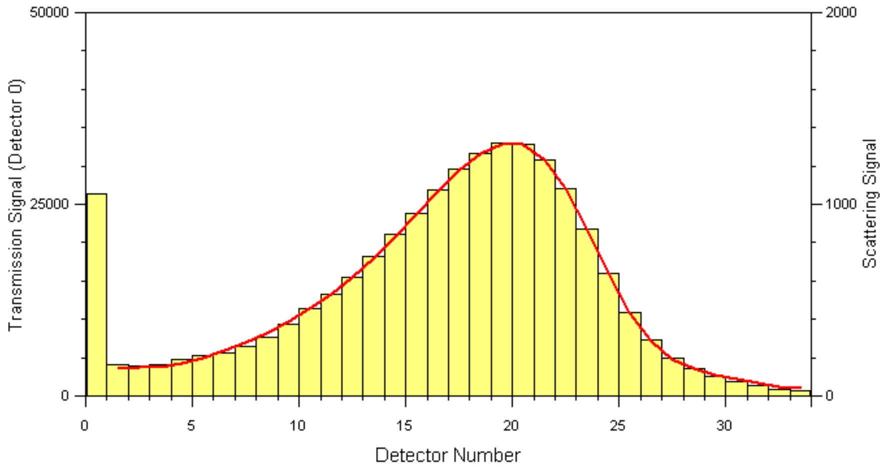
   ill 7427

   This diagram shows a parallel light source ①, particles of different sizes ②, the focusing lens ③ and the detector array ④. There is also one extinction detector.

   Diffraction is also influenced by the material which makes up the particles. To take account of this, the user can supply information on the optical properties (refractive index and density). For details see **Chapter 10**.

6. The scattering pattern from the spray is captured. This is known as the **measurement**. The capture is controlled by the user, either manually or using an SOP.

A typical light scattering pattern is shown below. Each bar in the histogram represents the scattered light captured by one of the detectors (channels):



The detector array takes a snapshot of the scattering pattern. Note the following:

- The pattern is a snapshot in time which relates directly to the size of the particles.
- The Spraytec can take snaps at a rate of 10kHz.
- Continuous acquisition allows a history of the spray event to be built up.

Multiple scattering

In cases where the particle concentration is high, the measurement process is complicated by scattered light being re-scattered by other particles before it reaches the detector. The Spraytec software can apply a patented **multiple scattering algorithm** to correct for this.

Background factors

The measured scattering signal is made up of these components:

- An electronic background component.
- An optical background component.
- A scattering component.

The electronic and optical backgrounds are measured and automatically subtracted from the total signal to leave the scattering pattern that is caused by the presence of spray in the beam.

The two background components are measured as follows:

- **Electronic background (noise)** – the laser beam is automatically switched off by the software to make this measurement, termed the **Dark background** measurement. At this point there is no transmission reading and there should also be minimal light diffraction as no light should be able to enter the sealed unit.
- **Optical background** – this measures the laser power, the scattering caused by contamination on the optics, the scattering caused by daylight or artificial illumination, and flare caused by the optical surfaces. This measurement, termed the **Light background**, is made when the laser beam is switched on but no spray is present.

Note

Excessive dirt on the optics degrades the instrument's sensitivity. **Chapter 8** gives instructions on cleaning the windows and advice on how to keep them clean for an acceptable amount of time.

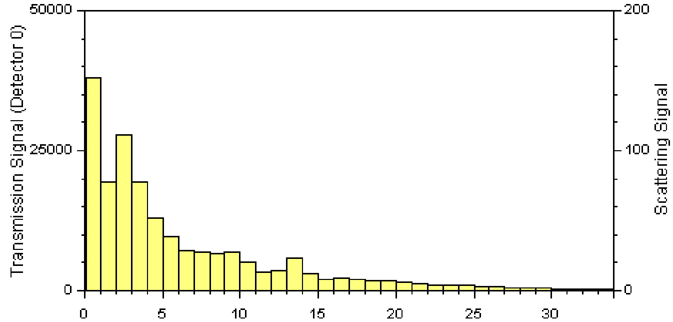
Avoid excessive background light, for example strong sunlight.

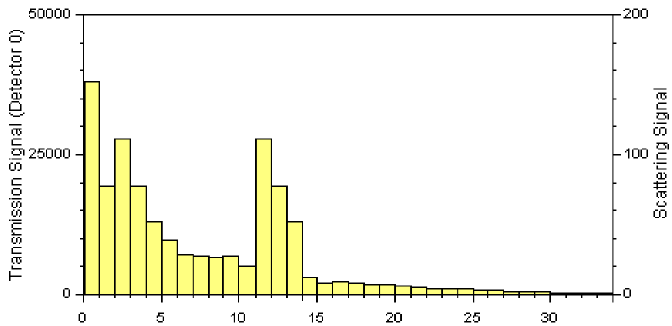
The light scattering components are:

- **Raw light scattering** – this is the scattering signal from the detector with the dark background subtracted from it. This pattern can be viewed at any time, regardless of the instrument status.
- **Corrected light scattering** – this is the scattering signal from a detector with both the light and dark background subtracted from it. (The light background is modified using the multiple scattering algorithm and corrected for the transmission, which is affected by some of the background light being obscured by the spray particles.) The Particle Size Distribution is calculated from the corrected light scattering pattern.

The relationship between these measurements is not quite as simple as described above. In fact the multiple scattering algorithm is applied to the corrected light scattering pattern.

The following graphics show examples of good (top graphic) and bad (lower graphic) background measurements.





Alarms

Alarms are used to send the user a warning if conditions are not suitable for measurement, for example if the optics are contaminated.

Calculating the particle size

The Spraytec software calculates the particle size of sprays by comparing the acquired light scattering pattern to an optical model which predicts how particle scattering changes with particle size. To understand the meaning of the results from the Spraytec, two fundamental concepts require explanation. These are:

- The theory behind the calculations.
- Why the result is expressed in terms of equivalent spheres.

Theory

Scientists have for centuries tried to predict the way particles scatter and absorb light. There are many theories and models that the modern particle size analyst can use.

One of the simplest theories used is the **Fraunhofer approximation**. This model predicts the scattering pattern that is created when a solid, opaque disc of a known size is passed through a laser beam. This model is satisfactory for large particles (over 50μm diameter) but it does not describe the scattering exactly. Very few particles are disc shaped and most particles are transparent.

The accepted theory which accurately predicts the light scattering behaviour of all materials under all conditions is known as the **Mie theory**. This was developed to predict the way light is scattered by spherical particles and deals with the way light passes through, or is absorbed by, the particle. This theory is more accurate, but it does assume that the analyst knows some specific information about the particle, such as its refractive index and its absorption.

The key point about these theories is that if the size of the particle and other details of its structure are known, the user can accurately predict the way it will scatter light. Each size of particle has its own characteristic scattering pattern, like a fingerprint, unlike that for any other size of particle.

Equivalent spheres

Mie theory presumes that the particles being measured are perfect spheres. In practice they are very rarely so. If the particle is an irregular shape, which particular dimension should be measured?

As an example, imagine trying to measure the size of a matchbox. An exact description of the matchbox's dimensions might be “50mm wide x 25mm long x 10mm high”.

In fact all three dimensional objects require three numbers to describe them. Considering this, it is difficult to see how we can arrive at a single number which uniquely describes the matchbox's particle size. Obviously the situation is even more complex for irregularly shaped particles.

In particle size analysis, most people want to have a single measurement to describe their spray, for example, they wish to say that their spray is made up of droplets with a 50μm diameter. What is required is a unique number that describes the droplet. If we say we have a sphere with a 50μm diameter, this describes it exactly.

One way to get a single unique number to describe an irregular shaped droplet is to compare some feature of the actual droplet to an imaginary spherical droplet. This technique is known as **equivalent spheres**.

Some typical methods of doing this are:

- **Equivalent surface area** – calculation of the diameter of a theoretical sphere that has the same surface area as the original droplet.
- **Equivalent maximum length** – calculation of the diameter of a theoretical sphere that has the same maximum dimension as the original droplet.

- **Equivalent minimum length** – calculation of the diameter of a theoretical sphere that has the same minimum dimension as the original droplet.

Many other methods are also available.

The Spraytec uses the volume of the droplet to measure its size. In the example above, the matchbox has a volume of 50 x 25 x 10mm = 12500mm^3. If the Spraytec was able to measure this size of "particle" it would take this volume and calculate the diameter of an imaginary sphere that is equivalent in volume – in this case it is a sphere of about 30mm diameter.

Obviously, a different answer is obtained if the surface area or maximum dimension of the matchbox is used to calculate an equivalent sphere. All of these answers are correct but each is measuring a different aspect of the matchbox. We can therefore only seriously compare measurements that have been made using the same technique, or measurements of spherical particles.

Displaying results

The final step is to display the results. This section explains:

- Why the results are volume-based.
- How the distribution parameters are derived.
- What parameters can be derived from the analysis.

Volume-based results

The first point to remember in interpreting results is that the fundamental size distribution derived is volume-based. This means, for example, that a result indicating that 11% of the distribution is in the size category 6.97-7.75µm means that the volume of all particles with diameters in this range represents 11% of the total volume of all particles in the distribution.

A simple numerical example illustrates this point. Suppose a spray consists of only two sizes of particle, 50% by number having a diameter of 10µm and 50% by number a diameter of 100µm. Assuming that the particles are spherical, the volume of each larger particle is 1000 times the volume of one of the small ones. Thus, as a volume distribution, the larger particles represent 99.9% of the total volume.

Note
Number-based size distributions can be produced, although this is not the default; set this up using the **SOP Wizard**'s **Analysis** section. The online help has details. Also see the information on **Percentiles** below.

Derived distribution parameters

The second point to remember is that the analysed distribution is expressed in a set of size bands, optimised to match the detector geometry and optical configuration which gives the best resolution. All parameters are derived from this fundamental distribution.

Distribution parameters and derived diameters are calculated from the fundamental distribution using the summation of the contributions from each size band. In performing this calculation the representative diameter for each band is taken to be the geometric mean of the size band limits, defined as:

$$\sqrt{d_{i-1} d_i}$$

This number is slightly different from the arithmetic mean, defined as:

$$\frac{d_{i-1} + d_i}{2}$$

For example, the size band 404.21 - 492.47μm has a geometric mean of 446.16μm and an arithmetic mean of 448.34μm. In most cases the difference is small but the geometric mean is chosen in these calculations as more appropriate to the logarithmic spacing of the fundamental size classes.

The same principle of calculation applies to the standard deviation.

For **mono-size** distributions the distribution mean is reported as the geometric mean of the size class and the standard deviation is reported as zero.

For other parameters in the distribution a **piecewise-cubic fit** is created for the fundamental result. Intermediate values are then read from this curve, allowing interpolation of percentile points, which do not coincide with the measurement size band boundaries.

What is measured?

The software always calculates a number of **standard values**, described below. In addition to these, the user can select or define a set of **derived parameters** according to need. These are described in **Chapter 10**.

The **standard values** are the following:

- **Trans** – the transmission, a measure of the amount of laser light reaching the beam power detector. When no spray is present in the measurement zone, the transmission is 100%. A certain amount of light is blocked out when particles are introduced into the measurement area.

  The drop in transmission that occurs when a spray is introduced into the measurement zone can be used to trigger the start of a measurement.

- **Cv** – the volume concentration. This is calculated from the Beer-Lambert law and is expressed as a percentage.
- **SSA** – the Specific Surface Area, the total area of the particles divided by their total weight. If using this value, the density of the spray must be defined (this is one of its optical properties). Note that this figure is a mathematical calculation based on the assumption that the particles are both spherical and non-porous.
- **Percentiles** – **Dx(10)**, **Dx(50)** and **Dx(90)**. In a result the **x** in these parameters is replaced by either **v** for a volume-based size distribution or **n** for a number-based size distribution.

  For a volume-based size distribution, for example, **Dv(10)** is the particle size below which 10% of the spray lies. This may be termed the "ten percent cut-off point".
- **Span** – this measures the width of the distribution. The narrower the distribution, the smaller the span becomes. The span is calculated as:

  $$\frac{Dx(90) - Dx(10)}{Dx(50)}$$
- **Moments** – the volume mean diameter **D[4,3]** and the surface area mean diameter **D[3,2]**. **D[3,2]** is also called the Sauter Mean Diameter.

The additional user-defined **derived parameters** include the following:

- Obscuration.
- Percentages above, between or below a specified particle size.
- Arithmetic and Geometric Standard Deviations.
- **Aux x1**, the value read from an auxiliary port.
- **R** (**Residual %**), the fit between the measured scattering data and the calculated data, and **Rms** (**Multiple scatter residual %**), the fit between the measured scattering data and data calculated by the multiple scattering algorithm.
- Rosin-Rammler and Log-normal parameters.

Full details of all these parameters are given in **Chapter 10**.

Experiments, records and files

This section clarifies the meaning of some common terms.

Experiments and records

An **experiment** is defined as everything that happens during one full run of an SOP, or between pressing the **Start** and **Stop** buttons to make a manual measurement.

During the experiment a single measurement or a series of measurements is taken. For a nasal spray this could be 2500 individual measurements made within a one second experiment. Each of these measurements will produce data for a series of parameters for that individual snapshot. This data is stored in a single **record**.

The record is the fundamental unit of storage. It contains all the information for an individual measurement, including the original measurement data and all parameters that have been set to calculate the size distribution.

Records are stored within a **measurement file**, grouped as one or more experiments. A measurement file can contain just one record or multiple experiments, each containing a series of records.

Saving data - the measurement file

Each time a measurement is made the measurement data are saved to a measurement file. This has the extension **.smea**.

Measurement file management depends on user preference. For example:

- A separate measurement file can be used for each type of spray.
- A separate measurement file can be used for each study or work programme.
- A separate measurement file can be used for each day.

Note
Users are prompted to specify where to save data at the start of a measurement.

Files are large so file sizes must be monitored.

3

The Spraytec hardware

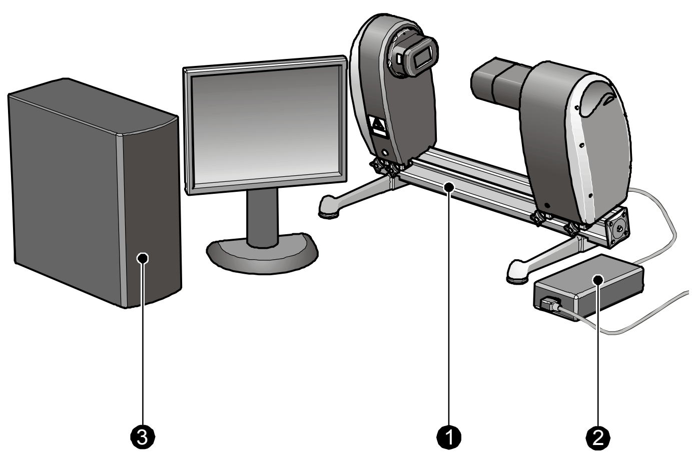
Introduction

This chapter introduces the Spraytec hardware components. It provides:

- A summary of the key hardware components.
- For each key component, a description of its main parts.

Key components

This diagram shows the key components of a typical complete system:



ill 7421

These are:

① Spraytec instrument.

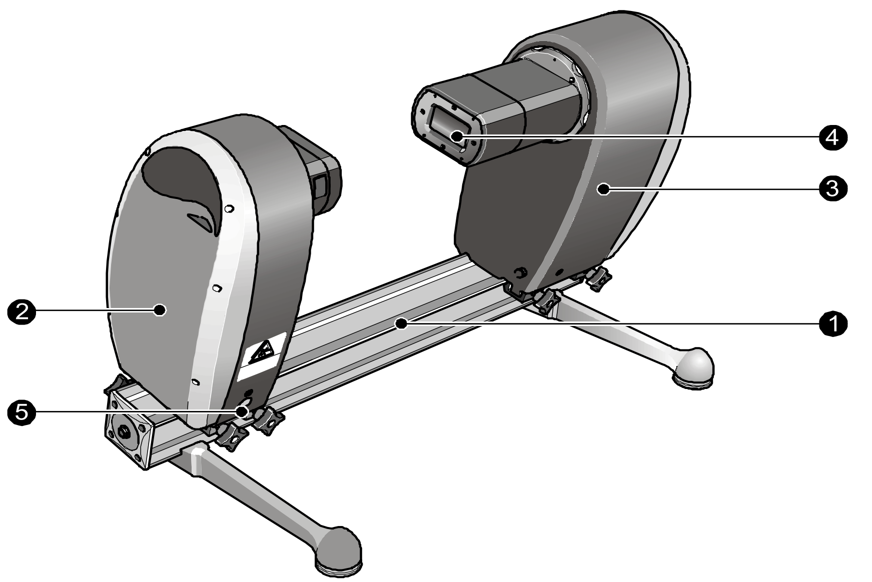
② External Power Supply Unit (PSU).

③ Control computer running the Spraytec software.

The following sections describe these components. Accessories are described in the **Spraytec Accessories User Manual**.

The Spraytec instrument

The Spraytec instrument is shown below:



ill 7422

The Spraytec has the following major components:

① Optical support bench (X-bar).

② Transmitter.

③ Receiver.

④ Lens (attached to the Receiver).

⑤ Power switch.

This section summarises the functions of these components.

There are two versions of the instrument:

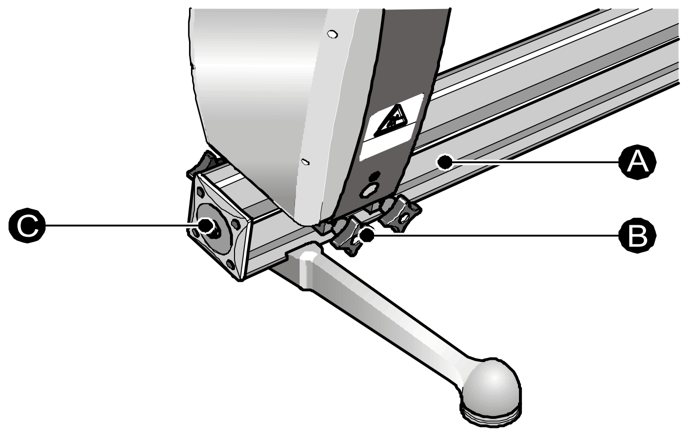
- **Standard** – identified by a green label on the Receiver cover.
- **High speed** – identified by a red **10K** label on the Receiver cover. This is only available as a 'feature key' option/upgrade.

① Optical support bench

The optical support bench or X-bar holds the Transmitter and Receiver modules in position. It is an extruded length of metal with flanges (forming an X shape) that hold mountable components stable and secure. The X-bar has zero deflection over its length and accurate parallelism between all sides.

The advantage of the X-bar is that the transmitter and receiver can be moved to different positions, with the certainty that the detector optics remain aligned to the transmitter laser path. This is the basis for the Spraytec instrument alignment.

The optical support bench is shown below:



ill 7423

This graphic shows:

Ⓐ **X-bar** – a PTFE strip on the base of the modules makes it easy to move them along the bar. Covers on the end of the X-bar prevent spray and dirt ingress.

Ⓑ **Clamps** – the Transmitter and Receiver are attached to the X-bar using two clamps as shown above. When tightened, the clamps pull the modules into the correct alignment plane and angle.

Ⓒ Socket for **LEMO cable connection** between Transmitter and Receiver.

Note
Any possible misalignment caused by moving the modules is compensated for by the detector alignment routine.

Options

The two Spraytec options have different X-bar configurations:

- **Angle of 12°** – this is available as short bench (950mm in length, with a measurement zone of 300mm) or long bench (1400mm in length, with a measurement zone of 750mm).
- **Vertical mounting** – short bench and long bench options are available as for the angled model. A Bench shroud is provided with these to stop spray being deflected back into the measurement zone; this is described below.

Spacing the modules on the X-bar

Follow these guidelines:

- For nasal sprays start at the minimum distance (150mm from the Receiver). Unless the spray fouls the detector (shown by the background measurement falling), there is no need to increase the distance from the Receiver.
- For any spray, if the distance from the Receiver is too great **vignetting** may occur. This is caused by a lack of data reaching the top end detectors. It can cause narrow mode results; see **Chapter 6**.

Adjusting the feet

The laboratory Spraytec X-bar must be kept at an angle of 12°. The instrument will be installed like this but if the feet are ever moved vertically out of position readjust them as described in **Appendix E**.

② Transmitter

The Transmitter contains the laser source. This produces a collimated beam of 10mm diameter with a wavelength of 632.8nm.

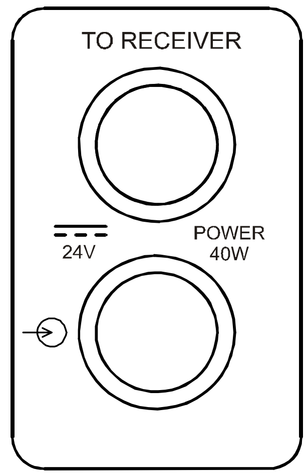
The laser beam from the Transmitter passes through the measurement zone where spray is sprayed, then through a lens and protective windows to the detector array in the Receiver. The laser beam is directed through the spray and the resultant scattered light is detected by the detectors in the Receiver.

Note
The Spraytec instrument is a Class 3R laser product.

Both the Transmitter and Receiver are installed inside cast aluminium covers. The cover body and end caps are painted with solvent protective paint. A rubber seal between the cover body and the end cap stops the ingress of moisture, dirt or contamination. This gives an IP65 protection rating in normal use. The power switch is on the front of the Transmitter.

Connections

The connections on the back of the Transmitter are labelled as shown here:



ill 7425

These are used as follows:

- **TO RECEIVER** – a LEMO cable with blue connectors is connected from here to the socket in the Transmitter end of the X-bar. This connects to the Receiver through the centre of the X-bar.
- **POWER 40W** – plug the power input cable with the red connectors from the PSU into this.

③ Receiver

The Receiver holds the lens assembly and photodiode detector elements. The lens focuses the scattered light onto the detectors. The main parameters for the two types of receiver lens are as follows (the Specification, **Appendix B**, has details):

	300mm	**750mm**
Detectors	36	33
Nominal particle sizes:		
Dx(50)	0.5 to 600µm	5 to 1600µm
Dx(95)	0.1 to 900µm	2 to 2000µm
Minimum working distance	150mm	500mm

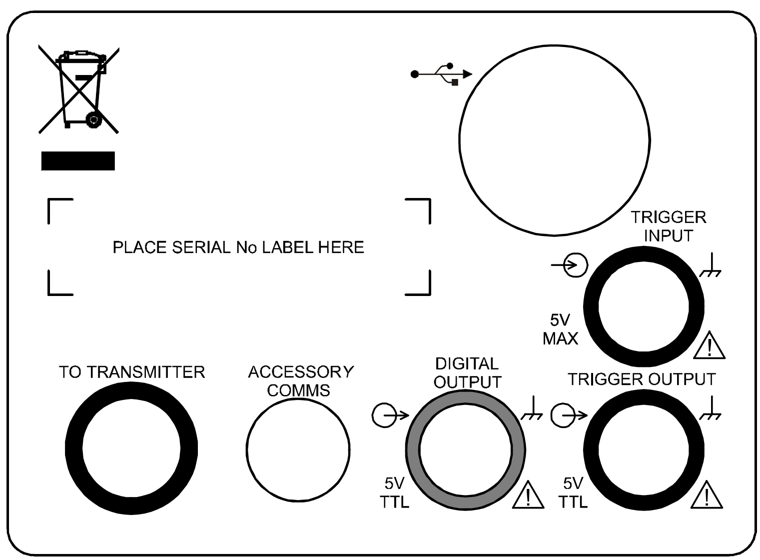
Note
The **electrical background** measurement includes any signal caused by ambient light in the room. Ensure no bright lights shine directly into the Spraytec optics. Do not work next to a window where sunlight can interfere with the measurement as this may cause the overall ambient light levels to change during the measurement.

In addition to the detectors shown above there is one extinction detector channel which measures unscattered light from the Transmitter, giving 34 and 37 data channels for the 750mm and 300mm lenses respectively.

The Receiver has a status indicator on the front. This is illuminated when the instrument is fully powered on.

Connections

The connections on the back of the Receiver are labelled as shown below:



ill 7426

These are used as follows:

- **USB** – the large shielded end of the USB cable plugs into this socket, connecting to the USB port on the back of the control computer.
- **TO TRANSMITTER** – a LEMO cable with blue connectors is connected from here to the socket in the Receiver end of the X-bar. This connects to the Transmitter through the centre of the X-bar.

- **DIGITAL OUTPUT** – this 5V TTL output is used to drive an extractor unit or a mains-powered device (via the switching box). This output can be set high or low using the command **Tools-Digital Output**. The **Spraytec Accessories User Manual** gives details on connecting the extractor unit.
- **TRIGGER INPUT, TRIGGER OUTPUT** – these are general purpose TTL ports. External devices can be connected to these to synchronise other events with the Spraytec measurement.

  There are two main uses for the TRIGGER input:

  - To receive a signal from a cable-mounted manual trigger device.
  - To receive a signal from an actuator or a fuel injection system, triggering a Spraytec measurement.
- **ACCESSORY COMMS** – this is the port for connection of accessories other than those connected to the above ports. The accessory must support the **CAN Port protocol**. This port could be connected to the Spraytec NSS input or, for a fuel injection system, the input on a pressure sensor. Multiple accessories can be connected in sequence to this output.

Note
A USB error may be reported when the USB cable is in fact connected properly, but one of the other cables is not connected. If such an error is seen, check all cable connections.

④ Power switch

The mains power input is on the Transmitter. The push button on/off switch toggles the system between its low power (stand-by) and fully on states. This means there is always power supplied to the instrument. When the instrument is switched on a blue light ring around the switch illuminates.

External Power Supply Unit (PSU)

To supply power to the instrument, an external autosensing switched mode 24V PSU is used. This is connected to the **POWER 40W** input on the back of the Transmitter.

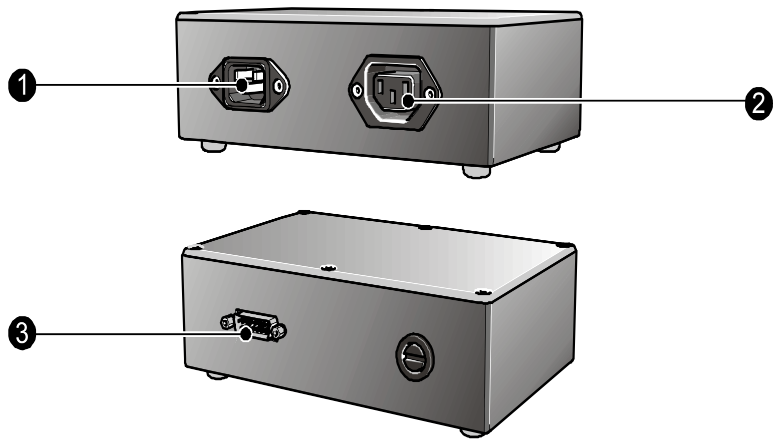
The power supply is fitted with a custom made connector cable with a special connector for attaching to the Transmitter module. This cable is fitted with red sleeves for identification.

Universal switching box

This switching box acts as an interface to another device, for example an extractor. It turns the device on/off, synchronising its operation with the Spraytec. The Universal switching box is connected between the Spraytec and the device.

Caution!
This is not for use with the extractor provided by Malvern Instruments for use with the Spraytec. That device uses a dedicated Extractor interface box.

These diagrams show the Universal switching box from the front (top picture) and the back:



ill 7466

The connections are as follows:

① Mains power socket.

② Connection to auxiliary device.

③ Connection to Spraytec.

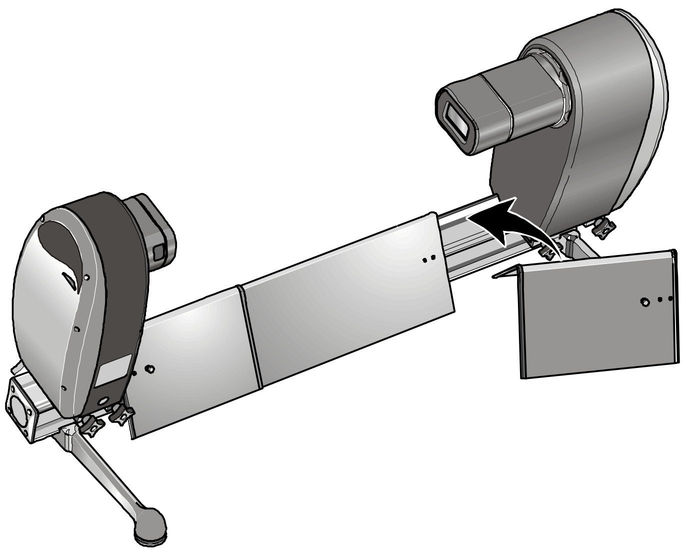
Computer and monitor

A computer of suitable specification is normally supplied. For information on the computer requirements, contact Malvern Instruments.

We recommend that this control computer is used to run the Spraytec software only.

Bench shroud

The wet environment Spraytec includes a detachable Bench shroud which covers the X-bar. The Bench shroud is used when measuring high volume sprays to ensure the spray is not deflected back into the Spraytec measurement zone.



ill 7467

The shroud has three similar sections which clip onto the X-bar using clips on their lower surface. The central section has four clips, the others have two.

▶ To fit the bench shroud:

1. Place the central section over the X-bar first, pushing its clips into place.
2. Place the end sections so that they overlap the central section on each side.
3. Push the end sections out from the centre until they reach the base of the Transmitter and Receiver modules.

4

The Spraytec software

Introduction

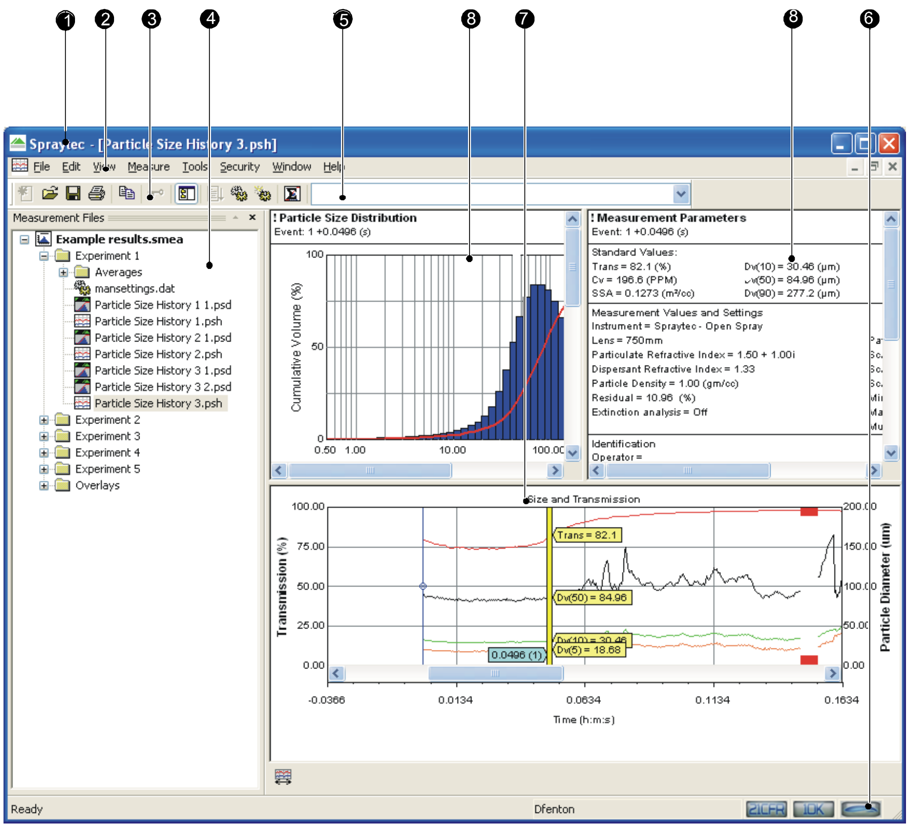
This chapter introduces the features of the software application. Its sections are as follows:

- The main window – gives a quick introduction to what the software looks like at startup and after a measurement.
- The Measurement File window – describes the components of this window.
- Result windows – describes the **Size History** and record view windows which display the measurement results.
- The **Measurement Manager** – describes the components of this window which is used to control measurements.
- **Average PSD** (Particle Size Distribution) and **Particle Size Overlay** (PSO) windows – describes two windows which are used to display results after optional further processing by the user.
- Menus – explains what each menu command does.
- The toolbar – describes the functions of the toolbar buttons.

A complete measurement tutorial is given in **Chapter 5**. **Chapter 6** shows how to interpret measurement results.

The main window

This section shows what the Spraytec window looks like. This example shows a typical Spraytec display when the software is launched and a measurement file (**.smea** file) opened:



ill 7451

The components are:

① **Title bar** – shows the product name and, if a result window (see below) is maximised, the name of that window.

② **Menu bar** – the commands are described later in this section. Commands which end with a row of dots (...) are those which open a dialogue box. Clicking an item which ends with an arrow displays a further menu of commands.

③ **Toolbar** – contains shortcuts for common commands. To help identify a button, a tooltip describing its action is displayed when the cursor is moved over it. Display of the toolbar can be toggled on/off.

④ **Measurement file window** – lists all files in tree form. This is described in detail below.

⑤ **Message bar** – shows status information, including warning messages. This is part of the toolbar.

⑥ **Status bar** – contains a number of icons displaying information about the state of the system, as detailed below:

- **21 CFR** – when coloured, this indicates that the software features providing compliance with 21 CFR Part 11 are enabled.
- **10K** – the instrument is the 10kHz version.
- **Spraytec** – when coloured, this shows the computer is communicating with the instrument.

Note
An additional **Remote control** icon activates when remote control (useful to advanced users only) is operating.

The remainder of the Spraytec window is initially taken up by three **result panes** containing views as described below. These windows can be cascaded or tiled if required, using options in the **Window** menu. To change between the views that a window can show, right-click on it and select from the displayed list.

⑦ **Size History** view – plots the values of derived variables for each record against time. This is described in detail below.

⑧ Two **record views** – these provide any one of seven views summarising the measurement. These are the **Particle Size Distribution** (**PSD**), **Derived Parameters**, **Measurement Parameters**, **Corrected Light Scattering**, **Raw Light Scattering**, **Light Background** and **Dark Background** views. These views are described in detail in **Chapter 6**.

In the above example, the left-hand view shows a **Particle Size Distribution** and the right-hand view **Measurement Parameters**.

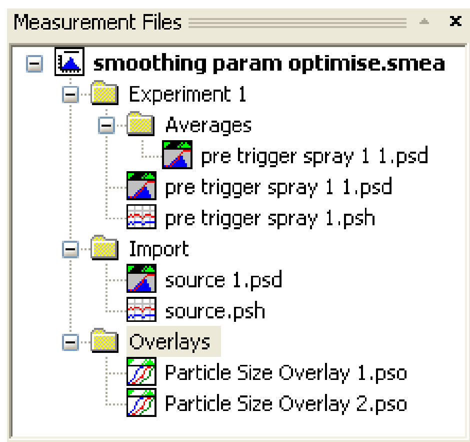
The information given by the record views is for the single record selected in the **Size History** view. Each time a different record is selected in the **Size History** view, these windows update their display to show data for that record.

The Measurement file window

Measurement results are automatically saved to a **measurement file**. This file and the experiment(s) and record(s) it contains are described in **Chapter 2**. The measurement file contains a virtual folder structure and the window displays its contents as a tree based on this. The measurement file can be considered as a folder where all results (records) can be viewed. It can be used to average and re-analyse results.

Open a measurement file by selecting **File-Open-Measurement file**. An example set of records in a file named **Example results.smea** is opened when the software is first launched after installation. Subsequently the software defaults to the last measurement file that was used before the previous shutdown. To close a measurement file, right-click on it and select **Close** in the pop-up menu.

Turn display of this window on/off as required using the button on the toolbar. This example shows a typical window:



Each component of the measurement file is denoted by a symbol in the tree:

- **.smea** file – the measurement file itself, this is the root of the tree.
- Folder – there is one of these for each experiment.
- **.dat** – manual measurement settings are stored as **mansettings.dat**.
- **.psh** – **Particle Size History** file.
- **.psd** – **Particle Size Distribution** file.
- **.ssop** – SOP file/SOP template.
- **.pso** – **Particle Size Overlay** file.

If averages are calculated, a new virtual folder named **Averages** is created with the average **.psd** files listed within it, as shown above for Experiment 1.

If overlays are produced, a new virtual folder named **Overlays** is created to hold these and the **.pso** files listed within this.

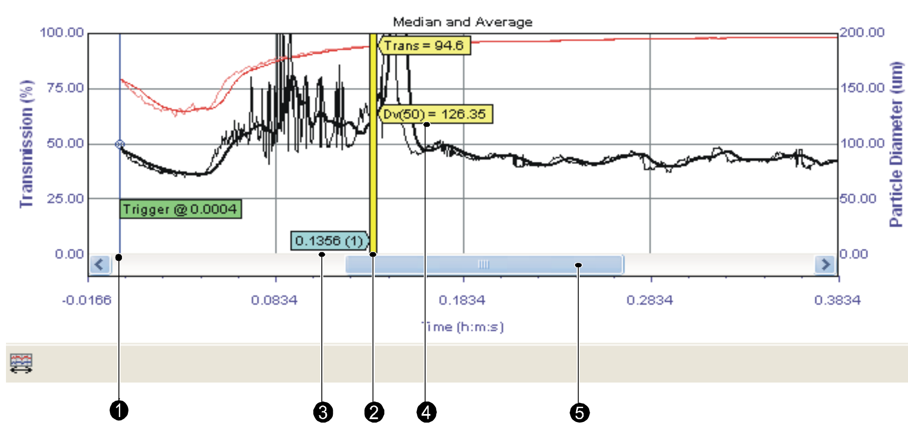
Measurement file window commands

Right-clicking on any file in this window displays a list of commands available for the file type. These are the following:

File type	Commands
.smea	Close, Import PSH
Folder	Delete, Rename
.psh, **.psd**	Open, Delete, Rename, Add to Overlay
.pso	Open, Delete, Rename
.ssop, **.dat**	Extract (open settings used for the SOP or measurement).

Size History view

The **Size History** view plots the values of all derived parameters for each record against time. Initially it shows the **Size and Transmission** view, showing how the particle size and concentration changed over time:



ill 7459

The key components are:

① Vertical line showing a **trigger mark**. When the cursor is held over this line, the trigger time is shown in a pop-up box as shown above.

② **Selector bar** – click on any record and this vertical bar moves to that point. The pop-up ③ to the left of the bar shows the time of the selected record, relative to the start time. The number in parentheses after the time shows the event number. If record view windows are also open, these show data for this record only. Each time the selector bar moves, those windows update their display to show the new current record.

④ **Parameter information boxes** – these appear to the right of the selector bar and display information on variables. In **Size and Transmission** view these show the **Transmission** and **Dx(50)** values by default.

⑤ **Horizontal scroll bar** – use this to select the time frame to view.

Alarms are indicated by red horizontal bars in this window; see **Chapter 6**.

Other views

Besides **Size and Transmission** the following views are available, showing parameters as follows:

- **Average Size and Transmission** – shows **Transmission** and **Avg[Dx(50)]**.
- **Mean Sizes** – shows **Avg D[4,3]** and **Avg D[3,2]**.
- **Transmission and Percentiles** – shows **Transmission** and **Dx(10)**, **Dx(50)** and **Dx(90)**.
- **Custom** – there are two of these which the user can modify as required using **Tools-Options-Default Size History View.**

To change to one of these views, right-click in the window and select the view in the menu which appears.

Selecting records

To select a range of records in this window, double-click on the first record in the range and then hold down the left mouse button and drag. A grey box shows the selection. The selected records can be averaged, re-analysed, printed, etc.

Zooming in on the display

There are two easy ways to zoom in on a period of time:

- Right-click and select **Size History Duration**. Specify the length of the period to display in the window.
- Select one or more records using the mouse as described above then right-click and select **Zoom in to Selection**. There is also a **Zoom Out** option to undo this.

Keyboard shortcuts

Use the left arrow and right arrow keys to move the selector bar by one record. These keys can be combined with:

- The Shift key – to move the bar by 10 records.
- The Ctrl key – to move the bar by 100 records.
- Both Shift and Ctrl – to move the bar by 1000 records.

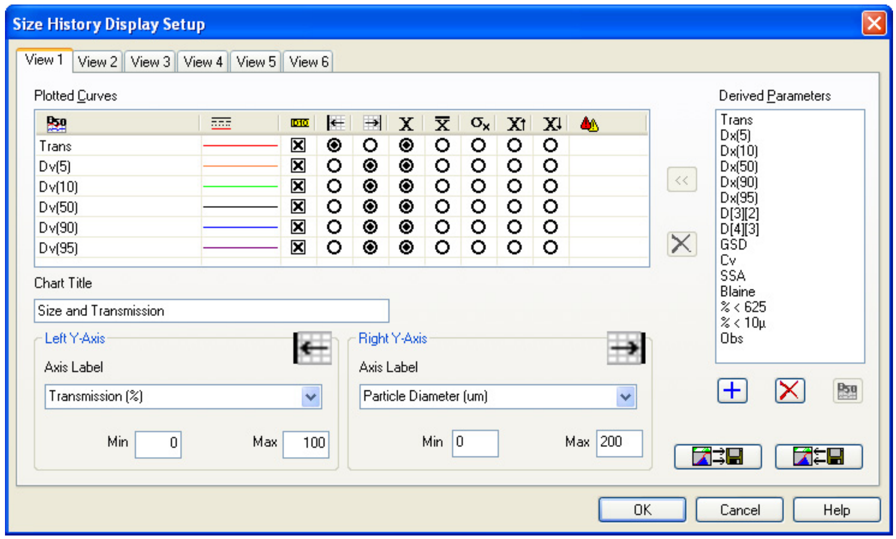
Note
If the time axis duration is very long compared to the time between records, the above numbers are approximate.

Other key commands for **Size History** windows are:

- **Home** – moves the time axis so the first measurement in the file is at the start of the chart (zero relative time).
- **End** – moves the time axis to show the last measurement in the file (i.e. to the right-hand side of the chart).
- **Page Up** – moves the selector bar to the first record of the previous event (if the measurement is split into events).
- **Page Down** – moves the selector bar to the first record of the next event (if the measurement is split into events).
- **Number pad "+"** – zooms the display to show the selected range of records (**Zoom in to selection** on the right-click menu).
- **Number pad "-"** – zooms the display to show all of the records (**Zoom out** on the right-click menu).

Changing the display options

To change the chart title, axes, derived parameters shown, colours used, line symbols, etc, right-click on the **Size History** view and select **Properties** to display the **Size History Display Setup** dialogue:

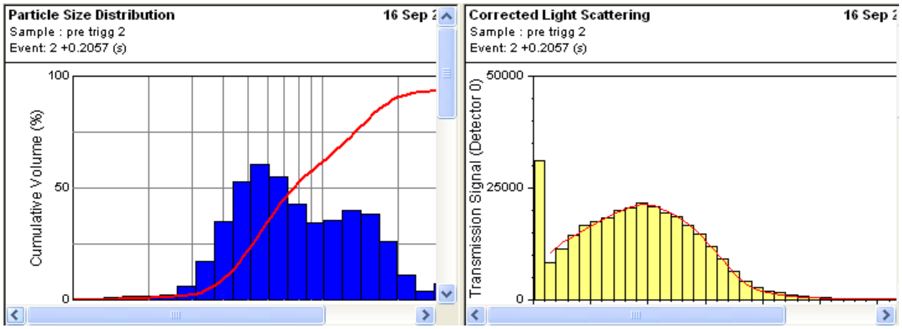


There is one tab for each of the views the **Size History** can show. The online help gives full details on how to use this window.

The record views

The record views give detailed information about the individual record selected in the **Size History** view. By default they appear above the **Size History** view. For details on all parameters that can be displayed, see **Chapter 10**.

Several views are available, selected by right-clicking in a record view. This example shows the **Particle Size Distribution** and **Corrected Light Scattering** views:



The available views are:

- **Particle Size Distribution** – this is the left-hand view in the above example. It shows a histogram and a cumulative “percent volume smaller than” line. A table of values is shown below the graph. This view is described in detail in **Chapter 6**.
- **Derived Parameters** – displays a table of values for each parameter analysed. This view is described in detail in **Chapter 6**.
- **Measurement Parameters** – gives textual information on the way the instrument is set up. This view is described in detail in **Chapter 6**.
- **Corrected Light Scattering** – this is the right-hand view in the above example. The first bar in the histogram shows the transmission signal (laser intensity) plotted against the left-hand Y axis. The remaining bars show the scattering signal for each detector (plotted against the right-hand Y axis). The scattering signal for each detector is shown in a table beneath the graph. The curve is the fitted curve for the chosen optical model. This relates to the calculated result and the residual value.
- **Raw Light Scattering** – the scattered light received by each detector, before the removal of noise. The table shown below the graphic includes a **Monitor** value, giving the laser intensity measured at the Transmitter.
- **Dark Background** – also called the electronic background, this is the background with the shutter closed. This table also includes a **Monitor** value.

- **Light Background** – also called the optical background, this is the background with the shutter open. This table also includes a **Monitor** value.

Note
Excessive dirt on the optics yields high background signals and degrades the instrument's sensitivity. See **Chapter 8** for instructions on cleaning the windows and advice on how to keep the windows clean for acceptable periods of time.

Display settings

Right-click in a record view and select **Properties** to change its settings. The dialogue differs depending upon the view selected, as described below.

For **Particle Size Distribution** and overlay views, the following can be changed:

- The style and limits for both the X and Y axes.
- The length of the X axis. Enter minimum and maximum particle sizes, then enter these limits in µm or in mesh sizes (select the **Use Mesh** check box). On clicking the **Use Mesh** check box, the **Minimum Size** and **Maximum Size** fields are automatically converted between µm and mesh values.
- For the **Particle Size Distribution** only, a **Maximum Frequency** value can be set. This defines the limit of the V**olume Frequency %** axis.
- Axis style (outside, inside, grid, or none).

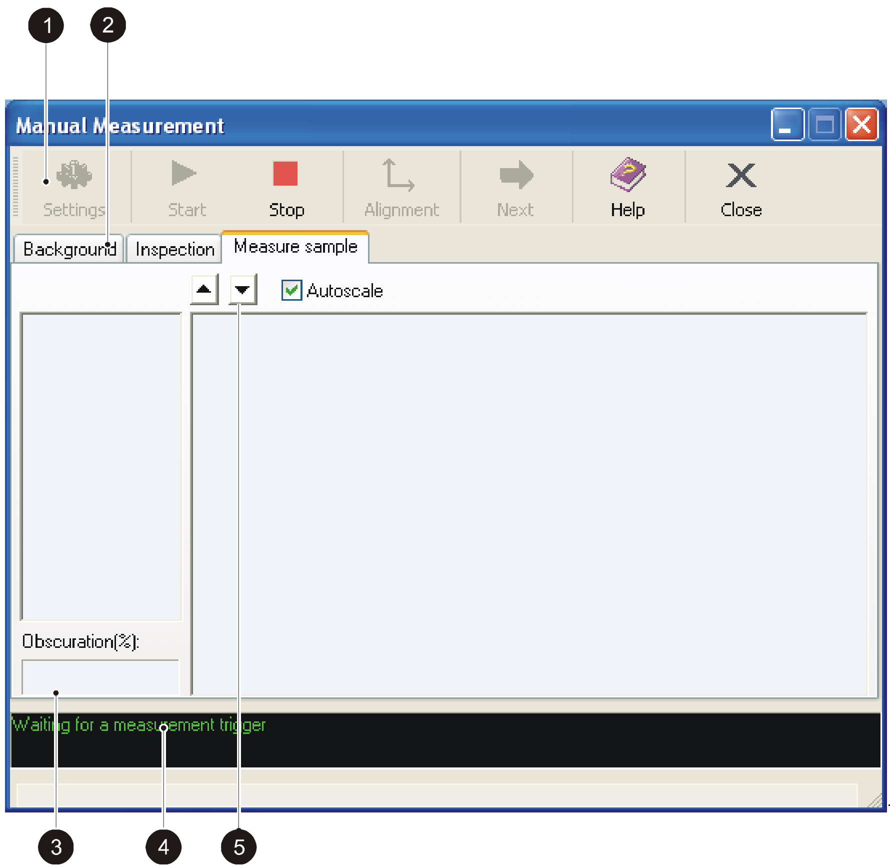
For raw and corrected scattering, light and dark background views, the following can be changed:

- The style and limits for both of the y-axes.
- The scattering limit refers to the axis that shows the scattering signal. The beam power limit refers to the axis that shows the transmission signal. Specify the maximum value that is to be displayed on each axis.
- Axis style (outside, inside, grid, or none).

The Measurement Manager

When a manual or SOP measurement is started the **Measurement Manager** display appears, giving control of the measurement. When this display opens, the software automatically makes an electrical background measurement, followed by a check on the alignment of the optics and an optical background measurement.

The display is similar for all measurement types:



ill 7460

The **Measurement Manager** components are as follows.

① Toolbar

The button bar controls the measurement operation. The buttons are:

Button	Function
	**Settings** – opens a dialogue showing the measurement settings. Extra comments can be added and changes made to the measurement parameters before the measurement is started. This button is disabled in SOP mode.
 	**Start**, **Stop** – starts or stops the measurement. **Stop** is not like a pause button; after it is pressed during a measurement, the user can choose to continue or to abort the measurement.
	**Alignment** – aligns the instrument (this is performed automatically the first time). This is disabled in SOP mode.
	**Next** – moves to the next logical stage of the measurement. For example, after completion of a background measurement (if the **Pause between stages** check box is selected), pressing **Next** moves to the **Measure sample** tab.
	Opens online help showing how to use the **Measurement Manager**.
	**Close** – closes the **Measurement Manager** and returns to the **Records View**. If **Close** is pressed while a measurement is in progress, the user can choose to continue or abort the measurement.

② Tabs

There are three different tabs, used as follows:

- **Background** – performs a background measurement. The measurement data from a spray is contaminated by background electrical noise and by scattering data from dust on the optics.

  The **measure background** facility makes a measurement with no spray present as well as a measurement of the electrical background. This background information is subtracted from the spray measurement in order to "clean" the data.

- **Inspection** – shows the background-corrected scattering prior to starting a measurement. If the background subtraction succeeds this tab should show random low level signals on each detector.

- **Measure sample** – displays the scattering information during the actual measurement.

③ Obscuration level

This shows the obscuration level during the **Inspection** and **Measure sample** stages. It gives a visual indication of the spray concentration; 0% means no spray is present. The exact obscuration is given at the bottom left of the dialogue. The instrument has a wide range of acceptable concentrations so concentrations do not have to be precise.

④ Status bar

This shows instructions and the current operation in the measurement sequence.

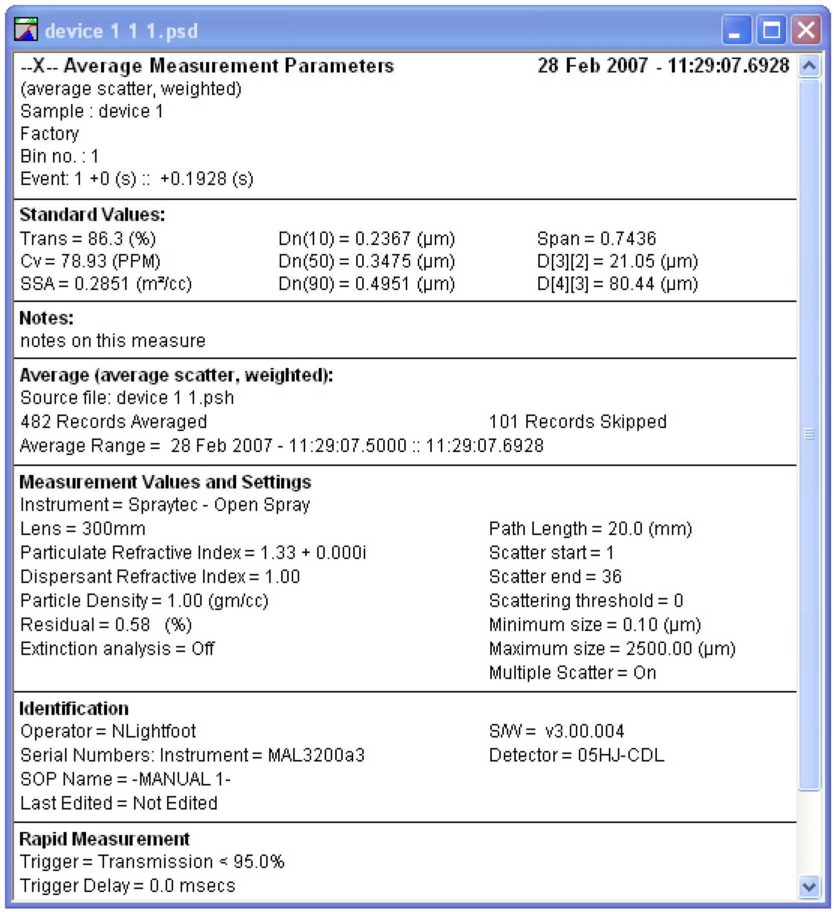
Right-clicking here displays a menu where the text size can be changed.

⑤ Scale buttons and Autoscale

When the **Autoscale** check box is selected, the X and Y axes are scaled by the software. The and buttons can be used to change the scale manually.

Average PSD window

The **Average PSD** window appears after an average is calculated. It can be based on scattering or size distribution; the line below the heading in the window shows which it is. This example shows its **Measurement Parameters** view:

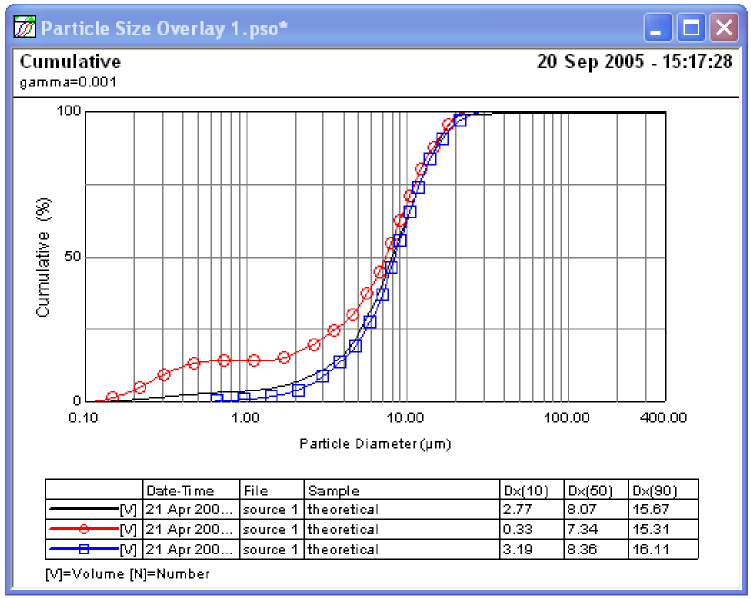


The window shows the same set of parameters as the **Measurement Parameters** window, but as averages for the range of records selected. This can be the whole measurement or a subset of records; the online help shows how to select a range and calculate averages.

The **Event** line, the fourth line in the window, shows the range the data are based on. Right-click to change the view to a different view type.

Particle Size Overlay window

A **Particle Size Overlay** (**PSO**) is used to compare data from up to eight **Particle Size Distributions**. These are shown in a **PSO** window like that shown below. This example shows data for three separate distributions:



The text "**[V]**" or "**[N]**" in the first column of the table indicates a **V**olume or **N**umber distribution.

The window can show data on the following:

- **Cumulative** (as shown above).
- **Frequency**.
- **Corrected light**.
- **Light Background**.
- **Dark Background**.

To switch to any of these views, right-click on the window and select it in the list displayed. For more details on producing overlays, refer to **Chapter 6**.

Menus

The menu bar contains the main menu headings for all software functions. The menu commands are described below.

File menu

The commands in this menu are:

Command	Function
New >	
Overlay	Opens a fresh overlay window for dragging **.psd** files to.
SOP...	Opens the **SOP Wizard** ready to produce a new SOP.
Open >	
Measurement file	Opens a measurement (**.smea**) file.
SOP...	Opens a list of **.ssop** files for selecting an SOP.
Save	Saves the current view window.
Save As…	Saves the currently selected **.psh** file as a stand-alone **.psh** file. Use this to send data to Malvern Instruments customer support.
Export…	Exports details from a measurement file to a software package such as Excel or Wordpad; see **Chapter 7** for details.
Import...	Imports a **.txt** or **.csv** file, formatting the data according to a user-selected configuration file.
Print...	Prints specified experiment information from the active (or selected) window to a printer.
Print to PDF...	Prints the active window contents or an average to a **.pdf** file. This is only enabled if the 21 CFR part 11 feature key has been installed.
Print Setup...	Specifies the printer to use and its setup.
Page Setup...	Specifies the default paper size, orientation and margins.
<Recent files list>	Lists recently accessed **.smea** files.
Close	Closes the current window.
Exit	Shuts down the software.

Note the following:

- Items which end with a row of dots (...) open a dialogue box.
- Items which end with an arrow (>) present a list of available sub-options when the user clicks on the arrow.

- Items shown in grey are not available at the time. This shows that the user has no permission to use it, or that the item is not relevant in the current context. For example, if the software is started with no instrument connected or powered on, the **Measure** menu commands will be unavailable.

Edit menu

Use this menu to manipulate records in a **Size History** or record view. For the **Size History** we recommend selecting the appropriate records using the mouse before choosing a command, but records can be selected from the dialogue itself.

Delete Records, **Find** and the two **Average** options are only available for a **Size History** view.

Command	Function
Records... /Record	Edits the selected record(s). The command is **Records** in a **Size History** view but **Record** in a PSD view.
Delete Records...	Deletes the selected record(s) from a measurement file.
Modify	Changes overlay properties (only available for an overlay).
Find...	Finds a record within a measurement file.
Copy	Copies the selected record(s) to the Windows clipboard for pasting into another application, for example Microsoft Word.
Copy Text	Copies the selected record(s) to the Windows clipboard.
Calculate Average...	Calculates the average of scatter data or size distribution for the records selected in the **Size History**.
Advanced Average...	Calculates the phase average or average between triggers or phase marks for the records selected in the **Size History**.

View menu

Use this menu to configure the main window display. The options are:

Command	Function
Default Layout	Returns all toolbars, etc. to default positions.
Size History Only	Closes result windows, apart from the **Size History**.
Record Views Only	Closes the **Size History**, leaving the record views open.
Toolbar	Toggles display of the toolbar on/off. A tick appears against this option when the toolbar is displayed.
Status bar	Toggles display of the status bar on/off. A tick appears against this option when the status bar is displayed.
Measurement Files	Toggles display of the measurement files list on/off. A tick appears against the option when the list is displayed.

Measure menu

Use this menu when ready to make a measurement. Once measurement details have been entered or an SOP chosen, the **Measurement Manager** appears.

Command	Function
Start SOP	Opens and runs an existing measurement SOP.
Manual	Lets the user set up the measurement and spray details manually, then run a measurement.

Tools menu

The commands in this menu are:

Command	Function
Digital Output	Allows the output to be set to a high or low state.
Laser Control	Opens or closes the laser shutter.
Remote Control	This mode is only for advanced users.
Options >	
Serial port...	Specifies the serial port to use.
Default Size History View...	Opens the **Size History Display** dialogue, showing its default options.
Colours...	Changes the colours of elements shown in result windows.
Engineering	Used by Malvern service engineers to perform maintenance tasks. The engineering options are password-protected.

Security menu

To prevent unauthorised changes, the software can be configured to limit each user's access to functions like modifying SOPs. Users are assigned operating **permissions** that allow or restrict access; this is fully explained in **Chapter 9**.

The menu options are:

Command	Function
Login, Logout	Logs a user on or out.
Configure Security	Sets up user accounts, permissions and groups.
Change Password	Changes the user's password.
ER/ES Settings...	Edits the ER/ES settings (only if 21CFR Part 11 is in use).
Install Feature Key...	Installs a key for a new Spraytec option (only if 21CFR Part 11 is in use).
Audit Trail...	Displays the current audit trail (only if 21CFR Part 11 is in use).
Add Audit Trail Entry...	Adds to the current audit trail (only if 21CFR Part 11 is in use).

Window menu

These commands alter the characteristics of open measurement file windows.

Command	Function
Cascade	Overlaps all open windows.
Tile	Fits all open windows into the available space.
Arrange icons	Lines up all open icons.
Close All Documents	Closes all open windows.
<Window list>	Lists all open windows by name.

Help menu

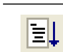
The commands in this menu are:

Command	Function
Help Topics...	Opens the help file.
About…	Gives details on the software version installed. Quote this version if contacting Malvern Instruments.

The toolbar

The toolbar is located below the menu bar. It provides button shortcuts for performing the most popular operations. Each button has an equivalent menu command. For example, clicking the  button is the same as using the **File-New-Overlay** menu command.

The toolbar commands are the following:

Button	Function
	Creates a new overlay.
	Opens a file.
	Saves a file.
	Prints a file.
	Copy (as a Windows metafile).
	Logs in or out
	Toggles on/off display of the measurement file list.
	Starts an SOP.
	Opens an existing SOP.
	Creates a new SOP.
	Averages the selected range of records.

Note that:

- As with menu commands, if a tool is not available its button appears “greyed out”.
- To identify a button’s function, move the cursor over it. A tooltip is displayed and a short description appears in the status bar.
- Display of the toolbar can be turned on/off using **View-Toolbar**.

5

Measurement tutorial

Introduction

After reading this chapter a user should be able to make simple measurements. The chapter covers the following:

- Getting started – powering on the system, starting the software, device and actuator preparation.
- Creating a Standard Operating Procedure (SOP) – setting up and saving measurement parameters to ensure that measurements of similar sprays are consistent. This optimises all software and hardware variables.
- Manual measurements – describes briefly how these differ from a SOP measurement.
- Measuring the spray – describes how to use the SOP to make the measurement.

SOP creation is described for three types of SOP separately:

- **Continuous spray** – these sprays are used in coatings and agrochemicals, for example. The aim is for a stable size distribution over time.
- **Pulsed spray** – this type of spray is internally triggered. Examples are nasal sprays and Measured Dose Inhalers (MDIs).
- **Externally-triggered spray** – a fuel spray is an example.

Chapter 6 describes how to interpret the results of a measurement. This includes a description of the results windows, re-analysing records, averaging data, etc.

Chapter 7 describes how to use the data (export data and print records).

Getting started

The first steps involve powering on the instrument and starting the software. Before powering on the instrument, we recommend ensuring that the optical windows are clean; see **Chapter 8** for advice on cleaning the system.

Note
If in doubt about the optical cleanliness, check the live display of the background measurement. This shows whether the optics are clean.

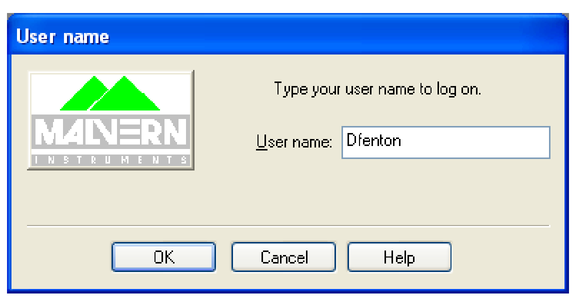
▶ To power on the instrument:

1. Turn on the instrument at its power switch.
2. Turn on the computer at its power switch.

Note
For a continuous measurement of over 30 minutes, the instrument requires 90 minutes to warm up to a completely stable state. This does not affect other measurement types.

▶ To start the Spraytec software:

1. Double-click on the Spraytec desktop icon. (If the icon is not available, open the Windows **Start menu** and select **Programs-Malvern Instruments-Spraytec** to start the software.)
2. The logon screen shown below is displayed; type your user name and click **OK**. (If security is configured, it prompts for a password too. For supervisors, **Chapter 9** describes how to administer security and set up users and groups.)



3. The software opens. If a measurement file was open in the previous session, this reopens automatically. If this is the first use of the software the **Example results.smea** file is opened in the Measurement file window.

Instrument preparation

This section presents guidelines on how to set the instrument up, depending on the type of spray being tested. Read each guideline below and take account of any which are relevant to the spray tested.

Take account of ambient conditions, for example direct sunlight, at all stages.

Priming the spray

It may be necessary to prepare the spray as follows:

- **Nasal sprays** – actuate the spray several times until a plume is obtained. For suspension-based sprays, turn the container end over end several times, but do not shake it vigorously.
- **Aerosols** – shake the spray container and spray for a couple of seconds to clear the nozzle. This is needed, for example, for most paint sprays, deodorants and MDIs.

Note
For some formulations shaking hard introduces air bubbles. For suspension formulations it may cause the solid particles to sediment out of suspension.

Propellant sprays

For sprays containing propellants, be aware that the presence of the propellant may affect the calculated size distribution. If using a spray which contains a propellant, refer to the section on **beam steering** in **Chapter 6**.

Positioning the spray

When positioning the spray take the following into account:

- The working range of the lens. This depends on the spray particle size, as described in the section **Problems with poor data** in **Chapter 6**. Outside of the working range **vignetting** may occur.
- The distance of the spray from the measurement zone. It is important to sample at the same point each time a measurement is made to ensure reproducibility.
- The beam position relative to the centre of the spray plume.
- The risk of contaminating the optics (this can be minimised by using the Air Purge accessory).

Particle size range

Check that the lens used is suitable for the particle size range. The lens ranges are:

- 300mm lens: 0.1 - 900μm. **Dx(50)**: 0.5 - 600μm.
- 750mm lens: 2 - 2000μm. **Dx(50)**: 5 - 1600μm.

If the **Dx(50)** is close to the limits given above, the measurement resolution may be affected.

Extraction

Extraction is used to draw the spray through the measurement zone. The reasons for using this, in order of importance, are:

- To protect the user from sprays.

Warning!
Extraction must be used with any material which may harm the test personnel.

- To ensure that the spray passes through the measurement zone at a constant velocity.
- To prevent **rain-down**. This occurs when a spray is sprayed vertically upwards; the coarser particles may fall back down through the measurement zone, introducing bias to the results. This affects nasal sprays especially and may cause **vignetting**; **Chapter 6** has details.

Follow these guidelines:

- Always extract the spray in the direction the spray is moving in, not at an angle to the spray direction.
- Do not use extraction in such a way that it changes the plume geometry in a way that changes the particle size distribution.

Setting up an actuator

The **Spraytec Accessories manual** gives full details of the Spraytec NSS. The actuator manufacturer's documentation describes the setup of the actuator itself.

Creating an SOP

Creating an SOP to make the measurement is the main step in the process. This means using the **SOP Wizard** as described here. This wizard consists of several dialogues that can be stepped through by using **Next** and **Back** buttons.

On each SOP dialogue there is a **Help** button; this gives more information than this manual on the individual parameters in the dialogue.

There are two ways to complete an SOP:

- Create a new SOP from scratch.
- Use the manual measurement facility to test and optimise settings, then save the resulting settings as an SOP. This is described in the section after this one.

Note
After creating the first SOPs in this way, try creating a new SOP by editing an existing one. This is described at the end of this section.

As examples, this section shows how to set up SOPs for continuous sprays, pulsed sprays and externally-triggered sprays.

Measurement types

Three measurement types are available, selected from the second **SOP Wizard** dialogue:

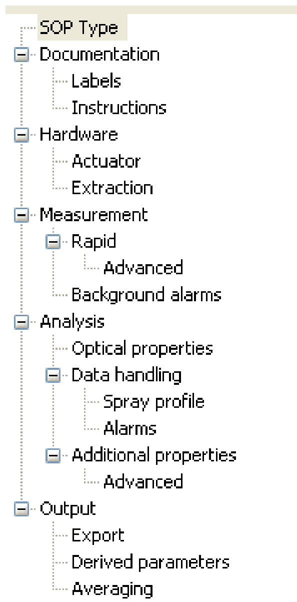
- **Continuous** – used for continual sampling of a spray. The measurement continues, adding new results to the **Size History**, until the **Stop** button is pressed. The frequency at which spray is measured and the **Size History** updated is controlled by the sampling rate set. The minimum sampling rate is every second (1s), the maximum is once every 30 seconds (30s).

  With continuous sampling the measurement data is sent directly to the computer and Spraytec software for analysis.
- **Timed** – as continuous, but the measurement can be requested to stop after a set amount of time. The stop time is set using the **Minutes:** and **Seconds:** boxes. These boxes only appear when the timed option is selected.
- **Rapid** – this is used to measure rapid pulsed spray events, for example nasal sprays, MDIs or fuel injectors, but can also be used for rapid measurements of continuous sprays.

  The data acquisition rate for the measurement data can be set between 2.5Hz and 2.5kHz. Due to the speed of data acquisition, data obtained during a rapid measurement is stored by the instrument electronics until the measurement finishes, then passed to the computer and Spraytec software for analysis. The Spraytec Measurement Processor downloads the measurement data from the instrument to the computer.

SOP structure

This graphic shows the basic stages in the **SOP Wizard** and the parameters these are concerned with:



SOP type – hardware, measurement type and lens.

Documentation
- spray details
- operator instructions.

Hardware
- actuator type and details
- extraction setup.

Measurement – background, use of output trigger.
- number of events, trigger type
- filters, optical, electronic and expiry alarms.

Analysis
- optical properties of the particle
- detectors to use
- plume details
- scattering alarms
- curve fit and correlation.

Output
- exporting data
- parameters to report
- how to average.

Some SOPs do not have all of these stages. When an existing SOP is modified, this tree is shown to allow quick access to any of the dialogues.

Templates

Several templates are available, selected from the **SOP Wizard**'s welcome page. When one of these is selected, suitable defaults for that measurement type are supplied throughout the remaining dialogues.

The templates are:

- **Default continuous** – used for continual sampling of a spray.
- **Default nebuliser** – the default parameters anticipate a continuous measurement using the Inhalation Cell.
- **Default rapid** – used to measure rapid pulsed spray events.
- **Default inhaler** – the default parameters anticipate a rapid measurement using the Inhalation Cell.
- **Default nasal spray** – the default parameters anticipate a rapid measurement using the Spraytec NSS.
- **Default wet measurement** – the default parameters anticipate a timed measurement using the Wet Dispersion Unit.

Templates are stored as **.ssop** files in the folder **SOP Templates**. Users can add their own templates to this folder; these will then appear in the selection list.

SOP types

The following sections describe how to create SOPs for the following spray types:

- **Continuous spray** – these are used in applications like coatings and agrochemical sprays. Here the aim is stability in spray parameters over time.
- **Pulsed spray** – examples include nasal sprays and MDI sprays. Here the aim is to meet the FDA requirements for a spray. These are discussed in more detail in **Chapter 6**.

  For an MDI, follow the pulsed spray SOP section but select **Inhalation Cell with Actuator** as the hardware configuration.
- **Externally-triggered spray** – an example is a fuel injection spray. Here the emphasis is on setting up a series of triggers and averaging the data measured between successive triggers, then comparing these average values.

▶ To create an SOP:

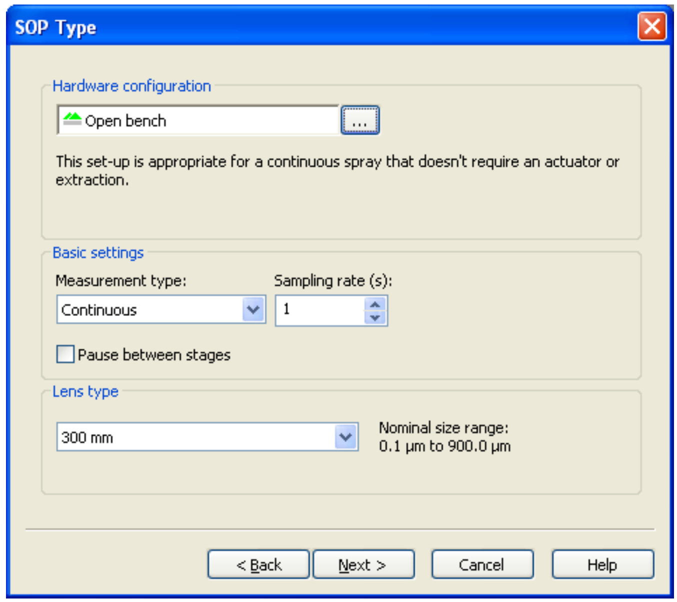
1. Select **File-New-SOP...** or click to open the **SOP Wizard**.
2. In the **Welcome** dialogue shown below select the required template. This selects suitable defaults throughout the wizard.

3. Proceed as described below for the appropriate spray type.

Continuous spray SOP

This section describes how to create an SOP for use with a continuous spray, for example a coatings or agrochemical spray.

1. In the **Welcome** dialogue select the **Default continuous** template and click **Next**.
2. The **SOP Type** dialogue is displayed:



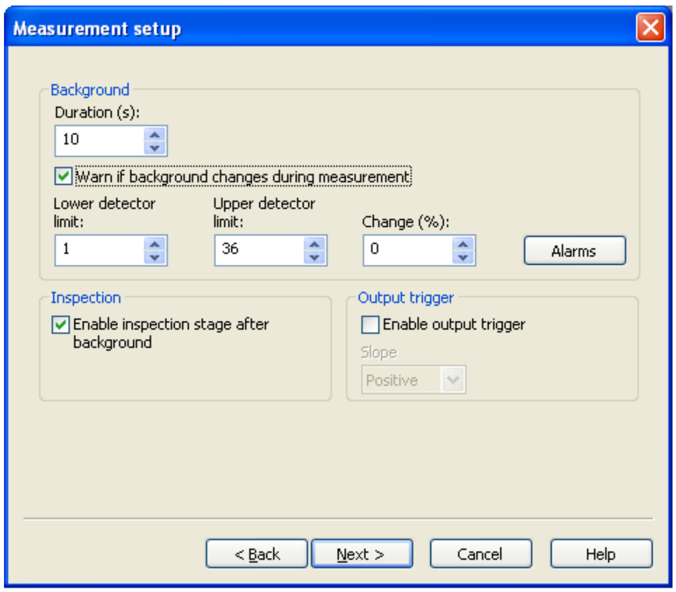
Click the **Hardware configuration** ... button and select **Open bench** as the hardware unless using extraction, in which case select **Open bench with extraction**. Under **Basic settings** keep the measurement type as **Continuous** and sample at one measurement a second or less. Click **Next**.

Note
The **Lens type** is automatically detected. If the lens specified here is not installed on the instrument, the SOP will not run (see **Chapter 8**).

3. In the **Labels** dialogue specify any required information on the spray, its source and lot, etc. to allow the spray to be traced in the future. If required, the operator can change/add to these when they run the test. Click **Next**.
4. In the **Instructions** dialogue type any instructions for operators to follow at the SOP start or end. For either, select the relevant check box and type in the

instruction text below it. These instructions will pop up on the screen when an operator runs the SOP. Click **Next**.

5. The **Measurement setup** dialogue shown below appears. At the bottom of the dialogue select the **Enable inspection stage after background** check box. This pauses the measurement after the background measurement and allows a trial spray before measurement starts so pre-measurement checks can be performed. There's no need to set up an output trigger so leave the **Enable output trigger** check box deselected.



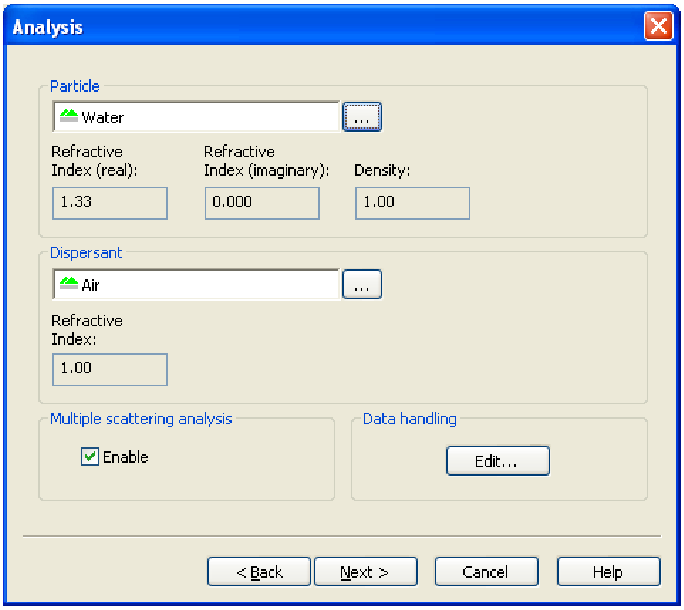
Use the **Duration** box to specify how long the background measurement will run for before moving to the next measurement stage.

Significant changes in the background may indicate spray deposition on the optics during the measurement, reducing the accuracy of the results. To check for these, select the **Warn if background changes during measurement** check box. This makes two further options available:

- **Lower Detector Limit** and **Upper Detector Limit** – set the range of detectors that should be monitored as part of the background check.
- **Change (%)** – sets the maximum acceptable percentage change in the average signal measured across the specified detector range during the background check. If the background shift between the beginning and end of the measurement exceeds this percentage, a warning at the end of the measurement states that the optics may have been contaminated by spray.

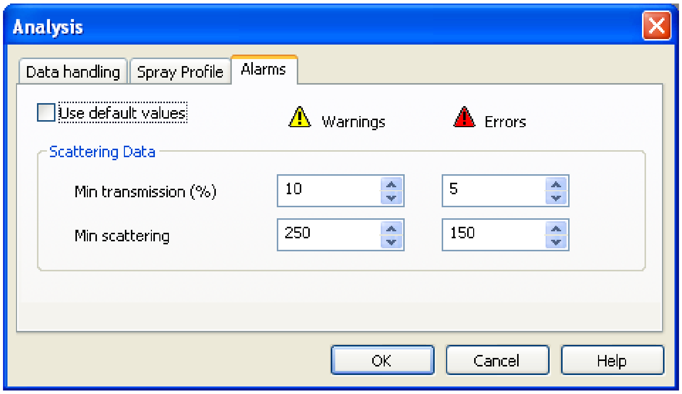
The default set of alarms will suit most purposes; click the **Alarms** button if required to review these. For full information on alarms, refer to **Chapter 10**. Click **Next**.

6. The first **Analysis** dialogue appears. Select water as the particle and air as the dispersant. Enable **Multiple Scattering Analysis**, especially if testing a high concentration spray:



The **Data Handling** options allow for refining the measurement further and are detailed in **Chapter 6** and in the online help. In brief there are three tabs:

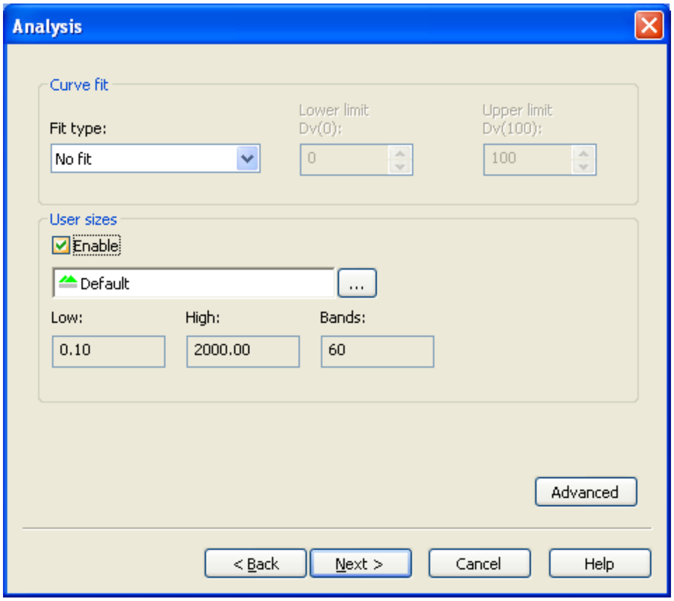
- **Alarms** – configures the system to log a warning or error if transmission or scattering fall to specified levels:



- **Data handling** – used to “kill” (discard) data from specified detectors.
- **Spray profile** – lets the user define the path length of the laser beam through the spray, providing a more accurate measure of the spray concentration. Advanced options allow users to specify the spray plume geometry, improving the accuracy of data analysis.

Specify any required parameters and click **Next**.

7. The second **Analysis** dialogue appears, as shown below. Only change the **Curve fit** from **No fit** if the Rosin-Rammler or Log-Normal size distribution models are to be used to interpret the recorded size distributions.

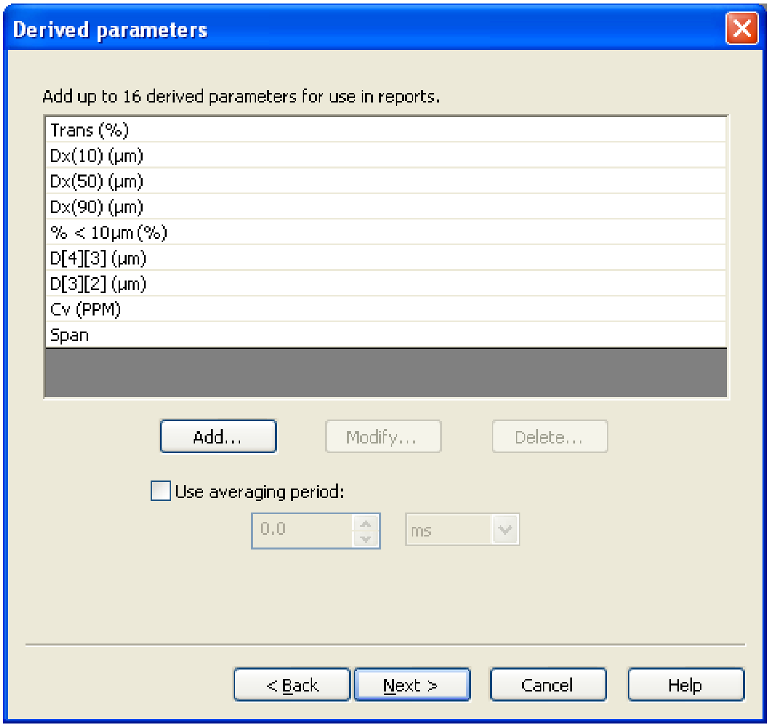


User size bands control the way data is aggregated; **Chapter 6** has details. To use a different set of bands, select the **Enable** check box and click the ... button; **Chapter 6** details the procedure.

If required to exclude small or large particles from the analysis, click the **Advanced** button. Use the **Minimum (μm)** and **Maximum (μm)** parameters to specify the lower and upper size limits. Click **OK** to return to the **Analysis** dialogue.

8. Click **Next**. The **Export** dialogue, used to configure automatic exporting of results, appears. This is not specific to a measurement type; it is described in **Chapter 7** and the online help for the dialogue.

9. Click **Next**. In the **Derived parameters** dialogue shown below specify the parameters which are relevant to the measurement. To remove each parameter which is not needed, select it and click the **Delete** button. Next use the **Add** and **Modify** buttons to set up the list. The online help shows how to configure each type of parameter; **Chapter 10** describes how each is calculated.



The list above shows the recommended parameters for a continuous measurement.

This is the final dialogue. When all parameters are set up, click **Next** to display the **Wizard Complete** dialogue. Click **Finish**.

10. When prompted to save the new SOP, give it a name which will make it easy for operators to identify what to use it for.

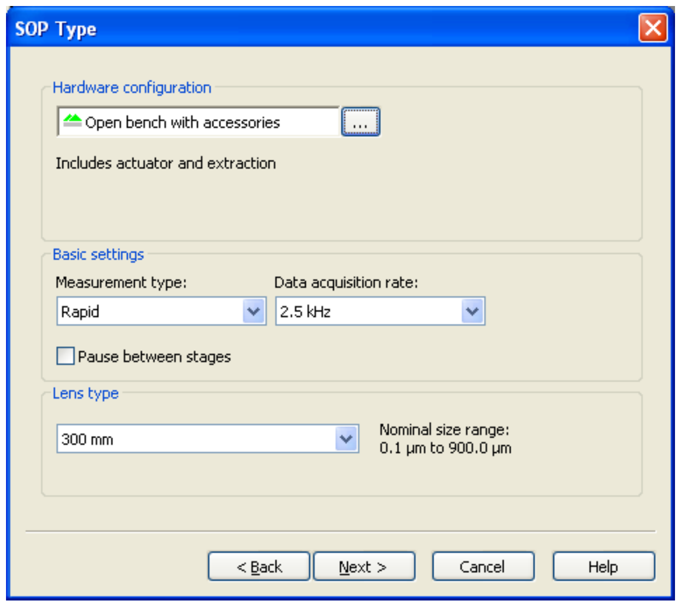
The SOP can now be run as described later in this chapter.

Pulsed spray SOP

This section describes how to use the **SOP Wizard** to create an SOP for use with pulsed sprays like nasal sprays and MDIs.

1. In the **Welcome** dialogue select the **Default rapid** template. Alternatively, for a nasal spray select the **Default nasal spray** template, or for the Inhalation Cell select the **Default inhaler** template. Click **Next**.

2. The **SOP Type** dialogue is displayed:



Click the **Hardware configuration** ... button and, if an actuator or extraction is being used, select **Open bench with accessories**. Otherwise just select **Open bench**. Under **Basic settings** the measurement type will be **Rapid** and the **Data acquisition rate** 2.5kHz. Click **Next**.

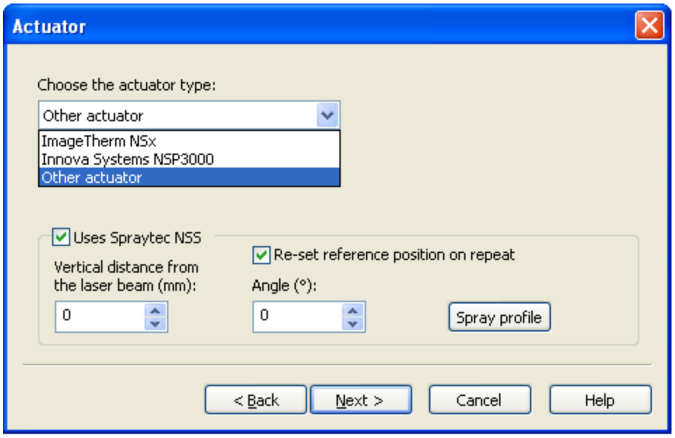
Note
The **Lens type** is automatically detected. If the lens specified is not installed on the instrument, the SOP will not run (see **Chapter 8**).

3. In the **Labels** dialogue specify any required information on the spray, its source and lot, etc. to allow the spray to be traced in the future. If required, the operator can change/add to these when they run the test. Click **Next**.

4. In the **Instructions** dialogue type any instructions for operators to follow at the SOP start or end. For either, select the relevant check box and type in the

instruction text below it. These instructions will pop up on the screen when an operator runs the SOP. Click **Next**.

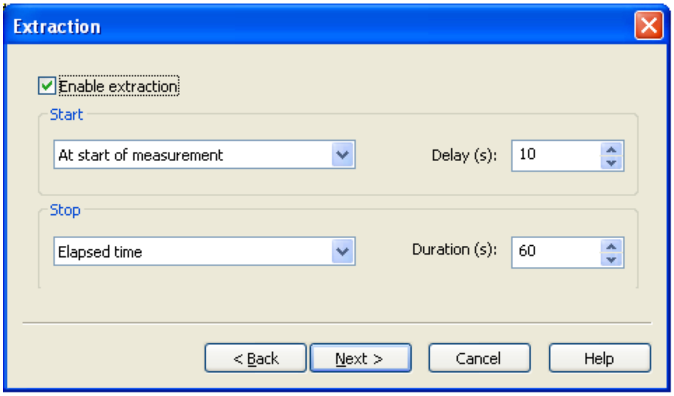
5. If an actuator has been selected, the **Actuator** dialogue shown below appears. Select an actuator from those listed. A set of parameters for the actuator appears; set these up according to the manufacturer's documentation.



If using a Spraytec Nasal Spray Support (NSS), select the **Uses Spraytec NSS** check box and specify its setup; the online help gives full details. The **Spraytec Accessories manual** describes the NSS.

Select the **Reset reference position on repeat** check box if intending to run the SOP multiple times (by clicking **OK** after a measurement when asked whether to repeat it). In this case the settings specified the first time will automatically be used for each run without any need to reposition the spray. Click **Next**.

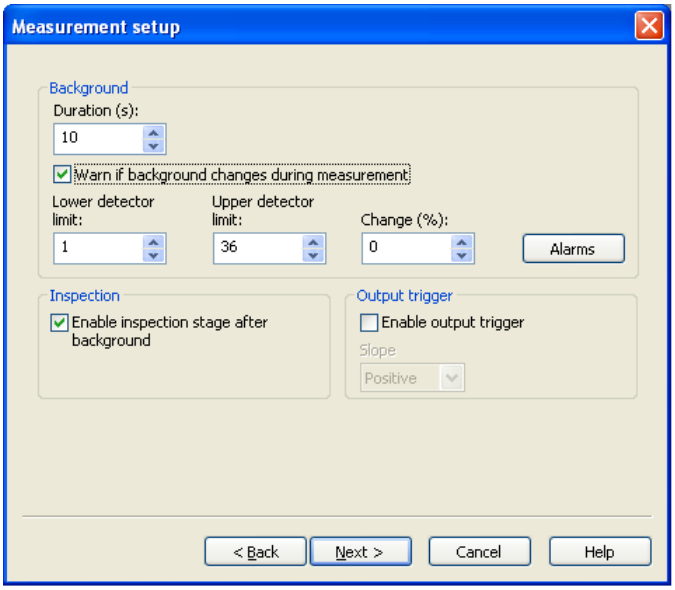
6. If extraction has been selected the **Extraction** dialogue appears:



Select the **Enable extraction** check box and specify the extraction period.

This can begin before alignment, before the background measurement or at the start of measurement (with a delay of up to 10 seconds if required). It can continue for up to 60 seconds after the measurement if required; select **Elapsed time** in the **Stop** list and set a time. Click **Next**.

7. The **Measurement setup** dialogue shown below appears. At the bottom of the dialogue select the **Enable inspection stage after background** check box. This pauses the measurement after the background measurement and allows a trial spray before measurement starts so pre-measurement checks can be performed. There's no need to set up an output trigger so leave the **Enable output trigger** check box deselected.



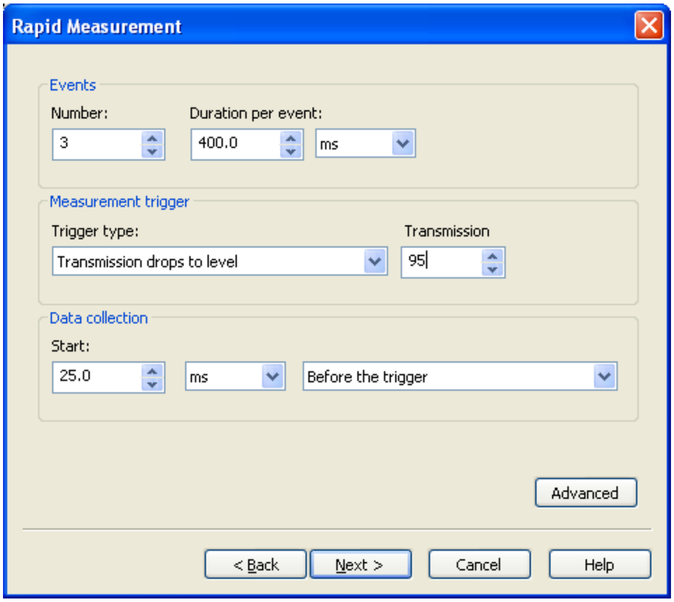
Use the **Duration** box to specify how long the background measurement will run for before moving to the next measurement stage.

Significant changes in the background may indicate spray deposition on the optics during the measurement, reducing the accuracy of the results. To check for these, select the **Warn if background changes during measurement** check box. This makes two further options available:

- **Lower Detector Limit** and **Upper Detector Limit** – set the range of detectors that should be monitored as part of the background check.
- **Change (%)** – sets the maximum acceptable percentage change in the average signal measured across the specified detector range during the background check. If the background shift between the beginning and end of the measurement exceeds this percentage, a warning at the end of the measurement states that the optics may have been contaminated by spray.

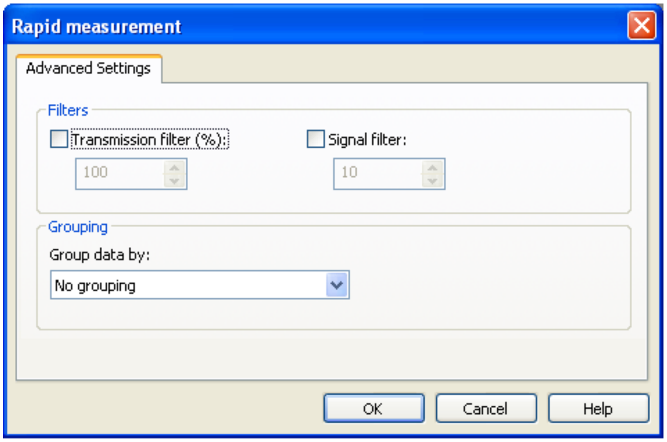
The default set of alarms suits most purposes; click the **Alarms** button to review these. For full information on alarms refer to **Chapter 10**. Click **Next**.

8. The **Rapid measurement** dialogue appears, as shown below:



Set this up as shown here. This produces three 400ms events triggered by transmission falling to the 95% level, with data collection starting 25ms before the trigger condition is met.

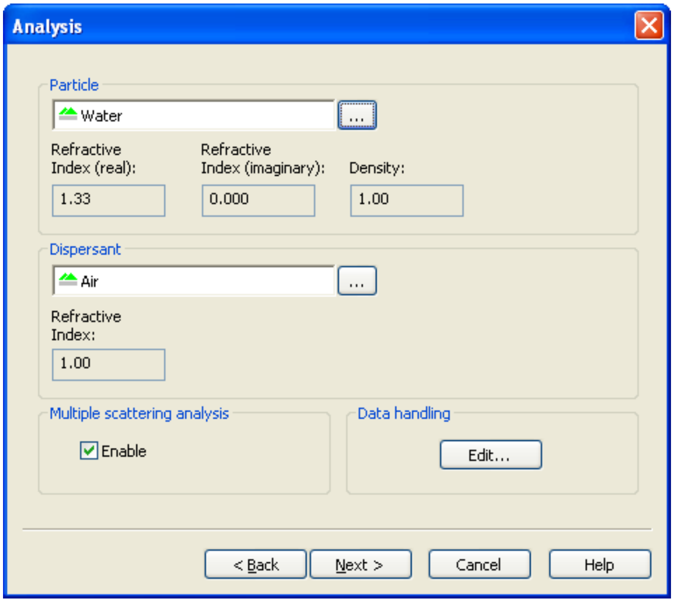
The **Advanced** button enables thresholds to be set so poor signals can be excluded, and the grouping method for the collected data specified. The dialogue it opens is shown below:



The **Transmission filter** removes results that exceed the indicated transmission level. The **Signal filter** excludes data signals that are below the indicated signal level. The signal level relates to the average scattering signal recorded across the active detector channels.

If using an external trigger, select this in the **Grouping** list. **Chapter 10** describes external triggers and grouping.

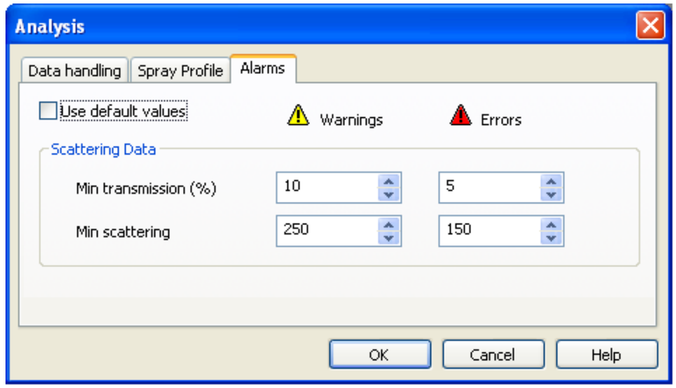
9. The first **Analysis** dialogue, shown below, appears. Select water as the particle and air as the dispersant. **Chapter 10** describes use of optical models.



Note
The FDA guideline for nasal sprays is to disable **Multiple Scattering Analysis.**

The **Data Handling** options allow for refining the measurement further and are detailed in **Chapter 6** and in the online help. There are three tabs:

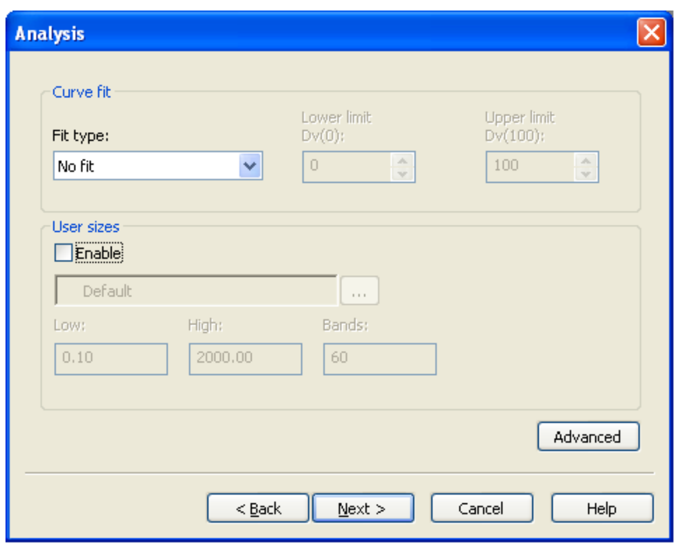
- **Alarms** – configures the system to log a warning or error if transmission or scattering fall to specified levels:



- **Data handling** – used to “kill” (discard) data from specified detectors.
- **Spray profile** – lets the user define the path length of the laser beam through the spray, providing a more accurate measure of the spray concentration. **Advanced options** allows users to specify the spray plume geometry, improving the accuracy of data analysis.

Specify any required parameters and click **Next**.

10. The second **Analysis** dialogue appears, as shown below. Only change the **Curve fit** from **No fit** if the Rosin-Rammler or Log-Normal size distribution models are to be used to interpret the recorded size distributions. **Chapter 10** has more information on this.

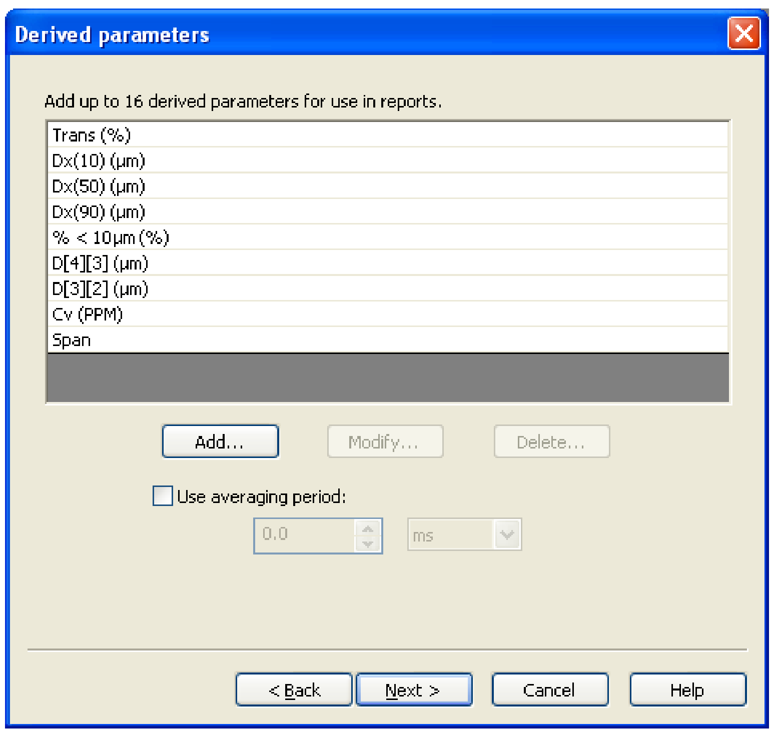


User size bands control the way data is aggregated; **Chapter 6** has details. To use a different set of bands, select the **Enable** check box and click the ... button; **Chapter 6** details the procedure.

If required to exclude small or large particles from the analysis, click the **Advanced** button. Use the **Minimum (µm)** and **Maximum (µm)** parameters to specify the lower and upper size limits. Click **OK** to return to the **Analysis** dialogue then click **Next**.

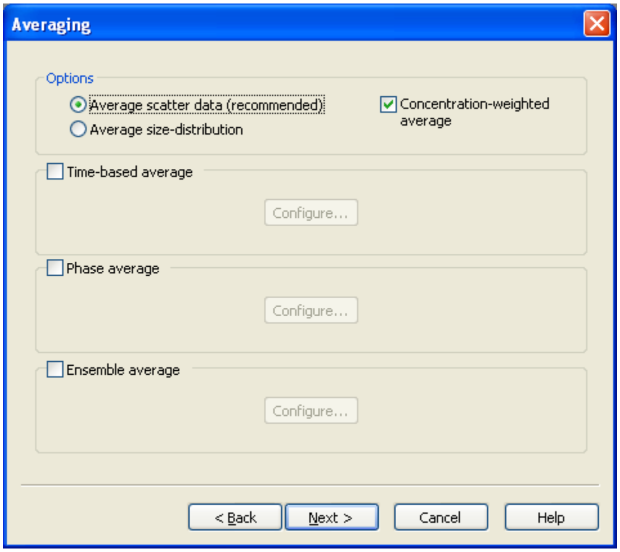
11. The **Export** dialogue, used to configure automatic exporting of results, appears. This is not specific to a measurement type; it is described in **Chapter 7** and the online help for the dialogue. Click **Next**.

12. Use the **Derived parameters** dialogue shown below to specify which parameters are relevant to the measurement. Use the **Delete** button to remove any parameters which are not needed, then the **Add** and **Modify** buttons to set up the list.



The example above shows the recommended parameters for a nasal spray measurement. Use the **Delete** button to remove any parameters which are not needed, and the **Add** and **Modify** buttons to set up the list. When the parameters are listed as shown above, click **Next**.

13. The **Averaging** dialogue appears:



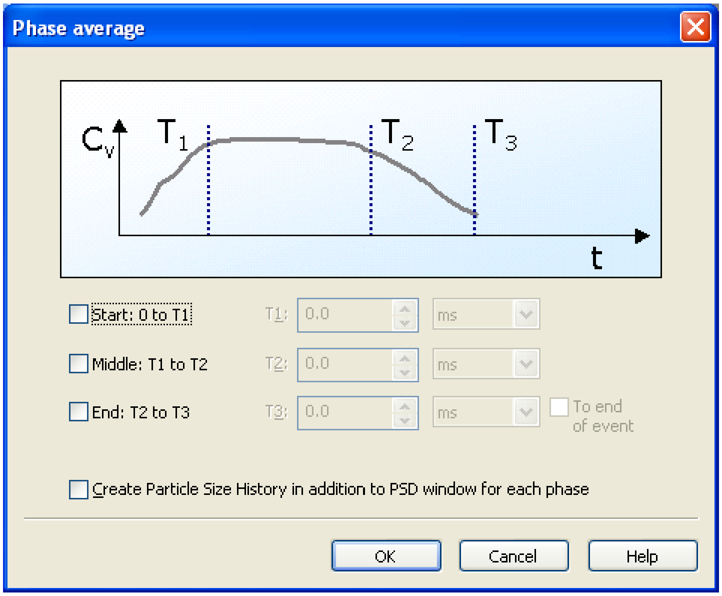
The **Options** section determines how average size distributions are calculated. The choices are listed below:

- **Average scatter data** – the Spraytec calculates the average scattering pattern associated with the records selected for averaging. The average size distribution is then calculated from this average scattering data set. This is the default and recommended option.
- **Average size-distribution** – the average distribution is based on the size distribution data reported for each of the records selected for averaging. This is done by averaging the percentage reported in each size band to produce the average distribution. This option is provided to provide compatibility with older laser diffraction systems.
- **Concentration-weighted average** – this weights the calculated average size distribution for the volume concentration measured for each record in the range. This allows for fluctuations in the spray concentration during the measurement. It is enabled by default.

Note

Disabling **Concentration-weighted average** causes the average to be calculated based on the assumption that each record is equally important in determining the final result. Only do this if the spray concentration does not change significantly across the range of records selected.

14. Keep the **Average scatter data** button selected, select the **Phase average** check box, and click its **Configure** button to open this dialogue:



Phase averaging is generally used with single shot spray systems such as nasal sprays. It produces the averages of the start (formation), middle (fully developed) and end (dissipation) phases of a single event.

The averages produced are stored as **.psd** files.

The phase average is defined as follows:

- **Start phase** – from the first measurement recorded as part of an event (Time = 0 sec) until the specified time T1. This phase is termed the *formation phase* by the FDA guidance for nasal spray characterisation.
- **Middle phase** – from time T1 until time T2. This is generally set to include the region of the spray event where the particle size is relatively stable. This phase is termed the *fully developed phase* by the FDA guidance.
- **End phase** – from time T2 until time T3, this is generally set to include the region where the particle size starts to increase towards the end of the spray event. This phase is termed the *dissipation phase* by the FDA guidance.

Select the **Start**, **Middle** and **End** check boxes. Specify a time in milliseconds after the trigger to mark when T1, the point when the stable phase begins, is expected to occur. Repeat this for T2, the end of the stable phase. For **End** select the **To end of event** check box.

In some cases, it may be useful to save the average of each of the phases in a new Particle Size History (**.psh**) file as well as in separate **.psd** files. To do this enable the option **Create Particle Size History in addition to PSD window for each phase**.

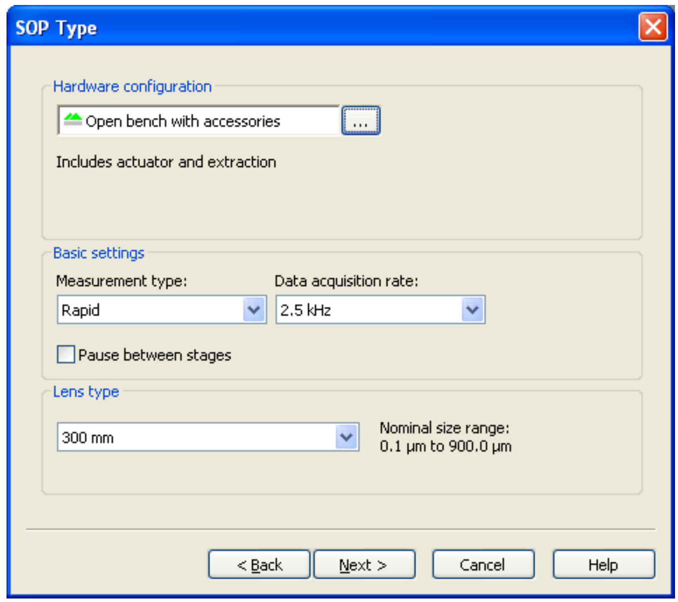
15. From the **Phase Average** dialogue click **OK**., then **Next** then **Finish**. When prompted to save the new SOP, give it a name which will make it easy for operators to identify what it is to be used for.

The SOP can now be run as described at the end of this chapter.

Externally-triggered spray SOP

This section describes how to use the **SOP Wizard** to create an SOP for use with an externally-triggered spray, for example a fuel spray.

1. In the **Welcome** dialogue select the **Default rapid** template and click **Next**. The **SOP Type** dialogue is displayed:



2. Click the **Hardware configuration** ... button and select **Open bench with accessories**. Keep the **Basic settings** measurement type as **Rapid** and the maximum **Data acquisition rate** (2.5 kHz). Click **Next**.

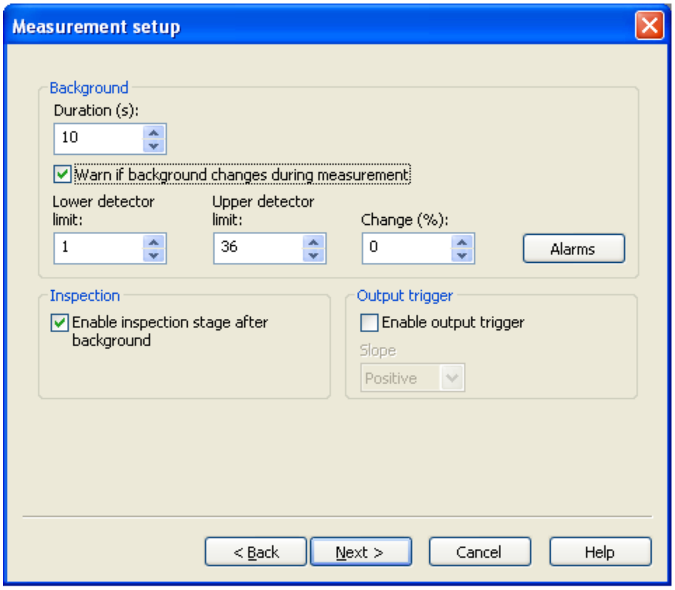
Note
The **Lens type** can only be changed on dual lens systems. Change to the appropriate lens if required (also see **Chapter 8**).

3. In the **Labels** dialogue specify any required information on the spray, its source and lot, etc. to allow the spray to be traced in the future. If required, the operator can change/add to these when they run the test. Click **Next**.

4. In the **Instructions** dialogue type any instructions for operators to follow at the SOP start or end. For either, select the relevant check box and type in the instruction text below it. These instructions will pop up on the screen when an operator runs the SOP. Click **Next**.

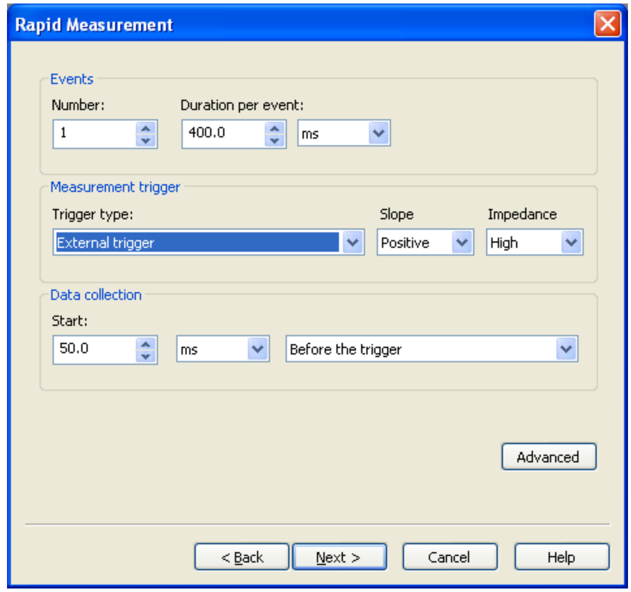
5. In the **Actuator** dialogue select the actuator to use from those listed. A set of parameters for the actuator appears; set these according to the manufacturer's documentation.

6. The **Measurement setup** dialogue shown below appears. At the bottom of the dialogue select the **Enable inspection stage after background** check box. This pauses the measurement after the background measurement and allows a trial spray before measurement starts for pre-measurement checking.



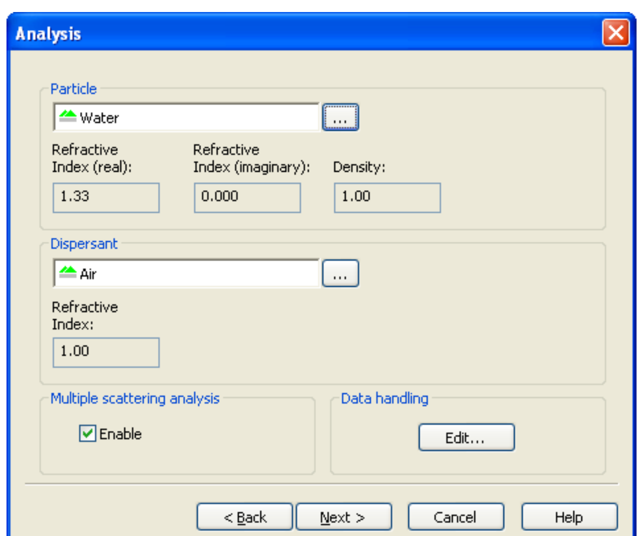
Select the **Enable output trigger** check box. This provides an industry standard TTL trigger output for the control of other devices including accessories such as nasal spray actuators. This trigger is activated when the measurement starts and returns to its initial state when the measurement ends. **Chapter 10** describes these triggers. Click **Next**.

7. The **Rapid Measurement** dialogue appears:



Specify an external trigger with positive slope and high impedance. This trigger can be grouped; to do this click the **Advanced** button to open the **Advanced settings** dialogue. In the **Group data by:** list select **External trigger**.

8. Click **Next**. The first **Analysis** dialogue appears, as shown below:

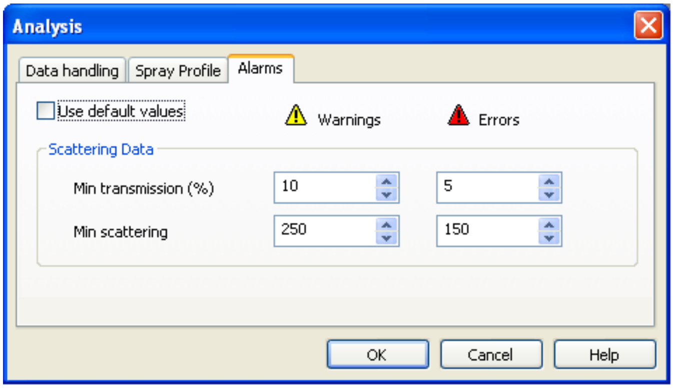


Select water as the particle and air as the dispersant. Enable **Multiple Scatter-**

ing Analysis, especially if testing a high concentration spray.

The **Data Handling** options allow for refining the measurement further and are detailed in **Chapter 6** and in the online help. There are three tabs:

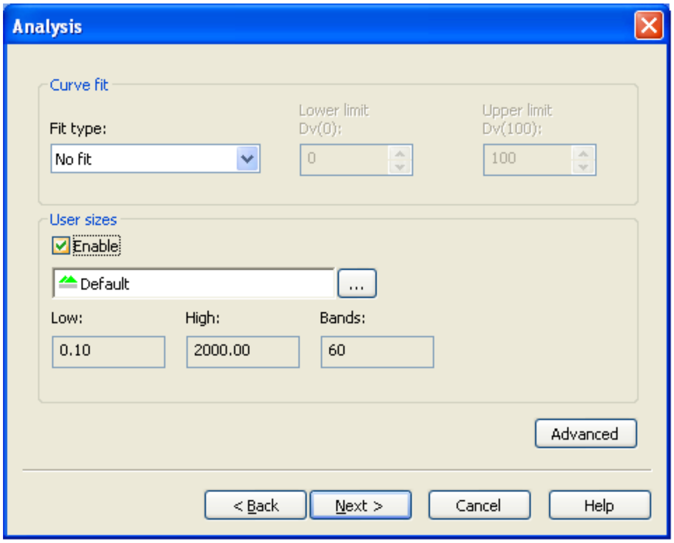
- **Alarms** – configures the system to log a warning or error if transmission or scattering fall to specified levels:



- **Data handling** – used to “kill” (discard) data from specified detectors.
- **Spray profile** – lets the user define the path length of the laser beam through the spray, providing a more accurate measure of the spray concentration. Advanced options allow users to specify the spray plume geometry, improving the accuracy of data analysis (see **Chapter 10**).

Specify any required parameters and click **Next**.

9. The second **Analysis** dialogue appears, as shown below.



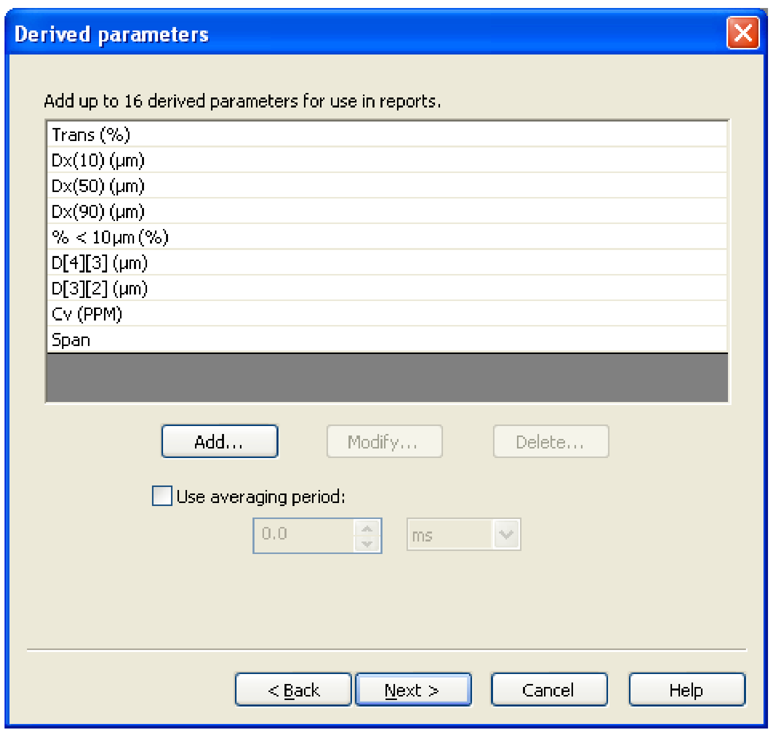
Only change the **Curve fit** from **No fit** here if the Rosin-Rammler or Log-Normal size distribution models are to be used to interpret the recorded size distributions. **Chapter 10** has more information on this.

User size bands control the way data is aggregated; **Chapter 6** has details. To use a different set of size bands, select the **Enable** check box and click the ... button; **Chapter 6** details the procedure.

If required to exclude small or large particles from the analysis, click the **Advanced** button. Use the **Minimum (μm)** and **Maximum (μm)** parameters to specify the lower and upper size limits. Click **OK** to return to the **Analysis** dialogue.

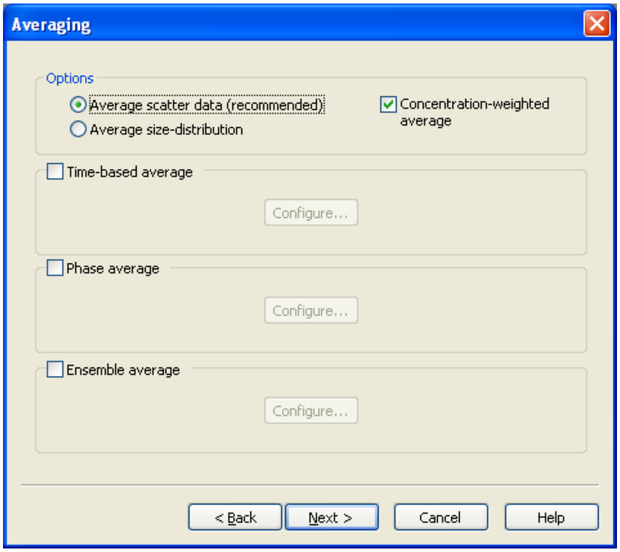
10. Click **Next**. The **Export** dialogue, used to configure automatic exporting of results, appears. This is not specific to a measurement type; it is described in **Chapter 7** and the online help for the dialogue.

11. Click **Next**. Use the **Derived parameters** dialogue to specify the parameters relevant to the measurement. Use the **Delete** button to remove any parameters which are not needed, then the **Add** and **Modify** buttons to set up the list.



The list above shows the recommended parameters for a fuel spray measurement. When these parameters are listed click **Next**.

12. The **Averaging** dialogue appears:



The **Options** section determines how average size distributions are calculated. The choices are:

- **Average scatter data** – the Spraytec calculates the average scattering pattern associated with the records selected for averaging. The average size distribution is then calculated from this average scattering data set. This is the default and the recommended option.
- **Average size-distribution** – the average distribution is based on the size distribution data reported for each of the records selected for averaging. This is done by averaging the percentage reported in each size band to produce the average distribution. This option provides compatibility with older laser diffraction systems.
- **Concentration-weighted average** – this weights the calculated average size distribution for the volume concentration measured for each record in the range. This allows for fluctuations in the spray concentration during the measurement. It is enabled by default.

Note

Disabling **Concentration-weighted average** causes the average to be calculated based on the assumption that each record is equally important in determining the final result. Only do this if the spray concentration does not change significantly across the range of records selected.

13. For an externally-triggered SOP, two types of average are appropriate:

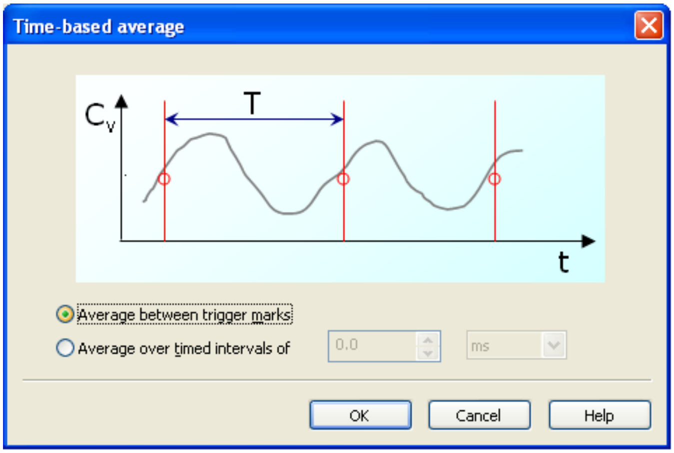
- **Time-based average** – produces a **.psh** file containing average results for rapidly repeating pulsed spray events such as observed during fuel injector operation. Here the average is calculated either between **Group Trigger marks** or over fixed, repeated time periods.

  This produces an average across one event. For this type of average proceed with step 14.

- **Ensemble average** – produces a second Size History window showing a single event or cycle, the average of the multiple source events/cycles. The absolute times associated with the ensemble average cycles are the same as the first cycle of the source measurements.

  This produces an average across all events. For this type of average skip to step 16.

14. To produce a Time-based average keep **Average scatter data** selected and select the **Time-based average** check box. Click the **Configure** button to open the **Time-based average** dialogue shown below:



The **Time-Based Average** is configured using these options:

- **Average between trigger marks** – calculates a new size history containing the averages calculated between group trigger marks. To use this, **Grouping** must be enabled after clicking **Advanced** on the **Rapid Measurement** dialogue (see step 7).

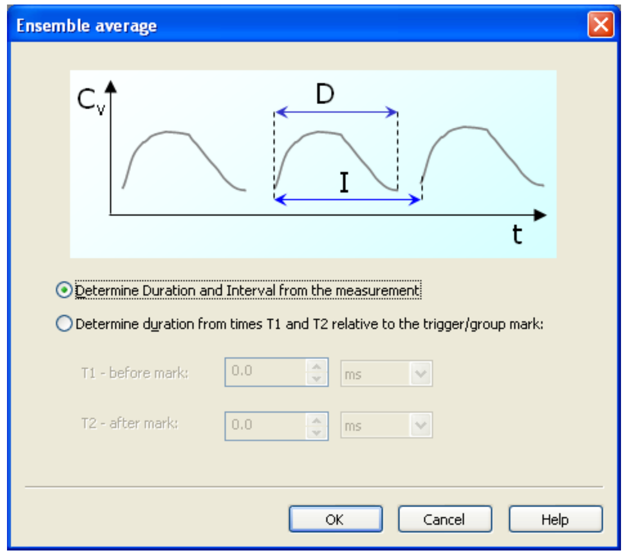
- **Average over timed intervals** – calculates a new size history containing the averages calculated over a fixed, repeating time window. Use the time interval selection box to specify the length of the time window.

Select the **Average between trigger marks** radio button. As the graphic in the dialogue shows, this averages the data between successive triggers.

For a fuel spray the averages over a series of these periods should be flat.

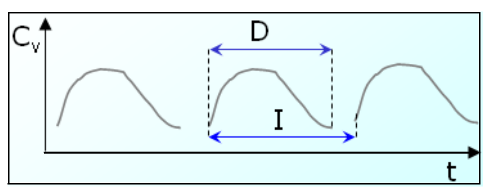
15. Click **OK** then **Next** then **Finish** to complete the SOP setup.

16. To produce an Ensemble average, keep **Average scatter data** selected on the **Averaging** dialogue and select the **Ensemble average** check box. Click the **Configure** button to open the **Ensemble average** dialogue shown below:



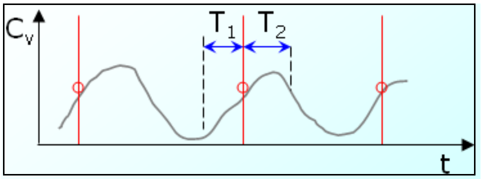
There are two options:

- **Determine Duration and Interval from the measurement**



The measurement processor marks each event, triggered either by a transmission or signal transition or an external trigger, with an identifier. The ensemble averaging processor uses the event identifier and the position of the trigger mark to synchronize each event even though the intervals between events may have wide variations.

- **Determine duration from times T1 and T2 relative to trigger/group mark**



Use this for events which have group trigger marks inserted by an external time signal. The duration of the cycle is defined by times T1 and T2 relative to the trigger mark. The positions of the trigger marks define the interval between cycles.

Specify the T1 and T2 times using the **T1 - before** and **T2 - after** boxes in the dialogue.

17. Click **OK**, then **Next**, then **Finish** to complete the SOP setup.

Manual measurements

Manual measurement is like designing an SOP while actually making the measurement, rather than designing the SOP first as a separate task. In a manual measurement the measurement parameters are configured as part of the measurement procedure, immediately before the sample is measured.

Why use manual measurement? Two reasons to do so are:

- As a “temporary SOP” for trying out new settings.
- When a new spray is being tested and the user is unsure about the parameters to use.

Once settings are optimised the completed measurement is added to the list in the Measurement file window. The SOP used can be saved and re-used by right-clicking the record in this window and selecting **Extract SOP,** then saving it with a new name.

Note
The default settings during a manual measurement are based on the last set of parameters used.

Measuring the spray

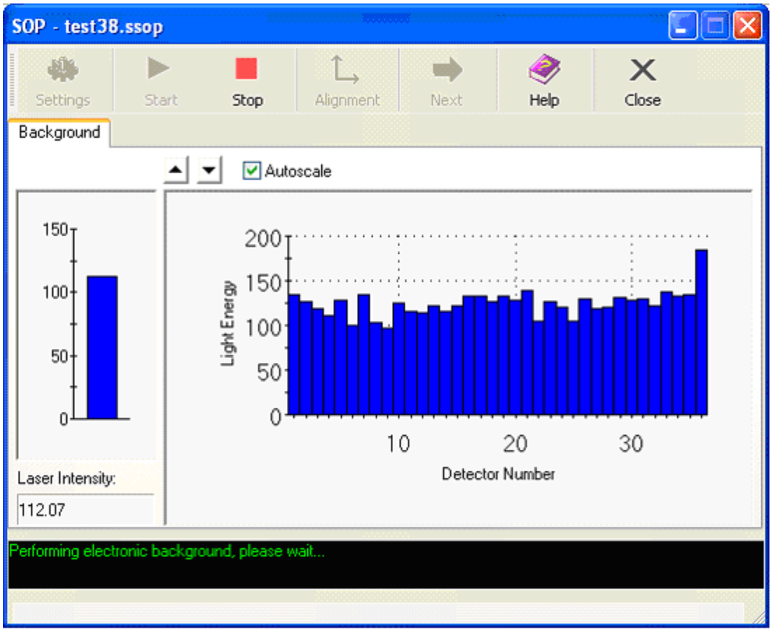
This section explains how to measure a spray using an SOP or manual measurement.

▶ To make the measurement:

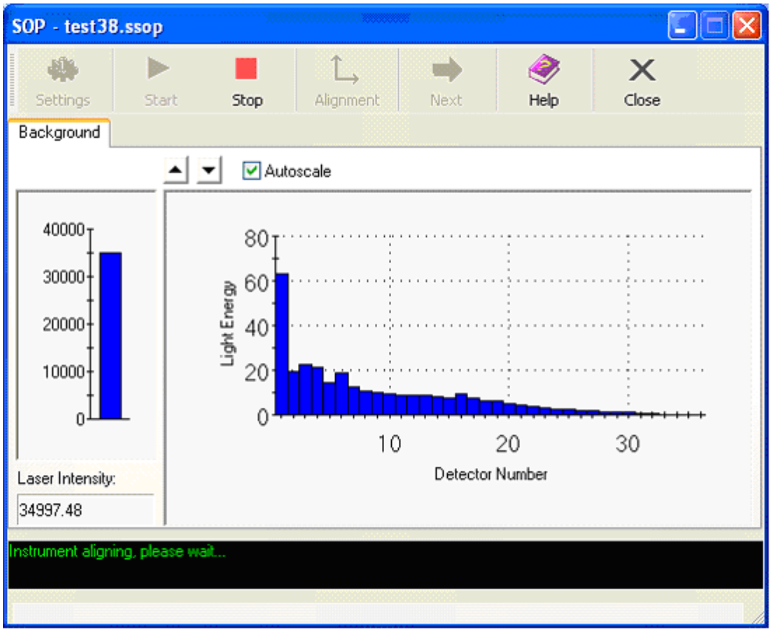
1. Check that the Spraytec and any required accessories are ready to use.
2. Do one of the following:
   - To make an SOP measurement, select **Measure-Start SOP** or click the button. In the **Open SOP** dialogue select the SOP to use and click **Open**.
   - To make a manual measurement, click **Measure-Manual**.
3. The **Save As** dialogue opens, prompting for the name of a measurement file (**.smea**) to hold the results. Supply a file name.

   If the SOP has any pre-measurement instructions, these are displayed, advising of actions that need to be performed before the measurement can proceed. Follow the instructions then close the display.
4. The **Edit Documentation** dialogue appears, prompting for information on the spray, lot, etc. Type this in as required.
5. The **Measurement Manager** appears (for a description of its features, see **Chapter 4**).

   For a manual measurement, unless it is known that the default settings are all suitable, click the **Settings** button and review the parameters. Change any setting as necessary. The dialogues which appear are the same as described above for SOP creation, but with a tree structure to allow quick selection of any dialogue.
6. The **Measurement Manager** title bar gives the name of the SOP being used. Wait while the Spraytec measures the electrical and optical backgrounds, as shown below (the status bar will show what is happening):



The instrument checks its alignment between the electrical and optical background measurements. If this is the first alignment in this session this may take some minutes, otherwise just a short time.

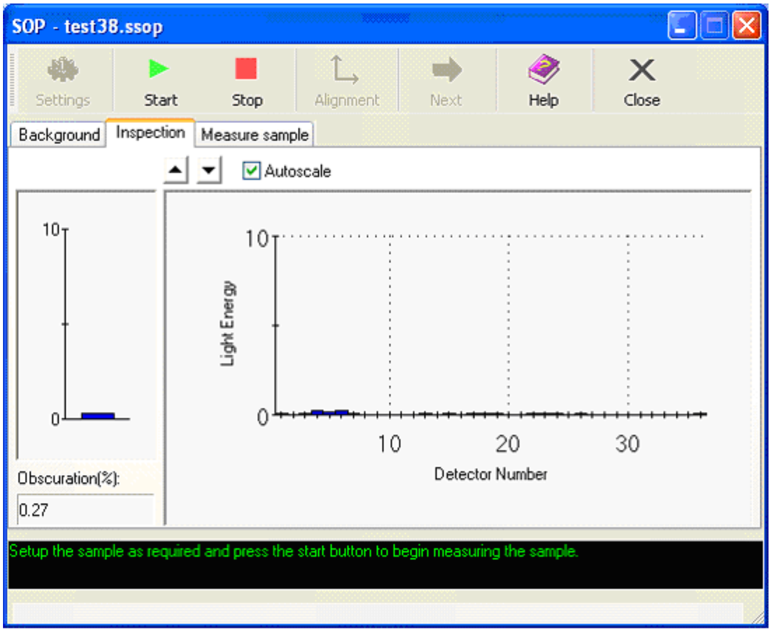


The **Laser intensity** is the non-scattered light measured by the Receiver. The example above shows this for the electrical background.

7. After displaying the electrical background, the optical background is shown. This is shown as a percentage value.

- Typically on a clean instrument the value should be between 70% and 95%, accompanied by a background of less than 50 for a dry measurement, or 100 for a wet measurement.
- If the laser intensity is low (around 60%) and the background level is over 200 the instrument optics need cleaning.
- If the optics have been cleaned to give an acceptable background but the laser intensity is still low (60% or below) the laser may be failing; contact Malvern Instruments.

8. If an **Inspection Stage** was specified by the SOP the **Inspection** tab shown below appears. Spray some of the material into the measurement zone and observe the obscuration and light energy histogram the dialogue shows. These should be enough to confirm whether the instrument settings and any accessories are set up correctly:



If there is anything obviously wrong, change the setup here. Otherwise, click the **Start** button to begin the measurement. Follow any instructions given.

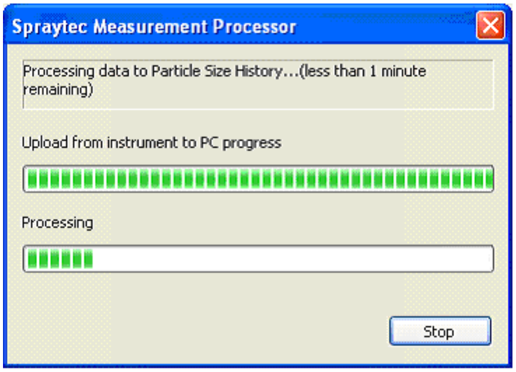
9. Now the checks have been performed, the **Measure sample** tab appears as the third tab in the dialogue and the **Start** button becomes available. (The first two tabs in the window remain available for repeating background or alignment checking if the user requires.)

10. The next step depends on the type of measurement:

    - For a **continuous measurement** a **Size History** window will open. The system immediately starts displaying the measured particle size in real time in the **Size History** window as the spray is produced. To display the most recent measurement, right-click on the window and select **Real Time Tracking**.

    - For a **rapid mode measurement**, if **Manual Triggering** was selected the system starts measuring immediately. If transmission, scattering or external triggering was selected a "Waiting for a measurement trigger" message is displayed in the status bar. Spray the sample through the measurement zone the number of times required by the SOP or send an external trigger to start the measurement.

11. Once the rapid measurement finishes the **Spraytec Measurement Processor** dialogue shown below appears and the system starts to process the data. Wait for this process to complete (the dialogue shows how long it will take).



12. When processing is complete, the results appear in the **Size History** window. Review the results as described in **Chapter 6**.

13. When either kind of measurement finishes a prompt appears: "Would you like to repeat the measurement?".

14. When the measurement finishes or the user presses the **Stop** button, the Spraytec waits for another spray. Either prepare this and press **Start** again or click **Close** to end the session.

Results

Once completed, the measurement will be added to the folder in the Measurement file window, together with the **.ssop** file used to configure the measurement parameters.

For a manual measurement the settings are stored in a **mansettings.dat** file.

Interpreting the results

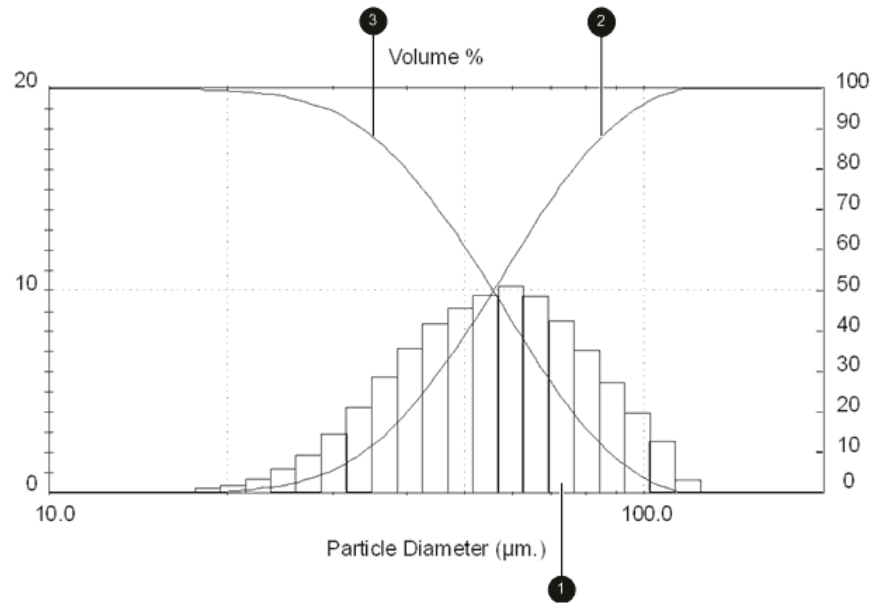
Introduction

This chapter describes how to review measurement results. It covers:

- The available plot and curve types.
- Warnings and errors – how these appear in the views.
- Volume-based and number-based results – how to distinguish between these.
- The **Size History** view – this includes the method for selecting records in the **Size History** view. This is the basis for all operations on records – editing, printing, averaging, etc. It also describes how to re-analyse (edit), find and delete records.
- The other types of Result view – these sections show how results are displayed in the **Particle Size Distribution**, **Derived Parameters** and **Measurement Parameters** windows, also other window types.
- Averaging data – this is used to analyse different phases within a spray.
- **Curve Fit** – this is used to provide compatibility with data from older laser diffraction systems.
- **User size bands** – how to change these bands to focus on a particular area of the distribution.
- Using overlays to compare results.
- Problems which lead to poor data – this describes the effects of **vignetting** and **beam steering**, and how to solve these problems.
- **Data handling** options – data handling means excluding from the analysis the data obtained from specified detectors. This can be used to cure **beam steering** and **vignetting** problems.

Plot and curve types

Results can be displayed in several ways. This diagram shows three of the more common ways of displaying the result:



ill 7450

This shows:

① **Histogram** – this displays the result as “in band” percentages. Each bar in the graph represents a size band of particles (52-59µm for example) and the height of the bar represents the percentage of the spray that is within that band.

Unless the user changes the size bands (as described later in this chapter), the initial analysis uses size bands set for the detector design.

② **Result-under plot** – this is also known as **cumulative undersize** or **result less than**. It displays the percentage of the spray which is below a certain size.

The result-under plot is calculated from the initial size bands by fitting a curve to the analysis data so that values within a size band can be read.

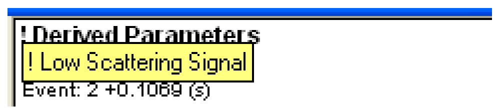
③ **Result-over plot** – this is also known as **cumulative oversize**. It displays the percentage of the spray which is above a certain size.

Warnings and errors

If a warning or error condition existed at the time a record was measured, one of the following appears on the header line in a record view:

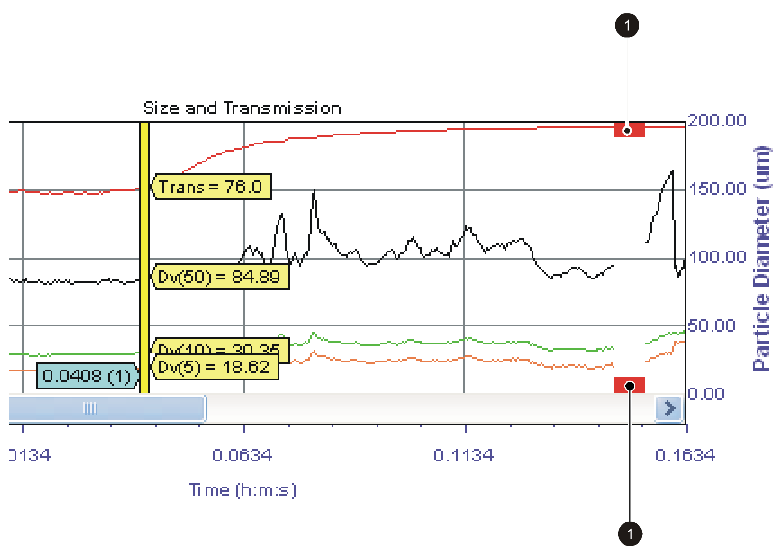
- **!** = warning.
- **!!!** = error.

To determine the cause of the message, Ctrl-click and hover above the **!** symbol. A pop-up like this gives more information (**Chapter 8** explains the messages):



This applies in all views except the **Measurement Parameters** view, where the information is printed at the bottom of the view instead.

The **Size History** is the only view type which omits these. In this window red bands show times when the system cannot analyse data, for example because the signal does not meet a user-specified threshold. In the following example these bands ① show two short periods when this situation occurred:



ill 7458

The “No record” situation

If the first row of a record view starts with the characters “**???**”, this means the selector bar in the **Size History** is in an area where no measurement took place so there is no record to display data for.

Volume- and number-based results

As explained in **Chapter 2**, the default size distribution is volume-based but number-based size distributions can also be produced. For a volume-based result, the 10% percentile is shown as **Dv(10)**. For a number-based result, this appears as **Dn(10)**. Some result displays may show both of these and in these the text "**[V]=Volume [N]=Number**" explains what each result is based on.

In other places a simple **V** or **N** shows this. For example, the following sections are from tables showing results based on **V**olume and **N**umber respectively:

Size (µm)	% V <	% V	Size (µm)	% V <	% V	Size (µm)	% V <	% V
0.118	0.00	0.00	3.20	0.00	0.00	86.90	38.01	0.74
0.139	0.00	0.00	3.78	0.00	0.00	102.50	38.65	0.64
0.164	0.00	0.00	4.45	0.00	0.00	120.89	40.40	1.75

Size (µm)	% N <	% N	Size (µm)	% N <	% N	Size (µm)	% N <	% N
1.14	24.75	24.75	15.46	99.45	0.11	209.85	100.00	0.00
1.30	43.27	18.52	17.62	99.53	0.08	239.08	100.00	0.00
1.48	57.19	13.92	20.07	99.60	0.07	272.38	100.00	0.00

Size History view

This view, described in **Chapter 4**, shows the value of the derived parameters the user has specified at every point at which data was collected during the measurement. By default it displays **Size and Transmission** data, but can also display any of the other categories listed below, showing parameters as follows:

- **Size and Transmission** – plots the **Transmission**, **Dx(10)**, **Dx(50)** and **Dx(90)** parameters.
- **Average Size and Transmission** – plots **Transmission** and **Avg[Dx(50)]**.
- **Mean Sizes** – plots **Avg D[4,3]** and **Avg D[3,2]**.
- **Transmission and Percentiles** – shows **Transmission** and **Dx(10)**, **Dx(50)** and **Dx(90)**.
- **Custom** – there are two of these, which the user can modify as required using **Tools-Options-Default Size History View**.

Double-click on a record view above the **Size History** view to open a new PSD window of that view type.

Selecting records

Before printing, copying, exporting, averaging, editing or deleting records, the appropriate records need to be selected in the **Size History**. For each of these operations a different dialogue is displayed, but they all select records the same way. As an example of how this works, the **Edit-Records** dialogue is described below. Alternatively, use the mouse to select records before opening the dialogue.

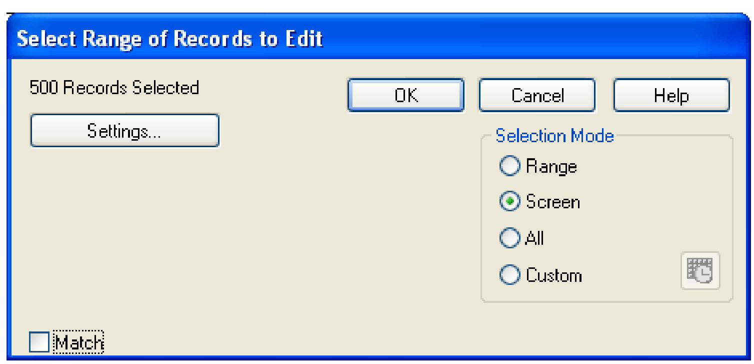
To select records using the mouse:

1. Double-click the selector bar in the **Size History** view.
2. Hold down the left mouse button and drag the selector bar across the records to select these.
3. Release the mouse button. A grey band marks the selection.
4. Select the appropriate command – **Edit**, **Print**, **Copy**, **Average**, etc. – and in the dialogue which appears select the **Range** button. The operation will be performed on the records selected with the mouse.

Note
To deselect a band of records, double-click in the **Size History** view.

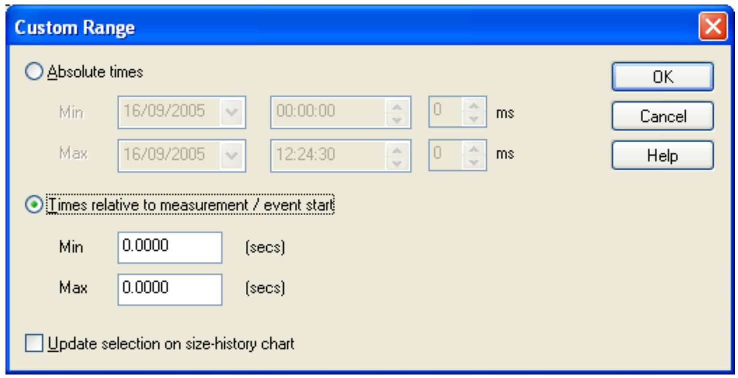
To select records using Edit-Records:

1. Open the **Size History** view and select **Edit-records** to open this dialogue:



2. Choose one of the following **Selection Mode** options:
   - **Range** – to use a range selected using the mouse (see above).
   - **Screen** – to use the records currently visible in the **Size History** view (this is affected by any scrolling or zooming in or out).
   - **All** – to use all records in the measurement file.

- **Custom** – to use a custom range based on the measurement timing, usually the time relative to the start of a given measurement or event. Click the button to define a custom range. This is useful for selecting records after the initial spray plume burst but before the main spray plume ends, to analyse the moment that important measurement characteristics changed.



3. Alternatively, select the **Match** check box to select on the basis of **Sample**, **Source name**, **Lot value** or **Notes** data supplied for the spray. The search fields are detailed in the online help.

Re-analysing (editing) records

Each record in a **Size History** can be edited and re-analysed, producing a new result obtained using different measurement parameters.

For example, suppose the refractive index value used for the spray initially is found to be incorrect. Select the record then edit the **Refractive Index** parameter and re-analyse the result to produce the correct values.

Records may need editing when any of the following change:

- Optical properties.
- Data alarm levels.
- Analysis options.

Editing can be performed on one record in a PSD or a group of records from a **Size History**. The method is different for each of these. (If the PSD is an average result it cannot be recalculated.)

Note
Unless in 21 CFR Part 11 mode, when a backup is produced, the new result replaces the previous record in the **.psh** file. We recommend saving the file to be edited under a new name and performing the edit on this file. This preserves the original record(s).

To re-analyse one record:

1. Select the record and select **Edit-Record** to open the **Edit Result** dialogue. This shows the SOP settings used to create the original record.
2. Make any required changes to the SOP parameters and click **OK**.
3. After processing, the edited and re-analysed record is displayed in place of the original record.

To re-analyse a group of records:

1. Optionally, use the mouse to select the records to re-analyse.
2. Select **Edit-Records**. The **Select Range of Records to Edit** dialogue is displayed. Use the **Selection Mode** options as described above.
3. Press the **Settings** button; this opens the **Edit Result** dialogue. This shows the SOP settings used to create the original record. Make any required changes to the SOP parameters and click **OK**.
4. Click **OK** to start processing.

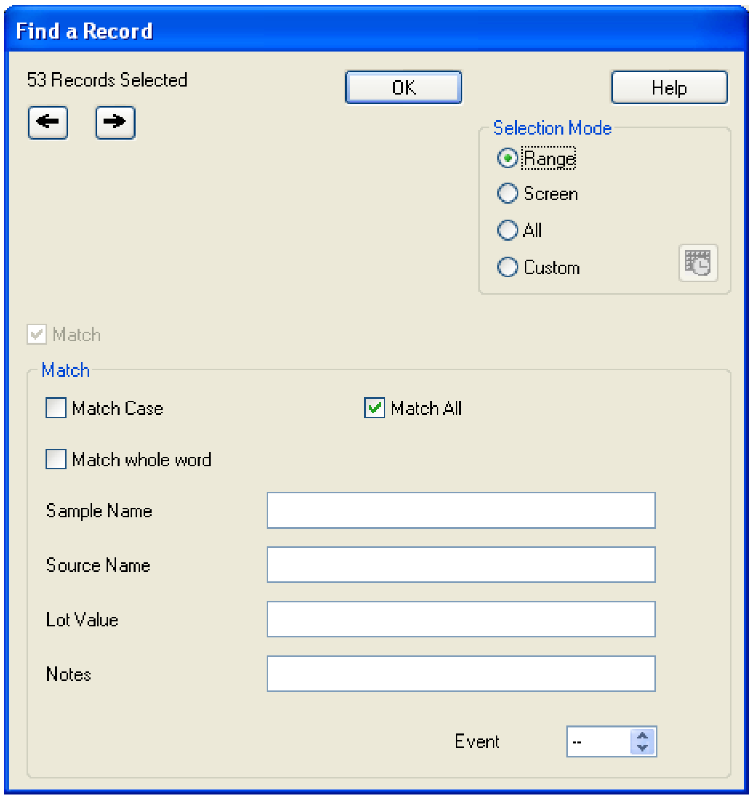
After processing, the re-analysed records are displayed in place of the original records.

Finding a record

If information on the spray was entered into the **SOP Wizard**'s **Labels** dialogue, use **Edit-Find** to locate a measurement record(s) subsequently based on this.

To find a record:

1. Choose **Edit-Find**. The **Find a Record** dialogue is displayed:



2. Based on spray information that has previously been entered, enter the search criteria into the text entry boxes in the **Match** area.
3. Use the **Selection Mode** options if possible to narrow down the set of records to search in.

Note
If using the **Range** option, select the required records in the **Size History** before opening the **Select Range of Records to...** dialogue.

Clicking the  and  buttons moves the **Size History** selector bar through the set of records selected for searching.

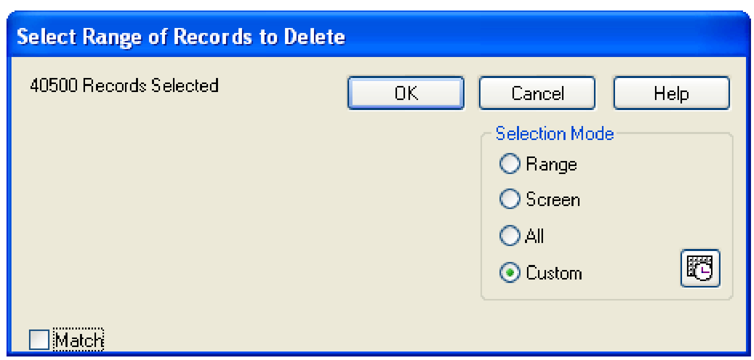
Deleting records

Records can be deleted from a **Size History** plot. This is useful if the plot contains more records than are required. Deleting unwanted records also reduces the size of the **.smea** file.

Note
A user must have **Delete Size History records** permission to perform this procedure. Deleted information cannot be retrieved, except in 21 CFR Part 11 mode where a backup is kept.

To delete records:

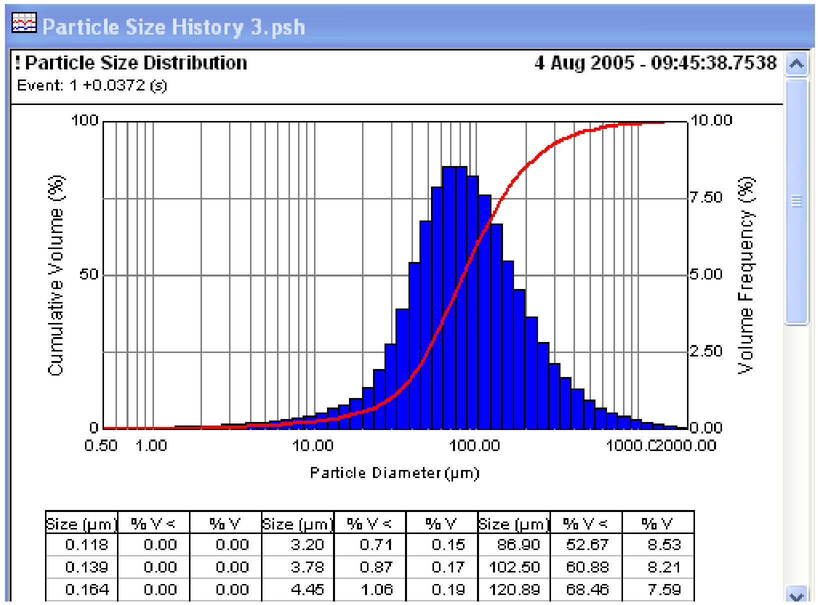
1. Optionally, select the records to delete with the mouse.
2. Choose **Edit-Delete Records** from the menu to display the **Select Range of Records to Delete** dialogue:



3. Select the records required in the normal way described above then click **OK**.
4. The message **Are you sure you want to delete the records?** appears. Click **OK** to delete the records, otherwise click **Cancel**.

Particle Size Distribution view

The **Particle Size Distribution** view shows two graphs, a histogram and a cumulative result-under curve:



Size (µm)	% V <	% V	Size (µm)	% V <	% V	Size (µm)	% V <	% V
0.118	0.00	0.00	3.20	0.71	0.15	86.90	52.67	8.53
0.139	0.00	0.00	3.78	0.87	0.17	102.50	60.88	8.21
0.164	0.00	0.00	4.45	1.06	0.19	120.89	68.46	7.59

The histogram displays the result in the form of “in band” percentages. Each bar in the graph represents a size band of particles and its height represents the percentage of the spray that is within that size band. The user can edit the bands used.

Right-click on the view to change its properties.

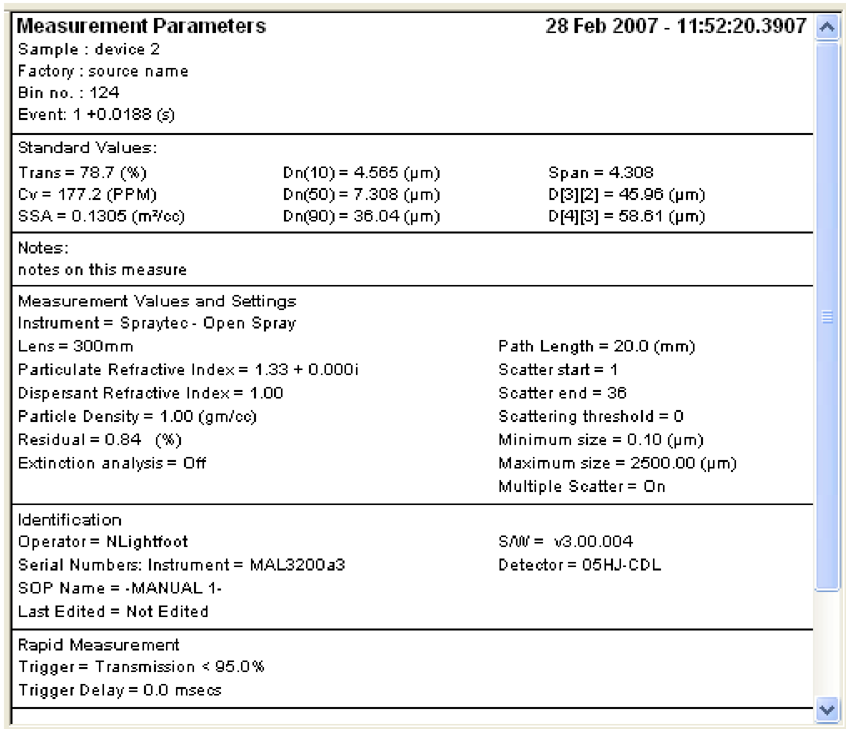
The table below the histogram and graph shows the numeric values that correspond to the bars. It has three columns:

- **Size (µm)** – the value is the upper limit of the size band. In the above example the first size band is from 0 to 0.118µm.
- **%V<** or **%N<** – the cumulative percentage volume (V) or number (N) below the given size. In the example above 60.88% of the spray has a particle size less than or equal to 102.50µm (refer to the table above). This is what the curve shows.
- **%V** or **%N** – the percentage of the sample that is within a size band. In the above example 8.21% of the spray has a particle size that falls between 86.90µm and 102.50µm (refer to the table above). This is what the histogram shows.

There’s a row for each size band. Several frequency curves can be plotted on one overlay to compare results from different measurements; see the section below.

Measurement Parameters view

The **Measurement Parameters** view shows the values of the standard values and measurement parameters used:


Measurement Parameters **28 Feb 2007 - 11:52:20.3907**
Sample : device 2
Factory : source name
Bin no. : 124
Event: 1 +0.0188 (s)

Standard Values:
Trans = 78.7 (%) Dn(10) = 4.565 (µm) Span = 4.308
Cv = 177.2 (PPM) Dn(50) = 7.308 (µm) D[3][2] = 45.96 (µm)
SSA = 0.1305 (m^2/cc) Dn(90) = 36.04 (µm) D[4][3] = 58.61 (µm)

Notes:
notes on this measure

Measurement Values and Settings
Instrument = Spraytec - Open Spray
Lens = 300mm Path Length = 20.0 (mm)
Particulate Refractive Index = 1.33 + 0.000i Scatter start = 1
Dispersant Refractive Index = 1.00 Scatter end = 36
Particle Density = 1.00 (gm/cc) Scattering threshold = 0
Residual = 0.84 (%) Minimum size = 0.10 (µm)
Extinction analysis = Off Maximum size = 2500.00 (µm)
Multiple Scatter = On

Identification
Operator = NLightfoot S/W = v3.00.004
Serial Numbers: Instrument = MAL3200a3 Detector = 05HJ-CDL
SOP Name = -MANUAL 1-
Last Edited = Not Edited

Rapid Measurement
Trigger = Transmission < 95.0%
Trigger Delay = 0.0 msecs

After summary information on the date and timing, the following sections appear.

Standard Values

These are the standard values described in **Chapter 2**.

Measurement Values and Settings

This section summarises significant settings used for the measurement, including:

- **Particulate Refractive Index**, **Media Refractive Index** and **Particle Density** – these are optical properties specified by the user; see **Chapter 10**.
- **Residual** – this gives an indication of how well the optical model was fitted to the measurement data when calculating the spray droplet size.
- **Path Length** – this is the estimated length of the sample field that is measured; see **Chapter 10**. This is the length of the part of the laser beam which passes through the spray plume.

- **Scatter start**, **Scatter end** – these show the range of detectors used.
- **Minimum size**, **Maximum size** – these show the range of particle sizes included.
- **Multiple scatter** – whether the multiple scattering algorithm was used.

Other sections

The remaining sections are:

- **Identification** – this identifies the operator, the hardware and the software.
- **Rapid Measurement** – this describes the trigger setup.
- **Spray properties** – these parameters are described in detail in the **Spray Profiles** section in **Chapter 10**.
- **B_l, B_d** – this text may appear at the end of the parameter list, indicating a problem as follows:
  - **B_d** (Background Dark) – this is probably caused by excessive light reaching the instrument.
  - **B_l** (Background Light) – this usually indicates a dirty window or misalignment.

These are described in more detail in **Chapter 8**.

Derived Parameters view

The **Derived Parameters** view displays a table of values for each parameter:

! Derived Parameters **16 Sep 2005 - 14:47:09.6538**
Sample : pre trigg 2
Event: 5 +0.2481 (s)

Title	Value	Average	σ	Min	Max
Trans (%)	100.0	99.9	0.021	99.9	100.0
Dv(10) (µm)	41.81	52.94	36.650	35.31	152.56
Dv(50) (µm)	119.19	192.28	15.156	119.19	249.97
Dv(90) (µm)	320.67	330.53	240.231	224.54	930.61
D[3][2] (µm)	81.34	93.98	29.354	4.53	164.34
D[4][3] (µm)	150.05	227.38	59.289	129.71	433.16
Cv (PPM)	0.58	0.58	0.853	0.24	3.65
SSA (m²/cc)	0.0738	0.0638	0.11994	0.0365	1.324
Obs (%)	0.0	0.1	0.021	0.0	0.1

Averaging period = 10.0 (ms)

The parameters are described in **Chapter 10**. For each parameter the value, average (over the period shown after the table), standard deviation, minimum size and maximum size are listed.

Averaging data

Averages can be used to compare different stages of atomisation or look for consistency between measurements at different times. The average particle size for selected records can be calculated in two ways:

- Using the button or **Edit-Calculate Average** command.
- Using the **Edit-Advanced Average** command.

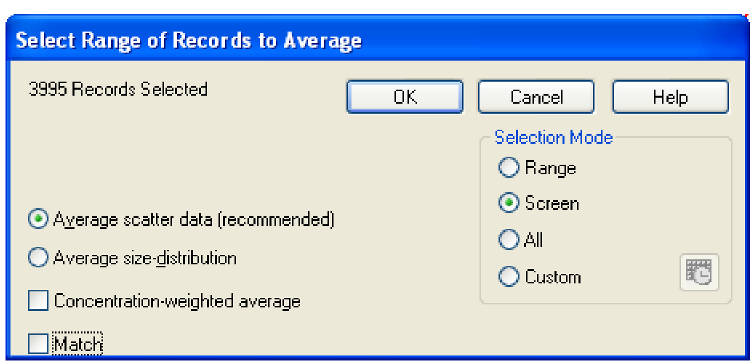
In both cases two types of average can be calculated:

- **Average scatter data** – arranges the scattering data across the selected range and then calculates the average PSD based on the average data. This is the preferred method.
- **Average size distribution** – averages the size band data for all the records in the range to derive an average PSD.

There is also a **Weighting** option. By default all averages are weighted according to the spray concentration at each point. This provides a true volume-based average. Selecting **Concentration-weighted average** causes the averaging routine to assume that all records relate to the same concentration so are equally important in calculating the average.

To produce an average:

1. Open the **Size History** and select **Edit-Calculate average** or click the button to open this dialogue:



2. If the records are not already selected, use the buttons on the right-hand side to do this.

3. Specify the average type (see above) and whether it's to be un-weighted or not, then click **OK**.

4. A progress bar shows that processing is taking place. On completion, a set of views showing the averaged measurement parameters becomes available, starting with the **Average PSD** view. Right-click on this to see a list of the other available views.

5. The averaged results appear in the Measurement file window. The average is created as a new measurement record with the extension **.psd**. A new folder named **Averages** appears in the Measurement file tree to hold it.

Advanced averages

For pulsed and externally-triggered sprays, three more averages can be calculated:

- **Phase-based average** – generally used for one shot spray applications like nasal sprays. Averaging is based on the three stages of the spray plume: formation, stabilisation and dissipation.
- **Time-based average** – used for repetitive spray applications (i.e. fuel injectors). Analysis is based on the triggering points for the repetitive spray generations.
- **Ensemble average** – used for samples (often nasal sprays) either where several repeat measurements are made, or where the sample has a natural repetitive nature, such as fuel injection in an internal combustion engine.

  An ensemble average provides a size history which is an average of several event cycles. Each point in the averaged size history is an average of the corresponding points in each event cycle.

These averages can be incorporated into the SOP design as described in the second and third examples (those which include the **Averaging** dialogues) in **Chapter 5**.

In addition, either type can be calculated for measurement results using the **Edit-Advanced Average** command.

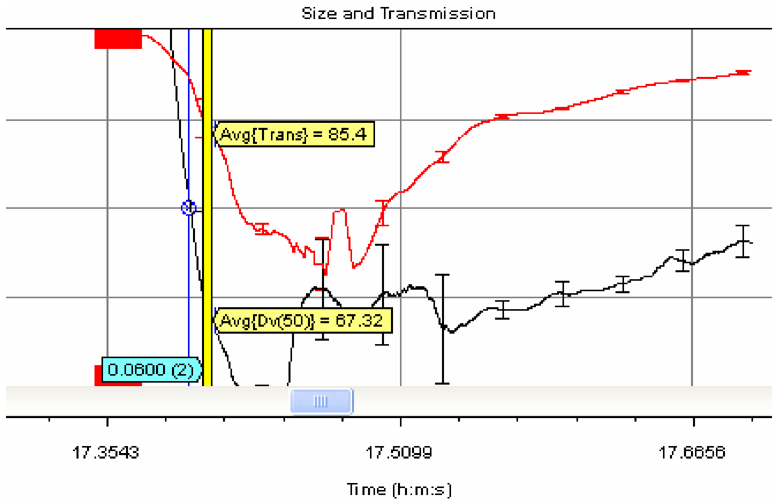
Statistics bars

Statistics ('error') bars can be displayed on the derived parameter curves on the average size-history graph produced by the advanced averaging options.

The statistics bar styles available are 1 x standard deviation, 2 x standard deviation, 3 x standard deviation and maximum-to-minimum. The Standard deviation, maximum and minimum are shown numerically in the **Derived Parameter** view.

The statistics bars are not necessarily shown for every measurement point; this would make the graph too crowded. As the time axis duration increases, a maximum of 20 points are shown across the extent of the graph.

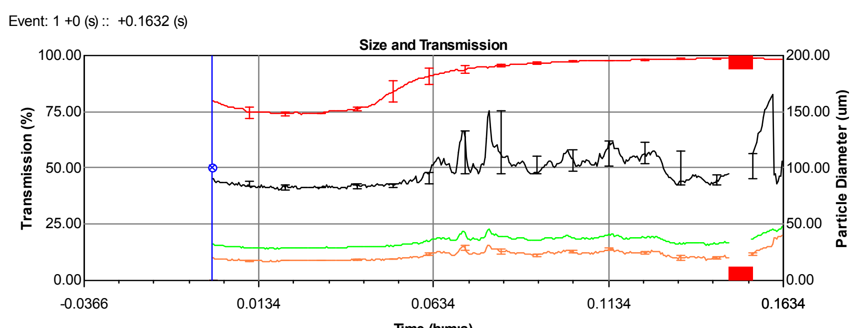
The statistics bars look like this on a size history chart:



▶ To enable the statistic bars:

1. Right-click on the display and select **Properties**.
2. In the **Size History Display Setup** dialogue, double-click on one of the line colours in the  column. This opens the **Line Style** dialogue which contains the **Statistics bar** options.

If a size history graph is copied to the clipboard, saved as a metafile or printed, a table is appended, showing the details of the statistics bars, like this:



Title	Legend	Average	σ	Min	Max	Correction Equation
Trans (%)		88.9	8.29	74.0	98.7	—
Dv(5) (µm)		19.19	3.269	16.83	40.15	—
Dv(10) (µm)		31.17	3.722	28.24	47.89	—
Dv(50) (µm)		87.59	11.49	80.7	165.7	—
Dv(90) (µm)		289.8	74.31	241.3	900.3	—
Dv(95) (µm)		446.4	118.7	351.8	1243	—

391 Records Averaged (average scatter, weighted)

Example results.smea\Experiment 1\Particle Size History 3.psh

Curve fit

By default the Spraytec uses a model-independent analysis where the distribution shape is allowed to vary according to the nature of the collected scattering data. However, for comparability with results obtained using older laser diffraction systems, the Spraytec can be set up to produce size distributions using a simple two parameter distribution model. This is set up using the second **Analysis** SOP dialogue.

Two models are available, the Rosin-Rammler distribution and the Log-Normal distribution. Users can select from the following options:

- **No Fit** - uses the standard Spraytec analysis. This is the default setting.
- **Rosin-Rammler** - uses the Rosin-Rammler two parameter distribution model. The analysis reports the central size point (**Drr**) and distribution width (**Nrr**) for this distribution (**Chapter 10** defines these).
- **Log-Normal** - uses the Log-Normal two parameter distribution model. The analysis reports the Geometric Mean (**Drr**) and Geometric Deviation (**Nrr**) for this distribution (**Chapter 10** defines these).

For each two parameter model, specify the range over which the data fit is to be carried out. This is specified in terms of these distribution percentiles:

- **Lower Limit** – the lower percentile limit for the two parameter model fit. By default this is set to the **Dx(0)**.
- **Upper Limit** – the upper percentile limit for the two parameter model fit. By default this is set to the **Dx(100)**.

These limits allow for the fact that the actual size distribution of the spray seldom agrees with the selected model distribution, with the largest error being observed at the tails of the distribution.

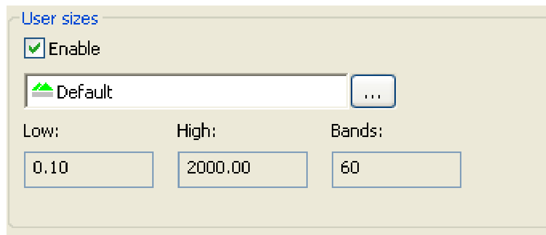
User size bands

The particle size distribution reported by laser diffraction systems is not a continuous distribution. Instead, the volume of particles present within different size bands is reported. The size band intervals can either be set to the Malvern Instruments defaults or configured by the user to report the volume of material at specific sizes. User size bands are also used to set the format of the size distribution data when it is exported to a text file.

The default size bands have been pre-defined by Malvern Instruments. These are identified by a small Malvern Instruments logo ( ) next to the name. It is not possible to modify or delete these default size bands.

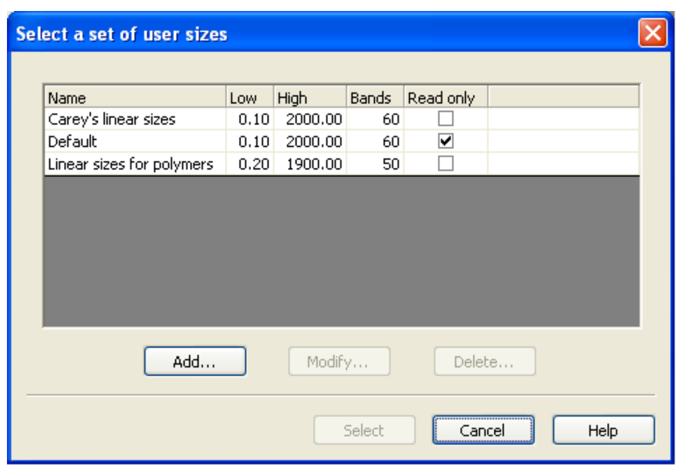
Within a histogram or result table, each column represents a **size band** of particles, for example from 0.25µm to 0.7µm. Complex sets of size bands can be set up for different purposes and saved, making them available to other users. Size bands are defined during SOP creation using the second **Analysis** dialogue.

The relevant part of the dialogue is shown below:



As this shows, the default is 60 bands dividing the range 0.1 to 2000µm. If the **Enable** box is left unchecked the defaults are used. The procedure for creating/editing a set of bands is described below. The permitted number of bands is from three to 60, inclusive.

If multiple sets of size bands have been set up, to select one of these rather than the defaults, select the **Enable** check box then click the ... button to display a list of these. Here's an example:



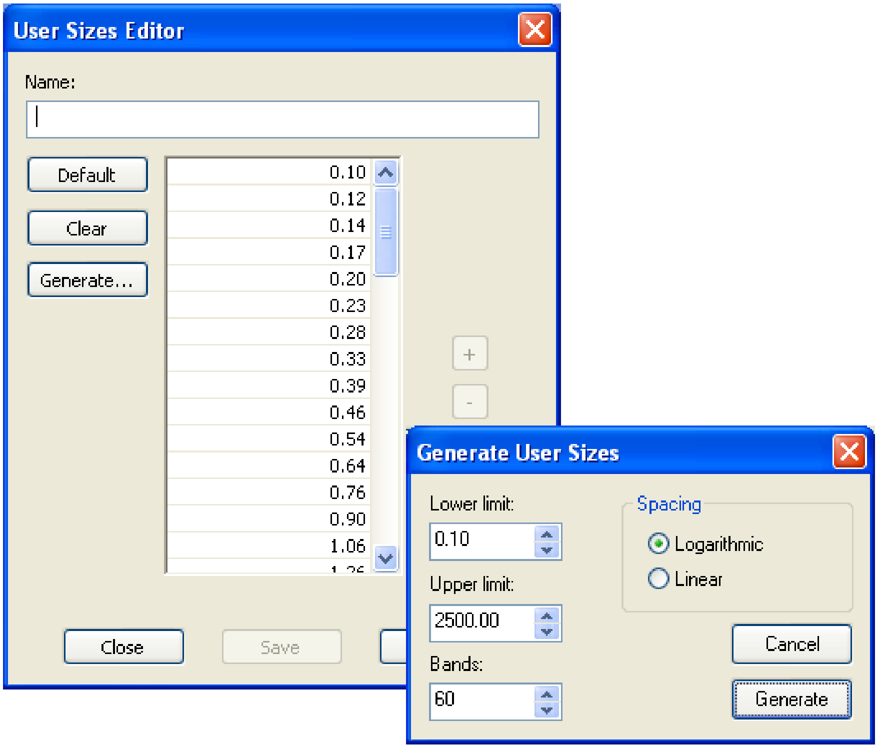
Select the required set in the list and click **Select**.

Note
The size bands used do not affect the calculation of the derived parameters associated with a given result. The selected intervals are only used to set the size bands displayed in size distribution graphs and tables.

To define a new set of user size bands:

1. Click the [...] button under **User sizes**.
2. In the **Select a set of user sizes** dialogue (shown above) click **Add**. This opens the **User Sizes Editor** shown below.

Note
To modify an existing band, select it and click **Modify** instead of **Add**.



3. Type a name for the new set of bands into the **Name** box.
4. The editor initially lists the default set of values. There are two ways to create bands:
   - To modify the bands manually, type in new values. To replace an unwanted size point, select it and type a new value over it. To remove an existing size point completely, select it and click the [-] button. To add a new size point, click the [+] button; this adds a blank line below the cur-

rent selection for typing the new value. To remove all bands click the **Clear** button.

- Alternatively, click **Generate** to open the **Generate User Sizes** dialogue (shown above on the right). This is used to generate linear or logarithmic sequences of size bands. Select the limits, the type of spacing required and the number of bands, then click the **Generate** button. The minimum is 0.10 and the maximum is 3000.

Note
Using the **Generate** facility ensures that the size bands are distributed as evenly as possible.

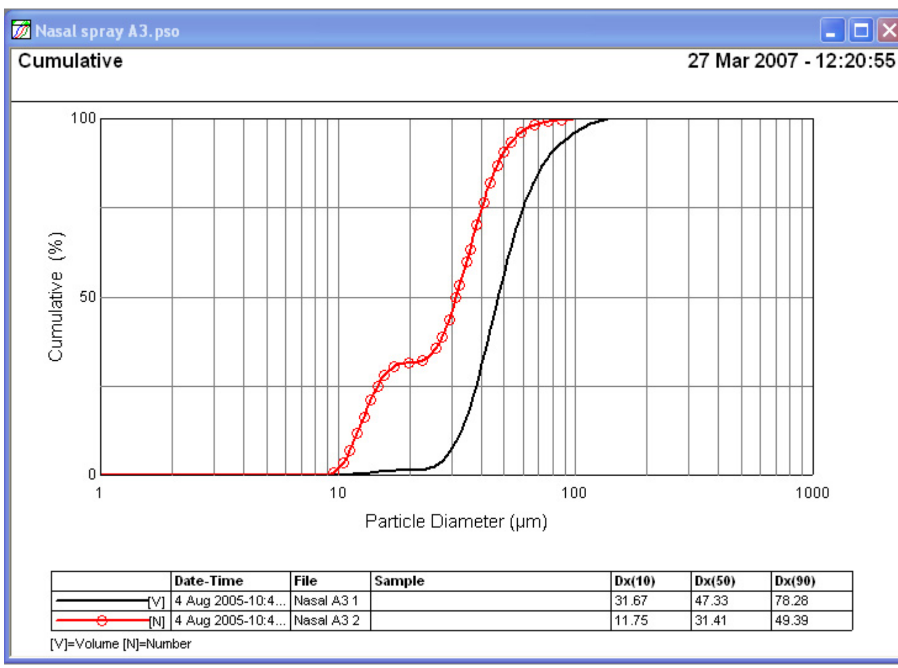
5. When the size bands shown in the list are suitable, click **Save** then **Close**.

Using overlays

A **Particle Size Overlay** (**PSO**) window can be used to compare data from up to eight PSD views. The data from all these is shown on one display. An overlay can show any of the following views (right-click on the PSO window to select one):

- **Cumulative** – PSD cumulative curves.
- **Frequency** – PSD frequency curves. This is the recommended view.
- **Corrected light scattering**.
- **Dark background**.
- **Light background**.

This example shows cumulative data for two PSD files:



The table below the graph is a key to the lines and point symbols used and shows summary information for each file. Each data element is assigned a unique line style and colour; to change this follow the procedure below. To reformat the table, right-click on it.

This window can overplot a mix of Volume and Number result distributions, as in this example. The plot key in the overlay table shows the result type, **V** or **N**.

To create an overlay:

1. Click on one or more **.psd** files in the Measurement file window and right-click. In the menu this displays, select **Add to Overlay-New Overlay**. Alternatively, use the button or **File-New -Overlay.**
2. The PSO window opens showing the data for any **.psd** files selected.
3. To add data from another **.psd**, drag the file from the Measurement file window and drop it on the PSO window.

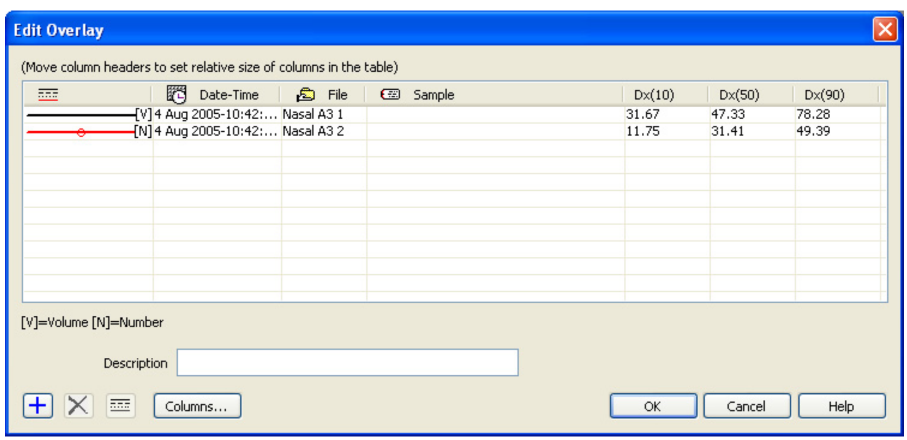
Note
PSD data can also be dragged and dropped into an open PSO window from the Windows File Manager.

To change the overlay display settings:

- To change the window setup (axes, scaling, etc.), right-click on it and select **Properties**.

To modify the overlay display:

1. Click on the PSO window and select **Edit-Modify** to display the following dialogue, which gives information on each PSD plotted:



2. To add a title to the overlay, type it into the **Description** box.
3. The button is an alternative way to add **.psd** files to the overlay. Click the button then select the **.smea** file and click **Open**. An **Add Distributions** dialogue opens listing the contents of the **.smea** file. Select all the **.psd** files required then click **OK**.
4. To remove a PSD from the display, select it and click the button.

5. New data elements are automatically assigned a unique line style and colour. To change these for any PSD, select it and click the button.
6. To change the format of the table shown in the window click the **Columns** button. In the dialogue displayed use the pull-down lists to change the content of any column.
7. When all data are suitable click **OK**.

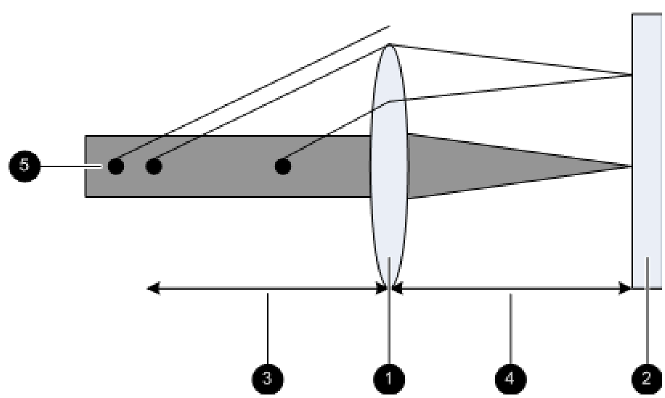
Problems with poor data

Two problems, **beam steering** and **vignetting**, may lead to erroneous size distribution data. These can be fixed using the **Data handling** options described in the following section.

Note
Do not remove detector data unless there is good reason – the accuracy and resolution of the analysis will be reduced.

Vignetting

When measuring the particle size of sprays using laser diffraction, it is important that the spray is close enough to the lens to allow the wide-angle scattered light from small particles to be collected by the focusing lens. The maximum distance between the spray and the lens that allows resolution of the smallest particle size that can be measured defines the lens working range.



ill 7452

In this graphic:

① is the focusing lens.

② is the detector array.

④ is the focal length of the lens.

Light scattered by the two particles closest to the lens is collected by the lens. Light from particle ⑤ is scattered beyond the lens. This shows the extent of the working area ③.

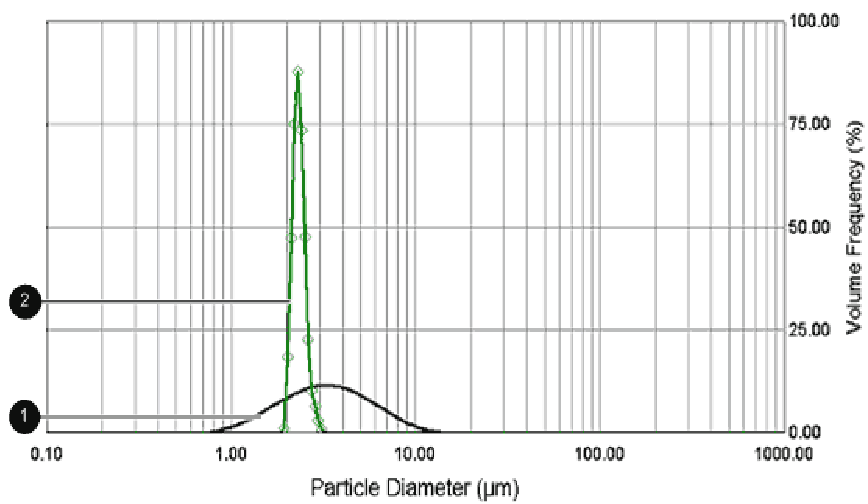
The minimum working range of the 300mm lens is 150mm, allowing measurement of particles down to size 0.5µm. The working range for the 750mm lens is 500mm, allowing for the resolution of particles down to 2µm.

The working range for each lens increases as the particle size increases. This is because large particles scatter light at smaller angles and can therefore be resolved at a greater distance away from the lens.

Note
The recommended solution whenever possible is to repeat the test, with the spray closer to the Receiver module.

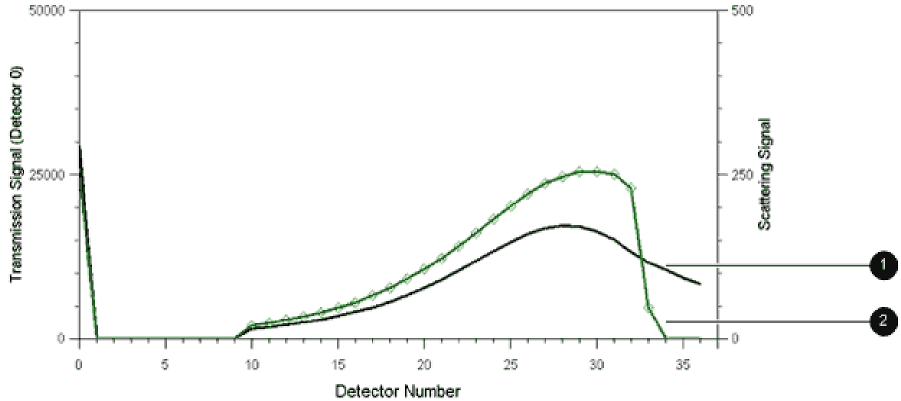
If measurements are made outside the working range of the lens, the system measures incorrectly the light scattered at wide angles. This causes the light scattering measured by the outer detectors to be "cut off", in which case the measured intensity is less than expected. This effect is called **vignetting**.

An example of vignetting is shown below for a nebuliser. The output of a nebuliser contains a significant number of sub-micron particles. When the nebuliser aerosol is measured within the working distance of the lens the correct result ① is obtained. If the nebuliser is measured outside the working area, the scattering observed for the outer detector channels is reduced. This causes an incorrect result ② to be calculated.



ill 7456

The diagram below shows the scattering data associated with the size distributions shown above:



ill 7457

Curve ① shows the measurement made within the working range. Curve ② shows the measurement made outside of the working range. Here the lack of data on the last five detectors is obvious. This is caused by vignetting.

There are two ways to stop vignetting:

- Move the spray source towards the Receiver lens to a point where the reported result does not vary with distance. This should be within the quoted working range for the lens.
- Use the **Detector Range** options to eliminate the detector channels affected by vignetting. This reduces the resolution of the analysis in the sub-micron size range, so should only be done if it is not possible to position the spray closer to the Receiver.

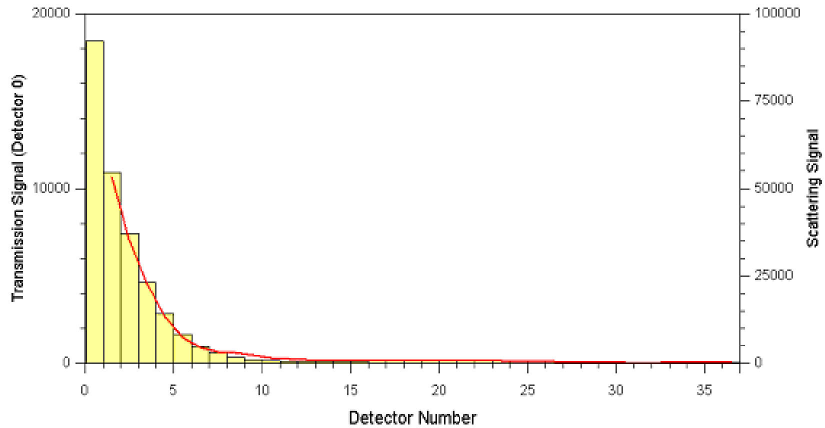
In the above example, the effect of vignetting can be overcome by eliminating the last five detector channels from the analysis.

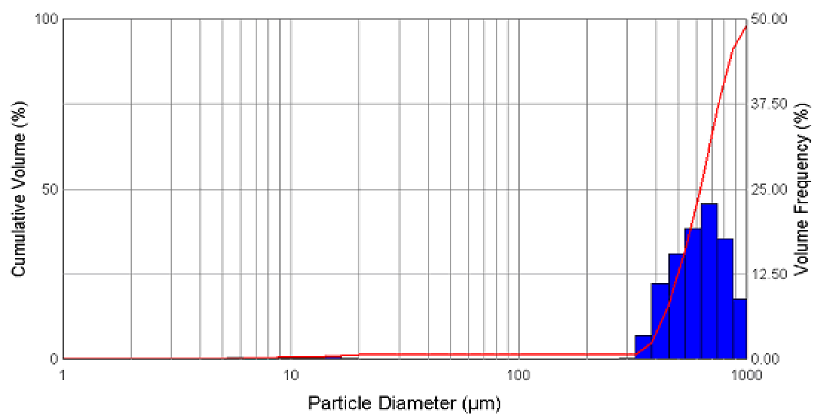
Beam steering

Beam steering occurs when a significant volume of propellant gas or another gaseous phase apart from air is present in the measurement zone. When the Spraytec is set up the system is aligned with air present in the measurement zone. Gases such as propellants have a refractive index significantly different from air. This causes the laser beam to become unfocused, leading to a high scattering signal on the first set of detector channels. Although this signal is not caused by particle scattering, it is interpreted by the analysis as indicating the presence of coarse particles.

The only way to overcome this is to eliminate from the analysis the detector channels affected by beam steering.

An example of beam steering is shown by the following two views:



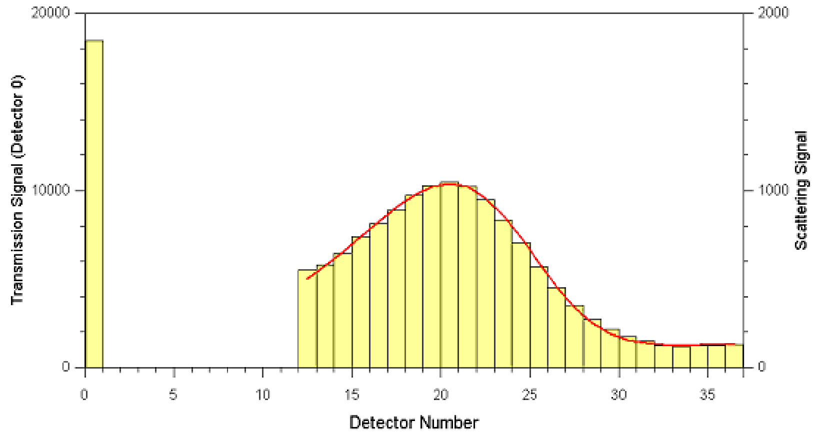


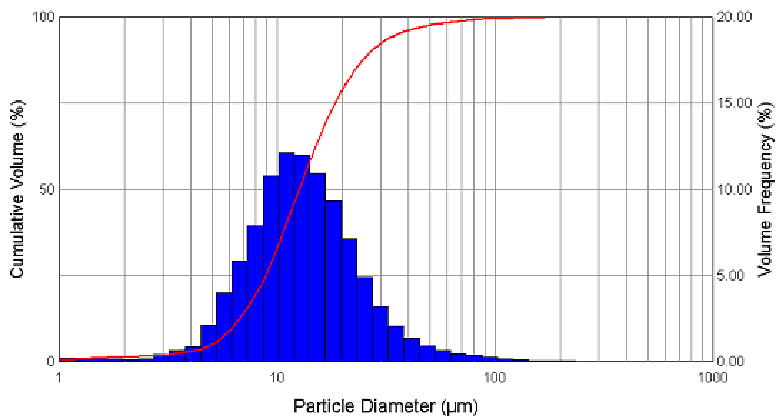
This spray contains a high concentration of propellant, causing a large scattering response on the first detector channels. This signal is much larger than the scattering response seen from the particles within the spray (detectors 30-35). As such the analysis reports a large particle mode, with only a small volume of fine particles being present.

There are two ways to overcome beam steering:

- Move the spray further away from the measurement zone – this can limit the effect of beam steering in some cases, allowing accurate results to be obtained.
- Eliminate the detectors affected by beam steering from the analysis using the **Detector Range** options. This is used more often. It reduces the size range of the analysis as large particles are not detected, but realistic results are obtained.

In the above example the first detector for the analysis must be set to 12 in order to obtain a realistic particle size. The result of the analysis using a reduced detector range is shown below.

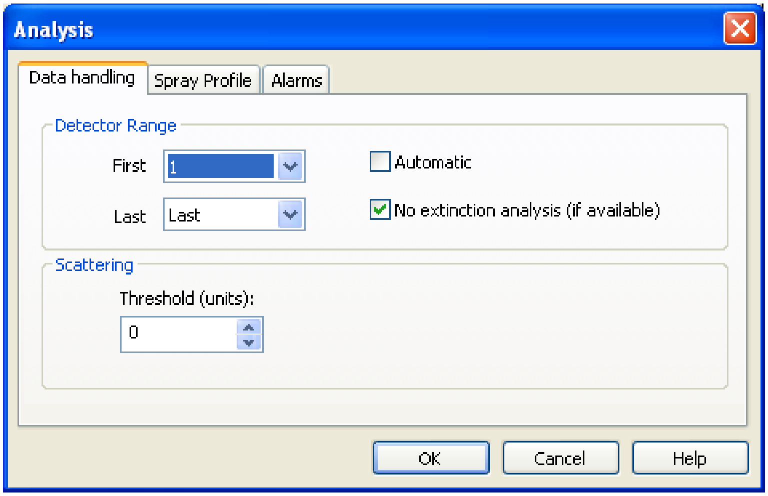




Using the Data handling options

The **Data handling** options allow users to specify which of the scattering detectors to use when calculating the spray size distribution. The detector range to use can be specified and/or a scattering threshold set to decide whether to accept the signal received on each detector.

Use the **SOP Wizard**'s **Data handling** tab, shown below, to set up the options:



The options are described in turn below.

Detector Range

If either of the following problems, described in the previous section, is seen it may be necessary to exclude some detector channels from the analysis:

- **Beam steering** – here it may be necessary to exclude the first set of detectors from the analysis.
- **Vignetting** – it may be necessary to exclude the last set of detectors from the analysis.

Detectors can be included or excluded from the analysis using these options:

- **First** – sets the first detector used in the analysis. For instance, if detector 4 is selected then detectors 1-3 will be excluded from the analysis.
- **Last** – sets the last detector used in the analysis. Here the actual detector number depends on the lens being used. For the 300mm lens 36 detectors are included in the full analysis whereas for the 750mm lens only 33 detectors are

included. Selecting **Last-4** from the list would change the last detector to 32 for the 300mm and 29 for the 750mm lens.

- **Automatic** – selecting this option enables an automatic algorithm designed to automate the selection of the first detector when beam steering is known to be a problem. The algorithm sets the first detector to the detector number at the scattering minimum between the beam steer signal and the particle scattering signal. The **Beam Steering** section above has more details.
- **No Extinction Analysis (if available)** – when measuring very fine materials, the Spraytec software can use the amount of light extinguished by the sample as a data point in order to improve the sub-micron resolution.

  This option can only be used if the measurement path length is correctly set in the **Spray Profile** options (see **Chapter 10**). By default this option is disabled.

Note
Excluding detectors from the analysis limits the dynamic range of the analysis. Do not exclude detectors unless it is known that an issue such as beam steering or vignetting has affected the results.

Scattering threshold

The **Scattering threshold** defines the number of scattering units that must be reported on a single detector before the response from that detector is included in the analysis. The threshold is set to one by default. In applications where a significant amount of optical noise is observed users can increase the threshold.

Note
Increasing the detector threshold impacts the accuracy of the reported size distribution. In particular, it may affect the reported distribution width, as the small signals associated with particles at the limits of the spray size distribution may be excluded from the analysis.

7

Using measurement files

Introduction

This chapter describes how to print and export Spraytec data It covers:

- Measurement file types.
- Using measurement files.
- Exporting information (data and views) for use in other applications.
- Printing results.

Measurement file types

The Spraytec Measurement file (**.smea**) is the main file type and this contains all the measurement information. The Measurement file window shows a folder structure when a **.smea** file is opened, but in fact the "sub-folder" information is stored within this single file. There are no separate folders or files on the disk.

The main view types can also be saved as stand-alone files. This is useful for transferring files between sites or sending files to the Malvern Instruments help desk, as these are much smaller than **.smea** files. The stand-alone files are:

- **Particle Size History** (**.psh**) – this is the primary data file, containing all the information in the **Size History** view and its associated record views.
- **Particle Size Distribution** (**.psd**) – this file contains the information seen in the two record views. The **.psd** files are used to store averages as well as single point size distributions.
- **Particle Size Overlay** (**.pso**) – holds the contents of an overlay window.

These files can be imported as new measurement files, as described in the next section.

Using measurement files

Opening and closing files

Use **File-Open-Measurement file** to open a saved Spraytec measurement file. To close a measurement file, right-click on it in the Measurement file window and select **Close** from the menu this displays.

To save data to a file:

1. Open the appropriate window and click it to make it the current window.
2. Select **File-Save As**. In the **Save as** dialogue select the folder to save the file in and type the name of the file to be created into the **File Name** field.
3. Click **Save** to save the measurement information.

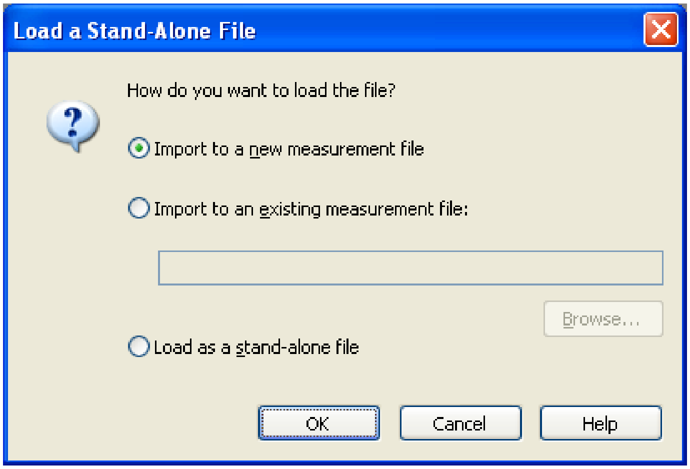
Importing/loading stand-alone files

There are two ways to open a stand-alone **.psd** or **.psh** file.

- **Importing** – adds the file to a new or existing **.smea** measurement file. (The user must have import permission.) This file can then be edited and used in averaging.
- **Loading** – loads the file read-only for simple viewing and printing.

▶ To import/load a stand-alone file:

1. Use **File-Open-Measurement file**.
2. In the **Open** dialogue change the **Files of type** list from the default **.smea** to the required type, select the file and click the **Open** button.
3. The **Load a Stand-alone file** dialogue appears:



4. Select the required option. The **Import** options are:
   - **Import to a new measurement file** – creates a new **.smea** measurement file containing the stand-alone file in a folder named **Import**.
   - **Import to an existing measurement file** – adds the file to an existing **.smea** file, specified using the text box.
5. Click **OK**.

Exporting information

The values of any of the parameters from one or more records, as well as PSH images, can be exported via the Windows clipboard to other applications such as Microsoft Excel, Word and Wordpad. The export commands are:

Command	Available for	Produces:
File-Export	Size History	One of the following: - All data for selected records in a new **.psh** file. - Specified parameters for records selected as text in a text file. -Image: a graph showing selected records in an **.emf** file.
File-Save As	Size Distribution Overlay	One of the following: - A new **.psd** or **.pso** file. - A **.txt** file. - An **.emf** file (graphic).
Edit-Copy	Size History	Contents of view to Windows clipboard.
	Size Distribution	Contents of view to Windows clipboard.
Edit-Copy text	Size History	Specified parameters for selected records as text to Windows clipboard.
	Size Distribution	Summary of data in each view to Windows clipboard.
	Average	Specified parameters for selected records as text to clipboard - includes section on averages.
	Overlay	Summary of the results shown on the overlay in text format.

These commands are described below.

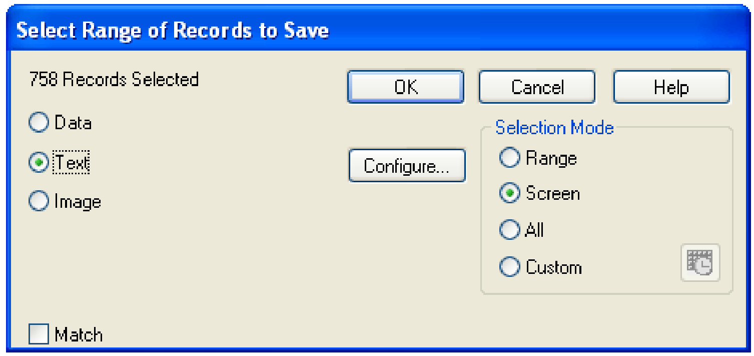
Exporting directly to a file

Three output options are available, as described above:

- **Data** – produces another **.psh** file containing the selected records.
- **Image** – produces an **.emf** file (enhanced metafile) containing the view as an image.
- **Text** – produces a **.txt** file.

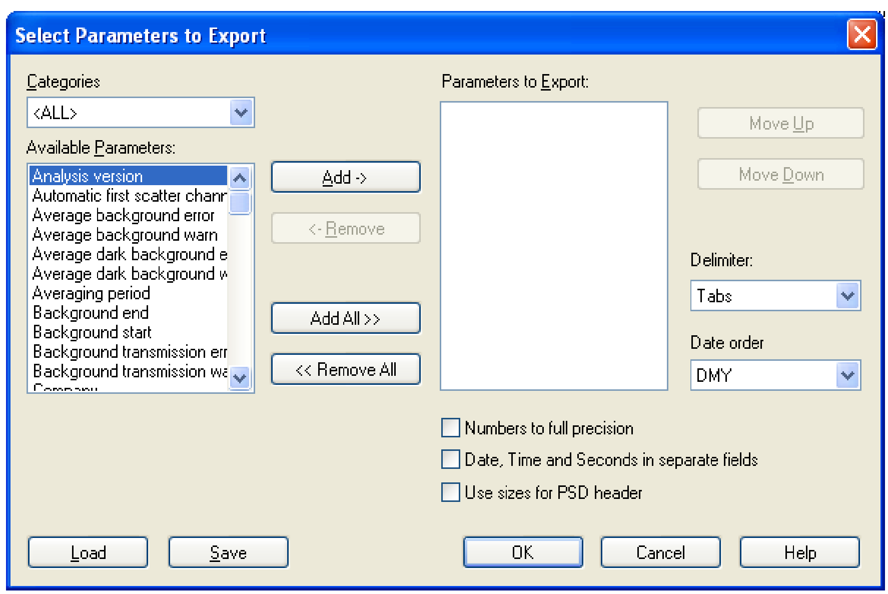
To export size history directly to a file:

1. Click on the **Size history** window. Select **File-Export...** to display the **Select Range of Records to Save** dialogue:



2. To change the selected records use the **Selection Mode** as described in **Chapter 6**.

3. Select the **Data**, **Text** or **Image** radio button. (The **Configure** button appears only when **Text** is selected.) To produce a text file, click this button to open the **Select Parameters to Export** dialogue shown below:



4. Use the **Add->** and **<-Remove** buttons to build the list of **Parameters to Export**. These will all be included in the exported text file. Use the **Move Up** or **Move Down** buttons to reorder parameters as appropriate.

5. If desired, an **Export parameters file** defining the settings can be created and used repeatedly, loaded when needed using the **Load** button. The online help gives full details on this and the other parameters.
6. Click the **OK** button.
7. The **Save As** dialogue is displayed. Specify the file location and name in the normal way then click **Save**.

To export size distribution or overlay data directly to a file:

(This is not available for a **Size History** and does not give the option of specifying a range of records.)

1. Click in a **PSD** or **Overlay** window and select **File-Save As**.
2. In the **Save As** dialogue save the file as a **.txt** file or an **.emf** file.

Copying graphics to the clipboard

This copies a **Size History**, **PSD** or **PSO** window to the clipboard as a graphic.

To copy graphics to the clipboard:

1. Click in the window and select **Edit-Copy**.
2. The **Select Range of Records to Copy** dialogue appears. If required, change the record selection using the **Selection Mode** (see **Chapter 6**).
3. To save time deselect the **Calculate Averages** check box.
4. Click **OK**.

Copying text to the clipboard

This copies **PSH** or **PSD** data to the clipboard as text. When pasted, this creates a text file with a row for each particle and a column for each size/shape parameter. Header rows explain what follows, as for this **PSH**:

```
Date-Time,Dv(50),D[4,3],D[3,2]

4 Aug 2005 09:45:38.7290,82.6862258911,129.346847534,44.7595939636

4 Aug 2005 09:45:38.7294,82.9062576294,131.626480103,45.0271644592

4 Aug 2005 09:45:38.7298,83.031211853,132.130691528,45.1666145325
```

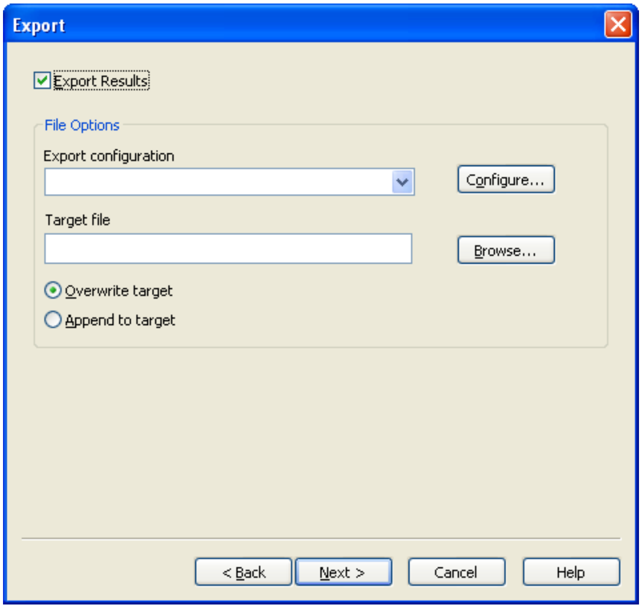
For a **PSD** the output summarises each view in turn.

To copy text to the clipboard:

1. Click in the window and select **Edit-Copy Text**.
2. The **Select Range of Records to Copy** dialogue appears. If required, change the selection of records using the **Selection Mode** as described in **Chapter 6**.
3. Click the **Configure** button to open the **Select Parameters to Export** dialogue shown above.
4. Use the **Add->** and **<-Remove** buttons to build the **Parameters to Export** list. These will all be included in the exported text file. Use the **Move Up** or **Move Down** buttons to reorder parameters as appropriate.
5. If desired a file defining the list of parameters can be created and used each time, loaded with the **Load** button. The online help gives full details on this and the other parameters.
6. Click the **OK** button.

Configuring export from an SOP

The **SOP Wizard**'s **Export** dialogue, shown below, can be used to configure automatic exporting of results when the SOP is run:



To set up export of data at the end of a measurement:

1. Select the **Export Results** check box.

2. Select an **Export configuration** from the list or click **Configure** to create a new configuration (using the **Select Parameters to Export** dialogue shown earlier in this chapter).
3. Specify a **Target file** to store the exported data.
4. Specify how the data will be stored in the file. If the file already exists, its contents can be **overwritten** by the new data, or the data **appended** at its end.

Printing

The procedure for printing out information is different for the **Size History** and **PSD** windows. Both are detailed below.

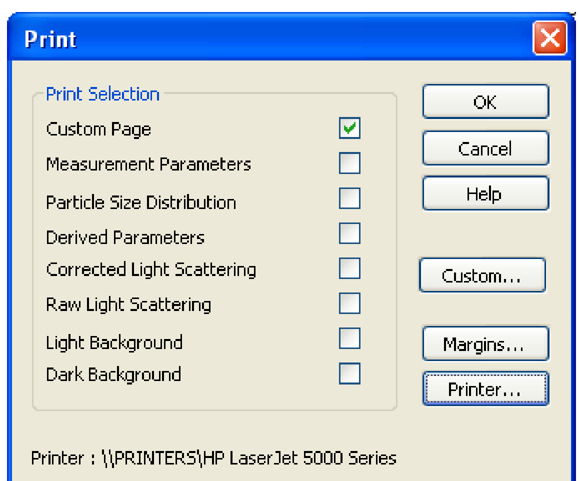
Information can be printed to a physical printer or a **.pdf** file.

To print from a Size History view:

1. Click on the **Size History** view and choose **File-Print** or **File-Print to PDF** to display the **Select Range of Records** dialogue.
2. Use the  and  buttons if necessary to set up the printer or the page respectively.
3. Select the records required as described in **Chapter 6** and click the **OK** button.

To print from a PSD window:

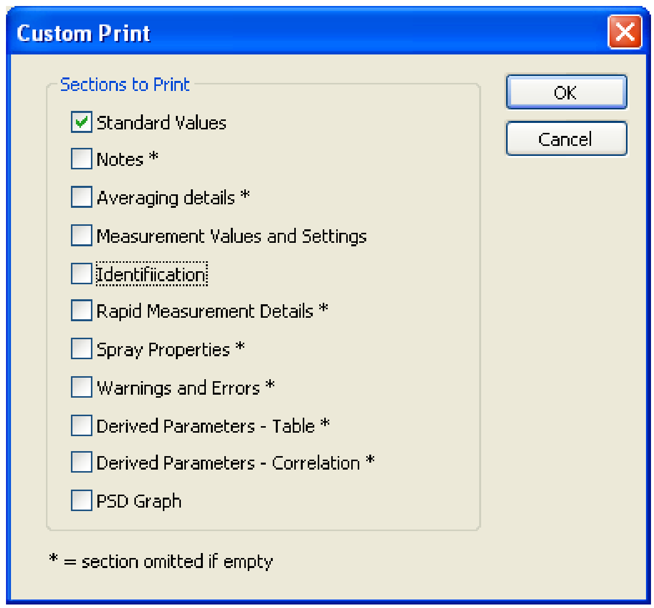
1. Click on the **PSD** window and choose **File-Print** or **File-Print to PDF** to display the **Print** dialogue:



2. There are two alternatives:

   - To print the contents of views as they appear on the screen, select the check box for each view to include in the print. Each view will be printed on a separate page on the paper or in the **.pdf** file. The printed page will show the same information that is displayed in that type of view.

   - To customise the contents of the views into a single page report, select the **Custom Page** check box then click the **Custom** button to open the **Custom Print** dialogue shown below:

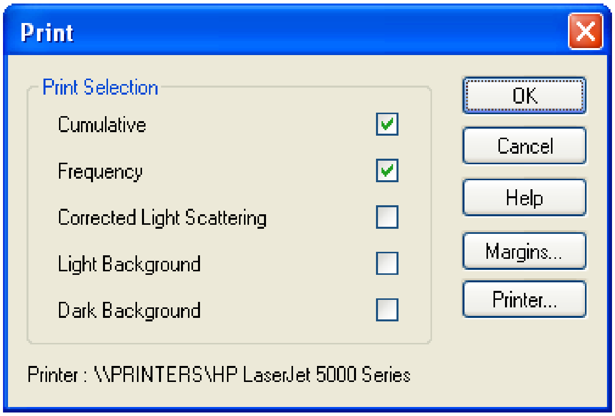


     Select the check box for each section to include in the print. These sections will be compressed to fit onto one page. Click **OK** then on the **Print** dialogue check that the **Custom Page** check box is selected.

3. Use the **Margins** and **Printer** buttons if necessary to configure the print, then click **OK**.

▶ To print from a Particle Size Overlay window:

1. Double-click on the **PSO** window and choose **File-Print** or **File-Print to PDF** from the menu to display the **Print** dialogue:



2. Select the check box for each view to include in the printout. Each view will be printed on a separate page on the paper or in the **.pdf** file. The printed page will show the same information that is displayed in that type of view.

3. Use the **Printer** and **Margins** buttons if necessary to configure the print, then click **OK**.

Basic maintenance

Introduction

The instrument has been designed to keep user maintenance to a minimum. This chapter explains the routine user maintenance procedures that can be performed. These procedures are:

- Moving optical modules along the X-bar.
- Changing the lens.
- Troubleshooting – this section explains the meaning of error and warning messages.
- Cleaning the instrument.

Warning!
Nobody except a qualified Malvern representative should remove the main covers. The system fuse must only be replaced by a Malvern Instruments engineer.

Moving the optical modules

As the size of a spray plume changes it may be necessary to change the distance between the Receiver and Transmitter modules. This means moving one or both modules along the X-bar.

Note
Hold the module casing well away from its windows.

To move an optical module:

1. Power off the instrument.
2. Loosen the two clamps holding the module on the X-bar (see **Chapter 3** for an illustration).
3. Slide the module gently along the bar.
4. Tighten the two clamps firmly but finger-tight.

Changing the lens

Note
This applies to dual lens systems only.

On instruments supplied with both 300mm and 750mm lenses, it may be necessary to change between these. The lens is attached to the Receiver casing.

Note
Before fitting the 750mm lens, keep the lens close to the same room temperature as the instrument for 30 minutes. Alternatively, fit the lens but give it 30 minutes to reach the instrument temperature. One-off measurements can be made anyhow, but if the 30 minute period is not allowed for, longer measurements will show alignment drift during this period.

Caution!
Take care to support the lens while loosening the bolts – it is heavy.
Avoid touching the window in the Receiver.

▶ To change the lens:

1. Power off the instrument.
2. While holding the lens securely, use an Allen key to remove the two bolts attaching the lens to the main casing. These are located diagonally, one above and one below the lens.
3. Carefully remove the lens and place it in its storage case in a clean, dry place.
4. Fit the new lens and tighten the two bolts.

Troubleshooting

Errors and warnings are reported in the message bar, in dialogue boxes or in the **Measurement Parameters** view. This section lists the possible messages and explains what causes them. Two symbols are used:

- **!!!** – indicates an error. If a measurement is in error no result is calculated.
- **!** – indicates a warning. If a measurement produces a warning, the result is calculated but may need checking.

Warnings or errors in background measurements

Dark background:

- **Signal outlier (Bd)**– excessive stray light is entering the Receiver lens.
- **High background signal (Bd)** – as above but there may be a problem with the electronics offset.

Light background:

- **High background signal (Bl)** – windows dirty or system not aligned.
- **Signal outlier (Bl)** – as above or problem with reflections in the optics.
- **Low laser power (Bl)** – the laser is faulty or has not warmed up.
- **Low light transmission (Bl)** – system not aligned or windows obscured.

Warnings or errors in spray measurements

The possible messages are as follows:

- **Empty record- no data available** – the record could not be analysed as no scattering data was measured.
- **Low scattering signal** – the scattering signal is too low to measure. If possible, increase the spray concentration.

- **Low light transmission** – sample concentration is too high, the windows are obscured, or the system is not aligned.
- **Signal outlier** – the system is not aligned, there is excessive stray light reaching the Receiver, or there's a problem with reflections in the optics.
- **Low laser power** – the laser is faulty or has not warmed up.
- **Signal saturation** – the system is not aligned or there's too much stray light.
- **Insufficient signal above the scattering threshold** – the spray concentration is too low or the threshold is set too high.
- **There is no scattering data within the size limits selected** – the size limits are too restrictive or the spray concentration is too low.

Cleaning the instrument

Laser scattering is a high resolution optical method in which the detectors and windows are an integral part of the measurement zone. Dust or smears on windows scatter light that is measured with the spray scattering. The process of measuring both a background and a spray and then subtracting the background does correct for such contributions. However, this correction is first order only and excessive dirt on the optics will degrade the instrument's sensitivity.

We recommend cleaning the instrument after each set of measurements.

Warning!
Always ensure that the instrument is disconnected from the power supply and all electrical cables are disconnected.

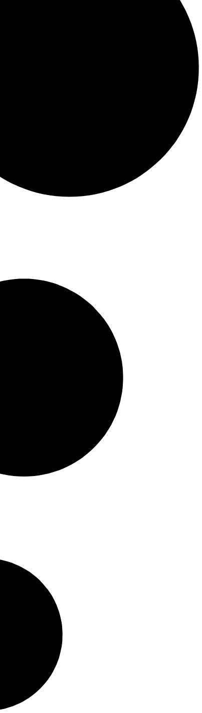
Thoroughly clean the following:

- The covers – periodically, using a mild soap solution and silicon cloth. The paint has a solvent resistant finish, but it is good practice never to use a solvent based solution as this may result in damage to the painted surfaces.
- The windows – using a suitable anti-static spray or mild soap solution.

Guidelines

- **Always** ensure the instrument is completely dry before applying power.
- If using alcohol to remove grease or fingerprints, be careful when handling it. It is **flammable** so keep away it from power switches, etc.
- **Never** use an abrasive cleaner to clean the instrument as this may result in damage to the painted surfaces.

Part 2 -
Supervisor's Guide



9

Security

Introduction

This chapter describes:

- Security principles – administrators, users and their permissions.
- Setting up the Administrator.
- Security guidelines.
- Setting up user groups – all users must be a member of at least one group.
- Setting up individual users – user properties and group memberships.

Security principles

As Spraytec users may have varying skill levels, user access can be limited so that certain functions such as editing SOPs, deleting records and editing results are reserved for specific users only.

Administrators, users and permissions

One or more persons are set up as **administrator**. The administrators then control access to the instrument by defining **User groups** and **Permissions**:

- A **User group** consists of one or more users that have the same access rights.
- **Permissions** are the access rights that are allowed for each user group; these range from the right to edit SOPs to the right to disable view selection.

An administrator:

- Creates users – normally they assign each user a password, although this is not mandatory. If passwords are not set up, the user just has to type their username to log in, otherwise they must provide the password too.
- Creates user groups.
- Adds users to one or more user groups.

After installation

The first time the software is run the security system will be disabled and an administrator user and administrators group will be created by the system. This is so at least one user will have permission to configure the security system.

21 CFR Part 11

The security system can be upgraded to provide technical compliance with 21 CFR Part 11 by installing a **feature key**. Once this is installed, 21 CFR Part 11 security settings can be applied and **audit trails** can be viewed. If the feature key is installed the grey **21 CFR** icon on the status bar becomes coloured.

This manual does not detail the 21 CFR Part 11 option but concentrates on the standard security software.

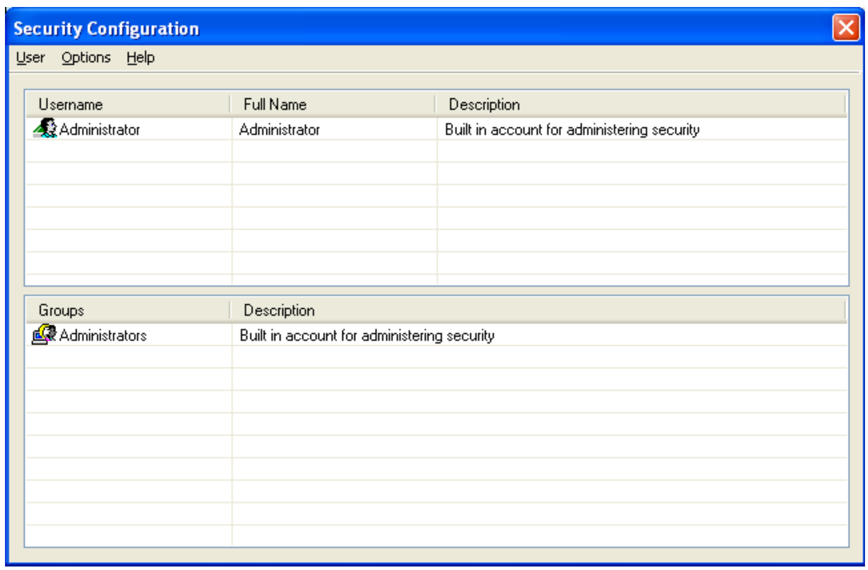
Setting up the Administrator

The first time the system is run just one user (named **Administrator**) and one user group (named **Administrators**) are created automatically. The **Administrators** group is originally set to only allow configuration of the security system and to deny access to all other features of the system.

The first task is to set up the **Administrator** account.

To set up the administrator:

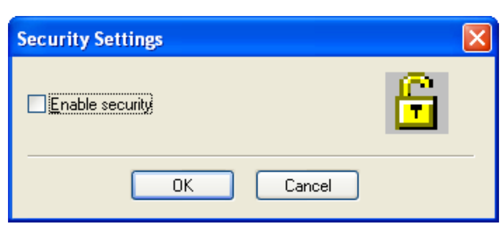
1. Select **Security-Configure security** to display this dialogue:



When the software is run for the first time, the security system defaults to a member of the **Administrators** group with no password.

2. Select the **Administrator** name in the first row and then **User-Properties.** Confirm the blank password for the **Administrator** account (that is, do not type anything in) and click **OK**.

3. Click **Options-Security settings...** and in the **Security Settings** dialogue shown below select the **Enable security** check box and click **OK**.



Security is now enabled on the system. This forces subsequent users to log in to access the software.

Note
If the **21 CFR part 11** feature key is installed a different dialogue is displayed. Once **21 CFR part 11** security is enabled, it cannot be disabled.

Security guidelines

Once security is enabled, each user must log in when the software starts. Once the user is logged in, only functions matching their relevant permissions will be accessible; all other functions will be greyed out.

To change from one user to another without closing down the software, the first user must select **Security-Logout** and then the second user must select **Security-Login** and enter the appropriate username/password.

Note
It is preferable to assign at least two users to the **Administrators** group. These users' user names and passwords should be stored in a secure location. This is to safeguard against accidental lockout or deletion of permissions that may prevent the security settings being available.

Remember that after any changes to the security system – adding users, changing permissions, etc. – the new changes must be saved (by selecting **User-Save**). A dialogue will appear on exit reminding the user to save changes.

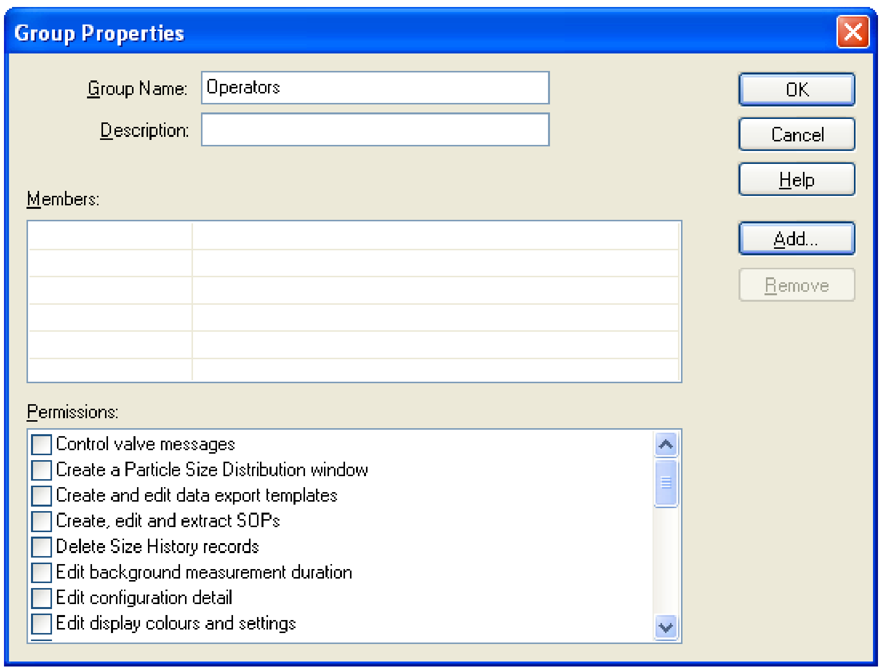
Setting up user groups

All users must be a member of at least one user group.

Note
Only users assigned to the **Administrators** group can add or edit the user group properties.

To add a new group:

1. In the **Security Configuration** dialogue select **User-New Group...** or double-click on an empty **Groups** row to display the **Group Properties** dialogue shown below:



2. Enter a **Group name** and a **Description** of the group's purpose. Example names might be:

- **Operators** – general users of the system.
- **Supervisors** – skilled users who can perform configuration and create SOPs.

3. The **Members** list shows all the users currently assigned to the group. To add a user click **Add**; a list of all users not currently allocated to that group is shown. Select one or more users (hold down the Ctrl key to select multiple users) and press **OK** to add those users to the group.

   If no users have been added yet, add these as described below, then add them to the group.

Note
To remove a member from the group, select them in the **Members** list and click **Remove**. This removes them from the group but not from the system.

---

4. Use the **Permissions** list to enable/disable functions of the software for the group. Simply check the boxes for the permissions required. Scroll through the **Permissions** list using its scroll bar. Click **OK** to save the group.

To edit an existing group:

1. Double-click on an existing group in the **Security Configuration** dialogue to display the **Group Properties** dialogue.
2. Proceed as described above for adding a group.

Setting up individual users

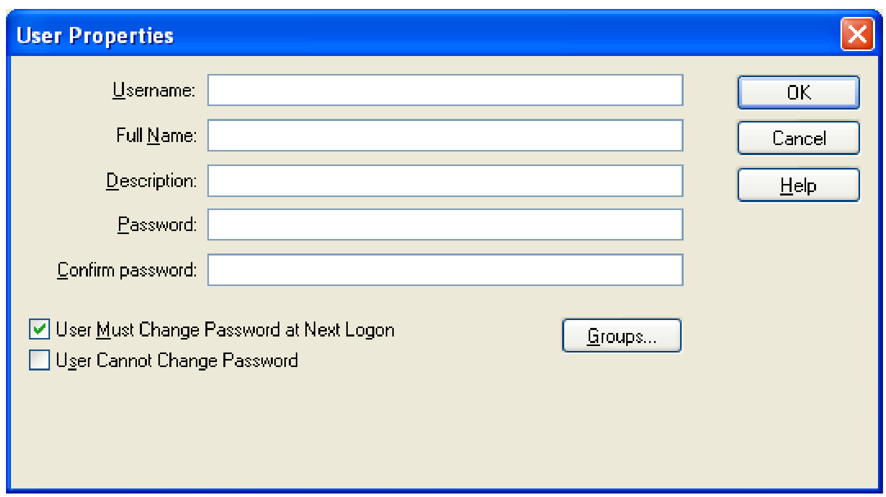
Each user is defined by their:

- Unique **Username** – this, along with the user **Password**, forms the unique key required to identify each individual using the system. The **Username** is commonly an abbreviated form of the individual name or a unique identifier such as an employee code.
- **Full Name** – the full printed name of the individual. This can be used on reports to identify the user if an employee code is used as a **Username**.
- **Description** field (optional) – this is used to add descriptive text for the user.

Note
Only **Administrators** group members can add or edit user properties.

To add a user:

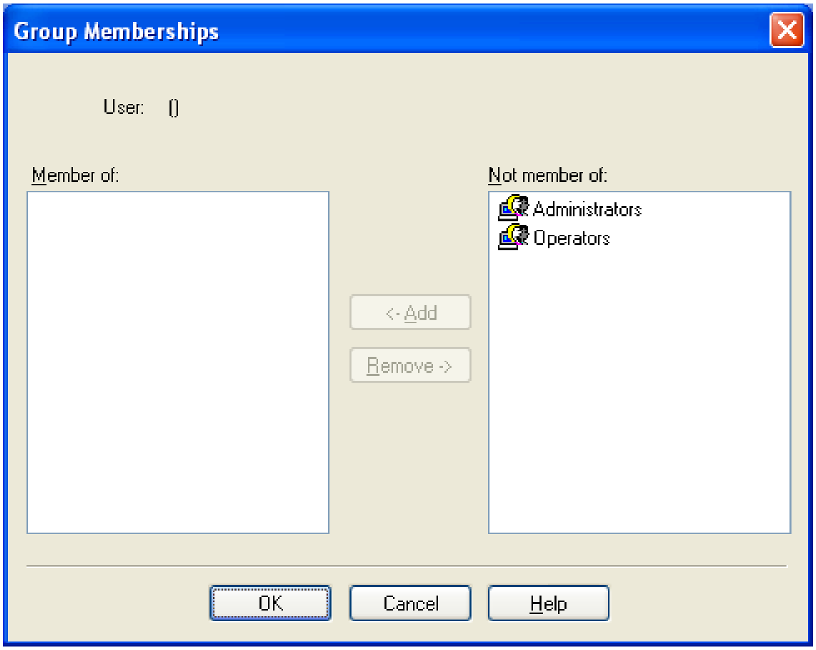
1. In the **Security Configuration** dialogue select **User-New User** or double-click on an empty **Username** row to display the **User Properties** dialogue:



2. Type in the user information in the first three fields.

   To set passwords, the recommended approach is for the administrator to specify a previously arranged password, such as the user's name, and force the user to change their password the next time they log on by selecting the **User Must Change Password at Next Logon** check box.

3. Press the **Groups** button to display the **Group Memberships** dialogue shown below:



4. Use the **Add** button to allocate the user to appropriate group(s) by moving each group to the **Member of:** list.

5. After adding the user to all required groups, click **OK**.

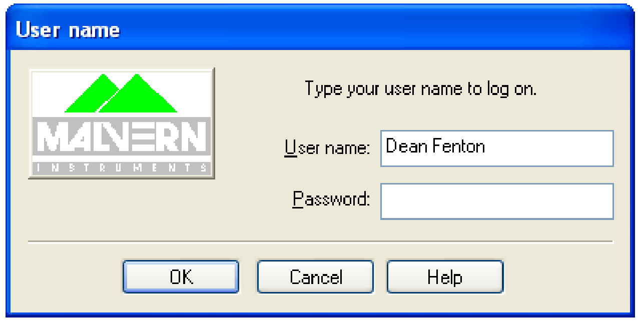
To edit a user:

1. To edit an existing user double-click on their name in the **Security Configuration** dialogue to display the **User Properties** dialogue.

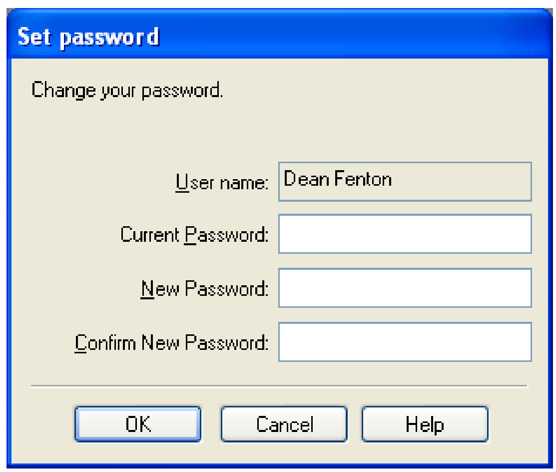
2. Proceed as described above for adding a user.

When a user logs on

If security is configured, the user is asked for a password by this dialogue when they try to log in:



If the administrator selected the **User Must Change Password at Next Logon** check box (see above), the user sees this dialogue when they log in:



To change the user password, the user has to enter the current password and specify a new password with confirmation. Pressing **OK** changes the security settings.

If the administrator used the **User cannot change password** option, this prevents a user from changing a password once it has been initially set. Otherwise, once they have logged in, a user can change their own password by using **Security-Change password**.

To keep the system secure, it is advisable for users to change their passwords regularly to prevent unauthorised access. The only possible exception is the security administrator's account as forgetting the password to this account could prevent any further configuration of the security system.

10

Advanced Features

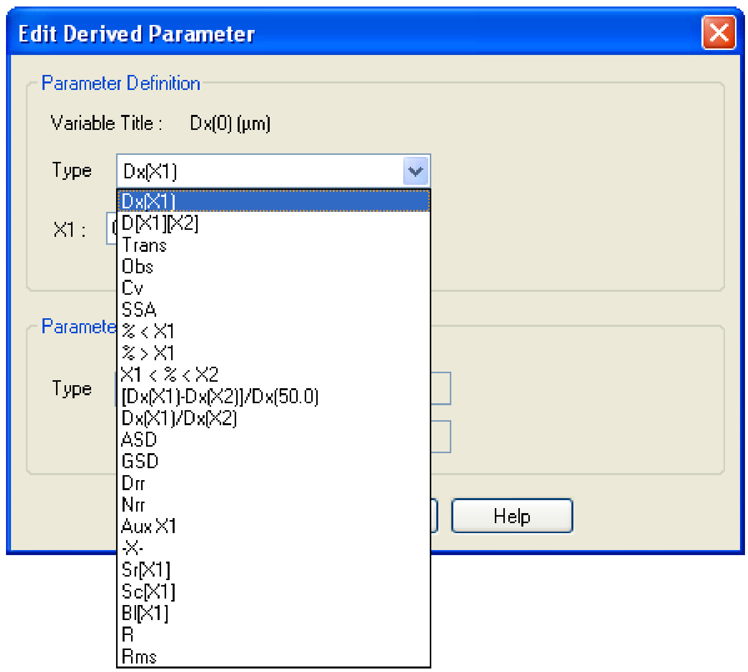
Introduction

This chapter describes advanced Spraytec features. It covers:

- Derived parameters – describes in detail each parameter the user can produce.
- Calculating the Concentration (Cv).
- Rosin-Rammler parameters.
- Log-Normal parameters.
- Triggers – these are used with rapid measurements to signal when to start measurement.
- Alarms – describes how warning and error generation is controlled.
- Spray profiles – to improve the analysis, the Spraytec SOP gives the user the option of defining the shape, size, and position of the spray plume in relation to the Spraytec optical bench.
- Optical models – describes the Fraunhofer approximation and the Mie theory, then the information (refractive indexes and density) which the Mie theory needs from the user.

Derived parameters

The **Measurement Parameters** window shows the "standard values", those derived parameters which are most commonly used. In addition a wider set of parameters can be defined by the user during SOP creation. These are listed under **Type** in the **Edit Derived Parameter** dialogue:



The following parameters are available:

- **Dx(x1)** – the **percentiles**, the size in microns which the specified % of the spray is smaller than. The commonest are **Dx(10)**, **Dx(50)** and **Dx(90)**, which are among the **Standard Values,** but any other % can be specified.

  The value is **Dv(x)** when volume-based, **Dn(x)** when number-based.

- **D[x1, x2]** – the **moment means**. The most commonly used are:
  - **D[3,2]** – the Surface Area Moment Mean Diameter, also known as the Sauter Mean Diameter.
  - **D[4,3]** – the Volume Weighted or Mass Moment Mean Diameter.

Note
The statistics of the distribution are calculated from the results using the derived diameters **D[m,n]**, an internationally agreed method of defining the mean and other moments of particle size. See British Standard BS2955:1993 for details.

- **Trans** – the transmission %, described in **Chapter 2**.
- **Obs** – a % measure of the amount of laser light obscured by the spray. When no spray is present the obscuration is 0%. The value increases as the spray concentration increases. It is equivalent to **100-Trans**, for example 95% transmission ≅ 5% obscuration.
- **Cv** – the volume concentration. This is calculated in volume (%) from the Beer-Lambert law and is expressed in **parts per million** (ppm). For full details see the following section.
- **SSA** – Specific Surface Area, the total area of the particles divided by the total weight. If using this value, it is important that the density of the spray material is defined (on the **SOP Wizard**'s first **Analysis** dialogue). This figure is a mathematical calculation based on the assumption that the particles are both spherical and non-porous.
- **%>x1, %<x1** – percentages above or below a particle size.
- **x1 < %< x2** – the percentage between two particle sizes.
- **[Dx(x1) - Dx(x2)]/Dx(50)** – this measures the width of the distribution.

  The final parameter is always the **Dx(50)** and **x1** should be greater than **x2**.

  When **x1**=90 and **x2**=10 the value is called the **span**. The narrower the distribution, the smaller the span becomes. The **span** is calculated as:

$$\frac{Dx(90) - Dx(10)}{Dx(50)}$$

- **Dx(x1)/Dx(x2)** – this is the ratio between two percentiles.
- **ASD** – Arithmetic Standard Deviation, calculated as:

$$ASD = \sqrt{\sum [V_i \langle d_i - Dv(50)\rangle^2]}$$

  Where: V_i=relative volume of band i and d_i=size of band i.

- **GSD** – Geometric Standard Deviation, calculated as:

$$GSD = \exp\sqrt{\sum [V_i \langle \ln(d_i) - \ln(Dv(50))\rangle^2]}$$

Where: V_i= relative volume of band *i* and d_i=size of band i.

- **Drr** – the Rosin-Rammler central size point (see below for details).
- **Nrr** – the Rosin-Rammler distribution width (see below for details).
- **Aux x1** – the Spraytec interface unit has a number of auxiliary ports. These can be used to acquire a signal from other instruments. To view the signal in the Size History view, select this variable type and specify the **x1** value, the name of the instrument and the units in which the signal is displayed. The **x1** value is the number of the auxiliary port the instrument is connected to.

  The dialogue allows the user to name the external instrument and the units it uses. These will be printed.
- **Sr [x1]** – raw scattering on detector x1.
- **Sc [x1]** – corrected scattering on detector x1.
- **BI [x1]** – background intensity on detector x1.
- **-X-** – when selected, this shows whether a record coincides with a trigger. It writes a 1 to the result if a trigger is used or 0 if no trigger is used. For these records the text "**--X--**" appears in the header line of the record views.
- **R** (**Residual %**) – the fit between the measured scattering data and the calculated data.
- **Rms** (**Multiple scattering residual %**) – the fit between the measured scattering data and the data calculated by the Multiple scattering algorithm. This is zero when multiple scattering correction is not used.

Calculating the Concentration (Cv)

Beer-Lambert law

The Spraytec uses the Beer-Lambert law to calculate the concentration of the spray. This may be expressed as:

$$\frac{I}{I_0} = e^{-\alpha b}$$

Where:

- I is the intensity of light at a distance b in the particle field of absorbance α.
- I_0 is the intensity of the light beam as it enters the particle field.
- I / I_0 is the relative transmission T of the beam (measured directly by the Spraytec). I_0 is the intensity of the laser beam measured at the receiver when no spray is present and I is the intensity with spray sample in the beam.

Expressing the Beer-Lambert law in terms of relative transmission and re-arranging to solve for absorbance gives:

$$\alpha = \frac{-1}{b} Ln \langle T \rangle \qquad (1)$$

Volume concentration

The term α contains information about the concentration and size of the particles. From scattering theory the light attenuated by a particle i may be described by:

$$a_i = Q_i \pi r_i^2 n_i$$

Where:

- Q_i is the efficiency of light extinction (by scattering and absorption) and is calculated from Mie theory for a particle of radius r_i.
- The second term is the cross-sectional area of the particle and the final term n_i is the number of particles of radius r_i.

In terms of the volume of particles $V_i = \frac{4}{3}\pi r_i^3 n_i$, the equation above becomes, for an ensemble of particles:

$$\alpha_i = \frac{3}{4}\sum \frac{Q_i V_i}{r_i}$$

The size of the particles is expressed by the diameter *d* and the volume terms can be separated into a relative volume distribution *v* and a total concentration *Cv* (total volume of particles in a unit volume of dispersant). The equation then becomes:

$$\alpha_i = \frac{3}{2}C_v\sum\frac{Q_iV_i}{d_i}$$

Substituting the above into equation (1) and solving for the concentration gives:

$$C_v = \frac{-2Ln(T)}{3b\sum\frac{Q_iv_i}{d_i}}$$

If *d* is measured in µm and *b* in mm, and *v* is the relative concentration of the size distribution (such that $\sum v_i = 1$) then:

$$C_v(ppm) = \frac{-2000Ln(T)}{3b\sum\frac{Q_iv_i}{d_i}}$$

Concentration is measured in parts per million (ppm). If a volume percent concentration display is required the ppm value is divided by 10000.

In the above equation:

- The Transmission (*T*) is a value between 0 and 1 and is measured directly by the Spraytec.
- The particle size distribution v_i is the relative volume in size-class *i* with mean diameter d_i.
- Q_i - the mean extinction term for size-class *i* - is calculated from scattering theory and is a function of the optical properties of the particle and dispersant media.

Concentration calculation and Multiple scattering

The transmission measurement involves spatially filtering the collimated laser beam that has passed through the particle field. The spatial filter is the pinhole at the centre of the detector array which, as well as being used to ensure the detector array is centred on the laser beam, also rejects any scattered light. In this way the detector behind the pinhole only measures unscattered light. As particle concentration increases, multiple scattering inevitably causes some light to be re-scattered back to a near-zero scattering angle. However, the high efficiency of the spatial filtering minimises the effect this has on the transmission measurement, and hence the concentration calculation.

The use of high-efficiency spatial filtering means the concentration calculation is reliable over a much wider concentration range than a method based on measuring total scattered energy as well as having the advantage of requiring no calibration.

Rosin-Rammler parameters

The Rosin-Rammler equation is a two parameter fit applied to a size distribution that has the shape of a skewed distribution with a tail of fines. It has traditionally been used in the cement and coal industries, though is less commonly used now. Its parameters are provided for historical comparisons. It uses the following equation to fit the size distribution:

$$R^{(d)} = \exp\left\{-\left\{\frac{d}{x}\right\}^{N}\right\}$$

$R^{(d)}$ is the cumulative result smaller than size *d*.

The Spraytec calculation fits a straight line to this data and obtains the two parameters used in the fit:

- **Drr** – Rosin-Rammler central size point (*x* in the above equation).
- **Nrr** – N the distribution width (gradient of the fit).

Log-Normal parameters

When the Log-Normal two parameter distribution model is used the analysis reports:

- **Drr** – Geometric Mean.
- **Nrr** – Geometric Deviation for this distribution.

The Log-Normal equation is:

$$F(d) = \frac{1}{\ln(n)\sqrt{2\pi}}\exp\left(\frac{-(\ln(d)-\ln(x))^2}{2(\ln(n))^2}\right)$$

Where:

- *F(d)* is the relative frequency at size d and x and n are the characteristic size and width of the distribution.
- *ln* is the natural logarithm.
- The cumulative distribution is the integral of *F(d)*.

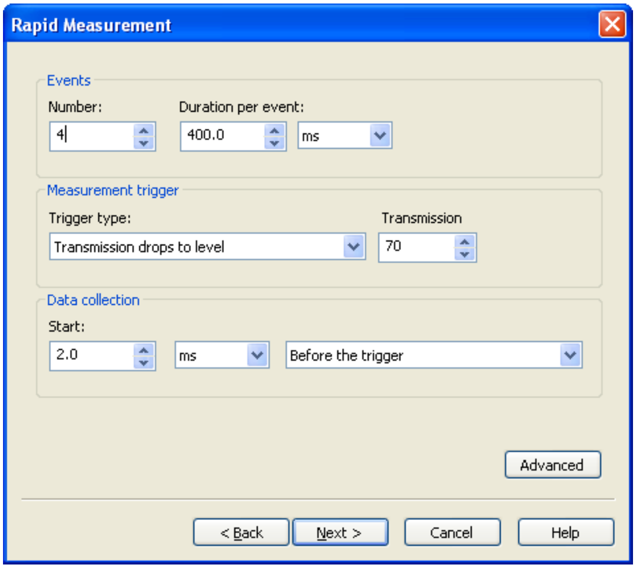
Triggers

A trigger is used in rapid measurements to signal that measurement must start. There are several types of trigger:

- **Manual** – measurement begins when the user presses the **Measurement Manager's Start** button.
- **Transmission drops to level** – measurement begins when transmission drops to a specified level.
- **Scattering increases to level on detector** – measurement begins when a specified scattering level is reached on the specified detector.
- **External trigger** – measurement begins when an external TTL signal is received from another device.

Event number and duration

A trigger can be set up which requires an event to occur multiple times, each event lasting for a specified duration. In the example below a **Transmission drops to level** trigger starts measurement when transmission has fallen to 70% four times, with the measurement period after each of these events lasting for at least 400ms.



Data collection – trigger advance or delay

Use the **Data collection** settings in the above dialogue to determine when data collection starts, relative to the trigger. A trigger advance or delay can be applied to all trigger options. In the above example data collection starts 2ms before the trigger. The options are:

- **Advance** – measurement begins a set time before the trigger. This is possible because data is collected in advance and buffered.
- **Delay** – measurement begins a set time after the trigger.

External triggers

With an external trigger, measurement begins on receipt of an electrical signal from an external device. The external device must be connected to the TRIGGER INPUT port on the back of the Receiver module.

The Spraytec can respond to two types of trigger signal:

- **Closed Switch Trigger** – here a simple switch trigger is used to start the Spraytec measurement. If this is required set the slope as required and the impedance to high.
- **TTL Trigger** – this is an industry standard trigger configuration, triggering a system by an electronic input moving between two states: a **low** state where the applied voltage is 0 volts and a **high** state where the applied voltage is 5 volts. The trigger can activate the Spraytec measurement, either based on a move from low to high voltage (a positive slope trigger) or a move from high to low voltage (a negative slope trigger).

The Spraytec can be used with low impedance (<50 Ohm) or high impedance (up to 1kOhm) sources. Select the correct slope and impedance settings for the trigger during SOP creation.

Grouping

To display the **Grouping** option, click the **Advanced** button on the **Rapid Measurement** dialogue shown above. Grouping allows users to specify different data groups within a given event.

The start and end time for each data group is defined by the receipt of an external trigger. This trigger must be defined in the same way as an external trigger which is used to indicate the start of a measurement event.

The available options for grouping are:

- **No grouping** – in this case the Spraytec will not record any external trigger activity during an event.

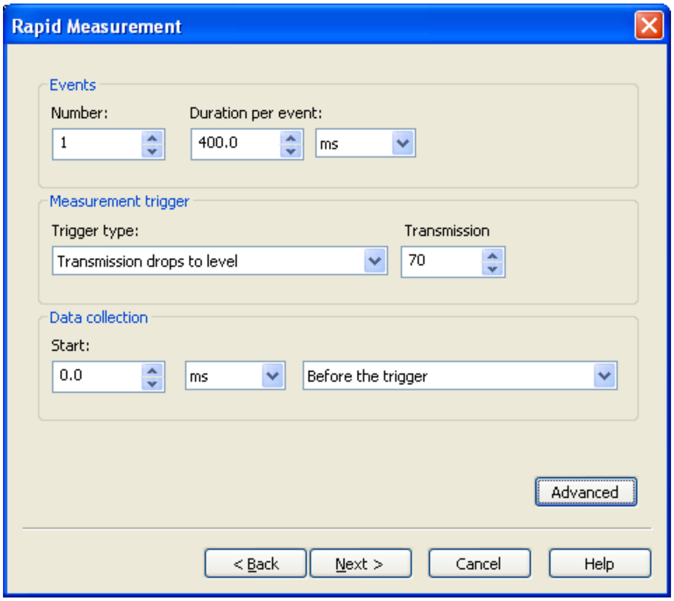
- **External Trigger** – if this is selected the Spraytec will monitor any external trigger activity during an event and log the position of any trigger events on the **Size History** plot. Users can use these trigger marks to group data and to calculate the average particle size recorded across each group using the **Time-Based Average** option **Average between trigger marks** (described in **Chapter 5**).

Output trigger

An output TTL trigger is provided to fire an external device connected to the Spraytec's TRIGGER OUTPUT port.

▶ To set up a trigger:

1. In the **SOP Wizard**'s **Measurement Setup** dialogue, select the **Enable output trigger** check box. Clicking **Next** there opens the **Rapid Measurement** dialogue shown below:



2. Under **Events** specify the number and duration of the event(s) needed to trigger a measurement.

3. Under **Measurement trigger**, select the trigger type in the list. The parameters for each type differ, as follows:

Trigger	Parameters
Manual	No parameters
Transmission drops to level	Transmission %
Scattering increases to level on detector	Scattering level, detector number
External trigger	Slope, impedance

4. Specify these as described in the appropriate description above.
5. Under **Data collection** specify any advance or delay on the trigger.

Alarms

The system can be set up to warn if the particle size cannot be measured accurately, for any one of a number of reasons. Alarm thresholds are stored as part of an SOP. An alarm is automatically produced if this threshold is passed.

The messages that may appear are described in **Chapter 8**.

There are two alarm levels:

- **Warning** – if this occurs the measurement data continues to be analysed. A warning message, denoted by an exclamation mark (!), is displayed at the bottom of the **Measurement parameters** record view.
- **Error** – if this occurs the measurement data are not analysed and red bars are displayed in place of the expected results in the **Size History** view.

  Messages are also displayed at the bottom of the **Measurement parameters** window (where they are denoted by three exclamation marks). Warning (!) and error (!!!) markers also appear at the top left of each window.

The alarm settings provide a one-off check that the measured background is in range. Select the **Warn if background changes during measurement** option to monitor for changes in the background during the measurement.

There are two types of alarm, Background alarms and Scattering alarms.

Background alarms

Background alarms are used to alert the user of errors if the background signal at the start of the measurement is too high. A background measurement has two components:

- **Electrical background measurement** – measures only the amount of electrical noise generated by the instrument and background light; a laser shutter moves in front of the laser during this measurement to block all laser light.
- **Optical background measurement** – measures the environment the measurement will be performed in. It is a measurement of the cleanliness of the optics and the dispersing environment (the air) around the instrument.

An alarm can be raised if:

- An electrical background measurement finds the electrical background noise is too high or detects too much ambient light. In this case an **electronic background alarm** is raised.
- An optical background measurement detects a high background; in this case an **optical background alarm** is raised.

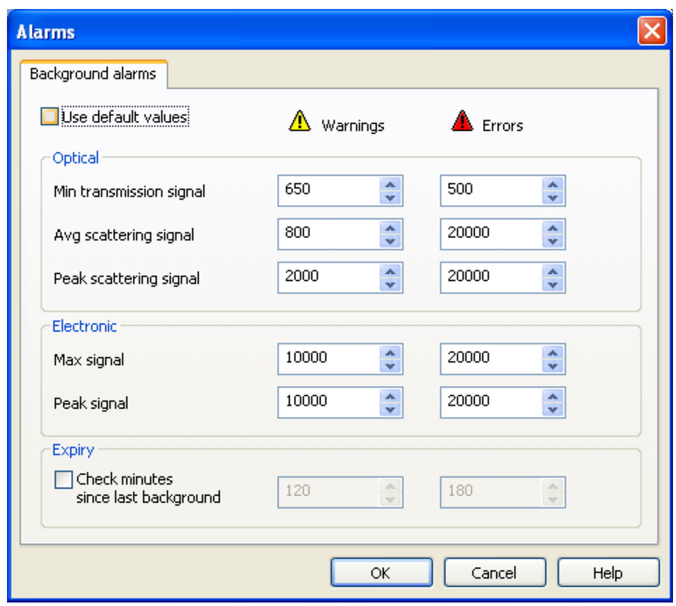
A high optical background may be present if:

- The transmission (laser beam power) is too low.
- The optics are dirty – this will cause light scattering on the detectors.
- The instrument is poorly aligned.

Note
During a manual measurement the background screen can be displayed for the user to make a judgment on the cleanliness of the system.

Setting background alarms

The **SOP Wizard**'s **Background alarms** dialogue is shown below. Set the warning threshold in the first column and the error threshold in the second column.



Optical alarms

The optical alarm types are as follows:

- **Min Transmission signal** – a measurement falling below the specified minimum transmission may mean that the optical windows are too dirty to make accurate measurements, or that the detector is badly aligned. This alarm is triggered when transmission falls below the values entered.

The detected signals should be minimal if the windows are clean and there's no sample in the measurement zone. If this alarm occurs clean the windows.

- **Avg scattering signal** – this alarm occurs when the average scattering across all active detectors is greater than the threshold levels set. This indicates that the optics are dirty or that there was spray in the measurement zone during the background measurement.
- **Peak scattering signal** – this alarm is triggered when any detector reaches the set level during background measurement. This indicates that the optics are dirty or that there was spray in the measurement zone during the background measurement.

Electronic alarms

As no spray is in the beam during measurement of the light background, any light diffraction is probably due to optical contamination. The **Max signal** and **Peak signal** alarms are measures of the light that is hitting the detectors. This should be minimal if the windows are clean and there is no spray in the measurement zone.

- **Max Signal** measures the average light intensity across all the detectors.
- **Peak Signal** measures the light intensity from the detector that is receiving the most light.

If the measurements are higher than the values entered in these fields, the alarm is raised and the windows should be cleaned.

Expiry alarms

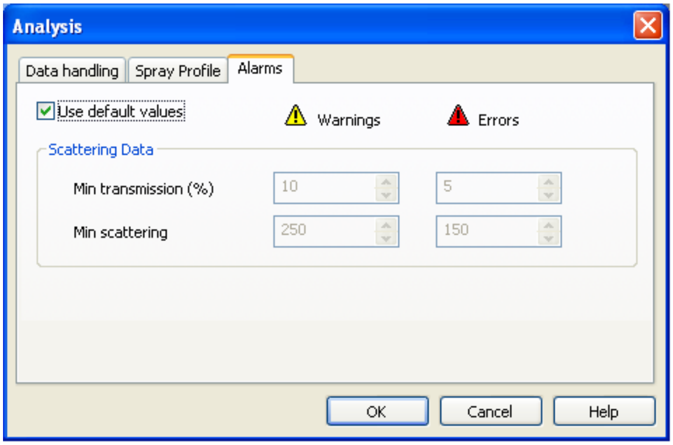
This alarm occurs if the specified time passes without a background check being performed.

Scattering alarms

Scattering alarms are used:

- To warn the user or stop the measurement when the transmission or scattering level falls below a set threshold.
- To warn the system if the scattering data is out of range for the analysis.

Set these up alarms using the **Scattering Data limits**, defined in terms of the transmission and average scattering signal recorded during the measurement:



These alarms can be used to guard against two possibilities:

- **High spray concentration** – in some applications the spray concentration is too high for accurate results to be obtained. This situation is detected using the **Min Transmission** warning and error level values.
- **Low spray concentration** – in some applications the spray concentration may be too low for accurate results to be obtained. This situation is detected using the **Min Scattering** warning and error values.

Set the **Warning** threshold in the first column and the **Error** threshold in the second column. When a threshold is reached, a warning or error symbol will be shown in the record views and the **Size History** view.

The parameters in the dialogue are:

- **Use Default Values** – if this is selected a set of default alarm settings is used for measurements. In most cases these allow routine measurements to be made. If measuring very concentrated or very dilute sprays, the user may need to enter custom alarm values, so they must deselect this check box.
- **Min Transmission (%)** – sets the minimum transmission which will be accepted as part of a measurement. If the measured transmission falls below the Error level set here, no Particle Size Distribution is calculated. This error occurs at high spray concentrations.
- **Min Scattering** – relates to the average scattering intensity recorded across the active detectors. If the average scattering falls below the **Error** level set here, a particle size distribution is not calculated. This error occurs at very low spray concentrations.

Spray profiles

The **Spray profile** options let the user define the path length of the laser beam through the spray, also termed the beam path, *b*. This is the distance through the spray plume that the laser beam travels. It allows the spray concentration to be calculated accurately.

Confined and unconfined sprays

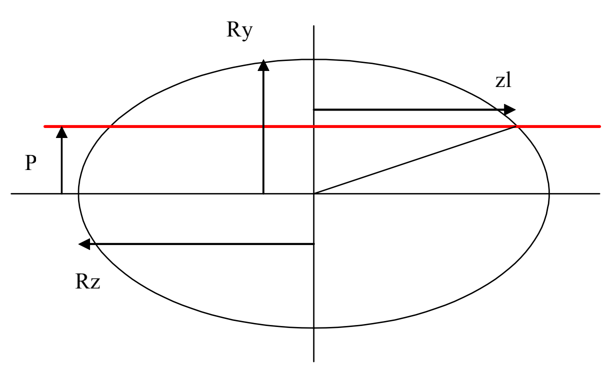
The beam path *b* is easily calculated when the Wet Dispersion Unit or Inhalation Cell is used as the sample is confined in a cell. The particles are assumed to be uniformly distributed in the cell and the beam path is taken to be the distance between the inner surfaces of the cell windows. When **Wet Dispersion** or **Inhalation Cell** is chosen in an SOP the appropriate beam path is set automatically.

For an unconfined spray the beam path is less easily calculated. The SOP allows entry of a value for beam path length (the **Path length (mm)** field in the **Spray profile** dialogue), but this assumes the spray concentration is uniform along the beam path.

The **Spray Profile Editor** (described below) allows users to specify the spray plume geometry, improving the accuracy of data analysis. The user can define the shape, size, and position of the spray plume in relation to the measurement zone. The primary purpose of a spray profile is to calculate whether any light scattered from the spray will be lost because it falls outside the aperture of the receiver lens, a process known as **vignetting**. The software can compensate for a degree of vignetting but if too much light is lost it will eliminate detectors from the size analysis.

Spray profile geometry

If the dimensions of the spray profile are entered, along with an estimate of the concentration profile, a concentration-weighted beam path length can be calculated. This diagram shows the geometry of the spray profile:



From the equation of an ellipse:

$$\frac{zl^2}{Rz^2} = 1 - \frac{P^2}{Ry^2}$$

Or:

$$zl = \sqrt{Rz^2\left(1 - \frac{P^2}{Ry^2}\right)}$$

If *Rz* is divided into seven regions where a different relative concentration can be assigned, then the above equation gives the proportional length along the beam *zl*.

From the table of relative radii and concentration entered into the **Spray Profile Editor** the relative concentration is scaled and an average value calculated for each region:

$$\bar{C}_i = 0.005(CvR_i + CvR_{i-1})$$

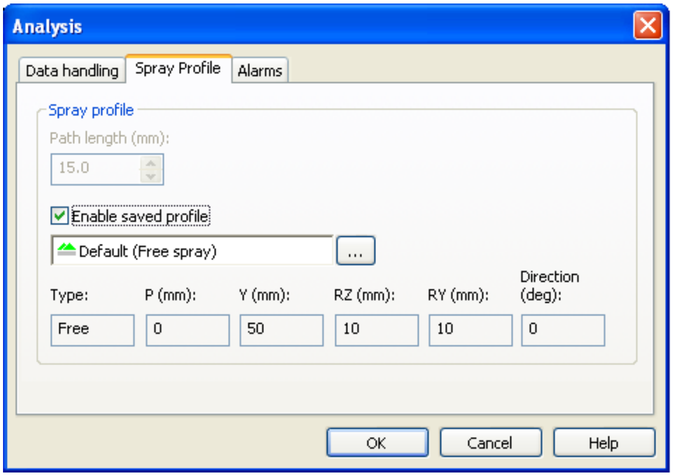
The concentration weighted path length *L* is then:

$$L = 2\sum_{i=1}^{7}(zl_i - zl_{i-1})\bar{C}_i$$

To use a Spray profile:

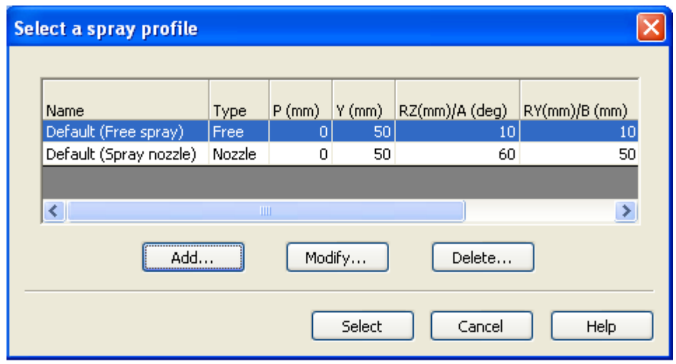
While creating an SOP or using manual measurement:

1. On the first **Analysis** dialogue click the **Edit...** button under **Data handling**.
2. Select the **Spray Profile** tab. This initially has a default path length set:



Default spray profiles for free spray and spray nozzle are provided. The parameters for the selected profile are displayed in the dialogue as shown above. Additional profiles can also be set up; these will be made available to other users at the site.

3. To select one of the default profiles or create a new profile, select the **Enable saved profile** check box and click the ... button to display this list:

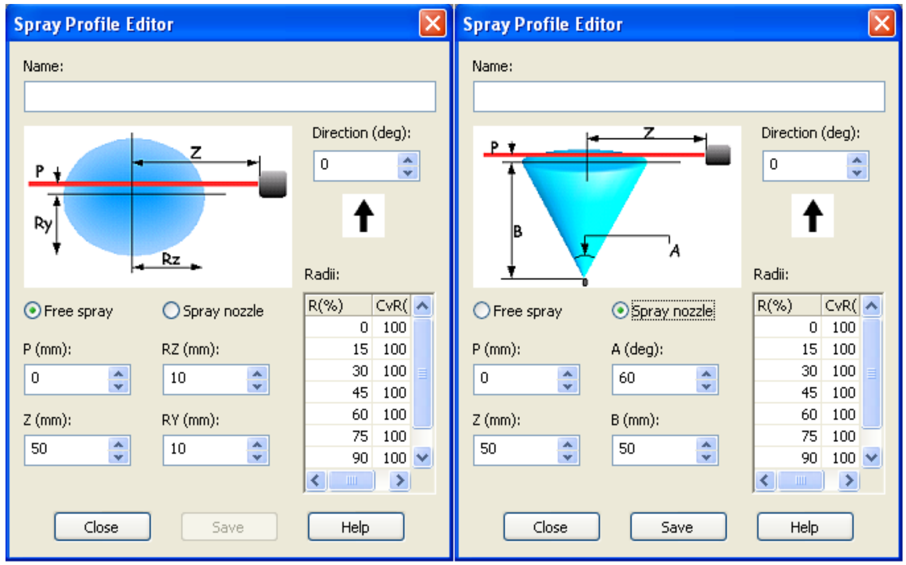


4. To use an existing profile select it in the list and click **Select**.

5. To create a new profile click the **Add** button to open the **Spray Profile Editor** (described below). Specify values for the parameters as described there then click **Save** and **Close**.

The Spray Profile Editor

The **Spray Profile Editor** shows how the profile is defined, with different versions for free sprays and nozzle sprays:



Begin by selecting the type of spray to profile, **Free spray** or **Spray nozzle**.

The parameters for a **free spray** are:

- **Rz** – the horizontal radius of the spray plume. Input fields for both **Ry** and **Rz** are provided as the radius values will be different when measuring an elliptical plume.
- **Ry** – the vertical radius of the plume.
- **Z** – the offset of the centre of the plume from the lens.
- **P** – the offset of the centre of the plume from the beam.

For a **nozzle spray** the following two parameters replace **Rz** and **Ry**:

- **A** – the angle of the spray cone.
- **B** – the distance of the nozzle from the laser beam.

The value of the **Direction** parameter is indicated by the large arrow. This sets the angle at which the spray enters the measurement zone. In the above examples this is 0, meaning the spray will be vertically upward. For a vertical downward spray the value will be 180°.

Set up the Radii table as described below then click **Save**. The new spray profile will appear in the selection list in the **Select a Spray Profile** dialogue.

The Radii table

By default it is assumed that a spray is homogeneous in terms of concentration. If users have measurement data showing the true concentration profile along the radius of the spray, this can be entered using the Radii table:

- **R(%)** – the percentage distance along the radius of the spray at which the concentration is to be set. 0% represents the centre of the plume. 100% represents the extreme edge of the plume.
- **CvR(%)** – the relative concentration of the plume at the specified position along the radius. Here, the most concentrated part of the plume will have a relative concentration of 100%. The concentration at every other point is then specified as a relative percentage of the highest concentration.

For a homogeneous spray the relative concentration at each point along the radius would be 100%. For a nozzle where the spray is most concentrated at the centre of the plume, the profile might be as shown in the following table in the central column. This shows that the relative spray concentration decreases with increasing distance from the centre, with the concentration at the plume edge being only 20% of the concentration at the centre.

R (%)	Plume concentrated at centre	Hollow cone nozzle
0	100	20
15	85	25
30	75	40
45	50	60
60	40	100
75	30	60
90	25	40
100	20	20

The right-hand column above shows a typical profile for a hollow cone nozzle. Here the highest concentration of spray is observed close to the edge of the plume. A low concentration region exists towards the centre.

Optical models

This section contrasts the **Fraunhofer approximation** used in some instruments with the **Mie theory** which underpins Spraytec operation.

Fraunhofer approximation

Older instruments and some existing instruments rely on the Fraunhofer approximation only. This assumes that:

- The particle is much larger than the wavelength of light employed. ISO 13320 defines this as being greater than 40x wavelength (25μm when a He-Ne laser is used).
- All sizes of particle scatter with equal efficiencies.
- The particle is opaque and transmits no light.

These assumptions are incorrect for many materials and for small particles they can give rise to errors approaching 30%, especially when the relative refractive index of the material and medium is close to unity, or when the particles are transparent, as is the case for water droplets. When the particle size approaches the wavelength of light, the scattering efficiency becomes a complex function with maxima and minima present.

Mie theory

Spraytec uses the full Mie theory which completely solves the equations for interaction of light with matter. This allows completely accurate results over a large size range.

Requirements for using Mie

The Mie theory assumes the particle is spherical, as opposed to Fraunhofer which is a projected area prediction. The penalty for this complete accuracy is that the refractive indices for the material and medium must be known and the absorption part of the refractive index must be known or estimated. However, for the majority of users this will present no problems as these values either will be known or can be measured.

A standard set of particles is available for selection in the SOP (presented in the first **Analysis** dialogue). More can be defined by a user, but the following parameters must be specified accurately:

- **Refractive Index (Real)** – describes the amount of scattering that takes place as a result of light interacting with the particle.

- **Refractive Index (Imaginary)** – the imaginary or complex refractive index. This describes the amount of absorption that takes place as the light enters the particle.
- **Density** – the density in g/cm^3. This is used to calculate **Specific Surface Area** (**SSA**). If the user wants to include the SSA as a derived parameter, they must complete this field.

The **residual** shown in the **Measurement Parameters** view indicates how well the calculated data fitted the measurement data.

Refractive index of medium

This value is needed by both the Fraunhofer approximation and the Mie theory. For sprays the medium is air and the refractive index is 1.0.

SOP Management

Introduction

This chapter shows how to:

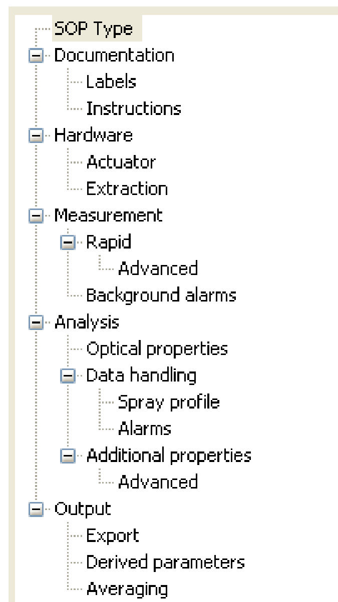
- Edit an SOP.
- Produce new SOP templates.
- Delete an SOP.
- Extract an SOP from a **.ssop** or **mansettings.dat** file.

Editing SOPs

▶ To edit an existing SOP:

1. Use **File-Open-SOP** or click and open the SOP in the list.
2. Using the **SOP Editor**, review the settings for each stage and make any required changes. (For details on any of the parameters, refer to **Chapter 5**). The **SOP Editor** has all the same dialogues as the **SOP Wizard**.

   The tree structure shown below appears in the left-hand side of each dialogue. This offers a quick way of moving through the wizard; just click on any branch in the tree to move straight to that stage.

3. When all changes are complete, click **Close** then **Yes** when prompted to save changes.

SOP templates

An SOP template is essentially the same as an SOP, but appears in the **Use template:** list on the first **SOP Wizard** dialogue.

To produce a new template:

Create an SOP and save it to the directory **SOP Templates** rather than **SOP**.

Deleting an SOP

To delete an SOP:

In Windows Explorer navigate to the Spraytec SOP directory and delete the **.ssop** file.

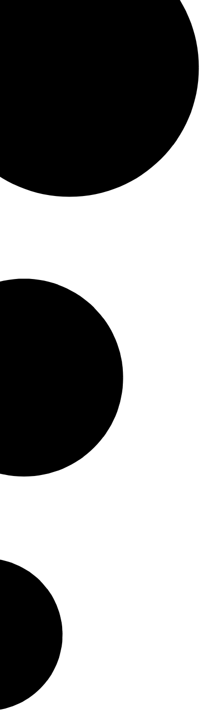
Extracting an SOP

The SOP settings used to produce a measurement can be extracted for reuse.

To extract an SOP:

1. Select a **.ssop** file or a **mansettings.dat** file from the measurement files list.
2. Right-click on the file and select **Extract** in the menu displayed.
3. The **SOP Editor** opens, showing the SOP or manual measurement parameters used to make the original measurement.
4. Make any required changes to the settings and then save the changes as a new SOP.

Part 3 - Appendices



A

Health and safety

General warnings

General warnings and safety regulations

Warning!
The instrument or the sprays to be measured may be hazardous if misused. Read and fully understand this section before operating the system.

Warning!
Use of the system in a manner not specified by Malvern Instruments Ltd. may impair the protection provided by the system.

The instrument must only be stored or operated in environmental conditions conforming to the specification in **Site requirements**, **Appendix C**.

Electrical warnings and safety regulations

Warning!
The Spraytec system contains high voltage components. Only Malvern trained personnel are permitted to remove the main cover of any part.

This product **must** be connected to a protective earth. The metal parts of the optical unit are earthed using a protective earth connection.

The Spraytec system components are mains powered devices and all power cables and electrical sockets should be treated accordingly. Do not place cables where they are likely to become wet.

PAT testing

If PAT testing is required, connect the earth lead to the earth stud underneath the rear right-hand corner of the instrument.

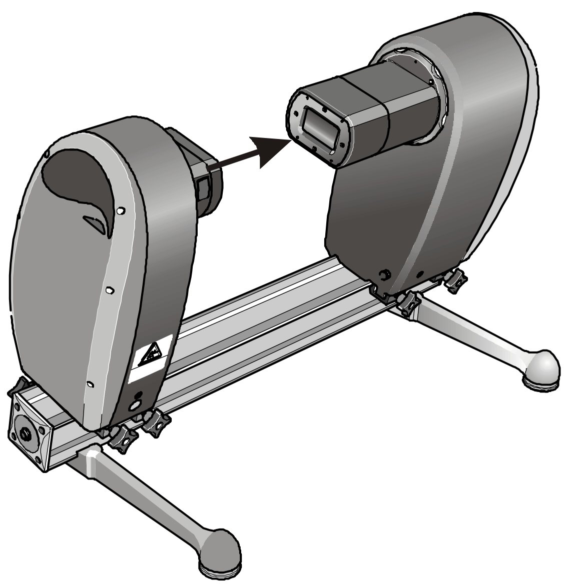
Laser safety regulations

The Spraytec is a Class 3R laser product. The instrument contains a Helium-Neon laser with a continuous laser beam of wavelength 632.8nm, power less than 5mW and collimated beam diameter less than 20mm.

Warning!
Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

Laser path

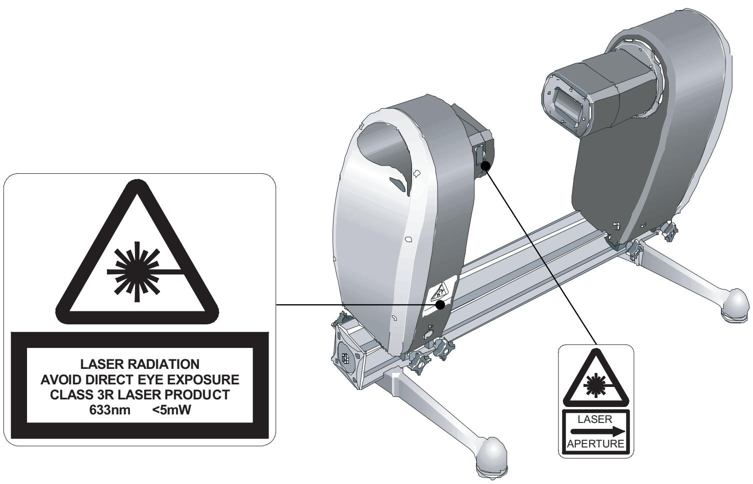
This diagram shows the path of the laser beam:



ill 7482

Transmitter front panel labels

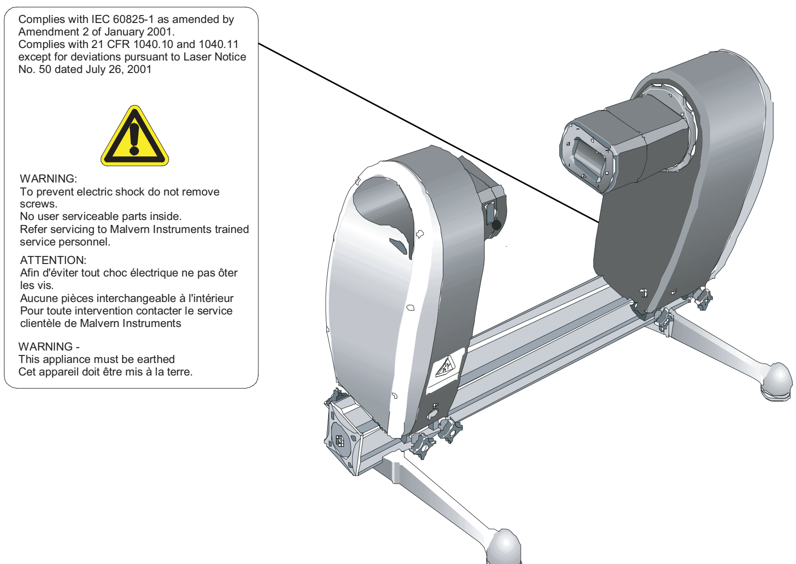
There are two laser warning labels on the front of the Transmitter:



ill 7641

Transmitter back panel label

There is one laser warning label on the back of the Transmitter:



ill 7642

General laser warnings

Although staring directly at the laser beam momentarily causes no known biological damage, avoid staring at the beam as one would with any strong light source, such as the sun. Do not allow the laser beam to hit the eye of an observer, even via reflective surfaces such as watch straps, etc.

Power cords and Power safety

The notes in this section indicate best practice. Follow these when connecting the instrument to the power supply.

Warning!
Do not operate this product with a damaged power cord set. If the power cord set is damaged in any manner, replace it immediately.

Warning!
Do not use the power cord received with this product on any other products.

Power cord set requirements

Power cord sets must meet the requirements of the country where the product is used. For further information on power cord set requirements, contact a Malvern Instruments representative.

General requirements

These requirements apply **to all countries**:

- The power cord must be approved by an acceptable accredited agency responsible for evaluation in the country where the power cord set will be installed.
- The power cord set must have a minimum current capacity of 10A (7A in Japan only) and a nominal voltage rating of 125 or 250 volts AC, as required by each country's power system.
- The area of the wire must be a minimum of $0.75mm^2$ or 18AWG, and the length of the cord must be less than 3m.
- Route the power cord so it is not likely to be walked on or pinched by items placed upon it or against it, or become wet. Pay particular attention to the plug, the electrical outlet, and the point where the cord exits the product.

Power safety information

The following notes indicate guidelines to follow when connecting the Malvern Instruments power supply using single and multiple extension leads, connection via AC Adapters and use of Uninterruptible Power Supplies (UPS).

Warning!
To prevent electric shock, plug the instrument or accessory into correctly earthed electrical outlets.

The power cord supplied is equipped with a grounding connection to ensure grounding integrity is maintained.

Advice on use of Extension leads

Follow this advice when using single or multiple socket extension leads. These are also called "trailing sockets".

- Ensure the lead is connected to a wall power outlet and not to another extension lead. The extension lead must be designed for grounding plugs and plugged into a grounded wall outlet.
- Ensure that the total ampere rating of the products being plugged into the extension lead does not exceed the ampere rating of the extension lead.
- Use caution when plugging a power cord into a multiple socket extension lead. Some extension leads may allow a plug to be inserted incorrectly.
- Incorrect insertion of the power plug could result in permanent damage to the instrument or accessory, as well as risk of electric shock and/or fire. Ensure that the ground connection (prong/pin) of the power cord plug is inserted into the mating ground contact of the extension lead

Advice on use of AC adapters

Follow this advice when using AC adapters:

Warning!
Do not use adapter plugs that bypass the grounding feature, or remove the grounding feature from the plug or adapter.

- Place the AC adapter in a ventilated area such as a desk top or on the floor.
- The AC adapter may become hot during normal operation of the instrument or accessory. Use care when handling the adapter during or immediately after operation.

- Use only the Malvern-provided AC adapter approved for use with the instrument and/or accessory. Use of a different AC adapter may cause a fire or explosion.

Advice on use of Uninterruptible Power Supplies (UPS)

To help protect the instrument and/or accessory from sudden, transient increases and decreases in electrical power, use a surge suppressor, line conditioner or UPS.

Spray handling warnings

- Always handle substances in accordance with the **COSHH (Control Of Substances Hazardous to Health) regulations (UK**) or any local regulations concerning spray handling safety.
- Before using any substance, check the **Material Safety Data Sheets** for safe handling information.
- Use the instrument in a well ventilated room, or preferably within a fume cupboard, if the fumes from the spray are toxic or noxious.
- Wear personal protective equipment as recommended by the Material Safety Data Sheets if toxic or hazardous sprays are being handled, particularly during spray preparation and measurement.
- Wear protective gloves when handling hazardous materials, or those that cause skin infections or irritations.
- Do not smoke during measurement procedures, particularly where inflammable sprays are used or stored.
- Do not eat or drink during measurement procedures, particularly where hazardous sprays are used or stored.
- Take care when handling glass (e.g. beakers). Hazardous materials may enter a wound caused by broken glass.
- Always test a new spray for chemical compatibility before use.
- After measuring hazardous sprays, scrupulously clean the system to remove any contaminants before making another measurement.
- Always label sprays for analysis using industry standard labelling, particularly if they are handled by a number of staff or stored for long periods. Clearly mark any operator hazard and associated safety precautions that are required for the handling of dangerous materials.
- Keep a record of all hazardous substances used in the system for protection of service and maintenance personnel.

- Always adopt responsible procedures for the disposal of waste sprays. Most local laws forbid the disposal of many chemicals in such a manner as to allow their entry into the water system. Seek local advice on the means available for disposal of chemical wastes in the area of use. Refer to the **Material Safety Data Sheets**.

Moving the system

If it is necessary to move the system, follow these guidelines. **Appendix E** details the procedure.

Warning!
Use proper lifting techniques and at least two people to avoid back injury. One person must support each module on the X-bar. Always lift the instrument by holding it under its base.

Never lift an instrument by precision parts such as the lens, or by its covers.

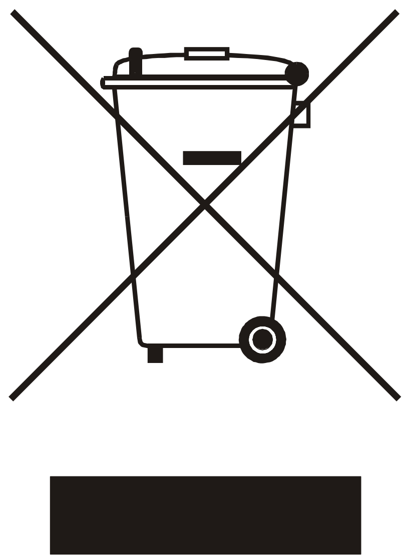
- Power off all components and disconnect the cables to any accessories before attempting to move the system.
- The system can be moved short distances with the Transmitter and Receiver modules fitted to the X-bar.
- If the system is to be moved large distances, we recommend repacking it in its original packaging.

Disposing of the system

When the need eventually arises to dispose of the system, do this in a responsible manner. Follow these guidelines:

- Refer to any local regulations on disposal of equipment; in Europe refer to the information below.
- Seek advice from the local Malvern Instruments representative for details.
- Decontaminate the instrument if hazardous materials have been used in it.

Disposal of Electrical & Electronic Equipment (Applicable in the European Union and other European countries with separate collection systems)



ill 7610

This symbol on the product or on its packaging indicates that when the last user wishes to discard this product it must not be treated as general waste. Instead it shall be handed over to the appropriate facility for the recovery and recycling of electrical and electronic equipment.

By not discarding this product along with other household-type waste, the volume of waste sent to incinerators or landfills will be reduced and natural resources will be conserved.

For more detailed information about recycling of this product, please contact the local city office, waste disposal service, or the Malvern Instruments representative.

Specification

Dimensions

Dimension	Short X-bar	Long X-bar
Length	950mm	1400mm
Width	550mm	550mm
Height	610mm	610mm
Weight	36kg	37kg

Laser

CDRH and IEC60825-1 compliant	Class 3R laser product
Maximum output power	<5mW
Beam diameter (measurement zone)	10mm ($1/e^2$)
Beam wavelength	632.8nm

Operating environment

Enclosure ratings	IP65 rating for the main transmitter and receiver modules in normal use i.e. with all cables connected. The Universal switching box is rated IP20 but can be kept well away from the spray area.
Air Purge	Air purge system available to prevent optics contamination when measuring wide spray plumes. Requires a continuous supply of clean, compressed at a flow rate of at least 80 l/min.
Temperature	10°C – 35°C (+50°F to +95°F).
Humidity	35% - 80%, non-condensing.

Optical unit

Measurement principle	Laser diffraction.
Size range	0.1μm to 2000μm
Lens ranges	
300 mm lens	0.1 – 900μm. **Dx(50)**: 0.5 – 600μm
750 mm lens	2.0 – 2000μm. **Dx(50)**: 5 – 1600μm
Working range	
300mm lens	150mm minimum working distance.
750mm lens	500mm minimum working distance.
Optical models	Mie Theory and Fraunhofer Approximation.
Concentration range	Patented Multiple Scattering Correction (US Patent No. 5,619,324) enables operation at high concentrations.
Minimum acceptable transmission	5% (95% obscuration), dependent on particle size range.
Detection system	36 element log-spaced silicon diode detector array.
Light source	632.8nm, 2mW helium-neon laser.
Optical alignment system	Automatic rapid align system.
Maximum acquisition rate	Continuous Mode: 1Hz Rapid Mode (Standard): 2.5kHz Rapid Mode (Enhanced): 10kHz (requires a software feature key).
Maximum measurement time	Continuous Mode: > 60 mins at 1Hz Rapid Mode (Standard) 30 secs at 2.5kHz Rapid Mode (Enhanced) 30 secs at 10kHz
Accuracy	Better than +/- 1% on the **Dx(50)** for NIST-traceable latex standards.
Precision/Repeatability	Better than +/- 1% COV on the **Dx(50)** for NIST-traceable latex standards.
Reproducibility between instruments	Better than +/- 1% COV on the **Dx(50)** for NIST-traceable latex standards.

Triggering

Measurement triggering	Internal: Based on transmission or light scattering levels External: Based on TTL input or simple switch trigger
External device synchronisation	Via two TTL trigger outputs

Computer and software

Minimum PC specification	Pentium PC 2.8GHz, 512MByte RAM, 160MByte free hard disk space. 1024 x 768 screen resolution, CD-ROM drive. Windows XP professional (Service pack 2a or higher). One free USB port.
Operating modes	Automated using SOPs created in the software. Manual using on-screen controls and hot keys.
Analysis Method	Model independent analysis to provide accurate droplet size distributions. Rosin-Rammler and Log-Normal two parameter models available.
Data Display	User-configurable **Particle Size History** display, enabling frame-by-frame data analysis.
Database utility	Searching, sorting and filtering by search criteria of data records on all parameters of interest.
Data Export	Direct to Microsoft Excel or other spreadsheet packages.
21 CFR Part 11	Technical compliance provided through layered access security system, audit trails and links to Adobe Acrobat for electronic signatures.

Chemical compatibility

Spraytec components that may come into contact with the spray are manufactured from materials that are considered to give the widest protection from chemical attack. However, it is important to check that any spray used is chemically compatible with the materials mentioned.

C

Site requirements

This is a copy of Appendix C of the Spraytec User Manual MAN 0368 issue 3.0

Head office:

Malvern Instruments Ltd.
Enigma Business Park,
Grovewood Road,
Malvern,
Worcestershire WR14 1XZ
United Kingdom.

Tel + [44] (0)1684-892456
Fax + [44] (0)1684-892789

Printed in England

Introduction

This document outlines all site requirements needed to install a Spraytec system. Ensure that all site requirements are fulfilled **before** the Malvern Instruments engineer arrives to install and commission the system.

Environmental conditions

When choosing a site for the system, ensure the following conditions are met.

The following guidelines apply to both instrument types:

- Avoid passing electrical cables through areas where liquids can be spilt.
- Rooms must be well ventilated if noxious sprays are used.

Warning!
Do not position the system where it obstructs power sockets; they may need to be disconnected in an emergency.

The **laboratory Spraytec** instrument and its accessories are intended for indoor use only. The **wet environment Spraytec** is suitable for indoor use and wet environments.

When using either instrument:

- Position the instrument away from strong light sources (e.g. windows).
- Position the instrument away from strong heat sources (e.g. radiators).
- The bench that carries the system must be horizontal and vibration free. It must also be capable of supporting the weight of the system. This table lists the weights of the system components:

Component	Weight
Spraytec	36kg (short X-bar), 37kg (long X-bar)
NSS	5.3kg
Air Purge (passive air supply)	6kg
Extractor	14kg
Wet Dispersion Unit	16.5kg
Inhalation Cell	5.9kg
Aerosol Adapter	2.9kg
Computer and Printer	See manufacturer's documentation

The system is designed to be stored and operated in the following conditions:

Operating temperature	+10° to +35°C (+50°F to +95°F)
Humidity	35 to 80% (non-condensing)
Altitude	Up to 2000m
Pollution degree	2 (IEC 60664)
Enclosure (with all cables and plugs fitted)	IP65 (IEC 60529) The Universal switching box is rated IP20 but can be kept well away from the spray area. This excludes the external PSU. Locate this outside of the spray zone.
Overvoltage Category	II (IEC 60664)
Mains supply voltage fluctuations	±10% of nominal voltage

Storage

Store the instrument in a dry place between -20°C and +50°C (-4°F to +122°F) where no mould will form.

Space required

Dimensions of all components of the system are given below.

Component	Width	Depth	Height
Spraytec	950mm or 1400mm	550mm	610mm
NSS	170mm	390mm	260mm
Air Purge	350mm	160mm	350mm
Extractor	290mm	360mm	390mm
Wet Dispersion Unit			
Dispersion unit	360mm	320mm	640mm
Controller unit	225mm	180mm	80mm
Inhalation Cell	Fits inside Spraytec space		
Aerosol Adapter	Fits inside Spraytec space		
Computer and printer	See manufacturer's documentation		

Provide enough space to allow easy access to all components of the system. Allow for 2500mm (width) x 850mm (depth) of bench space. Allow at least 800mm above the bench surface for access to the cell area.

Power requirements

The mains power supply must be clean and filtered. If necessary, fit an Uninterruptible Power Supply (UPS) to remove any spikes or noise. The power requirement for each component of the Spraytec system is given below.

Component	Power requirement	Power sockets required
Spraytec	~ 100-240V, 50-60Hz	1
NSS	~ 100-240V, 50-60Hz	0
Switching box	~ 100-240V, 50-60Hz	1
Extractor	~ 100-240V, 50-60Hz	1
Computer	See manufacturer's documentation	1
Computer monitor	See manufacturer's documentation	1

Power cords

Power cord set requirements

Power cord sets must meet the requirements of the country where the product is used. For further information on power cord set requirements, contact a Malvern Instruments representative.

General requirements

The requirements listed below are applicable to all countries:

- The power cord must be approved by an acceptable accredited agency responsible for evaluation in the country where the power cord set will be installed.
- The power cord set must have a minimum current capacity of 10A (7A Japan only) and a nominal voltage rating of 125 or 250 volts AC, as required by each country's power system.
- The area of the wire must be a minimum of $0.75mm^2$ or 18AWG, and the length of the cord must be less than 3m.
- Route the power cord so it is not likely to be walked on or pinched by items placed upon it or against it, or become wet. Pay particular attention to the plug, electrical outlet, and the point where the cord exits the product.

Warning!
Do not operate this product with a damaged power cord set. If the power cord set is damaged in any manner, replace it immediately.

Do not use the power cord received with this product on any other products.

Additional services

For remote support over the Internet, a direct Internet connection is required.

Computer usage

The Spraytec software can be run on a network but this is not recommended as running other software at the same time may impact on the speed of the Spraytec software.

Unpacking instructions

Déballez l’instrument

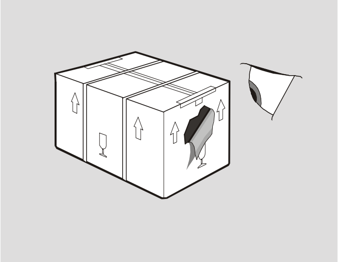
Auspacken des Gerates

Desempaquetado del aparato

Desempacotamento do instrumento

▶ To unpack the instrument:

1. **If there is any sign of damage contact the freight carrier immediately.**



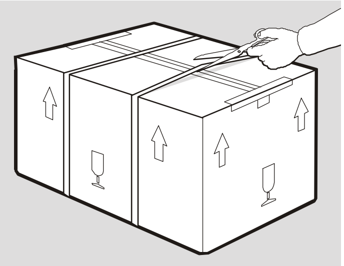
Si vous constatez des signes de dommages quelconques, contactez immédiatement le transporteur.

Bei irgendwelchen Zeichen von Transportschäden den Spediteur sofort benachrichtigen.

Si se advierte algún signo de deterioro, contactar inmediatamente con el transportista.

Contacte imediatamente a empresa transportadora se houver qualquer sinal de embalagem danificada.

2. **Cut through the plastic bonding straps.**



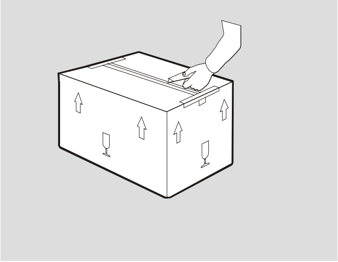
Découpez les courroies d’attache en plastique.

Die Kunststoffbänder durchschneiden.

Cortar las tiras de sujeción de plástico del embalaje.

Corte as tiras plásticas que prendem o conjunto.

3. **Carefully cut the plastic packing tape along the fold lines.**



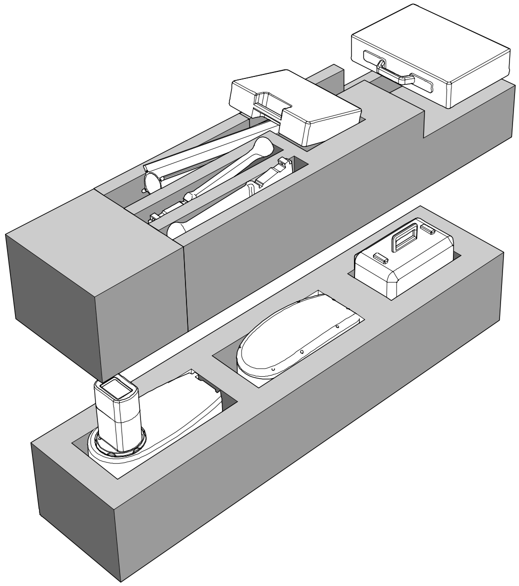
Découpez avec précaution le ruban d’emballage en plastique, le long des pliures.

Die Kunststoffverpackungsbänder vorsichtig entlang den Falzlinien durchschneiden.

Cortar con cuidado la cinta de embalaje de plástico por la líneas de doblado.

Com cuidado, corte a fita de embalagem plástica ao longo das dobras.

4. **Open the wings of the carton and remove the top foam insert.**



Ouvrez les rabats du carton et retirez les blocs de mousse du haut.

Die Klappen des Kartons öffnen und die oberen Schaumeinlagen entfernen.

Abrir los costados de la caja y extraer las piezas intercaladas de espuma de la parte superior.

Abra as abas da caixa e retire o enchimento de espuma que está em cima.

5. **Remove all other packages from the carton and unwrap.**

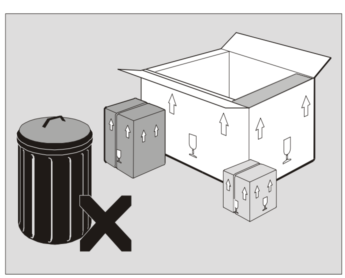
Sortez tous les autres paquets du carton et déballez-les.

Sämtliche andere Pakete aus dem Karton nehmen und auspacken.

Retirar todos los demás paquetes de la caja y desenvolverlos.

Retire todas as outras embalagens da caixa e abra-as.

6. **Retain all packaging in case the instrument requires transporting in the future.**



Conservez tous les emballages, au cas où l'instrument devrait être transporté ultérieurement.

Das gesamte Verpackungsmaterial aufbewahren, falls in Zukunft ein weiterer Transport des Geräts erforderlich wird.

Conservar todo el material de embalaje por si el aparato debiera ser transportado en el futuro.

Guarde todo o material de embalagem, caso seja necessário no futuro transportar o instrumento.

Installation

Introduction

The Spraytec system should initially be commissioned by Malvern trained personnel. This appendix shows how to **re-install** the system. This is typically required under the following circumstances:

- **Moving the instrument** – if the system has to be moved from one laboratory to another, read the information in this appendix to reconnect the system correctly.
- **Changing the computer** – it may be company policy to upgrade computers periodically. Detail is given on the procedure.

Only install the system in a suitable environment as detailed in **Appendix C**, **Site Requirements**.

Moving the instrument

Handle the instrument carefully and do not subject it to any strong physical shock.

Warning!
Use proper lifting techniques and at least two people to avoid back injury. One person must support each module on the X-bar. Always lift the instrument by holding it under its base.

Never lift an instrument by precision parts such as the lens, or by its covers.

Short distance movements

If moving the system just within a room:

1. Power off all components and accessories.
2. Disconnect the mains power cable from the Spraytec.
3. The instrument can be moved with the Transmitter and Receiver mounted on the X-bar, so long as this is done with care as described in the warning above.
4. Move the computer equipment by following the manufacturer's instructions.
5. At the new location reverse the above procedure.

Warning!
This product must be connected to a protective earth.

Longer distance movements

If moving the system a significant distance, for example between sites:

1. Power off all components.
2. Disconnect the mains power cable and cables between components and to accessories.
3. Remove the Transmitter and Receiver from the X-bar. (Leave the lens on the Receiver.)
4. Pack all components, if possible in their original packaging.
5. **Do not remove the feet from the X-bar.** This is important as it is difficult to replace them in exactly the same position.
6. Disconnect and pack the computer and monitors, following the manufacturer's instructions.
7. At the new location, reverse the above procedure.
8. Set up all computer connections, following the manufacturer's instructions.

Adjusting the Spraytec feet

Laboratory Spraytec

If not using a Spraytec NSS accessory, simply adjust the back feet until the instrument does not rock.

If the Spraytec NSS is used with the **laboratory Spraytec** the X-bar must be at exactly 12°. To achieve this adjust the feet as follows:

- **Front feet** – screw both feet in fully home.
- **Back feet** – these are adjustable. Place the levelling and alignment tool supplied with the NSS on the X-bar and adjust the back feet until the instrument is at 12° and does not rock. Use the nuts to lock the feet in place once their height is correct.

Wet environment Spraytec

This has simple feet. Only adjust these if the instrument rocks when placed on a surface.

Changing the computer

If the computer used with the instrument is changed, follow this procedure.

Note
If the computer already has an older version of the Spraytec software, remove this before installing the new version. Use the **Add/Remove Programs** function in the **Windows Control Panel**.

To install the software:

1. Insert the Spraytec CD in the CD drive.
2. If **Autorun** is enabled on the computer the software will start to install automatically. Follow all on-screen instructions to complete the installation.
3. If **Autorun** is not enabled select **Start-Run-Setup.exe** and follow the on-screen instructions.

Note
If the software is subsequently updated with a new version, any custom reports, parameter settings, SOPs, etc. will be preserved.

F

Regulatory statements

This appendix contains regulatory information.

CE Declaration of Conformity

The CE badge on this product signifies conformance to European Commission Directives.

CE Declaration of Conformity

(in accordance with ISO/IEC 17050-1)

Form:CE declaration of conformity for STP5000 (2007).doc

Supplier details

Document (NAME / NUMBER)
CE declaration of conformity for STP5000 (2007)

Issuer's Name (NAME OF MANUFACTURER)
Malvern Instruments Limited

Issuer's Address
Enigma Business Park,
Grovewood Road,
Malvern,
Worcestershire, WR14 1XZ, UK

Product details

Product description – name and model number(s)

Name: Spraytec

Model(s): STP5000 Series

Description: Particle Characterisation System

Directive(s) and Standard(s) to which conformity is declared

EMC directive 89/336/EEC as amended by 92/31/EEC and 93/68/EEC
Low Voltage Directive 2006/95/EC

BS EN 61326-1: 1997 Incorporating Amendments A2: 2001
BS EN 61010-1: 2001 and part 2 as required

Additional Information

None.

Declaration

I hereby declare that the product specified conforms with the provisions of Council Directive(s) and standard(s) listed above.

Signed for and the behalf of Malvern Instruments Limited.

Signature

Date of issue
23/04/2007

Place of issue
Malvern Instruments Limited (UK)

Name (Function)
Alan Bragginton (Production Director)

ill 8049

This product's CE compliance is valid only if it is powered with the Malvern-provided and CE marked AC adapter.

FCC Notice (US only)

The Federal Communications Commission (FCC) mark on this product signifies conformance to FCC regulations relating to Radio Frequency Devices. These have been satisfied by testing the product against, and being found to be compliant with:

FCC CFR 47 Part 15:August 2002.Class A digital device.

The device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference, and
2. this device must accept any interference received, including interference that may cause undesired operation.

Note
This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Note
Changes or modifications not expressly approved by Malvern Instruments Limited could void the user's authority to operate the equipment.

Canadian Regulatory Information (Canada Only)

This digital apparatus does not exceed the Class A limits for radio noise emissions from digital apparatus set out in the Radio Interference Regulations of the Canadian Department of Communications.

Note that Canadian Department of Communications (DOC) regulations provide that changes or modifications not expressly approved by Malvern Instruments Limited could void your authority to operate this equipment.

This Class A digital apparatus complies with Canadian ICES-003.

Cet appareil numérique de la classe A est conforme à la norme NMB-003 du Canada.

VCCI acceptance (Japan only)

The Voluntary Control Council for Interference (VCCI) mark on this product signifies compliance to Japanese EMC regulations as specified by VCCI.

この装置は、情報処理装置等電波障害自主規制協議会（ＶＣＣＩ）の基準に基づくクラスＡ情報技術装置です。この装置を家庭環境で使用すると電波妨害を引き起こすことがあります。この場合には使用者が適切な対策を講ずるよう要求されることがあります。

ill 6793

Translation:

This is a Class A product based on the standard of the Voluntary Control Council for Interference by Information Technology Equipment (VCCI). If this equipment is used in a domestic environment, radio disturbance may occur, in which case the user may be required to take corrective actions.

Index

U

V

W

X