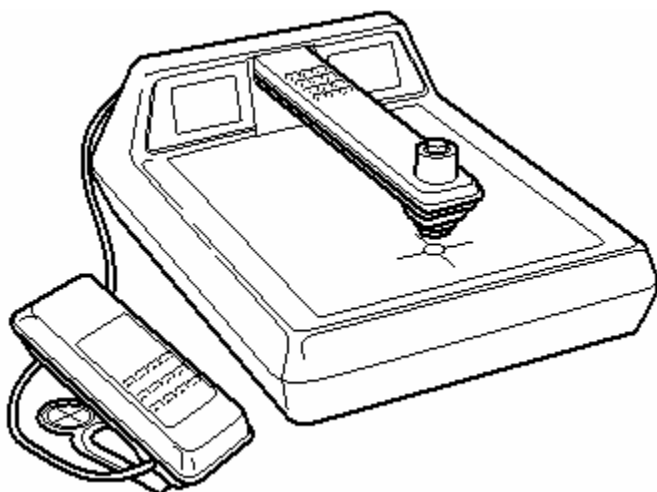# 310
Color Transmission Densitometer

Operator Manual

For **310T** Color Transmission Densitometer and
310TR Color Transmission/Reflection Densitometer

Dear Customer:

Congratulations! We at X-Rite, Incorporated are proud to present you with your X-Rite 310 Transmission/Reflection Densitometer. This instrument represents the very latest in microprocessors, integrated circuits, and display technology. As a result, your 310 is a rugged and reliable instrument whose performance and design exhibit the qualities of a finely engineered laboratory instrument.

To fully appreciate and protect your investment, we suggest that you take several minutes to read this manual. As always, X-Rite stands behind your 310 Instrument with a full one-year limited warranty and a dedicated service organization. If the need arises, please do not hesitate to call on us.

Thank you for your trust and confidence.

X-Rite, Incorporated

NOTE: Shielded interface cables must be used in order to maintain compliance with the desired FCC and European emission requirements.

CAUTION: To prevent electrical shock. DO NOT remove cover. No user serviceable parts inside. Refer servicing to qualified service personnel.

ADVERTENCIA: Para evitar un choque eléctrico, NO QUITE el recubrimiento del aparato. No hay ninguno componente reparable de usuario, dentro del aparato. Consulte un técnico calificado para servicio o arreglo.

AVVERTIMENTO: Per evitare una scossa elettrica, non staccare la coperta del apparecchio. C'è nessuno componenti riparabili d'utente, interno del apparecchio. Consultare un tecnico qualificato per servizio o manutenzione.

VORSICHT: Diese Abdeckung darf nicht entfernt werden. Sie schützt vor elektrischem Schock. Sie deckt auch keine vom Benutzer zu wartenden Teile ab. Mit notwendigen Wartungen wenden Sie sich bitte nur an autorisiertes Fachpersonal.

ATTENTION: Pour prévenir un choc électrique, ne pas enlever le couvercle. Aucune pièce se trouvant á l'intérieur n'est réparable par l'utilisateur. Toute réparation doit être adressée à du personnel compétent.

CAUTION: For continued protection against risk of fire, replace only with same type Time Delay fuse.

ADVERTENCIA: Para evitar el peligro de incendio en el caso de funcionamiento defectuoso del fusible de retrasar, es preciso reemplazarlo con un fusible del mismo tipo

AVVERTIMENTO: Per evitare il pericolo di un incendio nel caso di funzionamento difettoso del fusibile di ritardare, rimpiazzarlo solamente con un fusibile dello stesso tipo.

VORSICHT: Für fortgesetzten Schutz gegen Feuer, ersetzen Sie die Verzögerungssicherung nur mit einer vom gleichen Typ.

ATTENTION: Pour éviter les risques d'incendie, ne remplacer le fusible à retard qu'avec un fusible du même type.

CE DECLARATION

Manufacturer's Name:	X-Rite, Incorporated
Manufacturer's Address:	3100 44th Street, S.W.
	U.S.A.
Model Name:	Densitometer
Model No.:	310
Directive(s) Conformance:	EMC 89/336/EEC LVD 73/23/EEC

As of August 13, 2005, X-Rite products meet the European Union – Waste Electrical and Electronic Equipment (WEEE) directive. Please refer to www.xrite.com for more information on X-Rite's compliance with the WEEE directive.

Limited Warranty

X-Rite, Incorporated warrants each instrument manufactured by them to be free of defects in materials and workmanship for a period of 12 months. THERE ARE NO WARRANTIES OF MECHANTABILITY OR FITNESS. THIS WARRANTY OBLIGATION IS LIMITED TO SERVICING THE UNIT RETURNED TO THE FACTORY FOR THAT PURPOSE AND EXCLUDES THE TUNGSTEN-HALOGEN LAMPS. The instrument shall be returned with transportation charges prepaid. If the fault has been caused by misuse or abnormal conditions of operation, repair will be billed at a nominal cost. If requested, an estimate will be submitted before non warranty work is started.

An Instrument Registration Card is enclosed with each instrument. The purchaser should fill in the card completely and return it to X-Rite postmarked no later than 10 days form the date of receipt. This card registers your instrument with us for warranty coverage. Once your instrument is registered we are able to maintain a file to help expedite service in case it is needed. Always include serial number and place of purchase in any correspondence concerning your instrument. The serial number is located at the rear of the instrument.

X-Rite, Incorporated offers a repair program for instruments our of warranty. For more information, contact X-Rite Technical Services Department.

This agreement shall be interpreted in accordance with the laws of the State of Michigan and jurisdiction and venue shall lie within the courts of Michigan as selected by X-Rite, Incorporated.

Proprietary Notice

The information contained in this manual is derived from patent and proprietary data from X-Rite, Incorporated. This manual has been prepared solely for the purpose of assisting operation and maintenance personnel in their use of the X-Rite 310 Instrument.

Publication of this information does not imply any rights to reproduce it or use it for any purpose other than installing, operating, or maintaining the equipment described herein.

This instrument is covered by the following U.S. and foreign patents: U.S. Patent #4.080.075 and other patents pending.

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Getting Started

This chapter contains the introductory information and setup procedures you'll need to get your 310 powered up and ready to use.

Chapter Contents

INTRODUCING THE X-RITE 310

When we designed the 310, we took a close look at the needs of the photofinishing industry. Then, we applied years of experience in densitometry to develop this sophisticated color transmission/reflection densitometer.

Simple, Quick Process Control Readings

The X-Rite 310 simplifies your process control readings, allowing you to take an accurate series of readings in less than a minute. Two technological features make this possible:

- **Electronic Filter Selection (EFS).** Our unique optical design enables you to *electronically*—not *manually*—switch from one color channel to another. This feature also allows the instrument to read and display the values for all colors: visual, red, green, and blue.
- **Automatic color measurement.** The instrument automatically recognizes and measures only the *dominant* color that is being read. When you move from one reading to the next, the 310 automatically responds to color changes.

EFS and auto color measurement deliver the performance advantages you need to quickly plot the numbers used to monitor your color print processor control strips.

Additional Features

- Instrument also reads density differences, enhancing its automatic color measurement capabilities.
- Off-easel negative evaluation capability gives you the color balance needed to produce quality prints from a wide range of negatives.
- The 310 includes five memories for storing commonly used target densities. Access to these standard color values is fast and convenient.
- The 310 can interface with computerized photofinishing systems such as the Kodak® TECHNET® system. It can also interface with a dot matrix printer.
- Allows nulling (zeroing) on a standard, base density, or other measurement while measuring density or density x 10.
- Allows simple keyboard selection of Status A or Status M response for transmission densitometry.
- Calibration method is extremely simple. Calibrations for each status are stored in memory.
- The superior optical design minimizes dust and dirt to reduce errors and increase sensitivity and accuracy.
- The instrument has a quick warm-up time of just two minutes.

UNPACKING INSTRUCTIONS

When you remove your instrument from its shipping carton, you should inspect for any damage. If damage is evident, contact your carrier's agent and *do nothing more* until the agent has inspected the damage.

If damage is not evident, check to ensure that the following items are included:

1. X-Rite 310 Operator Manual
2. Registration Card
3. X-Rite 310 Color Transmission Densitometer (P/N 310T); or X-Rite 310 Color Transmission/Reflection Densitometer (P/N 310TR)
4. Calibration Step Tablet (P/N 319-68)
5. Spare Tungsten-Halogen Lamp Assembly (P/N 310-60)
6. Three Apertures—1mm (P/N 319-01), 2mm (P/N 319-40-02), and 3mm (P/N 319-40-03)

If your ordered a 310 Color Transmission/Reflection Densitometer (P/N 310TR), the following items are also included:

7. Reflection Head (P/N 310-06)
8. Calibration Check Plaque (P/N 302-12)
9. Spare Tungsten-Halogen Lamp Assembly (P/N 302-33)

Your X-Rite 310 was packaged and shipped in a specially-designed carton to protect the instrument from damage. If you need to ship the instrument back to X-Rite, Incorporated, *use the original carton*. If the original carton is not available, X-Rite can ship a replacement to you.

A padded carrying case for your 310 is available from X-Rite. It provides the safest possible storage for your instrument, and also makes it easily portable. To order, specify part number 319-91.

INSTRUMENT VOCABULARY

310 TRANSMISSION DENSITOMETER

Keyboard

Display Panel

Reading Head Arm

Read Button

Light Table

REFLECTION HEAD ASSEMBLY (310TR ONLY)

Reflection Head

Target Window

Keyboard

Target Window with Aperture
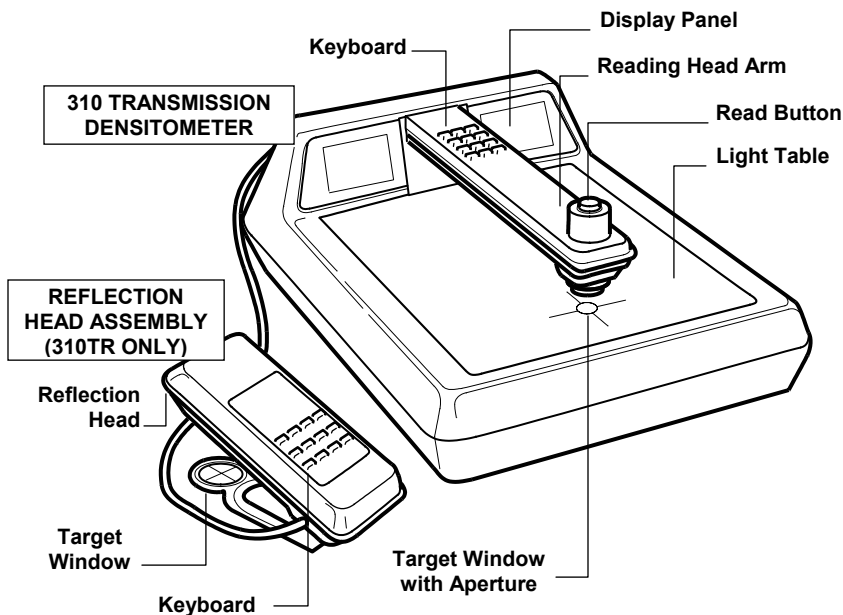
The 310 Transmission Densitometer

The 310 Transmission Densitometer provides a Light Table platform for backlighting transmissive measurement targets such as film and transparencies. The Reading Head Arm that extends over the Light Table features the Keyboard and the Reading Head.

The Keyboard is used to activate different functions and modes, and to enter numerical data. Keyboard selections and measurement data are indicated on the Display Panel.

The Reflection Head Assembly (310TR Only)

The Reflection Head Assembly is provided with 310TR models for measurement of reflective targets. It is a hand-held instrument that attaches to the main Transmission unit via interface cable.

Measurements are taken by centering the Target Window over the target, then pressing the Reflection Head down onto the Target Window. The Reflection Head has its own Keyboard. Reflection Head Assembly Keyboard selections and measurement data are indicated on the Transmission unit's Display Panel.

SETUP AND POWER

To set up your 310, you simply select and install the desired aperture, then plug the instrument in and turn its power on. If you have the Transmission/Reflection unit, you must also connect the Reflection Head Assembly before powering up.

Installing the Aperture

You can select an aperture (measuring area) of 1mm, 2mm, or 3mm. All three sizes are supplied with your 310. If you are unsure which size is best for your application, use the 3mm aperture; it provides the best results for averaging film measurements.

To install the aperture:

1. Insert the selected aperture into the Light Table opening at the Target Window crosshairs. Press the aperture completely down into place.
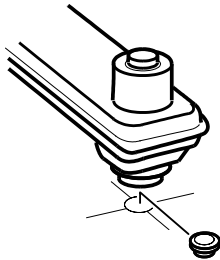
Installing the Reflection Head (310TR Only)

The Reflection Head assembly included with models 310TR must be connected to the main 310 Transmission Densitometer assembly.

To install the Reflection Head:

1. Plug the Reflection Head assembly cable end into the 15-Circuit D Connector—labeled **REFL. HEAD**—in the Transmission Densitometer assembly back panel.
2. Press the cable end into the connector firmly, then tighten the two cable end screws into the connector standoffs to secure the connection.

Turning On Power

Your X-Rite 310 operates using a standard ground power source.

To apply power:

1. Plug female end of the Line Cord into the receptacle labeled **POWER INPUT** in the unit's back panel.
2. Plug the male end of the Line Cord into a 3-wire grounded receptacle.
3. Click the **POWER** switch at the left end of the back panel. The Light Table automatically illuminates when unit power is turned on.
4. Allow the 310 to warm up for about 2 minutes before using.

INSTRUMENT SPECIFICATIONS

Reflection Specifications

Conforms to ANSI PH 2.17

Response:

Visual:...	X-Rite Visual
Red (Cyan):	Status A
Green (Magenta):.............................	Status A
Blue (Yellow)	Status A

Measuring Range:.................................. 0.0D - 2.5D

Accuracy:.. ±.02D from 0-2.5D

Repeatability: .... ±.01D

Zero Stability: .... ±.01D max. per 8 hours

Scale Factor (Slope) Stability:............... ±1% max. per 6 months

Measuring Area: .... 4.67mm (3/16 in.)

Warm Up Time:.................................... 1 minute

Time Accuracy: .... ±30 seconds per month typical

Transmission Specifications

Conforms to ANSI PH 2.19

Response:

Visual:...	X-Rite Visual
Red (Cyan):......................................	Status A/M
Green (Magenta):..............................	Status A/M
Blue (Yellow):	Status A/M

Measuring Range:.................................. 0.00D - >4.0D

Accuracy:

w/3mm aperture	±.02D from 0-3.7D, ±1% to 4D
w/2mm aperture	±.02D from 0-3.4D
w/1mm aperture	±.02D from 0-3.0D

Repeatability: .... ±.01D

Zero Stability: .... ±.02D max. per 8 hours

Scale Factor Stability: .... ±1% max. per 6 months

Measuring Area: .... 1mm, 2mm, or 3mm

Warm Up Time: .... 2 minutes

Time Accuracy: .... ±30 seconds per month typical

Safety .... UL 3101-01
C22.2, No. 1010-1-92

Altitude 2000m

IEC 664 .... Pollution Degree 2

Installation Type .... Category 2

Usage .... Indoor Only

FCC.. Part 15, Class A, Digital Device

Industry Canada .... ICES-03 Issue 2, Revision 1

International   EN50081-1:1992 Class B
Generic Emission Standard
EN50082-1:1992 Generic
Immunity Standard

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Using the 310

This chapter first helps you become familiar with your instrument by defining some of the technical terms used throughout the manual. Then, a vocabulary overview of the instrument keyboards, reading heads, and displays is provided.

Next, this chapter covers the 310's main features and functions, including Calibration; Null procedures; and Density, Range, and Color Balance measurement.

Chapter Contents

DEFINITIONS OF TERMS

Absolute Color Balance Allows the density of each primary color to be expressed as a *difference* value—the difference between that color density and the *highest* of the three primary color densities.

Absolute Density Absolute density measurements are computed based on calibrations made to the X-Rite calibration standard, or some other calibration reference.

Absolute Range Determines the difference between the lowest and highest densities measured. The **MN/MX** function allows you to alternately view the minimum or maximum density measurement.

Auto Color This function automatically recognizes the *primary* color being read, and then displays the precise density measurement without having to determine which color key to press.

Color Balance Difference Subtracts *target densities* from the sample before computing color balance.

D x 10 Provides density measurement with an extra digit of resolution (three digits to the right of the decimal point instead of two).

Density Difference Allows you to null (zero) on a base material or standard (for example, negatives or transparencies), and then have that value subtracted out of the density measurement.

Memory Provides five different Display Memory locations and Null Value Locations for Density, D x 10, and Color Balance.

Quick Zero A quick procedure that reestablishes the zero ("Cal-Lo") value for the instrument without repeating the entire calibration procedure.

Range Difference Allows a stored null value to be subtracted from range measurements. This is useful in determining the plus/minus variation of the measured range as compared to a standard.

Status A/M (Transmission only.) The 310 can be set at Status A response or Status M response. By simply pressing a key—and without mechanically changing optics—Status can be switched between the two.

NOTE: Range Difference and Quick Zero are available in 310 Instruments with a software date code of 3414 or greater. To check the date code press **F**, **MODE**, **9**, **9**, **CAL-SET** on the Reading Head Arm Keyboard. The date code appears if your unit has this feature. To exit date code press **CAL-SET** again.

KEYBOARD VOCABULARY

Your 310's functions are controlled via the Keyboard on the Reading Head Arm. The Reflection Head Assembly (Model 310TR only) also has a Keyboard. Each has twelve keys: The 310 Transmission Densitometer Keyboard has three rows of four keys; the Reflection Head Assembly has four rows of three keys. Some key labels and functions are common between the two Keyboards, while other buttons control slightly different functions.

Using the F (Function) Key

Some keys have two different functions. These keys have one function listed above the key and the other listed below the key. When you power up your unit, the functions listed above these keys are active. On both units, pressing the **F** (function) key activates the functions listed below the keys. Pressing F again re-activates the top functions, and so forth.

For example, the **CAL-SET** function shares a key with the **TIME** function. To use the **TIME** function, you would simply press this key. To use the **CAL-SET** function, Press **F**, then the key. This manual will simply refer to the relevant key function. It would instruct to "Press **TIME**"; or "Press **F**, then **CAL-SET**."

Using the Keyboard to Enter Numeric Values

Also, on both units some keys are numbered. These keys allow you to use the keypad for manually entering the numeric values. When you activate a function that requires you to manually enter numeric values, the keyboard automatically switches to numerical format.
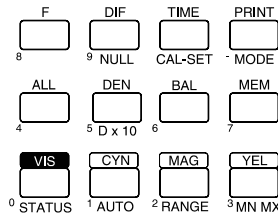
310 Transmission Densitometer Keyboard
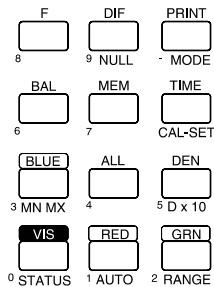
Key Pressed	Function
F (Function)	Toggles key functions between those listed *above* the keys to those listed *below* the keys.
DIF (Difference)	Indicates the difference between a stored reference value and a new measurement.
NULL	Zeroes the instrument to allow Difference comparisons.
PRINT	Sends out displayed information via the I/O Port.
-(Minus)/**MODE**	Activates special purpose functions. The Minus function is used to enter negative values for calibration and manual entry of standard procedures.
BAL (Balance)	Activates the color balance function.
MEM (Memory)	Changes memory locations sequentially from location M1 through location M5.
TIME	Displays the time and date in the Display Panel.
CAL-SET	Used for calibrating Density and Time. Also used for entering numeric values via the keyboard for Difference measurements.
BLUE	Activates the Blue measurement channel.
MN/MX	Displays the minimum or maximum density measurement used to determine range.
ALL	Activates the Visual, Red, Green, and Blue measurement channels simultaneously.
DEN (Density)	Activates the density channel, allowing density measurement.
D x 10	Activates extra digit of resolution for density channel.
VIS (Visual)	Activates the Visual measurement channel.
STATUS	Selects Status A or Status M measurement response.
RED	Activates the Red measurement channel.
AUTO	Automatically determines the primary color being read.
GRN (Green)	Activates the Green measurement channel.
RANGE	Calculates the difference between the lowest and highest density measurements.

Reflection Head Assembly Keyboard

| Key Pressed	Function
F (Function)	Toggles key functions between those listed *above* the keys to those listed *below* the keys.
DIF (Difference)	Indicates the difference between a stored reference value and a new measurement.
NULL	Zeroes the instrument to allow Difference comparisons.
TIME	Displays the time and date in the Display Panel.
CAL-SET	Used for calibrating Density and Time. Also used for entering numeric values via the keyboard for Difference measurements.
PRINT	Sends out displayed information via the I/O Port.
-(Minus)/**MODE**	Activates special purpose functions. The Minus function is used to enter negative values for calibration and manual entry of standard procedures.
ALL	Activates the Visual, Cyan, Magenta, and Yellow measurement channels simultaneously.
DEN (Density)	Activates the density channel, allowing density measurement.
D x 10	Activates extra digit of resolution for density channel.
BAL (Balance)	Activates the color balance function.
MEM (Memory)	Changes memory locations sequentially from location M1 through location M5.
VIS (Visual)	Activates the Visual measurement channel.
CYN (Cyan)	Activates the Cyan measurement channel.
AUTO	Automatically determines the primary color being read.
MAG (Magenta)	Activates the Magenta measurement channel.
RANGE	Calculates the difference between the lowest and highest density measurements.
YEL (Yellow)	Activates the Yellow measurement channel.
MN/MX	Displays the minimum or maximum density measurement used to determine range.

READING HEADS

The instrument Keyboards are used to activate measurement functions and enter measurement values; however, *actual measurements* are performed using the Reading Head and Read Button on the Reading Head Arm; and the Reflection Head on the Reflection Head Assembly.

To take a Transmission measurement reading, center the target over the Aperture, using the crosshairs as guides. Next, press the Reading Head down onto the target. *Make sure that the target area is completely covered by the seal and opal glass at the end of the reading head.* Depending on the type of measurement you are taking, you will press and hold the Read Button for brief a period of time to transmit the measurement reading.

Seal and Opal Glass
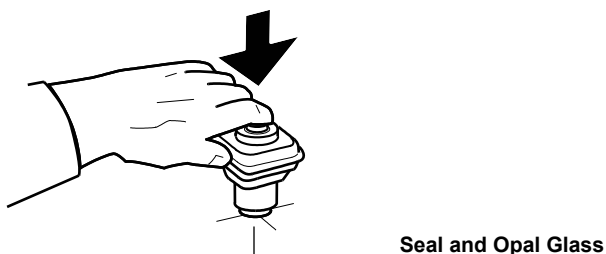
To take a Reflection measurement reading, carefully center the target under the Target Window, using the crosshairs as guides. Note that the Target Window is designed to be slightly larger than the actual area measured to minimize dust errors.

Next, press and close the Reflection Head down onto the Target Window. Depending on the type of measurement you are taking, you will hold the unit closed for a brief period of time to transmit the measurement reading.
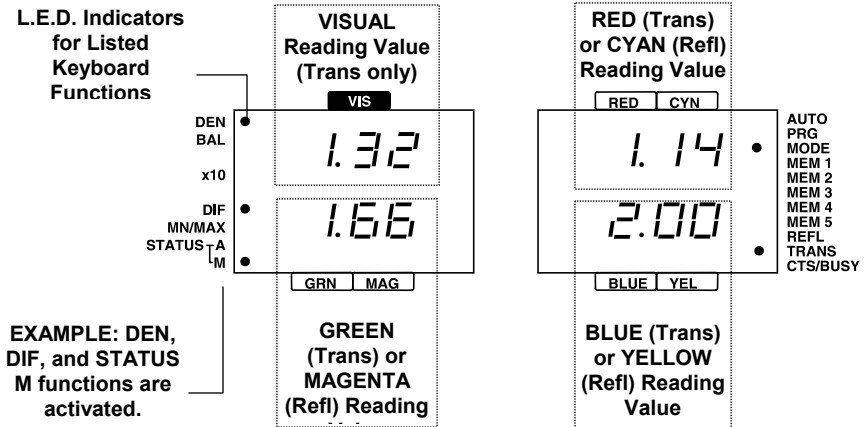

Target Window
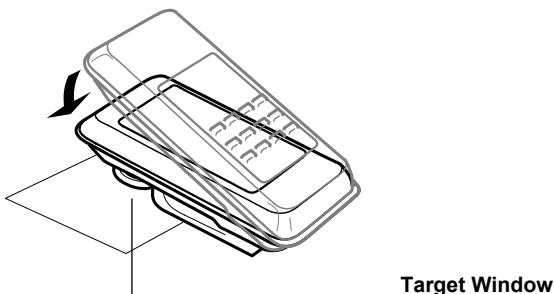
About the Model 310TR

The Model 310TR Color Transmission/Reflection Densitometer is two densitometers in one. You can select different, separate colors and functions for Transmission and Reflection measurements. This dual functionality will be addressed in more detail later in this chapter as you begin using these instruments.

DISPLAY PANEL VOCABULARY

Function and measurement information for both the 310 Transmission Densitometer and the Reflection Head Assembly is displayed in the Left and Right Display Panels on the 310.

Along the outside edge of each display panel, functions related to the Keyboard keys are listed. When a function is activated via the Keyboard, an L.E.D. indicator appears next to the function listed on the display.

L.E.D. Indicators for Listed Keyboard Functions

VISUAL Reading Value (Trans only)

`VIS`

`1.32`

DEN
BAL
x10
DIF
MN/MAX
STATUS A
M

`1.66`

`GRN` `MAG`

EXAMPLE: DEN, DIF, and STATUS M functions are activated.

GREEN (Trans) or MAGENTA (Refl) Reading

RED (Trans) or CYAN (Refl) Reading Value

`RED` `CYN`

`1.14`

AUTO
PRG
MODE
MEM 1
MEM 2
MEM 3
MEM 4
MEM 5
REFL
TRANS
CTS/BUSY

`2.00`

`BLUE` `YEL`

BLUE (Trans) or YELLOW (Refl) Reading Value

To display reading values, the Display Panel is divided into four parts:

- The upper left value is for Visual measurement (Transmission only).
- The lower left displays Green measurement value for Transmission; or Magenta measurement value for Reflection.
- The upper right displays Red value for Transmission; or Cyan for Reflection.
- The lower right displays Blue value for Transmission; or Yellow for Reflection.

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CHECKING STATUS (TRANSMISSION ONLY)

The first thing you should do before performing a measurement or a calibration is to check your Status response setting. Status responses are industry standards for densitometric measurements. Your 310 allows two response settings:

- *Status A*, which defines the response function for the measurement of photographic products such as snapshots and other photographic prints, 35mm slides, and transparencies that are intended for display using direct or projection methods; and
- *Status M*, which defines the response function for the measurement of preprint (sometimes called internegative) films, which are camera films such as those used to create color prints that are to be printed on photographic paper but are not to be viewed directly.

To check and set status:

On the Left Display Panel, an L.E.D. Indicator appears to the right of **STATUS** label, next to either **A** or **M**—whichever is active.

If the desired Status response is active, continue to your next procedure. If it is not, press **F**, then **STATUS** on the Reading Head Arm Keyboard to toggle the Indicator to the desired response.

CALIBRATING THE 310

Your X-Rite 310 is designed for long life and extremely stable readings. To maintain proper quality control procedures, you should calibrate your instrument. Once your instrument is calibrated, you should then periodically check calibration to verify measurement accuracy and proper operation of the unit. *Under normal operating conditions, the instrument should be calibrated once a week, or whenever the instrument displays a message regarding calibration.*

Both the 310 Transmission Densitometer and the Reflection Head Assembly must be calibrated. Each has a separate calibration procedure.

Frequency of Calibration

Under normal operating conditions, the instrument(s) should be calibrated once a week, or whenever instrument displays a message regarding calibration.

Transmission Density Calibration

To assist you in verifying transmission density performance, a calibrated step tablet has been provided with your 310. The correct density values are listed on this tablet. The step tablet has a stable 5-step gray scale ranging from about .060 on Step 1 to approximately 4.00 on Step 5. Step 4 is recommended for calibrating the "CAL HI" density. The step tablet values are derived from the National Bureau of Standards (NBS).

NOTE: Make sure that your step tablet is kept free of smudge marks and dust.

To calibrate your 310 for transmission density:

1. Press **DEN** on the Reading Head Arm Keyboard to select Transmission Density. An L.E.D. Indicator appears next to **DEN** on the Left Display Panel, and next to **TRANS** on the right.
2. Select the desired Status.
3. You can calibrate between one and four colors at a time by simultaneously pressing the key(s) for the color(s) you are calibrating; or—if you are calibrating all transmission primary colors (Visual, Red, Green, and Blue)—by simply pressing **ALL**.
4. Press **F** and **CAL-SET**. The Cal Lo density value of the farthest left color selected starts blinking and the words Cal Lo appear on the display. The blinking is to indicate that this Cal Lo value can be modified if needed.

NOTE: Cal Lo density values are generally the densities measured with no film in the measurement path or 0.00D.

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5. The Display Panel displays the Cal Lo density value for Visual (or the first color selected), and the Keyboard is automatically set in numeric format. As necessary, enter the Cal Lo density for Visual using a four-digit value. For example, if the value is 0.00D, press **0**, **0**, **0**, **0**. "0.000" correctly appears.

> **NOTE:** It is possible to set Cal Lo on a density higher than 0.00D by entering the appropriate calibration number as shown in Step 4. This is required only for specialized calibrations.

6. Once the desired value appears, press **CAL-SET**.
7. If more than one color has been selected, the next color's (Red) current "Cal Lo" value begins blinking. Enter the "Red Lo" value by repeating Steps 4 and 5, then repeat them again for Green and Blue.
8. The Display Panel displays "read den" and "Cal Lo". This indicates that you may begin calibration starting with the Lo density value. Normally, Cal Lo is set by measuring with no film over the target window.
9. *Without placing any film over the Target Window*, lower the Reading Head down to the target, then press the Read Button. The Display Panel turns off momentarily. Hold the Read Button until two seconds after the display turns back on, then release.
10. The Display Panel displays the Cal Hi density value for Visual (or the first color selected), and the Keyboard is automatically set in numeric format. As necessary, enter the Cal Hi density for Visual, using a four-digit value. For example, if the value is 3.06D, press **3**, **0**, **6**, **0**. "3.060" correctly appears.
11. When the desired value appears, press **CAL-SET**.
12. If more than one color has been selected, the next color's (Red) current "Cal Hi" value begins blinking. Enter the Cal hi value by repeating Steps 9 and 10 for Red, then repeat them again for Green and Blue.
13. The Display Panel displays "read den" and "Cal Hi". This indicates that you may begin calibrating the Hi density value on your step tablet or reference.
14. Center the Cal Hi area of the step tablet or reference over the Aperture, using the crosshairs as guides. Lower the Reading Head down to the target area, then press the Read Button. The Display Panel turns off momentarily. Hold the Read Button until two seconds after the display turns back on, then release.

    The Transmission Densitometer is now calibrated for the density of the colors you selected.

If density calibration mode was mistakenly entered, you can exit without re-calibrating or upsetting the current calibration.

To safely exit calibration mode:

1. Press **CAL-SET** until "read den" and "Cal Lo" appear on the Display Panel.
2. Press the Read Button and *briefly* hold for less than one second.
3. Press **CAL-SET** until "read den" and "Cal Hi" appear on the Display Panel.
4. Press the Read Button and *briefly* hold for less than one second.

    The instrument is now set to its original calibration.

Reflection Density Calibration

To assist you in verifying reflection density performance, a calibrated ceramic check plaque has been provided with your 310TR Reflection Head Assembly. This plaque has a stable multi-step gray scale ranging from about .10D to about 2.00D. The lowest step is used for the "Cal Lo" calibration measurement, and the highest step is used for the "Cal Hi" measurement. The values listed for the check plaque are measurements traceable to certified reference standards maintained at X-Rite, Incorporated.

NOTE: Make sure your check plaque is free of smudge marks and dust, which can dramatically affect measurement of the darker steps. The plaque should be wiped clean with a lint-free cloth, using a commercially-available glass cleaner or a *mild* soap solution.

To calibrate your 310 for reflection density:

1. Press **DEN** on the *Reflection Head* Keyboard to select Reflection Density. An L.E.D. Indicator appears next to **DEN** on the Left Display Panel, and next to **REFL** on the right.
2. You can calibrate between one and four colors at a time by simultaneously pressing the key(s) for the color(s) you are calibrating; or—if you are calibrating all transmission primary colors (Cyan, Magenta, and Yellow)—by simply pressing **ALL**.
3. Press **F**, then **CAL-SET**. The Display Panel displays the Cal Lo density value for Cyan (or the first color selected), and the Keyboard is automatically set in numeric format. As necessary, enter the Cal Lo density for Cyan, using a four-digit value. For example, if the value is 0.00D, press **0**, **0**, **0**, **0**. "0.000" correctly appears.
4. When the desired value appears, press **CAL-SET**.

   NOTE: It is possible to set Cal Lo on a density higher than 0.00D by entering the appropriate calibration number as shown in Step 3. This is required only for specialized calibrations.

5. If more than one color has been selected, the next color's (Magenta) current "Cal Lo" value begins blinking. Enter the "Mag Lo" value by repeating Steps 3 and 4, then repeat them again for Yellow.
6. The Display Panel displays "read den" and "Cal Lo". This indicates that you may begin calibration starting with the Lo density value. Normally, Cal Lo is set by measuring with no film over the target window.
7. *Without placing any film over the Target Window*, lower the Reading Head down to the target, then press the Read Button. The Display Panel turns off momentarily. Hold the Read Button until two seconds after the display turns back on, then release.

8. The Display Panel displays the Cal Hi density value for Cyan (or the first color selected), and the Keyboard is automatically set in numeric format. As necessary, enter the Cal Hi density for Cyan, using a four-digit value. For example, if the value is 2.23D, press **2**, **2**, **3**, **0**. "2.230" correctly appears.
9. When the desired value appears, press **CAL-SET**.
10. If more than one color has been selected, the next color's current "Cal Hi" value begins blinking. Enter the Cal Hi value using the procedure in Steps 8 and 9 for the current color, then each remaining color.
11. The Display Panel displays "read den" and "Cal Hi". This indicates that you may begin calibrating the Hi density value on your step tablet or reference.
12. Center the Cal Hi area of the step tablet or reference over the Aperture, using the crosshairs as guides. Lower the Reading Head down to the target area, then press the Read Button. The Display Panel turns off momentarily. Hold the Read Button until the display turns back on (about two seconds), then release.

    The Reflection Head Assembly is now calibrated for the density of the colors you selected.

If density calibration mode was mistakenly entered, you can exit without re-calibrating or upsetting the current calibration.

To safely exit calibration mode:

1. Press **CAL-SET** until "read den" and "Cal Lo" appear on the Display Panel.
2. Press the Reflection Head down and *briefly* hold for less than one second.
3. Press **CAL-SET** until "read den" and "Cal Hi" appear on the Display Panel.
4. Press the Reflection Head down and *briefly* hold for less than one second.

    The instrument is now set to its original calibration.

Quick Zero

You can reestablish the "Cal Lo" (zero) value for the instrument without repeating the entire calibration procedure by performing a "quick zero."

To quick zero:

1. Measure the absolute "Cal Lo" density.
    —for transmission, take a measurement with no film in the Target Window, holding down the Read Head and pressing the Read Button.
    —for reflection, measure the Lo density value on the calibration step tablet, pressing down the Reflection Head.
2. Continue holding. As you hold the measurement, press **F**, then press **CAL-SET** and hold for three seconds.

NULLING (ZEROING) ON A STANDARD

Before taking measurements, you should "null" or "zero" your instrument. This establishes the "zero" measurement according to which measurements that follow will be calculated.

You can null by measuring a standard; or by manually entering the desired standard values.

Nulling by Measuring a Standard

You can zero on a standard for the Single Color Method, where you select one color to measure; or the Multicolor Method, where you select All colors to measure.

To zero on a standard for the *single color* method:

1. Check Status A/M (transmission only).
2. Select the desired mode.
   —Press **DEN** for Density mode; or
   —**F**, then **Dx10** for D x 10 mode; or
   —**BAL** for Color Balance mode.
   An L.E.D. Indicator appears next to the selected function on the Left Display Panel.
3. Select the desired memory location. Press **MEM** until the L.E.D. Indicator appears next to the desired memory location (**MEM 1** through **MEM 5**) on the Right Display Panel.
4. Press **DIF**. The **DIF** L.E.D. Indicator appears.
5. Press the desired color key—either **CYN**, **MAG**, or **YEL** on the Reflection unit; or **RED**, **GRN**, or **BLUE** on the Transmission unit. *If you wish to use Auto Color in place of a specific color, press **F**, then* **AUTO**.
6. Center the standard sample to be nulled on the Target Window.
7. Press and hold the Read Button.
8. While holding the Read Button, also press and hold **DIF**. Hold both keys until 0.00 (or 0.000) appears, then release **DIF**. (If you are in Color Balance mode, 0.00 does not appear until you release **DIF**.)
9. Release the Read Button.

To zero on a standard for the *multicolor* method:

1. Check Status A/M (transmission only).
2. Select the desired mode.
   —Press **DEN** for Density mode; or
   —**F**, then **Dx10** for D x 10 mode; or
   —**BAL** for Color Balance mode.
   An L.E.D. Indicator appears next to the selected function on the Left Display Panel.
3. Select the desired memory location. Press **MEM** until the L.E.D. Indicator appears next to the desired memory location (**MEM 1** through **MEM 5**) on the Right Display Panel.
4. Press **DIF**. The **DIF** L.E.D. Indicator appears.
5. Press **ALL**, or press the desired color keys simultaneously.
6. Center the standard sample to be nulled on the Target Window.
7. Press and hold the Read Button.
8. While holding the Read Button, also press and hold **DIF**. Hold both keys until 0.00 (or 0.000) appears, then release **DIF**. (If you are in Color Balance mode, 0.00 does not appear until you release **DIF**.)
9. Release the Read Button.

Manually Entering a Standard

You can manually enter a standard value for the Single Color Method, when you select one color to measure; or the Multicolor Method, when you select All colors to measure.

To manually enter a standard for the *single color* method:

1. Check Status A/M (transmission only).
2. Select the desired mode.
   —Press **DEN** for Density mode; or
   —**F**, then **Dx10** for D x 10 mode; or
   —**BAL** for Color Balance mode; or
   —**RANGE**.
   An L.E.D. Indicator appears next to the selected function on the Left Display Panel.
3. Select the desired memory location. Press **MEM** until the L.E.D. Indicator appears next to the desired memory location (**MEM 1** through **MEM 5**) on the Right Display Panel.
4. Press **DIF**. The **DIF** L.E.D. Indicator appears.
5. Press **F**.
6. Press the desired color key—either **CYN**, **MAG**, or **YEL** on the Reflection unit; or **RED**, **GRN**, or **BLUE** on the Transmission unit. *If you wish to use Auto Color in place of a specific color, press **F**, then* **AUTO**.
7. Press **CAL-SET**. The Display Panel flashes the present standard value, along with "CAL-NUL."
8. The Keyboard switches to numerical format. Use the numbered keys (**0** through **9**) to enter the desired standard values.
9. Press **CAL-SET**.

To manually enter a standard for the *multicolor* method:

1. Check Status A/M (transmission only).
2. Select the desired mode.
   —Press **DEN** for Density mode; or
   —**F**, then **Dx10** for D x 10 mode; or
   —**BAL** for Color Balance mode; or
   —**RANGE**.
      An L.E.D. Indicator appears next to the selected function on the Left Display Panel.
3. Select the desired memory location. Press **MEM** until the L.E.D. Indicator appears next to the desired memory location (**MEM 1** through **MEM 5**) on the Right Display Panel.
4. Press **F**.
5. Press **DIF**. The **DIF** L.E.D. Indicator appears.
6. Press **ALL**, or press the desired color keys simultaneously.
7. Press **CAL-SET**. The Display Panel flashes the present standard value, along with "CAL-NUL."
8. The Keyboard switches to numerical format. Use the numbered keys (**0** through **9**) to enter the desired standard values, pressing 0 first, then the value. The decimal point will be automatically placed before the last two digits entered.
      For Example: To enter "1.23" as the standard, press **0**, **1**, **2**, **3**.
9. Repeat steps 7 and 8 until all desired colors are set.

NOTE: You can Null on negative densities (such as fluorescent inks or dyes), and enter negative densities on the Keyboard. To enter negative values, first press **PRINT/MODE**. The value that you enter next will be calculated as a negative number.

MEASURING DENSITY

There are two ways to measure density using the 310:

- You can take an *absolute* density measurement that is computed using the values derived from measuring the calibration reference; or
- you can take a density *difference* measurement that is computed by subtracting a standard (null) measurement from the density measurement. For example, you could subtract the paper or base material from the measurement value.

Also, if you have the model 310TR Transmission/Reflection unit, you can measure transmissive targets and reflective targets. Remember, the 310TR is two densitometers in one. You can select different, separate colors and functions for transmission and reflection measurements. For example, you can have the colors Red, Green, and Blue, the Density function, and Status M selected for **TRANS** (transmission) measurements; and at the same time have All colors, Range function, and Status A selected for **REFL** (reflective) measurements.

Density measurement procedures are basically the same for transmission and reflection, except for Status selection and reading head technique.

NOTE: For all measurement procedures, you should begin by verifying instrument calibration, and nulling the instrument.

Measuring Absolute Density

You can measure absolute density using the *single color* method, where you select one color to measure; the *auto color* method, where you have the instrument automatically determine the primary color measured; or the *multicolor method*, where you select multiple or All colors to measure.

To measure absolute density using the *single color* method:

1. Check Status A/M (transmission only).
2. Select transmission or reflection by pressing either **DEN** (transmission) on the Reading Head Arm Keyboard; or **DEN** (reflection) on the Reflection Head Keyboard. L.E.D. indicators appear next to **DEN** on the Left Display Panel; and next to either **TRANS** or **REFL** on the Right Display Panel.
3. Select the memory position to store measurements. Press **MEM** until the L.E.D. indicator appears next the desired position (**MEM 1** through **MEM 5**) on the Right Display Panel.
4. Press the desired color key. The appropriate display area activates.
5. Measure the target sample.
   —For *transmission*, center the sample over the Target Window, then lower the Reading Head down onto the sample. Press the Read Button and hold; the Display turns off momentarily. When the Display turns back on, release the Button.

—for *reflection*, center the sample under the Target Window, then lower the Reflection Head down onto the Target Window. The Display turns off momentarily. When the Display turns back on, release the Reflection Head.

The measurement values displayed are now stored in memory until its memory position is updated.

To measure absolute density using the *auto color* method:

1. Check Status A/M (transmission only).
2. Select transmission or reflection by pressing either **DEN** (transmission) on the Reading Head Arm Keyboard; or **DEN** (reflection) on the Reflection Head Keyboard. L.E.D. indicators appear next to **DEN** on the Left Display Panel; and next to either **TRANS** or **REFL** on the Right Display Panel.
3. Select the memory position to store measurements. Press **MEM** until the L.E.D. indicator appears next the desired position (**MEM 1** through **MEM 5**) on the Right Display Panel.
4. Press **F**, then **AUTO**. The **AUTO** L.E.D. indicator in the Right Display Panel turns on.
5. Measure the target sample.
   —For *transmission*, center the sample over the Target Window, then lower the Reading Head down onto the sample. Press the Read Button and hold; the Display turns off momentarily. When the Display turns back on, release the Button.
   —for *reflection*, center the sample under the Target Window, then lower the Reflection Head down onto the Target Window. The Display turns off momentarily. When the Display turns back on, release the Reflection Head.
6. The densitometer measures the primary color content (red, green, blue or cyan, magenta, yellow) of the sample. Then, it takes the color channel with the highest density and compares it to the color with the next-highest density. The appropriate display area(s) activate.
   —If the difference between the two is greater than 1.2, then the highest color is calculated as the sample. The densitometer automatically activates that color's channel, and turns off any other channels.
   —If the difference is less than 1.2, then no color is found to be dominant and ALL color channels are automatically activated.

   To turn off **AUTO**, press any color key, or **ALL**.

   The measurement values displayed are now stored in memory until its memory position is updated.

To measure absolute density using the *multicolor* method:

1. Check Status A/M (transmission only).
2. Select transmission or reflection by pressing either **DEN** (transmission) on the Reading Head Arm Keyboard; or **DEN** (reflection) on the Reflection Head Keyboard. L.E.D. indicators appear next to **DEN** on the Left Display Panel; and next to either **TRANS** or **REFL** on the Right Display Panel.
3. Select the memory position to store measurements. Press **MEM** until the L.E.D. indicator appears next the desired position (**MEM 1** through **MEM 5**) on the Right Display Panel.
4. Simultaneously press the desired color keys, or press **ALL** to activate all colors. The appropriate display area activates.
5. Measure the target sample.
   —For *transmission*, center the sample over the Target Window, then lower the Reading Head down onto the sample. Press the Read Button and hold; the Display turns off momentarily. When the Display turns back on, release the Button.
   —for *reflection*, center the sample under the Target Window, then lower the Reflection Head down onto the Target Window. The Display turns off momentarily. When the Display turns back on, release the Reflection Head.

   The measurement values displayed are now stored in memory until its memory position is updated.

Measuring Density Difference

You can measure density difference using the *single color* method, where you select one color to measure; the *auto color* method, where you have the instrument automatically determine the primary color measured; or the *multicolor method*, where you select multiple or All colors to measure.

To measure density difference using the *multicolor* method:

1. Check Status A/M (transmission only).
2. Select transmission or reflection by pressing either **DEN** (transmission) on the Reading Head Arm Keyboard; or **DEN** (reflection) on the Reflection Head Keyboard. L.E.D. indicators appear next to **DEN** on the Left Display Panel; and next to either **TRANS** or **REFL** on the Right Display Panel.
3. Select the memory position to store measurements. Press **MEM** until the L.E.D. indicator appears next the desired position (**MEM 1** through **MEM 5**) on the Right Display Panel.
4. Press **DIF**. The **DIF** L.E.D. indicator appears on the Left Display Panel.
5. Press the desired color key for the color you wish to compare to the standard. The appropriate display area activates.
6. Measure the target sample (see Step 5 of Measuring Absolute Density instructions).

   The measurement values displayed are now stored in memory until its memory position is updated.

To measure absolute density using the *auto color* method:

1. Check Status A/M (transmission only).
2. Select transmission or reflection by pressing either **DEN** (transmission) on the Reading Head Arm Keyboard; or **DEN** (reflection) on the Reflection Head Keyboard. L.E.D. indicators appear next to **DEN** on the Left Display Panel; and next to either **TRANS** or **REFL** on the Right Display Panel.
3. Select the memory position to store measurements. Press **MEM** until the L.E.D. indicator appears next the desired position (**MEM 1** through **MEM 5**) on the Right Display Panel.
4. Press **DIF**. The **DIF** L.E.D. indicator appears on the Left Display Panel.
5. Press **F**, then **AUTO**. The **AUTO** L.E.D. indicator in the Right Display Panel turns on.
6. Measure the target sample (see Step 5 of Measuring Absolute Density instructions).
7. The densitometer measures the primary color content (red, green, blue or cyan, magenta, yellow) of the sample. If density difference is greater than 1.2, then the dominant color is calculated as the sample. If the difference is less than 1.2, then no color is found to be dominant and ALL color channels are automatically activated.

   To turn off **AUTO**, press any color key, or **ALL**.

   The measurement values displayed are now stored in memory until its memory position is updated.

To measure absolute density using the *multicolor* method:

1. Check Status A/M (transmission only).
2. Select transmission or reflection by pressing either **DEN** (transmission) on the Reading Head Arm Keyboard; or **DEN** (reflection) on the Reflection Head Keyboard. L.E.D. indicators appear next to **DEN** on the Left Display Panel; and next to either **TRANS** or **REFL** on the Right Display Panel.
3. Select the memory position to store measurements. Press **MEM** until the L.E.D. indicator appears next the desired position (**MEM 1** through **MEM 5**) on the Right Display Panel.
4. Press **DIF**. The **DIF** L.E.D. indicator appears on the Left Display Panel.
5. Simultaneously press the desired color keys, or press **ALL** to activate all colors. The appropriate display area activates.
6. Measure the target sample (see Step 5 of Measuring Absolute Density instructions).

   The measurement values displayed are now stored in memory until its memory position is updated.

MEASURING DENSITY X 10

You can use density values with an additional point of resolution by activating the **D x 10** function. This function provides density values with an extra digit to the right of the decimal point.

Measuring density x 10 uses the same basic procedures as normal density. For density x 10, you simply press **F**, then **D x 10** on the Keyboard instead of **DEN**. This is covered in Step 2 of the "Measuring Density" procedures listed earlier. An L.E.D. indicator appears next to **x 10** on the Left Display Panel. Once the D x 10 function is activated in this step, all procedures that follow are the same.

MEASURING RANGE (MINIMUM/MAXIMUM)

In addition to normal density measurements, your 310 also provides Range and Minimum/Maximum measurement features.

There are two ways to measure range using your 310:

- You can take an *absolute* range measurement that determine the difference between the lowest and highest densities in a series of measurements; or
- you can take a range *difference* measurement that allows a stored null value to be subtracted from range measurements. This is useful in determining the variation of the measured range in relation to the standard.

NOTE: For all measurement procedures, you should begin by verifying instrument calibration, and nulling the instrument.

Measuring Absolute Range

Absolute range measurement procedures are the same for transmission and reflection.

To measure absolute range using the RANGE and MIN/MAX features:

1. Check Status A/M (transmission only).
2. Press the desired color key for the color you wish to measure; or you can simultaneously press multiple color keys, or press **ALL** to select all colors.
3. Press **F** and hold until Step 4 is completed.
4. Press **RANGE**. Once the **DEN** and **RNG** (range) L.E.D. indicators appear on the Display Panel, release **F**.
5. Measure the first target sample in your series. Hold the measurement (the Read Button or Reflection Head down) until the display turns on.

6. Measure the second target sample in your series. Hold the measurement (the Read Button or Reflection Head down) until the display turns back on. The difference range value between these two measurements is displayed. Since these are the only two measurements so far, they are the Minimum and Maximum.
7. Continue reading samples as necessary to determine range. As different minimum and maximum values are measured, the difference range value displayed will adjust accordingly.
8. To view the current *minimum* measurement, press **F**, then **MIN/MAX**.
9. To view the current *maximum* measurement, press **F**, then **MIN/MAX** again.

   To clear the difference range value for a new series of measurements, press **F** and hold, then press **RANGE**.

Measuring Range Difference

Range difference measurement procedures are the same for transmission and reflection.

To measure range difference:

1. Check Status A/M (transmission only).
2. Press the desired color key for the color you wish to measure; or you can simultaneously press multiple color keys, or press **ALL** to select all colors.
3. Press **F** and hold until Step 4 is completed.
4. Press the **RANGE** key. Once the **DEN** and **RNG** (range) L.E.D. indicators appear on the Display Panel, release **F**.
5. Press the **DIF** key. The **DIF** L.E.D. indicator appears on the Display Panel, and "minus (-) null value" is displayed.
6. Measure the first target sample in your series. Hold the measurement (the Read Button or Reflection Head down) until the display turns on.
7. Measure the second target sample in your series. Hold the measurement (the Read Button or Reflection Head down) until the display turns back on. The difference range value between these two measurements *minus the null value* is displayed. Since these are the only two measurements so far, they are the Minimum and Maximum.
8. Continue reading samples as necessary to determine range. As different minimum and maximum values are measured, the difference range value displayed will adjust accordingly.
9. To view the current *minimum* measurement, press **F**, then **MIN/MAX**.
10. To view the current *maximum* measurement, press **F**, then **MIN/MAX** again.

   To clear the difference range value for a new series of measurements, press **F** and hold, then press **RANGE**. The "minus (-) null value" appears.

MEASURING COLOR BALANCE

In addition to normal density measurements, your 310 also provides Color Balance measurement features.

There are two ways to measure color balance using your 310:

- You can take an *absolute* color balance measurement that express the density of each color as the difference between the color and the highest of the three primary color densities. For example, if a given sample had absolute density values of 1.10, 1.20, and 1.25 in Cyan, Magenta, and Yellow, respectively, the color balance measurement for the sample would read 0.15 (1.25-1.10), 0.05 (1.25-1.20), and 0.00 (1.25-1.25); or
- you can take a color balance *difference* measurement that subtracts "target densities" from the sample before computing color balance. For example, if a given sample had absolute density values of 1.10, 1.20, and 1.25 for cyan, magenta, and yellow, respectively, and the "target densities" for these colors were 1.10, 1.15, and 1.30, the color balance difference values displayed would be 0.00 (1.10-1.10), 0.05 (1.20-1.15), and 0.05 (1.30-1.25). These values are the amount of density that would need to be added to the sample to achieve the color balance determined by the target densities.

NOTE: For all measurement procedures, you should begin by verifying instrument calibration, and nulling the instrument.

Measuring Absolute Color Balance

To compute absolute color balance, the density of the sample is simultaneously measured for all three process colors (excluding VIS). Then, those densities are compared to one another.

Absolute color balance measurement procedures are the same for transmission and reflection.

To measure absolute color balance:

1. Check Status A/M (transmission only).
2. Press the **BAL** key. The **BAL** L.E.D. indicator appears.
3. Select the memory position to store measurements. Press **MEM** until the L.E.D. indicator appears next the desired position (**MEM 1** through **MEM 5**) on the Right Display Panel.
4. Press the desired color key for the color you wish to measure; or you can simultaneously press multiple color keys, or press **ALL** to select all colors.
5. Measure the target sample. Hold the measurement (the Read Button or Reflection Head down) until the display turns on.

The display for the color with the highest measured density is set to 0.00. The other two color displays show the additional density required for these colors to "balance" with the high-density color to achieve a neutral gray color. The VIS display contains the greatest density value computed, which may be used to help adjust exposure time or illumination intensity.

Measuring Color Balance Difference

To compute color balance difference, the density of the sample is simultaneously measured for all three process colors (excluding VIS). "Target densities" that are stored as null values and represent known, desired color tones (such as flesh tone, sky blue, grass green) are then subtracted from the measured densities. Color balance is then computed on the differences.

Absolute color balance measurement procedures are the same for transmission and reflection.

To measure absolute color balance:

1. Check Status A/M (transmission only).
2. Press the **BAL** key. The **BAL** L.E.D. indicator appears.
3. Select the memory position to store measurements. Press **MEM** until the L.E.D. indicator appears next the desired position (**MEM 1** through **MEM 5**) on the Right Display Panel.
4. Simultaneously press the desired color keys; or press **ALL** to select all colors.
5. Measure the target sample. Hold the measurement (the Read Button or Reflection Head down) until the display turns on.

   The display for the color with the highest measured density is set to 0.00. The other two color displays show the additional density required for these colors to "balance" with the target densities color to achieve the target color balance. The VIS display contains the greatest density value computed, which represents the deviation from "balanced" densities to "target" densities. This number may be used to help adjust exposure time or illumination intensity.

USING MEMORY

Your X-Rite 310 comes equipped with five display memory locations—labeled M1 through M5—for Status A Transmission, five Status M Transmission, and five for Status A Reflection.

Density, Density x 10, and Balance each have five display memory locations for Status A Transmission, Status M Transmission, and Status A Reflection. In each of these locations, VIS, RED (CYN), GREEN (MAG), and BLUE (YEL) measurements can be stored.

Additionally, there are equal numbers of null value locations as there are display memory locations. It is therefore possible to have different null values in memory 1 through memory 5 for different jobs.

NOTE: Both absolute and difference measurements share the same display memory locations.

To select M1 through M5, press **MEM**. The memory positions will sequentially be selected with each depression of the **MEM** key.

DISPLAYING AND SETTING TIME AND DATE

To display time and date, press the **TIME** key.

• The time is show across the top of the Display Panel in hours/minutes/seconds. Because there is no a.m./p.m. indicator, the time is shown in military format—for example, 1 p.m. is 13:00; 2 p.m. is 14:00; and so on.
• The date is show across the bottom of the Display Panel in Months/Days/Years.

For example, if the time is 3:21:53 p.m., the Display reads 03. 21 53. If the date is March 16, 1995, the Display reads 03. 16 95.

The time and date settings are maintained in the 310 even after it has been turned off or unplugged and the turned back on after a long period of time.

Your 310 was shipped with the current time and date pre-set for the factory time zone. Also, the 310's internal clock does not automatically adjust for leap year. Occasional adjustments may be required.

To adjust time and date:

1. Press **TIME**.
2. Press **F**, the **CAL-SET**. The hours start blinking and the seconds are reset to zero.
3. Enter two digits for the hours display using the Keyboard numerals **0** through **9**. For example, 3 p.m.=15; 9 a.m.=09.
4. Press **CAL-SET**. The minutes start blinking.
5. Enter two digits for the minutes display using the Keyboard numerals **0** through **9**.
6. Press **CAL-SET**. The month starts blinking.
7. Enter two digits for the month display.
8. Press **CAL-SET**. The day starts blinking.
9. Enter two digits for the day display.
10. Press **CAL-SET**. The year starts blinking.
11. Enter two digits for the year display.
12. Press **CAL-SET**. Your new time and date settings are activated.

USING MODE FUNCTIONS

The **MODE** function is used to access and modify control variables for some functions, and to access other, more seldom-used functions.

Several functions can be accessed using the **MODE** key. Each function has a two-digit code. A mode function is activated by pressing **F**, then **MODE**, then the function's two-digit code. When you activate a mode function, it remains active even if you change from transmission to reflection, or change Status. Functions and their codes are listed below.

Two-Digit Code Function

00 and **01** ....Exits **MODE** function without changing anything.

02........................Auto-print OFF.

03........................Auto-print ON. Each time **READ** button is released; or reflection head lifted; the display information plus any other data is transmitted via the I/O port.

04........................Auto-time with Print OFF.

05........................Auto-time with Print ON. Each time **PRINT** is pressed or read button/reflection head is released, the time and date are output first before any other data.

06........................Buzzer OFF.

07........................Buzzer ON. Each time a key is depressed, the buzzer gives a short tone to indicate that the key has been depressed. Also, the buzzer is used to indicate an improper key depression or operation.

08 and **09**.............Not used. If 09 is entered, the display shows #.#=n. To exit this mode, press **CAL-SET**.

10........................Activates output for optional X-Rite 20 Column Printer P/N 309-13 (used in conjunction with mode function 18 or 19). Also, deactivates mode function 21.

11........................Activates Kodak Technet operation (used in conjunction with mode function 14 or 15). Also, deactivates mode functions 10 and 21.

12........................Selects 300 baud rate for I/O port. This is the baud rate required by the Kodak TECHNET system.

13........................Selects 1200 baud rate for I/O port.

14........................Selects normal Technet format for mode function 11. This format has color identification but does not identify densitometer type (Transmission or Reflection) or Status (A or M). Enabling 14 disables 15.

15........................Selects advanced Technet format for mode function 11. Similar to the Technet format selected in Mode 14, except this advanced format has identifiers for densitometer type and Status. Enabling 15 disables 14.

16 and **17**.............Not used.

18........................Selects full length printout for mode function 10 which gives information on function and memory selected.

19........................Selects short printout for mode function 10, which only lists a letter for the color and the measurement value.

20........................Disables mode function 21 and enables functions 10 and 11.

21........................Enables a change in the delimiter when multiple colors are transmitted in the Technet (14) or advanced Technet (15) format. The carriage return (CR) normally transmitted between colors is replaced with a space. A carriage return line feed (LF) is transmitted after the last color.

NOTE: Your 310 is shipped with the following modes selected: 02, 04, 07, 11, 12, 14, and 18.

TROUBLESHOOTING

If a problem with your 310 occurs—for example, if you cannot get a reading or you are stuck in a certain function—in most cases the problem can be corrected by simply turning the 310 power off and then back on.

Some problems can occur if the 310 is not operated properly. Below are some of these problems and their possible solutions.

	Problem	Solution
1.	A reading cannot be taken.	You may have inadvertently pressed the **F** key. Press another key that has not effect on your current measurement procedure.
2.	Display keeps blinking.	Unit is in calibration mode and waiting for numeric entry and **CAL-SET**; or turn unit off and then on again to reset the display.
3.	As you attempt to measure, the display turns off for a long period of time.	Calibrate the unit.
4.	Display is erratic.	Calibrate the unit, then turn the unit off for about one hour, then turn back on and re-check calibration. If display remains erratic, your unit may be in need of service.
5.	A minus sign (-) appears in the display and you cannot get rid of it.	Press the **MODE**/**PRINT** key until the sign is off.

3

Input/Output Functions

Your X-Rite 310 is equipped with a port that allows information to be transmitted from the densitometer to another device, such as a printer or a computer. This chapter covers the different functions you can perform using your densitometer with these other devices.

Chapter Contents

USING THE INPUT/OUTPUT (I/O) PORT

To gain access to the densitometer's input/output (I/O) port, locate the 25-circuit D-type connector at the rear of the 310. A cable is available that allows connection from the densitometer to a computer (such as Kodak's TECHNET®) via a standard RS232 Interface (P/N 319-83).

Connect one end of the cable assembly to the 25-circuit D type connector on the back of the 310. Connect the other end of the cable to the computer as designated by the computer manufacturer's documentation.

The following is a technical overview of the I/O port and its various modes of operation.

I/O Port Modes of Operation

The I/O port socket has the following connections:

1. Pin 3 is the serial input. Information to be received by the densitometer form external devices is sent in a serial format using RS232 levels.
2. Pin 7 is a ground connection for signal return.
3. Pin 2 is the serial output pin. This pin is used for transmitting data and information from the densitometer to the outside world using RS232 levels.
4. Pin 5 is a Clear-to-Send (Mode 11) or Busy (Mode 10) *input* to the densitometer. It is used in conjunction with a computer, printer, or other external device to control (to either inhibit or enable) the flow of 310 densitometer output data on Pin 2. This flow is dictated by the logical status of Pin 5 as sent from the computer, printer, or external device. (Pin 4 is internally connected to Pin 5 for the matrix printer.)

SERIAL OUTPUT FORMATS

The X-Rite 310 has four different output formats. The first two formats are designed for a matrix printer or sophisticated computer interface. The third format is the format specified by Kodak for their TECHNET system. The fourth format offers some advanced features for use on a TECHNET type of system.

Printer Formats

The printer format can output display information such as DENSITY, TIME, MEMORY location, etc., or can just give the color and measurement value. This provides a hard printed copy of measured sample data.

The printer format can vary, depending on which mode codes have been selected (see "Using Mode Functions," Chapter 2).

Print Samples

The following print samples show various outputs using different mode selections:

1. **MODE 18 and MODE 19 (Enable/Disable)**
   The header contains information on functions and memory selected (i.e., DEN, DIF, AUTO, MEM 3). Output of header data can be controlled via Modes 18 to 19.

   MODE 18 enables output of header data. Print sample when Mode 18 enabled (Modes 5, 14, and 20 are also enabled):

   ```
   09:14:10
   08/16/95
   DEN DIF AUTO MEM 3
   V00.16
   R00.09
   G00.19
   B01.32
   ```

   MODE 19 disables output of header data. Print sample when Mode 19 enabled (Modes 5, 14, and 20 are also enabled):

   ```
   09:14:10
   08/16/95
   V00.16
   R00.09
   G00.19
   B01.32
   ```

2. **MODE 20 and MODE 21 (Color Values)**

A color value indicates the selected color and the corresponding density that was measured. Each of the four color values can be printed on individual lines, or on the same line.

MODE 20 enables color value data to be output on individual lines. Print sample when Mode 20 enabled (Modes 5, 14, and 18 are also enabled):

```
09:14:10
08/16/95
DEN DIF AUTO MEM 3
V00.16
R00.09
G00.19
B01.32
```

MODE 21 enables color value data to be output on the *same* line. Print sample when Mode 21 enabled (Modes 5, 14, and 19 are also enabled):

```
09:14:10
08/16/95
V00.16, R00.09, G00.19, B01.32
```

NOTE: Only the colors that were measured will be printed. Also, Mode 14, 15, 18, and 19 may be interchanged in each sample.

NOTE: It is possible to print out the "NULL" values for the function selected. This is done by pressing **F**, then pressing and holding **NULL**; then pressing **PRINT**; and then releasing **NULL**.

The Clear-to-Send/Busy pin is "busy" for this format. This means that if this pin is a logic 1 (high) the printer is busy. If the pin is at a busy state when PRINT is commanded, the PRINT is ignored. If busy is low when PRINT is commanded, the data is output. If, during the output, busy goes high, the data stops at the end of a character until busy returns to low.

There is a visual indicator of the condition of the Clear-to-Send (CTS)/Busy pin. Below the Transmission LED there is an LED that turns on when CTS/Busy is high.

It is important that the baud rate at which the data is output is correct for the external device (Printer, Computer, etc.) being used.

The printer format baud rate is dictated by the external device that the 310 is connected to. The 310 can be selected for a 300 or 1200 baud rate. Refer to "Using Mode Functions" in Chapter 2 for information on selecting baud rate.

TECHNET Format

The third format follows the format specified by Kodak for TECHNET®.

Each time a "PRINT" command is given (manually or automatically), a lead character identifying the color is output, then the density (MSD to LSD), and then the delimiter using an ASCII "carriage return" (CR).

The 310 will output this information for each color selected, but in the order from VIS, CYN, MAG, to YEL. For example, if CYN, MAG, and YEL are selected, the densitometer will output the CYN, information first, then MAG, and then YEL.

The lead characters for this format are:

V = Visual
R = Cyan
G = Magenta
B = Yellow

The 310 is also capable of outputting data in this TECHNET format while in the DENSITY x 10 function. The four density characters are output MSD to LSD. Though presently, TECHNET only accepts three digits of data.

The Clear-to-Send/Busy pin is used as a Clear-to-Send for this format. In other words, if the Clear-to-Send is at a logic one (high) the densitometer will output data. If during the output, Clear-to-Send goes low, the 310 will stop sending at the end of the character being transmitted and will wait until the Clear-to-Send goes high before continuing. If Clear-to-Send is low when a PRINT command is given, the 310 will wait until the Clear-to-Send goes high.

There is a visual indicator of the condition of the Clear-to-Send (CTS)/Busy pin. Below the Transmission LED there is a LED that will turn on when CTS/Busy is low and is off when CTS/Busy is high.

The TECHNET format presently requires a 300 baud rate and the X-Rite 310 is shipped from the factory with the 300 baud rate selected. It is possible, however, to select the 1200 baud rate. Refer to "Using Mode Functions" in Chapter 2 for information on selecting baud rate.

Advanced TECHNET Format

The fourth format generally follows the densitometer interface specified by Kodak, except that the lead character that is used for identifying color has been modified.

The TECHNET format described in the previous discussion uses the lead characters V, R, G, and B to represent visual, cyan, magenta, and yellow. However, using V, R, G, and B, does not indicate whether those densities were Transmission or Reflection densities, or whether Status A or Status M densitometry was used.

When using this advanced format, each time a "PRINT" command is given—manually or automatically—a single lead character identifying the color, densitometer type, and status type is output, then the density (MSD to LSD), and then the delimiter using an ASCII "carriage return" (CR).

The 310 will output this information for each color selected, but in the order from VIS, CYN, MAG, to YEL. For example, if CYN, MAG, and YEL are selected, the densitometer will output the CYN, information first, then MAG, and then YEL.

The lead characters used for this operation are:

	Trans. Status A (lowercase)	Trans. Status M (lower)	Refl. Status A (upper)
Visual	v	p	P
Cyan (Red)	r	c	C
Magenta (Green)	g	m	M
Yellow (Blue)	b	y	Y

The 310 is also capable of outputting data in this format while in the DENSITY x 10 function. The four density characters are output MSD to LSD.

The Clear-to-Send/Busy pin is used as a Clear-to-Send for this format. In other words, if the Clear-to-Send is at a logic one (high) the densitometer will output data. If during the output, Clear-to-Send goes low, the 310 will stop sending at the end of the character being transmitted and will wait until the Clear-to-Send goes high before continuing. If Clear-to-Send is low when a PRINT command is given, the 310 will wait until the Clear-to-Send goes high.

There is a visual indicator of the condition of the Clear-to-Send (CTS)/Busy pin. Below the Transmission LED there is a LED that will turn on when CTS/Busy is low and is off when CTS/Busy is high.

It is possible to select the 1200 baud rate for the I/O port. Refer to "Using Mode Functions" in Chapter 2 for information on selecting baud rate.

SERIAL INPUT FORMAT

Your 310 is equipped with an input that allows the 310 to be controlled or monitored remotely. Every function that can be performed at the keyboard —plus a few functions not activated by the keyboard—can be activated via the serial input.

Basically, the remote control input format consists of a series of characters (a command string) sent to the 310 in ASCII format with a carriage return or a line feed at the end of each command string to act as a delimiter. The densitometer then acts on that command. The Serial Input Buffer of the 310, upon receiving its first command string character, generates a "Buffer Full" interrupt to the microprocessor.

The 310 microprocessor then halts all normal operation (except the display buffer) and dedicates itself to receiving and responding to remote control command strings. Normal execution is returned upon receiving a GO command via the serial port.

Instruction Format

In general, the format used for serial input is as follows:

1.	2.	3.	4.	5.	6.
XX	XX	X	LF	G	LF

1. **MODIFIER**—this is a two character hexidecimal code that is written to the key or control register that is being addressed and is used during a Write Action ("W") only.

2. **ADDRESS**—this is a two character hexidecimal code that selects the key or control register that will be acted upon.

3. **ACTION CODE**—This is a single character that is used to define the Remote Control Action as follows:

    a. READ ("R") is used to prompt the 310 to serially output in ASCII format two hexidecimal characters representing the binary data specified in the ADDRESS portion of the command string.

    b. WRITE ("W") is used to cause the 310 to replace the contents of the microprocessor RAM location designated in the ADDRESS portion of the command string with 8 bits of binary data represented by the two hexidecimal characters in the MODIFIER.

    c. SELECT ("S") is used to remotely select between Transmission M, Transmission A, and Reflection without physically pressing any keys on either densitometer keyboard.

    d. SWITCH 1, 2, 3, or 4 ("1" or "2", "3" or "4") is used to turn ON or OFF certain special operational features (see "Address and Modifier Format" next).

    e. GO ("G") is used to release the 310 from the remote control/monitor software to the normal operation software from which it was interrupted by a serial command.

4. **"LF"** is an ASCII "Line Feed" that is used as a delimiter and tells the densitometer to perform the preceding command. Unless that command was "G," it waits for the next command.

    NOTE: a "carriage return" (CR) can be sent instead of an "LF" if necessary.

5. **"G"** is an ASCII character that is sent to the densitometer to release it to operate as instructed after the "LF" (or "CR") is received.

    NOTE: When the densitometer senses that data is being received on the serial input, it stops normal operation and only allows the serial input to modify or monitor keys and control registers until a "G" Action Code is given to the densitometer to normal operation.

6. **"LF"** is an ASCII "Line Feed" that is used as a delimiter and tells the densitometer to perform the preceding command. Unless that command was "G," it waits for the next command.

    NOTE: a "carriage return" (CR) can be sent instead of an "LF" if necessary.

Address and Modifier Format

The following is a list of the addresses and the keys or control registers at each of those addresses.

Address	Keys or Control Registers
1E	Tone Timer
2D	Color
30	Blue (Yellow) Digit 4
31	Blue (Yellow) Digit 3
32	Blue (Yellow) Digit 2
33	Blue (Yellow) Digit 1
34	Green (Magenta) Digit 4
35	Green (Magenta) Digit 3
36	Green (Magenta) Digit 2
37	Green (Magenta) Digit 1
38	Red (Cyan) Digit 4
39	Red (Cyan) Digit 3
3A	Red (Cyan) Digit 2
3B	Red (Cyan) Digit 1
3C	Visual Digit 4
3D	Visual Digit 3
3E	Visual Digit 2
3F	Visual Digit 1
40	Print Key
41	Mem Key
42	Yel Key
43	Time Key
44	Bal Key (6 Key)
45	Mag Key
46	Dif Key
47	Den Key
48	Cyn Key
49	F Key
4A	All Key
4B	Vis Key
4E	*Read Key

*The Read Key can only be used for momentary READ action.

The following is a list of the modifiers to be used with various keys or control registers.

Modifier	Keys or Control Register	Remarks
01 thru FF	Tone Timer	Least significant bit= 10ms of tone

0-F	0-F	Color	To be used if more than one color on at a time is needed.
MSB	LSB		
X I X I AUTO I 0	VIS I RED I GRN I BLU		
X=Don't Care			

INT I PRESSED I X I X DEBOUNCE COUNTER	Any Key	Use an ASCII "C3" as the modifier for a key depression. C3= Pressed Key, not yet serviced.

0-F	0-F	Digits 1 thru 4 of any color	Used to write messages to the display.
MSB	LSB		
DP I g I f I e	d I c I a I b		
		1 is left most digit 4 is right most digit	Any segment can be ON or OFF

Remote Control Switches and Selects

("1", "2", "3", "4", or "5" is the Action Code and its prefix of "ON,"
"OFF," "0", "1", or "2" is used instead of an ADDRESS and
MODIFIER.)

ON1	Read + Light Source	Turns on Light Source and forces a "READ"
OFF1	Read + Light Source	Turns off Light Source and disables a "READ"
ON2	Keys On	Enables keys on the unit to be function
OFF2	Keys Off	Disables all keys except the "READ" button
ON3	Display On	Enables the displays
OFF3	Display Off	Disables the 7-segment displays, but leaves the side annunciators on
ON4	Transmit at EOC ON	Enables a transmit of data at the end of every A/D conversion
OFF4	Transmit at EOC OFF	Disables a transmit of data at the end of every A/D conversion
0S	Transmission Status M	Turns on the Transmission Status M mode of operation
1S	Reflection	Turns on the Reflection mode of operation
2S	Transmission Status A	Turns on the Transmission Status A mode of operation

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Serial Input Notes

Additionally, the following is required in order to use the serial input:

1. The baud rate of the serial input must be the same as the densitometer uses for serial output.

2. Data shall be transmitted with one start bit (logic 0) and one or two stop bits (logic 1) added to the data (7 bits of ASCII).

   The parity bit is set to zero. The logic 1 (marking) condition of the data signal is defined to be between 0 and 15V. The logic 0 (spacing) condition of the data signal is defined to be between 2.4 and +15V.

3. Each "Write" action to a Key Address must be followed by "G" "LF" because the densitometer must process each "keystroke" one at a time. An exception to this rule is while writing to the displays. After each "W" "LF" the display digit addressed shows the newly written character. When "G" "LF" is finally sent the display returns to its original state.

4. After each "READ" action, the contents of the selected address are sent out of the serial output, most significant character first. Also, multiple "READs" do not require multiple "G" "LFs".

5. The Remote Control Switches and Selects are not stored or maintained when power is turned off. The default condition at power up is as follows:

   OFF1
   ON2
   ON3
   OFF4

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Maintenance

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GENERAL

The X-Rite 310 Densitometer is covered by a one-year limited warranty (excluding lamps and bulbs), and should be referred to the factory or authorized repair station for repair within this warranty period. Attempts to make repairs within this time frame may void the warranty.

Factory Repair

X-Rite recognizes the need to provide complete technical repair services to its customers. Because of the complexity of this unit's circuitry, all circuitry repairs should be referred to the factory or to an authorized repair station.

X-Rite will repair any 310 submitted past warranty. Shipping costs to the factory or authorized repair station shall be paid by the customer, and the instrument shall be submitted in its special carton as a complete, unaltered unit.

LAMP AND BULB REPLACEMENT

There are separate lamp and bulb replacement procedures for the Transmission Densitometer and the Reflection Head.

Transmission Tungsten Halogen Lamp Replacement

IMPORANT: Disconnect the line cord from power receptacle before replacing bulb.

A spare Halogen Lamp Assembly (P/N 310-60) is provided for the Transmission Densitometer. Should the lamp fail, replace as follows:

1. Disconnect line cord.

2. Set unit upside down and remove the larger bottom cover by removing the three screws located in the front portion of the cover.

3. Unplug lamp connector from circuit board (located under small bottom cover).

4. Remove lamp assembly by removing the two Phillips-head screws and washers from the bottom of lamp assembly, then discard the lamp assembly.

5. Fasten new lamp assembly in place with two Phillips-head screws, and two flat washers supplied with lamp.

6. Plug lamp connector into circuit board.

Alignment check:

7. Set unit upright, plug line cord into wall receptacle, then turn power switch "on."

8. Locate your calibration step tablet. Using the 3mm aperture, center step "3" or "CAL" step over aperture.

9. Look at the light coming through the round aperture. The lamp's filament will appear as a square in the middle of the aperture.

10. If lamp is properly aligned, unplug line cord, turn unit upside down, then fasten bottom cover in place with three screws removed in step 2. If lamp is *not* properly aligned, proceed with the following steps.

11. **Unplug line cord**, then loosen the two screws in the bottom of the lamp assembly.

12. Set front half of unit over edge of table, then plug line cord into wall receptacle.

13. Carefully move lamp assembly until lamp filament is centered with aperture. Repeat steps 8 through 10.

Reflection Tungsten Halogen Lamp Replacement

A spare reflection halogen lamp assembly is included with the Reflection Head for models 310TR. Should the lamp fail, replace as follows:

1. Remove the top cover from the Reflection Head by removing the four Phillips head screws from the nameplate.

2. Locate the lamp assembly toward the front of the head and unplug the burned-out lamp assembly.

3. Remove the two long screws holding the lamp assembly and remove the assembly from the optics column.

4. Fasten the new lamp assembly onto the optics column with the two long screws removed in Step 3.

   NOTE: Make sure the new lamp surface is clean. Remove smudgemarks with alcohol and a lint-free cloth or cotton swab.

5. Mate the lamp assembly connector with the contact pins from which the old lamp assembly was removed.

6. Fasten the top cover to the reflection head using the four screws removed in Step 1.

   NOTE: The lamp assembly is prealigned for optimum performance.

CLEANING OPTICS

There are separate procedures for cleaning the optics on the Transmission Densitometer and on the Reflection Head.

Cleaning Transmission Optics

Clean smudges from the apertures and opal glass on the bottom of the Reading Head Optics with a Q-tip moistened with alcohol. Remove lint and dust with a lens paper.

NOTE: To prevent contamination of the optics, while cleaning the opal glass and apertures always cover the hole where the aperture sets in.

Cleaning Reflection Optics (310TR only)

Dust is the primary cause of reflection density errors. Your 310 Reflection Head has been designed to minimize this problem.

Dust causes light diffusion in the optical bath, and thereby lowers the maximum density the instrument can read. Test for dust errors by verifying accuracy on the darkest step of the reference check plaque. Make sure the reference is clean.

Should dust or lint errors be detected, clean the optics as follows:

1. Remove dust and lint from the target window by wiping it with a moist, lint-free cloth.

2. Remove dust and lint in the optics by removing three screws that hold the sensor nose on the bottom of the Reflection Head Optics Assembly. Brush away the dust with a camel hair brush and re-fasten the nose with the three screws.

FUSE REPLACEMENT

To replace the fuse, locate the fuseholder at the rear of the 310 and replace as follows:

1. Remove the fuseholder cap by pushing it in, rotating counter-clockwise, then pulling the cap off.

2. Pull out the bad fuse and replace with a new fuse of the appropriate rating, which is listed on the label near the fuseholder.

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