



CLM-196

Benchtop colorimeter

User Guide
Rev.1.10 - 03/2025

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Made in Italy by

**Eoptis Srl**

Via Kufstein, 15 - 38121 Trento (TN) - Italy

Tel: +39 0461 260552

Email: info@eoptis.com

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Contents

1	OVERVIEW	5
1.1	Packing list	5
2	Colorimetry Background	6
2.1	Measurement Geometry	6
2.2	Sample Preparation	7
3	System Setup on First Use	8
3.1	Recommended system configuration	8
3.2	Drivers and Software Installation	8
4	Software Operations	10
4.1	Main Controls	10
4.2	Measure and Reference Acquisition	12
4.3	Color Difference Check	13
4.3.1	How to Perform a Color Difference Check Analysis	14
4.3.2	Color Check analysis modes	14
4.3.3	Using the Interface	18
4.3.4	Chroma and Lightness plot	18
4.4	Color Matching	19
4.4.1	How to Perform a Color Matching Analysis	20
4.4.2	Using the Interface	20
4.5	Color Classification	21
4.5.1	How to Perform a Color Classification Analysis	22
4.5.2	Using the Interface	22
4.6	L*a*b* Chart	23
4.7	Report Generation	24
4.8	User Calibration	25
4.9	Advanced Features	26
4.9.1	Database Management	26
4.9.2	Database context menu	27
4.9.3	Project Management	28
4.9.4	Multiple Acquisition	28
4.9.5	Illuminant-ObsERVER Pair Selection	28
4.9.6	Preferences Panel	30
4.9.7	Custom color spaces	30
4.9.8	Access system memory	30
5	Technical Specifications	31
6	Appendices	33
6.1	Precautions and System Maintenance	33
6.2	Troubleshooting	33
6.3	Standards	34
6.4	Warranty and Repair	34

7 Revision History 35

1 OVERVIEW

Thank you for purchasing the Eoptis' CLM-196, a benchtop tristimulus colorimeter. The CLM-196 is a compact device for colorimetric detection with a reliability higher than human eye and at a competitive price. Colour measurements can be performed on the surface of a wide range of matte and glossy materials, thanks to a (45°c:0°) measurement geometry and the very uniform illumination provided by integrated LEDs. Long-term stability reduces the need of calibration by the user. The device is powered and interfaced through a USB port using a standard PC or laptop with a Microsoft Windows operating system.

After having performed the measurement of the sample of interest, the application software allows you to:

- evaluate the colour difference from a reference patch, to determine whether a sample is within a user-defined acceptance limit
- classify samples among a set of selected colours, in order to group them in classes with homogeneous colour and improve uniformity
- find the best match of the sample, looking up a colour database to reproduce the measured colour.

The colour database is encoded in software, avoiding the use of bulky physical sample libraries. Colour sets such as RAL are included as standard and a custom or application-specific colour database can be added by the user or with Eoptis's support on request.

1.1 PACKING LIST

The package contents:

- | | |
|---|--------------------------------------|
| 1 | CLM-196 colorimeter |
| 1 | White reference standard |
| 1 | USB stick with software and manuals |
| 1 | Certificate of traceable calibration |

2 COLORIMETRY BACKGROUND

This section provides you with useful information about colorimetry and how to get the best results from the system in real world applications.

2.1 MEASUREMENT GEOMETRY

The CLM-194 colorimeter is designed to measure the samples the way the human eye does in the real world. It implements a $(45^\circ\text{c}:0^\circ)$ geometry, that uses 45° circumferential illumination by means of multiple directional sources and 0° viewing perpendicular to the sample plane, according to ASTM E 1164. The circumferential illumination is essential to achieve repeatable measurements on directional and structured surfaces.

The $(45^\circ\text{c}:0^\circ)$ instrument is capable of specular excluded (*SPEX*) readings, that exclude the specular or gloss component from measurement. The $(45^\circ\text{c}:0^\circ)$ geometry simulates the normal condition used for color evaluation, where a difference in gloss and texture of a sample with same pigmentation results in a difference in color. A gloss sample is indeed visually judged darker by the eye when compared to a matte or structured sample.

Several applications require agreement between measurement and visual assessment, therefore implicitly assuming the $(45^\circ\text{c}:0^\circ)$ measurement geometry:

- batch to batch comparison in production and quality acceptance
- assembly of multi-component products using different materials
- printed materials and the graphic arts industry, where a $(45^\circ\text{c}:0^\circ)$ is the conventional measurement geometry
- reproduction of the color of a sample taking into account texture and gloss
- and many others.

If only the pigmentation difference is to be detected or different textures of the same material are to be compared, a specular included geometry (*SPIN*) that includes the gloss components in readings is recommended. This is usually achieved with $(d:8^\circ)$ sphere geometries.

Note that only measurements taken under the same conditions can be compared. Measurements taken with $(45^\circ\text{c}:0^\circ)$ and other geometries match only under a very limited set of conditions and often exhibit differences of several ΔE units.

Relevant conditions affecting measurements are:

- measurement geometry
- illuminant / observer pair
- color system
- sample preparation and orientation.

2.2 SAMPLE PREPARATION

An ideal sample to achieve repeatable and accurate color measurements with a reflectance colorimeter like the CLM-194 has the following characteristics (see also ASTM E1164):

- a flat surface
- completely opaque with no translucency
- clean and dry
- uniform across the area being measured
- large enough to cover the instrument's sample port
- its color is not affected by light (photochromic), moisture (hygrochromic) or heat (thermochromic)
- it adequately represents the material or parts under evaluation.

If any of these qualities is not present, the sample must be made as ideal as possible for a correct measurement.

Translucency by a non-opaque sample is often the main source of error. Part of the light incident on a translucent sample penetrates the surface and undergoes internal scattering and lateral diffusion, which reduces the intensity of reflected light. Ambient light might also penetrate the instrument port and affect the measurement in an uncontrolled way. A translucent sample must be made as opaque as possible either by increasing the thickness and/or by backing it with a stable and durable opaque material (usually black or white). The chosen thickness and backing material should be logged in measurement report to ensure repeatability.

To select a sample which adequately represents the part under evaluation, examine a sufficient number of random samples from the lot, and average the readings.

In case of an uneven surface, the instrument optically averages the color on the area corresponding to the measurement spot. For longer range non-uniformities, it is recommended to average several measurements taken at different positions on the sample to find the closest match (see the Multiple Acquisition feature in 4.9.4).

Textured surfaces can be presented to the instrument at any orientation. The circumferential illumination allows reading which is unaffected by sample orientation. In very limited cases where the surfaces are highly textured, it is recommended to turn the sample and check differences on multiple readings.

Several published standards address sample selection for various industries (fibers, yarn, liquids, powders, coatings, paints, papers, leather, etc...). Contact Eoptis for additional information and support in identifying the best technique to exploits the full performance of the colorimeter.

Repeatable and accurate measurements may be difficult or impossible to obtain if some samples have any of the following characteristics:

- a surface which contains fluorescent pigments or appears unusually bright
- an appearance which changes based on the point of view (may contain metallic, flake, or pearlescent colorants)
- a very curved, highly uneven or corrugated surface.

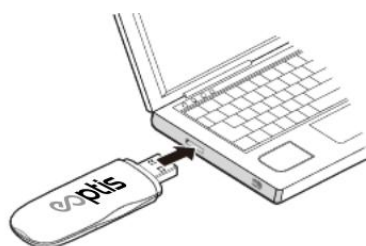
3 SYSTEM SETUP ON FIRST USE

3.1 RECOMMENDED SYSTEM CONFIGURATION

- Windows XP/Vista/Seven/10/11 32(x86) or 64(x64) bits
- Intel Pentium 4 2.0 GHz or compatible processor
- Graphics card and monitor capable of displaying 1280x1024 resolution at 32-bit color depth
- 100 MB of free hard disk space
- USB2.0 port, with a supply current of 500mA

3.2 DRIVERS AND SOFTWARE INSTALLATION

1) Connect the software USB stick



Software, drivers and third-party packages required by the system are installed by means of the Installer executable, provided on the USB stick. Automatic detection of the operating system and of any missing packages is supported.

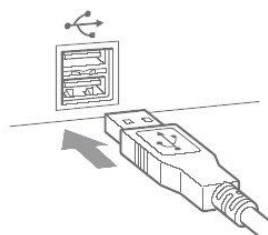
Launch the "CLM194Setup.exe" by double-clicking on it and follow the instructions. The file is not signed by Microsoft and the Operating System might prompt for approval to proceed. It is necessary to grant the approval in order to successfully complete the installation.

The installation sequence is:

- CLM194 application software
- Microsoft .NET Framework (*)
- Microsoft Visual C++ redistributable packages
- Device drivers

(*) installed only if not already present.

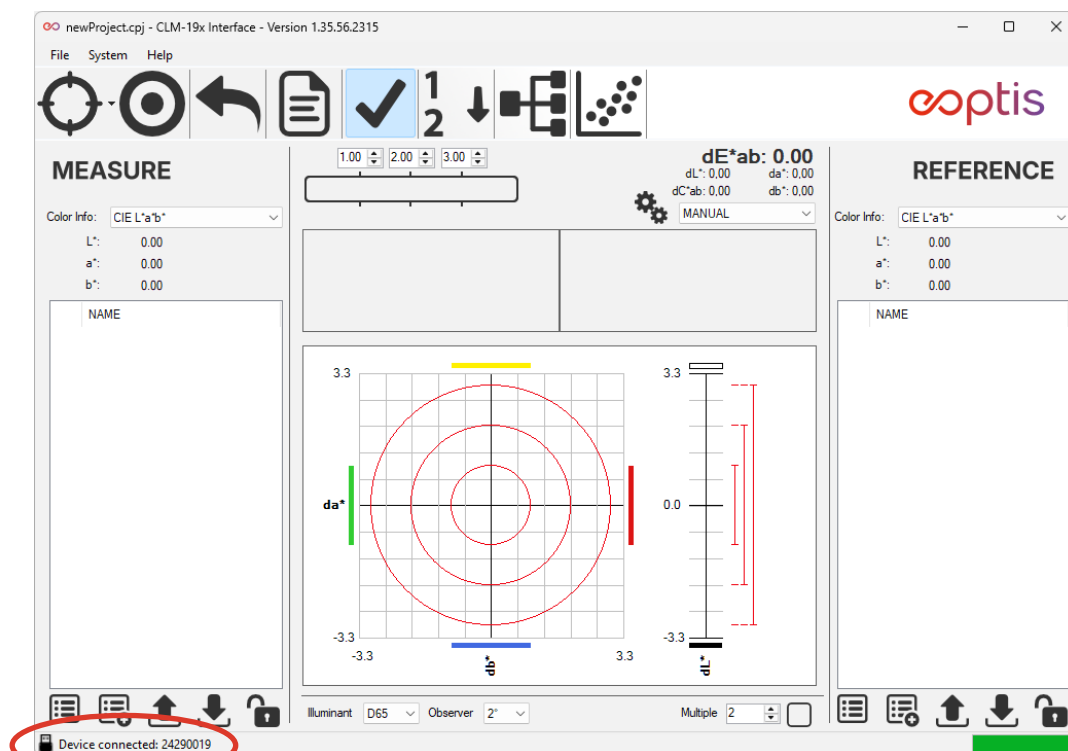
2) Plug the USB cable into the host machine's USB 2.0 port and confirm successful installation



At the end of the software and driver setup, plug the USB cable into a free USB port of the PC.

3) Launch the Application Software

A shortcut of the application software is created on the desktop and in the Start menu, unless otherwise specified during setup. Launch the software by double-clicking on the desktop icon. The green *M* indicator on the colorimeter will illuminate and the serial number of the device will be shown in the bottom-left corner next to the "Device connected" label. Congratulations, the system is ready for use!

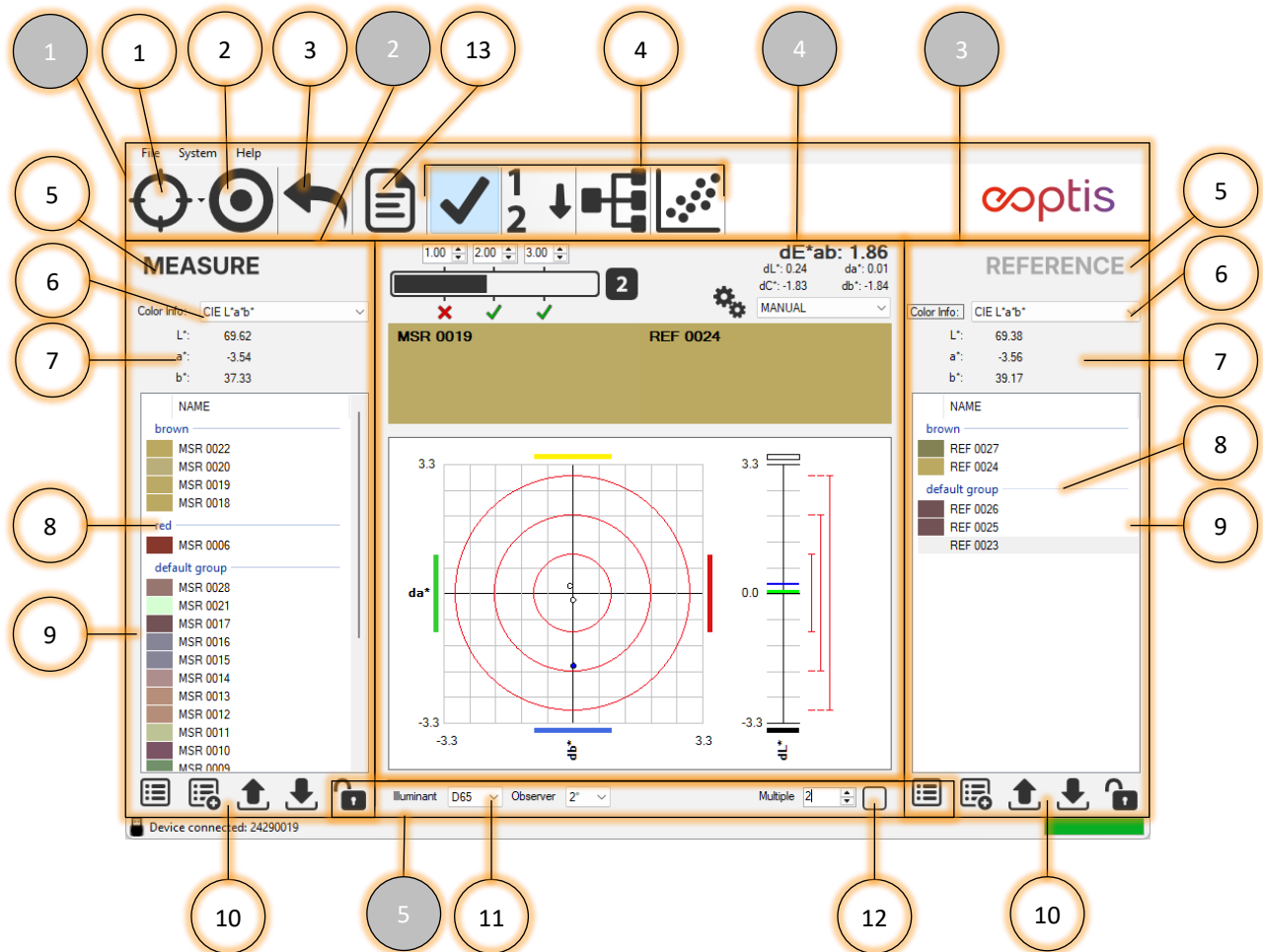


4 SOFTWARE OPERATIONS

This section explains the software features. The buttons, checkboxes or active items in the user interface include a pop-up help function which appears when the mouse is held over the item for few seconds.

4.1 MAIN CONTROLS

This section describes the main controls of the user interface.



Main controls

Item	Description
1	Main menu with toolbar
1	Measure Acquisition button
2	Reference Acquisition button
3	Undo button
4	Operating Mode selector
13	Save Report button
4	Output control panel

Item	Description
5	Advanced control panel
11	Illuminant/Observer selection
12	Multiple Acquisition control
2 3	Measure/Reference control panel
5	Measure/Reference active indicator
6	Color space selector
7	Color coordinates
8	Color Groups
9	List of Measures/References
10	Database control buttons

The main menu ① on the top of the interface allows you to:

handle Projects	see 4.9.3	File→New project Load project... Save project...
generate Reports	see 4.7	File→Save report...
perform user calibration	see 4.8	System→User calibration
reset user calibration	see 4.8	System→Reset user calibration
reconfigure system	see 4.9.8	System→Reconfigure system...
change language		System→Language
set preferences	see 4.9.6	System → Preferences...
get system information		Help→About

The main toolbar ① features three pushbuttons that allow you to:

- ① Acquire *Measure* data
- ② Acquire *Reference* data
- ③ Undo the last operation

The four central icons ④ switch between the various operating modes featuring the following functions:

Color Difference Check	see 4.3
Color Matching	see 4.4
Color Classification	see 4.5
L*a*b* Chart	see 4.6

The central Output control panel ④ changes according to the selected operating mode function and shows specific controls and outputs, as described in the relevant sections.

The *Measure* and *Reference* control panels ② ③ include all the controls needed to perform and manage the color data acquisition. Each acquisition can be either addressed as a *Measure* or a *Reference* depending on its expected usage. *Measure* and *Reference* data are indeed handled in different ways depending on the selected operating mode function, as described in 4.3 to 4.6. It is possible to exchange previously acquired *Measures* and *References*, as described in 4.9.1.

The *Measure* and *Reference* Modes is highlighted ⑤ on the panel once a color is acquired and the data is added to the list of the highlighted section. In both cases, each acquired color will be added to the Default Group ⑧ of the Color List ⑨. The last acquired color will become the current color, used as input by the operating mode functions, and its coordinates will be displayed ⑦ in units according to the selected color space ⑥. The user can select a previously acquired color by double clicking on it in the list or by dragging it to the corresponding Display Area in the Output control panel.

The *Measure* and *Reference* Lists can be managed by means of the Database Control buttons ⑩, as described in 4.9.1.

The Save Report button ⑬ allows you to save a report of the current measures and analysis results in .pdf and Excel-readable .xml formats. See 4.7 for details.

The Advanced Control panel ⑤ includes:

- ⑪ Multiple Acquisition control, to average a sample see 4.9.4
- ⑫ Illuminant and Observer controls see 4.9.5

4.2 MEASURE AND REFERENCE ACQUISITION

The acquisition of *Measure* and *Reference* color data is performed through these steps:

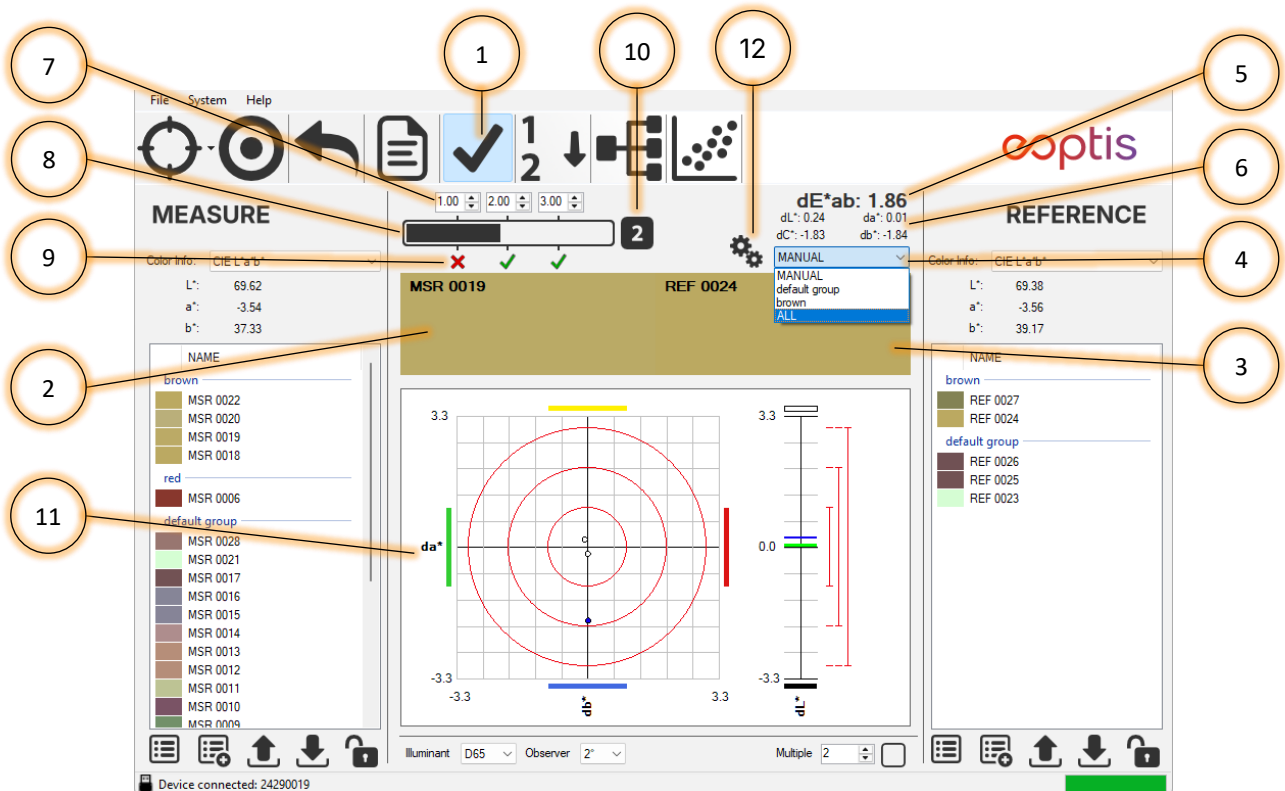
1. Connect the device
2. Launch the software
3. Ensure that the sample to be acquired has the characteristics listed in the section, 2.2
4. Ensure that the device's glass window is clean, otherwise follow the instructions in 6.1.
5. Place the colorimeter's measurement aperture in perfect contact with the sample surface
6. Trigger the acquisition clicking the *Measure* or *Reference* acquisition button
7. Wait for the new measure value to displayed on the software interface
8. Select the desired Operating Mode function and configure its options to analyse the acquired data.

If required, the system allows you to average multiple acquisitions. This feature is useful in the case of samples with uneven or structured surfaces. See 4.9.4 for details.

4.3 COLOR DIFFERENCE CHECK



The Color Difference Check function performs a fast check of the color difference between the *Measure* and the *Reference* colors, a group of *Reference* colors or the entire *Reference* database, providing a quantification of the CIE 1976 a,b color difference (CIELAB) ΔE^*_{ab} . Measure is ranked according to threshold levels set by user, allowing to definition of acceptance or rejection criteria based on objective elements. The result can be used for the quality control of a product, to evaluate the color aging of an object and for many other applications.



Color Difference Check interface

Item	Description
①	Color Difference Check mode selector
②	<i>Measure</i> color display area
③	<i>Reference</i> color display area
④	Reference Mode selector
⑤	CIELAB ΔE^*_{ab} color difference between <i>Measure</i> and <i>Reference</i>
⑥	CIELAB ΔL^* lightness difference, CIELAB ΔC^*_{ab} chroma difference, Δa^* and Δb^* components difference between <i>Measure</i> and <i>Reference</i>
⑦	Acceptance Thresholds values for ΔE^*_{ab} color difference
⑧	Visual representation of the ΔE^*_{ab} color difference compared to the Acceptance Thresholds
⑨	Acceptance threshold validation result
⑩	Acceptance class (rank) of the current <i>Measure</i>
⑪	Plot of the current <i>Measure</i> in the $L^*a^*b^*$ color space with <i>Reference</i> set at the origin of axes.
⑫	Open Color Check settings panel

4.3.1 HOW TO PERFORM A COLOR DIFFERENCE CHECK ANALYSIS

1. Select the Color Difference Check function from the Operating Mode selector
2. Select and setup the Color Check mode from the Color Check settings panel ⑫
3. Acquire a desired *Reference* sample. Either select an existing sample from the *References* list or let the software detect the closest to *Measure*, belonging to the selected group of the *Reference* list
4. Acquire the data of the *Measure* sample under evaluation. If acquisition has already been performed, any color in the *Measure* list can be selected by double-clicking on it
5. The software performs the color difference calculation and shows the results of acceptance threshold validation and plots the CIE L*a*b* *Measure* coordinates against the *Reference* ones

4.3.2 COLOR CHECK ANALYSIS MODES

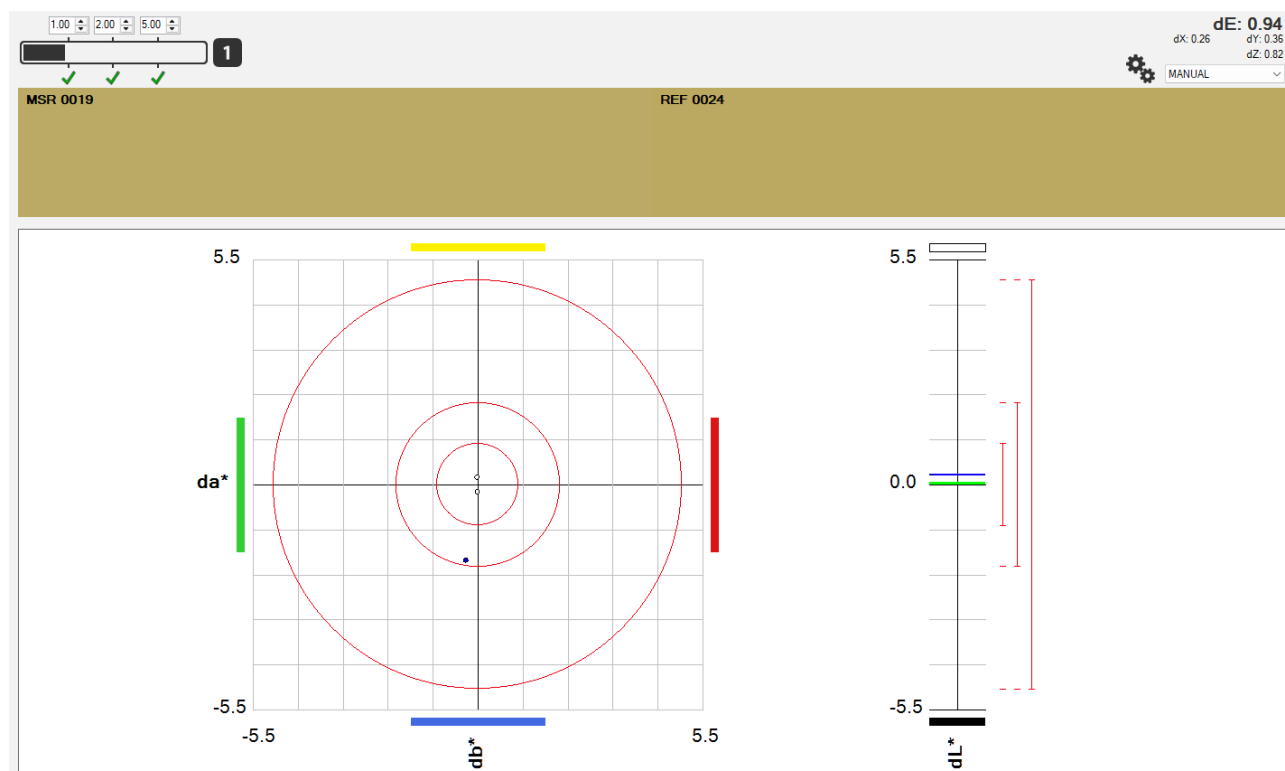
Color Check analysis works in Classes mode or in Thresholds mode. The mode and parametrization is done via the Color Check settings panel ⑫. The analysis results are displayed in a different way, given the mode selected.

Classes mode

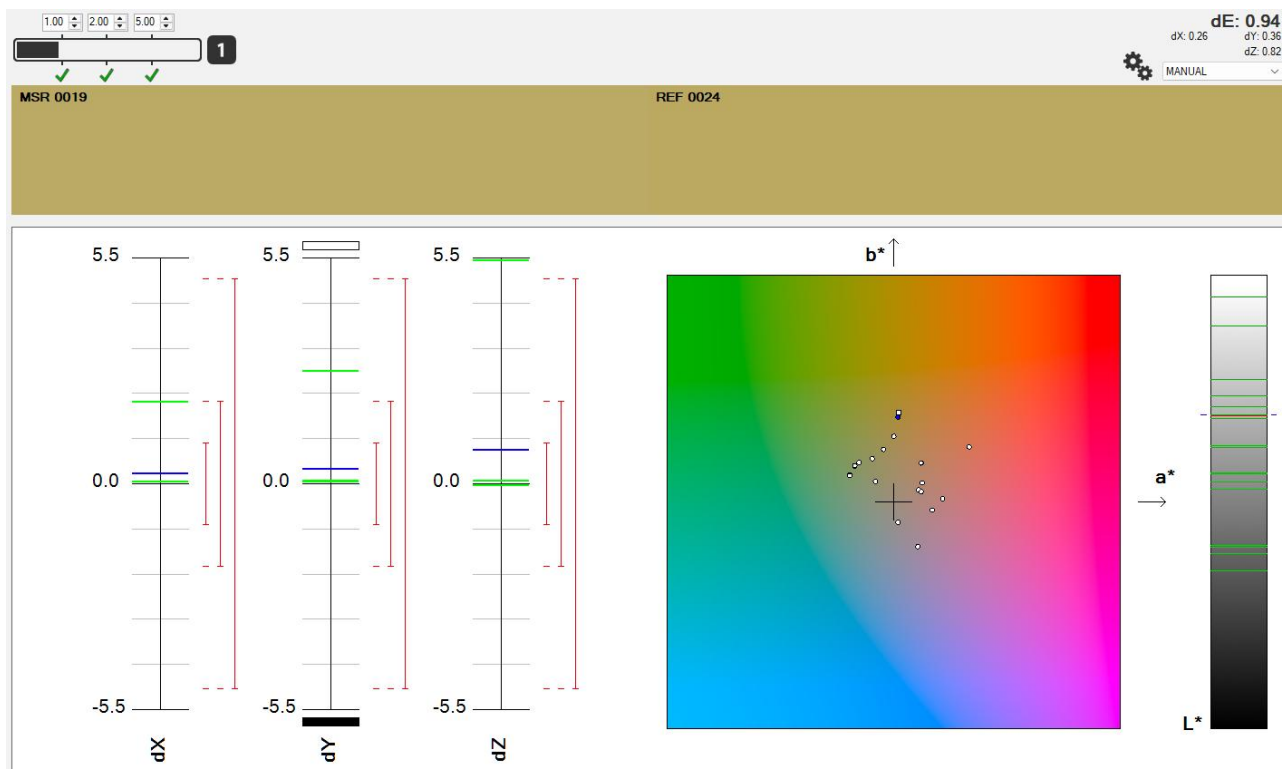
In Classes mode, the software will compute the distance between the current measure and reference colors, and puts the measure in a given “quality class” given the set classes thresholds. The measure can fall in 3 classes, or be out of threshold.

Given the selection in the Preferences Panel (see 4.9.6) the user can select to display the results graph in two ways:

- Classes range: controls the dE ranges for the CIE L*a*b* color check graph

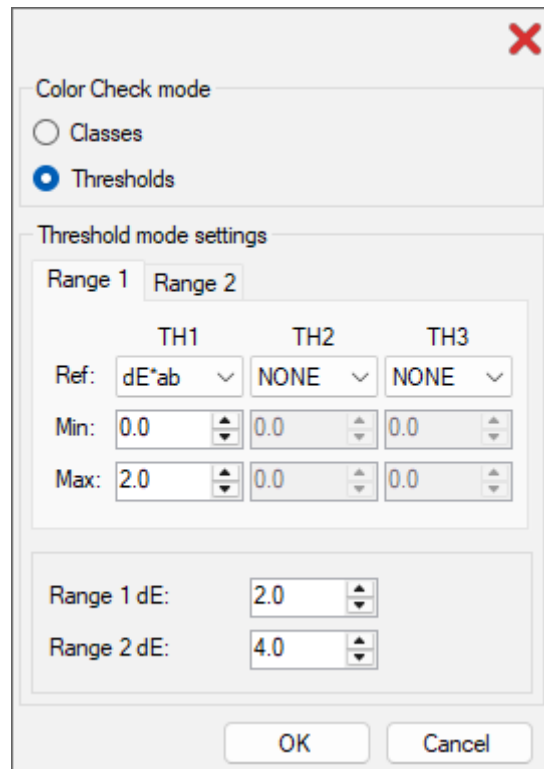


- Coordinates range: controls the single coordinates ranges displayed when the color check chart is displayed in the current color space (different from CIE $L^*a^*b^*$)



It also possible to show the $L^*a^*b^*$ chart (see also 4.6).

Threshold mode

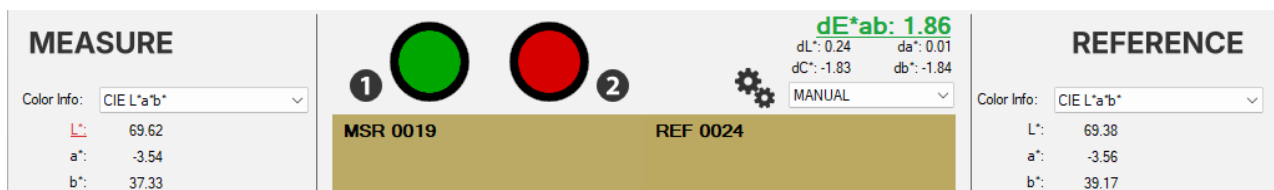


The dialog box is titled 'Threshold mode' and has a red 'X' icon in the top right corner. It contains two main sections: 'Color Check mode' and 'Threshold mode settings'.

Color Check mode: There are two radio buttons: 'Classes' (unselected) and 'Thresholds' (selected).

Threshold mode settings: This section has two tabs: 'Range 1' (selected) and 'Range 2'. Under 'Range 1', there are three columns for thresholds: TH1, TH2, and TH3. Each column has a 'Ref:' dropdown (TH1 is 'dE*ab', TH2 and TH3 are 'NONE'), a 'Min:' input field (all are '0.0'), and a 'Max:' input field (all are '2.0'). Below these, there are two more input fields: 'Range 1 dE:' (set to '2.0') and 'Range 2 dE:' (set to '4.0'). At the bottom are 'OK' and 'Cancel' buttons.

In Thresholds mode the user can setup two acceptance ranges, each defined by up to three thresholds on various quantities. The user can define limits for the various measure/reference distances (e.g. $-2 < dL^* < 2$ and $dE^*ab < 3$); the software will signal if any of the quantities exceeds the threshold. A range of values can be defined for the measure's coordinates (e.g. $80 < L^* < 85$), without comparing it to a reference; again, the software will signal when the selected coordinates' ranges are exceeded. The quantities used for the analysis are highlighted in the main interface; when a quantity exceeds its range it will be displayed in red; otherwise in green.



The main interface is divided into three main sections: 'MEASURE', a central status area, and 'REFERENCE'.

MEASURE: Color Info: CIE L*a*b*. L*: 69.62, a*: -3.54, b*: 37.33.

Central Status Area: Features two large colored circles: a green circle labeled '1' and a red circle labeled '2'. Below them are labels 'MSR 0019' and 'REF 0024'. To the right, a gear icon and a 'MANUAL' dropdown are visible. Above the circles, the text 'dE*ab: 1.86' is displayed in green, with smaller values for dL* (0.24), da* (0.01), dC* (-1.83), and db* (-1.84) in grey.

REFERENCE: Color Info: CIE L*a*b*. L*: 69.38, a*: -3.56, b*: 39.17.

To display info on the Chroma and Lightness plot (see 4.3.4), based on measure/reference dE*ab, the user can select two dE*ab ranges, even when this quantity isn't selected for any range.

4.3.3 USING THE INTERFACE



The acquired color is displayed on the monitor as a guide only. It is very likely that it will appear to be different from the actual color of the sample. This is due to several factors (such as the ambient light, monitor calibration, gamma settings, ...) which must be controlled and fine tuned in order for the colors to match.

The *Reference* can be selected in two different ways, using the *Reference Mode* selector ④.

Manual mode. Manual mode is enabled by selecting the *MANUAL* option in the *Reference Mode* selector ④. In Manual mode, the user selects a color from the *Reference* List by double-clicking on it, by dragging it to the *Reference* color display area ③, or by acquiring a new *Reference* color. Manual mode allows the color difference of the current *Measure* (either that just acquired or selected from the *Measure* list) to be evaluated with respect to a *Reference* which is fixed and does not change during operations.

Automatic mode In automatic mode the software automatically chooses the *Reference* color selecting the most similar (lower ΔE^*_{ab}) to the current *Measure*. If the *ALL* option is selected in the *Reference Mode* selector ④, the color will be chosen among all colors in the *Reference* list. If the corresponding group name is selected, a color group will be chosen. Automatic mode allows the user to highly speed up the Color Difference Check when a large set of samples comprised of a subset of various colors is to be checked. The user does not need to select the right *Reference* when a new sample is being acquired since the software automatically detects it. The automatic selection process is effective even on very similar colors if a group of *Reference* colors to be selected is specifically built and the ΔE^*_{ab} difference between these colors is larger than the highest Acceptance Threshold.

The software displays the color difference between *Measure* and *Reference* following the formula used in the CIE 1976 a,b (CIELAB) ΔE^*_{ab} color difference ⑤; the same formula for color difference is used for other color spaces, using the relative color space's coordinates. Single components differences, as well as chroma difference, are also provided ⑥.

$$\Delta E^*_{ab} = \sqrt{(L^*_1 - L^*_0)^2 + (a^*_1 - a^*_0)^2 + (b^*_1 - b^*_0)^2}$$

$$\Delta C^*_{ab} = \sqrt{(a^*_1)^2 + (b^*_1)^2} - \sqrt{(a^*_0)^2 + (b^*_0)^2}$$

$$\Delta L^* = L^*_1 - L^*_0 \quad ; \quad \Delta a^* = a^*_1 - a^*_0 \quad ; \quad \Delta b^* = b^*_1 - b^*_0$$

being $(L^*_1; a^*_1; b^*_1)$ the *Measure* coordinates and $(L^*_0; a^*_0; b^*_0)$ the *Reference* coordinates.

Note that not all color spaces have chroma info available, and not all color spaces have 3 coordinates (e.g., see 4.9.7 Custom color spaces).

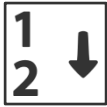
The color differences will be used to perform the analysis. Classes mode will always use the colors' distance. Threshold mode will use the selected differences/coordinates.

4.3.4 CHROMA AND LIGHTNESS PLOT

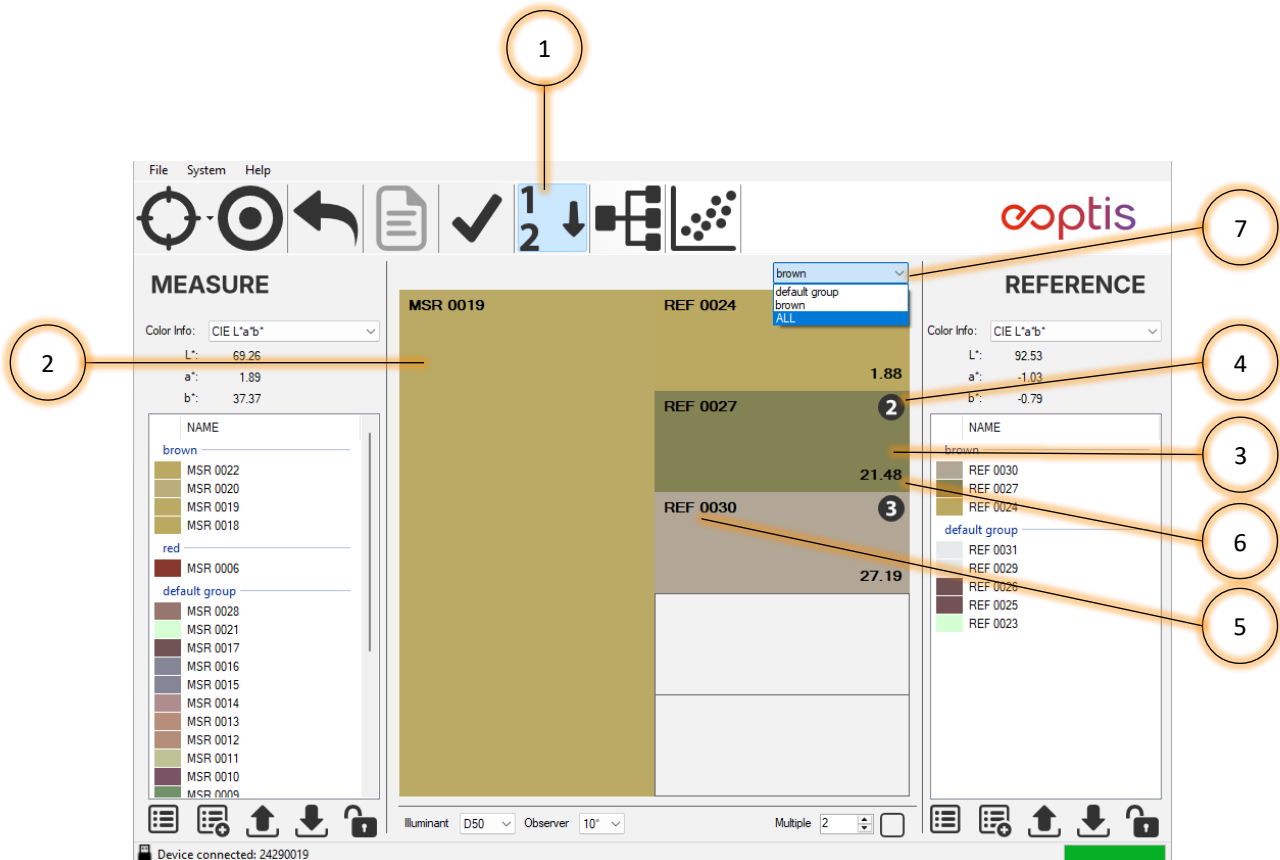
The Chroma and Lightness plots ⑪ show the *Measure* coordinates, plotted against the *Reference* coordinates set at the origin of axes. Also the three Acceptance Thresholds are displayed as boundaries in these plots. The graphs and the colored ticks (Red/Green for a^* , Yellow/Blue for b^* , Black/White for L^*) help the user to understand which component is the prevalent source of color difference between *Measure* and *Reference*.

See also 4.3.2 for details regarding the plot display modes.

4.4 COLOR MATCHING



Given a current *Measure*, the Color Matching function displays the 5 most similar colors, looking up the *References* list or a subset of it. A proprietary or standard database (RAL classic and RAL design) can be used as the *Reference* list. The closest matching colors are ranked by increasing CIELAB color difference with respect to the current *Measure*. This information can be used to select the color that resembles the measured sample by simply checking a best-candidate color palette instead of looking up a large set of physical samples.



Color Matching interface

Item	Description
①	Color Matching mode selector
②	Measure color display area
③	Reference color display area (up to 5)
④	Reference rank
⑤	Color ID
⑥	CIELAB color distance between <i>Measure</i> and <i>Reference</i>
⑦	Reference group selector for best match look-up

4.4.1 HOW TO PERFORM A COLOR MATCHING ANALYSIS

1. Select the Color Matching function from the Operating Mode selector
2. Select a group from the *Reference* group selector.
3. Acquire the data of the *Measure* sample to match. If acquisition has already been performed, any color in the *Measure* list can be used by double-clicking on it.
4. The best matching candidates will be shown.

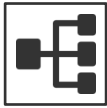
4.4.2 USING THE INTERFACE



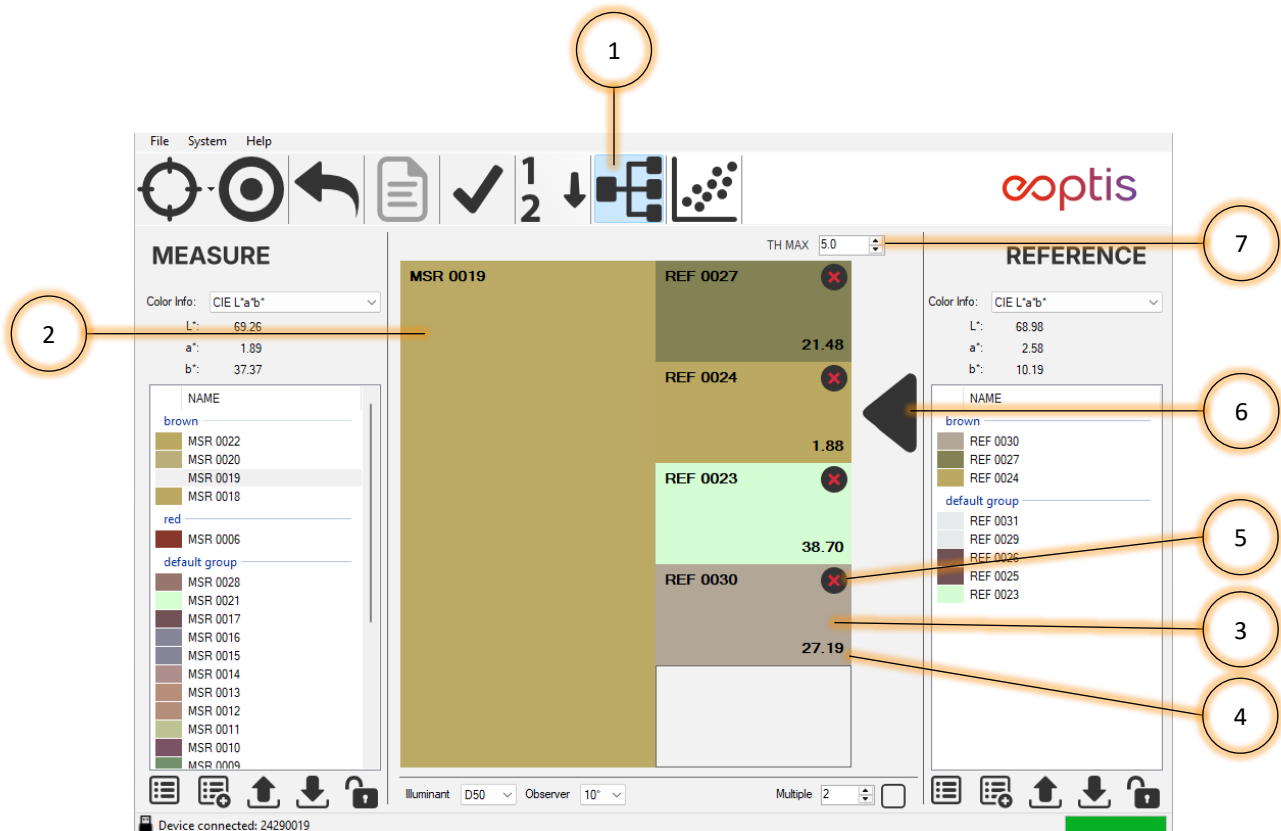
The acquired color is displayed on monitor the as a guide only. It is very likely that it will appear to be different from the actual color of the sample. This is due to several factors (such as the ambient light, monitor calibration, gamma settings, ...) which must be controlled and fine tuned in order for the colors to match.

The Color Matching function shows the *References* ranked according to the CIELAB difference of each *Reference* with respect to the current *Measure*. The search will be performed among colors belonging to the group selected by the *Reference* group selector ⑦. To search all colors from the *Reference* list, select the *ALL* option. More info about the management of color groups can be found in 4.9.2.

4.5 COLOR CLASSIFICATION



The Color Classification allows the user to select up to 5 colors and check which is the most similar to a measured sample. This is useful when sorting products with similar but slightly different colors or when assigning an object to a batch of homogenous colors, using the color as classification parameter. Samples can be grouped into sets with a color shift towards the same direction (lighter, darker, greenish, bluish, reddish) and therefore improve color homogeneity by reducing the color difference among samples of the same set. With this feature, sorting and classification processes become much more reliable and accurate than visual inspection.



Color Classification interface

Item	Description
①	Color Classification Mode selector
②	Measure color display area
③	Reference color display area
④	ΔE^*_{ab} color difference between Measure and Reference
⑤	Color Remove button
⑥	Classification Result indicator
⑦	Maximum Threshold

4.5.1 HOW TO PERFORM A COLOR CLASSIFICATION ANALYSIS

1. Select the Color Classification function from the Operating Mode selector
2. Select up to 5 colors to be used as class identifiers from the *References* list by dragging them in the *Reference* color display area
3. Set a Maximum Threshold value. This prevents a *Measure* which exceeds a specified color difference.
4. Acquire the data of the *Measure* sample under evaluation. If acquisition has already been performed, any color in the *Measure* list can be used by double-clicking on it.
5. Verify which class the sample has been assigned to.

4.5.2 USING THE INTERFACE



The acquired color is displayed on the monitor as a guide only. It is very likely that it will appear to be different from the actual color of the sample. This is due to several factors (such as the ambient light, monitor calibration, gamma settings, ...) which must be controlled and fine tuned for the colors to match.

In the Color Classification interface, the user can select up to 5 colors from the *References* list. The selection can be made by dragging the colors from the *References* list to one of the five sections in the *Reference* color display area ③. These colors will set the classes to which the measured sample may belong. The colors can be removed by clicking on the remove button ⑤.

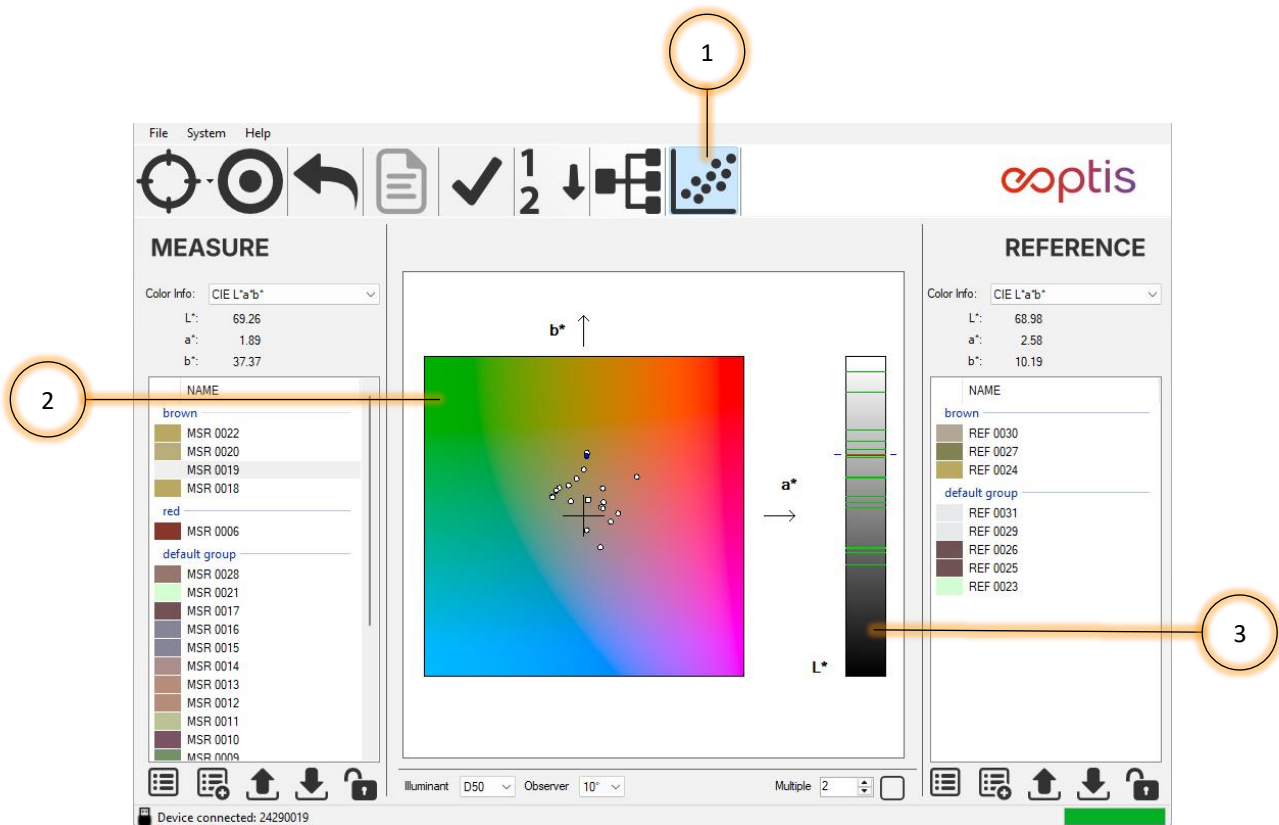
Once a *Measure* is available (either just acquired or selected by double-clicking in the *Measure* list), the Color Classification engine will identify the class to which the *Measure* belongs and place the Classification Result indicator ⑥ next to the corresponding *Reference* color. The ΔE^*_{ab} difference between the *Measure* and each *Reference* is also shown ④.

If the difference between the *Measure* and all the classes exceeds the set maximum threshold ⑦, the *Measure* is not assigned to any class. In this case the classification result indicator is removed and an 'X' icon will be displayed next to the Maximum Threshold selector ⑦.

4.6 L*A*B* CHART



The L*a*b* chart displays all the colors in the *Measure* list on a graphical representation of the CIELAB color space. This provides the user with visual information about where the sample lie in the color space.



CIE L*a*b* interface

Item	Description
①	CIE L*a*b* Chart Mode selector
②	Chromaticity plot (a^* , b^*)
③	Lightness plot (L^*)

4.7 REPORT GENERATION

The software can generate a report of the data in the *Measure* list by clicking the Save Report button ① or accessing the menu option "File→Save report...". The report can be saved in PDF or XML format.



The PDF report shows the name and the actual color of each measured sample, as well as the CIELAB coordinates and other relevant information related to the selected analysis feature. All data are sorted by groups. If a note is added to the color, it will also be printed on the PDF. A user logo will be printed at the top of the report. To customise the printed logo, replace the file "UserLogo.png" in the software executable folder with an image file with the same name and format; this file will be automatically loaded during report generation. The recommended size is 277x165 (other sizes will be rescaled).

The XML format is meant to be used for off-line analysis purposes. The file can be opened with a spreadsheet program (such as MS Excel, LibreOffice Calc, ...), so the included data can be used to analyse the acquired data. For each entry, the report displays the color name, the CIELAB coordinates, the group, any note added by the user and date/time information and other relevant information related to the selected analysis feature.

4.8 USER CALIBRATION

Each colorimeter is supplied with its own white reference standard, necessary to perform the user calibration. The standard is manufactured from highly stable materials and labelled with a unique serial number. Ensure that the colorimeter is used with its matching white reference standard and that the serial numbers match, otherwise calibration will lead to unpredictable results that may compromise system accuracy. The software prompts for calibration when necessary. Before proceeding with the creation of a database, it is recommended to calibrate the system using the white reference standard.

To perform the calibration:

1. Ensure the standard is clean otherwise clean it with a moist cloth. Do not use acetone or alcohol.
2. Access the calibration panel on the "System→User calibration" software menu.
3. White target: apply the measurement aperture of the colorimeter to the White Calibration Standard and click the *MEASURE* button on the dialog box.
4. Dark: dark calibration can be skipped for this device. Press the X close button on the White Balance window after the white target acquisition.



Step 3. Acquisition of White Calibration standard

Reset user calibration

If the measures look wrong after an user calibration, it is possible that the procedure failed due to target coupling or other factors. Repeat the procedure to fix the error.

If the measures continue to look wrong, the user can restore the factory calibration from the menu "System→Reset user calibration".

4.9 ADVANCED FEATURES

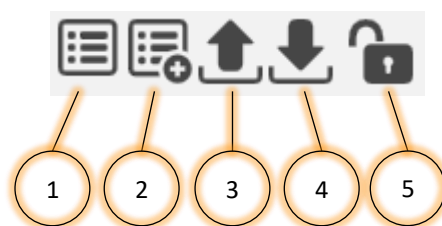
4.9.1 DATABASE MANAGEMENT

The colors acquired and added to the *Measures* and *References* lists are organized in databases. In this way, the colors lists can be saved/loaded for future use. Note that the *Measures* and *References* databases are fully interchangeable, so one can choose to use a *Measures* database as a *References* database (and vice versa) when performing analysis.

The colors are added to the database when performing an acquisition; they can then removed by right-clicking on a color in the list and selecting "Remove item". From this same menu one can also add notes to the color and rename it.

All colors in a database are organised in groups. There will always be a "default group", while other groups are user defined; the maximum allowed number of user defined groups is 15. Every newly acquired sample will be added to the default group. For more info about groups management, see 4.9.2.

The groups of the *Measures* list are used mainly to organise the colors, while groups in the *References* list can be used to filter the results in Color Difference Check and Color Matching functions. The Database Control buttons can be used to manage the software's current databases as well as previously stored databases.



Database control buttons

Item	Description
①	Create new database
②	Merge databases
③	Load database
④	Save database
⑤	Lock/Unlock database

The Create new database button ① removes all colors from the list so you can start with an empty database.

The Merge databases button ② allows you to merge a previously saved database with the current database; all the colors and groups in the saved database will be added to the current database.

With the Load database button ③ you can load a previously saved database, removing all current colors.

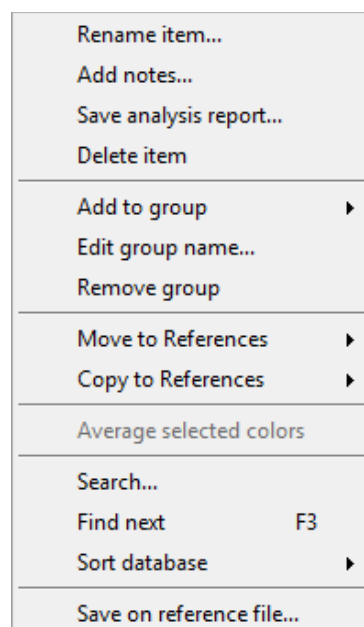
The Save database button ④ allows you to save a database on the computer for future use. Files can be saved in .cdb (proprietary), in .pdf and .xml (Excel readable) format. The following flags can be adding to the database when saving:

- Is read only: the database becomes a read-only; no colors or colors grup can be added, removed or updated, as well as color groups. This is a "soft" lock that can be removed with the Lock/Unlock database button
- Has hidden coordinates: the colors coordinates are hidden; only the color name can be seen by the user. This flag can be used to release a proprietary database without sharing sensitive data about the colors. Note that this flag, once set, can't be removed.

The Lock/Unlock database button ⑤ allows you to toggle the read-only mode for the database. This can be used to prevent database modification during color analysis.

4.9.2 DATABASE CONTEXT MENU

A context menu, displayed by right-clicking on the colors list, allows the user to perform several actions on single and multiple colors, as well as on the whole database.



- **Rename item...:** change name of the selected color
- **Add notes...:** add notes to the selected color for future reference
- **Save analysis report...:** (only for *Measures* database) save report only for the selected measures
- **Delete item:** remove the selected color(s) from the database
 - The action can be done without accessing the context menu by selecting the desired color(s) and pressing Canc or Backspace key
- **Add to group:** the selected color(s) will be added to one of the existing listed group, or a new group can be created ("New group..." option)
- **Edit group name...:** change the name of the group that the selected color belongs to
- **Remove group:** remove the color's group from the database. All the colors belonging to this group will be moved to "default group"
- **Move to References|Measures:** move the selected colors in a given group in the other database, removing them from the current database
- **Copy to References|Measures:** copy the selected colors in a given group in the other database
- **Average selected colors:** generates a new color with coordinates set to the average coordinates of the selected colors
 - NOTE: the average will be performed on the coordinates of the currently selected Color space (e.g. CIE L*a*b*); due to the non-linear nature of color spaces transformations, the new color's coordinates can differ from the average in color spaces different from the currently selected one
- **Search...:** search a color in the database that contains a given string
- **Find next:** find the next item in the database that satisfies the search request
 - The action can be done without accessing the context menu by pressing the F3 key when the desired database is selected (any color on the database is selected)
- **Sort database:** sort the database by color name or by color acquisition date
 - The database will be sorted alternately ascending and descending
- **Save on reference file...:** save the selected color as a reference file for CLM195 Interface software

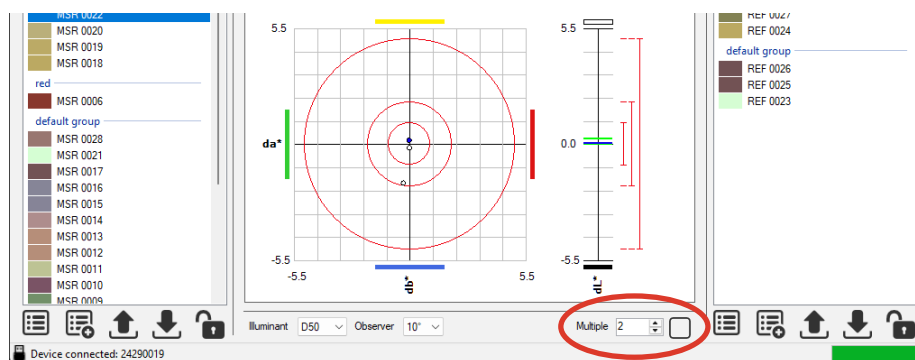
4.9.3 PROJECT MANAGEMENT

The "File" list in the software main menu is used to manage projects. The software treats each program session as a project that contains all relevant information about the *Measures* and *References* databases, including analysis parameters. With this feature you can save the current session and resume a previously saved one.

When loading a previously saved project or creating a new project, the current database entries and analysis parameters are replaced by the saved data or deleted.

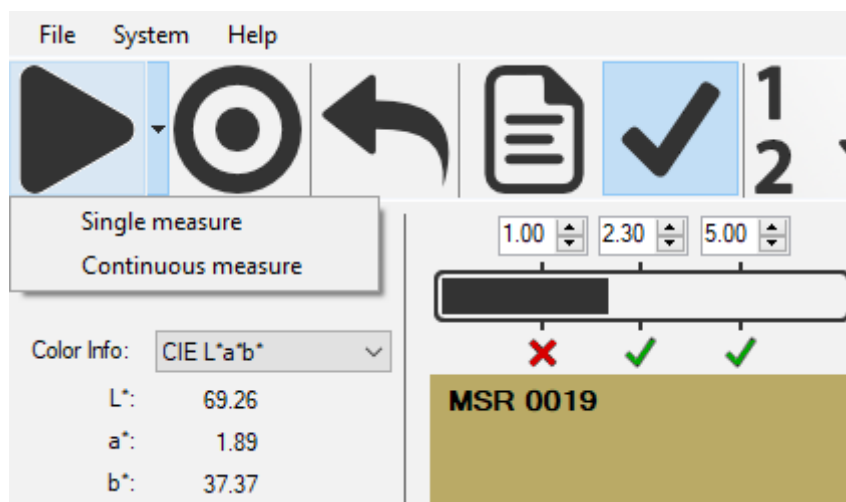
4.9.4 MULTIPLE ACQUISITION

Multiple Acquisition should always be performed in cases of uneven or structured surfaces. The advantage of Multiple Acquisition is that the visual evaluation is supplemented by the calculation of a mean for the measured values. The Multiple Acquisition feature is enabled by specifying the number of measurements to be averaged and by thickening the corresponding checkbox.



Continuous measure

When multiple acquisition is enabled, the user can enable and start Continuous measure. Once started, the software will automatically acquire all the multiple measures needed to generate the final average measure, with a delay of 2 seconds between each acquisition.



4.9.5 ILLUMINANT-OBSERVER PAIR SELECTION

The interface's Advanced control panel allows the user to set the *Measure* Illuminant (SI) and Observer (SO) pair. The following options are available and can be selected in any (SI/SO) combination. The

selected combination is automatically saved for future software sessions, when it will be restored and used as default settings.

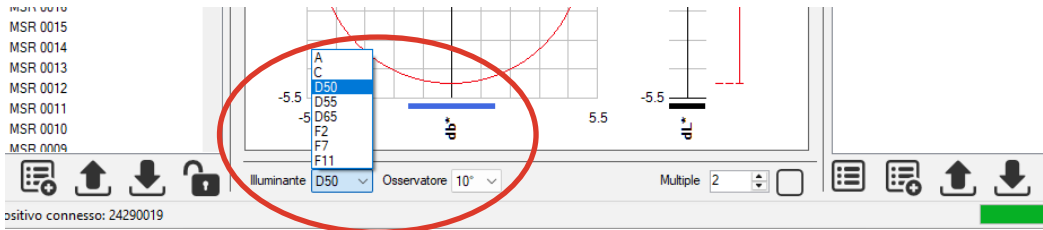
<i>Illuminant</i>	<i>Notes</i>	<i>Approximate correlated color temperature</i>
D65 (*)	Noon daylight (reference for sRGB color space)	6500K
D55	Mid-morning daylight	5500K
D50	Horizon light	5000K
A (*)	Incandescent / tungsten	2850K
C	North sky daylight	6800K
FL2	Cool white fluorescent	4230K
FL7	Broadband fluorescent, D65 daylight simulator	6500K
FL11	Narrow band fluorescent Philips TL84, Ultralume 40	4000K

(*) CIE standard illuminant

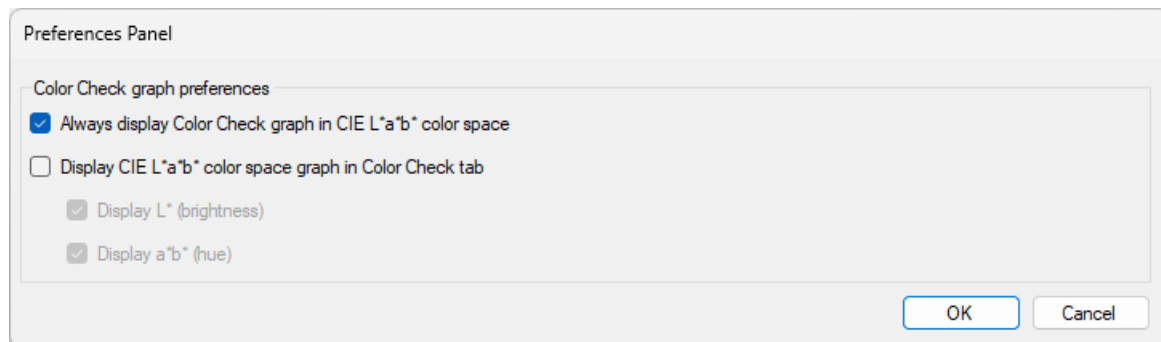
Observer

CIE 1931 2° standard colorimetric observer
CIE 1964 10° standard colorimetric observer

Performance specifications refer to (D65; 2°) pair, which is the recommended setting to be used whenever possible.



4.9.6 PREFERENCES PANEL



From the preferences panel the user can configure some extra options for the color analysis modes.

Color Check

The user can select the format of the Color Check graph.

- Always display Color Check graph in CIE L*a*b* color space: if checked, the graph will be displayed in CIE L*a*b* color space regardless of the currently selected color space. If not checked, the single coordinates' delta is displayed.
- Display CIE L*a*b* color space graph in Color Check tab: if checked, a copy of the L*a*b* chart from the relative tab will be displayed in the Color Check tab. The user can select which part of the chart to display.

See 4.3.2 for further details.

4.9.7 CUSTOM COLOR SPACES

The software manages various standard color spaces (CIE-XYZ, CIE-xyY, CIE-L*a*b*, ...). It is possible to add further user-defined color spaces and perform analysis on them.

The coordinates of the custom color spaces are computed by applying user-defined mathematical operations on the coordinates of a given source standard color space. The formulas, as well as other color space's parameters (the new color space's name, coordinates' names, ...) will be defined in a text file that must be saved in the folder

`C:\Users\Public\Documents\EOPTIS\CLM19x Software Suite\ini\customColorSpaces`

An example file README.ini is provided; all instructions to generate new files and edit the parameters are described in said file.

All custom color spaces' files will be parsed by the software CLM19x Interface at startup. Custom color spaces can be selected from the Color space selector (see 4.1 Main Controls) as any other standard color space.

4.9.8 ACCESS SYSTEM MEMORY

The user can upload system memory files (*.clm) on the device. This features useful when multiple field of views adapters are used. When switching to a new field of view adapter, the user must upload the corresponding memory file to ensure correct color readings.

To upload a memory file:

1. Open the panel from System→Reconfigure system...
2. Press "Load file..." button and select the correct .clm file
3. Press "Apply" to load the data

It is also possible to download current memory data, that EOPTIS can use to debug any major measurement problem, using the menu System→Download system data...

5 TECHNICAL SPECIFICATIONS

Item	Description
Instrument class	Tristimulus colorimeter
Sensor type	Color sensor based on the standard spectral value of the CIE 1931 color matching functions as per DIN ISO 13655 and DIN 5033
Measurement mode	Reflective
Acquisition mode	Software-triggered Single or multiple readings
Working distance	Contact
Measurement geometry	Circumferential 45° illumination and 0° viewing, according to CIE15:2004, ASTM E1164
Light source	16 LEDs
Color scales	CIE-XYZ, CIE-xyY, CIE-L*a*b*, CIE-L*C*h*, CIE-L*u*v*, sRGB (where applicable), user-defined
Color differences	ΔE^*_{ab} (CIE 1976), ΔC^*_{ab} , ΔL^* , Δa^* , Δb^*
Illuminant	D65, D55, D50, A, C, FL2, FL7, FL11
Observer	CIE1931-2° and CIE1964-10° standard colorimetric observers
Short-term repeatability	0.03 ΔE^*_{ab} typ – D65/2°, standard deviation of 30 measurements every 5 s on white reference standard under Eoptis standard conditions (*)
Illumination/Measurement area	Ø10mm /Ø18mm
Size of smallest measurable specimen	Ø23mm flat surface
Measurement time	<0.1 s, with 5 s minimum recommended measurement interval
Recommended warm-up time	20 minutes
Dimensions	Approx. 120 mm (L) x 84 mm (H) x 90 mm (W) excluding cable
Weight	Approx. 710 g
Interface	USB 2.0, 500 mA rated
Power requirements	USB self-powered, 2.5 W peak, 0.6 W typical
Operating ambient temperature	10 °C to 40 °C 50 °F to 104 °F
Storage temperature	0 °C to 60 °C 40 °F to 140 °F
Humidity range	20-80% RH non-condensing
Protection rating	IP54
Usage	Indoor use
Standards traceability	Instrument standard assignment in accordance with National Institute of Standards and Technology (NIST) following practices described in CIE Publication 44 and ASTM E259 (Standard Practice for Preparation of Pressed Powder White Reflectance Factor Transfer Standards for Hemispherical and Bi-Directional Geometries)
Standard accessories (Packing list)	- White reference standard - User guide - PC utilities disk and interface drivers - Certificate of traceable calibration (if ordered)

Main Software features	<ul style="list-style-type: none"> - <i>Check</i>: Pass/fail with thresholds and automatic look-up of reference color - <i>Match</i>: Search for closest standard in pre-loaded or custom database - <i>Classify</i>: Classification under selected standards - Average multiple readings - Data import/export to proprietary database - Data export to .pdf and Excel-readable . xml format - Generation of analysis report in .pdf and Excel-readable . xml format <p>Note: availability of some features may vary by version</p>
Data view	<ul style="list-style-type: none"> - Color Data (see available scales above) - Color Difference Data (see color differences indexes above) - CIE-L*a*b* Color Plot
Software language	English, Italian (Italiano), Chinese (中文), Portugues (Portugues), French (Français)

(*) 25 °C, 50% RH, 20' warm-up

Specifications subject to change without notice.

6 APPENDICES

6.1 PRECAUTIONS AND SYSTEM MAINTENANCE

When handling the colorimeter, avoid touching the glass window. The window is recessed and therefore protected from dirt during normal usage. However, if it does require cleaning:

- at first, blow short bursts of clean, dry air onto the window
- if dirt has not been removed, use an optical lint-free cloth dampened with distilled water and gently wipe the window without applying excessive force
- in the case of a very soiled surface, contact Eoptis for support.

Occasionally wipe the outside of the meter with a soft water-dampened cloth. The housing components are made out of synthetic materials. Thus, avoid contact with acetone and similar detergents that contain solvents. Remove any splashes immediately.

The device is designed for indoor use. Extended exposure to bright sunlight, rain, dusty environments, etc. may damage the electronics and the optics of the system. Avoid excessive shaking, dropping or mishandling of the device.

6.2 TROUBLESHOOTING

Problem

The usb cable is plugged but software displays "Device not connected."

Solutions

- 1) The drivers are not correctly installed: check proper driver installation section and, in case the CLM194 is not displayed, install drivers. To check the Device Manager to confirm that installation was successful, go to the Windows Start menu, select Run and enter "devmgmt.msc". You will find the "CLM-194 Colorimeter" under the "Ports (COM & LPT)" section.
- 2) The USB port is not capable of supplying full current (500mA): change port or disconnect USB devices (such as external hard drives and speakers) which are connected to other ports.
- 3) Operating condition undefined or excessive EMC load: unplug and reconnect the USB cable, then re-start the software.
- 4) A system error initial: re-start software and re-connect the cable.

Problem

The color displayed on the screen differs from the color of the sample.

Solutions

This is not a malfunction. The measured color is displayed on the monitor as a guide only. Differences are common and it is very likely that the measured color will appear to be different from the color of the sample. This is due to several factors (such as the ambient light, monitor calibration, gamma settings) which must be controlled and fine tuned in order for the colors to match. Contact Eoptis to check how your PC can be tuned to improve matching.

Problem

The measured color data are obviously incorrect.

Solutions

- 1) Ensure the sample perfectly adheres to the measurement port.
- 2) Ensure the sample and the glass window of the measurement port are clean.
- 3) Check that the units is within its operating temperature range.
- 4) Perform a user calibration using the white reference standard.

6.3 STANDARDS

<i>CIE15:2004</i>	General terminology of colorimetry and basic data
<i>DIN 5033</i>	Colorimetry; basic concepts
<i>DIN 5036</i>	Radiometric and photometric properties of materials; definitions characteristics
<i>DIN 6174</i>	Colorimetric evaluation of color differences of surface colors according to the CIELAB formula
<i>ASTM D2244</i>	Standard Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates
<i>ASTM E308</i>	Standard Practice for Computing the Colors of Objects by Using the CIE System
<i>ASTM E1164</i>	Standard Practice for Obtaining Spectrophotometric Data for Object-Color Evaluation

6.4 WARRANTY AND REPAIR

Eoptis warrants to the Original Purchaser that the product provided with this package is guaranteed to be free from material and manufacturing defects for a period of one (1) year from shipment date. Should a unit fail during this period, Eoptis will, at its option, repair or replace the damaged unit. Repaired or replaced units will be covered for the remainder of the original equipment warranty period. This warranty does not apply to units that, after being examined by Eoptis, have been found to have failed due to customer abuse, mishandling, alteration, improper installation or negligence or are beyond reasonable reparability. Warranty is void if any proprietary labeling is removed.

Eoptis expressly disclaims and excludes all other warranties, express, implied and statutory, including, but without limitation, warranty of merchantability and fitness for a particular application or purpose. In no event shall Eoptis be liable to the Original Purchaser or any third party for direct, indirect, incidental, consequential, special or accidental damages, including without limitation damages for business interruption, loss of profits, revenue, data or bodily injury or death.

Products within the warranty period may be returned for repair. Outside the warranty period, products may still be returned for repair; however, a fee will be charged. The customer is responsible for shipping costs to and from Eoptis.

An RMA number is required before an Eoptis product can be returned. Products that are returned without an RMA number may be refused and returned to the sender, or may result in unnecessary processing delays. An RMA number and repair service may be requested via info@eoptis.com.

7 REVISION HISTORY

Version	Date	Description
Rev.0.9	08.2013	Preliminary release
Rev.0.10	09.2013	Software functions description added
Rev.0.11	09.2013	Advanced features added
Rev.1.0	09.2013	Initial full release
Rev.1.01	09.2013	Minor corrections
Rev.1.02	12.2013	Setup procedure updated, additional Illuminant and Observer pairs supported
Rev.1.03	12.2013	Minor updates
Rev.1.04	03.2014	Table of specs added. Upgrade for software Rel.1.3.2: - report features added database can be saved in .pdf and .xml format.
Rev.1.05	06.2014	English language corrections. Upgrade for software Rel. 1.3.5: (SI;SO) pair is saved and restored at new software session.
Rev.1.06	12.2014	User Calibration procedure updated with Dark acquisition.
Rev.1.07	02.2022	Added description of Database context menu
Rev.1.08	04.2022	Described USB stick installation
Rev.1.09	10.2022	Description of function Color Check; Thresholds mode Description of user-defined color spaces usage General revision
Rev.1.10	03.2025	Rebranding Added "Copy/Move to other database" context menu notes Added "Preferences panel" description Updated screenshots to last version Aligned some procedures for CLM196 functionalities

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