SpectraShop™ 4
Operation Manual

Version 4.0.9

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Introduction

SpectraShop™ is a powerful set of tools for measuring, organizing and analyzing visible light spectra.

With SpectraShop™ you can:

- Measure emissive, reflective and transmissive spectra directly from spectrometers
- Create collections of spectra
- Calculate colorimetric and densitometric values
- Measure monitor, print and transparency charts
- Import spectral data from other programs
- Export spectral data for use in other programs
- Convert spectral data between file formats
- Create graphs of colorimetric and densitometric values
- Calculate color differences with threshold Pass/Fail indications
- Analyze lighting with CRI and CQS
- Combine spectra mathematically
- Print graphs with publication quality
- Export graphs to files

System Requirements

Macintosh

- Intel processor
- MacOS 10.6 or later
- 1024 x 768 or larger monitor
- One of the supported spectral measurement instruments

Windows

- Windows XP or later
- 1024 x 768 or larger monitor
- One of the supported spectral measurement instruments

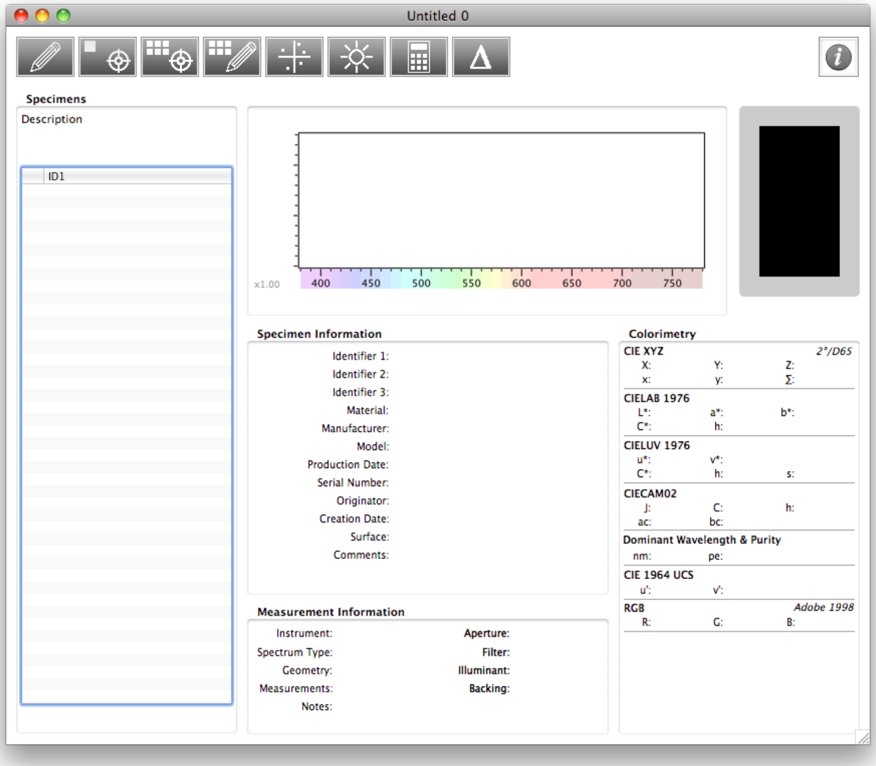
Collection

The Collection window is the heart of SpectraShop™. All the tools, operations and graphs derive from the data within a collection.

A *collection* is a group of one or more spectra along with the associated descriptive and measurement information, known as *metadata.* Each spectrum and its metadata is called a *specimen.* Typically, the specimens in a collection share some common characteristics. For example, a collection might be a series of manufacturer's inks, or a set of fluorescent lamps, or a group of photographic filters.

When SpectraShop™ opens, an empty collection window is displayed. At this point you may:

1. Open a spectral data file
2. Acquire new spectra
3. Create chart definitions

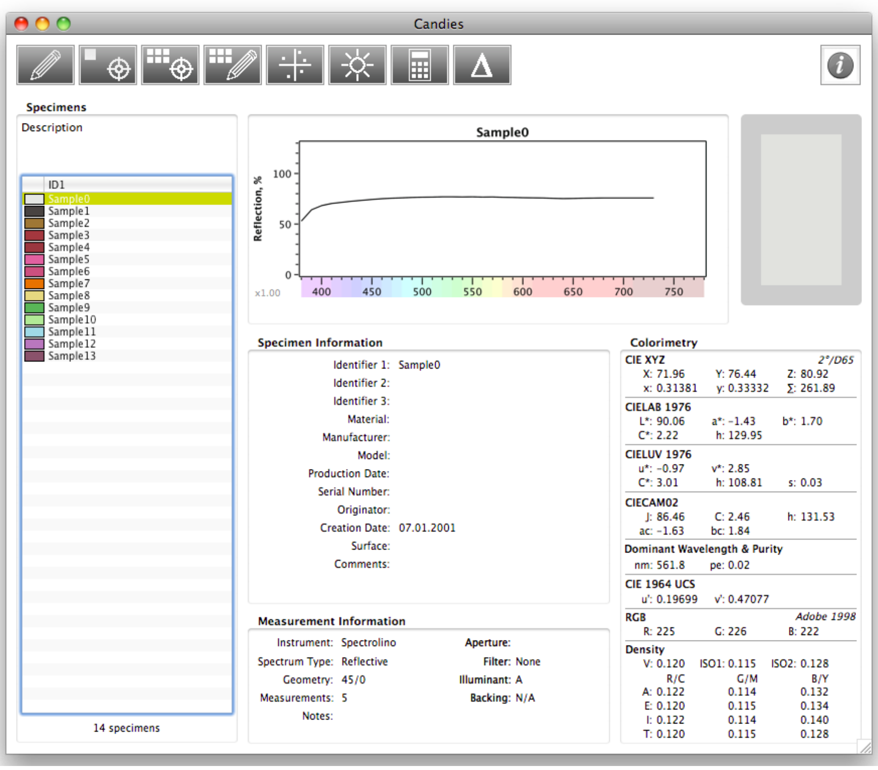


Empty collection window.

Open a Collection

Each collection is opened and displayed in its own window using the File/Open menu option. The window shows a list of all the specimens in the collection. As each specimen is selected in the list its associated information is displayed in the *Specimen Information* and *Measurement Information* areas.

The specimen's spectrum is displayed as a graph at the top of the collection window.



Opened collection.

A color patch representing the visual appearance of the spectrum is displayed to the graph's immediate right.

From the spectral data many color metrics are calculated, then displayed in the *Colorimetry* area.

Along the top of the collection window is a bar containing tools for working with collection information or creating test charts.

Opening SpectraShop 1 and SpectraShop 2 Collections

SpectraShop 3 will open older version 1 and 2 collections and will convert them as closely as possible into the version 3 format. Two items may need some editing after opening; specimen type and dates.

Reflective and transmissive specimens will be converted into their version 3 equivalents. In versions 1 and 2 all emissive specimens were treated equally. After delving into the issue more deeply, version 3 has two different types of emissive specimens; monitor and light. Version 1 and 2 files with emissive specimens will need to be edited before opening them in version 3. The only way to do this is to export the specimens to text files in versions 1 or 2, then edit the text files to convert them into version 3 import files. Check Appendix C for details.

In versions 1 and 2 the dates were treated as text strings, allowing for any format. SpectraShop 3 uses the ISO 8601 format of YYYY-MM-DD. Date strings will also need to be converted into the ISO format. Appendix C gives more information on converting the dates.

Specimen List

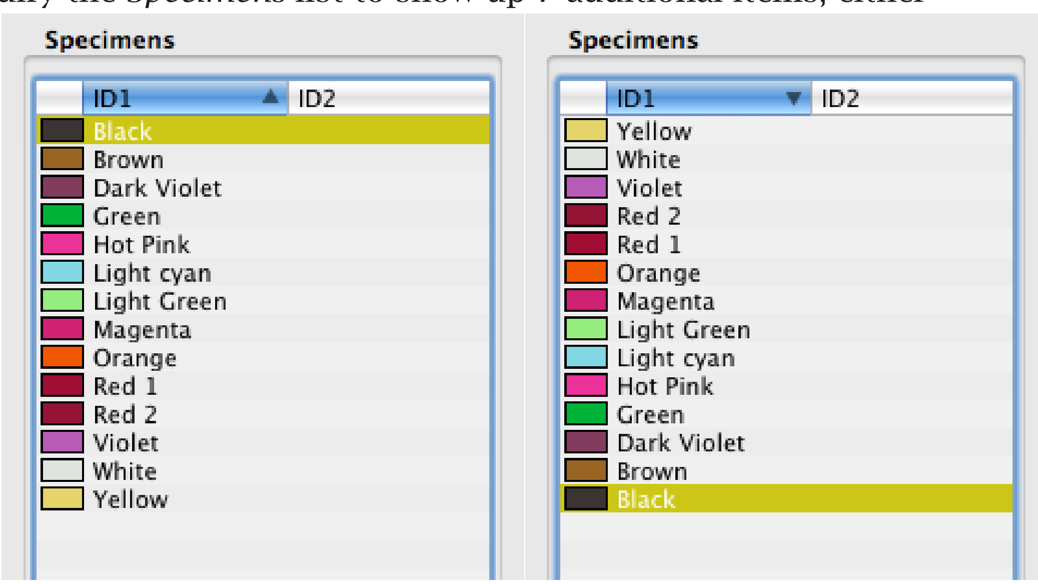
When a collection is first opened, the *Specimens* list displays the primary identifier, *ID1* and a small color swatch representing the approximate color of the specimen. The specimens are listed in the order they are stored within the file.

The first specimen is automatically highlighted once the collection file has been read into the *Specimens* list. Its associated metadata is displayed in the *Specimen Information* area with the details about how the specimen was acquired displayed in the *Measurement Information* area.

Note: It is possible to modify the *Specimens* list to show up 7 additional items, either metadata or colorimetric. For details, consult the *Properties* chapter in the *Specimens List Properties* section.

Sorting the List

The list can be sorted in ascending or descending alphabetic order by successively clicking on the *ID1* or *ID2* list column labels. A small triangle



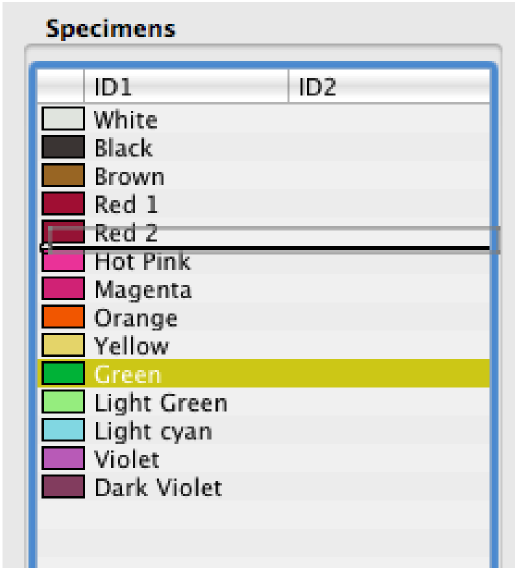
Ascendingly sorted list. *Descendingly sorted list.*

appears in the column heading to indicate the direction of the sort; ascending or descending.

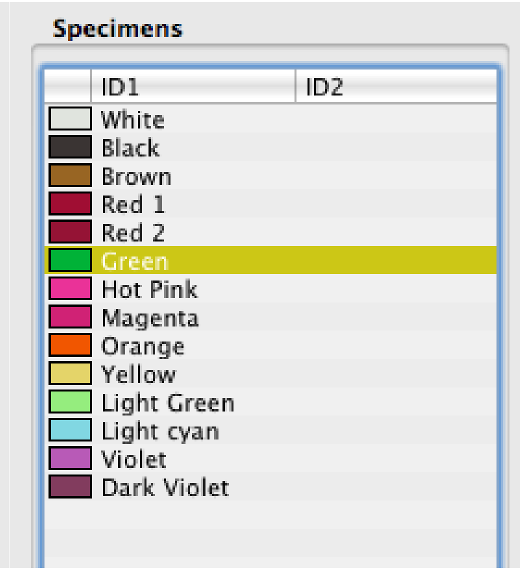
Note: When a specimen list is saved, the specimen order in the list is maintained, so saving a sorted list will result in the sorted order being retained in the file.

Editing the List

Specimens in the list can be manually rearranged by clicking on one of a specimen's identifiers, *ID1* or *ID2*, and dragging the specimen to a new position. A horizontal bar will appear to show where the specimen will be inserted in the list.



Beginning a drag reorder.



Drag reorder complete.

Deleting Specimens

Specimens can be deleted from the list by highlighting the specimen then pressing the *Delete* key (Macintosh) or the *Backspace* key (Windows).

A range of items can be selected and deleted by clicking on the first specimen to delete, then holding down the *Shift* key and clicking on the last specimen to delete. The entire range will be deleted when the *Delete* key is pressed.

Non-adjacent items can be selected by holding down the *Command* key (*Control* key on Windows) then clicking on the various specimens.

Adjusting the List Columns

Often it is necessary to see more of the identifiers than can be shown in the space allotted to the *Specimens* list. There are two ways to see more. The first is to expand the width of the collection window. The *Specimens* list will automatically widen as the window width increases.

The second way to show more of the identifiers is to click and drag the small vertical bar between the identifier names at the top of the *Specimens* list.

Copying Specimens Between Collections

Often it is necessary to put specimens from several collections into one collection. This can be easily accomplished by highlighting the specimens in the collection to copy from, then clicking on one of the selected specimens and with the mouse button held down, drag the specimen to the destination collection list. When the mouse button is released over the list the specimens will be copied, not moved, to the destination collection.

Saving a Spectral Graph

The spectrum graph can be saved to a file by using the *File/Save Graph* menu command. The file format can be selected from JPEG, PNG, GIF or TIFF in the File Save dialog window.

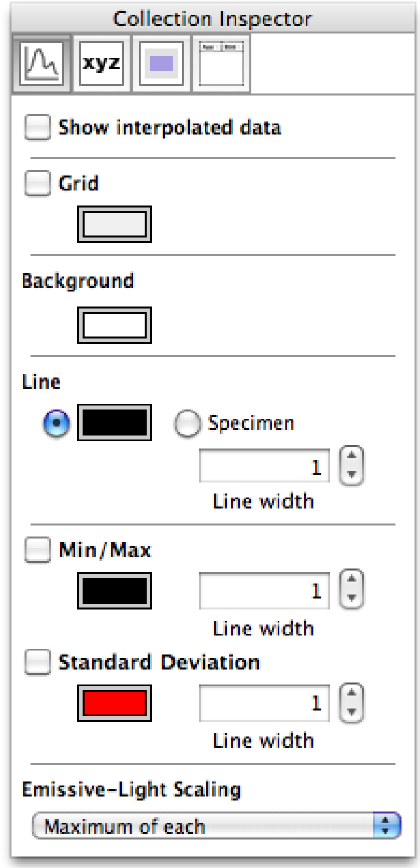
> All file types are not available on all platforms.

JPEG files are saved with the maximum quality setting to prevent any visible artifacts in the resulting image file.

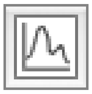
Printing a Spectral Graph

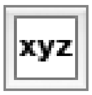
Spectrum graphs are created with sufficient resolution to allow for a minimum 10 inch print at a resolution of at least 300 ppi. To print the spectral graph, select the *File/Print* menu command. Parameters relating to the printer's page definitions may be set using the *File/Page Setup* menu command. If the page has not been defined before the *Print* command is issued, *Page Setup* will be automatically executed before the *Print* command executes.

Collection Window Properties

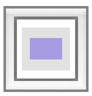


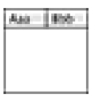
Click on the *Inspector* icon to access the properties for the collection window. The properties are grouped by functionality represented by icons at the top of the collection properties window.

 Graph properties



Colorimetry properties

 Sample patch properties

 Specimen list properties

Click on any of the icons at the top of the *Properties* window to show the associated attributes.

Graph Properties

Data Display

For reasons explained in the *Colorimetry* section, all spectra that are not natively sampled at 1 nm intervals are interpolated by SpectraShop™ to 1 nm. The resulting 1 nm spectrum can be displayed by checking *Show interpolated data* from the *Data Display* section.

The original measured data can be displayed by moving the cursor into the graph. The value at each sampling interval is displayed below the graph.

Grid

A grid can be displayed by checking the *Show* box. The color for the grid lines is selected by clicking in the *Color* box.

Background

The graph's background color can be selected by clicking in the associated *Color* box. This is a useful feature for improving the visibility of spectral graphs when the specimen's color is used for the line and the background color is similar to the specimen's color.

Line

This section controls the display of the specimen's line graph. The line color can be chosen to be the one in the *Color* box or the color calculated from the specimen's spectrum. When the *Specimen* color is used it is sometimes necessary to change the background color to improve the line's visibility.

Min/Max and Standard Deviation

When multiple measurements are averaged for the specimen's spectrum, the minimum and maximum values at each sampling interval are stored with the spectrum. In addition, the standard deviation is calculated at each sampling interval. The statistics can provide a measure of the uniformity between samples comprising the specimen.

When the graph is displayed, the min/max values are drawn as a vertical bar at each sampling interval, then the standard deviation is drawn as a vertical bar on top of the Min/Max bar. When different colors are used for the two statistical bars and the measurements are uniform, this does not present a problem because the minimum/maximum variance is usually larger than the standard deviation, so both bars can be differentiated visually.

When the measurements vary widely the min/max bars will be very tall. Sometimes this can be the result from not getting the instrument positioned properly on the specimen. It can also indicate problems with the specimen, such as a clogged inkjet printhead nozzle used to produce a print. Whatever the cause, tall min/max bars should be a flag to investigate and improve the situation, if possible.

These statistics can be displayed graphically by checking the appropriate *Show* boxes. The colors and line width are individually selectable.

Emissive–Light Scaling

Graphing emissive light spectra can present a problem for setting the scale. There can be a wide variance in the luminous flux from different sources which makes meaningful graphic comparisons problematic. When white light sources with relatively smooth spectra are displayed it is often the practice to scale the graph with the various source spectra scaled to put their 560 nm value at 1 on the graph's scale.

This presents a problem for sources that have 560 nm data with very low or high values in relation to the other spectra being displayed.

SpectraShop™ presents a choice between *560 nm*, *Maximum of each* or *Maximum of all* value scaling. When *Maximum of each* is selected each specimen's maximum spectral value is used to scale the graph to place this value at 1 on the scale. This may make darker specimens appear to be as bright as much brighter specimens, but it can make it easier to compare spectral features. *Maximum of all* examines each selected specimen to find the maximum value, then uses this to scale all the specimens. This is very useful for comparisons between light sources.

Colorimetry

To be compliant with the CIE recommendations for colorimetric calculations, SpectraShop™ 3 converts all spectra to 1 nm data prior to performing colorimetric calculations. While this means that there is much more data to process, the advantage is that spectra with different sampling intervals can now be interchangeably combined, something that was impossible with previous versions.

Parameters affecting the colorimetric calculations can be selected individually for each collection from the Properties window. Click on the *Colorimetry* icon at the top of the *Properties* window to access these attributes.

Colorimetric and Densitometric Values

Depending on the type of object type being analyzed, the following values are calculated:

Item	Description	Emissive-Flash	Emissive-Light	Emissive-Monitor	Reflective	Trans-missive
XYZ	CIE tristimulus	●	●	●	●	●
xy	CIE chromaticity	●	●	●	●	●
Σ	Sum of the spectral values	●	●	●	●	●
L*a*b*	CIELAB 1976 lightness, red-green, yellow-blue	○	○	○	●	
C*h	CIELAB 1976 chroma, hue	○	○	○	●	
u*v*	CIELUV 1976 red-green, yellow-blue	○	○	○	●	
C*hs	CIELUV 1976 chroma, hue, saturation	○	○	○	●	
JCH	CIECAM02 lightness, chroma, hue	○	○	○	●	
ab	CIECAM02 red-green, yellow-blue	○	○	○	●	
u'v'	CIE 1964 chromaticities	○	○	○	●	
nm	dominant wavelength	●	●	●	●	●
pe	excitation purity	●	●	●	●	●
RGB	Device RGB values	●	●	●	●	●
lux	photometric intensity	●	●			
cd/m^2	photometric intensity			●		
CCT	Correlated Color Temperature	●	●	●		
V	Visual density				●	●
ISO1	ISO density				●	
ISO2	ISO density				●	
Status A	density				●	●
Status E	density				●	
Status I	density				●	
Status M	density					●
Status T	density				●	

● Calculated, ○ Calculated in relative mode only

XYZ Tristimulus values

Standardized spectral response for the Standard Observer (a representation of a typical human observer).

xy Chromaticity values

A set of values derived from XYZ which are commonly used to produce a two-dimensional graphic representation of human color response, known as a chromaticity diagram.

u'v' Chromaticity values

A set of values derived from XYZ which produce more perceptually uniform chromaticity diagram than the xy diagram.

CIE L*a*b*C*h 1976 values

These values were derived from XYZ to make a color space where color differences are more perceptually uniform. L* corresponds to lightness, a* to redness/greenness, b* to yellowness/blueness. C* is chroma, how strong is the color. h is the hue angle in degrees. L*a*b* define a Cartesian coordinate system for color definition, L*C*h define a cylindrical coordinate system.

CIE L*u*v*C*hs 1976 values

These values were derived from the u'v' chromaticity values to make a color space where color differences are more perceptually uniform. L* corresponds to lightness (and is the same as in the L*a*b* 1976 system), u* to redness/greenness, v* to yellowness/blueness. C* is chroma, how strong is the color. h is the hue angle in degrees. s is the saturation. L*a*b* define a Cartesian coordinate system for color definition, L*C*h define a cylindrical coordinate system. This system is used for some applications instead of L*a*b*.

CIECAM02 JChab values

This is the latest attempt to create a set of color values more closely corresponding to perception than CIE L*a*b* 1976 or CIE L*u*v* 1976. J corresponds to lightness, C to chroma, and h to hue angle. The opponent color values a and b fill roles similar to the a* and b* opponent values of CIE L*a*b* 1976 system.

Dominant wavelength

A representation of the specimen's color calculated from the xy chromaticity diagram and expressed in nanometers. This value is calculated by projecting a line from the white point through the specimen's xy location to the spectral locus to find the wavelength. For the colors that project to the non-spectral purple line (the line connecting violet to red) the accepted convention is to express the wavelength as the negative value of the opposite green wavelength value.

Excitation purity, p_e

A representation of the specimen's colorfulness calculated from the xy chromaticity diagram. When used with the dominant wavelength and the Y value it can be used to define a color.

RGB

The red (R), green (G) and blue (B) values for the specimen in one of the selected RGB color spaces. A chromatic adaptation transform (CAT) used to adapt the values when the viewing illuminant is different from the RGB space illuminant.

Visual Density (reflective and transmissive)

Used to evaluate the lightness or darkness of an image to be viewed directly (e.g. prints) or projected (e.g. black-and-white transparencies). It can be used to evaluate any material viewed by the human visual system, with or without color.

ISO Type 1 Density (reflective)

Used for the evaluation of prints made from diazo or vesicular films used in the microfilm industry.

ISO Type 2 Density (reflective)

Used for the evaluation of black-and-white photographic prints.

Status A Density (reflective and transmissive)

The filter responses were designed to match the characteristics of prints or films viewed directly, or projected. Examples of these materials include transparencies (reversal film) and reflective color prints.

Status E Density (reflective)

The filter responses were designed to match reflective graphics arts materials used in Europe. Used to evaluate materials such as original art, printed materials, off-press proofs and press sheets.

Status I Density (reflective)

Narrow band filter responses designed to approximate monochromatic densitometry. Used for the evaluation of process inks on paper.

Status M Density (transmissive)

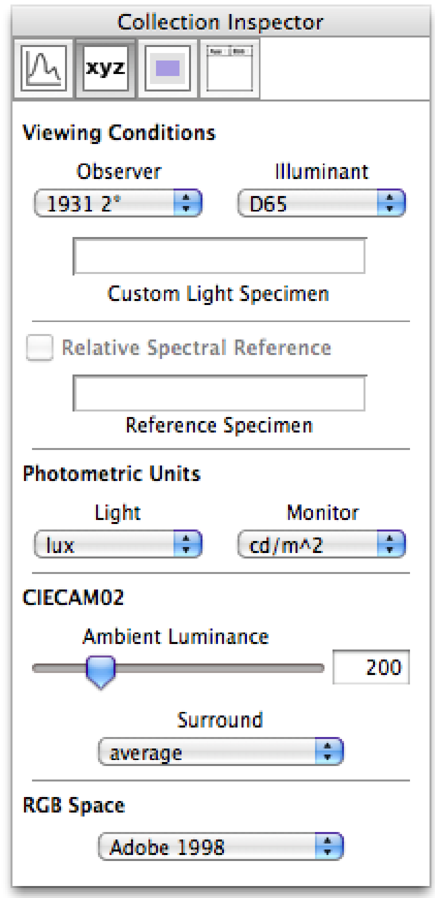
Used for the evaluation of color negative film which will be printed on photographic paper but will not be viewed directly.

Status T Density (reflective)

The filter responses were designed to match reflective graphics arts materials used in the United States. Used to evaluate materials such as original art, printed materials, off-press proofs and press sheets.

Colorimetry Properties

Viewing Conditions



The observer can be selected from the CIE 1931 2° observer or the CIE 1964 10° observer.

For reflective specimens a choice of standard illuminants is offered:

A	Tungsten
C	Daylight
D50	Simulated daylight at 5000 K
D55	Simulated daylight at 5500 K
D65	Simulated daylight at 6500 K
D75	Simulated daylight at 7500 K
E	Equal energy
F1	Fluorescent, standard
F2	Fluorescent, standard
F3	Fluorescent, standard
F4	Fluorescent, standard
F5	Fluorescent, standard
F6	Fluorescent, standard
F7	Fluorescent, broad band
F8	Fluorescent, broad band
F9	Fluorescent, broad band
F10	Fluorescent, narrow band
F11	Fluorescent, narrow band
F12	Fluorescent, narrow band
Custom	User specified light source

When *Custom* is selected, the light source specimen in the *Custom Light Specimen* field is used for the colorimetric calculations.

Spectral Reference

Emissive-light and emissive-monitor colorimetry can be referred to a white by dragging the white specimen from the specimen list into the field to the right of the *Relative* checkbox. This is especially important for monitor colorimetry where the measurements need to be referenced to the monitor white. The colorimetry will be recalculated and the colorimetric values are updated with the new values. Once the reference white is defined, the *Relative* checkbox can be used to switch between the original values and the relative values.

Light Measurement Units

The light measurement units for emissive specimens can be selected from the appropriate popup menus.

Light: illuminance (lx) or irradiance (W/m^2)
Monitor: luminance (cd/(m^2) or radiance (W/(m^2 sr)

CIECAM02

The adapting field luminance is selected from the *La* field and slider. The *Surround* popup menu selects the brightness of the area surrounding the specimen.

RGB Space

The XYZ values are converted into an RGB space selected from the popup menu. By default this space is *sRGB*. It can be changed in the *Preferences* window to any of the currently supported spaces.

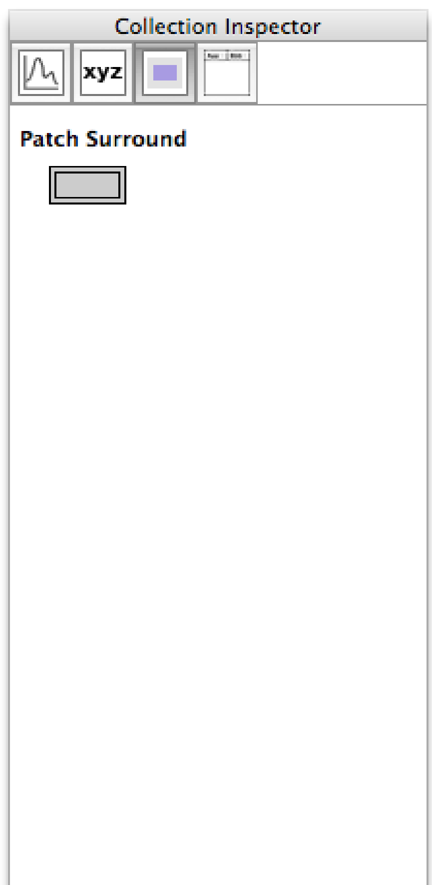
Note: In the current release there is no chromatic adaptation transform (aka CAT) applied to the RGB data. This means that if the currently selected RGB space has a different white point from the selected viewing illuminant, then the RGB values will not be valid.

Here is a list of the white points for the supported RGB spaces.

Adobe 1998	D65
Apple	D65
Beta	D50
CIE	E
ColorMatch	D50
eciRGB v2	D50
HDTV	D65
LCD	Custom
NTSC	C
ProPhoto	D50
SMPTE-C	D65
sRGB	D65
Wide Gamut	D50

The viewing environment white space can be set to match any of the RGB space white points except the *Custom* white point for the *LCD* space.

Note: The *LCD* space is provided to be complementary with the RGB spaces provided in Adobe Photoshop. It is not meant to be representative of any particular LCD monitor.



Patch Properties

The only patch property currently available is the color of the area surrounding the patch. For better color assessment, the patch should be a mid-tone neutral gray. Changing the surround to be more colorful allows for some interesting perceptual experiments. Click the *Patch* icon at the top of the *Properties* window to access these properties.

Specimen List Properties

Unsort

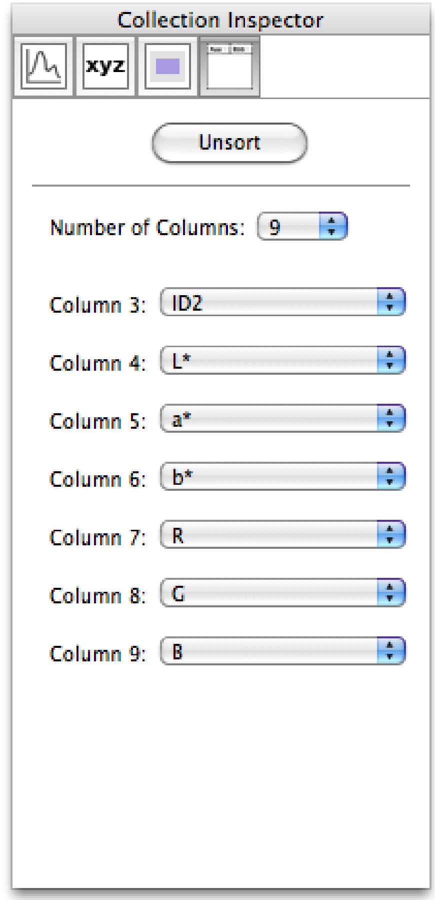
When the Specimen List has been sorted by the values in one of the columns, clicking this button will return the list to the original order as it was in the collection file.

List Columns

The first popup chooses the number of columns to display in the Specimen List. The list always shows two columns; a simulated color patch and Identifier 1. So the number of columns can only be selected from 3 to 9, inclusive. Once the total number of columns for the list has been chosen, select the item for each column from the corresponding popup menu.

You can choose from most of the Specimen and Measurement metadata items, along with all the Colorimetry items.

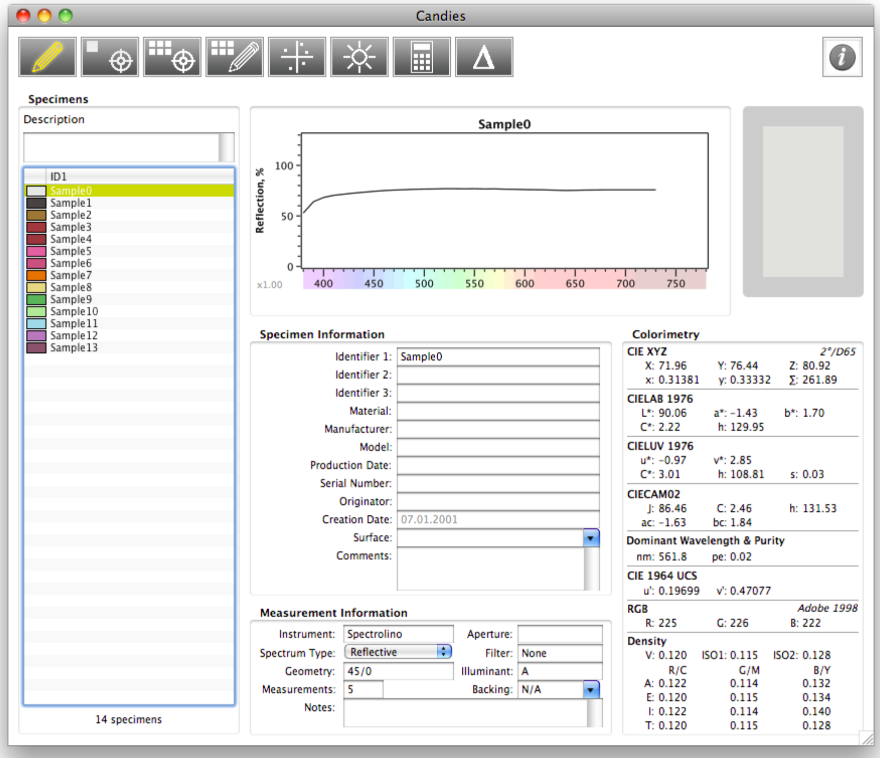
Note: SpectraShop allows for mixed data type lists, thus some colorimetric items may not be supported for a specimen, depending on the Spectrum Type. When this happens the column for that particular specimen will be left blank. For example, an emissive-light specimen will not display any L* values until the specimen is calculated in relative mode.



Editing

Specimen Information

A specimen's descriptive information, also known as metadata, may be edited by clicking on the *Edit Metadata* icon in the top-left corner of the collection window. Entering information into the edit fields will immediately update the information in the selected specimens.



Opened collection being edited.

Note: SpectraShop uses the ISO 8601 date format of *YYYY-MM-DD*. Entering less than the full date is possible but the ISO 8601 format is still used. For example, entering a year and month can be accomplished as *1998-10*, for October 1998. If only the year is known it can be entered as *1998*. Entering the year as the last two digits only is not allowed. The hyphens must be present if more than the year is entered. For single digit months and days it is not necessary to enter a leading 0, the field will add it for you. For example, 2001-1-5 can be entered for 5 January 2001, when the field is exited the value will be automatically updated with the leading zeroes to 2001-01-05.

Warning!

Changing Identifier 1 when multiple specimens are selected will result in all the selected specimens having the same primary identifier. This can make the specimens difficult to distinguish.

Measurement Information

The measurement information may also be edited like the specimen information. Click on the *Edit Metadata* icon to enable editing the measurement information. As you make your changes the data will be immediately updated for the selected specimens

Extremely Important Warning!

DO NOT CHANGE THE SPECTRUM TYPE UNLESS YOU ARE ABSOLUTELY CERTAIN IT IS NECESSARY!

Changing the specimen's type may cause unexpected side effects because it will change the interpretation of the spectral data. This may affect the colorimetric data, spectral graph scaling, simulated color and other items.

Measuring

Start Measuring Spectra

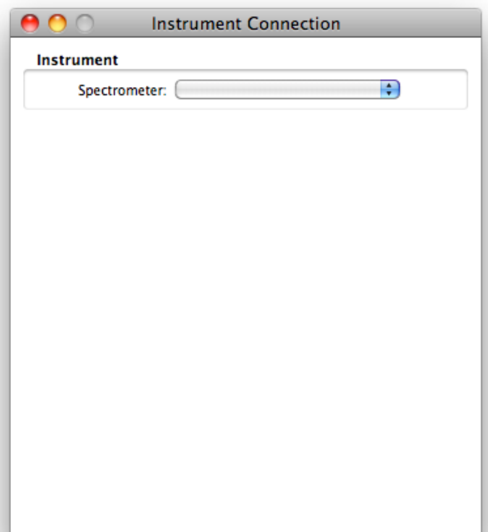
Spectral measurement begins by clicking on either of the *Measure Specimens* or *Measure Chart* icons at the top of the collection window. For both of these choices, the first item to appear will be the *Instrument* window. In this window the measuring instrument, it's options and hardware configurations are selected.

Once the instrument and its operational options have been chosen, the appropriate specimen or chart measurement window will appear, depending on the selected *Specimen Type*.

After you have finished with the measurement, you may connect to a different instrument or change to a different specimen type. Changing from specimen to chart measurement, or vice versa, requires closing the *Instrument Connection* window, then clicking the desired *Measure Specimens* or *Measure Chart* icon.

Instrument Window

Begin by selecting an instrument from the *Instrument* popup menu. Click the *Connect* button to open communications with the instrument. If the instrument connects with a serial interface, or, in the case of the PR-655/670, emulates a serial interface with a USB hardware connection, the serial port and possibly the baud rate must be set before clicking the *Connect* button.



As part of the connection process the serial number of the spectrometer is read from the instrument and displayed next to the *Connect* button. This serves to verify the connection.

Depending upon the instrument and its options, after the connection is established, the window will show the options available for that instrument and the type of spectrum being measured.

Supported instruments

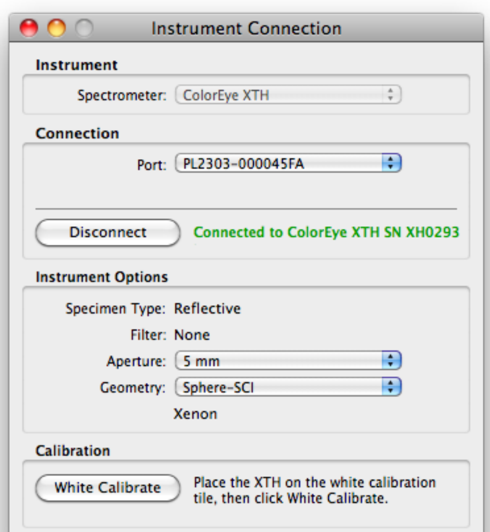
The currently supported measuring instruments are listed in the table below. Only **one** instrument at a time can be connected to SpectraShop™. Spectra measured with the connected instrument are sent to the front-most collection window.

Instrument	ColorEye XTH	FD-7	i1Pro, i1Pro 2	PR-655	PR-670	Spectrolino
Manufacturer	X-Rite	Konica-Minolta	X-Rite	Photo Research	Photo Research	X-Rite
Emissive-Light		●	Note 4	●	●	
Emissive-Monitor			●	●	●	●
Emissive-Flash			Note 4			
Reflective	●	●	●	Note 1	Note 1	●
Transmissive			Note 1	Note 1	Note 1	Note 1
Min. nm	360[2]	360[2]	380	380	380	380
Max. nm	750	730	730	780	780	730
Inc. nm	10	10 refl., 5 emis.	10	4	2	10
Geometry	Sphere	45/0	45/0			45/0
Apertures	5, 10 mm	3.5 mm	4 mm	1 deg	1, 0.5, 0.25, 0.125 deg.	4 mm
Filters	None	Ambient	Ambient, UV Cut (Note 3)	Neutral density	Neutral density	Null, UV Cut, D65, Polarizer

1. This functionality is provided by SpectraShop™ , not the instrument.
2. Values below 380 nm are not used by SpectraShop™ .
3. UV Cut filter is a factory installed option for revisions A through D, not user replaceable.
4. Not available on i1Pro Rev. A.

X-Rite ColorEye® XTH

The ColorEye XTH is a portable integrating sphere instrument manufactured by GretagMacbeth, now part of X-Rite. The omni-directional illumination and spectral capture of the integrating sphere makes it well suited to measuring textured surfaces, such as fabrics, in addition to smoother items. It has the ability to measure with the specular component included (SCI), excluded (SCE) or both simultaneously (SCI & SCE).



Note: When both the specular component included and excluded are chosen for simultaneous reporting, each geometry will be entered into the collection separately, generating two specimens for each item measured. **Multiple samples per specimen is disabled for this mode.**

The ColorEye® XTH uses an RS-232 hardware communication channel. A serial/USB adapter must be used with more recent computers that do not offer serial ports.

Minolta FD–7

This device measures both reflective and emissive-light specimens. When measuring reflective specimens, the instrument offers M0 (Illuminant A), M1 (Illuminant D50) and M2 (Illuminant A, UV excluded) measurement conditions. The instrument is a 45/0 geometry for reflective measurements. It also has the ability to scan patch strips for printer color management profile creation.

Note: SpectraShop does not currently support strip measurements for the FD-7.

Calibrating the FD-7 requires the use of the stapler attachment for all calibrations, including emissive-light. After clicking “Calibrate” in the Instrument window, place the FD-7 on the white plaque and press the stapler down to calibrate. Hold it there until the instrument signals the calibration is complete by beeping once.

Emissive-light measurements make use of the FD-7’s only filter, an ambient diffuser. After calibration, replace the stapler attachment with the ambient filter. Click the “Start” button in the Measure Emissive-light window, aim the device then click the instrument’s “Scan/Illuminance” button to make each measurement.

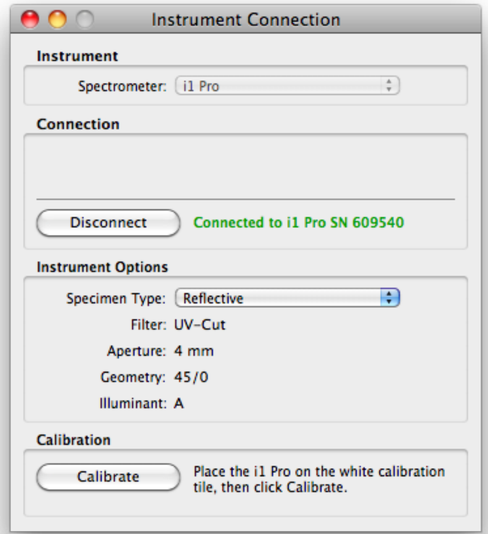
UV Cut Reflective Measurements

When operating with the M2 measurement condition (UV excluded), a filter is employed internally to cut light emission below 400 nm. However, the FD-7 produces values in the 380-400 nm region. Although this is permitted by some measurement standards, having values here may lead the user to erroneous conclusions. For this reason, SpectraShop sets these values to zero. The UV Cut illumination condition M2 affects reflective measurements only.

Emissive-light Measurements

The FD-7 spectral output is in 10 nm increments for reflective measurements. For emissive-light measurements the spectral output is in 5 nm increments. This can be very helpful for light sources with narrow band emissions, such as fluorescent, HMI, HID or other sources utilizing mercury vapor emissions.

X-Rite i1Pro



This handheld device is a 45/0 instrument manufactured by X-Rite. It can be ordered with a factory installed UV blocking filter for removing the effects of UV brighteners from reflective measurements. The only user replaceable filter is the ambient filter, used for measuring emissive light sources.

It has a variety of adapters which allow the i1Pro to measure emissive lights and flash (with the ambient filter), emissive monitors (with the counter-balanced monitor holder), reflective items with the spot adapter, strip charts with its strip measure ruler and emissive digital projectors with the beamer holder.

For automatic reflective chart measurement the i1Pro can be attached to the iO, an automated arm device.

Note: SpectraShop does not currently support strip measurements or the iO.

I1Pro Variations

The i1Pro has undergone four revisions; A, B, D and E (aka i1Pro 2) with some differences in the measurement capabilities between the revisions.

	Measurement Type				
i1Pro Revision	Emissive-flash	Emissive-light	Emissive-monitor	Reflective	Transmissive
A			●	●	●
B	●	●	●	●	●
D	●	●	●	●	●
E	●	●	●	●	●

SpectraShop™ will automatically detect the revision of the connected i1Pro, setting the available measurement types in the Type popup menu.

Note: SpectraShop supports multiple i1Pro units attached to the computer, but only one may be used at a time to make spectral measurements. The instruments are differentiated by their serial numbers in the Spectrometer popup menu.

I1Pro Filters

UV-Cut

The i1Pro revisions A through D can be ordered with a factory installed UV Cut filter. This filter is used for measuring reflective prints without activating the optical brighteners in the paper. This is accomplished by filtering out the UV component of the instrument's illumination. Without UV illumination the paper's optical brightening agent will not fluoresce. The presence of this filter on the instrument is automatically detected and entered in the Measurement Data section for reflective measurements.

The i1Pro Rev. E, also known as the i1Pro 2, has a user selectable UV Cut filter capability built into the instrument. This capability is selected as Illuminant M2.

Note: Although the UV Cut filter removes the UV component (380 to 400 nm) from the illumination, the i1Pro has an interpolation algorithm which attempts to fill the region from 380 to 400 nm with values. Putting estimated values into the spectrum is not appropriate because without illumination in this spectral region there should be no light energy to measure so the values would be expected to be zero. Another effect of the estimation algorithm is that these values can vary widely in magnitude from measurement to measurement on the same specimen. Since this behavior can cause problems with some programs, SpectraShop™ corrects the values for 380 and 390 nm to zero to make it easier to work with the spectra in other programs. **This affects reflective measurements only.**

Ambient

There is only one user replaceable filter available for the i1Pro, the Ambient filter.

This filter is used for taking measurements of ambient light, light sources and photographic flashes. It is a diffusion filter that can be user installed. Select *Emissive-Light* from the *Type* popup menu and the *Ambient* filter will be automatically selected in the *Filter* popup menu.

After the instrument is connected, put the ambient filter on the i1Pro with the black cap covering the filter and click the *Calibrate* button. When the calibration is complete a message will appear to confirm success. Remove the black cap to make emissive-flash or emissive-light measurements.

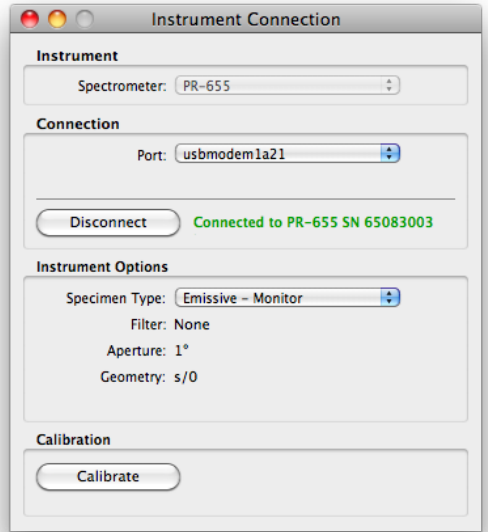
Measurement Modes

With the i1Pro 2, also known as the i1Pro Rev. E, the instrument now has user selectable lighting conditions for reflective measurements. These conditions are selected with the Illuminant popup menu. M0 is tungsten illuminantion, which contains a small amount of UV light. M1 is a combination of tungsten illumination combined with a UV LED, then processed to give a D50 illumination. M2 is tungsten with a UV-Cut filter. This is the same condition as a revision A through D instrument with a UV cut filter installed.

Photo Research PR-655 & PR-670

These two instruments are portable spectroradiometers. Using a design similar to a camcorder, the instrument is pointed at an object and whatever is beneath a black spot visible in the viewpiece is spectrally measured. They both offer a wide range of interchangeable lenses, filters and accessories which allow them to measure almost anything emissive, reflective or transmissive. For reflective measurements the user must supply their own lighting and a reflective reference target (e.g. Spectralon or Fluorinon 99% reflective white tile). For transmissive measurements the user must also supply a lighting setup.

Currently, the only Photo Research accessories supported by SpectraShop™ are the MS-75 primary lens and the CR-650 or CR-670 cosine correctors used for ambient light measurements.



X-Rite Spectrolino

This handheld device is a 45/0 instrument manufactured by GretagMacbeth, now part of X-Rite. It was the predecessor to the i1Pro.

It has a variety of adapters which allow the Spectrolino to measure emissive monitors (with the counter-balanced monitor holder) and reflective items with the spot adapter.

For automatic reflective chart measurement the Spectrolino can be attached to the SpectroScan, an automated stage.

Note: SpectraShop does not currently support using the Spectrolino with the SpectroScan automated stage.

Spectrolino Filters

Filters are used to adjust the measurement characteristics of a spectrophotometer to improve its results. The available Spectrolino filters are Null, D65, Polarizer and UV Cutoff.

The filters attach over the measuring head, the portion of the instrument where both the illumination and the sensor aperture are located. The Spectrolino illuminates the specimen with an annular 45 degree beam. This means the light is coming from a 360 degree circle around the center of the measuring head, oriented so the light arrives at the specimen from a 45 degree angle from the plane of the specimen.

The Spectrolino filters perform two functions; to adjust the spectrum of the illumination, and to modify the sensor's response. To achieve these functions, some filters have two distinct regions. The outer portion of the round filter is used to adjust the illumination, the filter's center area contains the sensor filter. By looking at the filter at an angle from the back side, the two filter region's can be observed.

Null

This is the most commonly used filter on the Spectrolino. It is marked with a "U". It is used for Illuminant A measurements and for all emissive and transmissive measurements. It is a clear glass filter that does not alter the illumination or measurement spectra. It is, however, necessary to maintain a common physical configuration of the instrument for measurements with the other filters.

D65

The illumination source in the Spectrolino is a tungsten lamp. The lamp emits a small amount of light at the violet wavelengths and a high amount of red light. Silicon sensors are more sensitive to red and infrared light than to ultraviolet and blue lights. This means that for the blue end of the spectrum, a larger scale factor is necessary to normalize the spectral data when reference illuminants that contain more blue light are selected for the measurements.

The D65 filter cuts back on the red end of the illumination and passes more blue light. This evens out the scale factors and evens the error distribution for the spectrum. Since less light is illuminating the specimen, the Spectrolino will take a longer time measuring the spectrum to increase the signal and improve the signal to noise ratio for the measurement.

Polarizer

When making measurements of glossy surfaces, a small amount of light will be polarized and reflect from the surface toward the sensor, thus altering the measured color.

The polarizing filter has an outer portion that polarizes the illumination and an inner portion set at a 90˚ rotation from the outer. The result is that the specular reflection from the surface is polarized by the outer portion and the inner portion will block this light, thus letting the instrument measure only the color. When the light is polarized, the full intensity is not transmitted through the filter. Typical polarizers pass only 38% of the light. The combined effect of polarization will then only transmit about 14% of the original illumination (0.38 x 0.38 = 0.14).

Due to this light loss, the Spectrolino will increase the measuring time to get an adequate signal to noise ratio when the polarizing filter is used.

UV Cut

This filter is most often used with substrates that have optical brighteners. Most white "plain" papers use brighteners to convert invisible ultraviolet light to visible blue light, thus offsetting the natural yellowness of paper fibers. Optical brighteners are also used in the fabric industry to offset the natural yellow color of textile fibers and the increasing yellowness that occurs as the fabric ages. This extra blue reflectance can cause problems with creating color management profiles, producing profiles that generate a yellow cast in the images to compensate for the bluishness of the paper.

The UV Cut filter is designed to remove ultraviolet light from the illumination, thus eliminating the blue fluorescence. The outer portion of the filter is yellow and removes the ultraviolet light from the illumination. The inner portion is blue to improve the measurement in the blue end of the spectrum to offset the decreased blue illumination. Again, the integration time is slightly longer to improve the signal to noise ratio.

Instrument Options

Spectrum Type

Depending on the instrument five types of spectra can be measured with SpectraShop™:

Emissive-flash (i1Pro only)
Emissive-light
Emissive-monitor
Reflective
Transmissive

The spectrum type and the choice of Specimen or Chart measurement will determine which window is presented for the actual spectral measurement.

Filter

Some instruments require adding or changing filters to the device for different spectral types. For example, the i1Pro requires an ambient diffusion filter be added for emissive-light measurements. Other spectrometers have filters to alter the way the spectrum is measured for various applications, such as a polarizer for glossy reflective measurements or a UV light blocking filter for reflective print measurements.

Geometry

The spectral type can also determine the instrument's measurement geometry. Some instruments have selectable geometries, such as integrating sphere instruments. After selecting the *Spectrum Type* and *Filter* the *Geometry* will either be automatically selected or the options available are presented in a popup menu.

Aperture

Some instruments have multiple apertures which can be switched programmatically or physically. The choice of an aperture can be very important, depending on the type of material being measured. For example, coarse woven cloth needs a larger aperture than a fine woven cloth.

Port

This option is only available for serial communication devices, e.g. Spectrolino, or ones that simulate serial devices, e.g. PR-655/PR-670. Select the port from the list presented in the popup menu.

Baud Rate

This option is only available for serial communication devices. Consult your device's manual and select the appropriate connection speed from the list presented in the popup menu.

Connecting to the Instrument

Click on the *Connect* button to open the communications with the instrument. Once the connection is established a verification message is displayed in green text next to the *Connect* button. If there is a problem initializing the connection, a message in red is displayed.

Calibration

After the connection is established and the instrument's options selected, follow the displayed calibration directions, then click *Calibrate*. It may take several seconds to calibrate the instrument. When the calibration is completed a message will be displayed confirming success.

Some instruments (e.g. ColorEye XTH) will require two calibrations; one for white, one for black.

Making transmission measurements with instruments that do not directly support it, such as the i1Pro, will require a measurement for the instrument and another for the light source. Instructions will be presented next to the *Calibrate* button to guide you through the process.

Measuring Specimens

Specimen Information

The descriptive information for the measurements is entered into the *Specimen Information* area. When the measurement is complete this data will be attached to the spectrum and sent to the top-most collection window.

Each measurement window presents the information applicable to that specimen type.

Measurement

When taking measurements it is often necessary to take more than one measurement and average the results for the final result. SpectraShop™ allows for a maximum of 99 measurements per specimen. As each measurement is made a high pitched bell tone is sounded and a message is displayed to indicate the current measurement in the sampling sequence. When the final measurement in the series is taken a low pitched bell tone is sounded.

The measurement tone may be disabled for quieter operation by unchecking *Audio tone*.

Once the measurement parameters have been selected, click the *Start* button to begin taking measurements. The *Start* button initiates a timer that periodically checks the instrument, retrieving the spectral information if a measurement was taken by pressing the instrument's measure button.

The *Measure* button can be optionally used to take a measurement without pressing the instrument's measurement button. This is very useful for situations where pressing the instrument's button might move the instrument, affecting the result, or for situations where the instrument's button may be inaccessible.

Auto Naming

To aid naming the specimens the *Auto Naming* feature can be activated by checking the *On* box.

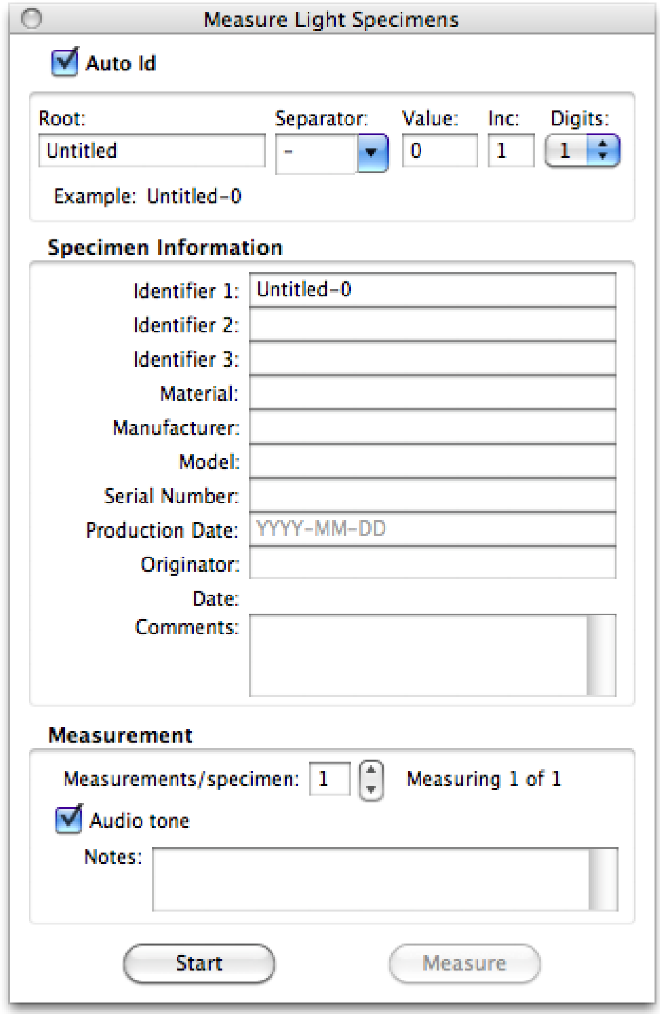
Template naming consists of a root name followed by a separator character then ending with a numeric value. The minimum number of digits for the numeric ending is selected from the *Digits* popup menu.

Most instruments measure emissive light sources with a diffusion filter attached. This serves two purposes; to diminish angular sensitivity of the device relative to the source and to minimize the chance of exceeding the instrument's range limit.

When multiple measurements per specimen are being taken, fixing the spectrometer to a rigid fixture is recommended to minimize the variance between measurements. Many portable spectrometers have a photographic tripod attachment point for this purpose.

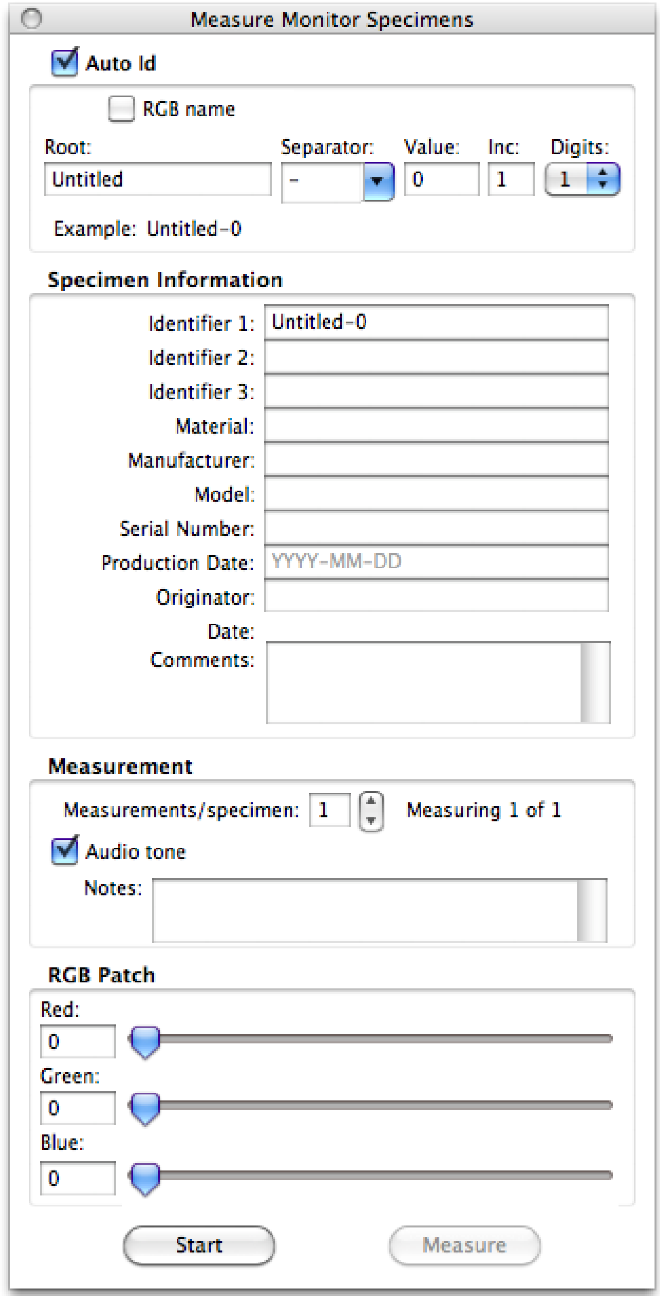
Emissive-Flash

Begin this mode with the i1Pro by clicking the *Start* button. Then press, and keep pressed, the measurement button on the i1Pro. There will be a beep to let you know it is waiting for the flash, then fire the flash one or more times. End the measurement by releasing the measurement button. The flash specimens will be entered into the collection. One specimen is entered for each flash. In this mode the *Measurements/specimen* value is not used.



Measure Emissive-Monitor Specimens

When measuring monitors there are several ways to improve the consistency and accuracy of the measurements.



Measurement

Many spectrometers have a fixture for attaching the device to the monitor. Some of the fixtures use gravity to suspend the spectrometer from the monitor top with gravity holding the instrument against the display surface. Usually these fixtures have a method for blocking ambient light from influencing the measurement. Be certain the fixture lays flat against monitor’s surface or the ambient light blocking will be compromised.

If it is possible, turning out the room lights will reduce the opportunity for ambient light to get around the block.

Another way to reduce ambient light is to cover the monitor and the attached spectrometer with a black cloth. Care must be taken with the cover that it does not affect the position of the instrument being flat to the monitor’s surface.

RGB Patch

When the *Measure Monitor Specimens* window appears, another window is also shown that is filled with a color patch. This window should be placed so it is under the mounted spectrometer. The RGB values for this patch are set by entering values into the *Red, Green* and *Blue* fields or by using the associated sliders. The range of values for each field is 0 to 255.

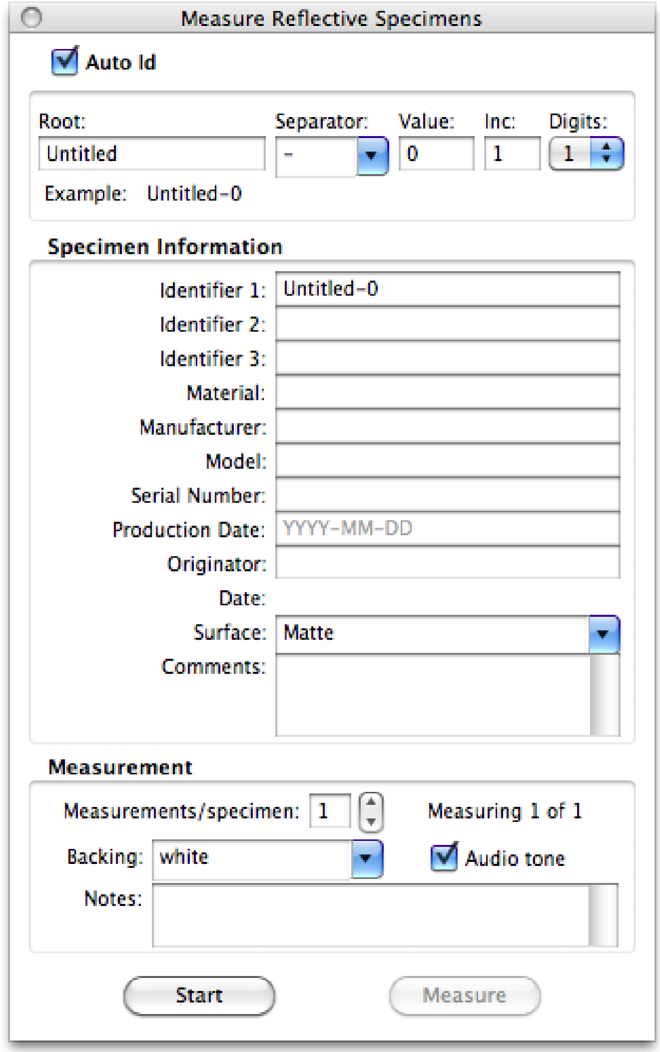
RGB Naming

In addition to the standard Auto Id naming, it is possible to have the specimens named with the red, green and blue values used to specify the patch. Check the RGB name checkbox to switch to this type of specimen naming.

Measure Reflective Specimens

Backing

When making measurements of reflective specimens, the choice of the material behind the specimen is very important. One of the optical properties of every specimen is its translucency. This is the amount of light that passes through the object. Translucency can range from totally transparent, passing all light, to totally opaque, not allowing any light through. Many specimens fall somewhere between these two extremes.



Since a spectrophotometer will measure any light arriving at its sensor, anything in the path of the illumination that affects the light will affect the measurement of the specimen's spectrum. This will include the specimen itself, any material on the back of the specimen and anything behind the specimen.

Objects on the back of the specimen will act as filters, modifying the transmitted light. This modified spectrum can be sensed by the spectrophotometer, depending on the material behind the specimen. One example of a back object would be any writing on the back of a paper; either a manufacturer's identification or notes written by someone.

The material the specimen rests on during the measurement is called the backing. The backing can have a very significant effect on a translucent specimen's measurement spectrum. A bright backing will reflect some light back through the specimen. The resulting measured spectrum will consist of the reflectance from the specimen, any material on the back of the specimen, the backing, and some of the specimen's transmitted spectrum.

A very dark backing will absorb the specimen's transmitted light, the effect of any material on the back of the specimen, and will not add any of its own spectrum to the measurement. It is for this reason that the ISO and ANSI specifications dictate a black backing with an optical density of 1.5.

For some specimens the dark backing will make the measured spectrum different from the perceived one. An example is the spectrum of a mustard plant. When the flower petal is measured with a white backing the resulting spectrum matches with the perceived bright yellow color, with a tinge of greenness. A measurement with a black backing results in a spectrum with a strong green component. This is because the color of many objects in nature is a combination of the reflected light and the transmitted light. Also, only high lightness colors are perceived as yellow. When yellows are lower in lightness, they are perceived as browns and greens.

Thus, the choice of backing depends on several items. If the specimen is to be measured in accordance to a standard that requires it, then a black backing should be used. Any translucent specimen with writing on the back, or a different color on the back surface, such as electronic printer papers or paint store color brochures, should be measured with a black backing. A white backing should be used when a transmitted light component is a significant part of the specimen's perception. Examples of these specimens would be flowers and leaves, translucent papers with no writing or markings on the back and most fabrics.

Opaque objects are insensitive to the backing since no light is transmitted through the object to be effected by it.

When viewing printed samples, the backing for the samples must be the same as the measurement backing. Most printer papers are translucent, allowing the backing to influence the measurements. Using a different backing will result in the sample not matching the results predicted by the measurements. This is a common problem in viewing booths where the printer targets have been measured with a black or white backing but the final output sample is simply placed in the booth and viewed with the booth's gray as a backing. The output will appear too light (compared to a black measurement backing) or too dark (compared to a white measurement backing). Placing the same backing behind the output sample, then placing them together in the viewing booth will improve the evaluation.

SpectraShop offers several default values for the choice of backing; *white, black, self* and *n/a*. You may also enter your own custom backing value.

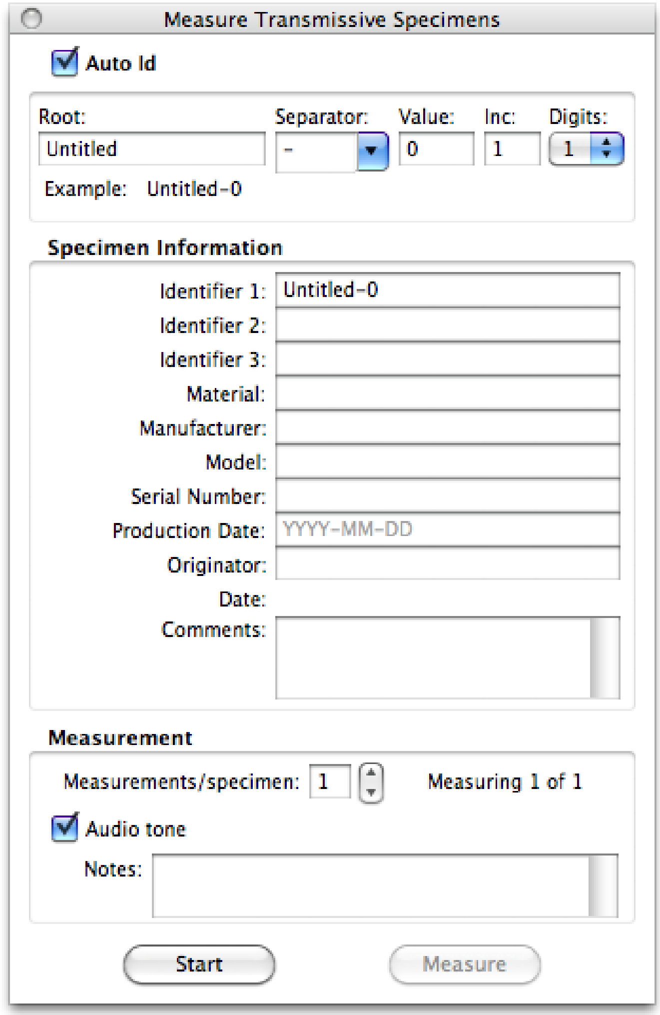
Reflective Measurements with the PR-655 or PR-670

When a reflective object is measured with the PR-655/PR-670 the result is a combination of the object's reflectance factors combined with the illumination. Other instruments with a fixed light source automatically remove the illumination component from the resulting spectrum to produce the reflectance factors only. To get this result with the PR-655/PR-670 it is necessary to measure a standard white tile using the same illumination as for the reflective object measurement.

While many different white sources may work satisfactorily for a white reference, a pressed PTFE white tile is recommended. Available under the trade names of Spectralon, Fluorinon, and others, these tiles have a very high reflectance across the visible spectrum and they do not fluoresce. The white reference is measured during the calibration step when connecting to the instrument.

In addition to the calibration, the white tile's reference data (the certified reflectance factors that accompanied the tile from its manufacturer) must be entered into SpectraShop. This is accomplished by opening the *Preferences* window and selecting the tile's reference file. This file is a SpectraShop file with **a single specimen**, the reference data.

Measure Transmissive Specimens



To measure transparent specimens with a device that does not have an inherent transparency capability, such as the i1Pro, some additional apparatus is necessary.

The basic requirements are a place to put the specimen and a constant full-spectrum light source. A light table can work very well for this purpose. Using a light table does present some challenges.

In spite of the best efforts from their manufacturers, light tables do not have a perfectly uniformly illuminated surface. To keep the illumination constant between measurements, mark a spot on a light table where the measurements will be made. This spot is measured during the calibration step in the Instrument window. It will be used as a reference for the subsequent transmissive measurements.

A light table surface is usually smooth, which makes it difficult to put the i1 into the same position between measurements. A template made from a thin piece of plastic can make the positioning much more consistent. Use either a colorless transparent or opaque black plastic to minimize the possibility of light reflected from the template affecting the measurements.

The most important item to consider in choosing a light table is the light source. It must be very constant in intensity and have a spectrum that extends beyond the range of the i1Pro (i.e. below 380 nm and above 730 nm).

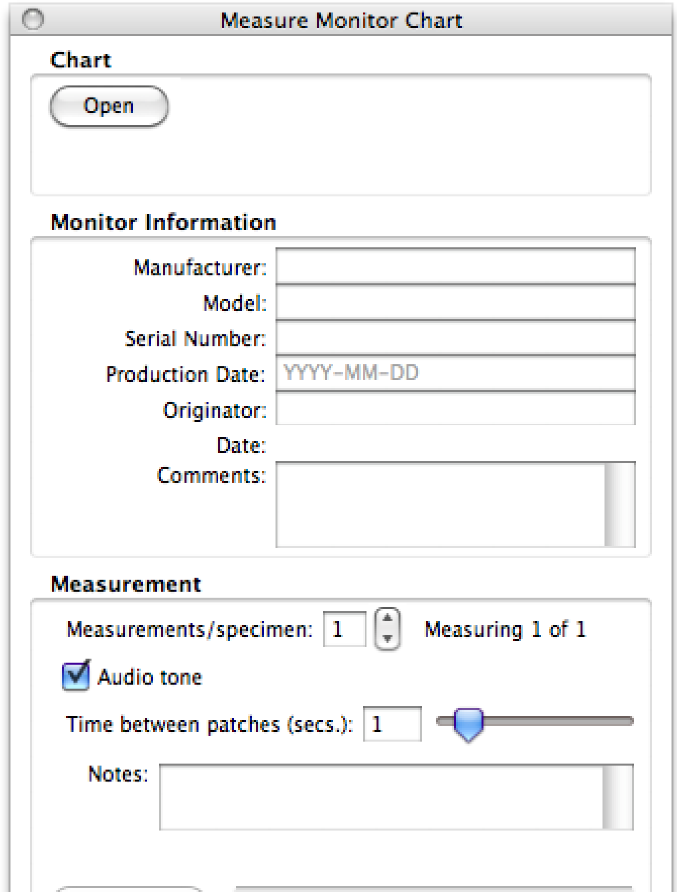
If the light source has low emission in part of the measured spectrum, then large errors will be introduced into the measured spectrum. One example of a good light source would be a fluorescent lamp with a continuous spectrum in excess of the i1Pro's measurement range, so there is no part of the spectrum with poor emission and it does not overheat the subject specimen.

Measure Charts

Measure Emissive-Monitor Charts

Operation

- Open a chart file
- Enter monitor information
- Select measurement parameters
- Click Start



Open a Chart

Begin by opening a predefined chart description file. The chart's name as defined in the file will appear next to the *Open* button. This chart file contains the list of all the patches with the patch Identifier and the associated R, G and B values. To define a chart click on the *Define Chart* button at the top of the collection window.

Enter Monitor Information

The information unique to the monitor being measured should be entered before .

Measurement

When taking measurements it is often necessary to take more than one measurement and average the results for the final result. SpectraShop™ allows for a maximum of 99 measurements per specimen. As each measurement is made a high pitched bell tone is sounded and a message is displayed to indicate the current measurement in the sampling sequence. When the final measurement in the series is taken a low pitched bell tone is sounded.

Once the measurement parameters have been selected, click the Start button to begin taking measurements. The *Start* button initiates a timer that periodically checks the instrument, retrieving the spectral information if a measurement was taken by pressing the instrument's measure button.

The *Measure* button can be optionally used to take a measurement without pressing the instrument's measurement button. This is very useful for situations where pressing the instrument's button might affect the result, for instance when measuring LCD panels where pressing on the display changes the screen's color.

Timing

With some monitors it is necessary to give the monitor some time to stabilize after changing the color patch display. A time delay of between 0.1 and 10 seconds, inclusive, can be selected from the *Time between patches* controls.

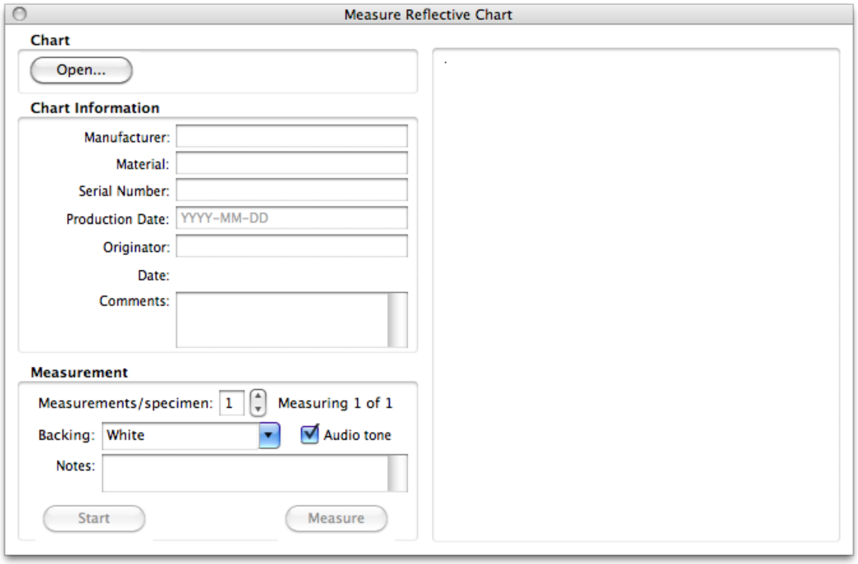
RGB Patch

When the *Start* button is clicked, a window appears that contains a color patch. This window should be placed so it is under the spectrometer. The RGB values for this patch are set by entering values into the *Red, Green* and *Blue* fields or by using the associated sliders. The values for each field must be in the range of 0 to 255.

Measure Reflective Charts

Operation

- Open a chart file
- Enter chart information
- Select measurement parameters
- Click Start
- Measure each patch



Open a Chart

Begin by opening a predefined chart description file. The chart's name as defined in the file will appear next to the *Open* button. This chart file contains the list of all the patches, their surface, and their locations in the chart.

Measurement

When taking measurements it is often necessary to take more than one measurement and average the results for the final result. SpectraShop™ allows for a maximum of 99 measurements per specimen. As each measurement is made a high pitched bell tone is sounded and a message is displayed to indicate the current measurement in the sampling sequence. When the final measurement in the series is taken a low pitched bell tone is sounded.

Once the measurement parameters have been selected, click the Start button to begin taking measurements. The *Start* button initiates a timer that periodically checks the instrument, retrieving the spectral information if a measurement was taken by pressing the instrument's measure button.

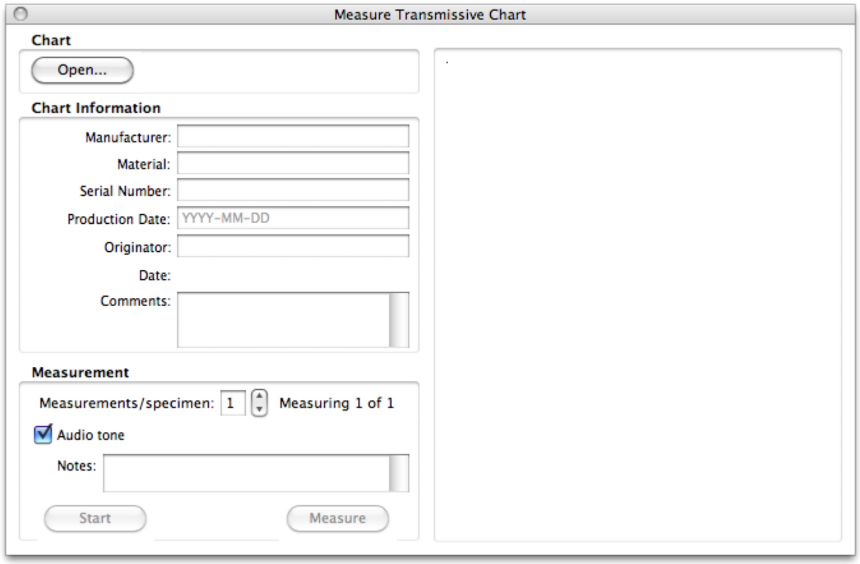
The *Measure* button can be optionally used to take a measurement without pressing the instrument's measurement button. This is very useful for situations where pressing the instrument's button might affect the result, for instance when measuring LCD panels where pressing on the display changes the screen's color.

Below the chart display a prompt is displayed prior to each patch's measurement. As each patch is measured it will be automatically entered into the current collection window. The chart display will update with the last measured patch's color.

When finished measuring the chart, close the window to end chart measurement.

Measure Transmissive Charts

Operation



- Open a chart file
- Enter chart information
- Select measurement parameters
- Click Start
- Measure each patch

Open a Chart

Begin by opening a predefined chart description file. The chart's name as defined in the file will appear next to the *Open* button. This chart file contains the list of all the patches, their surface, and their locations in the chart.

Measurement

When taking measurements it is often necessary to take more than one measurement and average the results for the final result. SpectraShop™ allows for a maximum of 99 measurements per specimen. As each measurement is made a high pitched bell tone is sounded and a message is displayed to indicate the current measurement in the sampling sequence. When the final measurement in the series is taken a low pitched bell tone is sounded.

Once the measurement parameters have been selected, click the Start button to begin taking measurements. The *Start* button initiates a timer that periodically checks the instrument, retrieving the spectral information if a measurement was taken by pressing the instrument's measure button.

The *Measure* button can be optionally used to take a measurement without pressing the instrument's measurement button. This is very useful for situations where pressing the instrument's button might affect the result, for instance when measuring LCD panels where pressing on the display changes the screen's color.

Below the chart display a prompt is displayed prior to each patch's measurement. As each patch is measured it will be automatically entered into the current collection window. The chart display will update with the last measured patch's color.

When finished measuring the chart, close the window to end chart measurement.

Define a Chart

Clicking the *Define Chart* tool icon at the top of the collection window allows for the creation of chart definitions. The chart definition files are based upon the CGATS.17 standard with extensions and changes to support charts.

Emissive–Monitor Chart

Monitor charts consist of a series of RGB values to be displayed, then measured on a monitor.

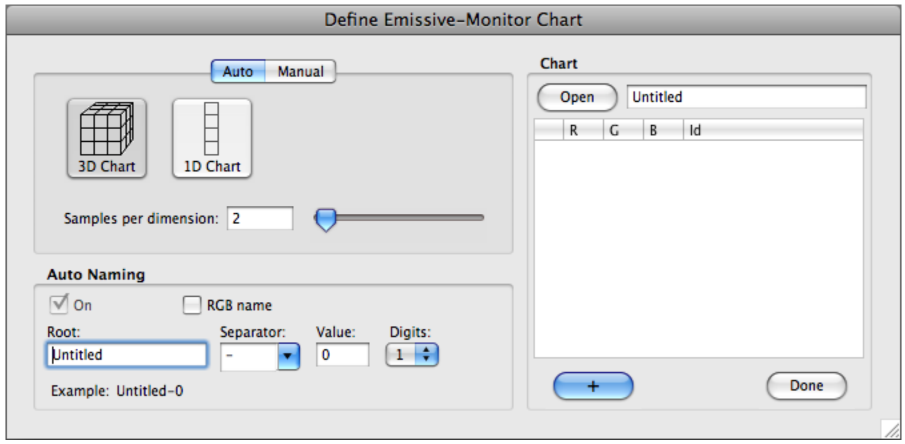
Charts can be created in one of two ways; automatically and manually.

Automatically created charts

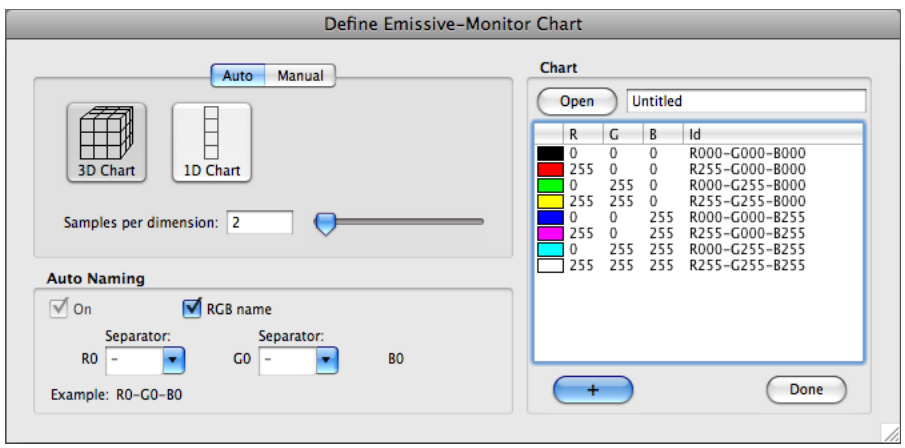
Charts can be created by varying the red, green and blue values to create a three-dimensional chart by selecting the *3D Chart* button. This type of chart is useful to determine the gamut of a monitor.

By selecting *1D Chart* a set of patches is generated with varying values for a single color selected from: red, green, blue, cyan, magenta, yellow or white. This type of chart is useful to measure the tonal reproduction curve for a monitor.

Once the parameters have been selected, clicking the + button will add patches to the chart patch list.



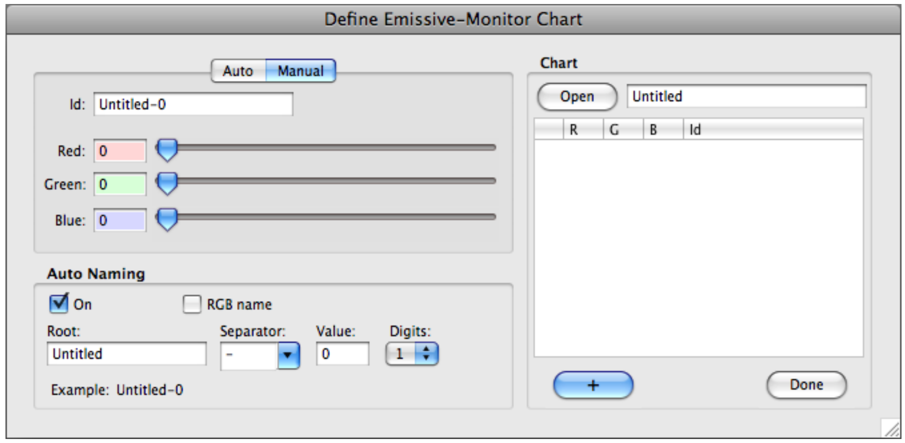
Define Emissive-Monitor Chart window before a chart is created.



A 3D chart created with the default of 2 samples per dimension and identifiers created from the RGB values.

Note: Since patches are added, not replaced, when the + button is clicked, charts can be defined with a mix of 3D, 1D and manually generated patches.

Manually created charts



Manual patch entry with pattern Auto Naming enabled.

When manual patch definition is selected the red, green and blue values are individually defined by numeric entry in the appropriate fields or by using the sliders, then the + button is clicked to add the patch to the list.

Editing a chart

Patches can be removed from the chart patch list by clicking on the patch to remove then pressing the *Delete* key (Macintosh) or the *Backspace* key (Windows).

Multiple contiguous patches are selected by clicking on the first patch to remove then shift-clicking on the last patch to select the range.

Non-contiguous patches can be selected by using command-click(Macintosh) or control-click (Windows) to select each patch.

Reflective Chart

A reflective chart can be defined as a rectangular array of patches or as a set of arbitrarily positioned patches.

Rectangular charts are the most common type, represented by physical charts such as the X-Rite ColorChecker®.

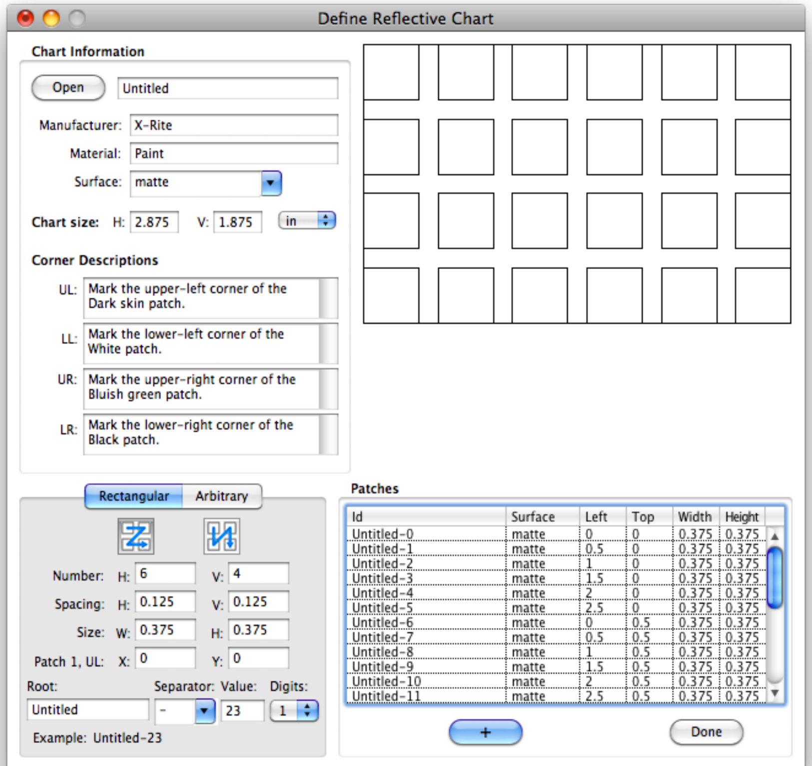
An example of an arbitrary chart is the OECF chart in which the patches are arranged in a circular pattern.

Rectangular Chart

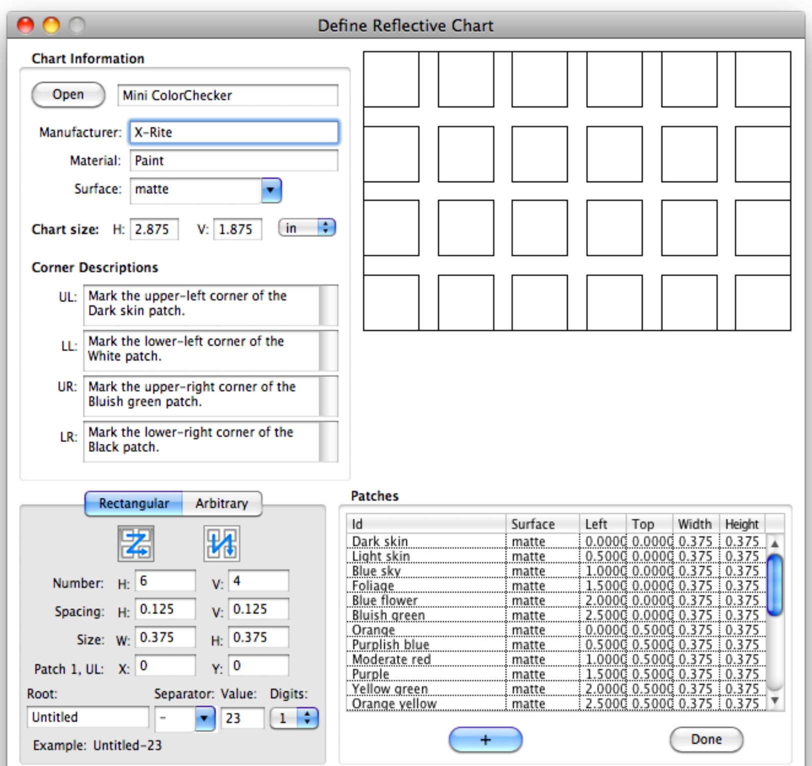
After filling in the physical description of the chart, corner descriptions and patch information, click the + button to add the patches to the patch list.

The *Corner Descriptions* are directions to an operator for locating the corner points of the chart. They are necessary because the physical corners of the chart are often not the ones used for locating patches. They allow the chart description file to be used for more than spectral measurements, such as processing images of the chart into XYZ or L*a*b* values.

After the patches have been entered into the list, the name and surface for each patch can be edited by clicking on the *Id* or *Surface* field in the patch list. The patch locations cannot be changed once they have been entered into the list.



Reflective chart definition after adding patches, before editing the patch names.



Reflective chart definition after editing the patch names.

However, it is possible to correct erroneous patches by deleting them then re-entering the patch. To delete one or more patches, click in the dimension area for the row with the patch to delete. The entire row will highlight. Press the Delete key to delete the patch from the list.

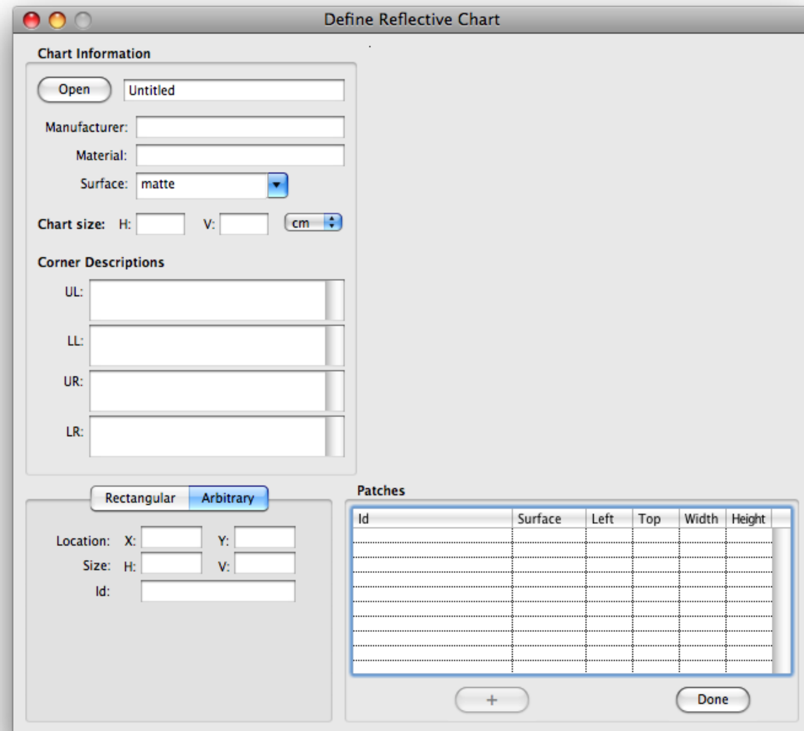
When the chart definition is complete, click the *Done* button. A dialog box will appear to allow for saving the chart definition or discarding it.

An existing chart definition can be edited by clicking the Open button and selecting the appropriate file. Then add or delete patches to make the new definition.

Arbitrary Chart

After filling in the definition for each patch, click the + button to add the patch to the patch list.

Since each patch can be added individually, any arbitrary layout of patches can be achieved.

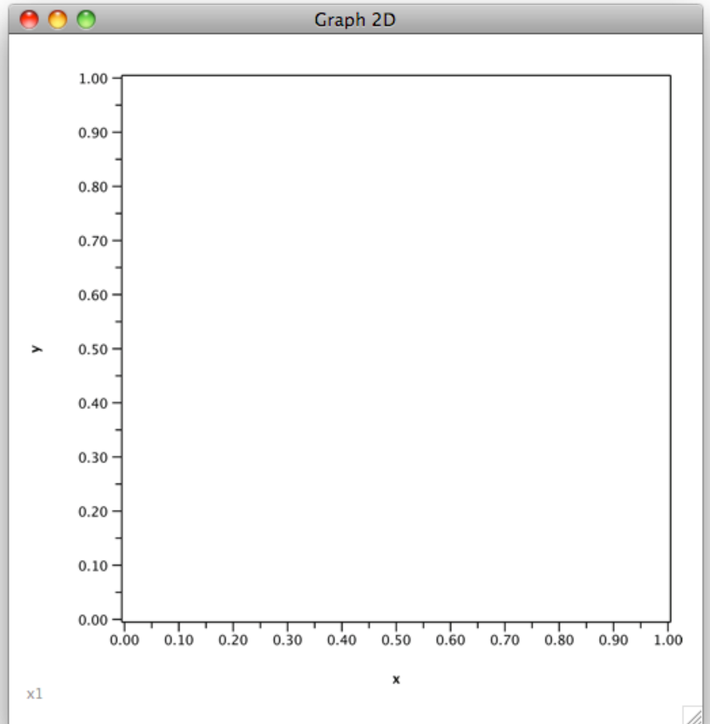


Arbitrary reflective chart definition before creating the chart.

Graph 2D Tool

Overview

This tool creates two-dimensional graphs of any two colorimetric values. These graphs are created as groups of specimens, either singly or paired. These groups can be linked with lines or directional arrows.

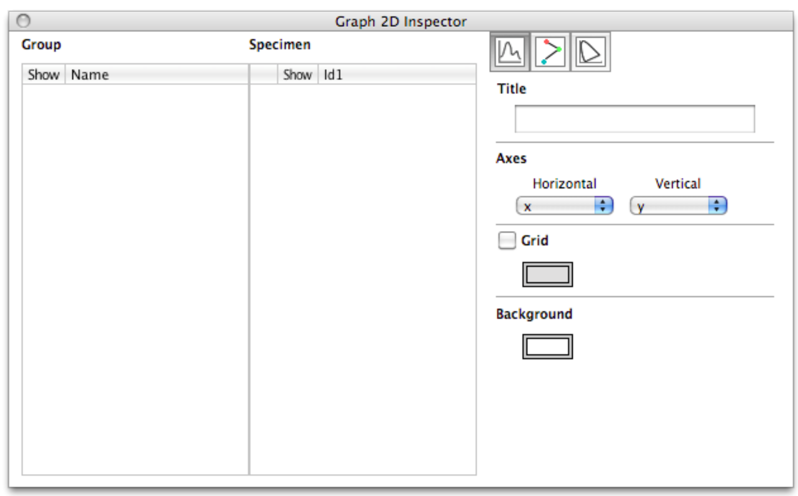


Graph Groups

Creating Groups

To create a graph, begin by selecting, then dragging specimens to the group area of the 2D Graph Inspector from any open collection. A group will be created and the colorimetric values displayed in the Graph 2D window.

Each set of specimens dropped into the Group list creates a new group. Each group can be individually selected for display by checking or unchecking the box next to each group's name, as can each individual specimen within a group.

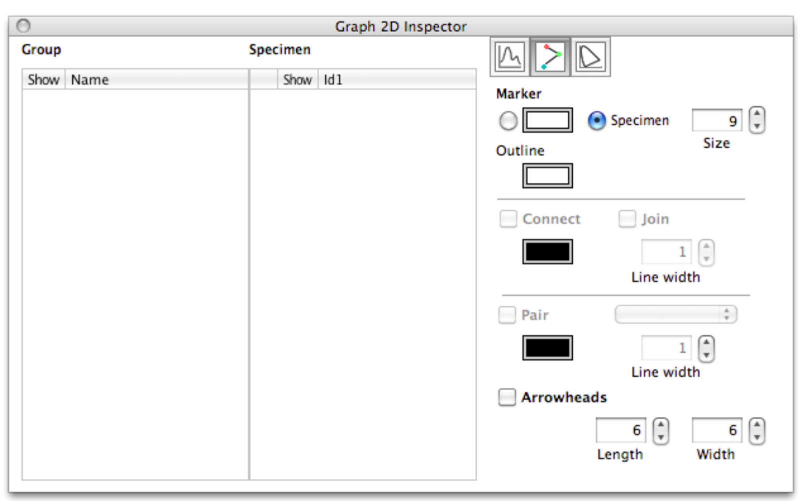


Renaming Groups

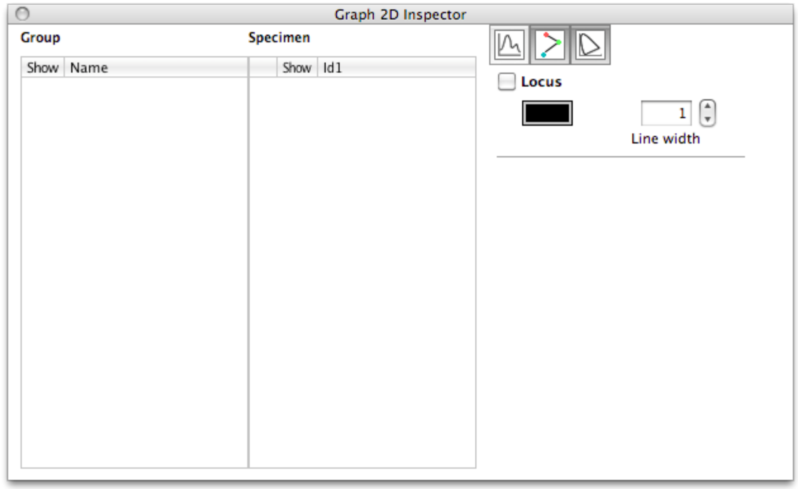
Each group can be renamed by selecting the group in the list, then entering a new name in the Name field.

Adding to a Group

When specimens are dropped into the Specimen list they are added to the currently selected group. Specimens are automatically displayed when added to a group. To hide a specimen, uncheck the Show box in the Specimen list.



Saving a Graph



When the Graph2D window is frontmost, the graph can be saved to a file by using the *File/Save Graph* menu command. The file format can be selected from JPEG, PNG, GIF or TIFF in the File Save dialog window.

> *Note: All file types are not available on all platforms.*

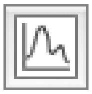
JPEG files are saved with the maximum quality setting to prevent any visible artifacts in the resulting image file.

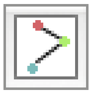
Printing a Graph

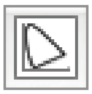
The graphs are created with sufficient resolution to allow for a minimum 10 inch print at a resolution of at least 300 ppi. To print the graph, select the *File/Print* menu command. Parameters relating to the printer's page definitions may be set using the *File/Page Setup* menu command. If the page has not been defined before the *Print* command is issued, *Page Setup* will be automatically executed before the *Print* command executes.

Graph 2D Properties

The properties are grouped by functionality represented by icons at the top of the *Graph 2D Inspector* window.

 Graph properties

 Group properties

 Locus properties

Click on any of the icons at the top of the window to show the associated attributes.

Graph Properties

Title

This is the title for the graph and it is displayed at the top of the graph window.

Axes

Any of the colorimetric properties may be selected for each graph axis.

When Specimen is selected for an axis, each specimen is listed along that axis versus the colorimetric value selected from the other popupmenu. A maximum of 24 specimens can be displayed in this manner. One use for this feature is to display tonal reproduction curves.

Grid

Checking the box will display the grid with the grid lines in the selected color.

Background

This is the color used for the graph's background. The default is a white background with black spectral curve lines. This works well unless the specimen's color is to be used for the line and the specimen is very light. The background may then be changed to a darker one to improve the visibility of the spectral curves.

Line

These properties control the color of the line; an arbitrary color or the specimen's color, and the width of the line. The default is to use a black line, one monitor pixel in width.

Min/Max

Checking the box will display a vertical line at each spectral sample interval. The line extends from the maximum to the minimum values at each interval. The default is to use a black line, one monitor pixel in width.

This feature is only displayed for averaged specimens with corresponding statistical data. Legacy specimens, or specimens from sources outside SpectraShop may not always provide this data.

Standard Deviation

Checking the box displays a vertical line at each spectral sample interval extending above and below the spectral curve by the standard deviation of that sample interval. The default is a red line one monitor pixel in width.

This feature is only displayed for averaged specimens with corresponding statistical data. Legacy specimens, or specimens from sources outside SpectraShop may not always provide this data.

Emissive Scaling

There are three choices provided for scaling emissive specimens.

Maximum of each scales each specimen so its maximum value corresponds to the 100% graph mark.

Maximum of all causes each specimen being graphed to be examined to find the one with the largest spectral maximum. All the other specimens are scaled to this value.

560 nm is often used to give all the displayed specimens a common reference point.

Group Properties

Marker

For reasons explained in the *Colorimetry* section, all spectra that are not natively sampled at 1 nm intervals are interpolated by SpectraShop™ to 1 nm. The resulting 1 nm spectrum can be displayed by checking *Show interpolated data* from the *Data Display* section.

Connect

All the members of a group can be connected with a line from member to member. This is a very useful property for showing gamuts and other group boundaries.

Checking the Join box will connect the last marker in the group to the first, creating a closed outline.

Pair

When the Pair box is checked individual members of a group will be connected by a line with the corresponding member of the group selected from the popup menu. If one group has more members than its pair, the number of pairings will be restricted to the group with the smallest membership.

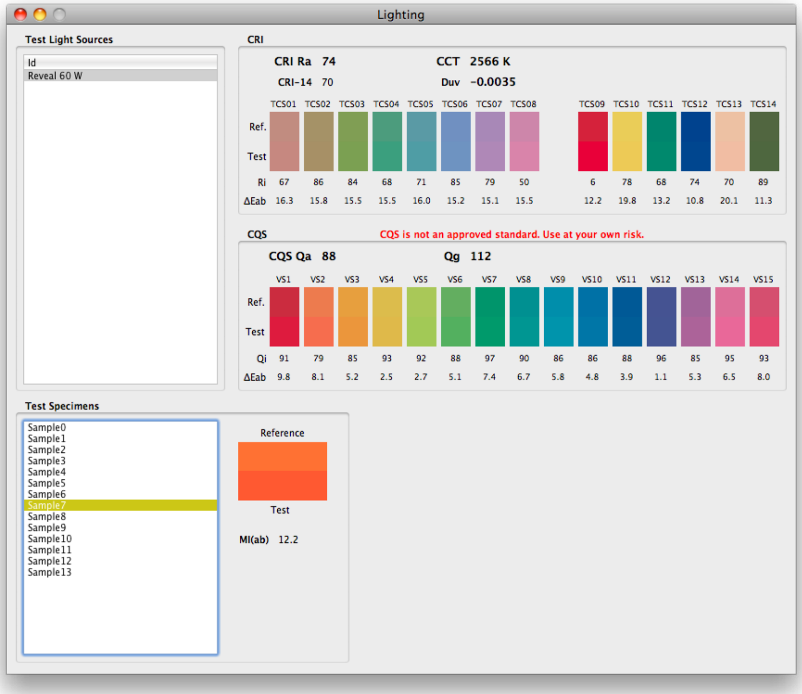
Checking the Arrowheads box will add arrowheads to each pairing line at the end of the line. The end of the line is always at the specimen in the group selected from the popup menu. One use for this feature is to show change trends between groups.

By carefully creating groups and pairings, spider graphs can be created.

Locus Properties

The spectral locus will be displayed for xy and u*v* diagrams when the Locus box is checked. The line width and color for the locus are also selectable.

Lighting Tool



When emissive-light specimens are dropped into the Test list the CRI and CQS will automatically be calculated for each specimen. Highlighting a Test specimen will display its computed values.

CRI

The Color Rendering Index (CRI) is intended to be a measure of how closely a light source mimics daylight. The standard CRI is calculated by simulating the test light reflected from 8 middle lightness, middle chroma colors and comparing the results with a simulation of a reference light source of the same correlated color temperature (CCT) as the test light source. For a CCT less than 4000 K, a plankian, or blackbody, radiator is used for the reference. Above 4000 K a simulated daylight reference source is used. The individual rendering indices (Ri) are averaged to obtain the General Color Rendering Index, reported as **CRI Ra**.

An additional 6 patches consisting of 4 high chroma patches, a flesh tone and a foliage patch are added to the 8 basic patches to create the Special Rendering Index, reported as CRI-14.

The distance in the 1960 uv color space of the test source from the reference source is displayed as Duv. A negative value indicates the test source coordinates are more magenta/red than the reference source. A positive value indicates the test source is more green/cyan than the reference source.

Simulated patch colors with the reference light source are displayed in two groups; the standard 8 patches and the 6 patch extended set. The test light source applied to each test patch is displayed immediately below the reference simulation. The individual patch rendering indices are displayed below each patch.

The ΔEab computed from the L*a*b* values for each patch with the test and reference sources is displayed below the patch.

CQS

When extending the results of the 8 middle chroma CRI patches to high chroma colors, the CRI often produces poor results. This is especially true for fluorescent, HID, HMI, LED and other sources whose spectra differ considerably from daylight or plankian radiators. This can be easily demonstrated by examining the high chroma patches in the extended CRI set for fluorescent sources. The red patch often produces negative values for some sources while the other extended patches produce low values, all while the basic patches result in a high CRI value. This makes the CRI value untrustworthy.

However, research has shown that when high chroma colors are used, then applying those results to middle and low chroma colors, the results are much more consistent. This is the basis of the Color Quality Scale (CQS).

In addition to using 15 high chroma colors, the equations used in calculating the CQS have been updated, replacing obsolete equations used for the CRI. Many low CCT sources produced unrealistically high CRI values which were not verified by actual optical comparison. CQS adds a slight penalty to low CCT sources to correct this situation.

The CQS has been proposed to the standards bodies as a replacement for CRI. Since it takes years for a proposal to be adopted, especially when it is supplanting an entrenched method, the CQS was included here to help foster research with new lighting sources. **However, since CQS is not an approved standard, use the CQS at your own risk.**

As with the CRI patches, the individual color quality indices and the ΔEab values are listed below each CQS patch.

Another new metric, intended to augment the CQS is the gamut area index. This is a ratio of the a*b* areas defined by the sample patches with the test illuminant and the reference illuminant. This value is reported as Qg.

Metamerism Index

CRI and CQS are calculated with specific color patch definitions with the individual differences between the reference light source and the test light source listed below each patch as ΔEab. In a similar manner the Metamerism Index (MI) can be calculated for any reflective specimens by dropping them into the Test Specimens list. When a test specimen is selected, the MI_{ab} is displayed along with simulations of the test specimen's appearance under the reference and test light sources, as shown in the screen capture.

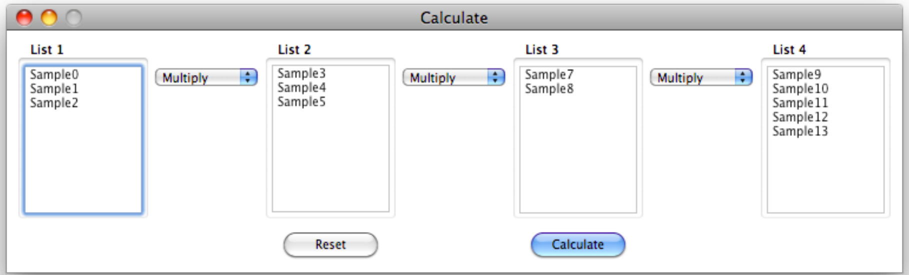
Exporting CRI/CQS Data

When the Lighting Tool is the active window the calculated CRI and CQS values for the specimens can be exported to a text file by choosing the File/Export menu command. A window will appear to ask whether the individual patch values should be added to the file. Once this question is answered, a file save dialog appears to allow naming the export file.

The file is derived from the CGATS.17 specification in a similar, but not exactly the same, format as the SpectraShop export file. The specimen identifiers, CCT, CRI, CRI-14 and CQS values are always output to the file. If requested, the individual Ri and Qi values are appended to each specimen's data.

Calculator Tool

Spectral calculations may be performed with up to four sets of specimens with this tool.



After dragging and dropping a set of specimens from a Collection into the List 1 area, the numerical operation popup menu for List 1 will be activated.

Depending on the selection from the first operation menu popup, List 2 list may or may not be activated. Operations that require only one operand (i.e. Average, Normalize, Scale by) will not enable the Spectrum 2 list.

Operators that require two operands (i.e. Add, Subtract, Multiply, Divide) will cause List 2 to be enabled for dragging and dropping the second set of specimens. Only two operand operators are permitted for the second and third operations.

Operations are performed by taking the first specimen in List 1, then performing the selected operation with the first specimen in List 2. The first List 1 specimen is then combined with the second List 2 specimen and so on until all the List 2 specimens have been combined with the first List 1 specimen. Operations continue with the second Spectrum 1 list specimen, and so on, until all the specimens of List 1 have been combined with all the List 2 specimens. If secondary or tertiary operations have been selected, the results from the first operation are combined with List 3 and List 4 specimens in a similar manner.

> *Note: This ability to cascade operations is a very powerful tool for performing some color analyses. For example; an illuminant could be placed in List 1, a reflective sample in List 2, with Multiply as the first operation, then a filter placed in List 3, with the Multiply operator for the second operation, and the spectral response of a sensor for List 4, again with the Multiply operator for the third operation. The result will then be a simulation of the sensor's spectral response for the reflective object in the color channel defined by the filter.*

The results of these calculations are placed in the topmost Collection window. The identifier for the resulting spectra will be a combination of the original specimen identifiers and the operation performed. For example, "SpecimenA" added to "SpecimenB" will result in a spectrum with an identifier of "SpecimenA+SpecimenB".

Note: To allow any specimen, regardless of the sampling interval and range, to be combined with any other, all the calculations are performed with the 1 nm data used for the colorimetric calculations in each Collection window.

Add

Each spectral band for each specimen in List 1 will be numerically added to the corresponding spectral band for each specimen in List 2. This is commonly used for combining colors in an additive situation, such as RGB color combining.

Subtract

Each spectral band for each specimen in List 2 will be numerically subtracted from the corresponding spectral band for each specimen in List 1. One use for this function is to remove offsets from the specimens.

Multiply

Each spectral band for each specimen in List 1 will be numerically multiplied with the corresponding spectral band for each specimen in List 2. This is a very commonly applied operation used to combine spectra for situations such as filters added to illuminants or light reflecting from an object's surface.

Divide

Each spectral band for each specimen in List 1 will be numerically divided by the corresponding spectral band for each specimen in List 2. This operation can be used to ratio one spectrum to another such as when a spectrophotometer is calibrated to an arbitrary white reference and the white reference must be removed from samples measured with this setup to result in the measured sample's spectrum.

Average

The spectra of all the specimens in List 1 list are averaged together to result in a single spectrum. The statistics of the minimum, maximum and standard deviation for each spectral band are calculated for the averaged result.

Normalize

Each specimen is the Spectrum 1 list is normalized to one of three choices; Maximum, 560 nm, or Wavelength.

Maximum will find the maximum response in each specimen's spectrum and normalize the spectrum to that value.

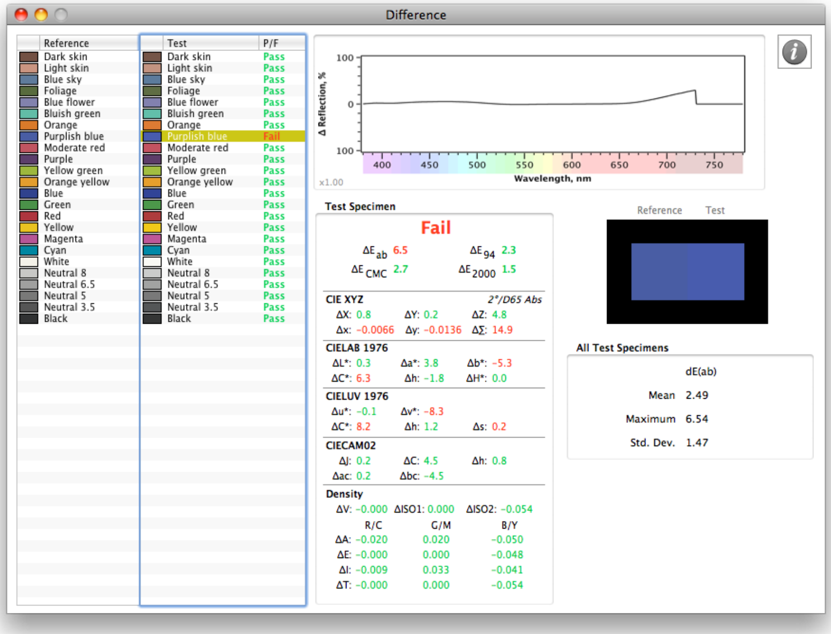
560 nm will cause the value for the 560 nm spectral band to be used to normalize the spectrum.

Wavelength will cause a field to appear adjacent to the Normalize Type popup menu. The spectrum will be normalized to the value corresponding to this wavelength.

Scale by

The spectrum will be multiplied by the value set in the numeric field below the operator popup menu.

Difference Tool



This tool allows for two types of comparisons; a list of specimens compared to a single reference specimen, or two paired lists of specimens.

Four combined metrics are computed; ΔE_{ab}, ΔE_{94}, ΔE_{CMC} and ΔE_{2000}. Any of these may be selected for the Pass/Fail indicator. Additionally, ΔCCT may be used for emissive-light specimens.

Single Reference Comparison

Drag a specimen from any open collection into the Reference list. Then drag one or more specimens into the Test list. Each test specimen will be compared against the reference. A pass or fail indicator is displayed next to each test specimen.

Selecting a test specimen will display all its calculated differences. For visual comparison, a simulated color patch is also displayed abutting a simulated reference color patch.

Paired Comparisons

When more than one specimen is placed in the Reference list, a paired comparison is created when specimens are dropped into the Test list. The comparisons are limited to the smallest list, additional specimens without a paired companion will not be used.

Difference Graph

When a test specimen is highlighted, a graph is displayed showing the spectral difference at each wavelength. The graph uses 1 nm data so if any of the comparisons involve specimens with unequal ranges or specimens which do not extend across the entire spectrum then sudden transitions may occur at the ends of the measurement range.

Saving a Spectral Graph

The spectral difference graph can be saved to a file by using the *File/Save Graph* menu command. The file format can be selected from JPEG, PNG, GIF or TIFF in the File Save dialog window.

> *All file types are not available on all platforms.*

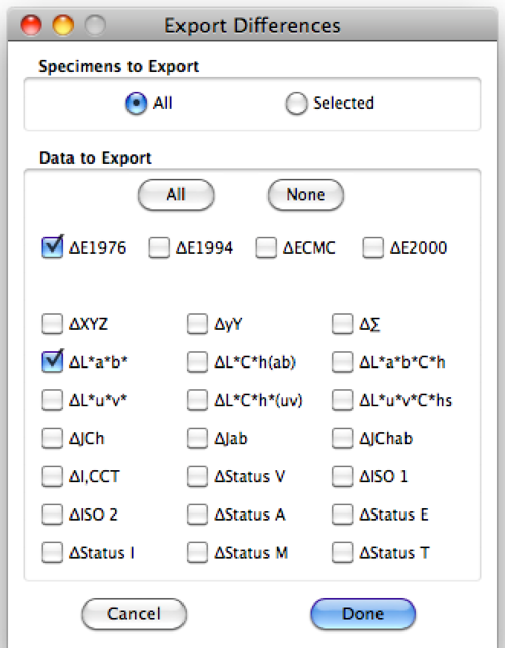
JPEG files are saved with the maximum quality setting to prevent any visible artifacts in the resulting image file.

Printing a Spectral Difference Graph

Difference graphs are created with sufficient resolution to allow for a minimum 10 inch print at a resolution of at least 300 ppi. To print the difference graph, select the *File/Print* menu command. Parameters relating to the printer's page definitions may be set using the *File/Page Setup* menu command. If the page has not been defined before the *Print* command is issued, *Page Setup* will be automatically executed before the *Print* command executes.

Exporting Difference Data

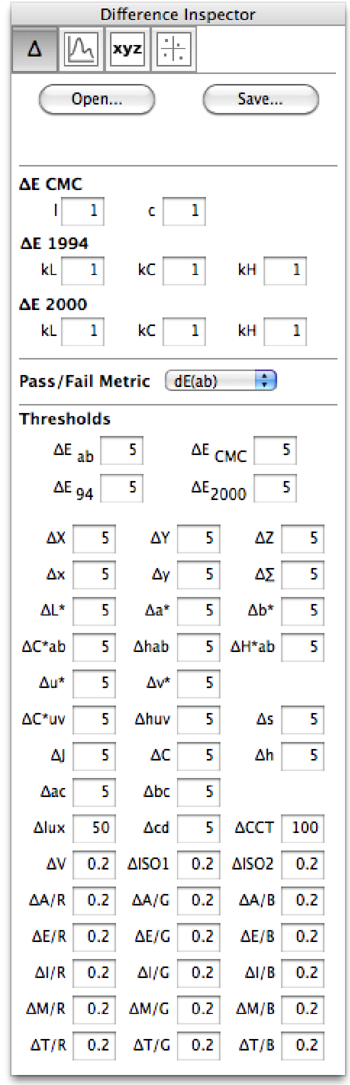
When the Reference and Test specimens have been specified, the difference data may be exported to a text file by selecting the *File/Export* menu command. A text file with a format similar to the SpectraShop text export is created which lists the ΔE values, the threshold values, the statistics for the entire test list and the Δ values selected from the *Data to Export* options.



Difference Inspector

Difference Properties

Opening and Saving Difference Thresholds



The values defined in the *Weighting Factors, Pass/Fail Metric and Thresholds* fields can be saved to, or retrieved from, a file with the *Open* and *Save* buttons.

Weighting Factors

Some metrics require setting weighting factors used to enhance or diminish aspects of the resulting ΔE value. Weighting factors may be set for the ΔE CMC, ΔE 1994 and ΔE 2000 calculations.

Pass/Fail Metric

In addition to the individual tolerance thresholds, one of the following values may be selected to control a pass or fail indicator for the entire specimen:

ΔE_{ab}

ΔE_{94}

ΔE_{CMC}

ΔE_{2000}

CCT

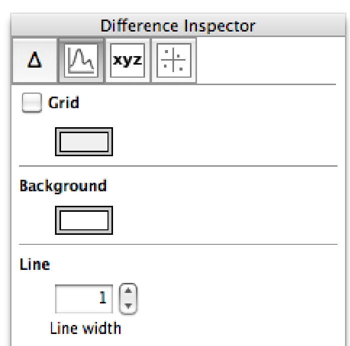
This indicator is useful when using the Difference tool for quality assurance and testing. It is displayed above the other difference values as either Pass, or Fail.

Thresholds

The Difference Inspector may be used to set the tolerance thresholds for all of the calculated metrics. These tolerances control the coloring of the values in the Difference window. Green text indicates the value is within the tolerance, red text for values outside their tolerance thresholds.

Difference Graph Properties

Grid



A grid can be displayed by checking the *Show* box. The color for the grid lines is selected by clicking in the *Color* box.

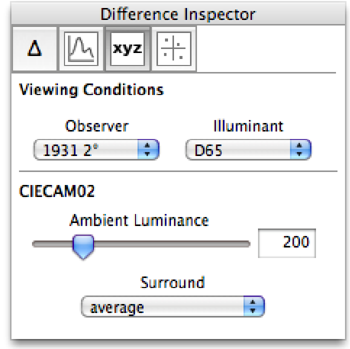
Background

The graph’s background color can be selected by clicking in the associated *Color* box.

Line

Currently the difference graph is always displayed with a black line. However, the width of the line can be adjusted to improve the line’s visibility.

Colorimetric Properties



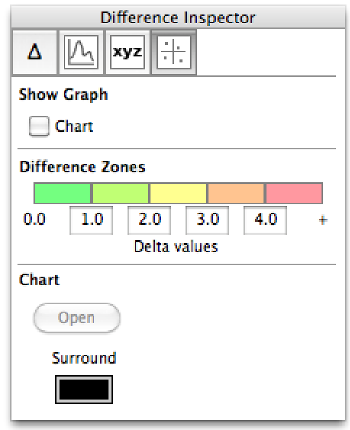
Viewing Conditions

Here the *Observer* and *Illuminant* can be selected for the colorimetric calculations.

CIECAM02

The adapting field luminance is selected from the *Ambient Luminance* field and slider. The *Surround* popup menu selects the brightness of the area surrounding the specimen.

Graph Properties



Show Graph

Checking the *Chart* box will display the chart difference graph window. In this window a color coded chart can be displayed with each patch's color defined by the difference values. The values used are the ones currently specified as the *Pass/Fail* metric.

Difference Zones

The zone boundary difference values are specified in the *Delta values* numeric fields below the zone patches. The number of zones and their colors are fixed to five with the given colors.

Chart

The chart displayed in the difference chart window can be either a reflective or transmissive chart which has been defined with the *Define Chart Tool*. It is selected with the *Open* button and its name will be displayed next to the button.

The color to use for the chart's background is selected with the *Surround* color box.

Differences for a ColorChecker® Passport's chart compared to a 1977 ColorChecker® Classic.

Import

SpectraShop™ can import spectral data in several different file formats for importing specimens from other programs and it can directly import stored data from a PR-655 instrument.

Supported formats:

- SpectraShop 3.
- MeasureTool, a program from the former GretagMacbeth, now X-Rite.
- CGATS.17, an ANSI standard color interchange format.
- Photo Research PR-655/PR-670 internally stored data.

SpectraShop 3

This format is based on the CGATS.17 format, but extended to include the additional metadata processed by SpectraShop but not found in CGATS.17. All the supported spectral types can be imported.

Note: the import file must include spectral data. Colorimetric only files will not be imported.

MeasureTool

This is a program for capturing measurements from a variety of X-Rite and GretagMacbeth instruments. Only reflective measurements are exported from MeasureTool.

CGATS.17

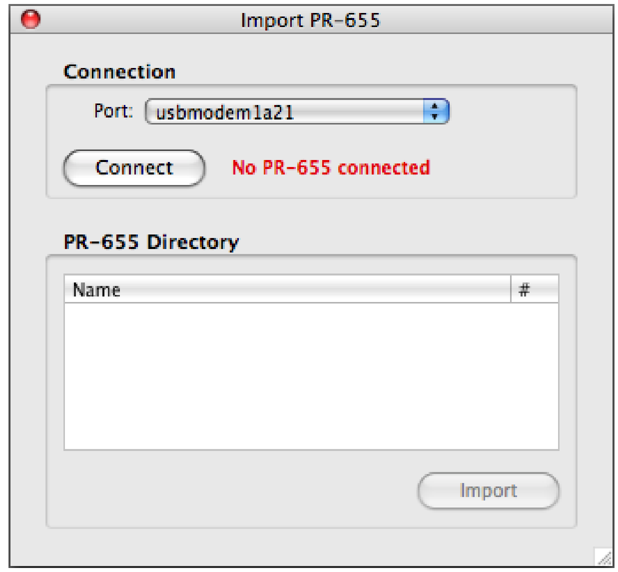
This is an ANSI standard format for interchanging colorimetric, density and spectral information between programs. There are ASCII and XML versions of this standard. At this time, only the ASCII version is supported by SpectraShop™.

Note: Only reflective and transmissive measurements are supported by the CGATS.17 format.

Note: SpectraShop will import only the spectral data from CGATS.17 files. Colorimetric files will not be imported and for files with both colorimetric and spectral data, only the spectral data will be imported.

PR-655/PR-670

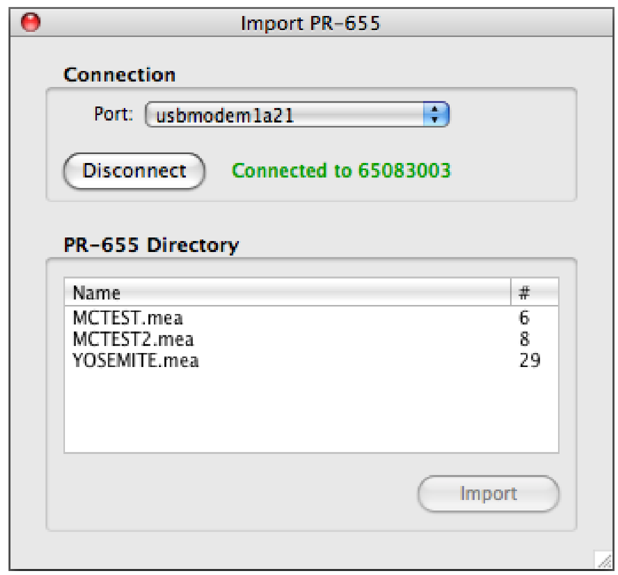
The PR-655 and PR-670 are non-contact telespectroradiometers. They can store data either in their internal memory or on an SD memory card. SpectraShop™ can import the data from the SD card, not from internal memory. There are some restrictions on how the data is stored.



Before connecting to the PR-655.

The PR-655/PR-670 stores multiple spectra into each data file on the card. Since the PR-655 can measure emissive, reflective and transmissive objects in any order, the spectra stored in each file could be a mixed collection of types. **SpectraShop™ requires that each file contain only a single type of specimen**. For example, all the spectra in a single file might be from reflective specimens. If multiple spectral types are to be measured, be sure to separate them into different storage files.

The second requirement is that **for reflective and transmissive files, the first spectrum in each file must be the white calibration tile**. SpectraShop™ will use this white tile data to properly scale the remaining spectra in the file. In the same manner as direct connect measurements, if a reference file has been opened in the Preferences for reflective specimens, the spectra will be imported as *absolute* referenced. Reflective specimens imported without the reference file will be marked as *relative*.



After connecting to the PR-655, with its directory information.

Here are the steps to import the PR-655 or PR-670 files.

1. Be sure the PR-655 or PR-670 is plugged into a USB port prior to selecting the *File/Import/PR-655* menu command.

2. Select the *File/Import/PR-655/PR-670* menu command.

3. Select the USB port into which the PR-655 or PR-670 is connected.

4. Click the *Connect* button. SpectraShop™ will attempt to open a connection to the PR-655/ PR-670.

5. If the PR-655 or PR-670 was not connected, click *Connect* a second time.

6. If the connection is not made then cancel the import process, reset the PR-655 or PR-670 then start the import process again.

7. If it is successful the PR-655 or PR-670 serial number will be displayed in green text, then the instrument’s file directory will be listed.

8. Select the files to import by clicking on the directory entries. Multiple entries may be selected by using the shift-click for contiguous files or the command-click (control-click on Windows) for non-contiguous files.

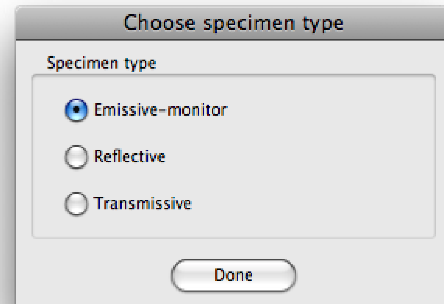
One or more files must be selected before the *Import* button is enabled.

9. Click the *Import* button.

10. Each file will be imported into its own new collection with each contained spectrum entered as a separate specimen.

a. If a CR-655 or CR-670 cosine corrector is used for the measurements then the specimen types will be entered as emissive-light.

b. If the MS-75 lens is used for the measurements then a window will appear to allow for selecting the specimen type. This will appear only once at the beginning of the import process for the instrument's file. Remember, all the specimens in a file are assumed to be of the same type. **Reflective and transmissive files MUST have a white calibration as the FIRST measurement in the file.**

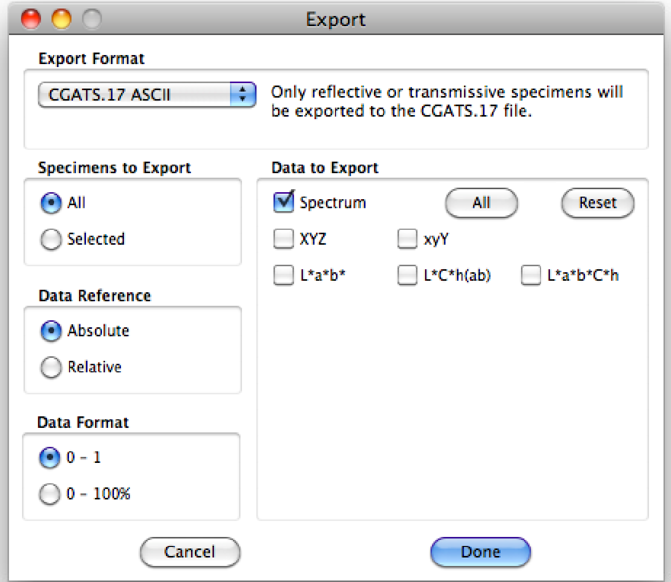


11. Edit the collection to add the appropriate specimen information, then save the collection.

12. When finished importing files, click the *Disconnect* button or close the window to return the PR-655 or PR-670 to normal operation.

Export

SpectraShop™ can export spectral data in several different file formats for working with the data in other programs.



Supported formats:

- SpectraShop 3.
- MeasureTool, a program from the former GretagMacbeth, now X-Rite.
- CGATS.17, an ANSI standard color interchange format.
- Raw spectral data only (no metadata is exported).
- InCamera illuminant file.

Supported Data Types

	File Format				
Specimen Type	**SpectraShop 3**	**CGATS.17**	**MeasureTool**	**Raw Data Only**	**InCamera Illuminant**
Emissive-light	●			●	●
Emissive-monitor	●			●	
Reflective	●	●	●	●	
Transmissive	●	●		●	

SpectraShop 3

This file format is based on CGATS.17, but extended to handle all the spectral types and metadata used by SpectraShop. All the colorimetric values can be exported.

MeasureTool

This is a program for capturing measurements from a variety of X-Rite and GretagMacbeth instruments. Only reflective measurements are exported from SpectraShop.

CGATS.17

This is an ANSI standard format for interchanging colorimetric, density and spectral information between programs. There are ASCII and XML versions of this standard. At this time, only the ASCII version is supported by SpectraShop™.

Note: Only reflective and transmissive measurements are supported by the CGATS.17 format.

The CGATS.17 format supports several types of colorimetric values which can be selected from the *Data to Export* section. Spectral data and colorimetric data can be exported in the same file. Along with the colorimetric data, the observer and illuminant will be included in the file's metadata.

Raw Spectra

There are a few programs that need raw spectral data only, usually for a single specimen. This format allows multiple spectra to be exported, but no metadata is included in the file. Wavelength and response are the only information. Multiple specimens are separated by a blank line.

Note: Because there is no metadata, not even an identifier, exporting with this format is very risky and should be used only if you have a program needing such basic data.

InCamera Illuminant

The camera profiling application InCamera uses a version of the SpectraShop 2 export format for its custom illuminant files. This file will contain a single emissive-light specimen with a minimum of metadata.

Data Reference

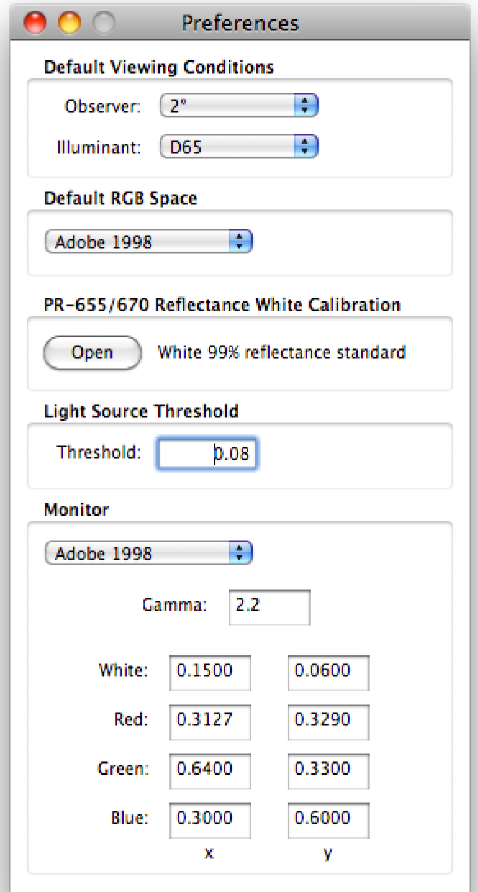
Used to select the reference for the data; absolute or relative. Absolute referred data is referred to an absolute physical standard, such as W/m^2sr. Relative data is referred to a particular spectrum, such as referencing monitor colors to the monitor's white spectrum.

Data Format

The CGATS.17 format allows for spectral data to be expressed in the range of 0.0 to 1.0, or in the range of 0.0 to 100.0%. The upper values represent the normal data limit, they are not absolute limits; data is not compressed or clipped to fit within these ranges. Fluorescent objects are an example of reflective objects that often exceed 100% reflectance.

Preferences

Default Viewing Conditions



You may specify the default observer and illuminant for new collections by selecting values from the popup menus.

Default RGB Space

This is used for the conversion of XYZ coordinates into RGB values. When SpectraShop is opened for the first time sRGB is the default RGB space.

PR-655/670 Reference White Calibration

Click the Open button to load the reference data for the white calibration tile to be used with a PR-655 or PR-670 for reflective measurements. This file is a standard SpectraShop 3 collection file with a single specimen.

Light Source Threshold

This value is used for transmissive calibration with the i1Pro, Spectrolino and PR-655/670 for determining when the illumination is too low to be reliable. It is also used with the PR-655/670 for reflective measurements.

Monitor

The Monitor preferences are used for calculating the simulated color patches in the Collection, Lighting and Difference windows. The values control the chromatic adaptation transform (CAT) and the calculation of the RGB values used for the simulated color patches. The CAT is used to account differences in between the viewing illuminant and the monitor's white point.

Selecting *Custom* permits setting the patch simulations to be more accurate when the monitor's white point and primaries are not one of the standard RGB spaces.

Saving Preferences

The preferences are automatically saved when the window is closed.

Note: The preference file contains the actual data for the PR-655/670 white reference, so there is no need to reopen the reference file if it is moved to a different storage location.

Appendix A – Chart Definition File Format

The file is an ASCII text file containing a sequence of lines consisting of one or more keywords followed by other keywords or the corresponding parameters and data. A line is terminated by the carriage return character. Each keyword is separated from its parameter by white space consisting of either a tab or a space character. A tab character is recommended for easier formatting in word processing programs.

Required keywords for all chart types

Keyword	Parameter	Explanation
`SpectraShop Chart`	version number	'3.0' for this release. Signifies the standard used for the file encoding. Must be the first item encountered in the file.
`SPECIMEN_ID`	string	Identifies the specimen.

`SPECTRUM_TYPE`	string
	one of:
	`"emissive_monitor"`
	`"reflective"`
	`"transmissive"`
		Defines the type of spectrum in the record.

`MANUFACTURER`	string	Manufacturer of the chart.
`MATERIAL`	string	Composition of the patches.
`NUMBER_OF_PATCHES`	integer	Number of patches contained in the chart.
`CHART_XSIZE`	float	Horizontal size of the chart from the defined chart origin.
`CHART_YSIZE`	float	Vertical size of the chart from the defined chart origin.
`BEGIN_DATA_FORMAT`		Marks the beginning of the list of data value identifiers.
`END_DATA_FORMAT`		Marks the end of the list of data value identifiers.
`BEGIN_DATA`		Marks the beginning of the data value list defined by the data value identifier list and the NUMBER_OF_SETS data keyword.
`END_DATA`		Marks the end of the data value list.

`SURFACE`	string
	one of:
	`"matte"`
	`"semi-gloss"`
	`"gloss"`
	`"metallic"`
	`"interference"`
	`"na"`
		Type of surface for a reflective specimen.

PATCH_LEFT	float	Horizontal position for the upper-left corner of the patch from the defined chart origin, in millimeters.
PATCH_TOP	float	Vertical position for the upper-left corner of the patch from the defined chart origin, in millimeters.
PATCH_WIDTH	float	Horizontal size of the patch, in millimeters.
PATCH_HEIGHT	float	Vertical size of the patch, in millimeters.
ID	string	Identifies the chart patch.

Required keywords for XY table charts

CHART_UPPER_LEFT	string	Message to the operator defining the chart origin.
CHART_LOWER_LEFT	string	Message to the operator defining the chart's vertical extent.
CHART_UPPER_RIGHT	string	Message to the operator defining the chart's horizontal extent.
CHART_LOWER_RIGHT	string	Message to the operator defining the chart's horizontal extent.

Optional keywords

#		Comment identifier. Any data until the next end-of-line character is ignored by the automatic reader.

Appendix B – SpectraShop 3 Import/Export Text Format

The file is a text file containing a sequence of lines consisting of one or more keywords followed by other keywords or the corresponding parameters and data. A line is terminated by a carriage return character and a linefeed character. Each keyword is separated from its parameter by white space consisting of a tab character. The tab character makes it easier to process the file in spreadsheet or text editing programs.

File Structure

The file is composed of three parts: a file header, measurement metadata, specimen data.

Part 1: The file header consists of keywords and parameters which apply to the entire collection contained within the file.

Part 2: The next section contains the measurement metadata in common to all the specimens within the following specimen section.

Part 3: The third section consists of the metadata and data for each specimen.

Whenever a metadata item in the measurement metadata changes, a new Part 2 is written, followed immediately by the associated Part 3 specimens. Thus Parts 2 and 3 are repeated until all the specimens within the collection are written.

Example: a collection consisting of reflective specimens followed by emissive-light specimens would be represented in the file as the file header, then the reflective measurement metadata, the reflective specimens, the emissive-light measurement metadata followed by the emissive-light specimens.

File Header Section
Metadata Section 1
Data Section 1
...
Metadata Section n
Data Section n

Import/Export file layout

File Section Keywords

Keyword	Parameter	Required?	Description
SpectraShop	3.0	Yes	Signifies the standard used for the file encoding. Must be the first item encountered in the file.
FILE_DESCRIPTOR	string		Description of the purpose or content of the record.
NUMBER_OF_SETS	integer	Yes	Number of specimens in the file.

Metadata Section Keywords

Keyword	Parameter	Required?	Description
#			Comment identifier. Any data until the next end-of-line characters is ignored by the file reader.
ACQUIRE_NOTE	string		Note relating to the spectra acquisition.
BEGIN_DATA_FORMAT		Yes	Marks the beginning of the list of data value identifiers.
CREATED	date string		Date the spectra were created or measured.
END_DATA_FORMAT		Yes	Marks the end of the list of data value identifiers.
ILLUMINANT	string	Note 1	Defines the illuminant used for calculating colorimetric values for reflective and transmissive specimens.
INSTRUMENTATION	string		Instrument used to make the spectral measurements.
MANUFACTURER	string		Manufacturer of the specimens.
MATERIAL	string		Composition of the specimens.
MEASUREMENT_GEOMETRY	string		Geometry of the instrument used to make the spectral measurements.
MEASUREMENT_SOURCE	string		Light source used with the instrument to make the spectral measurements.
MEASUREMENT_APERTURE	string		Instrument's measurement aperture size, usually expressed in millimeters.
MEASUREMENT_FILTER	string		Filter used on the spectrophotometer during the measurements.
MODEL	string		Model number, if applicable, for the specimens.
NMEASURE	integer		Number of measurements per specimen.
NOTE	string		Notes relating to the specimens.
NUMBER_OF_FIELDS	integer	Yes	Must precede the BEGIN_DATA_FORMAT keyword. Number of data format identifiers prescribed in the data format definition that follows.
OBSERVER	string	Note 1	Defines the standard observer used for calculating the colorimetric values.
ORIGINATOR	string		Specific system, organization, or individual originating the spectra.
PROD_DATE	date string		Date when the specimens were manufactured.
RGB_SPACE	string	Note 2	Defines the RGB space used for calculating RGB values.

Keyword	Parameter	Required?	Description
SAMPLE_BACKING	string		Backing used behind reflective samples during the measurement.
SERIAL	string		Serial number, if applicable, for the object being measured.
SPECTRUM_TYPE	string	Yes	Signifies the standard used for the file encoding. Must be the first item encountered in the file.
SURFACE	string		Type of surface for a reflective specimen.

Note 1: Required for colorimetric data export.

Note 2: Required for RGB data export.

Data Format Keywords

Keyword	Associated Data Value	Required?	Description
CCT	float		Correlated Color Temperature. Emissive light or monitor value.
CD	float		Cd/m^2. Emissive monitor radiance.
DOM_NM	float		Dominant wavelength.
ISO1	float		ISO1 density value.
ISO1	float		ISO2 density value.
JCH_A	float		CIECAM02 a* value. Redness-greenness.
JCH_B	float		CIECAM02 b value. Yellowness-blueness.
JCH_C	float		CIECAM02 C* value. Chroma.
JCH_H	float		CIECAM02 H* value. Hue angle, in degrees.
JCH_J	float		CIECAM02 J* value. Lightness.
LAB_A	float		CIELAB 1976 a* value. Redness-greenness.
LAB_B	float		CIELAB 1976 b* value. Yellowness-blueness.
LAB_C	float		CIELAB 1976 C* value. Chroma.
LAB_H	float		CIELAB 1976 h value. Hue angle, in degrees.
LAB_L	float		CIELAB 1976 L* value. Lightness.
LUV_C	float		CIELUV 1976 C* value. Chroma.
LUV_H	float		CIELUV 1976 h value. Hue angle, in degrees.
LUV_L	float		CIELUV 1976 L* value. Lightness.
LUV_S	float		CIELUV 1976 s value. Saturation.
LUV_U	float		CIELUV 1976 u* value. Redness-greenness.
LUV_V	float		CIELUV 1976 v* value. Yellowness-blueness.
LUX	float		Lux. Emissive light illuminance.
PE	float		Excitation purity.
RGB_B	integer		RGB blue value.
RGB_G	integer		RGB green value.
RGB_R	integer		RGB red value.
RGB_OUT_OF_GAMUT	string		RGB clipped? Value is “True” or “False”.
SAMPLE_ID1	string	Yes	First specimen identifier.

Keyword	Associated Data Value	Required?	Description
SAMPLE_ID2	string		Second specimen identifier.
SAMPLE_ID3	string		Third specimen identifier.
SPECTRAL_END	integer	Note 1	Ending wavelength for the specimen spectra.
SPECTRAL_INC	integer	Note 1	Width of each band for the specimen spectra.
SPECTRAL_START	integer	Note 1	Starting wavelength for the specimen spectra.
SPECTRAL_SUM	float		Sum of spectral bands, approximate integral.
SPECTRAL_VAL	float	Note 1	Denotes a spectral value for a measurement band. For non-fluorescing reflective and transmissive spectra the data is in the range 0-1. For emissive specimens the data is in W/(m^2 sr nm).
STATUS_A_B	float		Status A blue density.
STATUS_A_G	float		Status A green density.
STATUS_A_R	float		Status A red density.
STATUS_E_B	float		Status E blue density.
STATUS_E_G	float		Status E green density.
STATUS_E_R	float		Status E red density.
STATUS_I_B	float		Status I blue density.
STATUS_I_G	float		Status I green density.
STATUS_I_R	float		Status I red density.
STATUS_M_B	float		Status M blue density.
STATUS_M_G	float		Status M green density.
STATUS_M_R	float		Status M red density.
STATUS_T_B	float		Status T blue density.
STATUS_T_G	float		Status T green density.
STATUS_T_R	float		Status T red density.
STATUS_V	float		Visual density.
UV_U	float		1964 u' value.
UV_V	float		1964 v' value.
WATTS	float		W/(m^2 sr). Emissive light or monitor intensity.
XYY_X	float		Chromaticity x value.
XYY_Y	float		Chromaticity y value.
XYY_CAPY	float		Chromaticity Y value, same as XYZ_Y.
XYZ_X	float		Tristimulus X value.
XYZ_Y	float		Tristimulus Y value.
XYZ_Z	float		Tristimulus Z value.

Note 1: Required for a SpectraShop import file.

Specimen Data Keywords

Keyword	Parameter	Required?	Description
BEGIN_DATA		Yes	Marks the beginning of the specimen data list defined by the data format list and the NUMBER_OF_SETS data keyword.
END_DATA		Yes	Marks the end of the specimen list.

Keyword Parameters

Keyword	Parameter Values
ILLUMINANT	Select one of: “A”, “C”, “D50“, “D55“, “D65“, “D75“, “E“, “F1“, “F2“, “F3“, “F4“, “F5“, “F6“, “F7“, “F8“, “F9“, “F10“, “F11“, “F12“
MEASUREMENT_FILTER	Examples: “Polarizer”, “UV Block”
MEASUREMENT_GEOMETRY	Examples: “45/0”, “d/0”, “d/8 SCI”
OBSERVER	Select one of: “2 degree”, “10 degree”
RGB_SPACE	Examples: “Adobe RGB”, “sRGB”, “Wide Gamut”
SAMPLE_BACKING	Examples: “Black”, “White”, “Substrate”, “Self”
SPECTRUM_TYPE	Select one of: “Emissive-light”, “Emissive-monitor”, “Reflective”, “Transmissive”
SURFACE	Examples: “Matte”, “Semigloss”, “Gloss”, “Metallic”

Parameter and Data Values

Parameter or Value type	Description
date string	A series of numeric characters 0 through 9, inclusive, with separating hyphen characters and representing the ISO 8601 format YYYY-MM-DD. Example: 2001-01-25 is 25 January 2001
float	A combination of numeric characters 0 through 9, the decimal point character (.) and optionally including an exponent consisting of an E character with either a plus (+) or a minus (-) character. The data should include a decimal point character. A decimal point will be assumed at the end of the number if it does not contain one. Numbers less than 1 must contain a leading 0 and decimal point. Examples: 10.45 0.3456 1.2345E+1 2.4567E-2 1.2345E1
integer	A combination of numeric characters 0 through 9, inclusive, without a decimal point or other alphanumeric characters. Example: 123

Parameter or Value type	Description
string	A series of alphanumeric characters enclosed within quote (“) characters. Quote characters are not allowed within the string. The first occurrence of a quote within the string terminates the string, thus, the use of the double-quote to denote a single quote character (C language syntax) is not supported. Example: “this is a string”

Items Requiring New Metadata Section Definition

This table lists the keywords that when their values change within a collecton a new metadata section must be written to the import/export file.

Keyword
ACQUIRE_NOTE
CREATED
INSTRUMENTATION
MANUFACTURER
MATERIAL
MEASUREMENT_GEOMETRY
MEASUREMENT_SOURCE
MEASUREMENT_APERTURE
MEASUREMENT_FILTER
MODEL
NMEASURE
NOTE
ORIGINATOR
PROD_DATE
SAMPLE_BACKING
SERIAL
SPECTRAL_END
SPECTRAL_INC
SPECTRAL_START
SPECTRUM_TYPE
SURFACE

Example 1

This file illustrates a file with a single reflective specimen. All keywords and values are separated by tab characters. Each line ends with a carriage return character and a linefeed character. Spectral values are required to be contiguous within the file.

```
SpectraShop	3.0
FILE_DESCRIPTOR	"Theoretical 18% gray reference."
NUMBER_OF_SETS	1
ORIGINATOR	"Robin D. Myers"
CREATED	"2001-04-13"
SPECTRUM_TYPE	"Reflective"
SURFACE	"Matte"
INSTRUMENTATION	"Reference"
MEASUREMENT_GEOMETRY	"45/0"
MEASUREMENT_SOURCE	"A"
MEASUREMENT_APERTURE	""
MEASUREMENT_FILTER	"None"
NSAMPLES	1
OBSERVER	"2 degree"
ILLUMINANT	"D65"
RGB_SPACE	"sRGB"
NUMBER_OF_FIELDS	51
BEGIN_DATA_FORMAT
SAMPLE_ID1	SAMPLE_ID2	SAMPLE_ID3	XYZ_X	XYZ_Y	XYZ_Z	LAB_L	LAB_A	LAB_B	RGB_R	RGB_G	RGB_B
SPECTRAL_START	SPECTRAL_END	SPECTRAL_INC	SPECTRAL_VAL	SPECTRAL_VAL
SPECTRAL_VAL	SPECTRAL_VAL	SPECTRAL_VAL	SPECTRAL_VAL	SPECTRAL_VAL
SPECTRAL_VAL	SPECTRAL_VAL	SPECTRAL_VAL	SPECTRAL_VAL	SPECTRAL_VAL
SPECTRAL_VAL	SPECTRAL_VAL	SPECTRAL_VAL	SPECTRAL_VAL	SPECTRAL_VAL
SPECTRAL_VAL	SPECTRAL_VAL	SPECTRAL_VAL	SPECTRAL_VAL	SPECTRAL_VAL
SPECTRAL_VAL	SPECTRAL_VAL	SPECTRAL_VAL	SPECTRAL_VAL	SPECTRAL_VAL
SPECTRAL_VAL	SPECTRAL_VAL	SPECTRAL_VAL	SPECTRAL_VAL	SPECTRAL_VAL
SPECTRAL_VAL	SPECTRAL_VAL	SPECTRAL_VAL	SPECTRAL_VAL
END_DATA_FORMAT
BEGIN_DATA
"18% Gray aim point"	""	""	17.11	18.00	19.60	49.50	-0.00	-0.00	117	117	117
380	730	10	0.180000	0.180000	0.180000	0.180000	0.180000	0.180000
0.180000	0.180000	0.180000	0.180000	0.180000	0.180000	0.180000
0.180000	0.180000	0.180000	0.180000	0.180000	0.180000	0.180000
0.180000	0.180000	0.180000	0.180000	0.180000	0.180000	0.180000
0.180000	0.180000	0.180000	0.180000	0.180000	0.180000	0.180000
0.180000	0.180000
END_DATA
```

Example 2

This file illustrates a file with two specimens; a single reflective specimen and a single emissive light specimen. Since the spectrum type changes from the first to the second specimen a new metadata section is written for the second specimen. Also note that the data format declaration changes for the emissive light specimen. The "ICCT" data was selected in the Export window, but since that does not apply to reflective specimens it is not included in the first metadata section but it is included for the emissive light specimen's metadata section.

```
SpectraShop      3.0
FILE_DESCRIPTOR  "Theoretical 18% gray reference."
NUMBER_OF_SETS   2
ORIGINATOR "Robin D. Myers"
CREATED     "2001-04-13"
SPECTRUM_TYPE    "Reflective"
SURFACE     "Matte"
INSTRUMENTATION  "Reference"
MEASUREMENT_GEOMETRY  "45/0"
MEASUREMENT_SOURCE    "A"
MEASUREMENT_APERTURE  ""
MEASUREMENT_FILTER    "None"
NSAMPLES    1
OBSERVER    "2 degree"
ILLUMINANT "D65"
RGB_SPACE  "sRGB"
NUMBER_OF_FIELDS 42
BEGIN_DATA_FORMAT
SAMPLE_ID1 SAMPLE_ID2 SAMPLE_ID3 SPECTRAL_START   SPECTRAL_END     SPECTRAL_INC
SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL
SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL
SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL
SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL
SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL
SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL
SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL
SPECTRAL_VAL
END_DATA_FORMAT
BEGIN_DATA
"18% Gray aim point"  ""    ""    380   730   10    0.180000    0.180000    0.180000
0.180000    0.180000    0.180000    0.180000    0.180000    0.180000    0.180000
0.180000    0.180000    0.180000    0.180000    0.180000    0.180000    0.180000
0.180000    0.180000    0.180000    0.180000    0.180000    0.180000    0.180000
0.180000    0.180000    0.180000    0.180000    0.180000    0.180000    0.180000
0.180000    0.180000    0.180000    0.180000    0.180000
END_DATA
ORIGINATOR "Robin D. Myers"
CREATED     "10.07.2000"
SPECTRUM_TYPE    "Emissive-light"
SURFACE     "N/A"
INSTRUMENTATION  "Reference"
MEASUREMENT_GEOMETRY  "0/d"
MEASUREMENT_SOURCE    "N/A"
MEASUREMENT_APERTURE  ""
MEASUREMENT_FILTER    "None"
```

```
NSAMPLES   1
ACQUIRE_NOTE     "Measuring Colour, Second Edition, R.W.G. Hunt"
OBSERVER   "2 degree"
ILLUMINANT "D65"
NUMBER_OF_FIELDS 44
BEGIN_DATA_FORMAT
SAMPLE_ID1 SAMPLE_ID2 SAMPLE_ID3 LUX   CCT   SPECTRAL_START   SPECTRAL_END
SPECTRAL_INC     SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL
SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL
SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL
SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL
SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL
SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL
SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL     SPECTRAL_VAL
SPECTRAL_VAL     SPECTRAL_VAL
END_DATA_FORMAT
BEGIN_DATA
"A"   ""    ""    73682.3    2857  380   730   10    0.097951   0.120853   0.147080
0.176753   0.209950   0.246709   0.287027   0.330859   0.378121   0.428693
0.482423   0.539132   0.598611   0.660635   0.724959   0.791326   0.859470
0.929120   1.000000   1.071840   1.144360   1.217310   1.290430   1.363460
1.436180   1.508360   1.579790   1.650280   1.719630   1.787690   1.854290
1.919310   1.982610   2.044090   2.103650   2.161200
END_DATA
```

Appendix C – Converting SpectraShop 1 and 2 Files

SpectraShop 3 will read version 1 and 2 collection files, converting all the data with the exception of two item; emissive specimens and date formats.

Specimen Type

Since version 3 now differentiates between emissive-light and emissive-monitor measurements, when version 1 or 2 collections are opened there is no way to decide which type for each emissive specimen. By default they will be tagged as emissive-monitor. To change this designation, select all the specimens that should be changed then click the *Edit Metadata* icon. The specimen type may then be changed.

Date

SpectraShop 1 and 2 treated all dates as strings. This allowed for any date format but it made a problem for converting them into the ISO 8601 date format used by SpectraShop 3. As a string the date may be expressed in a wide variety of formats. A few examples are below.

7 January 2004

January 7, 2004

1/7/2004

1/7/04

7.1.2004

7/1/2004

2004.1.7

2004 Jan. 7

7 Jan 2004

The problem can be seen in the examples above. It is impossible to tell the day from the month in short date formats when the day is less than 13. Dates such as 1/7/2004 and 7/1/2004 can be correctly interpreted as January 7 or July 1.

SpectraShop 3 opens the version 1 and 2 files without changing the date strings, but any new specimens will use the ISO 8601 date format of YYYY-MM-DD. This could cause some confusion when old and new specimens are mixed in the same collection, or if one date in a specimen was edited in version 3 but another date was in the original format.

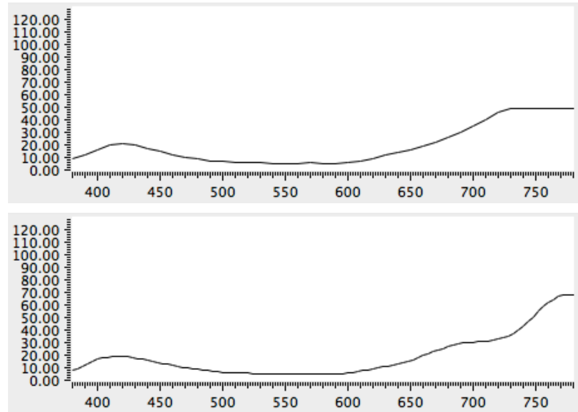
It is highly recommended that dates should be checked and edited, if necessary, when version 1 and 2 collections are opened.

Appendix D – Spectral Data

Spectrometers measure data in a variety of sampling intervals and ranges. For instance, an X-Rite i1Pro reports the spectrum from 380 to 730 nm in 10 nm increments. A Photo Research PR-655 measures from 380 to 780 nm in 4 nm increments. To allow spectra from these two instruments to be used together, common range and data formats need to be established.

Range

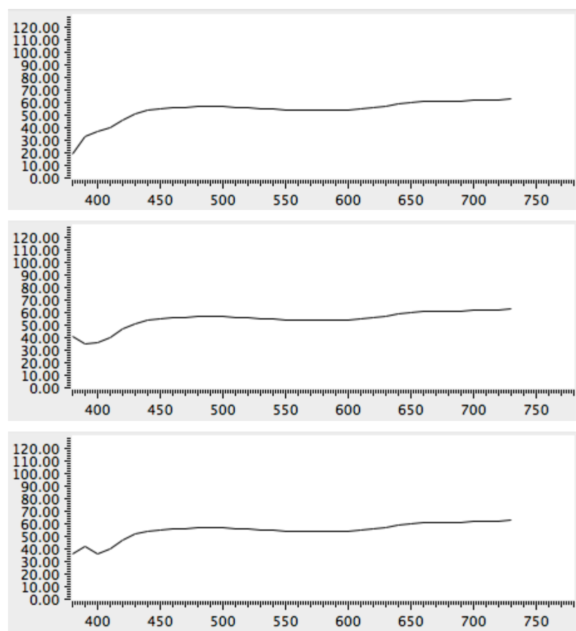
When working with shorter ranges there are several possible ways to handle the data. One technique is to take the last data value and replicate it for the missing values until the end of the range is reached. For example, if the instrument's last value is 730 nm and the range must be extended to 780 nm, then the 730 nm value is copied into the value for 740 nm, then 750, and so forth, until 780 nm is reached. This example assumes a 10 nm sampling.



The top spectrum shows the result of replicating the 730 nm data out to 780 nm. The bottom spectrum shows the actual peak in the 730-780 nm range missed by replicating data.

Another way to extend a range is to fit a mathematical function to the end of the spectrum and generate values from this function. The accuracy depends on the shape of the original spectrum and the function used. As the distance increases from the end of the actual data range the error in the extrapolated data usually increases.

The problem with copying data or extrapolating data is this generated data may not correlate with the actual spectral response of the specimen. Measurement noise can also alter the extrapolating function resulting in extremely high errors in the extrapolated spectral regions. In the three spectra at the right, the same spot was repeatedly measured with a spectrometer equipped with a UV-Cut filter which removes all illumination below 400 nm. Sensor noise has affected the interpolation routine resulting in wildly varying reflectances in this region.



Three measurements of a single specimen made with a UV Cut instrument showing misinterpretation of noise below 400 nm.

Perhaps the biggest problem with extrapolating or copying the data into regions the spectrometer does not report is that it **leads to false assumptions interpreting the spectrum**. If a peak is produced by this extension it would be interpreted as higher spectral output in these regions where there might actually be no spectral output there at all. In the two bottom spectra at the right the user might falsely assume reflectance peaks exist below 400 nm.

To keep from adding error to the spectral data, SpectraShop extends spectral ranges by putting zero values into the missing range.

Sampling

The other major issue with spectra is the sampling interval. Most low-cost spectrometers sample the spectrum in 10 nm increments. More expensive instruments sample at 5, 4, 2 or 1 nm increments. Some of the standards for illuminants are specified in 5 nm increments while the CIE observers are tabulated in 1 nm increments. Comparing data between instruments with differing sample intervals can create problems. The CIE has specified in standard 15:2004 that for rigorous calculations the data should be represented in 1 nm increments. To get 1 nm data from larger increment sampling (e.g. 10 nm) it is necessary to interpolate, or mathematically estimate the data between samples. While there are many possible methods to interpolate data (e.g. linear, polynomial, piece-wise polynomial) in CIE 167:2005 the Sprague interpolation, a fifth-degree polynomial, is the recommended method. It is designed to interpolate data which has fixed sampling intervals and it has the benefit that the interpolation curve passes through the original sample points.

SpectraShop uses the Sprague interpolation method to convert all data sampled at intervals greater than 1 nm into 1 nm data. It currently interpolates 2, 4, 5 and 10 nm data.

With all specimen spectra using 1 nm sampling and the range standardized from 380 to 780 nm, inclusive, ***spectra from almost any instrument may be freely compared and processed***.

References

In preparing SpectraShop™ 3 strict adherence to the standards has been made wherever possible. In those areas where the standards do not fully address the subject, published references and papers were consulted, established experts were contacted and sometimes the methods were augmented by the author's personal research and experiments.

Standards

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ANSI CGATS.5-1993, *Graphic technology – Spectral measurement and colorimetric computation for graphic arts images.*

ANSI CGATS.17-2005, *Graphic technology – Exchange format for color and process control data using XML or ASCII text.*

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