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HunterLab
ColorQUEST Sphere II with SpecWare Software
Instruction Manual

Manual Version 1.0
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Use of the Instruction Manual

The ColorQUEST™ Sphere II Instruction Manual is divided into the following chapters:

- Chapter 2 - System Description
- Chapter 3 - Installation
- Chapter 4 - Standardization
- Chapter 5 - Quick Start
- Chapter 6 - F3 Output
- Chapter 7 - F4 Clear
- Chapter 8 - F5 Setups
- Chapter 9 - F6 Procedures
- Chapter 10 - F7 Average
- Chapter 11 - F8 Data
- Chapter 12 - F9 Screens
- Chapter 13 - F10 Run
- Chapter 14 - Measurement Guidelines
- Chapter 15 - Options
- Chapter 16 - Maintenance

- Appendix A - Specifications
- Appendix B - Additional Programs
- Appendix C - Error Messages
- Appendix D - Instrument Replacement and Repair
- Appendix E - Glossary
- Appendix F - References

Chapter 2 describes the components of the ColorQUEST Sphere II system and lists the items in the standards box which accompanies the instrument. Lists of all color scales, color difference scales, and illuminants that can be used for measurements are also given.

Chapter 3 gives instructions for installing your ColorQUEST Sphere II system and loading the ColorQUEST SpecWare software for the first time.

Chapter 4 describes all the different modes available for instrument standardization and gives instructions on how to attain the appropriate hardware configuration for each mode. Instructions for saving standardization modes are also included.

Chapter 5 gives you an overview of the operation of the system by describing a typical measurement sequence.

Chapters 6 through 13 describe in detail each of the SpecWare software menu choices accessed through the function keys.

Chapter 14 gives you guidelines to follow when measuring certain types of specimens. These guidelines can help you attain accurate repeatable measurements.

Chapter 15 describes the software and hardware options available with the ColorQUEST Sphere II system.

Chapter 16 lists the procedures to be followed in order to keep your ColorQUEST Sphere II in good working condition. Instructions on replacing the lamp and the fuse are also given here.

Appendix A lists the specifications of the instrument and describes how all displayed values are calculated.

Appendix B gives instructions on installing software upgrades, changing port designations, and changing port parameters.

Appendix C describes all of the error messages.

Appendix D gives HunterLab warranty information and gives instructions for returning the instrument for repair.

Appendix E provides a glossary of some frequently used terms.

Appendix F gives a list of references.

The instruction manual is written describing keyboard operation. However, a mouse may also be used to make selections. Simply place the cursor over the desired item and click the left mouse button once.

Before you begin using the ColorQUEST, read Chapters 2 through 5 to familiarize yourself with the instrument and a typical operation sequence. In addition, read Chapter 16 to become familiar with the routine maintenance of the instrument. Later you can refer to Chapters 7 through 15 for a more thorough description of each function. At times you may also need to refer to one of the Appendices, such as when an error message appears or when you want to upgrade your software.

2

System Description

Parts of the System

The ColorQUEST™ Sphere II system consists of a ColorQUEST Sphere II optical sensor with a power supply and an IBM computer composed of the system unit, keyboard, math coprocessor and monitor. A printer and a mouse may also be used with the system.

The Sphere Sensor

The sphere sensor can measure either the reflected or transmitted color of a product. The integrating sphere is a chamber 6 inches in diameter coated by barium sulfate ($BaSO_4$) which diffuses the light from the lamp. The light illuminates the sample and is either reflected from it or transmitted through it. A lens is located at an angle of 8° from the perpendicular of the sample surface. The lens collects the reflected or transmitted light and directs it to a diffraction grating. The grating then disperses the light into its component wavelengths. This dispersed light is reflected onto a 32 element silicon diode array which measures the light every 10 nm across the spectrum of 400 nm to 710 nm. The signals from the diode array are amplified using laser trimmed operational amplifiers and processed by a 16 bit analog-to-digital converter. The computer receives the converted data and manipulates it to produce the information needed for the selected setup of the instrument.

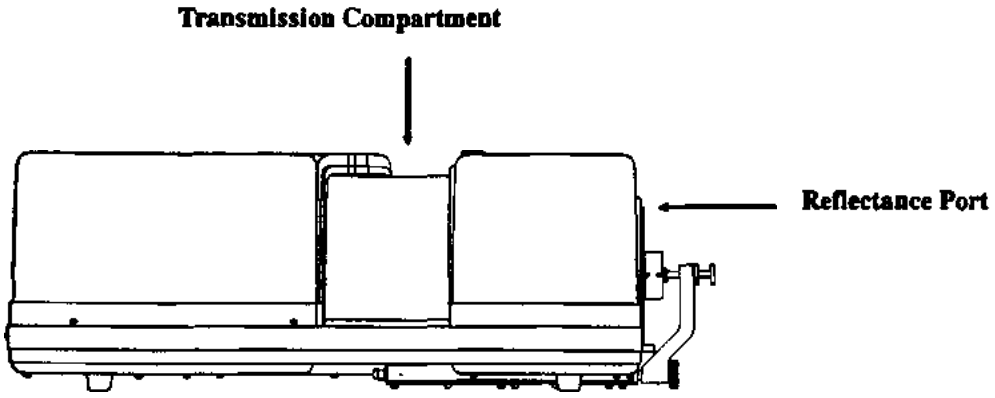
Power Switch

The sensor power switch is located on the right side of the sensor.

Reflectance Port

The reflectance port is located at the front of the sensor as shown in Figure 2-1. The port is covered by a port plate either with 1 inch or 1/4 inch opening. When using the small area view lens, the 1/4 inch port plate must be installed at the reflectance port. Spring clamps can also be attached to the small holes of the port plate to aid in the placement of specimens. The port plate is covered by a clamp which holds the specimen in place during measurement. The clamp pulls straight back from the port and locks when fully extended. It can then be released by pulling back on the clamp. The clamp also contains a damper to reduce the impact on the port when the clamp is released. The clamp can also be removed from the sensor when you are measuring large or otherwise cumbersome samples

Figure 2-1



Transmission Compartment

The transmission compartment located in the middle of the sensor and shown in Figure 2-1 is used when measuring the transmitted color of transparent objects or liquids. From the transmission compartment you can also install the small area view lens. The transmission compartment door must be closed while standardizing and taking measurements.

Computer System

Several computer systems are available from HunterLab with the ColorQUEST Sphere II.

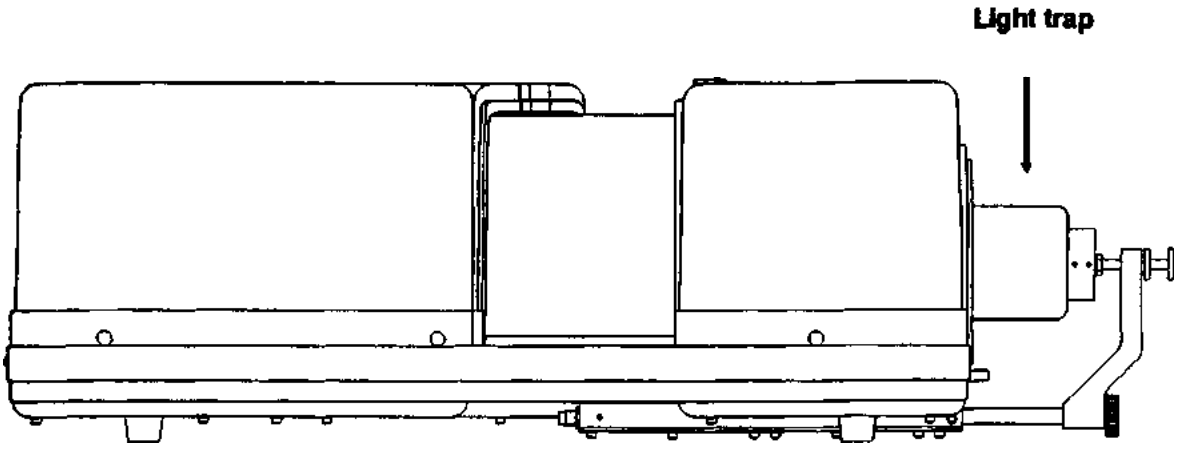
Accessories

The following accessories are provided with the ColorQUEST sphere system and can be found in the standards box.

- White calibrated tile - placed at the reflectance port during standardization.
- Gray calibrated tile - placed at the reflectance port during standardization.
- Light trap - placed at the reflectance port during standardization. The light trap is shown in Figure 2-2.
- Black card - placed in the transmission compartment during standardization.
- Green tile - used to check instrument performance.
- Transmission sample holder (optional) - used to hold samples in the light path when taking transmittance measurements. The transmission sample holder is shown in Figure 2-3.

- Cleaning procedure card - gives instructions on how to clean all of the ceramic standards.
- Fuse - a 1 amp fuse is provided as a spare.
- Lamp - one lamp is provided as a spare.

Figure 2-2



Options

Any or all of the following options may be included:

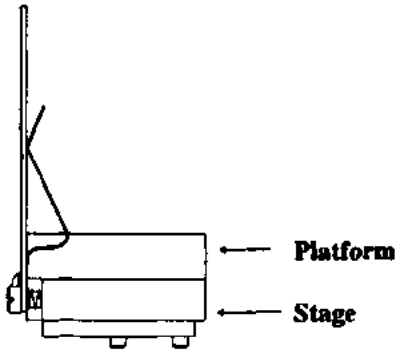
- Transmission specimen holder
- Reflectance sample shelf and light cover
- Small area view lens, sample port plate, and retroviewer
- Ultraviolet absorbing filter

Transmission Specimen Holder

The transmission specimen holder is used to hold samples in the light path when taking transmittance measurements and is shown in Figure 2-3. The pins on the bottom of the holder are placed into 2 of 3 positioning holes in the transmission compartment. The forward 2 holes are used to align samples at the sphere opening when making total transmittance measurements. The 2 rear holes are used to align samples at the lens when making regular transmission measurements.

An additional platform is also provided with the holder to raise the stage where the sample sits. The platform is a different width on each side and can be placed on the platform in either orientation. Choose the orientation that best fits the type of transmission cell you are using.

Figure 2-3



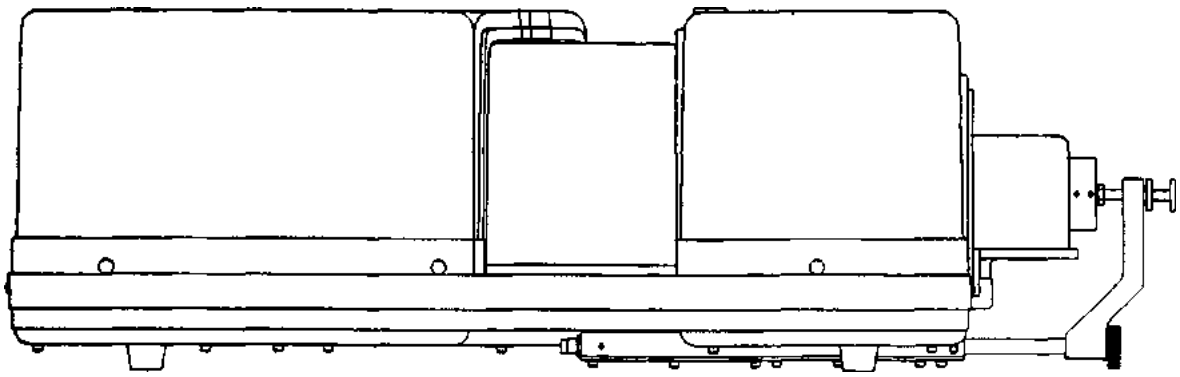
Reflectance Sample Shelf and Light Cover

The sample shelf and light cover is used to measure small translucent objects or translucent liquids and is shown in Figure 2-4.

To use the sample shelf

1. Pull back the sample clamp and lock it in position.
2. Place the pins of the shelf into the spacer block near the sample clamp.
3. Place your sample in a glass cell and place the cell against the opening in the instrument. Be sure the level of sample is high enough to cover the opening.
4. Place the light cover over the cell to prevent the room light from interfering with the measurement.

Figure 2-4



Small Area View

The small area view option consists of a small area view lens, a small area port plate and a retroviewer. Use of the small area view option is described in the chapter on standardization.

UV Filter

The UV filter is an option that is installed at the factory. The use of the UV filter is described in the chapter on standardization.

Color Measurements

The ColorQUEST Sphere spectrocolorimeter can be used to measure virtually any kind of product. Opaque and translucent materials can be placed at the reflectance port on the front of the sensor and the reflected color can be measured. Transparent samples such as films and liquids can be placed in the transmission compartment and transmitted color can be measured.

Reflectance Measurements

There are two types of reflectance measurements available. The first type, reflectance - specular included, measures the diffuse plus specular reflectance of the specimen at the port. These measurements are made with the specular exclusion port door closed. The specular included mode is recommended for interlaboratory measurement comparisons.

The other type, reflectance - specular excluded, measures the sample excluding a substantial part of the specular component reflected by the sample. These measurements are made with the specular exclusion port door open.

Transmittance Measurements

There are two types of transmittance measurements available. The first, total transmittance, includes both the light that is transmitted directly through the sample and the light that is diffusely scattered. When measuring total transmittance, place the specimen in the transmission compartment as close to the sphere as possible.

The second type, regular transmittance, measures the light that passes directly through the sample. When measuring regular transmittance, place the specimen in the transmission compartment as close to the lens as possible.

Color Scales

The following color scales are available for measurements

- XYZ
- Yxy
- Hunter Lab
- CIELAB (L* a* b*)
- CIELCh (L*C*h)
- Rdab
- AnLab

Information concerning calculation of all color scales is given in Appendix A.

Color Difference Scales

The following color difference scales are available.

- ΔE and ΔC for Hunter Lab and Rdab
- ΔE*, ΔC*, and ΔH* for CIELAB
- ΔE, ΔL, ΔC, and ΔH for CMC
- ΔE, ΔL, RG, YB for FMC2

Information concerning calculation of all color difference scales is given in Appendix A.

Indices

In addition to the color scales, 9 single indices are available.

- Whiteness Index E313
- Z%
- APHA20
- 457 nm Brightness
- Yellowness Index D1925
- Dominant Wavelength
- Yellowness Index E313
- Excitation Purity
- Metamerism Index

Information concerning calculation of all indices is given in Appendix A.

Illuminants and Observers

The following illuminants are available with the 2° standard observer or the 10° standard observer.

- A (Tungsten)
- C (Daylight)
- D_{65} (Daylight)
- F_2 (Fluorescent)
- TL*4* (Fluorescent)
- ULT (Fluorescent)
- D_{50}
- D_{60}
- D_{75}

3

Installation

The instructions in this chapter guide you through the initial installation of your ColorQUEST Sphere II system and SpecWare software. To upgrade software, change sensor port or change communication port parameters refer to Appendix B – Additional Programs.

Installation of Hardware

Refer to the IBM Installation Guide for detailed installation instructions of the computer.

1. Unpack all cartons and remove wrappings and cable ties. Inspect for damage and notify the carrier and HunterLab immediately if any is discovered. Save the packing materials in case it becomes necessary to return the instrument to the factory.

2. Place the instrument on a flat working surface where the measurements will be made. Place computer in close proximity to the sensor and the power supply.

3. Unwrap the IBM Guide to Operations Manual and insert the additions and updates in the proper locations.

Computer Setup

1. Open the IBM Guide to Operations to the tab labeled SETUP. This section contains step-by-step instructions and detailed diagrams to assist you while setting up your system. READ THE INSTRUCTIONS CAREFULLY.

2. Connect the cable from the monitor labeled VIDEO INPUT to the graphics board on the IBM system unit. For System 2 Model 30 computers, connect the cable to the **upper** 9 pin female socket on the back of the computer and not the one next to the 25 pin socket. For the Model 50 computers, connect the cable to the 15 pin female socket on the back of the computer.

3. Connect the keyboard cable to the DIN cable socket in the back of the IBM system unit.

4. Once the IBM is installed, there are a few tests which should be run to ensure the IBM components are operating properly. These tests are called diagnostics and are on the diskette located in the back of the IBM Guide to Operations Manual. Refer to the corresponding section of the manual and perform the tests.

   If the tests are positive, proceed with the next step. While performing Test 400, the error message ERROR - SYSTEM UNIT 401 will be displayed. This is due to the use of the high resolution Terminal Graphics Master color video adapter and is expected. The failure of this test does not affect the SpecWare software. Press ENTER to continue. If any test other than the one mentioned is negative, **do not go any further.**

   Note: When asked for the fixed disk test, answer 'Y'. It will not affect the SpecWare software.

All EGA cards for use with SpecWare must be configured for high resolution graphics. The bank of 4 switches located on the back panel of the IBM EGA card should be set as follows:

SW1	SW2	SW3	SW4
off	on	on	off

Enabling high resolution graphics on the EGA card has some noticeable side effects on the performance of the text screens. The text character set is more defined and the border that is usually displayed around text screens is absent.

If the switch settings are incorrect, the software does not switch into high resolution for the spectral plot and color plot screens.

Installation Of Mouse Hardware (optional)

Install mouse hardware according to the instructions provided with the mouse.

Printer Setup

1. Follow the instructions in the printer manual to set up the printer and install paper.

2. Connect the male plug of a RS-232 25 pin connector signal cable to the IBM system unit parallel port. Connect the other end to the printer.

3. Turn the printer on.

4. The POWER and READY lights on the printer should be illuminated. If they are not, turn the printer off and on.

   Note: The printer contains a group of switch settings which need to be properly set to ensure printing of spectral plots. Please refer to the Computer Configuration Guide for more information.

Sensor Setup

1. Connect the power cord to the sensor.

2. Connect the female plug of the 25 pin signal cable to the computer. Connect the male end of the 25 pin cable to the sensor.

   Note: If you are using an IBM compatible computer you may need to use a 25 to 9 pin conversion cable.

3. Remove the tape covering the sample port of the optical sensor and the exterior of the sphere in the transmission compartment.

4. Place the sample port plate at the reflectance port and snap it into place.

5. Locate the reflectance port sample clamp in the standards box and secure it to the reflectance port.

6. Place the reflectance port sample clamp against the sphere. Covering the sample port when the instrument is not in use prevents dust from accumulating inside the sphere.

7. Turn on the sensor using the switch on the right side of the sensor. If you pull back the sample clamp you should see light in the sphere.

The sensor should be allowed to warm-up for 1/2 to 2 hours to reach optimum operating temperature.

CAUTION

Keep the cables free from all air intake and exhaust vents on the IBM or the computer might overheat.

Installation of Software

If you puchased a computer from HunterLab, the program files are already installed on the computer in the C:\CQSPEC directory. If you purchased a computer separately, you must format the fixed disk and load the program files.

Preparing the Fixed Disk

1. Insert the DOS program disk into Drive A with the slot first and label facing up (as per the instructions in the IBM User's Guide) and close the door on the disk drive.

2. Turn on the power to the computer.

3. If the fixed disk is not already formatted, type the following command (using the correct parameter to copy the operating system files onto the fixed disk):
   FORMAT C:/S

   CAUTION
   This command will erase all files currently on the fixed disk.

4. Copy COMMAND.COM and ANSI.SYS from your DOS diskette onto the fixed disk if they are not present by typing the following:
   COPY A:COMMAND.COM C:
   COPY A:ANSI.SYS C:

5. Create a DOS directory if one is not present by typing the following command:
   MD C:\DOS

6. Type the following command:
   COPY A:*.* C:\DOS

7. Insert the supplemental DOS diskette into the disk drive and repeat step 6 to copy.

8. Create a file CONFIG.SYS if not currently present by typing:

   COPY CON C:CONFIG.SYS
   FILES = 10
   BUFFERS = 10
   DEVICE = ANSI.SYS
   After the commands have been entered, press X and ENTER to terminate entry.

   Note: If a CONFIG.SYS file currently exists, it must include DEVICE = ANSI.SYS to execute the software.

9. If you need to set the battery backed clock, refer to the manufacturer's manual included with the system.

10. Restart the system on Drive C (fixed disk) by pressing CTRL/ALT/DEL simultaneously.

Make a backup copy of the program diskette(s) using the DOS command 'DISKCOPY'. See the DOS manual for details.

Loading Program Files

When the program files need to be installed onto the fixed disk for the first time, the following procedure should be used. The installation program will create a directory (\CQSPEC) with files for the program and data.

1. Place the HunterLab program diskette 1 into Drive A.

2. At the system prompt type the following:
   A:INSTALL
   to load programs for the first time.

3. The screen will display COPYING while the files are copied from the diskette to the hard disk. You will be prompted to insert the next diskette.

4. After all files have been copied, new data files will be created.

5. You will then be lead through the following series of questions. The default selection for all questions is No (N).

   INSTALL ENGLISH? CQM (Y,N) N.
   This prompt will be displayed only if more than one language file is available.

   DO YOU WANT THE COLORQUEST SOFTWARE TO AUTOMATICALLY RUN WHEN THE COMPUTER IS TURNED ON OR REBOOTED? (Y,N) N.
   If you respond with Y, a batch file is created which automatically boots the CQ software. If you respond with N, you must type in the command CQSPEC to execute the software or create your own batch file.

   WILL THE SENSOR BE RUNNING ON A 50HZ POWER? (Y,N) N
   50 Hz power is very common, however, 60 Hz is normally used in the United States and Japan.

   WILL THE SENSOR BE CONNECTED TO SERIAL PORT 2? (Y,N) N
   The default selection for all questions is No (N).

Note: If a CONFIG.SYS file has not already been created, you will be asked if you would like to create one. Proper configuration is necessary for proper operation of the software.

6. The screen will display INSTALLATION COMPLETE after all parameters have been selected.

7. Remove the diskette and restart the system by pressing CTRL/ALT/DEL simultaneously. Enter the SpecWare software by typing CQSPEC or CQ. Below is a list of the files installed in the CQSPEC directory which are required to run the software:

AUTOCAL.TXT	CQSPEC.EXE
CQ_CAL.DAT	CQ_COM.EXE
CQ_FILES.EXE	CQ_ILL.DAT
ENGLISH.CMN	ENGLISH.CMU
ENGLISH.CQM	FSETUP.DAT
GSETUP.DAT	LOGO.GX1
PROCFILE.DAT	PROCLIST.DAT
SAMFILE.DAT	SAMFILE.IDS

Installation of Mouse Software (optional)

Software accompanying the mouse may be installed so that it will run automatically whenever the computer is turned on or rebooted. The following instructions will install the mouse software in the CQSPEC directory.

1. Insert the software diskette which accompanied the mouse into drive A.

2. At the system prompt type COPY A:MOUSE.COM C:\CQSPEC and press ENTER.

3. At the system prompt type REN C:\AUTOEXEC.BAT AUTO.BAT and press ENTER.

4. At the system prompt type COPY C:\AUTO.BAT + CON C:\AUTOEXEC.BAT and press ENTER.

5. Type CQSPEC\MOUSE and press ENTER.

6. When the cursor returns, press F6 and then press ENTER.

4

Standardization

Standardizing the Instrument

Standardization sets the top and bottom of the scale for the neutral axis. During a standardization procedure the first to be set is the bottom of the scale. For the bottom of the scale you simulate the case where all the light is absorbed by the sample. This is done using the light trap for reflectance modes and the black card for transmittance modes. The top of the scale is then set by scaling the light which is reflected or transmitted to a calibrated standard. This is done using a calibrated white tile for reflectance measurements and air or a solvent filled cell for transmittance measurements. Reflectance measurements also use a gray calibrated tile to correct for changes in sphere wall reflectance over time. At the end of all standardization procedures the sample clamp is read to set a base value for the Autocal function.

Standardization Modes

Four modes of measurement are available when you standardize the instrument:

- RSIN - Reflectance Specular Included
- RSEX - Reflectance Specular Excluded
- TTRAN - Total Transmittance
- RTRAN - Regular Transmittance

With varying hardware configurations such as UV filter and small area view there are a total of 16 ways to standardize the instrument. The instrument can be standardized when you first enter the software or at any time by selecting standardization from the procedures menu displayed by pressing F6.

During standardization, follow the prompts on the screen to indicate the proper instrument configuration. You must manually adjust the hardware for specular exclusion, UV filter, and small area view.

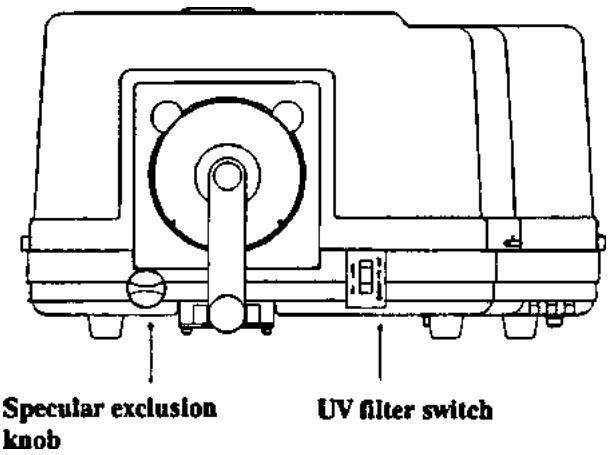
Note: Be sure that the transmission compartment door is closed while standardizing.

When standardizing in transmittance modes you are prompted to place the white calibrated standard at the reflectance port. Alternatively, a plug of barium sulfate ($BaSO_4$) or magnesium oxide (MgO) may be used to more closely approximate the actual sphere wall reflectance. When taking transmittance measurements, the calibrated white tile or the plug used during standardization must be kept at the reflectance port.

Specular Exclusion Port

When using RSIN, TTRAN, or RTRAN mode, you must keep the specular exclusion port door closed. However, when using RSEX you must open the specular exclusion port door to open up the sphere so that the specular component can be excluded from the light collected by the receptor lens. The specular exclusion port is located on the sphere inside the transmission compartment, but is opened or closed using the knob on the left front of the sensor shown in Figure 4-1.

Figure 4-1



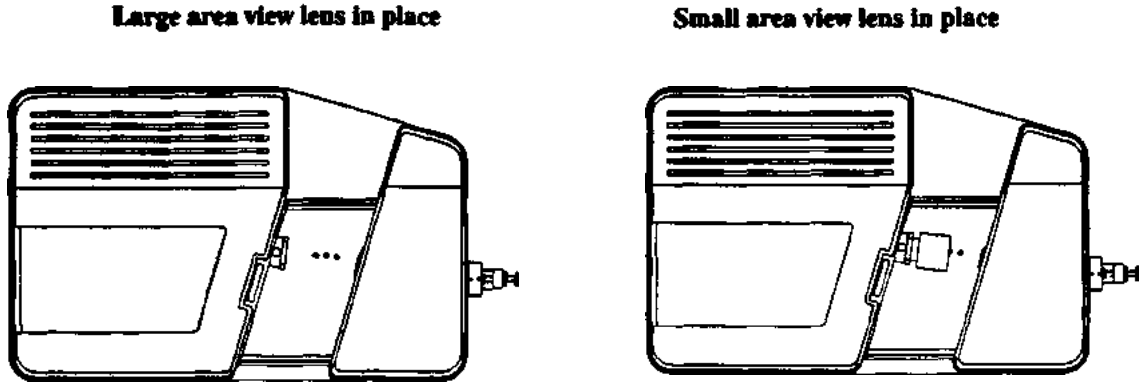
UV Filter

The UV filter is positioned either in or out of the light path by using the switch located on the right front of the instrument as shown in Figure 4-1. To move the filter into the light path and exclude UV light move the lever forward to the EXCL position. To move the filter out of the light path and include UV light move the switch back to the OUT position. For optimum stability the UV filter should be in the source path for ten minutes before standardization. The filter must be removed from the light path after use to prevent degradation.

Small Area View

The small area view lens is longer than the original large area view lens and is marked with an S. The large area view lens is shorter and is marked with an L. Both lenses are shown in Figure 4-2.

Figure 4-2



To use the small area view lens:

1. Loosen the thumb screw on the lens receptacle.
2. Pull the lens forward taking care not to touch the lens surface. Store the lens in a safe place to avoid scratches to the lens surface.
3. Place the small area lens in the lens receptacle positioning the pin in the hole at the bottom of the receptacle. The S mark on the lens should align with the white mark on the lens receptacle.
4. Tighten the thumb screw on the lens receptacle.
5. Pull all the way back on the sample clamp to lock it in the open position.
6. Remove the 1 inch port plate and snap in the 1/4 inch port plate.
7. Pull back on the sample clamp to release it.

Restandardization

Restandardization is available only through the procedures menu displayed by pressing F6. Restandardization resets the top scale of the neutral axis. In a reflectance mode, you are prompted to read the white tile again. In a transmittance mode, you are prompted to take a reading either through air or through a solvent filled cell (blank). At the end of any restandardization procedure you are also prompted to read the sample clamp.

Verifying Standardization

After standardizing or restandardizing the instrument in one of the modes you can recall an instrument standard from the data menu displayed by pressing F8. Place the appropriate tile at the port and press F1 to read a sample. Compare the standard and sample values on screen. Immediately after standardization, the two values displayed on the screen should not differ by more than 0.01 units in the XYZ color scale.

Prompt to Standardize

It is recommended that the instrument be standardized at least once every 8 hours. To remind yourself to standardize, you may enter a number of hours in the global setup screen selected from the setup menu displayed by pressing F5. After the designated number of hours has passed a prompt will appear on screen suggesting standardization.

To keep your instrument working accurately it is necessary to restandardize the instrument by setting the top of the scale every 4 hours in addition to standardizing at the start of each day or each shift. In addition, standardize the instrument or recall a standardization mode using mode select whenever a hardware component changes such as the specular exclusion port door, UV filter, or small area view lens.

Autocal

The instrument is equipped with an Autocal feature to monitor drift in the standardization of the sensor and sense instability of the sensor. The Autocal feature can be turned on and off from the diagnostics menu under the F6 procedures function. When Autocal is enabled the instrument automatically takes readings of the sample clamp when no samples are being read. These readings of the sample clamp are then compared to the reference value of the sample clamp that was established during standardization. A warning requesting standardization appears when the readings have drifted 1% or more at any wavelength. To effectively use the Autocal feature remove all samples from the port when not using the instrument. Frequent warning messages while using the Autocal feature indicate instrument instability due to fluctuations in power, temperature, or lamp voltage.

The Green Tile

The green tile is not used during the standardization procedure. The green tile can be used to verify that the instrument is reading properly. Read the green tile using the RSIN mode once a week and keep records of the readings. The readings should vary by no more than ±0.3 units from the values given on the back of the tile.

Saving Standardization

Whenever you exit the software to return to DOS, the current standardization is saved in a file. When you return to the software you have the option of using that saved standardization or going through a new standardization procedure.

CAUTION

The saved standardization should not be used if it was completed more than 8 hours ago.

Mode Select

Mode select allows you to save a standardization and recall it at a later time. This is useful when you are taking measurements under a variety of instrument conditions and you are switching back and forth frequently.

For example, if you are trying to determine the effect of ultraviolet light on a product's appearance you might want to take measurements of the samples with the UV filter in (EXCL position) and then with the UV filter out (INCL position). First standardize the instrument with the UV filter out of the light path and save this standardization using mode select. Then standardize with the UV filter in the light path and save this standardization. You can then place a specimen at the port and read it under one standardization as a standard, then recall the previous standardization using mode select and read the specimen as a sample. You can then determine the effects of UV by comparing the standard and sample data displayed on the screen.

The mode select feature does not eliminate the need for frequent standardization. Standardization saved under mode select should be used within 8 hours of saving. Standardization modes can be deleted from memory when no longer needed.

5

Quick Start

This chapter describes typical operation of the ColorQUEST Sphere II system. You can walk through a sequence of steps to get started. Normal operation includes:

- Standardizing the instrument.
- Creating a setup to define the type of measurements you want to take.
- Taking measurements and saving them in a data file.
- Clearing measurements from the screen so that you can start with the next set.

Use this chapter to get yourself started taking color measurements. To follow along with the instructions in this chapter you will need 2 specimens of your product. Designate 1 specimen as the standard and 1 as the sample.

Subsequent chapters describe each function of the SpecWare software in greater detail.

Starting and Standardizing

When the instrument has been turned off for long enough to completely cool to ambient temperature conditions, it will require time to reach operating temperature equilibrium before maximum performance is achieved. For the instrument to provide full specified performance a warm-up period of 30 minutes to 2 hours (depending on conditions) should be allowed. Naturally, if the instrument is subjected to a large temperature change such as being brought from an unheated storage area into a 70°F operating area sufficient time should be allowed for the instrument to stabilize.

1. Allow the system time to warm up. The instrument may be used after a few minutes initial warm-up. However, until thermal equilibrium is attained, frequent standardization is required.

2. Turn the printer and monitor on.

3. Open the door on drive A.

4. Turn the computer on.

5. Type CD\CQSPEC to switch to the ColorQUEST directory.

6. Type CQ and press ENTER to start the SpecWare software and display the following message:

   PLEASE STANDBY, while the following initialization sequence is performed.
   LOADING SYSTEM MESSAGES
   LOADING OPTION DATA
   LOADING ILLUMINANT DATA
   INITIALIZING THE SENSOR
   INITIALIZING THE PRINTER
   OPEN DATA FILES
   Initialization complete error count = 0

7. The screen clears and then displays ENTER DATE AND TIME with the current date and time. It is important to maintain the correct date and time since they are automatically printed with every printout as well as stored with standard and sample data.

8. Use the arrow keys or the mouse button to select the value to edit. Enter data in the format dd:mmm:yy for the date, where mmm is a three letter abbreviation for the month, and hh:mm for the time.

9. Press HOME to continue. Information concerning the last standardization is displayed with the prompt:

   1 Use last standardization
   2 Prompt for new standardization

   Selection of 1 displays the measurement screen. Selection of 2 begins the standardization routine.

10. Press 2 and follow the prompts on the screen to standardize in the appropriate instrument configuration.

    Note: The sensor must be turned on prior to the computer. If the system does not properly initialize, turn off all the system components and then turn them on again in the proper order.

Creating a Setup

Pressing F5 displays the setup menu. From the setup menu you can tailor the data that is displayed on the monitor as well as the data that is printed, sent to a peripheral device, or output to a file. All selections in setup menus are made using the INS key or the mouse. To control the information displayed on the monitor you need to make selections in 4 setup screens:

- Color
- Spectral Data
- Spectral Plot
- Global

You may also want to make selections in the print setup screen if you intend to print out the readings you are taking. Refer to Chapter 8 for more information on setups.

Color Setup

From the setup menu press 3 to enter the color setup screen. The parameters listed here control the color data and color plot screens. Under display fields you may select SAMPLE, STANDARD, and DIFFERENCES so that you can compare measurements on the screen. You should select TOLERANCES if you have tolerances to meet for your product standard and you should select AVG.COUNT if you are averaging a number of measurements for standards and samples. For this example, select all of these parameters.

Selecting SETUP NAME displays the current setup name on the screen.

You may also select one DELTA DESCRIPTOR which explains in words the color difference between the standard and sample.

You may only select one color scale, one color difference scale, and one observer. You may, however, select 2 illuminants and up to 3 indices. For this example, choose CIELAB as the color scale with DELTA E CIELAB as the color difference scale. Also select the 10 degree standard observer, illuminants A and D65, and MI for metamerism index.

Three choices are available for the type of color plot to be displayed. For this example choose the RECTANGULAR plot to graphically display the color differences. The color setup screen with all of the selections made for this example is shown in Figure 5-1.

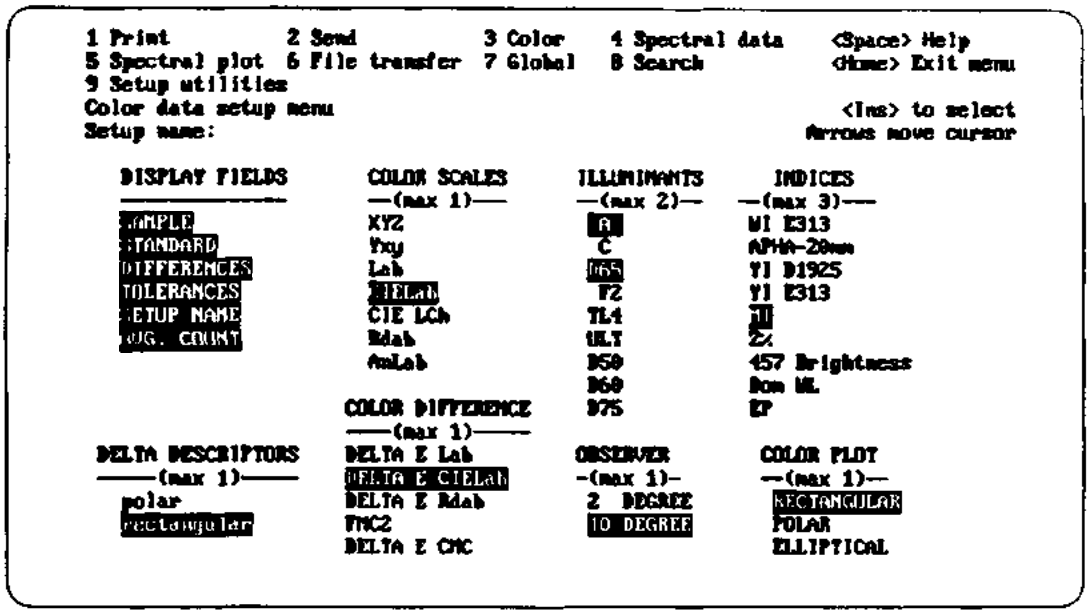
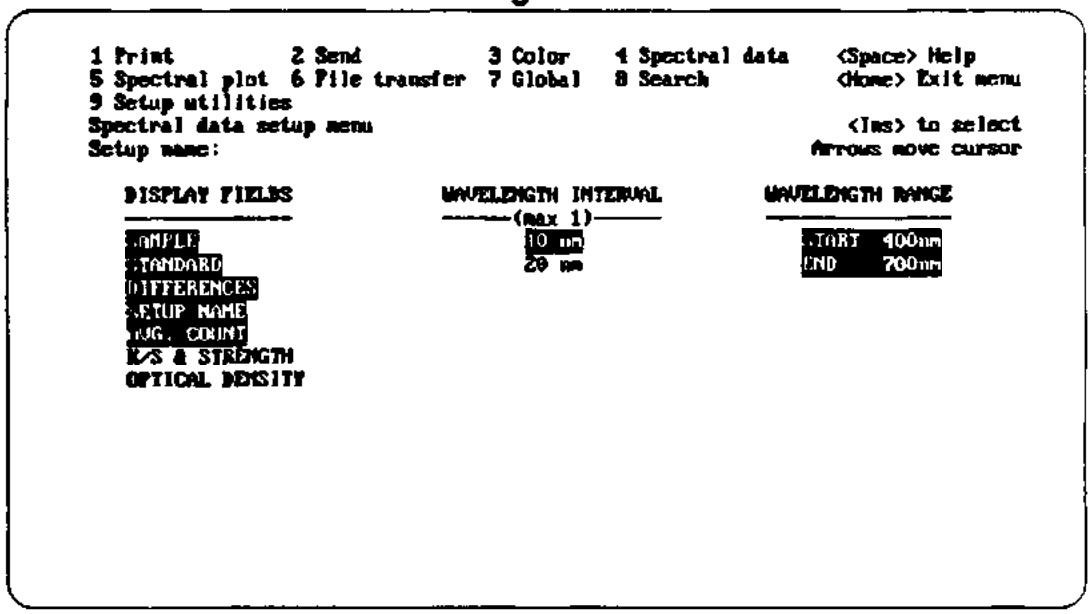


Figure 5-1

Spectral Data Setup

Press 4 to enter the spectral data setup screen. From the spectral data setup screen select the range and wavelength interval for the spectral data. The selection may be any range within 400 nm and 710 nm. For this example, select the 10 nm interval for the range 400 nm to 700 nm. The spectral data setup screen with all of the selections made for this example is shown in Figure 5-2.

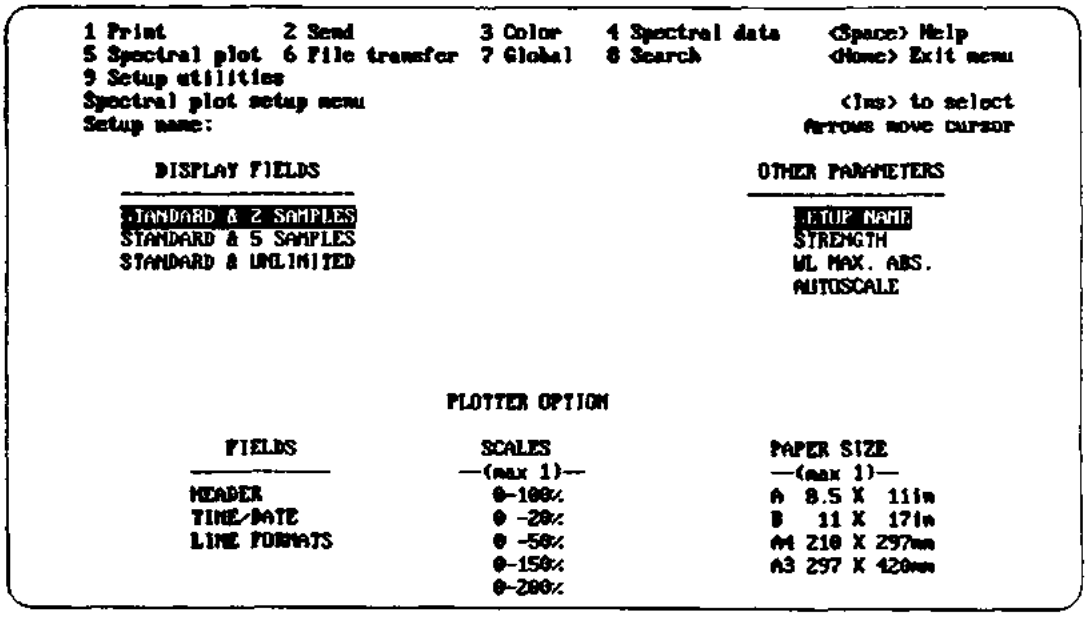
Figure 5-2



Spectral Plot Setup

Press 5 to enter the spectral plot setup screen. The parameters on this setup screen control the information displayed on the spectral plot screen or the optional plotter. For this example, select STANDARD and 2 SAMPLES to be displayed. The spectral plot setup screen with all of the selections made for this example is shown in Figure 5-3.

Figure 5-3



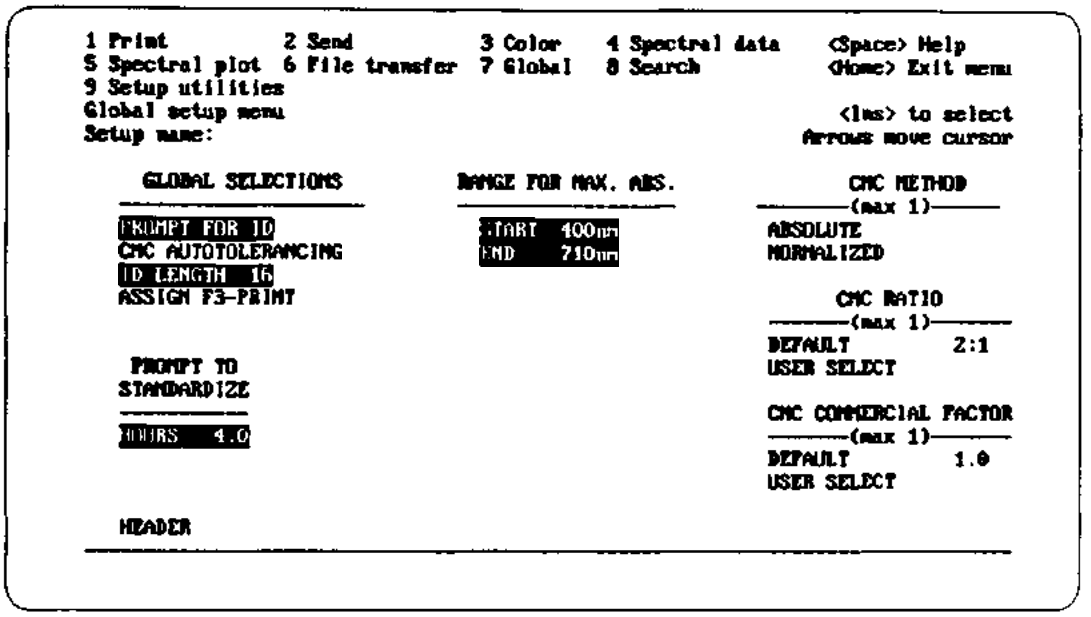
Global Setup

Press 7 to enter the global setup screen. From the global setup screen you can enable parameters that affect most of the display screens.

Select PROMPT FOR ID so that a name can be entered before reading each standard and sample. Select 16 for ID LENGTH to specify that all data saved in the current data file can have a maximum of 16 characters in the name. The global setup screen with all of the selections made for this example is shown in Figure 5-4.

Note: If you create a setup with an ID length greater than the one used in the previous setup, then you must create a new data file to accommodate the change.

Figure 5-4


1 Print
2 Send
3 Color
4 Spectral data
<Space> Help
5 Spectral plot
6 File transfer
7 Global
8 Search
<Home> Exit menu
9 Setup utilities
Global setup menu
<Ins> to select
Setup name:
Arrows move cursor
GLOBAL SELECTIONS
RANGE FOR MAX. ABS.
CMC METHOD
(max 1)
PROMPT FOR ID
CMC AUTOTOLERANCING
ID LENGTH 16
ASSIGN F3-PRINT
START 400nm
END 710nm
ABSOLUTE
NORMALIZED
CMC RATIO
(max 1)
DEFAULT 2:1
USER SELECT
PROMPT TO
STANDARDIZE
HOURS 4.0
CMC COMMERCIAL FACTOR
(max 1)
DEFAULT 1.0
USER SELECT
HEADER

Saving Setups

From the setup menu press 9 to display the setup utilities menu. Select 1 to save and give this setup a name such as DEMO. You can create and save up to 40 setups and recall them when you need them.

Press HOME to return to the measurement screen after you have saved the setup.

Measuring Standards and Samples

ColorQUEST can measure the color values of a standard, measure the color values of a sample, and compute color differences. Alternatively, if the standard no longer exists but the target color values are known, these values can be entered into the system from the data menu displayed by pressing F8. See Chapter 11 for more information on entering spectral or colorimetric values from the keyboard.

Current Setup

For this example you should be using the setup named DEMO that was just created. If you are not, enter the setup menu, press 9 to select setup utilities and press 2 to recall the setup named DEMO.

Measurement Screen

Press HOME to return to the current measurement screen. The screen for this example should show standard, sample, and difference columns for CIELAB data (L*a*b*) under the 10° standard observer and illuminant A. If you are not on the appropriate screen, then press F9 to enter the screen menu and press 1 to select Color data 1st illum.

Taking Measurements

You are now ready to take some measurements. You may take reflectance measurements or transmittance measurements depending on the specimens you have available. Be sure that the instrument is standardized in the appropriate mode.

Reflectance Measurements

1. Place the standard at the reflectance port. It should be held in place by the sample clamp.

2. Press F2. You are prompted to enter an ID for the standard.

3. Type in TEST as the standard ID and press ENTER. SCANNING appears on the screen to signify that the sensor is measuring the standard. When the measurement is complete the L*, a*, and b* values appear in the standard column on the screen.

4. Place the first sample at the port.

5. Press F1. You are prompted to enter an ID for the sample.

6. Type in SAM-1 as the sample ID and press ENTER. SCANNING appears on the screen to signify that the sensor is measuring the sample. When the measurement is complete the L*, a*, and b* values appear in the sample column on the screen.

Read the sample two more times using the ID's SAM-2 and SAM-3.

Transmittance Measurements

1. Place the standard in the transmission sample holder and place the sample holder in the transmission compartment. Place the standard against the sphere for total transmittance measurements and against the receptor lens for regular transmittance measurements.

2. Place the white calibrated tile at the reflectance port.

3. Press F2. You are prompted to enter an ID for the standard.

4. Type in TEST as the standard ID. Press ENTER and SCANNING appears on the screen to signify that the sensor is measuring the standard. When the measurement is complete the L*, a*, and b* values appear in the standard column on the screen.

5. Place the first sample in the transmission sample holder and place the sample holder in the transmission compartment. Place the sample holder against the sphere for total transmittance measurements and against the receptor lens for regular transmittance measurements.

6. Press F1. You are prompted to enter an ID for the sample.

7. Place the white calibrated tile at the reflectance port.

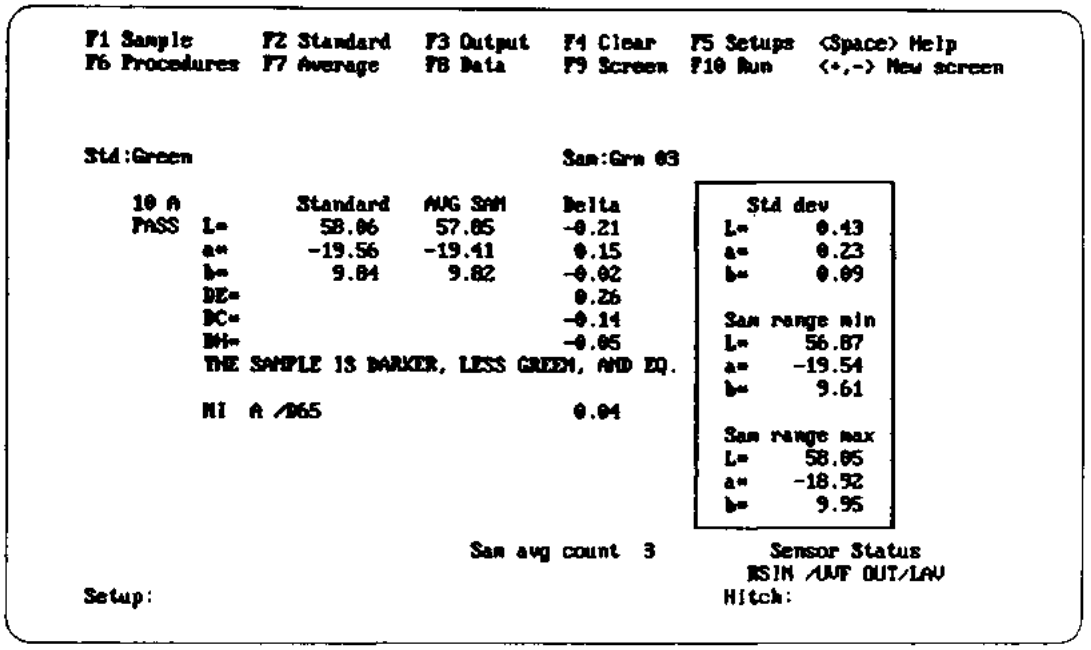
8. Type in SAM-1 as the sample ID and press ENTER. SCANNING appears on the screen to signify that the sensor is measuring the sample. When the measurement is complete the L*, a*, and b* values appear in the sample column on the screen.

Read the sample two more times using the ID's SAM-2 and SAM-3.

Averaging

The average count for the sample is now 3. Press F7 and the average L*, a*, and b* values for the 3 samples appear in the sample column. A box also appears on the screen listing the standard deviation, range minimum, and range maximum. Figure 5-5 shows an example of the average display.

Figure 5-5


F1 Sample F2 Standard F3 Output F4 Clear F5 Setups <Space> Help
F6 Procedures F7 Average F8 Data F9 Screen F10 Run <+,-> New screen
Std:Green
Sam:Grn 03
10 A
PASS
Standard
AVG SAM
Delta
L= 58.06 57.85 -0.21
a= -19.56 -19.41 0.15
b= 9.84 9.82 -0.02
DE= 0.26
DC= -0.14
DH= -0.05
THE SAMPLE IS DARKER, LESS GREEN, AND EQ.
MI A /D65 0.04
Std dev
L= 0.43
a= 0.23
b= 0.09
Sam range min
L= 56.87
a= -19.54
b= 9.61
Sam range max
L= 58.85
a= -18.52
b= 9.95
Sam avg count 3
Sensor Status
RSIN /UVF OUT/LAV
Setup:
Hitch:

Displaying Measurements

Measurement data can be displayed on any of these six screens:

- Color data for illuminant 1
- Color data for illuminant 2
- Color plot for illuminant 1
- Color plot for illuminant 2
- Spectral data
- Spectral plot

The data on the first 4 screens is controlled by the selections made in the color setup screen. If only one illuminant is selected the 2nd and 4th screens in the rotation will not display data. Likewise, if a color plot is not selected in the color setup, the 3rd and 4th screens will not display data.

The data displayed on the spectral data screen is controlled by selections made in the spectral data setup screen and the data displayed on the spectral plot screen is controlled by the selections made in the spectral plot setup screen.

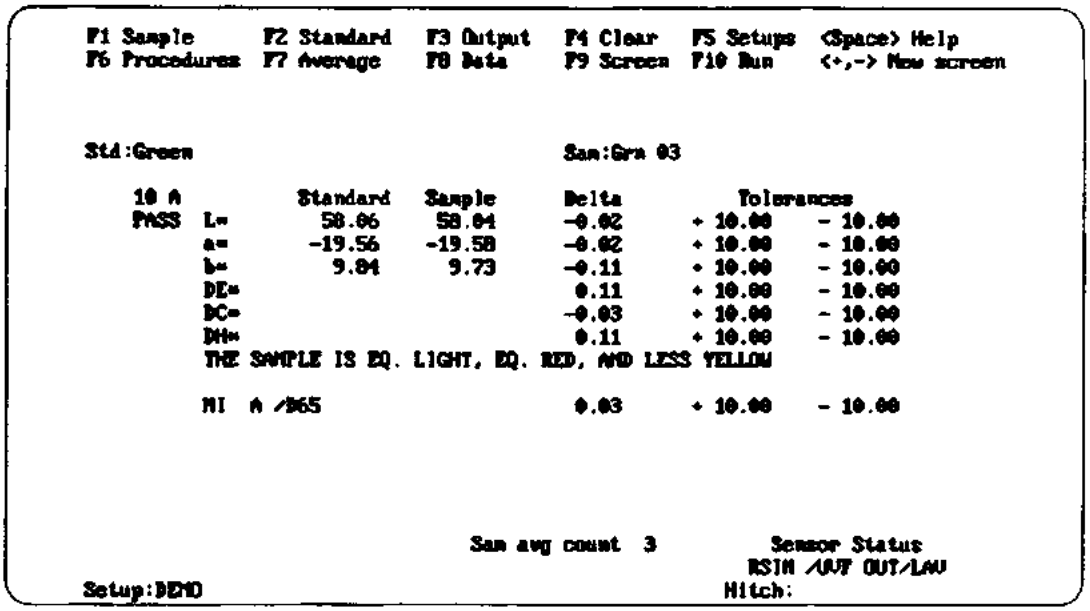
Changing Display Screens

You can cycle through all 6 screens by using the + and - keys on the numeric keypad. You can also select the screen to be displayed from the screen menu which appears when you press F9.

Color Data

The 2 color data screens can display data for the standard and sample along with differences, tolerances, illuminant, observer, and pass/fail designation. A delta descriptor message may also appear on the screen along with the average count, sensor status, and setup name. Figure 5-6 shows a color data screen.

Figure 5-6



Color Plot

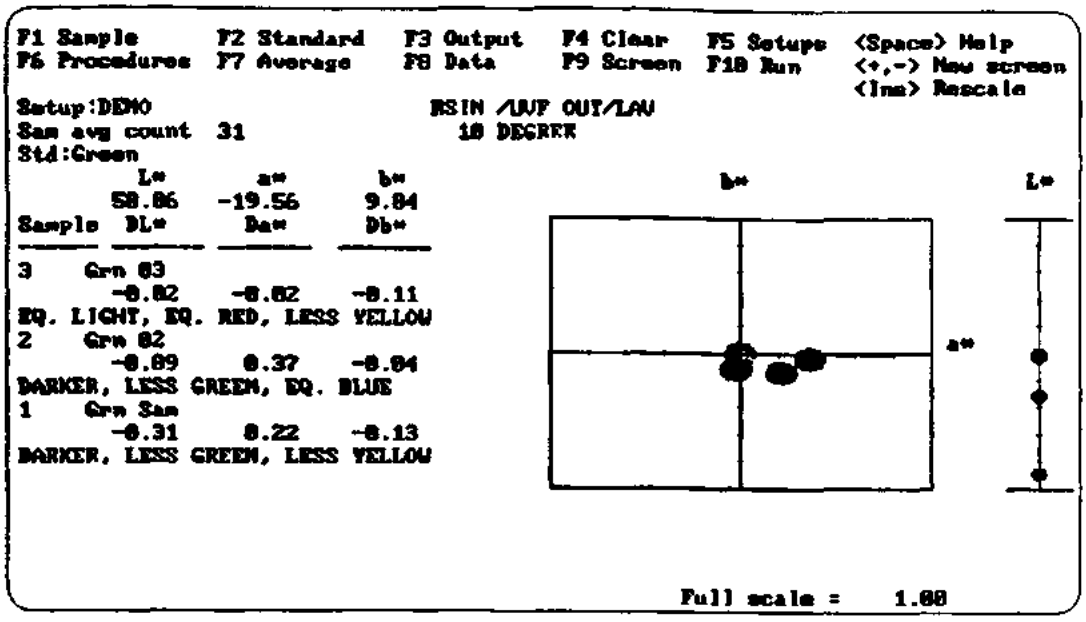
The 2 color plot screens graphically display the differences between the standard and the last 5 samples along with the illuminant and observer. Color values which exceed the specified tolerance range are highlighted.

The plot shows the difference between the standard and the samples. The standard is plotted in the center of the color plot which is defined by the axes a, b or c*, h*. The standard is also plotted on the center of the L axis. A red line shows the tolerances.

The scaling of the color plot can be changed by pressing INS and entering a new scale factor from .01 to 200. The default value is 10 meaning that the number of units from the center is ±10 or that there is a total of 20 units from side to side.

The rectangular plot can be selected when Lab, CIELAB, AnLab, or Rdab is the color scale. The polar and elliptical plots are available only with CIELAB and CIELCH. Selection of XYZ or Yxy disables the color plots. Figure 5-7 shows a rectangular color plot.

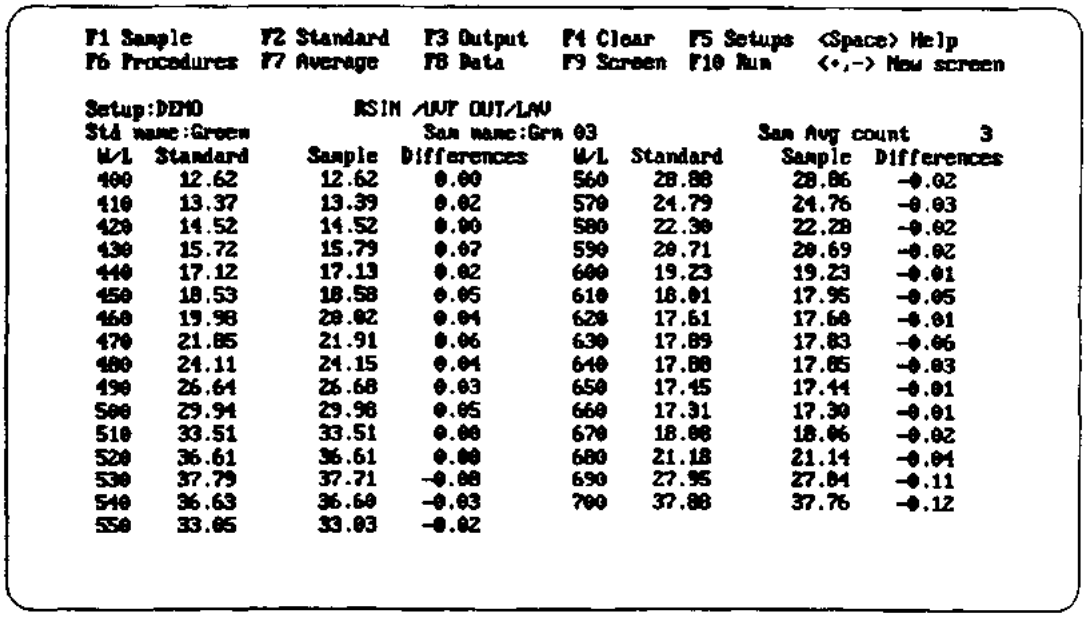
Figure 5-7



Spectral Data

The spectral data screen displays the percent reflectance over the range and interval selected in the spectral data setup. Data is shown only for the current standard reading and current sample reading and the difference. Figure 5-8 shows a spectral data display.

Figure 5-8



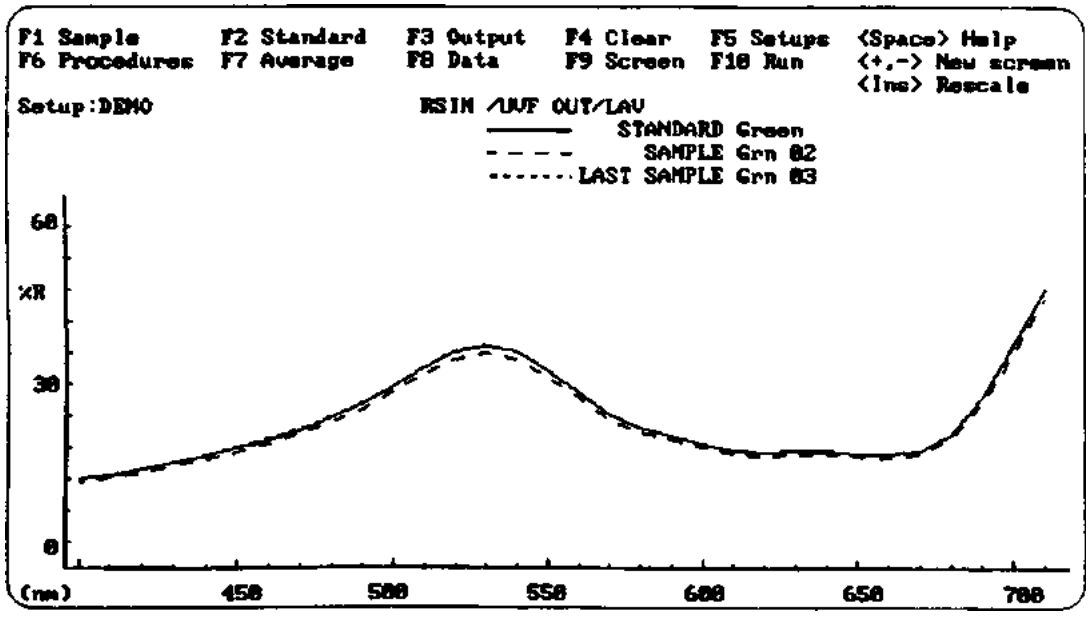
Spectral Plot

The spectral plot screen graphically displays the percent reflectance for the standard and the number of samples selected in the spectral plot setup. The scaling of the plot automatically adjusts to the range of data if AUTOSCALE is selected in the spectral plot setup. Scaling can also be changed directly from the spectral plot screen by pressing INS and entering new lower and upper bounds. If the plot exceeds the bounds the message *** point(s) exceed scale** is displayed.

Although using the INS key to scale the plot overrides the autoscale feature, taking a new measurement reverts to automatic scaling.

When taking a new measurement from the spectral plot screen, the screen will redraw the standard and only the last 5 samples even if UNLIMITED is selected in the spectral plot setup. Figure 5-9 shows an example of the spectral plot screen.

Figure 5-9



Saving Measurements

Measurements can be saved in a data file set and recalled later. The data file set includes a file with the extension .DTA where the data is stored and a file with the extension .IDS where the names of the records are stored.

Data Files

Data files are selected or created from the data menu.

To create a data file set:

1. Press F8 to display the data menu.
2. Press 7 to create the data file set. The following prompt appears:

   Enter the data file ID:

3. Type in the name of the data file including the drive and directory. For example type, C:\CQSPEC\DEMO. If you do not specify a drive and directory, then the current drive and directory is used.
4. Press ENTER. The following prompt appears:

   Create new files using this name? 1 Yes 2 No

5. Press 1 to create the files.

Saving Standards

The current standard can now be saved in the new data file from the data menu. In this example the standard has already been named since PROMPT FOR ID was selected in the global setup screen.

1. Press F8 to display the data menu.
2. Press 1 to select save. You are prompted to save either the standard or the sample.
3. Press 1 to save the standard. The tolerance window appears and you can enter tolerances for the delta values, color differences, and indices being displayed.
4. Use the arrow keys or the mouse to move through the tolerance window and make changes.

5. Press INS to accept the tolerances and return to the measurement screen. The tolerances will appear on the display screen only if TOLERANCES is selected in the color setup screen.

NOTE: If PROMPT FOR ID is not selected in the global setup, you are prompted to name the standard before saving.

Saving Samples

In this example the data displayed in the sample column is the average of the first 3 sample readings.

1. Press F8 to display the data menu.

2. Press 1 to select save.

3. Press 2 to select sample. The tolerance window appears and you can enter tolerances for the delta values, color differences, and indices. Tolerances are entered with the sample in case the data is recalled at a later time for use as a standard.

4. Use the arrow keys or the mouse to move through the tolerance window and make changes.

5. Press INS to accept the tolerances and return to the measurement screen.

NOTE: To save each individual reading and the average, save each reading after it is taken and then save the average after pressing F7. You are prompted to enter a new ID for the average so as not to overwrite the last sample.

Listing Data Records

Once you have saved several standards and samples you may want to list all the data records in the current data file.

1. Press F8 to display the data menu.

2. Select 3 to list the record ID's. You may list the ID's either to the screen or to the printer.

3. Press 1 to list the ID's to the screen.

Clearing Measurements

Before proceeding with another set of measurements you may want to clear the data from the screen, particularly if you want to measure a new product standard.

1. Press F4 to display the clear menu.

2. Press 4 to clear all data from the screen.

The clear function can also be used to clear only the standard, the sample, the average, or all samples.

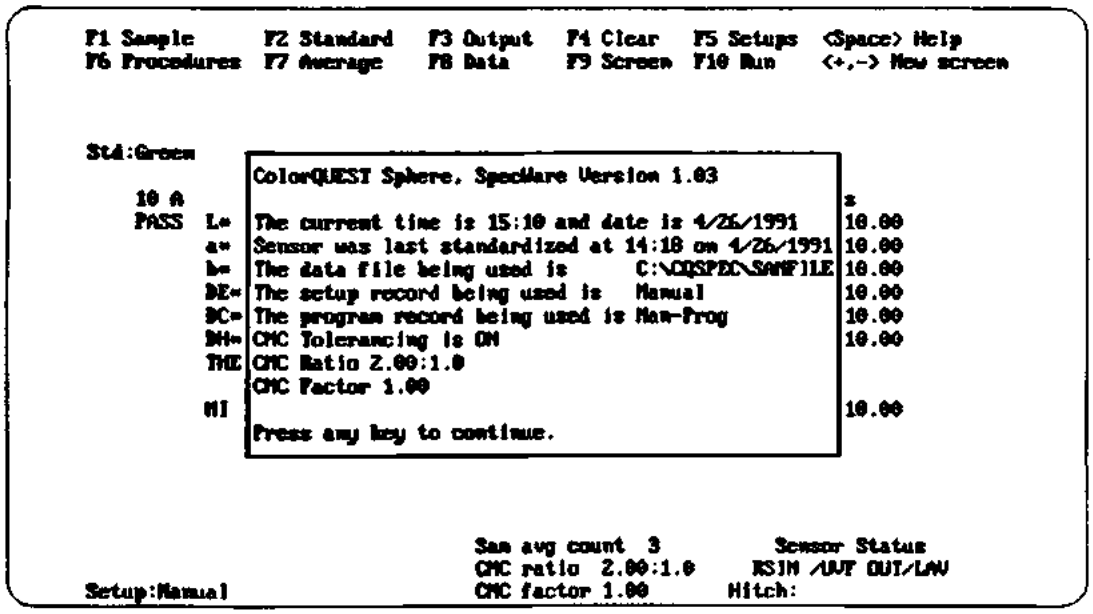
Instrument Status

You can check the status of the software by pressing the HOME key from any measurement screen. A press of the HOME key displays a box containing the following information:

- Current time and date
- Time and date of last standardization
- Data file
- Setup record
- Program record
- Hitch status
- CMC status

The sensor status in the bottom right corner of each measurement screen displays the configuration of the instrument at the last standardization. The instrument status is shown in Figure 5-10.

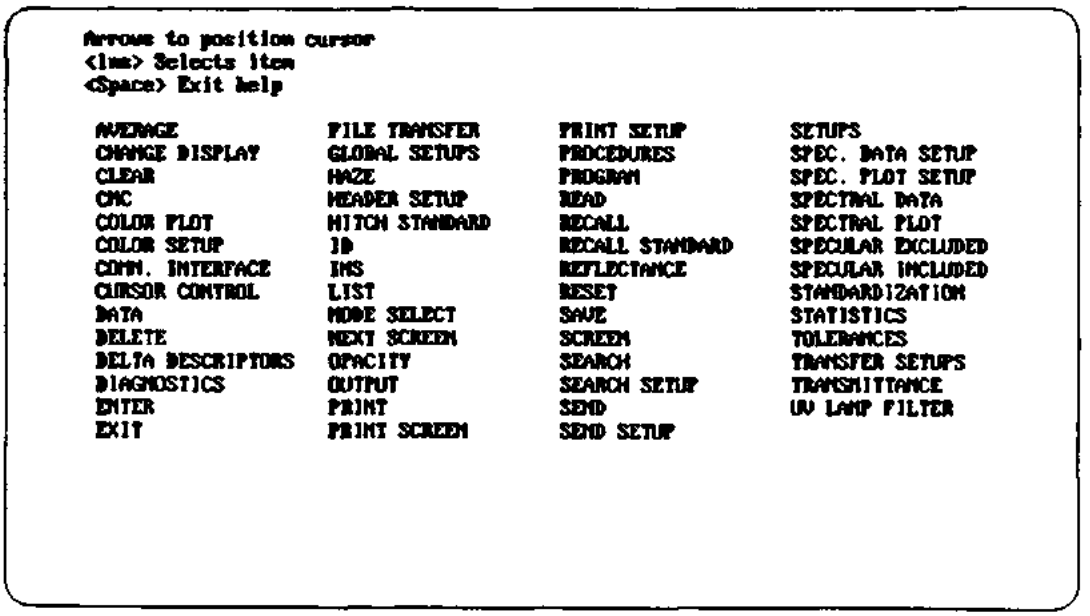
Figure 5-10



Help

Pressing the space bar displays the help screen. When the space bar is pressed from the measurement screen a list of topics from which you can choose is displayed. When the space bar is pressed while performing a particular function, help information concerning that function is displayed. An additional press of the space bar exits the help menu. Figure 5-11 shows the main help screen.

Figure 5-11



Exit to DOS

If it is desired to access DOS while in the SpecWare software, enter the Procedures menu by pressing F6 and press ESC to exit to DOS. Standardization is saved when exiting the SpecWare software. To re-enter the software, type CQ.

Upon restarting the software, if a prior standardization is found on the disk, the screen displays the latest standardization date and time and the prompt DO YOU WISH TO RESTANDARDIZE?. If NO is selected, the saved standardization is reinstated for use. If YES is selected, then the previous standardization is discarded and you are prompted through a full standardization.

Maintenance

To ensure proper operation of the instrument read the green tile at regular intervals, perform instrument diagnostics from the procedures menu once a week, and follow the maintenance procedures outlined in Chapter 16.

Be sure to keep all tiles and the light trap clean and free of dust. Also backup your data files on a regular basis as a precaution against hard disk failure. See Chapter 16 for details.

6

F3 Output

The F3 key controls the output of data to a printer, other communication device, or specific file format. When you press F3 the following menu is displayed:

1 Print
2 Send
3 File transfer

Note: If ASSIGN-F3 PRINT is selected in the global setup then pressing F3 prints the data selected in the print setup instead of displaying a menu. In this case, CTRL/F3 can be used for the send function and ALT/F3 can be used for the file transfer function.

Print

Pressing 1 prints all of the data selected in the print setup. This function allows you to view data under a variety of color scales and measurement conditions. See Chapter 8 for a description of the print setup.

Send

Pressing 2 sends the data selected in the send setup to the RS232-C communications port. This is an optional feature available as the extended communications package. See Chapter 15 for more information on this option.

File Transfer

Pressing 3 transfers the data to a file in the format selected in the file transfer setup. ASCII, DIF, and WORKSHEET are the available formats. Selections of data to be transferred are made from the file transfer setup screen.

To transfer a file:

1. Press 3 from the output menu or press ALT/F3. You are prompted to enter an ID for the output file.

2. Type in an ID of up to 8 characters for the output file and include the drive and directory. If you do not specify a drive and directory, then the output file is placed in the current directory. It is not necessary to add an extension to the file name. ASC, DIF, or WKS is automatically appended to the file name depending on the transfer format selected in the file transfer setup screen.

   Press ENTER and the file transfer menu appears

   1 Single record
   2 All records
   3 Some records

3. Type in the appropriate number and press ENTER. Selection of 1 requires entry of a single data record ID. Selection of 2 transfers all data records of the current data file. Selection of 3 allows you to transfer specified data records by entry of an ID search string using the ? or * wildcards.

F4 Clear

The F4 key allows you to clear readings when an error has been made or when you are switching from one set of readings to another. When you press the F4 key the following menu is displayed:

1 Standard
2 Sample
3 Average
4 All
5 All Samples

From this menu you can clear the last standard reading or last sample reading from the display and the average register. You can also clear the average after you have used F7 to display it. You can clear all measurements if you want to start a new set of readings with a new product standard or you can clear all the sample measurements if you want to start a new set of readings but retain the product standard values.

8

F5 Setups

The F5 key displays a menu of 8 setup screens from which you can tailor the data that is displayed on the measurement screens, printed, sent to a peripheral device, and output to a file. The menu also allows you to set parameters to search the current data file for desired data records. A utility function for saving, deleting, recalling, and listing setups is also provided. All current selections from the setup menus are saved when you exit the software. Forty setups can also be named and stored on the fixed disk for recall later.

Pressing the F5 key displays the following menu:

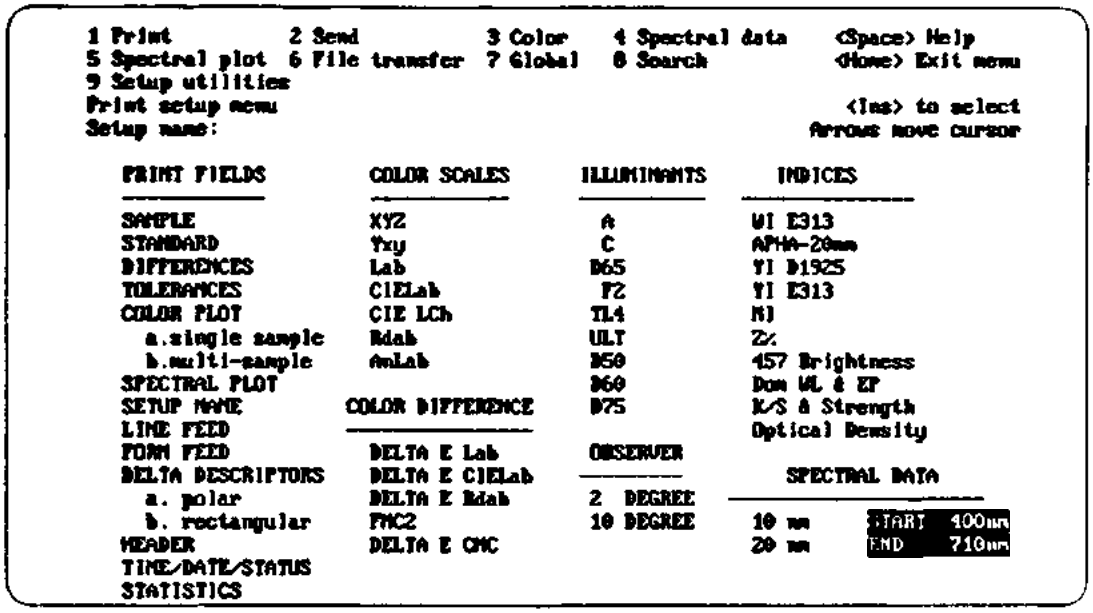
1 Print
2 Send
3 Color
4 Spectral data
5 Spectral plot
6 File transfer
7 Global
8 Search
9 Setup utilities

From the individual setup screens the INS key is used to select and deselect items or the mouse can be used. When selecting from a field where there is a maximum number of selections that can be made you must turn off the old choices before selecting new ones.

Print Setup

The selections made from the print setup screen shown in Figure 8-1 determine the information that is printed from the output menu. Unlike the data displayed on the measurement screens there are no limits on the amount of information that can be printed.

Figure 8-1



Print Fields

From the print fields column you can select the types of data you want to have printed. You must select STANDARD, SAMPLE or DIFFERENCES to have any data printed. If COLOR PLOT is selected you must also specify if the plot is to compare a single sample with the standard or compare multiple samples (up to 5) with the standard.

The LINE FEED and FORM FEED selections send commands to the printer to break the print at page breaks and advance to the top of the next page at the end of data transmission.

Selection of DELTA DESCRIPTORS prints a description of the color difference in terms of lightness, red-green, and yellow-blue for RECTANGULAR and lightness, hue, and saturation for POLAR.

Selection of HEADER prints a header that is entered by the user in the global setup screen.

Selection of STATISTICS prints the standard deviation and range limits for the averaged data for the first illuminant selected for display in the color setup screen.

Color Scales

All color scales can be selected from this column.

Color Difference

All color difference scales can be selected from this column.

Illuminants

All illuminants can be selected from this column.

Observer

One or both standard observers can be selected.

Indices

All indices can be selected from this column.

Spectral Data

If spectral data is to be printed, you must select the desired wavelength interval and enter the desired wavelength range.

Print Format

Upon exiting the print setup screen the following prompt appears:

Select print format
1 Short print
2 Full print

The short print format can only be chosen when the selections include only the setup name, tolerances, one observer, one illuminant, one color scale, differences, and two indices for one standard and any number of samples. The printout will contain a header, a standard, and one line of data per sample. When a new standard is read, the paper will form feed to begin on a new page. When using the short print only one line is printed for each sample reading which is helpful when reading several samples in reference to the same standard. LINE FEED and FORM FEED cannot be selected if using the short print format Figure 8-2 shows an example of the short print format. Figure 8-3 shows the same data in the full print.

Figure 8-2

```
                                                          PAGE    1
    10 DEGREE D65
    STANDARD NAME: Yellow
        L*        a*        b*
       78.66     11.04     73.05
        L*        a*        b*        DL*       Da*       Db*
Yellow 2
       78.72     11.02     73.02      0.06     -0.02     -0.03

Yellow 3
       78.70     11.05     73.00      0.04      0.01     -0.05
```

Figure 8-3

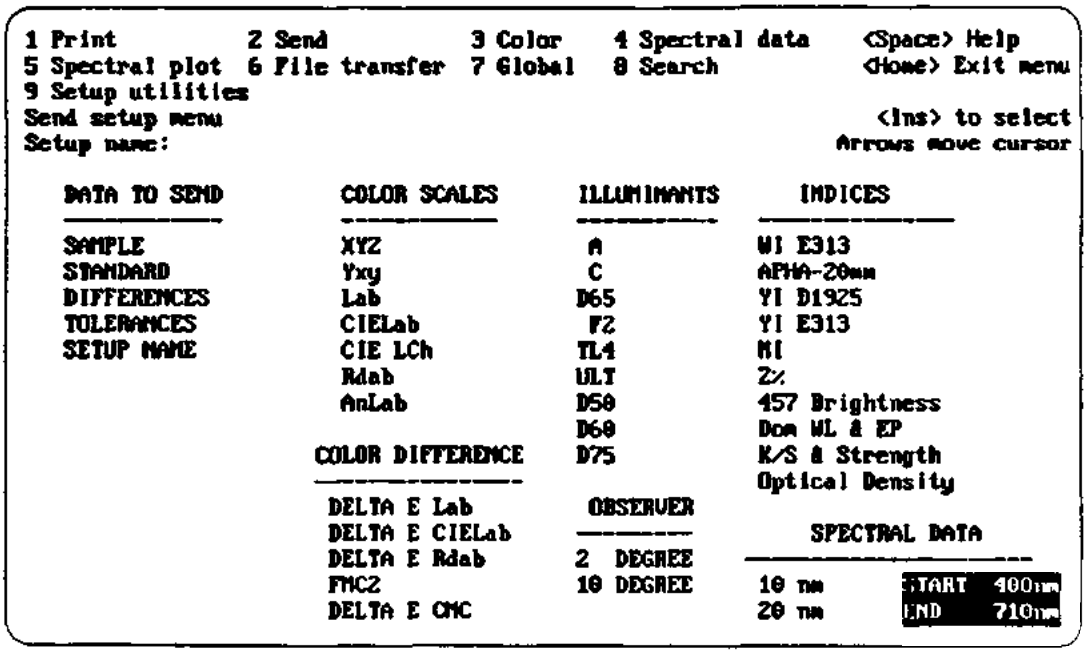
```
                                                          PAGE    1
      STANDARD NAME: Yellow
        SAMPLE NAME: Yellow 2
  10 DEGREE D65
           STD       SAM      DELTA
  L*     78.66     78.72       0.06
  a*     11.04     11.02      -0.02
  b*     73.05     73.02      -0.03

   STANDARD NAME: Yellow
       SAMPLE NAME: Yellow 3
           STD       SAM      DELTA
  L*     78.66     78.70       0.04
  a*     11.04     11.05      -0.01
  b*     73.05     73.00      -0.05
```

Send Setup Screen

The selections made on the send setup screen shown in Figure 8-4 determine the information that is sent to a peripheral device by selection of 2 from the output menu or by using the CTRL/F3 keys. This is an optional feature provided with the extended communications package. For more information on the extended communications package option, refer to Chapter 15.

Figure 8-4



Data to Send

The types of data to be sent to the peripheral device are selected from this column. You may send sample data, standard data, differences, tolerances, and the setup name.

Color Scales

All color scales can be selected from this column.

Color Difference

All color difference scales can be selected from this column.

Illuminants

All illuminants can be selected from this column.

Observer

One or both standard observers can be selected.

Indices

All indices can be selected from this column.

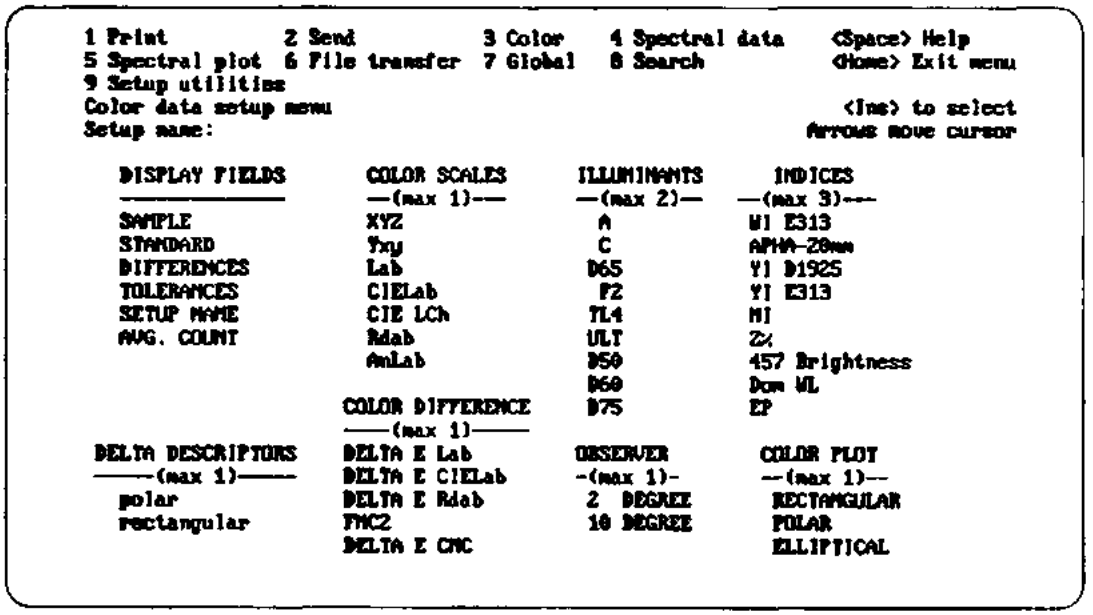
Spectral Data

If spectral data is to be printed, you must select the desired wavelength interval and enter the desired wavelength range.

Color Setup Screen

Selections made in the color setup screen shown in Figure 8-5 determine the information that is displayed on 4 of the measurement screens -- the 2 color data screens and the 2 color plot screens.

Figure 8-5



Display Fields

The selections made in this column determine the types of information that are displayed on the measurement screens. You may display sample data, standard data, differences, tolerances, the setup name, and the average count.

Delta Descriptors

A selection from this column provides a description in words of the color difference between standard and sample. Selection of POLAR states the difference in terms of lightness, hue, and saturation; selection of RECTANGULAR states the difference in terms of lightness, red-green, and yellow-blue.

Color Scales

Only one color scale may be selected for display on the measurement screens.

Color Difference

Only one color difference scale may be selected for display on the measurement screens.

Illuminants

A maximum of two illuminants may be selected for display. The first illuminant selected appears on the first color data screen and the first color plot screen. The second illuminant appears on the second color data screen and second color plot screen.

Observer

Only one standard observer may be selected.

Indices

A maximum of 3 indices may be selected from this column. If MI (Metamerism Index) is selected, then you must have 2 illuminants selected.

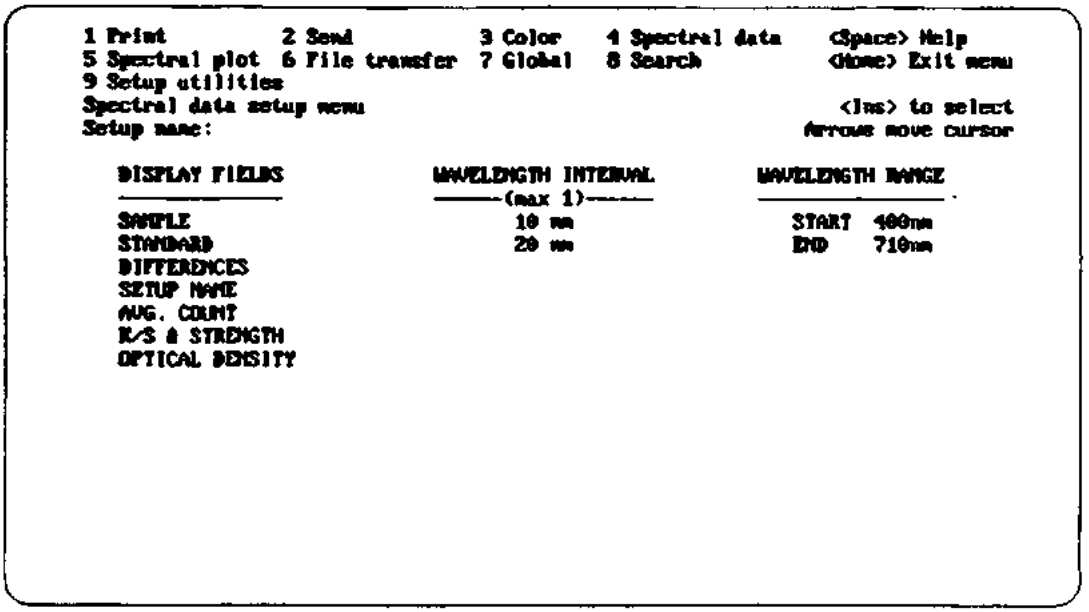
Color Plot

One type of color plot may be selected to be displayed on the third and fourth measurement screens in the rotation. Selection of RECTANGULAR requires that the color scale selected be either Lab, CIELAB, AnLab, or Rdab. Selection of POLAR requires that the color scale be either CIELAB or CIELCH. The ELLIPTICAL plot also requires either CIELAB or CIELCH. If XYZ or Yxy color scales are selected then no data will appear on the color plot screens.

Spectral Data Setup Screen

Selections made on the spectral data setup screen as shown in Figure 8-6 determine the information that is displayed on the spectral data measurement screen.

Figure 8-6



Display Fields

The types of data to be displayed are selected from this column. You may display percent reflectance or percent transmittance for sample data and standard data, differences, the setup name, and the average count. K/S & STRENGTH and OPTICAL DENSITY may be selected to replace the percentages in the spectral data listing.

Wavelength Interval

You may select one wavelength interval that controls the number of data points displayed over the designated wavelength range.

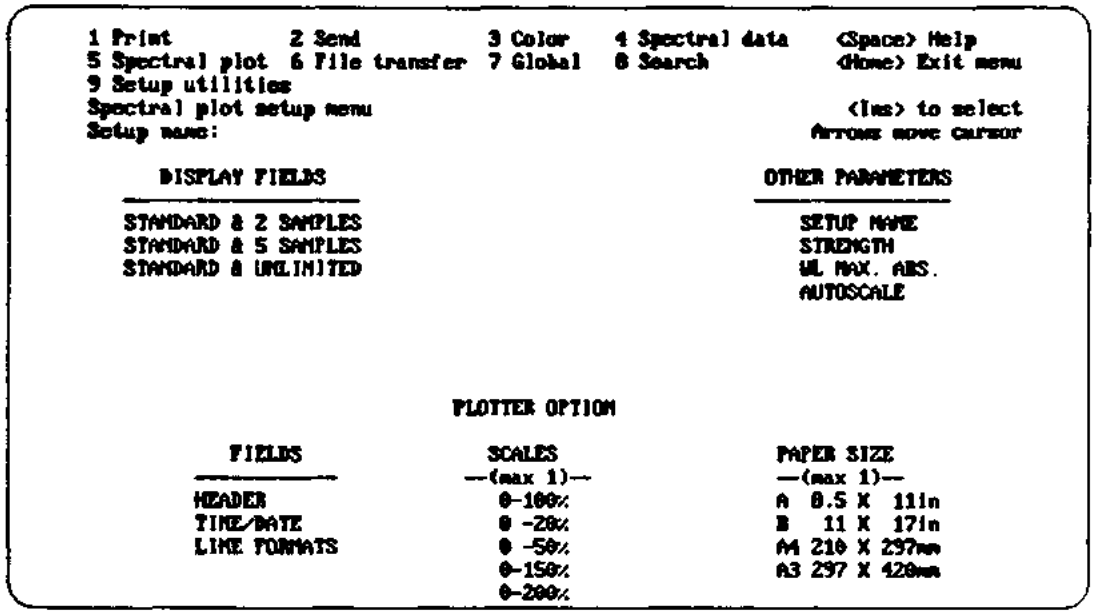
Wavelength Range

You must enter the range over which you want the data displayed. The ColorQUEST Sphere has a maximum wavelength range of 400 to 710 nm. When entering the wavelength range the START wavelength must always be equal to or lower than the END wavelength. If the current range is 600 to 620 and you wish to change it to 630 to 650, you must change the END value first and then the START value.

Spectral Plot Setup Screen

The selections made on the spectral plot setup screen shown in Figure 8-7 determine the information that is displayed on the spectral plot measurement screen or the information that is plotted using the optional XY plotter.

Figure 8-7



Display Fields

You may select to plot the standard with either the last 2 samples, the last 5 samples, or an unlimited number of samples.

Other Parameters

Selections from this column display other information on the spectral plot screen or determine the scaling of the screen.

Selection of SETUP NAME displays the name of the current setup on the spectral plot screen. Selection of STRENGTH displays the dyestrength (transmittance) or the relative colorant strength (reflectance) of the sample at the wavelength of maximum absorption.

Selection of WL MAX ABS displays the wavelength of maximum absorption and its value. The wavelength of maximum absorption is selected over the range set in the global setup screen.

Selection of AUTOSCALE causes the spectral plot to automatically scale itself to the current data for the upper and lower bounds.

Note: AUTOSCALE cannot be selected if STANDARD & UNLIMITED is selected.

Plotter Option

The spectral plot setup menu also controls the information printed on the plot when the optional XY plotter is used. The Fields column can enable the printing of the header entered in the global setup screen and the time and date. Selection of LINE FORMATS prints the legend for the plot.

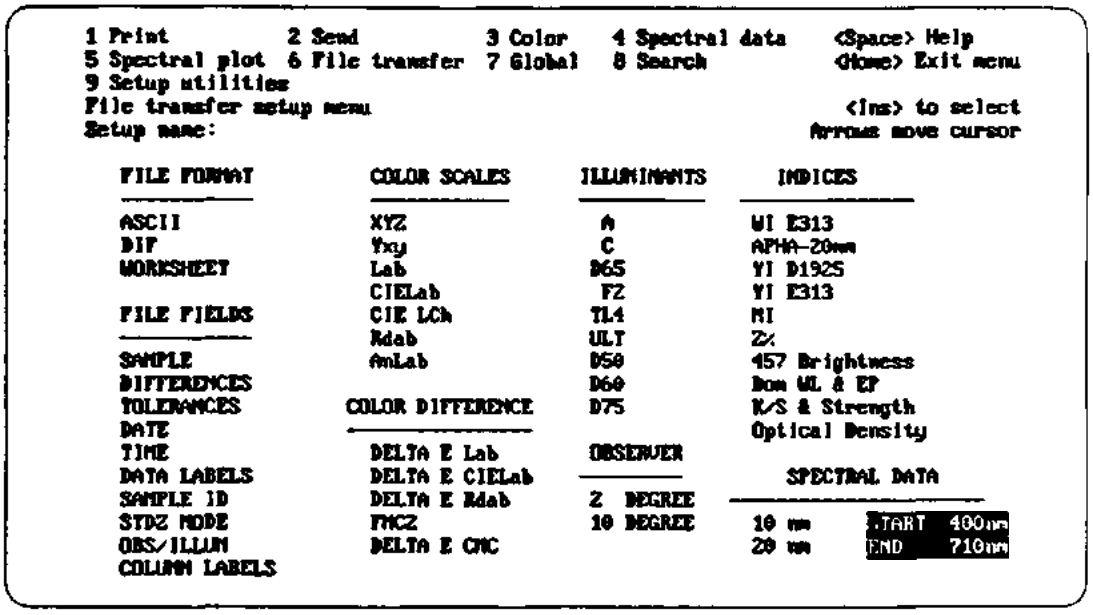
One scale may be selected from the Scales column. For normal operation 0-100% is recommended.

One paper size may be selected from the Paper Size column.

File Transfer Setup Screen

Selections made on the file transfer setup screen shown in Figure 8-8 determine the information that is sent to a file from the output menu or by using the ALT/F3 keys.

Figure 8-8



File Format

From this column you can select the file format for the transfer. ASCII, DIF, and WORKSHEET are the available formats.

File Fields

Selections from this column determine the types of information that are transferred. Selection of DATA LABELS transfers the ID's of the color scale, color difference scale, and index. Selection of COLUMN LABELS transfers column headers which are useful in the WORKSHEET format. If COLUMN LABELS is selected, then it is not necessary to select DATA LABELS and OBS/ILLUM.

Note: There is no limit on the amount of data that can be transferred. However, you should consider file size and spreadsheet constraints when selecting information from this setup screen.

Color Scales

All color scales can be selected from this column.

Color Difference

All color difference scales can be selected from this column.

Illuminants

All illuminants can be selected from this column.

Observer

One or both standard observers can be selected.

Indices

All indices can be selected from this column.

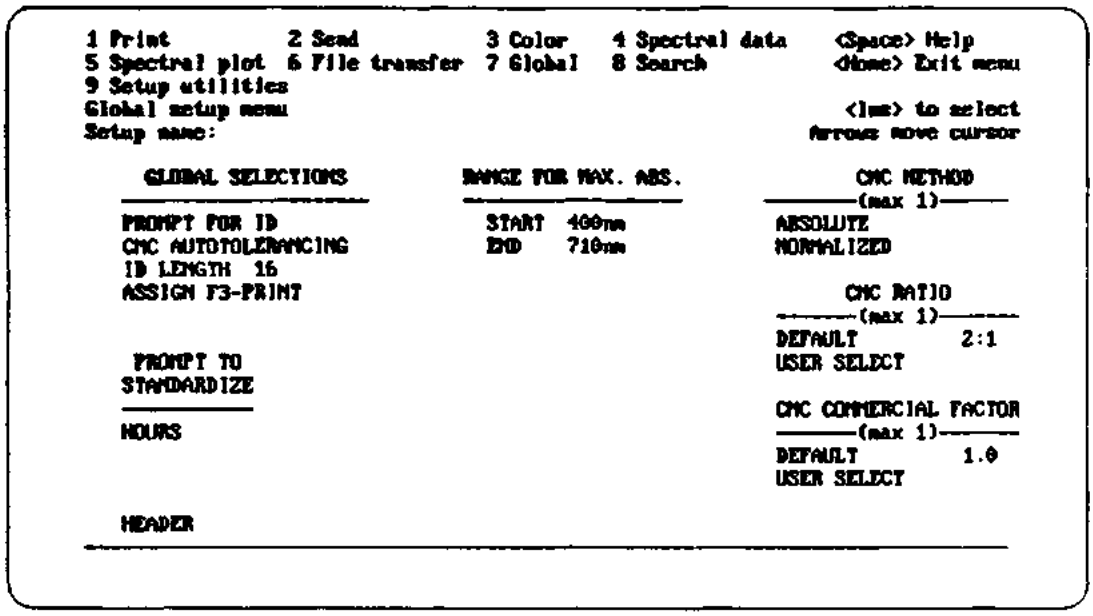
Spectral Data

If spectral data is to be transferred, then select the desired wavelength interval and enter the desired wavelength range. The selections made here are versatile enough to allow for a minimum of one wavelength and a maximum of all wavelengths.

Global Setup Screen

Selections from the global setup screen shown in Figure 8-9 define parameters that affect most of the display screens and output data.

Figure 8-9



Global Selections

Selections in this column control entry of an ID for samples and standards, automatic tolerancing, and the print function.

Selection of PROMPT FOR ID requires you to enter an ID for the standard or sample every time you take a reading.

Selection of CMC AUTOTOLERANCING automatically computes tolerances for the standard based on the other CMC parameters selected in this setup screen.

You are required to enter a value for ID LENGTH to determine the maximum length of the ID that can be saved in the current data file. If you switch to a new data file that uses a different ID length, the value on the global setup screen changes.

Selection of ASSIGN F3-PRINT reserves the F3 key for the print function only. The output menu is no longer displayed by pressing F3 so CTRL/F3 must be used to send data and ALT/F3 must be used for a file transfer.

Prompt to Standardize

You may enter a time interval (in hours) for prompting of standardization. For example, if you enter 8, then a message suggesting standardization appears upon the first key press 8 hours after the last standardization.

Header

You may enter a header up to 80 characters in length which is printed at the beginning of any printing function including print, print screen, and list. To clear the header select it using the INS key, then press ENTER.

Range for Max. Abs.

You may select any range within 400 to 710 nm over which you want the wavelength of maximum absorption identified on the spectral data and spectral plot screens.

CMC Method

If you are using CMC autotolerancing, you may select either the ABSOLUTE or NORMALIZED method of determining the CMC value.

CMC Ratio

If you are using CMC autotolerancing, you may select the DEFAULT lightness to chroma ratio of 2:1 or you may enter your own under USER SELECT.

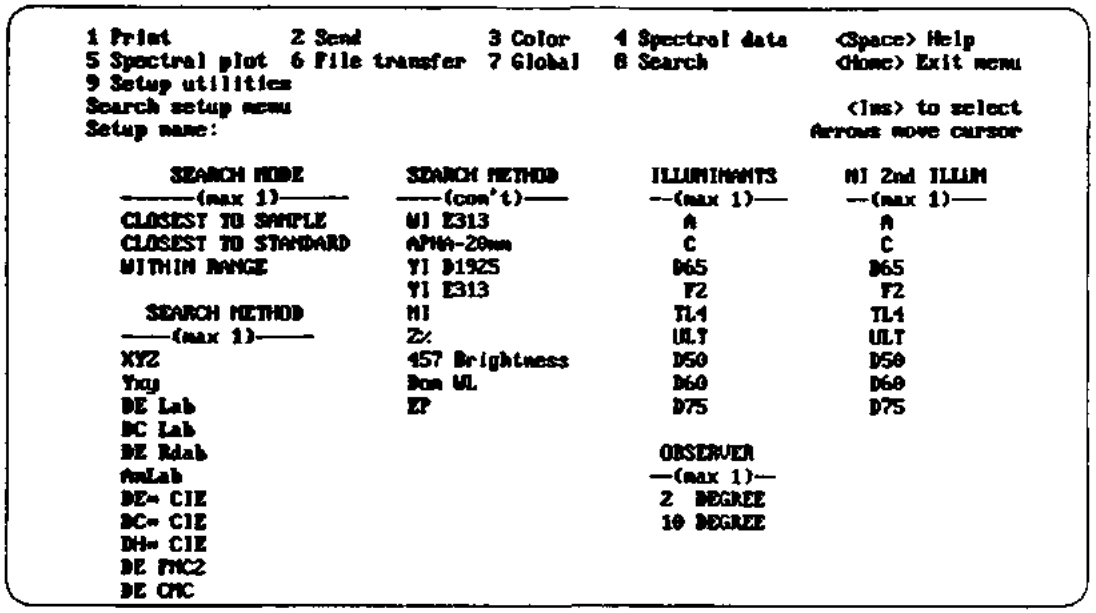
CMC Commercial Factor

If you are using CMC autotolerancing, you may select the DEFAULT commercial factor of 1.0 or you may enter your own under USER SELECT.

Search Setup Screen

The parameters selected from this screen control a search of the current data file which is executed from the data menu. The search setup screen is shown in Figure 8-10.

Figure 8-10



Search Mode

One search mode may be selected. CLOSEST TO SAMPLE locates the single data record in the current file with color values closest to the current sample. CLOSEST TO STANDARD locates the single data record in the current file with color values closest to the standard. Selection of WITHIN RANGE allows you to enter tolerances. Upon initiation of the search function all data records found within this tolerance range are printed.

Search Method

You may select one color scale, one color difference scale, or one index under which to conduct the search.

Illuminants

You may select one illuminant under which to conduct the search.

Observer

You may select one standard observer under which to conduct the search.

MI 2nd Illum

If you selected MI as the search method, then you must choose a 2nd illuminant under which to make the comparison for metamerism.

Setup Utilities

When you make a change to any of the setup screens, the changes are placed in the current working setup working register. The last used or last changed selections are always displayed upon start of the software. It is also possible to save up to 40 setup configurations on the fixed disk and then recall them as needed.

When you select setup utilities from the setup menu, the following menu is displayed:

1 Save
2 Recall
3 List
4 Delete

Save

When a setup is saved, the entire contents of the current working setup are copied to a file under an ID up to 12 characters long that you specify. Every saved setup includes selections made in all 8 setup screens. To save the current setup:

1. Press F5 to enter the setup menu.

2. Press 9 to display the setup utilities menu.

3. Press 1 to save the current setup. The prompt ENTER ID: appears

4. Type in an ID for the setup and press ENTER. Be sure that the ID does not begin with a space character.

NOTE: If a setup with that name already exists, you are prompted to either enter a new ID or overwrite the existing setup.

You may also press \ when saving a series of setups that you want to increment numerically. For example, if the last setup you saved was called PRODUCT 17, when you press \ from the ENTER ID: prompt the new setup is saved under the name PRODUCT 18.

Recall

After a setup has been saved it can be recalled for use at a later time.

To recall a setup:

1. Press F5 to enter the setup menu.

2. Press 9 to display the setup utilities menu.

3. Press 2 for recall. The prompt ENTER ID: appears.

4. Type in the name of a previously saved setup and press ENTER.

List

There may be times when it is useful to list the names of the stored setups to the screen or to the printer. For example, when you cannot remember the name of a setup.

To list setup names:

1. Press F5 to enter the setup menu.

2. Press 9 to display the setup utilities menu.

3. Press 3 to list setup ID's.

4. Press 1 to list the names to the screen or press 2 to list the names to the printer.

Delete

You may delete 1 setup or all setups using this function. Use caution when deleting setups for once deleted they cannot be recovered.

Note: If you delete the current setup it will be removed from the hard disk, however, the current selections remain in the current setup.

To delete setups:

1. Press F5 to enter the setup menu.

2. Press 9 to display the setup utilities menu.

3. Press 4 to delete setups.

4. Press 1 to delete a single setup or press 2 to delete all setups. When deleting a single setup, the prompt ENTER ID: appears.

5. Type in the name of the setup to be deleted and press ENTER.

F6 Procedures

The F6 key displays a menu from which you can perform several standardization functions, run instrument diagnostics, perform opacity or haze measurements, assemble a program, and enable the optional plotter. You may also switch between the ColorQUEST 45/0 sensor and the ColorQUEST Sphere sensor if you run both from the same software.

Pressing the F6 key displays the following menu:

1 Standardize
2 Restandardize
3 Mode select
4 Diagnostics
5 Hitch standardize
6 Opacity/Haze
7 Program
8 Plotter mode toggle
9 Sensor type

Standardize

This function allows you to perform a complete standardization routine in one of the four measurement modes. Pressing 1 from the procedures menu displays the following submenu from which you select the instrument mode:

1	Reflectance - Specular Included	RSIN
2	Reflectance - Specular Excluded	RSEX
3	Total Transmittance	TTRAN
4	Regular Transmittance	RTRAN

Before beginning any standardization routine be sure that the instrument is in the desired hardware configuration. For RSIN, the door of the specular exclusion port must be closed. For RSEX, the door of the specular exclusion port must be open. Install the SAV lens if you desire to use the small area of view. Place the UV filter in the proper position either in the light path or out of the light path. Refer to Chapter 4 for instructions on establishing the appropriate hardware configuration.

After selecting the instrument mode you are prompted as to whether you are using the small area of view or the large area of view and then whether the UV filter is in or out.

You will then be prompted to set the bottom of the scale. This is done by using the light trap over the port for reflectance modes or the black card placed against the receptor lens for transmittance modes and pressing INS to take a reading. SCANNING appears on the screen while the bottom of the scale is being set.

Next you are prompted to set the top of the scale. For reflectance modes, this is done by placing the calibrated white tile at the port and taking a reading. For transmittance modes, this is done by taking a reading with the transmission compartment empty and the white tile at the reflectance port. A blank may also be placed in the transmission compartment for this reading. A blank is an empty or solvent filled transmission cell.

For reflectance modes the gray tile is also read. As the last step in all standardization procedures the sample clamp is read to set the reference value used for the AUTOCAL function.

Note: The instrument should be standardized regularly, at the start of each shift or the start of each day and anytime that the hardware configuration of the instrument is changed.

Restandardize

Pressing 2 allows you to restandardize the instrument. Restandardizing resets the top of the scale only. In reflectance modes the top of the scale is set by reading the calibrated white tile. In transmittance modes the top of the scale is set by reading an empty transmission compartment or a blank. A blank is an empty or solvent filled cell. The sample clamp is also read when restandardizing in all modes. The instrument should be restandardized once every 4 hours.

When you press 2 from the procedures menu a prompt for setting the top of the scale is displayed that is appropriate for the current sensor status.

Note: Changing any hardware such as the specular exclusion port, UV filter, or small area view requires the full standardization procedure.

Mode Select

Mode select is used to save standardizations under different modes and hardware configurations and recall them at a later time. Pressing 3 from the procedures menu displays the following menu:

1 Save current mode
2 Select or delete mode

Save Current Mode

Pressing 1 allows you to save the standardization under the current mode and hardware configuration. When you press 1 you are prompted to enter an ID up to 80 characters in length for the standardization. You may want to enter a name that specifies the particular application the standardization is used for. The sensor status and date and time of standardization is saved with the standardization. Before starting your work you may want to standardize the instrument in every mode that you are using and save all the modes using mode select. Then you can switch between modes easily while taking color measurements.

Select or Delete Mode

Pressing 2 displays a listing of the saved standardization modes including the ID, the sensor status, and the time and date of standardization. From this display you can either select modes to be put into use or delete old modes. The PAGE UP and PAGE DOWN keys can be used to display additional modes.

To select a mode:

1. Highlight the desired mode using the arrow keys.

2. Press INS to select the mode.

NOTE: Before selecting a mode make sure that the instrument is in the same hardware configuration as the mode being recalled.

To delete a mode:

1. Highlight the desired mode using the arrow keys.

2. Press DEL to delete the mode from memory.

NOTE: Standardization performed more than 8 hours ago should not be used and should be deleted.

Diagnostics

Pressing 4 from the procedures menu displays the following menu of diagnostic routines:

1 Signal Strength
2 Sample Clamp
3 Turn Autocal mode ON/OFF

> If an error message is displayed while running any diagnostic note the message and call the HunterLab Service Department at (703) 471-6870.

Signal Strength

The signal strength (A/D counts) are continuously displayed detector by detector for each wavelength at 10 nm intervals. The peak sample signal on the sample clamp should not exceed 55,000 counts.

Sample Clamp

This diagnostic displays the tracking of the sample clamp to the last standardization. For each wavelength the reference value of the sample clamp REF is displayed with the adjusted reference value known as the TRACK and the current value of the sample clamp. The percentage of the current to the reference, PCT, is also given. When the current differs from the reference by more than 1% and AUTOCAL is enabled a warning message appears on the screen requesting standardization.

Autocal

This diagnostic toggles the autocal feature on and off. When autocal is first turned on you are prompted to read the sample clamp to set the reference value.

Hitch Standardize

Pressing 5 from the procedures menu allows you to perform a hitch standardization. Hitch standardization allows you to compare color measurements between different instruments with the highest possible precision.

Hitch standardization requires that a physical specimen be measured on a *reference* instrument and the values recorded. The physical specimen or hitch standard can then be measured on other instruments and the color values adjusted to agree with those of the reference instrument. If colorimetric values are used, then data analysis is limited to the illuminant and observer combination in which data is entered. If spectral values are used, then data analysis can include any illuminant and observer combination.

To hitch standardize:

1. Press 5 from the procedures menu. You are prompted to enter an ID for the hitch standard

2. Enter an ID of up to 16 characters for the hitch standard and press ENTER. The first time the name is entered you are prompted to enter the data as either

   1 Spectral
   2 Colorimetric

3. Choose either spectral or colorimetric. When spectral is chosen a screen appears for entry of the spectral values in 10 nm increments from 400 to 710 nm. If only 20 nm data is available, then it is necessary to interpolate between values to obtain 10 nm data. When colorimetric is chosen you are prompted to select the color scale, the observer, and the illuminant, then a screen appears for entry of the 3 color values.

   During entry of the data, ENTER is used to move the cursor from field to field and to edit the data; PGDN is used to display colorimetric data in all available color scales.

4. Press F8 to save the entered values. The tolerance window appears.

5. Enter tolerances if desired.

6. Press INS to accept the tolerances.

7. Place the physical specimen, the hitch standard, at the port.

8. Press INS to measure the hitch standard. You may read the hitch standard several times and then average the readings.

9. Press ENTER to average and save the hitch standard. The measurement screen appears with the hitch standard values in the STANDARD column.

The instrument is now hitched. To clear the hitch standardization you must perform a full standardization routine or recall a standardization from mode select.

Note: If colorimetric data was entered, then a message appears noting that the standard is tristimulus and referencing the appropriate illuminant and observer.

Note: Hitch standards can also be stored in the current data file using the enter function of the data menu accessed by pressing F8.

Opacity/Haze

Pressing 6 from the procedures menu begins either the opacity or haze measurement routine depending on the current instrument status. Opacity is measured in reflectance modes; haze is measured in transmittance modes.

Opacity

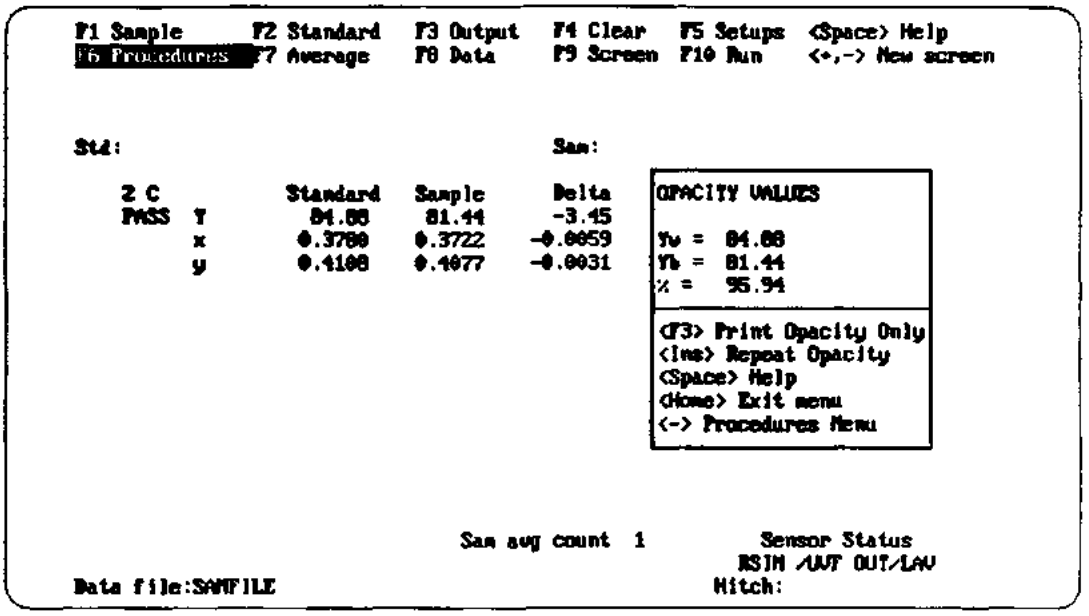
Opacity is the ratio of the CIE Y reflectance of the sample backed by black to the CIE Y reflectance of the sample backed by white. For normal laboratory use the sample is first backed by the uncalibrated white tile or white portion of a drawdown chart and then backed by the black card or the light trap. For strict adherence to a test method the backing used must conform to the reflectance specified in the test method. ASTM D2805, TAPPI T425, and TAPPI T519 are all test methods for the measurement of opacity. Refer to these test methods regarding requirements of instrument geometry since the ColorQUEST Sphere does not conform to all test methods.

To take an opacity measurement:

1. Standardize the instrument in one of the reflectance modes.
2. Press F6 to display the procedures menu.
3. Press 6 to select opacity.
4. Measure the sample backed with white. The color values appears in the STANDARD column.
5. Measure the sample backed with black. The color values appears in the SAMPLE column. The CIE Y values of the sample backed by white and the sample backed by black appear with the percent opacity in a box on the screen. Figure 9-1 shows an example of an opacity measurement.
6. Press F3 to print the Y values and the percent opacity.

Note: Opacity is calculated using the illuminant of the present measurement screen. If the spectral data or spectral plot screen is currently displayed, the first enabled illuminant in the color setup screen is used to measure opacity.

Figure 9-1



Haze

Haze is the ratio between diffuse light transmittance and total light transmittance. 0% haze indicates a perfectly clear transparent material and 100% haze indicates an opaque material. Before performing haze measurements standardize the instrument using the calibrated white tile at the reflectance port. In place of the white calibrated tile, a pressed tablet of barium sulfate, $BaSO_4$, or magnesium oxide, MgO, may also be used. Whatever white standard is used to standardize the instrument must also be placed at the reflectance port while the haze measurements are being taken.

To take a haze measurement:

1. Standardize the instrument in the total transmittance mode using the calibrated white tile or a pressed tablet of barium sulfate, $BaSO_4$, or magnesium oxide, MgO.

2. Press F6 to display the procedures menu.

3. Press 6 to select haze.

4. Place the sample flush against the sphere in the transmission compartment and close the transmission compartment door.

5. Place the calibrated white tile or the pressed tablet at the reflectance port.

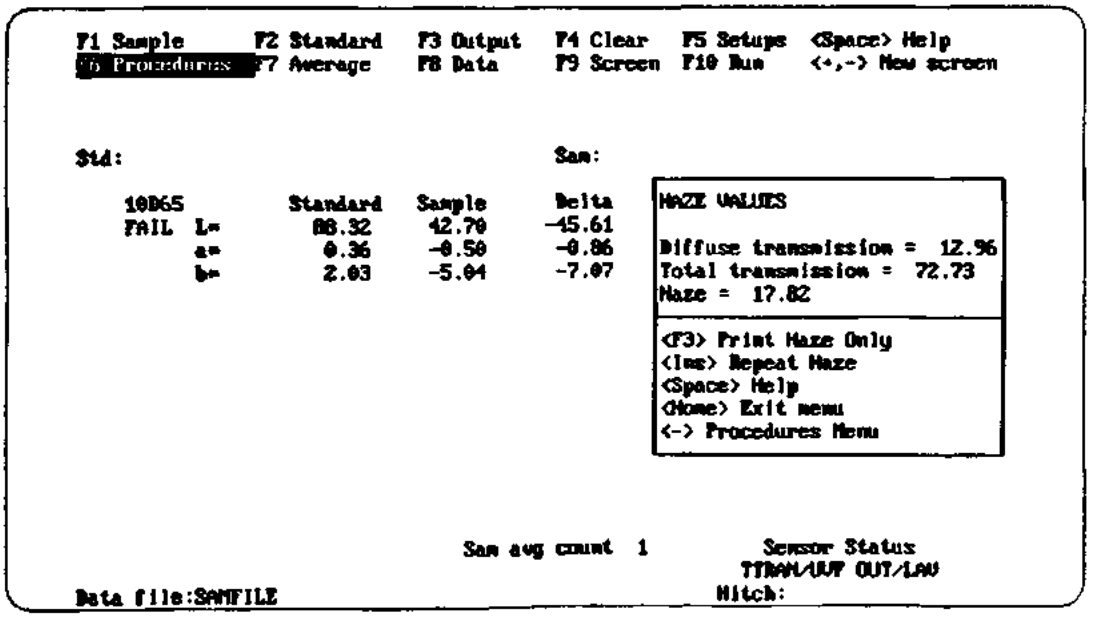
6. Press INS to measure the sample. The color values appear in the STANDARD column.

7. Place the light trap at the reflectance port. Do not move the sample.

8. Press INS to measure the sample. The color values appear in the SAMPLE column. The diffuse transmission, total transmission, and haze values are displayed in a box on the screen. Figure 9-2 shows an example of a haze measurement.

9. Press F3 to print the diffuse transmission, total transmission, and haze value.

Figure 9-2



Program

Pressing 7 from the procedures menu displays the following menu to assist you in programming:

1 Save
2 Recall
3 List
4 Enter
5 Delete

The program menu can also be displayed by pressing CTRL/F10.

Note: Programs cannot be run from the program menu. Programs can only be run by pressing F10 from a measurement screen.

Save

Pressing 1 from the program menu allows you to assign an ID up to 12 characters in length to the program currently in the working register and save it to the fixed disk. A maximum of 40 programs may be stored on the fixed disk.

Recall

Pressing 2 from the program menu prompts you to assign an ID for recall of a previously stored program. To recall a program you may type the program name at the ENTER ID: prompt or press INS to list the program names and select directly from the list. The recalled program is then placed in the working register and may be run by pressing F10 from a measurement screen.

List

Pressing 3 from the program menu gives you the option of listing all the program ID's or of listing the program steps of the current program. Once you make a selection you have the option of listing the information either to the screen or to the printer.

Enter

Pressing 4 from the program menu gives you the option of either entering a new program or editing the current program . Selection of program entry displays a blank program screen and you start by entering step 1 of the program. Selection of program editing displays all the program steps of the current program and you can use the BACKSPACE key to erase steps of the program until you get to the portion you want to edit.

CAUTION

Be sure that the current program is saved to the fixed disk before you begin editing.

The maximum number of program steps is 100. Program steps are entered using the function keys and some special keys. If a function key is pressed that normally displays a menu, then that menu will appear across the top of the programming screen so that you can make selections.

The following is a list of the keys used in programming and their functions.

- F1 through F5 and F7 through F9 perform their assigned functions.
- F10 introduces a RUN/STOP into the program which causes the program to stop so that information, such as an ID name, can be entered from the keyboard.
- \ increments an ID which is numeric or ends in a numeric sequence.
- PRINT SCREEN allows you to print the current measurement screen during the program.
- M allows you to enter a message up to 68 characters in length that prompts the operator during execution of the program.
- P allows you to enter a pause in the program which stops execution of the program for several seconds. This is helpful when extra time is required to replace samples.
- END terminates program entry and returns you to the program menu.
- BACKSPACE clears the last step.

Figure 9-3 gives an example of a program which recalls a setup, reads and saves a standard, reads two samples, averages the samples and saves the averaged data. The program then clears all measurements

Note: Be sure to save the program to the fixed disk after you have entered it so that you do not overwrite it when you enter your next program.

Figure 9-3

```
F1 Sample  F2 Standard   F3 Output  F4 Clear     F5 Setups  F7 Average   F8 Data
F9 Screen  F10 Run/Stop  <PrtSc>    <M> Message  <P> Pause  <End> End entry
<BackSpace> Clear last step              <Space> Help
                          ENTER PROGRAM STEP  21
  1  Setup
  2  Setup utilities
  3  Recall setup
  4  ID: Demo
  5  Read standard
  6  Data
  7  Save
  8  Standard
  9  ID: <R/S>
 10  Accept tolerances
 11  Read sample
 12  Read sample
 13  Average
 14  Data
 15  Save
 16  Sample
 17  ID: <R/S>
 18  Accept tolerances
 19  Clear
 20  All
```

Plotter Mode Toggle

Selection of 8 from the procedures menu toggles the instrument to the plotter mode if an optional XY plotter is installed. In this mode the plot menu is displayed at the top of the screen.

1 Plot Sample
2 Plot Standard
3 Plot Axes
4 Exit

Sensor Type

Selection of 9 from the procedures menu toggles the sensor type for the SpecWare software. This function is only used when one set of software is being used with both types of ColorQUEST sensors, the sphere sensor and the 45/0 sensor.

10

F7 Average

You can use the F7 key to display the average color values, standard deviation, range minimum and range maximum for several samples or standard measurements. Measurements can be accumulated by presses of the F1 and F2 keys. While measurements are being taken the average count appears on the screen if it was selected in the color setup screen.

Changing from measurement of standard to sample or vice versa resets the average count.

After taking the desired number of measurements press F7 to display the average under the appropriate column, either STANDARD or SAMPLE. At this time a box appears on the screen listing the standard deviation, range minimum, and range maximum. Averaged data is displayed on the spectral data and spectral plot screens.

The standard deviation is calculated using n-1 weighting.

$$\sigma_{(n-1)} = \sqrt{\Sigma(x_i - x)^2/n-1}$$

It is necessary to take measurements in a single color scale, illuminant, and observer in order to obtain valid calculations of range and standard deviation. Readings taken from the spectral data screen and the spectral plot screen, however, are included in standard deviation and range calculations. Standard deviation is calculated using colorimetric data. The average is calculated using spectral values. Therefore, the average values will be different from a calculation of the colorimetric values displayed.

The average can be cleared using the F4 key and selection 3.

F8 Data

The F8 key displays a menu from which you can save to, recall from, and list the current data file. Tolerances can be entered with data whenever it is saved. To edit tolerances you must recall data, and save the data again with new tolerances under the same or a different name. From the data menu you can also enter data from the keyboard, search the current data file, create a new data file set, or change to a different data file set.

Pressing F8 displays the data menu:

1 Save
2 Recall
3 List
4 Enter
5 Delete
6 Search
7 New Files
8 List Files

Save

Pressing 1 from the data menu allows you to save either the standard or sample data displayed on the screen and enter tolerances. Tolerances can be entered for sample data as well as standard data in case the sample data is later recalled into the standard position. Data is always saved in the current data file set. Spectral data is saved for each data record so that it can be recalled under any color scale, illuminant, or observer. If averaged data is displayed on the measurement screen, then averaged data is saved.

The default data file set created during installation of the software is SAMFILE located in the C:\CQSPEC\ directory. Approximately 1000 data records per file may be stored on the fixed disk; approximately 500 data records per file may be stored on a floppy disk.

To save the current data:

1. Press F8 to display the data menu.

2. Press 1 to select save. You are prompted to save either standard or sample.

3. Press 1 to save the standard data or 2 to save the sample data. You are prompted to enter an ID.

4. Enter an ID. The length of the ID is controlled by the value entered for ID LENGTH in the global setup screen when the current data file set was created. You may also press \ to increment the ID if it is numeric or ends in a numeric sequence. The tolerance window appears displaying the last entered tolerances.

   Note: Default tolerances are ±10.00.

5. Use the arrow keys or the mouse to move through the tolerance window and make changes.

6. Press INS to accept the tolerances. If it is the standard that has just been saved, then the tolerances are saved with the measurement data and the tolerances are displayed on the measurement screen if they are selected for display in the color setup screen. If it is the sample that has just been saved, then the tolerances are saved with the measurement data in case the sample data is later recalled as a standard.

Recall

Pressing 2 from the data menu allows you to recall a data record from the current data file into the standard or sample position. You may also recall an instrument standard into the standard position for comparison with a measurement of the instrument standard read as a sample.

Recalling Standards and Samples

There are two types of data records that can be recalled and displayed as either standard or samples. The first is spectral measurement data that you save from the measurement screen or enter from the keyboard. When spectral data is saved you can recall the data for display under any color scale, illuminant, and observer. However, the instrument operating status including standardization mode, UV lamp, UV filter, and area of view must be the same as when the data was saved or entered. If the data to be recalled is stored under a different instrument configuration you are prompted either to abort the recall or to recall the data anyway.

The second type of data is tristimulus data that is entered from the keyboard in a particular color scale under a particular illuminant/observer combination. When this data is recalled, the measurement screen must be in the same illuminant/observer combination, however, any color scale may be used.

To recall a data record as a standard or sample:

1. Press F8 to display the data menu.

2. Press 2 to select recall. The following menu appears:

   RECALL
   1 Standard
   2 Sample
   3 Instrument Standard

3. Press 1 or 2 to recall the data as either a standard or a sample. You are prompted to enter the ID of the data record you want to recall.

4. Type in the ID and press ENTER or press INS to list the data records and select from the list. The recalled data record is displayed under the appropriate heading, either STANDARD or SAMPLE. If the data record is recalled as the standard the tolerances are also displayed if they are selected in the color setup screen.

   If the data record recalled was entered as colorimetric data from the keyboard, then a message appears on the screen noting that it is tristimulus.

Recalling Instrument Standards

Values for the instrument standards are stored in the instrument at the factory. The values may be recalled as a standard, but the data records do not appear on a listing and cannot be edited. Instrument standards are used to verify a standardization that has just been completed. The instrument standard is recalled and then the appropriate standard is read as a sample and the values are compared. Instrument standards are available for reflectance-specular included, RSIN, reflectance-specular excluded, RSEX, and transmittance, TRANS, modes.

Pressing 3 from the recall menu lists the available instrument standards:

1 Rsin white
2 Rsin gray
3 Rsex white
4 Rsex gray
5 Trans

To recall an instrument standard and verify standardization:

1. Standardize the intrument in the appropriate mode.

2. Press F8 to display the data menu.

3. Press 2 to select recall.

4. Press 3 to select recall of an instrument standard. The list of instrument standards appears.

5. Select the appropriate number for the current standardization mode. The instrument standard values appear in the standard column.

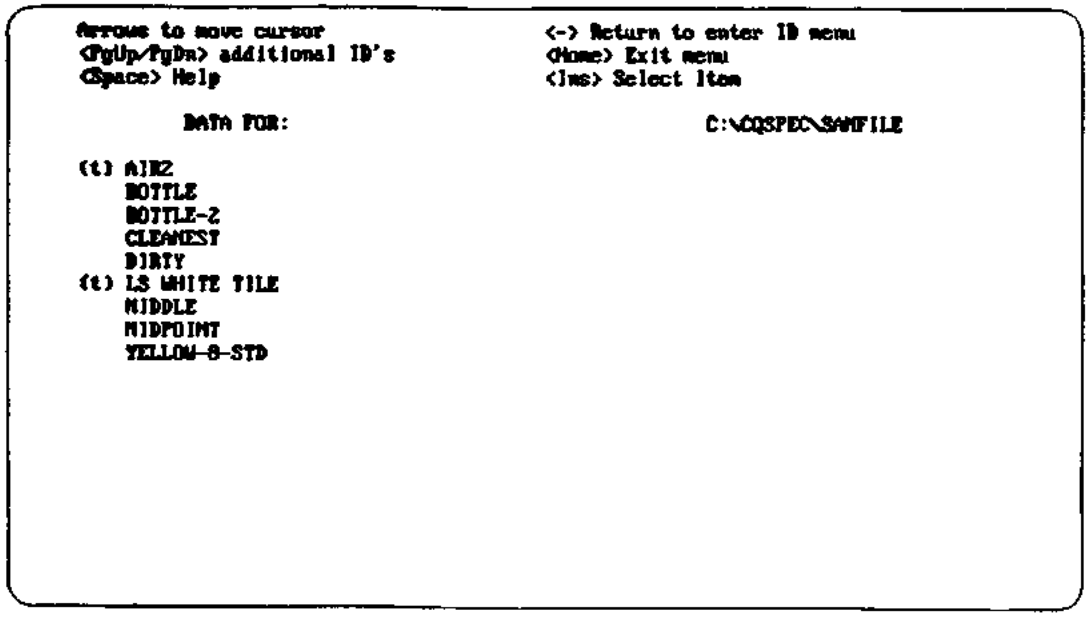
6. Place the appropriate tile at the reflectance port if you have selected one of the reflectance mode instrument standards. If TRANS is selected, then place the calibrated white tile at the port and leave the transmission compartment empty.

7. Press F2 to read the tile or the empty transmission compartment. The measurement values are displayed in the SAMPLE column. If the sample values differ from the instrument standard values by more than 0.01 in XYZ, then standardize the instrument again.

List

Pressing 3 from the data menu lists all the data records of the current data file set to either the screen or the printer. All data records that were stored as hitch standards or relative to hitch standards are designated with either a (t) for tristimulus data or a (s) for spectral data. Figure 11-1 shows the listing of a data file.

Figure 11-1



Enter

Pressing 4 from the data menu allows you to enter either spectral or colorimetric data for product standards that no longer exist or are not available. The enter function can also be used to enter hitch standards into the system. When entering hitch standards the spectral or colorimetric values are entered and then the hitch standard is measured. If entering data when the instrument is already using a hitch standard you may save the entered data as is or relative to the hitch standard.

Entering Spectral Data

1. Press F8 to display the data menu.

2. Press 4 to enter data. You are asked to select either spectral or colorimetric.

3. Press 1 to select spectral. You are prompted to enter the spectral data in 10 nm intervals from 400 nm to 710 nm.

4. Enter the data at each wavelength and press ENTER after each value to move to the next wavelength. When all the values have been entered you may use the arrow keys or mouse to move back and edit any values.

5. Press F8 to save the data. You are prompted to enter an ID.

6. Type in an ID or press \ to increment the ID if it is numeric or ends in a numeric sequence. The tolerance window appears.

7. Use the arrow keys or mouse to enter the tolerances.

8. Press INS to accept the tolerances. You are asked if the data is to be saved as a hitch standard or relative to the hitch standard if one is already in place.

9. Press the key corresponding to the appropriate response. If you are saving the data as a hitch standard you are prompted to read the hitch standard. You are then returned to the data entry screen to enter more data records. After entering all the data, press HOME. You are asked if you wish to display the last record as sample, standard, or neither.

10. Press the key corresponding to the appropriate response.

Entering Colorimetric Data

1. Press F8 to display the data menu.

2. Press 4 to enter data. You are asked to select either spectral or colorimetric.

3. Press 2 to select colorimetric. You are prompted to select a color scale.

4. Press the key which corresponds to the desired color scale. You are prompted to choose the standard observer.

5. Press the key which corresponds to the desired standard observer, either 2° or 10°. You are prompted to choose the illuminant.

6. Press the key which corresponds to the desired illuminant. You are prompted to enter the 1st color value.

7. Enter each color value and press ENTER after each value. When all the values have been entered you may use the arrow keys or the mouse to go back and edit the values.

8. Press PAGE DOWN to display the data in all other color scales.

9. Press F8 to save the data. You are prompted to enter an ID.

10. Type in an ID or press \ to increment the ID if it is numeric or ends in a numeric sequence. The tolerance window appears.

11. Use the arrow keys or mouse to enter the tolerances.

12. Press INS to accept the tolerances. You are asked if the data is to be saved as a hitch standard or relative to the hitch standard if one is already in place.

13. Press the key corresponding to the appropriate response. If you are saving the data as a hitch standard you are prompted to read the hitch standard. After entering all the data, press HOME. You are asked if you wish to display the last record as sample, standard, or neither.

14. Press the key corresponding to the appropriate response.

NOTE: Be sure that the measurement screen is using the same illuminant/observer combination as the entered data if the you want the data displayed as the standard or sample.

Delete

Pressing 5 from the data menu allows you to delete either a single data record or all data records from the current data file set. When deleting a single data record you may type in the name of the record to be deleted or press INS to list all data records and then select from the list.

CAUTION

Deletion of data records is permanent and cannot be reversed, therefore, use this function with care.

Search

Pressing 6 from the data menu initiates the search routine according to the parameters selected in the search setup screen.

The current data file can be searched for the record with color values closest to the standard or sample or for all the records within a selected tolerance range.

Before beginning any search routine it is necessary to make the desired selections in the search setup screen.

1. Press F5 to display the setup menu.
2. Press 8 to enter the search setup screen.
3. Select the mode, method, illuminant, observer, and 2nd illuminant for the search.
4. Press HOME to return to the measurement screen.

Searching for Closest to Standard

1. Place the standard at the reflectance port or in the transmission compartment.
2. Press F2 to read the standard. The standard values are displayed in the STANDARD column.
3. Press F8 to display the data menu.
4. Press 6 to initiate the search routine. The data record with color values closest to the standard is displayed in the SAMPLE column.

Searching for Closest to Sample

1. Place the sample at the reflectance port or in the transmission compartment.
2. Press F1 to read the sample. The sample values are displayed in the SAMPLE column.
3. Press F8 to display the data menu.
4. Press 6 to initiate the search routine. The data record with color values closest to the sample is displayed in the STANDARD column.

Searching Within Tolerance

1. Place the standard at the reflectance port or in the transmission compartment.

2. Press F2 to read the standard. The standard values are displayed in the STANDARD column.

3. Press F8 to display the data menu.

4. Press 6 to initiate the search routine. You are prompted to enter the tolerance range.

5. Enter the lower limit of the tolerance range and the upper limit of the tolerance range. Be sure to include negative signs where applicable.

6. Press INS to accept the tolerance limits and initiate the search. The ID's and color values of all data records within the selected tolerance are printed.

New Files

Data file sets can be recalled or created using this function.

1. Press 7 from the data menu. A prompt for entry of the data file ID appears.

2. Type in the name of the data file you wish to recall or create including the appropriate drive and directory. If no drive or directory is specified, then the current ones are used. The data file name can be up to 8 characters long. If the data file name you have typed cannot be located, then you are asked if you want to create new files using this name.

3. Type 1 to create new files. Two files are created. One file has the extension .DTA and stores the data; the other file has the extension .IDS and stores the names of the data records.

Data files cannot be deleted through the software, they must be deleted from DOS. Be sure to erase both the .DTA file and the .IDS file. Deletion of the current data file causes the software to display two error messages upon initialization. Before deleting the current data file switch to another data file such as the default SAMFILE in the C:\CQSPEC\ directory. Likewise, when saving data records in a data file created on a floppy diskette, be sure to switch to another data file on the hard disk before removing the diskette.

List Files

Pressing 8 from the data menu lists the names of all data files in the current directory to either the screen or the printer. Figure 11-2 shows a list of data files of the current directory.

Data files can also be listed by using the DIR command from DOS. Figure 11-3 shows a list of .IDS files from DOS.

Figure 11-2

```
ColorQUEST SpecWare, Version 1.09          1:Feb:91     11:39
Data files in directory: C:\CQSPEC\

BLUE          DEMO          MANUAL        SAMFILE       TEST
BROWN         GOOD          RED           SEMINAR       TEST2
CHIPS         GRAY          RED1          SHOW
```

Figure 11-3

```
Directory of  C:\CQSPEC
BLUE      IDS      172   9-13-90   1:50p
GOOD      IDS      100   9-13-90   1:50p
GRAY      IDS       82   9-13-90   1:50p
RED       IDS      100   9-13-90   1:50p
BROWN     IDS       64   9-13-90   1:50p
CHIPS     IDS       28   9-13-90   1:50p
MANUAL    IDS      100   9-13-90   1:50p
SHOW      IDS      226   9-13-90   1:51p
TEST2     IDS      262   9-13-90   1:51p
RED1      IDS       28   9-24-90   8:15a
SEMINAR   IDS       28   9-24-90   8:16a
SAMFILE   IDS       46   9-13-90   1:50p
TEST      IDS      154   1-17-91  11:19a
DEMO      IDS      388   1-23-91   5:42p
```

F9 Screens

Pressing F9 displays a list of all possible display screens:

1 Color data illum. 1
2 Color data illum. 2
3 Color plot illum. 1
4 Color plot illum. 2
5 Spectral data
6 Spectral plot

Selection from this menu takes you directly to the desired screen. You may also cycle through all 6 screens using the + and - keys on the numeric keypad.

Selection of 1 or 2 displays the color data screens for the 2 illuminants selected in the color setup screen. If only 1 illuminant is selected, then the 2nd color data screen does not display any data.

Selection of 3 or 4 displays the color plot screens for the 2 illuminants selected in the color setup screen. If only 1 illuminant is selected, then the 2nd color plot screen does not display any data. If XYZ or Yxy is selected as the color scale in the color setup screen, the 2 color plot screens do not display a color plot but display color difference data.

Selection of 5 displays the spectral data screen with a display defined by the selections made from the spectral data setup screen.

Selection of 6 displays the spectral plot screen with a display defined by the selections made from the spectral plot setup screen.

Measurements can be taken from any of the 6 display screens.

F10 Run

Pressing F10 from any measurement screen runs the current program.

Programs are entered from the procedures menu. Refer to Chapter 9 for instructions on creating and modifying programs.

F10 must be used during the execution of the program to resume the program after it has stopped to allow entry of data such as an ID. Pressing ENTER instead of F10 aborts the program.

Measurement Guidelines

Careful attention to proper instrument operation as well as consistency of sample handling are required for accurate color measurement.

There may come a time when you need assistance taking color measurements for a particular application. HunterLab's Technical Services Department is available to help you. When you need some expert advice, call (703) 471-6870 and ask to talk to an applications specialist.

Preparing Samples for Measurement

When measuring samples it is important to select samples appropriately, use an established measurement method, and handle all samples in a consistent manner. The following guidelines will help you while taking measurements.

Selecting Samples

Specimens representative of the entire batch should be selected for measurement.

1. Choose specimens that are representative of the material used.

2. Prepare specimens in exactly the same manner each time they are measured. Follow standard methods if they exist, such as the ASTM or TAPPI methods.

3. Present the specimen to the instrument in a standard, repeatable manner.

4. Results measured depend on the condition of the specimen and its presentation. For any established procedure, a checklist should be made so that operators may simply check each step. The checklist also helps in the training of new operators.

   The sample must also be representative of the attributes that are of interest. If specimens are non-representative of the batch or are spoiled, damaged or irregular, then the batch may be biased. When choosing a specimen, select in a random fashion and examine the specimen to avoid bias results. If sampling procedures are adequate, a different sample selected from the same batch should result in comparable measured values.

Measurement Method

Establish a method so that the same procedure is used each time specific specimens or types of specimens are measured, then a valid basis for comparison of measured results is formed. This also insures repeatability of results when measuring the same specimen.

Sample Handling

There are a variety of techniques that can be used in handling various forms of objects and materials so that the most valid and repeatable measurement of their appearance results. Consideration must be given to the conditions for specimen preparation that are dependent upon the type of measurement to be made. For example, when measuring the color of a specimen that might pillow into the viewing aperture, you should hold the surface flat by using a cover glass taped over the aperture window. Other materials being measured for color may be chopped up and placed in a glass specimen cell or made into a paste and applied to a glass plate. Sheets and films should be flattened by tension or by a vacuum, if necessary.

Directionality

Directionality can be minimized by averaging several measurements. Examination of the standard deviation displayed with the average function can guide you to selecting the appropriate number of readings to average.

Non-opaque Samples

Non-opaque specimens must have a consistent backing (the white uncalibrated tile is recommended). If the specimen can be folded to give multiple layers, such as tissue, the number of layers for each specimen should be specified.

Translucent Samples

Translucent specimens should be measured with a larger port opening than illumination area to allow light to escape. Light trapped in the specimen can distort the color.

When measuring attributes that depend upon the transmission of light, such as the color or cloudiness of iced tea, place the liquid in special optical cells that have flat parallel surfaces. The thickness of the specimen presented should be chosen to maximize the haze or color difference.

Fluorescing Samples

For some applications, the elimination of fluorescence in a measurement is important. Fluorescence is caused by ultraviolet (UV) excitation of the sample, where a material absorbs nonvisible wavelengths of energy and re-emits the energy as light in the visible spectrum. Since UV light is part of the normal sample illumination, measurements may include UV excitation. To eliminate fluorescence from the measurement, place the UV filter in the light path. When the filter is positioned, the energy present in the lamp below 418 nm is virtually eliminated from entry into the sphere.

It is necessary to know what type of fluorescence is involved in the samples being measured. Some materials fluoresce due to excitation by visible rather than ultraviolet wavelengths. An ultraviolet absorbing filter does not eliminate this type of fluorescence.

Tolerances

Since color difference measurements are usually made for the purpose of determining if samples are departing too far in color from the product standard, provisions have been made for entering and storing plus and minus tolerances for each of the color scales, color differences and indices associated with each product standard. These plus and minus tolerances may be symmetrical or asymmetrical. Information stored for any data record consists of either the spectral or colorimetric data and tolerances. When storing a standard or sample, tolerances may be entered into the tolerance register through the keyboard. If values are not entered for the tolerances, default values of ±10.00 are stored with the data record. Tolerances can also be calculated automatically if CMC autotolerancing is selected in the global setup screen. CMC autotolerancing can be used to help you set tolerances for a new product standard.

When display of color differences only is desired, tolerances should be disabled in the color setup screen.

> *HunterLab's Guide to Color Tolerancing* may be useful when establishing tolerances. To obtain a copy of the guide, contact HunterLab's Marketing Department at (703) 471-6870.

Note: Tolerances are stored with the standard in reference to the current color scale and illuminant/observer combination. If the standard is later recalled in another color scale or illuminant/observer combination the displayed tolerances are not valid.

Hitch Standardization

When it is desirable to compare color measurements between different instruments, you should use product specific hitch standards, sometimes referred to as transfer standards.

Product standards are measured on an instrument designated as the *reference* and assigned color values. The standard and the assigned color values are then used to calibrate other instruments. The product standard may be an actual product specimen or a ceramic tile which represents the target color of the product.

After measurement on the reference instrument, product standards are shipped to each cooperating laboratory where they are used as temporary standards for assignment of color values to more durable secondary working standards to be used only on that instrument for that product. This standard is the hitch standard. Hitch standards should be very close in color to the sample being measured.

Note: Geometric differences between instruments cause differences in measured values as do differences in sample preparation. Hitch standardization is recommended for use among instruments with the same geometry and using a set procedure for sample preparation.

Instructions for entering and using hitch standards are given in Chapter 9.

15

Options

The instrument can be equipped with several different options which provide added flexibility in working with data.

The following options are available with the ColorQUEST Sphere:

- Extended communications package
- XY plotter

Extended Communications Package

This option is used to send data to a peripheral device using the send function in the F3 output menu or using the CTRL/F3 keys.

This option consists of an additional bi-directional serial port at the rear of the comuter system unit for communication with a peripheral device such as another computer, plus a special program which is used to set up the parameters for the communications port. A minimum of 640K of memory and at least Version 3.1 DOS are required. The pin definition includes:

Pin 1	Frame Ground
Pin 2	Transmit Data
Pin 3	Receive Data
Pin 4	Request to Send
Pin 5	Clear to Send
Pin 6	Data Set Ready
Pin 7	Signal Ground
Pin 14	Test Voltage
Pin 18	Loop Back Test
Pin 20	Data Terminal Ready

This option provides for output from the computer system unit to the peripheral device, and input from the peripheral device to the computer.

The second communications port is set at the factory. However, if it becomes necessary to change the parameters, the COMMPORT program can be run to change the baud rate, parity, number of stop bits, and number of data bits. See Appendix B for information about the COMMPORT program.

TABLE 15-1
OUTPUT DATA FORMATS

SETUP (41 HEX)

7F, 41, Name, 03

Field	Length (Bytes)	Value
Name	12	ASCII setup name, uses blank (20H) for fill to 12

DATA INFORMATION (42 HEX)

7F, 42, Standardization Mode, Standardization Type, Transfer Type, Transfer Illuminant, Transfer Observer, Transfer Name, Standard Type, Standard Illuminant, Standard Observer, Standard Name, Sample Type, Sample Illuminant, Sample Observer, Sample Name, 03

Field	Length (Bytes)	Value (Hex)
Stdz mode	1	30 = RSIN, 31 - RSEX, 32 = TTRANS, 33 = RTRANS
Stdz type	1	30 = Normal, 31 = 100%, 32 = Transfer
Relevant to Transfer standardization only		
Tran type	1	30 = Spectral, 31 = Tristimulus
Tran ill	1	30 = A, 31 = C, 32 = D65, 33 = F2, 34 = TL4, 35 = ULT, 36 = D50, 37 = D60, 38 = D75
Tran obs	1	30 = 2 degree, 31 = 10 degree
Tran name	16	ASCII transfer standard name, uses blank (20H) for fill to 16
Relevant to all standardizations		
Std type	1	30 = Spectral, 31 = Tristimulus
Std ill	1	30 = A, 31 = C, 32 = D65, 33 = F2, 34 = TL4, 35 = ULT, 36 = D50, 37 = D60, 38 = D75
Std obs	1	30 = 2 degree, 31 = 10 degree
Std name	16	ASCII standard name, uses blank (20H) for fill to 16
Sam type	1	30 = Spectral, 31 = Tristimulus
Sam ill	1	30 = A, 31 = C, 32 = D65, 33 = F2, 34 = TL84, 35 = ULT3000, 36 = D50, 37 = D60, 38 = D75
Sam obs	1	30 = 2 degree, 31 = 10 degree
Sam name	16	ASCII standard name, uses blank (20H) for fill to 16

COLORIMETRIC (43 HEX)

7F, 43, Scale, Illuminant, Observer, Data Type, Data, 03

Field	Length (Bytes)	Value (Hex)
Scale	1	30 = XYZ, 31 = Yxy, 32 = Hunter Lab, 33 = CIELAB, 34 = Rdab, 35 = AnLab,
Ill	1	30 = A, 31 = C, 32 = D65, 33 = F2, 34 = TL4, 35 = ULT, 36 = D50, 37 = D60, 38 = D75
Std obs	1	30 = 2 degree, 31 = 10 degree
Data type	1	30 = Sample, 31 = Standard, 32 = Deltas, 33 = Average Sample, 34 = Average Standard
Data	21	3 Scale values in ASCII, 7 bytes/value, 2 decimal places for all scales except Yxy which has four.

SPECTRAL (44 HEX)

7F, 44, Data Type, Interval, Start, End, Spectral Type, Data, 03

Field	Length (Bytes)	Value
Data type	1	30 = Sample, 31 = Standard, 32 = Delta, 33 = Average Sample, 34 = Average Standard
Interval	1	30 = 1nm, 31 = 5nm, 32 = 10nm, 33 = 20nm
Start	4	375 - 1100 in ASCII
End	4	475 - 1100 in ASCII
Spectral	1	30 = Normal, 31 = K/S (Absorbance), 32 = Optical Density
Data	Variable	Variable number of spectral data values, based on range and interval. Each value is 7 bytes/value with 2 decimal places. K/S only has 9 bytes/value with 4 decimal places. Differences for K/S will be colorant strength values at 7 bytes/entry.

COLOR DIFFERENCE (45 HEX)

7F, 45, Difference Scale, Illuminant, Observer, Data, 03

Field	Length (Bytes)	Value (Hex)
Diff Scale	1	30 = DELab, 31 = DELCH, 32 = DERdab, 33 = FMC2, 34 = CMC
Ill	1	30 = A, 31 = C, 32 = D65, 33 = F2, 34 = TL4, 35 = ULT, 36 = D50, 37 = D60, 38 = D75

Field	Length (Bytes)	Value (Hex)
Obs	1	30 = 2 degree, 31 = 10 degree
Data	Variable	7 ASCII bytes/value, 2 values for DELab, DERdab, 3 values for DELCH, 4 values for FMC2. All values have 2 decimal places

INDEX (46 HEX)

7F, 46, Scale Type, Illuminant, Observer, Ill 2, Data Type, Data, 03

Field	Length (Bytes)	Value (Hex)
Scale type	1	30 = WI E313, 31 = WI CIE, 32 = YI D1925, 33 = YI E313, 34 = MI, 35 = Z%, 36 = DW/EP, 37 = K/S, 38 = Optical Density
Ill	1	30 = A, 31 = C, 32 = D65, 33 = F2, 34 = TL4, 35 = ULT, 36 = D50, 37 = D60, 38 = D75
Obs	1	30 = 2 degree, 31 = 10 degree
Ill2	1	Same as Ill field, relevant to MI only
Data type	1	30 = Sample, 31 = Standard, 32 = Average Sample, 33 = Average Standard, Relevant to WI and YI only
Data	7	1 scale value in ASCII with 2 decimal places. DW/EP has 2 data fields, each having 7 bytes with 2 decimal places

TOLERANCES (47 HEX)

7F, 47, Data, 03

Field	Length (Bytes)	Value (ASCII)
Data	54	6 Tolerance values at 9 bytes/tolerance, 4 decimal places

END OF DATA TRANSMISSION (48 HEX)

7F, 48, 03

TABLE 15-2
INPUT DATA FORMATS

FUNCTION KEY	8 BIT (HEX)	7 BIT (HEX)*	ASCII
			(ESC)
Read Sample	80	1B 30	0
Read Standard	81	1B 31	1
Output	82	1B 32	2
Clear	83	1B 33	3
Setups	84	1B 34	4
Procedures	85	1B 35	5
Average	86	1B 36	6
Data	87	1B 37	7
Spectral Plot	88	1B 38	8
Program Run	89	1B 39	9
Send	8A	1B 3A	:
Data Logging	8B	1B 3B	;
Plotter	8C	1B 3C	<
Program Modification	8D	1B 3D	=
Home	8E	1B 3E	>
Up Arrow	8F	1B 3F	?
Page Up	90	1B 40	@
Left Arrow	91	1B 41	A
Right Arrow	92	1B 42	B
End	93	1B 43	C
Down Arrow	94	1B 44	D
Page Down	95	1B 45	E
Insert	96	1B 46	F
Previous Display	97	1B 47	G
Next Display	98	1B 48	H
Print Screen	99	1B 49	I
Program - Message **	9A	1B 4A	J
Program - Pause **	9B	1B 4B	K
Color Data1	9C	1B 4C	L
Color Plot1	9D	1B 4D	M
Spectral Data	9E	1B 4E	N
Spectral Plot	9F	1B 4F	O

TABLE 15-2
INPUT DATA FORMATS

FUNCTION KEY	8 BIT (HEX)	7 BIT (HEX)*	ASCII
Color Data2	A0	1B 50	P
Color Plot2	A1	1B 51	Q
File Transfer	A2	1B 52	R
Delete Key	A3	1B 53	S
Print Function	A4	1B 54	T
Program ID Entry **	A5	1B 55	U

All other input is in the form of normal ASCII.

* These are two byte commands.

** Valid only while running a program. Cannot be used from keyboard or communications port.

XY Plotter

This option consists of plotter software for a 4 or 6 pen plotter which allows you to output spectral plots of the standard and multiple samples with coordinate axes. The plots may be differentiated either by the color of the pen used or by printing the names of the samples and the standard.

Installation

1. Install the plotter with pens and paper according to the manual accompanying the plotter.

2. Connect the female plug of an RS-232C 25 pin connector signal cable to the computer system unit serial port.

3. Connect the male end of the cable to the plotter.

4. Turn the plotter on.

The communications port used for the plotter is set at the factory. However, if it is necessary to change the setup parameters, run the COMMPORT program from DOS to change the baud rate, parity, number of stop bits, and number of data bits. See Appendix B for information on the COMMPORT program.

Operation

Before you begin plotting standard and samples, be sure to make the appropriate selections from the plotter option field in the spectral plot setup screen. Also select PROMPT FOR ID in the global setup screen if you want to print standard and sample ID's. Selection of PROMPT FOR ID requires you to enter an ID each time a standard or sample is measured.

1. Press F6 to enter the procedures menu.

2. Press 8 to toggle on the plotter mode. The following menu is displayed at the top of the screen:

   PLOTTER COMMANDS:
   1 Plot Sample
   2 Plot Standard
   3 Plot Axes
   4 Exit

3. Press 3 to plot the axes on the paper using pen 1.

4. Place the standard at the reflectance port or at the transmission port in the transmission compartment.

5. Press F2 to read the standard.

6. Press 2 to plot the standard using the next available pen.

7. Place the sample at the reflectance port or in the transmission compartment.

8. Press F1 to read the sample.

9. Press 1 to plot the sample with the next available pen.

   Repeat steps 8 and 9 to plot additional sample measurements. The pens cycle in turn as each new sample is added.

10. Press 4 to exit the plotter menu. The pen number is reset.

Note: All operations are available in the plotter mode. For example, measurements may be saved and recalled.

16

Maintenance

This section describes the maintenance necessary to keep your instrument functioning properly.

> Should you have any questions concerning the performance or maintenance of the ColorQUEST Sphere, call the HunterLab Service Department at (703) 471-6870.

Instrument Standards

It is important that the standards be treated with extreme care. When a standard is used, center it carefully at the sample port. Never use a calibrated standard to back up samples being measured. The sample clamp or a white uncalibrated tile is to be used as a back-up tile.

When not using the tiles, keep them in the standards box. Inspect the tiles for dust and fingerprints before standardizing the instrument. Tiles can be cleaned using a soft nylon bristle brush and laboratory grade detergent such as SPARKLEEN. Wipe tiles dry using a clean non-optically brightened, lint free paper towel.

Note: SPARKLEEN is manufactured by Fisher Scientific Co., Pittsburgh, PA 15219 and may be ordered from them using catalog number 4-320. One tablespoon of SPARKLEEN is added to every gallon of water.

Keep the light trap in the standards box when not in use to prevent it from becoming scratched or collecting dust. Before standardizing the instrument, check the light trap for scratches and dust. Significant scratches may cause standardization to be in error. If the light trap is scratched, call the HunterLab Customer Service Department at (703) 471-6870 to order a replacement.

Maintaining the Instrument

This section outlines the parts of the sensor you must maintain in order for the instrument to function properly.

Source Lamp

The low voltage halogen cycle lamp used in this instrument has an operating life of approximately 1000 hours at the full-on operating condition. When the lamp is approaching the end of its useful life, the light output may fluctuate, causing equivalent fluctuations in the instrument readout.

Note: Replace with a specified Quartz-Halogen Lamp, HunterLab part #15015100. Use of any other lamp can cause output instability.

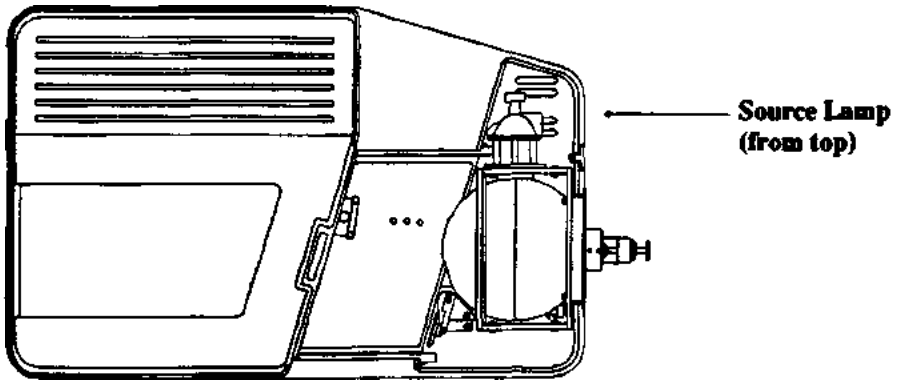
To change the source lamp:

1. Turn off the power switch located on the right side of the sensor. Allow the lamp to cool prior to removing.

2. Remove any samples from the reflectance port and the transmission compartment.

3. Loosen the 3 thumb screws from the sphere end of the optical sensor and lift the cover straight up. Figure 16-1 shows the location of the source lamp.

Figure 16-1



4. Remove the old lamp by pulling lever toward the outside edge of the optical sensor. The lamp slides up and out of the connector.

5. Return lever to original position.

6. Insert the new lamp making sure the two pins on the lamp fit into the socket. Be careful not to touch the bulb of the lamp or the reflector, as fingerprints reduce lamp life appreciably. If a fingerprint is deposited, remove it using a clean wipe and isopropyl alcohol. Note that lack of proper contact at the connector can be a major source of unsatisfactory instrument performance. Always check the lamp when unsteady operation is experienced.

7. Replace the optical sensor cover and tighten the thumb screws.

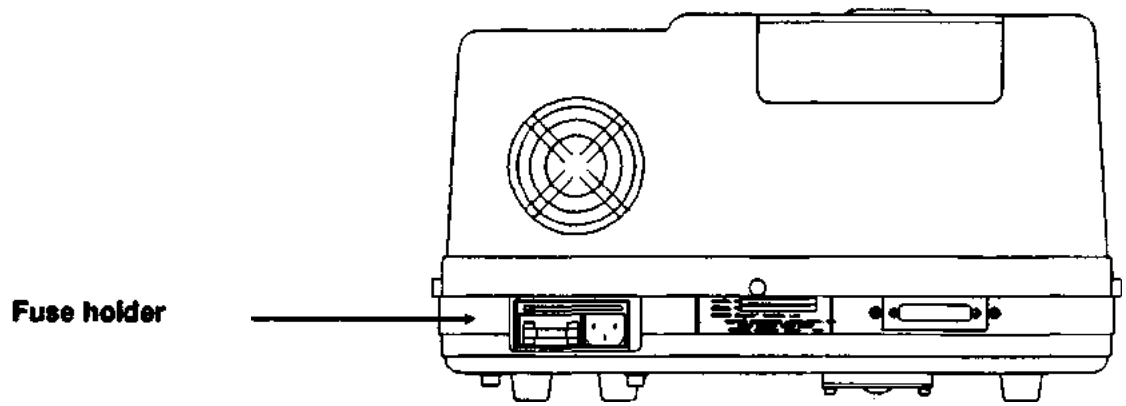
8. Turn on the power switch located on the right side of the sensor and allow the lamp to warm up 15 minutes to 2 hours depending on conditions.

9. Standardize the instrument as described in Chapter 4.

Fuse

The fuse is housed on the back of the sensor and shown in Figure 16-2.

Figure 16-2



1. Remove the power cord from the sensor.

2. Slide back the plastic window in front of the fuse holder to expose the fuse pull tab.

3. Pull the tab to remove the old fuse. Replace with a new fuse.

4. Slide the plastic window in front of the fuse holder and replace the power cord.

Lens Surface

The lens should be cleaned using photographic quality lens solution and lens paper. Put a few drops of solution on the lens paper and gently wipe the lens in a circular motion for a few seconds. Gently wipe the lens with a dry lens paper to remove streaks and any hazy film.

CAUTION

Do not disassemble the instrument and attempt to clean the optical components.

Sphere

Care should be taken to keep foreign materials from entering the sphere. The transmission compartment should be closed and the reflectance port door placed against the port when not in use. The sphere is coated with barium sulfate, $BaSO_4$, which can be damaged by putting any objects into the sphere. If any foreign material (dust, lint, etc.) falls into the sphere use the following steps to remove the material.

1. Move the sample clamp away from the reflectance port.

2. Open the transmission compartment and place a vacuum cleaner hose at the sphere opening but do not insert the hose directly into the sphere. Cup your hand around the end of the hose to provide a good seal.

3. Quickly cover and uncover the reflectance port with your other hand. This creates gentle air currents to swirl the foreign matter around and out of the sphere.

When shipping the sensor remove the sample clamp and tape a pad of foam rubber at the reflectance port. Failure to do so may cause severe damage to the instrument.

Holographic Grating

The sensor is equipped with a concave holographic grating. This grating is a 2-inch diameter concave piece of glass that disperses light into the various wavelengths of the spectrum. It is located under two separate covers in the end of the optical sensor opposite the reflectance port. Do not remove these covers unless specifically requested by the HunterLab Service Department.

Touching the reflectance area of the grating leaves marks that cannot be removed and that affect the performance of the ColorQUEST. Warranty replacement of the grating is not considered for any damage caused by the customer.

Diskette Maintenance

This section provides you with guidelines for handling your original program diskettes and diskettes containing files you have created through the software. For general information about diskette maintenance and handling refer to the user's guide which accompanies the computer system.

1. Do not store diskettes near heavy industrial equipment.

2. Keep diskettes away from any magnets or devices that might be magnetic, such as radios, loudspeakers, or clips for bulletin boards.

Backing Up Files

When a prompt is displayed informing the operator that a data file is full, it is then necessary to back up all the data files or delete some or all data records that do not need to be saved. In addition, it is strongly recommended to periodically backup the data in the unlikely event that data is inadvertently lost from the hard disk. In order to back up all data files and program files onto diskettes, the diskettes must first be formatted for use with the computer. See the user's guide for your computer system for directions. The command FORMAT should never be used without specifying the drive on which to format the diskette.

To backup files:

1. Press F6 to enter the procedures menu and press ESC to exit to DOS.

2. Type BACKUP C:\CQSPEC A: and press ENTER. You are prompted to insert a diskette into drive A.

3. Place a blank formatted diskette in drive A. BACKUP erases all existing files on the target diskette before it starts backing up the source disk. When BACKUP fills up a diskette, you are prompted to insert a new diskette. For more information, refer to your DOS Manual.

You may also copy just the data files or selected data files to a disk using the DOS copy command. Be sure to copy both the files with extension .IDS and the files with extension .DTA.

Reloading Data Files

If the data files and/or program files are lost from the hard disk or need to be reloaded, copy the data files using the program 'RESTORE'.

To restore files:

1. Press F6 to enter the Procedures menu and press ESC to exit to DOS.

2. Type RESTORE A: C:\CQSPEC*.* and press ENTER. You are prompted to insert the backup diskette into Drive A.

3. Place the backup diskette in Drive A. When the files from the first diskette are restored, you are prompted to insert the next diskette.

   For more information, refer to your DOS Manual.

A

Specifications

For best performance, the instrument should be placed where there is ample work space with medium or subdued illumination and no drafts. For optimum results, a clean, air-conditioned area is recommended with a relative noncondensing humidity of 20-80% [10-90% for sensor only] and relatively constant temperature not exceeding 90°F (32°C) [100°F (38°C) for sensor only]. For specification performance, the temperature range is 70-82°F (21-28°C).

The instrument should be connected to a stable, instrument-grade powerline. If other equipment is connected to the same power line, a transient power surge may be produced when the other equipment is turned on. If this happens restandardize the instrument before making measurements. HunterLab recommends using a line conditioner with a minimum of 600 VA rating and a battery back-up system.

Instrument Specifications

Physical Characteristics

Optical Sensor - 15.25 in. (38 cm) wide x 24 in. (60 cm) deep x 9.0 in. (22.5 cm) high, 42 lb. (19.1 kg).

Computer system - depends upon system selected. Refer to manufacturer's documentation for information.

Power Required

Voltage - 115V ±10 at 60Hz or 230V ±20 at 50Hz.

Current - 1A at 115V or 0.5A at 230V.

Conditions of Illumination and Viewing

Reflectance Measurements

Port size - 1.0 in. (25 mm) diameter

Viewed Area - 7/8 in. (22 mm) diameter

Maximum specimen - size unlimited

Transmittance Measurements

Port Size - 1.0 in. (25 mm) diameter

Maximum specimen - size unlimited, but measurement limited to 3.125 in. (7.9 cm) from an edge.

Illumination

Diffuse 6 inch (15.2 mm) diameter sphere coated with barium sulfate, $BaSO_4$, illuminated with simulated CIE D_{65} spectral distribution filtered to eliminate infrared specimen heating.

Viewing

8° from specimen normal

Specular component included or excluded

Receptor System

Concave holographic diffraction grating monochromator

32 cell silicon diode array

Lamp Life

1000 hours, typical

Measurement Modes

Reflectance - Specular Included

Reflectance - Specular Excluded

Total Transmittance

Regular Transmittance

Measurement Values

Color values as measured on the ColorQUEST Sphere are relative to the absolute value of the perfect white diffuser as measured under the same geometric conditions (see ASTM Method E 306), according to the recommendation of the International Commission on Illumination, CIE, of January 1, 1969. These values are traceable to measurements made at the National Institute of Standards and Technology.

CIE Tristimulus XYZ Scale

The SpecWare software performs 10 nm weighted ordinate method tristimulus integration of reflectance values from 400 to 710 nm to arrive at tristimulus X, Y and Z values. These values simulate the color matching response functions of the human observer as defined by the 1931 2° Standard Observer or the 1964 CIE 10° Standard Observer. Tristimulus integrations based on any or all of the illuminants may be selected.

CIE Chromaticity Coordinates, Yxy

The relationship between CIE XYZ values and the x,y chromaticity coordinates is as follows:

$$x = \frac{X}{X + Y + Z} \qquad y = \frac{Y}{X + Y + Z}$$

Opponent Color Scales (Hunter Lab - CIE 1976 L*a*b*)

The opponent color scales give measurements of color in units of approximate visual uniformity throughout the color solid. Thus, L measures lightness and varies from 100 for perfect white to zero for black, approximately as the eye would evaluate it. The chromaticity dimensions (a and b) give understandable designations of color as follows:

a measures redness when plus, gray when zero and greenness when minus
b measures yellowness when plus, gray when zero and blueness when minus

The relationship between the Hunter Lab Scale and the CIE XYZ Scale for the CIE 1931 2° Standard Observer and the CIE 1964 10° Standard Observer for the eight illuminations are as follows:

$$L = 100\sqrt{Y/Y_n}$$

$$a = K_a \frac{X/X_n - Y/Y_n}{\sqrt{Y/Y_n}}$$

$$b = K_b \frac{Y/Y_n - Z/Z_n}{\sqrt{Y/Y_n}}$$

where:

X,Y,Z are CIE tristimulus values.

Xn, Yn, Zn are tristimulus values of the standard illuminant as listed in Tables 1 and 2 with Yn always equal to 100.00 (normalized).

K_a, K_b are chromaticity coefficients for the illuminant used.

Illuminant A represents incandescent lamplight with an approximate color temperature of 2854 K. Illuminant C represents light from an overcast sky with a correlated color temperature of approximately 6770 K. Illuminant D_{65}, D_{50}, D_{60}, D_{75} represent daylight with a correlated color temperatures of approximately 6500 K, 5000 K, 6000 K and 7500 K respectively. Illuminant F2 represents light from a cool white fluorescent source.

Table 1
CIE 1931 2° Standard Observer
Standard Illuminant Tristimulus Values

Illuminant	Xn	Zn	Ka	Kb
A	109.83	35.55	185.20	38.40
C	98.04	118.11	175.00	70.00
D_{65}	95.02	108.82	172.30	67.20
F2	98.09	67.53	175.00	52.90
TL4	101.40	65.90	178.00	52.30
UL 3000	107.99	33.91	183.70	37.50
D_{50}	96.38	82.45	173.51	58.48
D_{60}	95.23	100.86	172.47	64.72
D_{75}	94.96	122.53	172.22	71.30

Table 2
CIE 1931 10° Standard Observer
Standard Illuminant Tristimulus Values

Illuminant	Xn	Zn	Ka	Kb
A	111.16	35.19	186.30	38.20
C	97.30	116.14	174.30	69.40
D_{65}	94.83	107.38	172.10	66.70
F2	102.13	69.37	178.60	53.60
TL4	103.82	66.90	180.10	52.70
UL 3000	111.12	35.21	186.30	38.20
D_{50}	96.72	81.45	173.82	58.13
D_{60}	95.21	99.60	172.45	64.28
D_{75}	94.45	120.70	171.76	70.76

The Hunter Lab total color difference (ΔE) and chromaticity difference (ΔC) for any illuminant or observer are calculated as follows:

$$\Delta E = \sqrt{\Delta L^2 + \Delta a^2 + \Delta b^2}$$

$$\Delta C = \sqrt{\Delta a^2 + \Delta b^2}$$

where:

$\Delta L = L_{SMP} - L_{STD}$ (if + ΔL, sample is lighter than standard
if - ΔL, sample is darker than standard)

$\Delta a = a_{SMP} - a_{STD}$ (if + Δa, sample is redder than standard
if - Δa, sample is greener than standard)

$\Delta b = b_{SMP} - b_{STD}$ (if + Δb, sample is yellower than standard
if - Δb, sample is bluer than standard)

The ΔE derived from these opponent-color scales approximates the NBS Unit of Color Difference (Judd-Hunter), which represents the average maximum difference acceptable in a series of dye-house commercial matches in 1939.

The CIE 1976 L*a*b* Scale is recommended by the Commission Internationale de l'Eclairage (CIE). It is a simplified cube root version of the Adams-Nickerson space produced by plotting in rectangular coordinates the quantities of L*a*b*.

The relationship between the CIE L*a*b* scale and the CIE XYZ Scale for any illuminant reference in Tables 1 and 2 is as follows:

If all values of X/Xn, Y/Yn, Z/Zn > 0.008856, use the following:

$$L^* = 116 \sqrt[3]{Y/Y_n} - 16$$

$$a^* = 500 \left(\sqrt[3]{X/X_n} - \sqrt[3]{Y/Y_n} \right)$$

$$b^* = 200 \left(\sqrt[3]{Y/Y_n} - \sqrt[3]{Z/Z_n} \right)$$

If any value of X/Xn, Y/Yn, Z/Zn ≤ 0.008856, use the following:

$$L^* = 903.3 \frac{Y}{Y_n}$$

$$a^* = 500 \left[f(X/X_n) - f(Y/Y_n) \right]$$

$$b^* = 200 \left[f(Y/Y_n) - f(Z/Z_n) \right]$$

where:

$$f(X/X_n) = \sqrt[3]{X/X_n} \qquad X/Xn > 0.008856$$

$$f(X/X_n) = 7.87(X/X_n) + 16/116 \qquad X/Xn < 0.008856$$

$$f(Y/Y_n) = \sqrt[3]{Y/Y_n} \qquad Y/Yn > 0.008856$$

$$f(Y/Y_n) = 7.87(Y/Y_n) + 16/116 \qquad Y/Yn < 0.008856$$

$$f(Z/Z_n) = \sqrt[3]{Z/Z_n} \qquad Z/Zn > 0.008856$$

$$f(Z/Z_n) = 7.87(Z/Z_n) + 16/116 \qquad Z/Zn < 0.008856$$

where Xn, Yn, Zn are tristimulus values for any illuminant.

Total Difference (ΔE*), CIE 1976 a,b Chroma-Differences (ΔC*) and CIE 1976 a,b Hue Difference (ΔH*).

$$\Delta E^* = \sqrt{\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}}$$

$\Delta C^* = C^*_{smp} - C^*_{std}$ where $C^* = \sqrt{a^{*2} + b^{*2}}$ and is termed metric chroma

$\Delta H^* = \sqrt{\Delta E^{*2} - \Delta L^{*2} - \Delta C^{*2}}$

ΔE^* is the same quantity as that described above, using CIE L*a*b* (CIELAB) values. It approximates the NBS Unit of Color Difference.

ΔC^* is the difference between the chroma of the sample and the chroma of the standard, as described in a polar coordinate system. Note that it is not the same quantity as the chromaticity difference ΔC.

ΔH^* describes the difference between the hue angle (h°) of the standard and the hue angle of the sample in a polar coordinate system, where:

If $h°_{smp} > h°_{std}$ then ΔH^* is regarded as positive
If $h°_{std} > h°_{smp}$ then ΔH^* is regarded as negative

See Recommendation on Uniform Color Spaces, Color Difference Equations, Psychometric Color Terms, Supplement No. 2 to CIE Publication No. 15 (E-1.3.1) CIE, Paris, 1978.

L^* = CIE 1976 psychometric lightness = $116\sqrt[3]{Y/Y_n} - 16$

a^* = Red(+) - Green(-) axis = $500\left(\sqrt[3]{X/X_n} - \sqrt[3]{Y/Y_n}\right)$

b^* = Yellow(+) - Blue(-) axis = $200\left(\sqrt[3]{Y/Y_n} - \sqrt[3]{Z/Z_n}\right)$

C^*_{ab} = CIE 1976 a,b chroma = $\sqrt{a^{*2} + b^{*2}}$

$h°$ = CIE 1976 a,b hue-angle = $\arctan(b^*/a^*)$

ΔH^*_{ab} = CIE 1976 a,b hue-difference = $\sqrt{\Delta E^{*2} - \Delta L^{*2} - \Delta C^{*2}}$

ΔC = Chromaticity difference in a*b* plane = $\sqrt{\Delta a^{*2} + \Delta b^{*2}}$

ΔE^*_{ab} = CIE 1976 L*a*b* color difference formula = $\sqrt{\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}}$

Δ = Difference between Sample and Standard

Reference: Commission International de l'Eclairage (CIE): Recommendations on Uniform Color Spaces, Color Difference Equations, Psychometric Color Terms, Supplement No. 2 to CIE Publication No. 15, Colorimetry, Bureau Central de la CIE, Paris, 1978.

Hunter Rdab Color Scale

The relationship between the Hunter R_d,a,b values and the CIE XYZ values for any illuminant (see Tables 1 and 2) is as follows:

$$R_d = Y$$

$$a_{Rd} = K_a f(Y) \left(\frac{X}{X_n} - \frac{Y}{Y_n} \right)$$

$$b_{Rd} = K_b f(Y) \left(\frac{Y}{Y_n} - \frac{Z}{Z_n} \right)$$

where

$$f(Y) = 0.51 \frac{21 + 0.2\,Y}{1 + 0.2\,Y}$$

See Tables 1 and 2 for values of K_a, K_b, X_n, and Z_n. Y_n is always equal to 100.00.

Adams - Nickerson (AnLab)

When the instrument is equipped with this scale, the optimal feature provides a readout of AnLab values. The relationship between the Adams-Nickerson (AnLab) Scale and the CIE XYZ Scale for Illuminant C is as follows:

$$L = 9.2\,V_y$$

$$a = 40\,(V_x - V_y)$$

$$b = 16\,(V_y - V_z)$$

Where V represents the Munsell value function for which X/Xn, Y/Yn or Z/Zn = $1.2219V - 0.23111V^2 + 0.23951V^3 - 0.021009V^4 + 0.0008404V^5$.

CMC

The equation for $\Delta E_{CMC} < 1$ describes an ellipsoidal volume, with axes in the direction of lightness and chroma and hue centered about a standard. When the semi-axes lengths for the ΔE_{CMC} formula equal the calculated lSL, cSC, and SH values for the standard, the resulting ellipsoid describes a 1.0 ΔE_{CMC} unit volume/tolerance. This volume, and the size of its component parts become the basis for the establishment of an appropriately sized volume of acceptability for a given commercial situation by the application of a commercial factor (cf).

When l = 2.0 and c = 1.0, the equation fixes the ratio of the three components (SL:SC:SH:) to correlate with visible assessment of typical textile samples. Other values of l may be required in cases where the surface characteristics change dramatically. The value of c is always left at 1.0.

$$\Delta E_{CMC} = \sqrt{(\Delta L^*/lSL)^2 + (\Delta C^*/cSC)^2 + (\Delta H^*/SH)^2}$$ Absolute

$$\Delta L_{CMC} = \frac{\Delta L^*}{lSL}$$

$$\Delta C_{CMC} = \frac{\Delta C^*}{cSC}$$

$$\Delta H_{CMC} = \frac{\Delta H^*}{SH}$$

$$\Delta E_{CMC} \text{ cf (l:c)} = \frac{1}{cf} \Delta E_{CMC}$$ Normalized

$$\Delta L_{CMC} = \frac{\Delta L^*}{(cf)\, lSL}$$

$$\Delta C_{CMC} = \frac{\Delta C^*}{(cf)\, cSC}$$

$$\Delta H_{CMC} = \frac{\Delta H^*}{(cf)\, SH}$$

where

L^*, C^*, and H^* are those of the standard unless otherwise specified.

CMC ratio l:c

commercial factor cf

$$SL = \frac{0.040975L^*}{1 + 0.01765L^*}$$ for $L^* > 16$

$SL = 0.511$ for $L^* < 16$

$$SC = \frac{0.0638\, C^*}{1 + 0.0131\, C^*} + 0.638$$

$SH = (FT + 1 - F)\, SC$

$$C^* = \sqrt{\Delta a^{*2} + \Delta b^{*2}}$$

$h^\circ = \arctan (b^*/a^*)$

$\Delta L^* = L^*SMP - L^*STD$

$\Delta C^* = C^*SMP - C^*STD$

$$\Delta H^* = \sqrt{\Delta E^{*2} - \Delta L^{*2} - \Delta C^{*2}}$$

$$F = \sqrt{C^{*4}/(C^{*4} + 1900)}$$

$T = 0.36 + |0.4 \cos(35 + h)|$ for h, 164° or h > 345°

$T = 0.56 + |0.2 \cos(168 + h)|$ for 164° < h < 345°

Tolerances are:

			Absolute	Normalized
ΔL^*	= (cf) lSL	ΔL_{CMC}	= cf = 1	
ΔC^*	= (cf) cSC	ΔC_{CMC}	= cf = 1	
ΔH^*	= (cf) SH	ΔH_{CMC}	= cf = 1	
		ΔE_{CMC}	= cf	= 1

For a more detailed description of CMC, refer to *Calculation of Small Color Differences for Acceptability*, AATCC Test Method 173-1989 published in AATCC Technical Manual.

FMC-2 (Friele - MacAdam - Chickering) Color Difference

Red-green (RG) differences, yellow-blue (YB) differences, total lightness differences (DL) and total color differences (DE) between standard and sample are computed according to the Friele-MacAdam-Chickering metric (JOSA, February 1968, p.292 and August 1969, p.986).

The FMC-2 unit of color difference is based on just noticeable, or threshold, color difference data published in 1942. Friele used the data in his suggested color-difference formula, which was modified later by MacAdam, and then by Chickering. The FMC-2 Scale is a color difference scale only and was designed for Illuminant C and 2° standard observer conditions only. It has been successfully used for non-saturated colors under illuminants D_{65} and A as well as 10° standard observer conditions.

Metamerism Index

The Metamerism Index is designed to indicate the degree to which 2 samples which match under 1 illuminant no longer match under a 2nd illuminant. The metamerism index feature allows the comparison of Hunter Lab values relative to operator selectable illuminants. These values must be calculated from spectral reflectance values. The formula for deriving the index is:

$$MI = \sqrt{(\Delta L_{n1} - \Delta L_{n2})^2 + (\Delta a_{n1} - \Delta a_{n2})^2 + (\Delta b_{n1} - \Delta b_{n2})^2}$$

where n1 is the 1st illuminant and n2 is the 2nd illuminant.

Opacity Measurements

Opacity measurements determine opacity by a contrast ratio measurement. The Y value of the specimen backed by the black glass or light trap is divided by the Y value of the specimen backed by the white tile. The resulting fraction is Y% or opacity.

$$\text{Opacity} = \frac{Y_{\text{black backing}}}{Y_{\text{white backing}}}$$

Haze Measurements

A transmission haze measurement is a ratio of the diffuse light to the total light transmitted by a specimen. Useful measurements of haze can be made on the ColorQUEST sphere although the results do not conform to ASTM method D1003, because of differences in instrument geometry.

$$\text{Haze} = \frac{\text{diffuse transmittance}}{\text{total transmittance}} \times 100$$

Whiteness Index

Whiteness is associated with a region or volume in color space in which objects are recognized as white. Degree of whiteness is measured by the degree of departure of the object from a *perfect* white.

Whiteness Index per ASTM E313 (displayed as WI E313):

$$\text{WI E313} = \frac{4\,Z_{CIE}}{1.18103} - 3Y = 4\,Z\% - 3Y$$

Yellowness Index

Visually, yellowness is associated with scorching, soiling and general product degradation by light, chemical exposure and processing. Yellowness indices are used chiefly to measure these types of degradation.

Yellowness Index per ASTM Method D1925-70* (displayed as YI D1925):

$$\text{YI D1925} = \frac{100\,(1.274641506\,X - 1.057434092\,Z)}{Y}$$

*The YI formula, as shown in ASTM D1925-70, is:

$$\text{YI D1925} = \frac{100\,(1.28\,X_{CIE} - 1.06\,Z_{CIE})}{Y_{CIE}}$$

The tristimulus values of clear air (for CIE illuminant C and the 1931 CIE 2° standard observer) are X = 98.041, Y = 100.000, Z = 118.103.** The ASTM formula gives YI = 0.303 for clear air, because the factors are truncated to 3 significant figures. In order to have the yellowness index for air equal to 0.0, the constant multipliers for X_{CIE} and Z_{CIE} have been expanded slightly. Work is in progress in ASTM to revise the test method accordingly.

** Wyszecki, G. and W. S. Stiles, Color Science, John Wiley and Sons, New York, 1982 - p. 768.

Yellowness Index per ASTM Method E313 (displayed as YI E313):

$$\text{YI E313} = 100\left(1 - \frac{B}{G}\right) = 100\left(1 - \frac{0.847\,Z}{Y}\right)$$

APHA-20 mm

APHA-20 mm is designed to yield APHA values that closely correlate to APHA standard solutions as defined by ASTM D1209. APHA-20 mm is calculated from the YI D1925 yellowness index using the following equation:

$$\text{APHA}-20\text{ mm} = K1 + K2\,(\text{YI D1925}) + K3\,(\text{YI D1925})^2 + K4\,(\text{YI D1925})^3$$

The constants are defined according to the value for YI D1925.

The values for the constants along with an upper bound for each range may be specified in an ASCII file APHA20.DAT. This file may be created by the user. If the file is not created the default values given in Table 3 are used.

Table 3

Upper Bound for YI-D1925	K_1	K_2	K_3	K_4
3.0	0.000000	9.063781	0.000000	0.000000
50.0	4.369262	7.825047	0.071435	-0.000158
1000.0	4.369262	7.825047	0.071435	-0.000158

Paper Brightness - Z%

Paper brightness or Z% is used in the evaluation of the degradation of white materials. It can also be a measure of the effectiveness of bleaching.

$$Z\% = \frac{100\,Z_{CIE}}{Z_n}$$

457 nm Brightness

457 nm brightness can also be used to measure the relative brightness of paper. 457 nm brightness reports the percent reflectance at 457 nm.

Dominant Wavelength and Excitation Purity

The dominant wavelength and excitation purity chromaticity system was one of the first systems for specifying the chromaticity of objects other than by their x, y values. It not only compensates for the influence of the illuminant's chromaticity, but also improves the correlation between the numbers and visual attributes because it permits chromaticity specification in terms of hue and saturation. The system is based on the additive-color-mixing properties of the x,y diagram. A color is specified by describing how it would be matched by additively mixing the illuminant and light of some single wavelength.

Dominant wavelength is the wavelength needed for mixture with the illuminant. In general, it identifies the hue of the object's color.

Excitation purity is the percentage contribution of the dominant wavelength to the mixture. Thus, 1.00 is the purity of all spectral colors and 0 is the purity of the illuminant. Excitation purity correlates with saturation.

In order to derive dominant wavelength and excitation purity for a sample, plot the position of the illuminant C - object color combination on the CIE x,y chromaticity diagram. The dominant wavelength for sample (S) under illuminant C is found by drawing a straight line from the Illuminant C point through S to the spectrum locus, where it intersects at the dominant wavelength. Excitation purity is the percentage of the distance from illuminant C to S compared to the total distance from illuminant C to the spectrum locus.

Dominant wavelength and excitation purity are calculated for the wavelengths of 397-673 nm. These values are always calculated and displayed relative to the CIE 1931 2° standard observer and CIE illuminant C regardless of the selected illuminant and observer. For complementary wavelengths, the displayed values are 0.

For further information see *A Digital Computer Technique for Calculation of Dominant Wavelength* by Charles G. Leete and Jack R. Lytle in Color Engineering, Volume 4, No. 1 (January - February 1966).

K/S and Relative Colorant Strength

Selecting K/S + COLORANT STRENGTH in the spectral data setup screen results in K/S and colorant strength calculations in the reflectance mode and absorbance and percent dye strength in the transmittance mode.

K/S values for the product standard and sample are calculated for all wavelengths. The point of minimum reflectance or maximum absorption of the product standard is highlighted. This method of strength calculation is most accurate when the standard and sample are chemically and physically identical and differ only in depth. The sample strength should not be more than ±20% that of the standard. If the strength difference is substantially larger than 20%, prepare the sample in a new concentration so that it falls within the ±20% interval where the Kubelka-Munk relationship is more nearly linear. This calculation is valid only for reflectance measurements. As in any test procedure, the statistical benefits of averaging data of multiple measurements should be considered.

The formula for calculation of percent strength in terms of percent of standard is as follows:

$$\frac{K}{S} = \frac{[1 - 0.01\,R]^2}{2[0.01\,R]} \qquad \text{where } R = \text{reflectance}$$

$$\text{Relative Color Strength (\% of Standard)} = \frac{K/S_{\lambda\ \text{samp}}}{K/S_{\lambda\ \text{std}}} \times 100 \quad \text{where } \lambda = \text{wavelength}$$

The relative effectiveness of a batch of a given colorant for generating the desired chromaticity and depth in a given formulation is frequently termed *relative color strength* and is calculated as shown above. This evaluation of strength is based on reflectance measurements using the Kubelka-Munk relationship between the diffuse reflectance (R) of the product standard, and the ratio of spectral absorption (K) to spectral scattering (S).

Absorbance and Percent Dye Strength

Absorbance values for the product standard and the sample are calculated for all wavelengths. The point of minimum transmittance or maximum absorbance of the standard is highlighted over the wavelength range specified in the global setup.

Industries using dyes may calculate percent strength of a dye in solution, relative to a standard, as a method of quality control of incoming dyes, or as an indication of how much additional dye, if any, is needed to bring the shade of a dyeing to the required depth. Relative dyestrength in terms of percent of standard may be determined by preparing solutions of the sample and of the standard as indicated in the reference below.

For further information, refer to *A General Procedure for the Determination of Relative Dye Strength by Spectrophotometric Transmittance Measurement* by Problem Committee 25 (Dyes) of the Inter-Society Color Council (ISCC), Rolf G. Kuhni, Co-Chairman, Textile Chemist and Colorist, Vol. 4, no. 5, May 1972, p.133.

The formula for calculation of dye strength in terms of percent of standard is as follows:

$ABS = -\log_{10} T$ where ABS = absorbance and T = transmittance.

$$\text{Dye Strength (\% of standard)} = \frac{ABS_{samp}}{ABS_{std}} \times 100$$

where ABS_{samp} is absorbance of a sample and ABS_{std} is absorbance of the standard.

Optical Density

In the fields of photography and graphic arts, colorants are frequently characterized by density measurements for their light absorbing ability in specific regions of the spectrum. Neutral density values are based on equal weighting of all wavelengths. Red, green and blue density values are based on specific spectral response functions designed to measure the quantity of dye colorants in photographic and printing materials. For further information, refer to "Objectives and Methods of Density Measurements in Sensitometry of Color Films," F. C. Williams, Journal of the Optical Society of America, Vol. 40, No. 2, February 1950.

The formula for calculation of optical density values from the spectral values is as follows.

For reflectance:

$OpD = -\log_{10} R$ where OpD = reflection optical density, and R = reflectance.

The relationship between optical density and reflectance is a log-reciprocal one. Therefore, increasing density values denote increasing obstruction to reflecting or transmitting light. In this attenuating effect, the density values are the exponent of 10. Therefore, a density of 3.0 means that 1/1000 of the light has been transmitted or reflected.

B

Additional Programs

The following instructions allow you to upgrade to new SpecWare software versions, change the sensor port, and change the communication port parameters after initial installation of the system.

Upgrading To New Software Versions

To upgrade from a previous version of SpecWare software use the UPDATE function to upgrade the software while preserving data files, programs, and setups.

1. Place the first HunterLab diskette in drive A and close the drive door.

2. At the system prompt type A: UPDATE. Follow the prompts to switch diskettes. The software is updated and all previously stored information is retained.

WARNING
Use of the INSTALL feature overwrites the current data files, saved programs, and saved setups.

To upgrade from versions of ColorQUEST software prior to SpecWare:

1. Place the HunterLab supplied diskette in Drive A and close the drive door. Use diskette #2 for a 3-1/2" drive and diskette #3 for a 5-1/4" drive.

2. From the SpecWare software exit to DOS by pressing F6 and then pressing ESC.

3. From the operating system prompt type A:INSTALL. The program files will be loaded onto Drive C and new data files will be opened.

Once the software is installed on the fixed disk you may copy the data files from the original software and use the CQ_FILES program to reformat the data files into the current software file format.

1. To translate previously saved files to the format used in this software version type: A:CQ_FILES. The following menu is displayed:

Possible file operations

1	sample data files (translation)	Specified .DTA Specified.IDS
2	index files (recovery).....	Specified.DTA Specified.IDS
3	alter id label lengths.....	Specified.IDS
4	create new files (initialization)	

Select a number (1-4):

2. Selection of 1, 2, or 3 prompts for the name of the data files you wish to translate, recover, or alter. Before using the current version of software, it is necessary to translate all data files. If there is more than one set of sample data files, it is necessary to execute this program once for each set of sample data files.

   Note: Sample data files are typically reduced in size after translating. This is because sample data files no longer have a fixed size and grow dynamically up to a limit of 1000 records per file.

   Selection of 4 displays the following menu of files to create:

   Type of file to create

1	setups data files	GSETUP.DAT FSETUP.DAT
2	program data file.....	PROCFILE.DAT PROCLIST.DAT
3	sample data files.....	Specified.DTA Specified.IDS
4	all data files	

   Select a number (1-4):

Changing Communication Port

Once the software is installed the CQ_COM.EXE program can be used to change the assignment of the serial port to be used for the sensor or to change the parameters of the 2nd serial port.

1. At the system prompt type CD\CQSPEC to enter the ColorQUEST directory.

2. Type CQ_COM to execute the program. If a 2nd serial port is used you are asked if you want to change the parameters.

3. Type Y for yes to change the parameters or N for no to keep the current parameters.

4. If you select to change the parameters you are prompted to enter the baud rate, the number of data bits, the number of stop bits, and the parity.

5. The screen then displays the current sensor communications port and you are asked if you want to change it.

6. Type Y for yes to change the port or N for no to keep the current port assignment.

C

Error Messages

If any error message is displayed which is not described in this section, check the section on error messages in your DOS Manual. Contact the HunterLab Field Service Department at (703) 471-6870 if the error message cannot be found or the problem persists.

Initialization Error Messages

Can't initialize the sensor displayed when there is a communications problem between the computer and the sensor. Reseat all cables, turn off the power and then restart the system.

Can't open system data file displayed when one of the files on the disk is inaccessible. Restore the file onto the hard disk from the backup diskette.

Communications error displayed when there is a communications problem between the computer and the peripheral device. Reseat all cables, turn off the power and then restart the system.

Error: unsuccessful initialization, continue? displayed when any error occurs during the initialization sequence.

File close error, recopy master disk displayed when one of the files on the disk cannot be closed. Restore the file onto the hard disk from the backup diskette.

File not found, recopy master disk displayed when one of the files on the disk is not available. Restore the file onto the hard disk from the backup diskette.

File read error, recopy master disk displayed when one of the files on the disk cannot be read by the computer. Restore the file onto the hard disk from the backup diskette.

File tampered, recopy master disk displayed when one of the files on the disk has changed. Restore the file onto the hard disk from the backup diskette.

Incompatible system data file displayed when the setup or program file is not in the appropriate format.

Insufficient amount of data displayed when one of the user modifiable files does not contain enough items.

Invalid data type in file displayed when one of the user modifiable files contains anything that is not supposed to be there, such as a message where a data value should be.

Sensor is not connected displayed when an attempt was made to communicate with the sensor and it did not respond. Be sure the sensor is connected to the proper port, the cables are seated correctly, and restart the system.

Autocal Error Messages

Autocal: Please clear sample clamp for proper Autocal operation displayed if a sample has been left at the port when measurements are not being taken.

Autocal Warning: Please re-standardize. Drift is nearing Autocal tolerances. displayed at any detector when the sample clamp has drifted between 1% and 2% from the reflectance of the last standardization.

Autocal Warning: Re-standardize instrument. Drift exceeds Autocal tolerances. displayed when the sample clamp has drifted more than 2% at any detector from the reference of the last standardization.

Standardization Error Messages

Gray standardization was not valid - try again displayed during the standardization procedures when the values for the gray tile are significantly different from those expected.

Standardization error displayed when the white tile reading during standardization does not exceed the level set for the zero level.

White standardization was not valid - try again displayed during the standardization procedures when the values for the white tile are significantly different from those expected.

Warning: SAV lens option not installed displayed when an attempt is made to select.

Warning: UV filter option not installed displayed when an attempt is made to select UV filter in the light path when the instrument is not equipped with a UV filter.

Operating Error Messages

*** point(s) exceed scale** displayed on the spectral plot screen when any point of the graph exceeds the current scale. Rescale the plot to include all of the points or use the autoscale feature. Rescaling the plot is not possible when unlimited is selected as the number of samples to be plotted.

A/D error: saturated or zero displayed when the data returned from the sensor indicates that an error has occurred in the sensor. Use the diagnostic section to determine what the error is and correct it, if possible. If the error persists, contact the HunterLab Service Department.

Can't display all zero data displayed when exiting the entry mode and the data record has spectral values of zeros. Re-enter the values.

Can't plot a tristimulus sample displayed when an attempt was made to send a tristimulus sample record to the plotter which can only plot spectral data.

Can't plot a tristimulus standard displayed when an attempt was made to send a tristimulus standard record to the plotter which can only plot spectral data.

Can't save all zero data displayed when trying to save zero value data. Read a sample or enter the spectral values again and then save.

Can't save all zero sample displayed when trying to save a sample which has spectral or tristimulus values of zeros. Either reread the sample or enter the values from the keyboard.

Change status or use <F6> to select a mode or standardize displayed when the sensor is determined to be in a mode other than what is being attempted to be set. Be sure that the lens size, filter position, and specular port door are in the proper position.

Color differences may not be printed for tristimulus data displayed when printing tristimulus data and the illuminant or observer is not the same as those stored with the data.

Data can be displayed for hitch illuminant/observer combination only displayed when tristimulus data is requested to be displayed for an illuminant/observer other than the one for the current instrument hitch.

Data can be printed for hitch illuminant/observer combination only appears on the printout when an illuminant/observer combination other than the one hitched is enabled.

Delta descriptor may not be printed for tristimulus data displayed when printing tristimulus data and the illuminant or observer is not the same as those stored with the data.

Data record not found displayed when the selected record ID does not exist in the setup or program data file.

Delta may not be printed displayed when printing tristimulus data and the illuminant or observer is not the same as those stored with the data.

Disk error occured while writing displayed when an error occurs while writing the file translation data file. The selected output drive may be full.

Error: opening data file displayed when the setup, program, or data file cannot be opened. Recopy file onto hard disk from the backup diskette.

Error: no room left in file displayed in the setup program or data mode when there are no more records available. Delete the setup or program to make room or backup the data onto a diskette and restore the empty file onto the hard disk from the backup diskette.

Error: reading data file displayed when the setup, program, or data file cannot be read. Recopy file onto hard disk from the backup diskette.

Error: seek error accessing file displayed when the .IDS data file and the .DTA data file do not match and an attempt has been made to access a record beyond the end of the .DTA data file. Restore the last correct set of data files before continuing.

Error: writing data file displayed when a DOS error has occurred while attempting to write to the current data file. The selected drive may be full.

File name exceeds 8 characters maximum displayed when entering a name for a new data file. Press 1 to enter the name again or 2 to return to the previous screen.

Illuminant/observer does not match for tristimulus data displayed when the selected illuminant/observer combination does not match the current data records illuminant/ observer combination.

Incompatible data file set displayed when an attempt is made to access a data file set that is not compatible with the current version of the data files. Exit to DOS and upgrade the requested data file with the program CQ_FILE.EXE.

Indices may not be printed for tristimulus sample data displayed when printing tristimulus data and the stored illuminant/observer combination.

Indices may not be printed for tristimulus standard data displayed when printing tristimulus data and the stored illuminant/observer combination.

Insufficient disk space for another file set displayed when creating a new data file. Use a new floppy diskette or erase some unwanted files.

Insufficient memory available in allocation step # displayed during system initialization when additional memory that is needed was found not to be available. Be sure that the system has 540K bytes of free memory before running the CQSPEC software.

Invalid character in file name displayed when entering a name for a new data file. Press 1 to enter the name again or 2 to return to the previous screen.

Invalid character in path name displayed when entering a path for a new data file. Press 1 to enter the name again or 2 to return to the previous screen.

Invalid drive specification displayed when entering a drive specification for a new data file. Press 1 to enter the name again or 2 to return to the previous screen.

Invalid range displayed when the entered range is too narrow or is entered in the wrong direction. Correct the range values.

Invalid signal due to sensor communications error displayed when reading data and the sensor does not respond with a complete set of data. Be sure that the sensor is properly connected before continuing.

No data file available. Use <F8> to select a data file displayed when file transfer is selected, but an error occurred at system initialization indicating that the last used data files could not be found. Select a data file set to use before attempting file transfer.

No file name specified with drive and/or path displayed when entering a name for a new data file and the file name is omitted. Press 1 to enter the name again or 2 to return to the previous screen.

No format and/or data selected for file transfer displayed when an attempt is made to perform the file transfer function when an output format is not selected.

No illuminant or observer selected displayed when the current search setup does not have either an illuminant or observer selected.

No match found displayed when no record currently exists within the selected range.

No output field selected for print function displayed when none of the output fields can be printed because source data has not been selected.

No sample available for plot displayed when an attempt is made to plot the sample data to the external plotter but no data yet exists for the sample. Read or recall a sample then plot.

No sample exists for this search mode displayed when the sample register is empty. Read or recall a sample, then search.

No sample or standard data for print function displayed when no source data exists for the print function to use. Read or recall data then print.

No search method is selected displayed when the current search setup does not have a mode selected.

No search mode is selected displayed when the current search setup does not have a search method selected.

No second illuminant for MI selected displayed when the current search setup does not have 2 illuminants selected.

No standard available for plot displayed when an attempt is made to plot the standard data to the external plotter but no data yet exists for the standard. Read or recall a standard then plot.

No standard exists for this search mode displayed when the sample register is empty. Read or recall a standard, then search.

No standard, sample, or differences selected for print function displayed when no source data is selected.

No standard observer/illuminant selected displayed when haze is selected and there is no standard observer, illuminant or color scale enabled. Exit haze and return to the color setup screen to select a color scale, illuminant, and standard observer.

Off hue, 90+ degrees, inapt.msg displayed when polar descriptors are enabled and the hue angle color difference is more than 90 degrees off.

Option not installed displayed when an option is selected in a setup menu that is not available.

Path not found displayed when entering a path for a new data file. Press 1 to enter the name again or 2 to return to the previous screen or exit to DOS to create the path.

Program aborted: Data file does not exist displayed while running a program that attempts to use a data file set that does not exist. Create the data file set using the <F8> data key, then run the program again.

Program aborted: Data record for save already exists displayed when the program attempts to overwrite an existing data record. Manually erase the current records, use a different file name to save the data into the file, or change to a new data file set.

Program aborted: File switch displayed when running a program and switching data files. The program cannot continue.

Program aborted: Setup not found displayed when an error occurred running a program and switching setup files. The program cannot continue.

Program not found displayed when an attempt is made to recall a program record that does not exist in the program data file. List the available program records and recall from the available records.

Record not found displayed when the selected record ID does not exist in the setup or program data file.

Sample data is tristimulus - spectral data may not be printed displayed when printing tristimulus data and the user has selected spectral data printout for the sample.

Sample is not hitched displayed when a record is being recalled into the sample register that is not hitched to the same hitched standard as is currently being used.

Sample may not be printed displayed when printing tristimulus data and the illuminant or observer is not the same as those stored with the data.

Sensor not standardized displayed when the initialization sequence has bypassed both refusing the previous standardization or setting a new standardization.

Setup not found displayed when an attempt is made to recall a setup record that does not exist in the setup data file. List the available setup records and recall from the available records.

Standard may not be printed displayed when printing tristimulus data and the illuminant or observer is not the same as those stored with the data.

Standard is not hitched displayed when a record is being recalled into the standard register that is not hitched to the same hitch standard as is currently being used. Recalling this record changes the current hitch information.

Standardization error displayed when the white tile reading during standardization does not exceed the level set for the zero level.

Standardization time interval has elapsed. Please standardize again displayed when the time interval set in global setup has elapsed. You may override the message with another keystroke.

Unable to initialize plotter displayed when an attempt is made to set the initialization parameters needed on the plotter and it does not respond. Be sure the plotter is connected, turned on, set to the correct baud rate, parity, data bits, and stop bits before continuing.

Warning: both K/S and optical density can't be selected at the same time displayed in the setup screen when the user selects both K/S and optical density.

Warning: Do you want to select spectral data (resolution) for the indices selected displayed when attempting to leave a setup screen with a spectral data index selected but no spectral data resolution selected in the same setup screen.

Warning: do you wish to display sample or standard plot displayed when none of the available plot modes have been selected in the spectral plot setup screen.

Warning: do you wish to print sample, standard, or differences? 1 yes 2 no displayed in the print setup screen when sample, standard, or difference are not enabled.

Warning: do you wish to send sample, standard, or differences? 1 yes 2 no displayed in the send setup screen when sample, standard, or differences are not enabled.

Warning: do you wish to display sample, standard, or differences? 1 yes 2 no displayed in the color setup screen when sample, standard, or difference are not enabled.

Warning: message file wrong or corrupted displayed when information is missing from the message files. Reload the message files from diskette before continuing.

Warning: this option is not included displayed when the user selects an option that is not installed on the instrument.

Warning: too many items selected - please re-select displayed when the user selects more items than allowed in a setup screen.

Warning: validate statistics for scales, diff or illuminants? 1 yes, 2 no displayed in the print setup when there is no scale, color difference or illuminant enabled.

Warning: Do you wish to display sample or standard plot displayed when none of the available plot modes have been selected in the spectral plot setup screen.

Warning: Do you want to select spectral data (resolution) for the indices selected displayed when attempting to leave a setup screen with a spectral data index selected but no spectral data resolution selected in the same setup screen.

Wavelength out of range, please re-enter displayed when in the spectral data setup screen and an invalid wavelength range is entered.

D

Instrument Replacement and Repair

The following is described in this section:

- Warranty
- Claims
- Returns
- Service

Warranty

HunterLab warrants that all instruments manufactured will be free from defects in material and workmanship under normal use and service. Our obligation under this warranty is limited to repairing or replacing any defective parts which our examination discloses to have been factory defective when returned to us by prepaid transportation. The time limit on this warranty is 1 year from date of shipment of new instruments and 2 months from the date of shipment of repaired instruments. The printer and IBM computer are covered under this warranty for a period of 90 days for the IBM-XT or one year for the IBM-AT or System 2 computers.

A Warranty Registration Card is shipped with major pieces of HunterLab equipment. It is important that you return this card promptly upon receipt of equipment. The Registration Card is kept on file with the HunterLab Service Department with complete information on the exact equipment purchased. Questions concerning operation, maintenance or repair of your equipment directed to the Service Department can then be knowledgeably handled. Before calling HunterLab please confirm the Model and Serial Number of your instrument. HunterLab Warranty does not cover expendable items such as lamps, fuses, batteries, diskettes, etc.

The Warranty is void if the user has made unauthorized repairs, improper installation, or improper use of the instrument.

Claims

All materials are sold F.O.B. Reston, Virginia (unless otherwise specified) and HunterLab responsibility ends upon delivery to first carrier. All claims for loss or damage must be rendered by the consignee against the carrier within 15 days of receipt of goods. A copy of this notice must also be forwarded to HunterLab within 5 days of its receipt.

Breakage or Damage

Freight or Express

According to the contract terms and conditions of the carrier, the responsibility of the shipper ends at the time and place of shipment. The carrier then assumes full responsibility.

1. Notify your local carrier.

2. Hold damaged goods with container and packing for inspection by the examining agent. Do not return any goods to this office prior to inspection and authorization of carrier.

3. File claim against carrier. Substantiate claim by examining agent's report. Certified copy of our invoice is available upon request. Original B/L is attached to our original invoice. If the shipment is prepaid, write for receipted transportation bill.

4. Advise HunterLab regarding replacement.

Parcel Post Shipment

1. Notify HunterLab at once in writing, giving details of the loss or damage. This information is required for filing a claim.

2. Hold damaged goods with container and packing for possible inspection by postal authorities.

3. Advise HunterLab regarding replacement.

United Parcel Service

1. Contact local UPS office regarding damage and insurance claim. Each UPS office has a different method of handling these occurrences and will advise you of procedure.

2. Retain container and packing.

3. Notify HunterLab at once for replacement.

Shortage

1. Check packing list notations. The apparent shortage may be a back ordered item and may be marked as intentional short-shipped.

2. Re-inspect container and packing material, particularly for the smaller items.

3. Ascertain that the item was not removed by unauthorized personnel prior to complete unpacking and checking.

4. Notify HunterLab immediately of shortage in writing.

Incorrect Shipment

1. If material received does not correspond with your order, notify HunterLab immediately referencing order number and item.

2. Hold incorrect items until return shipping instructions are received.

Returns

Do not return any damaged or incorrect items until all shipping instructions are received.

Note: Unless the above procedures are followed and HunterLab is notified within 15 days, we cannot accept responsibility.

Instruments may also be returned to a HunterLab service facility for repair. To facilitate scheduling and efficient repair, authorization should be obtained from HunterLab Service Department before equipment is returned. A purchase order or letter giving essential information on the instrument involved and the way it is malfunctioning should be enclosed with the instrument or sent under separate cover to the service facility nearest your location.

Customer is liable for incoming and outgoing freight charges for instruments being returned to HunterLab for all repairs including warranty.

CAUTION

Sample clamp must be removed from the reflectance port before return shipment. Failure to do so may cause damage to the instrument.

Service

HunterLab offers complete repair service for all instruments it manufactures. Call HunterLab for the service facility nearest your location. If your equipment is not functioning properly, contact the closest HunterLab Service Department for maintenance or repair instructions. In many instances this on-the-spot diagnosis is all that is required.

If repair is required, HunterLab offers two means of servicing. Instruments may be returned to a HunterLab service facility for repair or a HunterLab Service Department technician can come to your location for on-site repair. For schedule and terms for on-site repairs by trained service technicians, call the HunterLab Service Department.

Glossary

Absolute Reflectance Value: reflectance value relative to the perfectly reflecting and perfectly diffusing surface as 1.0.

Absorption: process by which light or other electromagnetic radiation is converted into heat or other radiation when incident on or passing through material.

Accuracy: conformity of a measured result to an accepted reference value or scale.

Achromatic Color: a neutral color, such as white, gray or black, that has no hue also termed nonchromatic.

Angle of Incidence: the angle between the axis of an impinging light beam and perpendicular to the specimen surface.

Angle of View: the angle between axis of observation and perpendicular to specimen surface.

Attribute: distinguishing characteristic of a sensation, perception or mode of appearance, distinction is made between chromatic and geometric appearance attributes.

Brightness: the attribute of visual sensation by which an observer is aware of differences in luminance.

Calibration: the graphic or mathematical relationship of a desired property to an instrument output.

Chromatic: perceived as having a hue - not white, gray or black.

Chromatic Attributes: those attributes associated with the spectral distribution of light, hue, and saturation.

Chromaticity: that part of a color specification which does not involve luminance.

CIE, Commission Internationale de l'Eclairage: in English, the International Commission on Illumination: the main international organization concerned with color and color measurement.

CIE Chromaticity Coordinates (Trichromatic Coefficients): the ratios of each of the tristimulus values of a color to the sum of the tristimulus values. In the CIE system they are designated by x, y and z.

CIE Luminosity Function: a plot of the relative magnitude of the visual response as a function of wavelength from about 380 to 770 nm, adopted by CIE in 1924.

CIE 1976 L*a*b* Color Space: a uniform-color space utilizing an Adams-Nickerson cube root formula, suggested in 1974 for adoption by the CIE in 1976 for use in measurement of small color differences.

CIE Standard Observer: a hypothetical observer having the tristimulus color-mixture data recommended in 1931 by the CIE for a 2° field of vision (x, y, z or x_2,y_2,z_2). A supplementary observer for a larger 10° field (x_{10}, y_{10}, z_{10}) was adopted in 1964.

CIE Tristimulus Values: the amounts of the three reference or matching stimuli required to give a match, with the color stimulus considered, in a given trichromatic system.

Clarity: the characteristic of a transparent material whereby distinct images may be observed through it.

CMC: color difference based on the CIELAB color scale which can automatically generate tolerances for perceptible or acceptable differences.

Color Perceived: the visual sensation produced by light of different wavelengths throughout the visible region of the spectrum. By such perception an observer may distinguish differences between two objects of the same size, shape and structure.

Color Attribute: a three dimensional characteristic of the appearance of an object, light source or aperture. One dimension usually defines the lightness, and the other two together define the chromaticity.

Color Constancy: substantial invariance of object-color perceptions in the presence of changes in illumination or viewing conditions.

Color Difference: the magnitude and character of the difference between two object colors under specified conditions.

Colorimeter: instrument which senses tristimulus values and converts them to chromaticity components of color.

Color Measurement Scale: a system of specifying numerically the perceived attributes of color.

Color Specifications: tristimulus values, chromaticity coordinates and luminance value, or other color-scale values, used to designate a color numerically in a specified color system.

Contrast Ratio: a measure of opacity. The ratio of the luminous reflectance of a specimen backed with black material of specified reflectance to reflectance of same specimen backed with white material of specified reflectance.

Delta Descriptors: words which describe measured color difference. Both the color setup menu and the print setup menu have fields that permit the selection of output of the delta descriptors. The descriptors are most valid for small color differences and a message will be displayed when the measured differences exceed a predetermined level.

Diffuse Reflection: process by which incident light is redirected over a range of angles from the surface on which it is incident.

Diffuse Transmission: process by which incident light, while being transmitted through an object, is redirected or scattered over a range of angles.

Haze: the scattering of light within or at the surface of a nearly clear specimen, responsible for cloudy appearance seen by transmission.

Hitch Standards: standards close in color to the specimens being measured, same as transfer standards.

Hue: the attribute of color perception by means of which an object is judged to be red, yellow, green, blue or purple.

Hunter L,a,b Scales: a uniform color scale devised by Hunter in 1958 for use in a color difference meter, based on Hering's opponent-colors theory of vision.

Illuminant: a table of spectral distribution as close to that of the natural light source, usually daylight, to be duplicated.

Instrument Standards: secondary standards which are only used with a particular instrument for maintaining the calibration of the instrument.

Light: electromagnetic radiation in the spectral range detectable by the normal human eye approximately 380 to 780 nm.

Lightness: perception of which white objects are distinguished from gray objects and light from dark color objects.

Light Source: that element in an instrument or in the visual observing situation that furnishes radiant energy in the form of light.

Metamerism: the phenomenon whereby colors of specimens match when illuminated by light of one spectral composition despite differences in spectral reflectance of the specimens, and that consequently may not match in light of some other spectral composition.

Metamerism Index: a measure of the degree of metamerism. A general index of metamerism is derived from 2 metameric spectral distribution curves without regard to the illuminant. A special index of metamerism is specified to 2 different illuminants.

Munsell Color System: the Munsell color identification of a specimen by its Munsell hue, value, and chroma as visually estimated by comparison with the Munsell Book of Color.

Nanometer (nm): unit of length equal to 10^{-9} meter.

Object Color: the aspect of the appearance of an object dependent upon the spectral composition of the incident light, the spectral reflectance or transmittance of the object, and the spectral response of an observer.

Observing Conditions: the geometric and spectral conditions of illuminating and viewing a specimen for visual or instrumental evaluation. In visual observations, the conditions include the surroundings and the state of adaption of the observer.

Opacity: the degree to which a sheet or film obscures a pattern beneath it.

Opponent-Colors System: a color system based on Hering's opponent-colors theory which states that there are six independent color dimensions which are perceived by three opponent color systems: black-white, red-green, and yellow-blue.

Perception: the combination of different sensations and the utilization of past experience in recognizing the objects from which the stimulation comes.

Perfect Diffuse Reflector: an ideal uniform diffuser with zero absorbance and zero transmittance.

Perfect Diffuse Transmitter: an ideal uniform diffuser with zero absorbance and zero reflectance.

Polychromator: a device for isolating narrow portions of the spectrum by dispersing light into its component wavelengths.

Precision: the degree of agreement of repeated measurements of the same property.

Primary Light: any one of three lights in terms of which a color is specified by giving the amounts required to duplicate it by additive combination.

Primary Standard: a standard whose calibration is determined by the measurement of parameters usually different from the parameter for which it will be used as a standard.

Regular Transmittance: process by which incident light is transmitted through an object in a rectilinear, straight-through manner, without diffusion.

Reflectance: the ratio of reflected to incident radiation.

Reflection: process by which incident light leaves a surface or medium from the side on which it is incident.

Refraction: the bending of light rays as they pass from one medium into another having a different index of refraction.

Repeatability: the degree to which a single instrument gives the same reading on the same specimen.

Reproducibility: the agreement attainable between measurements performed in different laboratories.

Restandardize: to set the top of the standardization scale only.

Saturation: the attribute of color perception that expresses the degree of departure from the gray of the same lightness.

Scattering: the process by which light passing through granular, fibrous or rough surface matter is redirected throughout a range of angles.

Secondary Standards: all standards other than primary standards.

Shade Sorting: the grouping together of similarly colored materials so that the materials within each group may be used together in a finished product.

Spectrocolorimeter: visible spectrum sensing full scanning or abridged spectrophotometers with either integral microprocessors or personal computers programmed to perform tristimulus integrations; normally with a broad bandpass of 10 to 20 nanometers.

Spectrophotometer: an instrument used for measuring the transmittance and reflectance of specimens as a function of wavelength.

Spectrum: spatial arrangement of electromagnetic energy in order of wavelength. For visible radiation, the spectrum is a band of color produced by breaking white light into its component colors.

Specular: having the qualities of a speculum or mirror; having a smooth reflecting surface.

Specular Reflectance: process by which incident light is redirected at the specular angle, as from a mirror, without diffusion.

Standard: a reference against which instrumental measurements are made.

Standardization: process by which a given method, procedure or protocol is made to conform to prescribed conditions. Standardization can only follow calibration.

Tolerance: Limits that determine how far a sample can deviate from a standard. Tolerances can be set for each color difference and index difference.

Total Reflection: diffuse plus specular reflection.

Total Transmission: diffuse plus regular transmission.

Transfer Standards: standards close to the color of the specimens being measured, same as hitch standards.

Translucency: the property of a material by which a major portion of the transmitted light undergoes scattering.

Transmission: process by which incident light is transmitted through an object.

Transparency: the property of a material by which a negligible portion of the transmitted light undergoes scattering.

Uniform Color Scale: a color scale or color solid in which the differences between points correspond to the perceptual visual differences between the colors represented by these points.

Wavelength: the distance, measured along the line of propagation, between two points that are in phase or on adjacent waves. Wavelength distribution determines the color of light. Wavelengths of visible light range from about 400 to about 700 nanometers.

F

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