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INSTRUCTION MANUAL

H U N T E R L A B

45°/0°

D 2 5 - P C 2 Δ

C O L O R I M E T E R

HUNTER ASSOCIATES LABORATORY, INC.
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Revision 1.7
7/87

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SECTION 1 - INTRODUCTION

The D25-PC2Δ colorimeter is compact in design and simple to operate. Software capabilities and proven optical design combine with Hunter-Lab's pre-eminence in the field of applications engineering to produce a colorimeter of superior performance. The D25-PC2Δ system includes an optical sensor, a sensor interface unit (SIU), and the Epson HX-40 personal computer.

The A and AA optical sensors use 45° incident light on the sample plane. Viewing is at 0° through a light receptor that is placed directly above the sample area. The reflected light is filtered to closely approximate CIE 2° Standard Observer for Illuminant C. This geometry excludes specular reflection from measurement. Electrical signals are directed by cable to the SIU, passed to the analog-to-digital converter and then to the personal computer.

The L and M optical sensors direct light through an infrared heat absorbing filter and onto the center section of the interior which is composed of faceted annular mirror rings. From these rings the light is reflected uniformly from many directions onto the sample at an average angle of 45° from the perpendicular. Viewing is at 0° via a light receptor that is placed directly above the specimen area. The reflected light is filtered to closely approximate CIE 2° Standard Observer for Illuminant C. This geometry excludes specular reflection from measurement and essentially eliminates the effect of directionality. Electrical signals are directed by cable to the SIU, passed to the analog-to-digital converter and then to the personal computer.

CIE XYZ and either Hunter L,a,b or CIE 1976 L*a*b* color scales are standard. Color differences from a product standard may also be computed in any of these scales using standard software.

Before using the D25-PC2Δ seriously, this entire Instruction Manual should be studied. However, to appreciate how easy the D25-PC2Δ is to use, and to get a feel for the simplicity of its logic, turn to Section 4 of the manual and follow carefully the directions for preparing the instrument for operation. Section 2 of the manual is a checklist of items furnished.

Now that you have a feel for the ease, rapidity and simplicity of operation of your D25-PC2Δ Colorimeter, let it complete its warmup period while you finish reading and studying this Instruction Manual. If you familiarize yourself with the Manual, giving particular attention to the list of keyboard functions (Sec 10.1), you will be able to envision how your D25-PC2Δ Colorimeter can answer some of your particular needs in ways that have not even been mentioned in this manual of standard operating procedures.

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There are a few things to be aware of which are not immediately obvious when reading the step-by-step operating procedures. First of all, although instrument calibration is usually the first step of any procedure it is not necessary to restandardize after initial standardization more often than once or twice a day. The use of certain options requires recalibration but this is made clear in the section of this manual describing that option.

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SECTION 2 - CHECKLIST

Serial Number 15612 Date 8/3/87

2.1 D25-PC2A Basic Instrument System

X Epson Personal Computer including system unit, cables, recharging power unit and documentation HX-40 code Serial# 015824 AA

X D25A Optical Sensor: 45° illumination, 0° viewing, 2 inch (51mm) diameter sample area

____ D25AA Optical Sensor: 45° illumination, 0° viewing through an optical fiber beam splitter, 2 inch (51mm) diameter sample area

____ D25L Optical Sensor: 45° circumferential illumination, 0° viewing, 3.75 inch (95mm) diameter sample area

____ D25M Optical Sensor: 45° circumferential illumination, 0° viewing through an optical fiber beam splitter, 2 inch (51mm) diameter sample area

X Sensor Interface Unit: 100, 120, 220 or 240 VAC +10%; single phase; 50/60 Hz; 200 VA maximum. Set for 120 VAC

2.2 Tridimensional Scales

X Standard - Hunter L,a,b and CIE X,Y,Z with component differences for Illuminant C, 2° Standard Observer

or

____ Standard - CIE 1976 L*a*b* (CIELAB) and CIE X,Y,Z with component differences for Illuminant C, 2° Standard Observer

or

____ Standard - CIE Y,x,y and CIE X,Y,Z with component differences for Illuminant C, 2° Standard Observer

or

____ Standard - Hunter Rd,a,b and CIE X,Y,Z with component differences for Illuminant C, 2° Standard Observer

____ Optional - Hunter L,a,b, CIE 1976 L*a*b* (CIELAB), CIE Yxy or Hunter Rd,a,b depending upon standard scales selected above, for Illuminant C, 2° Standard Observer

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_____ Optional - Hunter ΔE, ΔC; Rd,a,b ΔE, ΔC; CIELAB ΔE*, ΔC*, ΔH* depending upon scales selected above; for Illuminant C, 2° Standard Observer

2.3 Optional Software

_____ D25-2WI Whiteness Index per AATCC 110 and ASTM E 313

_____ D25-2YI Yellowness Index per ASTM D 1925

_____ D25-2CR Opacity (Contrast Ratio)

_____ D25-2TPC Tomato Product Color Indices per USDA calculations, includes 2.5 in. (64mm) diameter round sample cell with optically clear glass bottom, sample cup port holder assembly and tomato color standard calibrated for Hunter L,a,b and CIE XYZ.

_____ D25-2B_T TAPPI Brightness per TAPPI Method T-452, includes TAPPI filter, Optical Sensor Option D25-2RAI Reduced Area Illumination and calibrated B value on white standard

_____ D25-2Z Brightness (Z%)

_____ D25-2EXC External Communications Software

_____ D25-2TS1 Transfer Standard Storage for 1 Standard

_____ D25-2TS2 Transfer Standard Storage for 10 Standards

_____ D25-2PS Product Standard Storage for 10 Product Standards

_____ D25-2AVG Averaging

_____ D25-2IBM IBM Interface

2.4 Other Options

_____ D25-2RAI Reduced Area Illumination

_____ D25-2SAA Small Area Measurement includes Option D25-2LS and requires Option D25-2RAI

_____ D25-2RAV Reduced Area Viewing for A, AA or M optical sensor, includes Option D25-2LS

_____ D25-2RAL Reduced Area Viewing for L optical sensor, includes Option D25-2LS

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_____ D25-2UVA Internal Ultraviolet Absorbing Filter for A and AA optical sensors

_____ D25-2UVM Internal Ultraviolet Absorbing Filter for L and M optical sensors

_____ D25-2LS External Photodetector Output Adjustment with knobs in lieu of screw adjust type normally supplied

_____ D25-2SIU Additional Sensor Interface Unit

_____ D25-2SW Dual Sensor Serial Interface Switch

_____ D25-2SB Standby Box

_____ D25-2XLC Extra Length SIU and Sensor Interconnecting Cables (pair)

2.5 Packed in Standards Box

STANDARDS ILLUMINANT C 1931 CIE 2° Observer		CALIBRATED VALUES X	Y	Z	VALUES READ AT FACTORY X	Y	Z	Xa Xb
White	C2-27282	84.08	86.08	101.51	84.1	86.1	101.5	.2225
Pink	C2-27283	46.5	41.7	39.3	46.8	42.0	39.5	
Green	C2-27284	37.1	44.0	44.5	37.7	44.5	45.1	
Yellow	C2-27285	60.2	61.8	41.3	60.8	62.1	41.9	
Blue	C2-27286	38.7	42.1	62.8	38.9	42.5	63.1	
Gray	C2-27287	10.9	11.0	13.6	11.0	11.1	13.7	

YI = -0.3 W = 85.6 Z% = NA B_T = NA

__X__ White Uncalibrated Back-up Tile

__X__ Uncalibrated Black Glass

__X__ Card showing Standard Calibrated Values and Values Read at Factory

__X__ Spare Quartz-Halogen Lamp, Clear Bulb for A, AA, L Sensors (Part #02638300)

or

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_____ Spare Quartz-Halogen Lamp, Frosted Bulb for M Sensor (Part #02638302)

__X__ 3 Amp Slo-Blo Fuse (100 or 120 VAC operation) (Part #13260030)

or

_____ 1.5 Amp Slo-Blo Fuse (220 or 240 VAC operation) (Part #13260016)

__X__ SIU Test Plug

__X__ Standard Cleaning Procedure

__X__ Lens Brush (Part #2000010)

__X__ Trimpot Adjusting Tool (Part #3897500)

__X__ Bottle of Anti-static Lens Cleaner

__X__ Set of Allen Wrenches

_____ Cover Glass Port Insert Assembly, 6mm (Part #02662401) (Optional)

_____ Cover Glass Port Insert Assembly, 12mm (Part #02662405) (Optional)

_____ Cover Glass Port Insert Assembly, 25mm (Part #02662409) (Optional)

_____ Cover Glass Port Insert Assembly, 51mm (Part #02662400) (Optional)

_____ Sample Port Insert, 6mm (Part #04662300) (Optional)

_____ Sample Port Insert, 10mm (Part #04662303) (Optional)

_____ Sample Port Insert, 13mm (Part #04662305) (Optional)

_____ Sample Port Insert, 16mm (Part #04662307) (Optional)

_____ Sample Port Insert, 19mm (Part #04662308) (Optional)

_____ Sample Port Insert, 25mm (Part #04662309) (Optional)

_____ Sample Port Insert, 32mm (Part #04662310) (Optional)

_____ Sample Port Insert, 38mm (Part #04662311) (Optional)

_____ Sample Port Insert, 51mm (Part #04662312) (Optional for type L sensor only)

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_____ Capsule Shape Port Insert for 0.75 in. x 0.25 in. (19mm x 6mm) samples (Part #04662001) (Optional)

_____ Wet Sample Port Insert, 51mm diameter port with 4mm 'lip' for sample contact (Part #04662100) (Optional)

_____ Sample Cup Port Holder Assembly, 64mm diameter (Part #04662200) (Optional)

__X__ Cover Glass for A, AA or M Sensors (Part #12000020)

_____ Cover Glass for L Sensor (Part #12000120)

2.6 **Packed Separately**

__X__ Spring loaded Sample Positioning Device (Part #02836400)

_____ Sample Cell - 2.5 in. (63.5mm) diameter round plastic body with optically clear glass bottom (Part #13851210) (Optional)

_____ Sample Cell - 2.5 in. (63.5mm) diameter round all glass body and bottom for use with highly solvent liquids (Part #04720900) (Optional)

_____ Sample Dish - 5 inch (130mm) diameter round x 2 inch (51mm) all glass body and bottom (Part #04776700) (Optional)

_____ Cover, Sample Cup (Part #0440000) (Optional)

_____ Transmittance Ring and Disk Set (Part #13851209) (Optional)

__X__ Power Cord (Part #10000050)

__X__ 25 Pin Connector Signal Cable Extension (Part #13590104)

_____ Heater Assembly (Part #04220700) (Optional)

_____ P.C. Board Assembly, Photodetector Output (Screw adjust) (Part #02637603) (Optional)

_____ P.C. Board Assembly, Photodetector Output (Long shaft trimpots) (Part #02637602) (Optional)

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2.7 Final D25-PC2 Calibration Data

Photodetector Block Temperature 100°F (38°C)

Cyclic Redundancy Check (CRC) 15160

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SECTION 3 - SPECIFICATIONS

3.1 Instrument Specifications

3.1.1 General

1. Physical Characteristics

A and AA Optical Sensors (measurements include connectors) - 10.2 inch (25.9cm) wide x 10.5 inch (26.7cm) deep x 11.5 inch (29.2cm) high, 19 lb. (8.6kg).

L and M Optical Sensors (measurements include connectors) - 13.5 inch (34.4cm) wide x 15 inch (38.1cm) deep x 14.5 inch (36.8cm) high, 23.2 lb. (10.5kg).

Epson HX-40 - 11.5 inch (29.2cm) wide x 8.5 inch (21.6cm) long x 2.5 inch (6.4cm) high, 4 lb (1.8kg).

Sensor Interface Unit - 14.25 inch (36.2cm) wide x 8.5 inch (21.6cm) deep x 6.5 inch (16.51cm) high, 18 lb (8.2kg).

2. Power Required

Standard - 100, 120, 220, or 240 VAC ± 10%; single phase; 50/60 Hz; 200 VA maximum.

3.1.2 Conditions of Illumination and View

1. Size of sample

Unlimited with optical sensor mounted port up
Maximum with optical sensor mounted port down -
  A and AA optical sensors: 4.25 inch (11cm) from edge to center line of beam
  L and M optical sensors: 6.5 inch (16.5cm) from edge to center line of beam
Maximum with optical sensor unmounted - Limited by cable length

2. Diameter of opening in port

2.00 inch (51mm) (A sensor)
2.00 inch (51mm) (AA sensor)
3.75 inch (95mm) (L sensor)
2.00 inch (51mm) (M sensor)

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3. Intensity of illumination

900 foot candle (A sensor)
900 foot candle (AA sensor)
350 foot candle (L sensor)
1000 foot candle (M sensor)

4. Incident beam

A and AA optical sensors:
Two opposing incident beams
Average angle - 45° to the sample normal
Subtended (field) angle - 7°

L and M optical sensors:
Completely circumferential incident beams
Average angle - 45° to the sample normal
Subtended (field) angle - 22°

5. Reflected (viewing) beam

Average angle - 0° to the sample normal
Subtended (field) angle -
A and AA optical sensors: 11°
L and M optical sensors: 24°
Specular reflectance excluded

6. Detector System

Four solid state silicon diode detectors
Four broad band filters (tristimulus Y,Z,X amber and X blue)
Spectral response adjusted for average daylight, designated as Illuminant C by CIE specifications

3.1.3 Sensitivity and Data Display

Sensitivity adequate for measurement of diffuse reflectance as low as 1%.

Data display resolution - 0.1% of full scale. Four significant figures, maximum value 130.0.

3.1.4 Stability - Instrument Performance

Drift from standardization point, for a properly maintained instrument, should be no more than ± 0.1 Hunter L, a, or b units in one hour, or ± 0.3 in three hours when operated under the following conditions:

1. Instrument operating under conditions specified in Sec. 4.

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2. Instrument properly warmed up, standardized, and test run with uncalibrated white tile in position at the sample port.

3. Power source should be a stable, instrument grade line.

3.1.5 Precision and Accuracy

The repeatability, reproducibility and accuracy specifications listed below are based on properly operated and maintained instruments. Guidance for operating and maintaining the instrument will be found in the appropriate sections of the instruction manual. These specifications apply to all samples except those which are highly chromatic (more than 25 units from zero in 'a' or 'b' dimension).

1. Precision - Repeatability and Reproducibility

   Color values are REPEATABLE to a standard deviation of 0.1 L,a,b scale units. Repeatability is the deviation from mean experienced when measuring a single sample on a single instrument.

   Color values are REPRODUCIBLE to a standard deviation of 0.2 L,a,b scale units. Reproducibility is the deviation from mean experienced between instruments of a given type.

2. Accuracy

   Color values are accurate to a root mean square deviation of 0.7 L,a,b scale units. Accuracy is the deviation from an accepted reference level. The accepted reference for HunterLab colorimeters are CIE Illuminant C 1931 2° Observer values assigned to master reflectance standards. These values are computed directly from spectrophotometric measurements.

3.1.6 Basis of Standards Calibration

1. Traceability of Standards Calibration

   HunterLab standards are traceable to measurements at the National Bureau of Standards (USA) and the National Physical Laboratory (Great Britain).

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2. Standard Values

Instrument standard labels show calibration values which are derived by direct comparison to master standards. By using these values the accuracy of the instrument can be determined.

3.2 Measurement Values

Color values as measured on the D25-PC2Δ 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 of January 1, 1969.

1. CIE Tristimulus X,Y,Z Scale

The source-photodetector-filter combination in the D25-PC2Δ Colorimeter is designed to simulate the color matching response functions of the human observer as defined by the 1931 2° Standard Observer.

2. L,a,b Opponent Color Scales (Hunter L,a,b/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

a) The relationships between the Hunter L,a,b Scale and the CIE X,Y,Z Scale for the CIE 1931 2° Standard Observer is as follows:

$$L = 10\,Y^{1/2}$$

$$a = \frac{17.5[(X/0.98041)-Y]}{Y^{1/2}}$$

$$b = \frac{7.0[Y-(Z/1.18103)]}{Y^{1/2}}$$

where: X,Y,Z are CIE tristimulus values

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The Hunter L,a,b total color difference (ΔE) and chromaticity difference (ΔC) is calculated as follows:

$$\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2}$$

$$\Delta C = [(\Delta a)^2 + (\Delta b)^2]^{1/2}$$

where:

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

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

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

b) 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 L*a*b* Scale and the CIE X,Y,Z Scale is as follows:

For values of X/X_n, Y/Y_n, $Z/Z_n > 0.01$

$$L^* = 116(Y/Y_n)^{1/3} - 16$$

$$a^* = 500\,[(X/X_n)^{1/3} - (Y/Y_n)^{1/3}]$$

$$b^* = 200\,[(Y/Y_n)^{1/3} - (Z/Z_n)^{1/3}]$$

where:

1. X,Y,Z are tristimulus values (in %)

2. Xn, Yn, Zn are tristimulus values of the standard illuminant with Yn always equal to 100.00. For CIE Illuminant C the tristimulus values are as follows:

   Xn = 98.04
   Zn = 118.10

   $Y_n = 100.0$

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CIE 1976 a,b Chroma-Differences (ΔC*) and CIE 1976 a,b Hue Difference (ΔH*) and Total Difference (ΔE*) (see Fig. 3-1)

$$\Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

$$\Delta C^* = C^*_{SMP} - C^*_{STD}$$

where $C^* = (a^{*2} + b^{*2})^{1/2}$ and is termed metric chroma

$$\Delta H^* = [(\Delta E^*)^2 - (\Delta L^*)^2 - (\Delta C^*)^2]^{1/2}$$

ΔE* is the same quantity as that described in a) above, using 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 standard, as described in a polar coordinate system.

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 h° = arc tan (b*/a*).

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.

For the significance of ΔH* in terms of red, green, yellow, or blue differences between standard and sample, refer to Fig. 3-2. To use this diagram:

1. Divide the b* value of the standard by its a* value.

2. Determine in which quadrant the standard is located by reference to the signs of its a* and b* values.

   NOTE: When the sample falls in quadrant 1 and the standard falls in quadrant 4 (or vice versa) add 360° to h° sample (or h° standard) before determining the sign.

3. Use the value found in #1 to determine the block letter of the standard within its quadrant.

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4. Read the hue designated for that block. If ΔH* is plus, the hue difference direction is counterclockwise, if minus, it is clockwise.

For example:

For a standard shade with values of a = -5, b = +5, a hue difference from a sample is ΔH* = +0.4

1) b*/a* = +5/-5 = -1.0

2) Negative a value and positive b value places the standard in upper left quadrant.

3) Ratio of -1.0 found in step 1 places the standard in Block D (from -2.414 to -0.414).

4) Since the ΔH* was plus, we read the Block D hue change in the counterclockwise direction. This indicates that the sample is greener and less yellow than standard.

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L^* = CIE 1976 psychometric lightness = $116\ (Y/Y_n)^{1/3} - 16$ (Note 1)

a^* = Red(+) - Green(-) axis = $500\ [(X/X_n)^{1/3} - (Y/Y_n)^{1/3}]$ (Note 1)

b^* = Yellow(+) - Blue(-) axis = $200\ [(Y/Y_n)^{1/3} - (Z/Z_n)^{1/3}]$ (Note 1)

C^*_{ab} = CIE 1976 a,b chroma = $(a^{*2} + b^{*2})^{1/2}$

h_{ab} = CIE 1976 a,b hue-angle = $\arctan (b^*/a^*)$

ΔH^*_{ab} = CIE 1976 a,b hue-difference = $[(\Delta E^*_{ab})^2 - (\Delta L^*)^2 - (\Delta C^*_{ab})^2]^{1/2}$

Δc = Chromaticity difference in a*b* plane = $[(\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$

ΔE^*_{ab} = CIE 1976 L*a*b* color difference formula = $[(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$

Δ = Difference between Sample and Standard

Note 1. Limited to: $X/X_n,\ Y/Y_n,\ Z/Z_n > 0.01$

Where: (1) X,Y,Z are tristimulus values.

(2) X_n, Y_n, Z_n are tristimulus values for the perfect reflecting diffuser for the standard illuminant used with Y_n equal to 100.

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.

LEGENDS FOR FIGURE 3-1

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GRAPHICAL EXPLANATION OF PSYCHOMETRIC COLOR DIFFERENCE TERMS

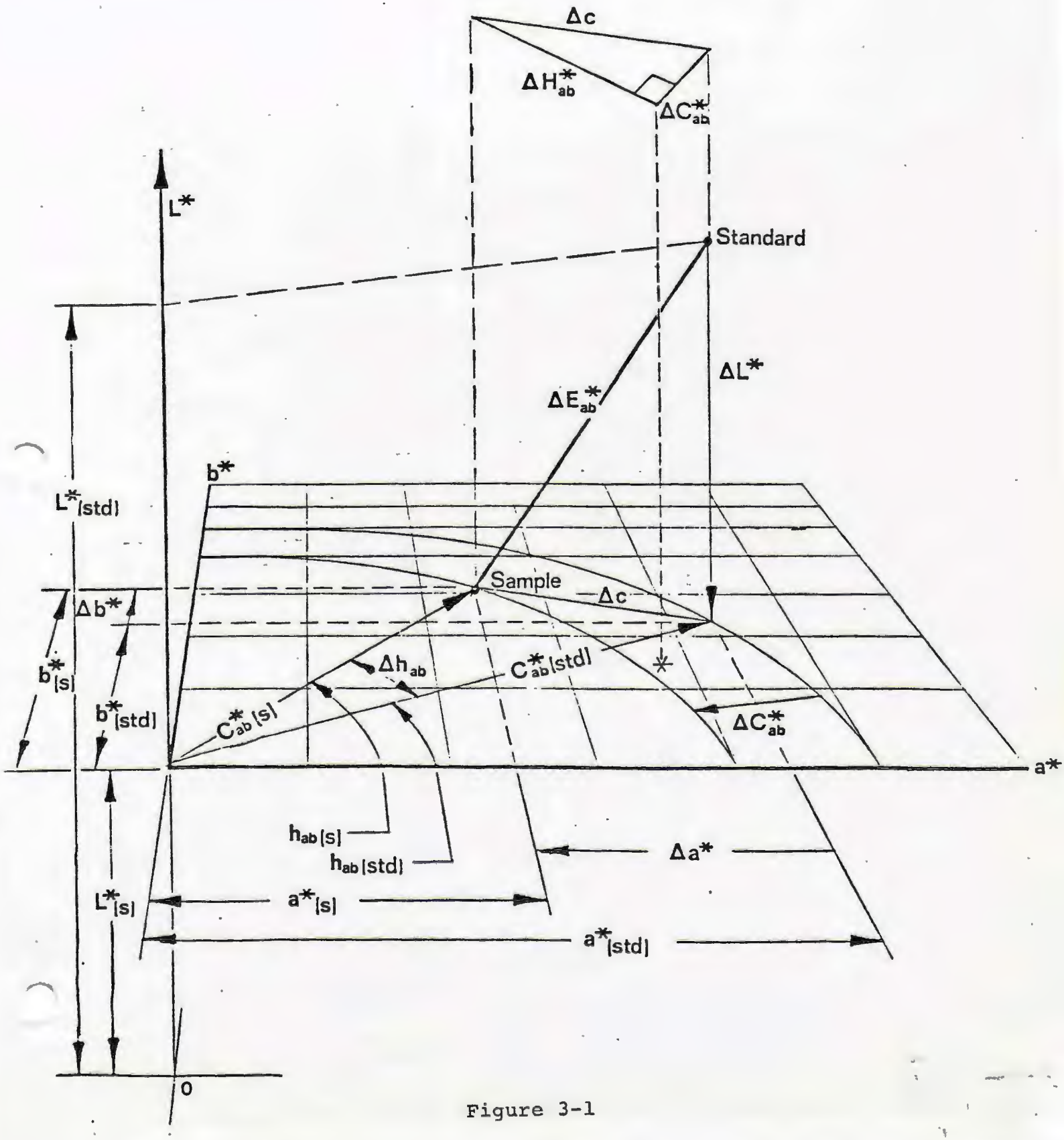


Figure 3-1

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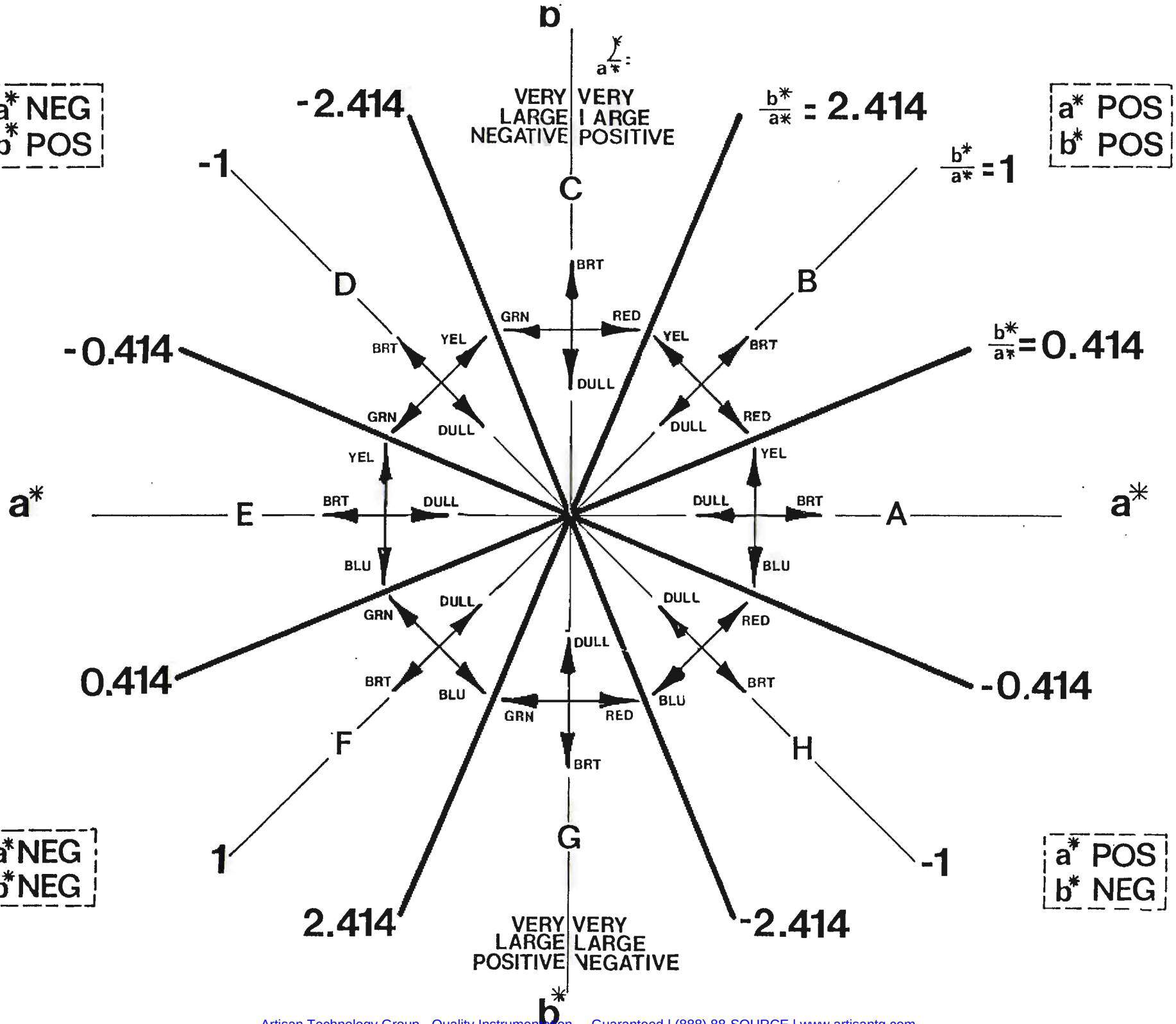


Figure 3-2

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3. CIE Chromaticity Coordinates Y,x,y

The relationship between CIE X,Y,Z values and the x,y, Chromaticity Coordinates is as follows:

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

4. Hunter Rd,a,b Color Scale

The relationship between the Hunter Rd,a,b values and the CIE X,Y,Z values is as follows:

$$Rd = Y$$

$$a = 175\ f(Y)\ (X/98.04 - Y/100)$$

$$b = 70\ f(Y)\ (Y/100 - Z/118.10)$$

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

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SECTION 4 - GETTING STARTED

4.1 Environment

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 30-80% and relatively constant temperature not exceeding 95°F (35°C).

The D25-PC2Δ should be connected to a stable, instrument-grade power line. If other equipment is connected to the same power line as the D25-PC2Δ, a transient power surge may be produced when the other equipment is turned on. If this happens, restandardize the D25-PC2Δ before making measurements.

4.2 Assembly

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.) Refer to Sec. 2 for a checklist of items shipped.

2. Remove the tape covering the sample port of the optical sensor.

3. Connect the Epson to the SIU by inserting the round end of the RS-232C cable into the port labelled 'SERIAL' on the back of the Epson. Insert the other end of the same cable into the connector on top of the SIU.

4. Connect the optical sensor to the SIU by two cables. One cable provides regulated DC power to the lamp, and 115 VAC power to the thermostatically controlled heater mounted in the block that contains the photodetectors. The other cable provides the DC power to the operational amplifiers and feeds the electrical signal from the photodetectors to the SIU. These cables can be connected in only one way, so there is no chance of error in making the interconnection.

5. Place the uncalibrated tile at the reflection port. Leaving the white uncalibrated tile at the sample port when the instrument is not in use helps protect the interior of the sensor from dust.

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6. Next, a check must be made to see if the proper voltage has been set in the SIU. A small card is mounted next to the fuse on the top of the SIU next to the ON/OFF switch. Slide the plastic shield, which covers the fuse and the card, to one side. The voltage designation, which is visible on the card is the one for which the instrument is presently set. If this is not the voltage desired, pull the small lever labeled 'Fuse Pull' and remove the fuse. The card can now be removed (use an Allen wrench to engage the small hole on the edge of the card to pull it out). Hold the card in a vertical position so that the desired voltage is positioned on the top of the card. Replace the card so that the proper voltage is visible through the window. Replace the fuse (a 3 amp Slo-Blo fuse must be used for 100 or 120 VAC operation, and a 1.5 amp Slo-Blo fuse must be used for 220 or 240 VAC operation), and close the plastic cover over the fuse and card.

7. The SIU must now be plugged into a power outlet, as specified in Sec. 2.1. The instrument is equipped with a three-pronged plug and will not operate properly unless it is plugged into a three-hole receptacle for proper grounding.

4.3 Initialization

The steps for initialization must be followed exactly. If there are problems, refer to Sec. 7.4.2.

SIU to OPERATE

1. Place the OPERATE/STANDBY switch on the SIU in the OPERATE position.

Epson on

2. Turn power switch on the right hand side of the Epson system unit to the ON position. Software loading messages will be briefly displayed. Then the white tile values will be placed in the instrument standard register and the following prompt will be displayed:

PLACE THE BLACK GLASS AT THE
SPECIMEN PORT AND
PRESS <READ>

NOTE: If the instrument retains a calibration for more than one sensor, a menu of applicable sensors will be displayed. Press the numeric key that corresponds to the type sensor presently connected to the SIU.

Black glass at port

3. Place the black glass at the sample port, shiny side toward the port.

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<READ>

4. Press <READ>. After the bottom of the scale has been set, the following prompt will be displayed:

'ZEROED'
PLACE THE WHITE STANDARD AT THE
SPECIMEN PORT AND
PRESS <READ>

White tile at port

5. Place the calibrated white instrument tile at the sample port.

<READ>

6. Press <READ>. After the top of the scale has been set, the instrument will be in the measurement mode.

4.4 Special Function Keys

When the D25-PC2A software is loaded into the Epson the special function keys on the top row of the Epson keyboard are primarily used to control the operation of the colorimeter. Refer to Section 10.1 for a detailed description of these function keys.

4.5 Considerations Preparatory to Making Measurements

4.5.1 Standards - Use and Care

It is important that the standards be treated with extreme care. They should be kept in the standards box when not in use. When a standard is used, center it carefully at the sample port. Never use a calibrated tile to back up samples being measured. The uncalibrated white tile may be used as a back-up tile, and is normally left at the sample port during periods of nonuse.

BE SURE STANDARDS ARE CLEAN BEFORE BEGINNING CALIBRATION CHECKS OR MEASUREMENT OF SAMPLES. Use a soft nylon brush and Sparkleen (Fisher Scientific Co. Cat. No. 4-320) water solution (1 tablespoon per gallon), followed by a running hot water rinse. Wipe dry with a clean, nonoptically brightened, lint-free paper towel to remove water marks.

4.5.2 Using A Cover Glass Port Insert (Optional)

A cover glass port insert (optional) is sometimes used when measuring samples that might pillow into the aperture. If a cover glass port insert is to be used during measurement of the sample, it should be in place when the instrument is calibrated. Always remove the cover glass port insert and replace with the standard port insert before making calibration checks (Sec. 4.5.5).

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4.5.3 The Sample Viewing Aperture and Proper Placement of the Sample

The sample area actually being measured can be examined through the viewing aperture in the front of the optical sensor by rotating the cover of the viewing aperture sidewards. Be sure the area measured is representative of your sample. Avoid flaws, fingerprints and irregularities. This aperture should be closed during actual measurement.

4.5.4 Instrument Warm-Up Time

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. At this time, color difference measurements may be made. For the instrument to provide full specified performance an additional warm-up period of 1/2 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 70°F operating area) sufficient time should be allowed for the instrument to stabilize.

4.5.5 Checking Calibration of the Instrument

The tiles supplied in the standards box may be used to check the instrument calibration by comparison with its Values Read at Factory. Zero and standardize the instrument with the standard illuminated area port as described in Sec. 5.1. Read the XYZ values of all five colored standard tiles and compare these values with the Values Read at Factory recorded in Sec. 2.5. It is useful to perform this check weekly and maintain records. If the Y value of the yellow and blue standards have shifted in opposite directions by more than a total of 0.3 units from the Values Read At Factory, see Sec. 7.2.2, Lamp Adjustment. If there are any other variations from Values Read At Factory for any of the standards of more that 0.3 units, see Sec. 7.4.5 Symptoms Involving Calibration Errors.

Any adjustments, such as to the lamp voltage must be followed by restandardization of the instrument before making measurements. STANDARDS MUST BE CLEAN WHEN PERFORMING THIS CHECK.

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4.5.6 Standard Instrument Techniques

When attempting to make repeatable measurements of a sample or when correlating measurements with another laboratory adhere to good analytical practice and use CONSISTENT SAMPLE PREPARATION TECHNIQUES. IN ADDITION, CONSISTENT PRESENTATION OF THE SAMPLE TO THE SAMPLE PORT IS ESSENTIAL.

4.6 Changing Position of Optical Sensor

For best mounting of the samples to be measured, the optical sensor can be positioned with sample port facing either downward or upward. To change from the normal port-up mounting, support the optical sensor, loosen the two knurled knobs holding it to the support post, lift off, invert and remount on the posts.

4.7 Exchanging Optical Sensors

When two optical sensors are supplied for use alternately with the D25-PC2A processor, the optical sensor in use can be exchanged with the alternate optical sensor. Depending on the configuration, the second sensor may be attached to a standby box, a second SIU, or a second SIU with a dual sensor serial interface switch.

NOTE: The calibrated white tile values are stored in the SIU. If two sensors were purchased as part of the original instrument, the SIU will contain the calibration for both sensors. If the second sensor was purchased at a later time, either a PROM was supplied for the SIU for multiple sensors or an additional SIU was also purchased. Therefore, **optical sensors cannot be transferred indiscriminately between SIU's** or the correct white tile values will not be placed in the instrument standard register upon initialization.

4.7.1 Exchanging Connections

A. If the second optical sensor is attached to a standby box, disconnect the two cables (signal and source) on each optical sensor that connect them to the SIU or to the standby box.

   Exchange sensors and make the new connections of the source and signal cables between optical sensor to be used with the SIU, and between the other optical sensor and the standby box.

B. If the second optical sensor is attached to a second SIU, disconnect the RS-232C cable from the SIU for both optical sensors.

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Switch the RS-232C cables between the SIU's and reconnect the RS-232C cables to the appropriate SIU.

C. If the dual sensor serial interface switch is installed, turn the switch on the RS-232 switch box to the appropriate optical sensor.

4.7.2 Initializing New Optical Sensor

1. Make sure that the optics are clean and in correct alignment (see Sec. 7.1.2).

2. Allow the instrument time to stabilize.

3. Follow the initialization routine as described in Sec. 4.3.

4.7.3 Standby Box Fuse

The standby box (optional) is protected by a 1 amp Slo-Blo Fuse. In the event of its failure the standby box will be completely inoperative. If new fuse fails immediately, the standby box should be inspected for burned or shorting wires. DO NOT USE A FUSE OTHER THAN A 1 AMP SLO-BLO FUSE.

4.8 Setting the Time and Date on an Epson HX-40

The following is the step-by-step procedure to be executed to change the time and/or date on the Epson HX-40 computer.

1. Turn off HX-40.

2. Turn HX-40 face down and open the ROM capsule compartment door. This is the door without the backup switch next to it.

3. Press the reset switch, which is visible without moving the plastic cover.

4. Replace the ROM capsule compartment door.

5. Turn HX-40 face up and turn power on.

6. Verify that the SYSTEM INITIALIZE screen is displayed. This screen appears as shown below:

   SYSTEM INITIALIZE

   DATE/TIME (MMDDYYhhmmss) 000000000000

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7. Input the current date and time. When doing this, enter the hour as a number from 0 to 23 (clock uses a 24 hour system). If you accidentally enter an incorrect number, you can correct it by moving the cursor, using the cursor arrow keys [<-] and [->]. After entering the date and time, press the [RETURN] key. This sets the HX-40's calendar/clock. For example, if the date is September 21, 1987, and the time is 16:30:15, enter this as follows:

   SYSTEM INITIALIZE

   DATE/TIME (MMDDYYhhmmss) 092187163015

8. After the date and time have been input, the screen changes as shown below:

   SYSTEM INITIALIZE

   DATE/TIME (MMDDYYhhmmss) 092187163015
   WEEK (0 to 6) 0

   Now enter the day of the week as a number for 0 to 6. Correspondence between numbers and days of the week is as follows:

0	1	2	3	4	5	6
SUN	MON	TUE	WED	THU	FRI	SAT

   For the date above, type 1 for Monday and press the [RETURN] key.

9. Press the [RETURN] key twice more to get the RAM disk and user BIOS sizes to their default values. This ends the system initialization section.

   NOTE: The system may not operate properly if invalid data is entered during system initialization (for example, if 7 is specified for the day of the week). If you press the [RETURN] key after accidentally entering an incorrect number, do system initialization over again from the beginning.

10. Press and hold the [CTRL] key and press the [HELP] key. This allows the SYSTEM DISPLAY to be displayed. At the bottom of the display area are several functions that can be set. We want to enable the πauto startπ feature.

11. Press the [3] key to select the 'auto start' feature. The bottom of the display will change to show the 'auto start' choices.

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12. Press the [2] key to assign an 'auto start' command. The bottom of the display will again change to allow entry of the 'auto start' string.

13. Type the following two characters: '^' and 'M'. These two characters will tell the HX-40 to automatically run the program at power up. Press the [RETURN] key when done. This will return the HX-40 to the SYSTEM DISPLAY menu.

14. Turn the power off on the HX-40. The HX-40 is now ready to be used as before with the new date and/or time.

4.9 Turning D25-PC2Δ Off

The Epson should be turned off whenever it is not in use by first turning off the printer and then turning off the Epson. The SIU should be turned off when it is not to be used for a period of eight hours or more by placing the OPERATE/STANDBY switch on the SIU in the STANDBY position. Turning the SIU to STANDBY will reduce the voltage to the lamp and, therefore, prolong the lamp life. Turn the system off ONLY when information is not being sent to the SIU, i.e. when the processor is waiting for instructions.

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SECTION 5 - OPERATION OF INSTRUMENT

5.1 Complete Standardization

This routine initiates complete standardization on a black glass and on the calibrated white instrument standard. This procedure may be used when the last used instrument standardization is uncertain or to set both the top and bottom of the scale.

<STDZ> 1. Press <STDZ> to display the following prompt:

PLACE THE BLACK GLASS AT THE
SPECIMEN PORT AND
PRESS <READ>

Black glass at port 2. Place the black glass at the sample port, shiny side toward the port.

<READ> 3. Press <READ>. After the bottom of the scale has been set, the following prompt will be displayed:

'ZEROED'
PLACE THE WHITE STANDARD AT THE
SPECIMEN PORT AND
PRESS <READ>

White tile at port 4. Place the calibrated white instrument tile at the sample port.

<READ> 5. Press <READ>. After the top of the scale has been set, the measurement screen will be displayed.

5.2 Checking Standardization

Before and after making critical measurements it is advisable to check instrument standardization. See Sec. 4.5.5 to check the calibration.

<SCALE> 1. Press <SCALE>. If there are only two scales, the key will toggle between them. Otherwise, a menu of the color scales installed in the instrument will be displayed.

XYZ Scale 2. Select XYZ scale.

Black glass at port 3. Place the black glass at the port.

<READ> 4. Press <READ>. The displayed XYZ values should be close to 0.0.

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White tile at port	5.	Place the calibrated white standard at the port, centered and with the label away from the port.
<READ>	6.	Press <READ>. The displayed XYZ values should be close to the Values Read at Factory as listed in Sec. 2.5. If not, rezero and restandardize.

5.3 Measuring the Color of a Sample

Standardize instrument	1.	Before taking any measurements, standardize the instrument (Sec. 5.1) and turn on the printer.
<SCALE>	2.	Press <SCALE>. If there are only two scales, the key will toggle between the two. Otherwise, a menu of the color scales installed in the instrument will be displayed.
<2>	3.	Press the numeric key which corresponds to the desired scale, <2> for example.
<INDEX>	4.	Press <INDEX>. A menu of indices installed in the instrument will be displayed.
<1>	5.	Press the numeric key which corresponds to the desired index, <1> for example.
Place sample at port	6.	Place the sample which is to be measured over the sample port.
<READ>	7.	Press <READ>. The values for the sample will be displayed in the current color scale.
<PRINT>	8.	Press <PRINT> to print the color values of the sample.
Sample at port	9.	Place a second sample at the sample port.
<READ>	10.	Press <READ>. The values for that sample will be displayed.
<SCALE>	11.	To change the color scale for which the color values are calculated, press <SCALE> and select the desired scale.
<PAPER FEED>	12.	To advance the paper, press <PAPER FEED> or gently pull the paper out.

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5.4 Making Color Difference Measurements

The instrument can be used for direct display of color differences between a desired standard color and samples. The D25-PC2Δ can measure the color values of a standard, measure the color values of a sample, compare them and compute their differences.

NOTE: Calculations are carried out to a higher precision internally than is displayed. This may result in an occasional display of delta values that may deviate by 0.1 from the calculated delta of the sample and standard values displayed.

Standardize instrument	1.	Before taking any measurements, standardize the instrument (Sec. 5.1) and turn on the printer.
‹SCALE›	2.	Press ‹SCALE›. If there are only two color scales, the key will toggle between the two. Otherwise, a menu of the color scales installed in the instrument will be displayed.
‹2›	3.	Press the numeric key which corresponds to the desired scale, ‹2› for example.
‹INDEX›	4.	Press ‹INDEX›. A menu of indices installed in the instrument will be displayed.
‹1›	5.	Press the numeric key which corresponds to the desired index, ‹1› for example.
Place sample at port	6.	Place the sample which is to be measured over the sample port.
‹READ›	7.	Press ‹READ›. The values for the sample will be displayed in the current color scale.
‹DELTA›	8.	Press ‹DELTA›. The current reading will be set as the working product standard and will display the initial delta values as zeros.
Place sample at port	9.	Place the sample which is to be measured at the sample port.
‹READ›	10.	Press ‹READ›. The delta values will be updated and will display the difference between the sample reading and the standard reading. If the Total Color Difference option (ΔE, ΔC and/or ΔE*, ΔC*, ΔH*) is installed, these values will be displayed with the component delta values.
‹PRINT›	11.	Press ‹PRINT› to print the color difference values of the sample.

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Place sample at port	12.	Place another sample at the port.
<READ>	13.	Press <READ>. The sample and delta values for that sample will be displayed. **CAUTION: Once the delta mode has been turned off, the reference point will be lost.** When DELTA is pressed again, the values that are currently in the sample register will be set as the product standard and the deltas will be displayed as zeros.
<PAPER FEED>	14.	To advance the paper, press <PAPER FEED> or gently pull the paper out.
<SCALE>	13.	To change the color scale for which the color values are calculated, press <SCALE> and select the desired scale.

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SECTION 6 - MORE ON STANDARDIZATION

6.1 Top of Scale Standardization

If the values displayed when viewing the values of the white tile are not those shown on the back of the white calibrated standard, the white standard is not the standard whose assigned calibrated values have been stored in the white standard register.

The white standard can still be used for standardization by entering its X,Y,Z and X function blue/amber ratio values into the working register. This method replaces the current instrument white tile standardization and SHOULD ONLY BE USED TO SET THE TOP OF SCALE.

This section is used ONLY when a white standard other than the calibrated white standard supplied with the instrument is being used for standardization of the instrument. Since this white standard will have no calibrated blue/amber ratio assigned to it, it will be necessary to determine the proper blue/amber ratio.

NOTE: Calculations are carried out to a higher precision internally than is displayed. When entering data, up to five significant figures may be entered.

Standardize instrument

1. Standardize the instrument as described in Sec. 5.1.

<DIAG>

2. Press <DIAG> to display a menu which includes diagnostic routines and viewing instrument standards:

```
ADDITIONAL CAPABILITIES

PRESS <1> DIAGNOSTICS
      <2> VIEW STANDARD
      <3> TOP OF SCALE STANDARD
      <ESC> EXIT
```

<3>

3. Press <3>. The following message will be displayed:

```
CURRENT TOP OF SCALE STANDARD VALUES

   X=  0.0          b/a= .0000
   Y=  0.0
   Z=  0.0

PRESS <1> ENTER TOP OF SCALE STANDARD
      <ESC> EXIT
```

<1>

4. Press <1> to enter the top-of-scale values.

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'80.5'	5.	Key in the first value for the standard, 80.5 for example. If an incorrect value is entered, press the HOME/BS key to delete the mistaken number. Correct the entry by keying in the correct value. NOTE: If an entry is six characters (including '-' and '.'), do not press <RETURN>.
<RETURN>	6.	Press <RETURN>. Prompting for the second value will be added to the display.
'82.2' <RETURN>	7.	Key in the second value for the standard, 82.2 for example, and press <RETURN>. That value plus prompting for the third value will be added to the display.
'95.4' <RETURN>	8.	Key in the third value for the standard, 95.4 for example, and press <RETURN>. That value plus prompting for the B/A ratio will be added to the display.
'.2300' <RETURN>	9.	Key in a trial B/A ratio, .2300 for example, and press <RETURN>.
<ESC>	10.	Press <ESC> to return to the additional capabilities menu.
<ESC>	11.	Press <ESC> to return to the measurement mode.
<STDZ>	12.	Press <STDZ> to initiate standardization on the entered top-of-scale standard.
Black glass at port	13.	Place the black glass at the port.
<READ>	14.	Press <READ>.
Place standard at port	15.	Place the white tile transfer standard at the sample port.
<READ>	16.	Press <READ>. The instrument will then return the operator to the measurement screen. The instrument will be standardized on the keyboard entered values of the white standard at the port. NOTE: The instrument will standardize on the top-of-scale standard whenever standardization is initiated until a value of '0.00' is entered into the B/A ratio of the top-of-scale standard.

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Read 'X' value for yellow and blue standards

17. Center the yellow standard at the sample port and read the 'X' value. Then center the blue standard at the port and read its 'X' value. If the 'X' readings of the two standards have shifted from the Values Read At Factory by more than a total of 0.3 units, an adjustment is necessary. For example, if the yellow 'X' reading is off by 0.2 in the minus direction in reference to its Values Read At Factory and the blue 'X' reading is off by 0.3 in the plus direction, the total offset is 0.5 and adjustment is necessary since there is too much blue in the response.

NOTE: If the yellow 'X' value was off in the plus direction and the blue was off in the minus direction, than the situation is reversed (i.e., too little blue response). The B/A ratio should be increased in this case.

<CALIB> Repeat steps 3-11

18. Press <DIAG> and repeat steps 3 through 11 above for entering values for a white tile transfer standard. Enter a reduced ratio, '.2200' for example.

Repeat steps 12-16

19. Restandardize on the transfer standard as described in steps 12 through 16.

Repeat step 17

20. Repeat step 17, above. If the 'X' values of the yellow and blue standards are still too far from the Values Read At Factory, try entering a still lower B/A ratio, restandardize on the white transfer standard and read the tiles again. Repeat until the 'X' readings of the blue and yellow tiles are within tolerances.

6.2 View Standard Values

<DIAG>

1. Press <DIAG> to display a menu which includes diagnostic routines and viewing instrument standards:

```
ADDITIONAL CAPABILITIES

PRESS <1> DIAGNOSTICS
      <2> VIEW STANDARD
      <3> TOP OF SCALE STANDARD
      <ESC> EXIT
```

<2>

2. Press <2> to display a menu of standard that may be displayed. After selecting this choice, the following menu will be displayed:

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VIEW STANDARD MENU

PRESS <1> WHITE STANDARD
<2> BLUE STANDARD
<3> YELLOW STANDARD
<ESC> EXIT

3. Press the numeric key that corresponds to the desired standard.

6.2.1 White Standard

<1>

1. While in the standards menu, press <1> to display the values of the white instrument standard for which the instrument is calibrated. The values will be displayed in the following format:

CURRENT WHITE STANDARD VALUES

X=
Y=
Z=
b/a=

PRESS <ESC>TO EXIT

<ESC>

2. Press <ESC> to return to the standards menu.

<ESC>

3. Press <ESC> to return to the additional capabilities menu.

<ESC>

4. Press <ESC> to exit to color measurements.

6.2.2 Blue Standard - Values Read at Factory

<2>

1. While in the standards menu, press <2> to display the Values Read at Factory of the blue instrument standard. The values will be displayed in the following format:

CURRENT BLUE STANDARD VALUES

X=
Y=
Z=

PRESS <ESC> TO EXIT

<ESC>

2. Press <ESC> to return to the standards menu.

<ESC>

3. Press <ESC> to return to the additional capabilities menu.

<ESC>

4. Press <ESC> to exit to color measurements.

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6.2.3 Yellow Standard - Values Read at Factory

<3> 1. While in the standards menu, press <3> to display the Values Read at Factory of the yellow instrument standard. The values will be displayed in the following format:

CURRENT YELLOW STANDARD VALUES

X=
Y=
Z=

PRESS <ESC> TO EXIT

<ESC> 2. Press <ESC> to return to the standards menu.

<ESC> 3. Press <ESC> to return to the additional capabilities menu.

<ESC> 4. Press <ESC> to exit to color measurements.

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SECTION 7 - MAINTENANCE AND TROUBLESHOOTING

7.1 Maintenance

The instrument should be operated under conditions described in Sec. 4.1. Check the calibration of the instrument as described in Sec. 4.5.5. When not in use, the line cord may be left connected to power for convenience. The OPERATE/STANDBY switch should be placed in the STANDBY position with the uncalibrated white tile at the sample port. If these conditions are met, maintenance will generally be limited to lamp replacement and the cleaning of air filters. In areas of heavy dust or contamination, the instrument should be regularly cleaned externally. See Figures 1 and 2 for diagrams of sensors.

7.1.1 Source Lamp

The type DZA low voltage halogen cycle lamp used in this instrument has an operating life of approximately 1000 hours in operating condition. The instrument was calibrated with a lamp voltage of between 8.5 to 10.5 volts to produce an approximate color temperature. When the lamp is approaching the end of its useful life, the light output may fluctuate causing equivalent fluctuations in the instrument readout.

To change the source lamp

1. Unplug the SIU.

2. Remove any samples from the sample port.

3. For the A and AA optical sensors: Remove the lamp cover from the condensing lens housing by removing the two knurled thumbscrews and washers.

   For the L and M optical sensors: Remove the finned lamp heat sink assembly by depressing the two push-to-release/push-to-fasten fasteners. Remember the orientation of the heat sink and old lamp assembly as they MUST be replaced in the same manner.

4. Separate the lamp leads connector from the source lamp PC assembly and remove the two knurled thumbscrews and washers securing it in place. Discard the old lamp assembly. CAUTION: The lamp will be very hot unless it has been off for an extended period of time.

5. Type A, AA, and L optical sensor replacement lamp assemblies must have a CLEAR bulb, type M, a FROSTED bulb. Clean the bulb with alcohol before installation as fingerprints or other deposits can cause rapid deterioration of the quartz.

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6. Install the new lamp assembly in the same orientation as the old assembly. Secure in place using the two knurled thumbscrews and washers removed earlier. Be careful not to touch the bulb of the lamp as fingerprints reduce lamp efficiency.

   Note: For the A and AA sensors, clearance in the mounting holes allows some vertical and horizontal adjustment of lamp position for balanced illumination at the sample port.

7. Reconnect the lamp lead connector securely. Lack of proper contact at this point can be a major source of unsatisfactory instrument performance. Always check the lamp circuit when unsteady operation is experienced.

8. For the A and AA optical sensors: Reattach the lamp cover using the two knurled thumbscrews and washers removed earlier.

   For the L and M optical sensors: Replace the lamp heat sink assembly, maintaining the original orientation, and secure in place by depressing the fasteners.

9. Plug in the SIU and allow the lamp to warm up 15 minutes to 2 hours depending on condition of the optical sensor.

10. Restandardize the instrument (Sec. 5.1) before making measurements, and run the lamp voltage adjustment diagnostic (Sec. 7.2.4).

7.1.2 Incident Beam Optics

Brush the lenses, heat filters, and mirrors free of dust and lint from time to time with the lens brush supplied with the instrument. If any of these surfaces develops a hazy film, wipe clean with a lens tissue or lintless cloth saturated with the anti-static lens cleaning solution, also supplied. Wipe dry, but do not rub. Be particularly careful of the first surface mirrors when cleaning.

NOTE: When illuminated by a bright light, the mirrors may appear to be slightly discolored and/or hazy. DO NOT ATTEMPT TO REMOVE BY CLEANING. Slight surface imperfections will not affect instrument performance.

The tolerance on the spatial location of the lamp filament in the precision focused lamps supplied with this instrument is plus and minus .010 inches. The use of any lamp within these tolerances should not materially affect the position of the illuminated spot.

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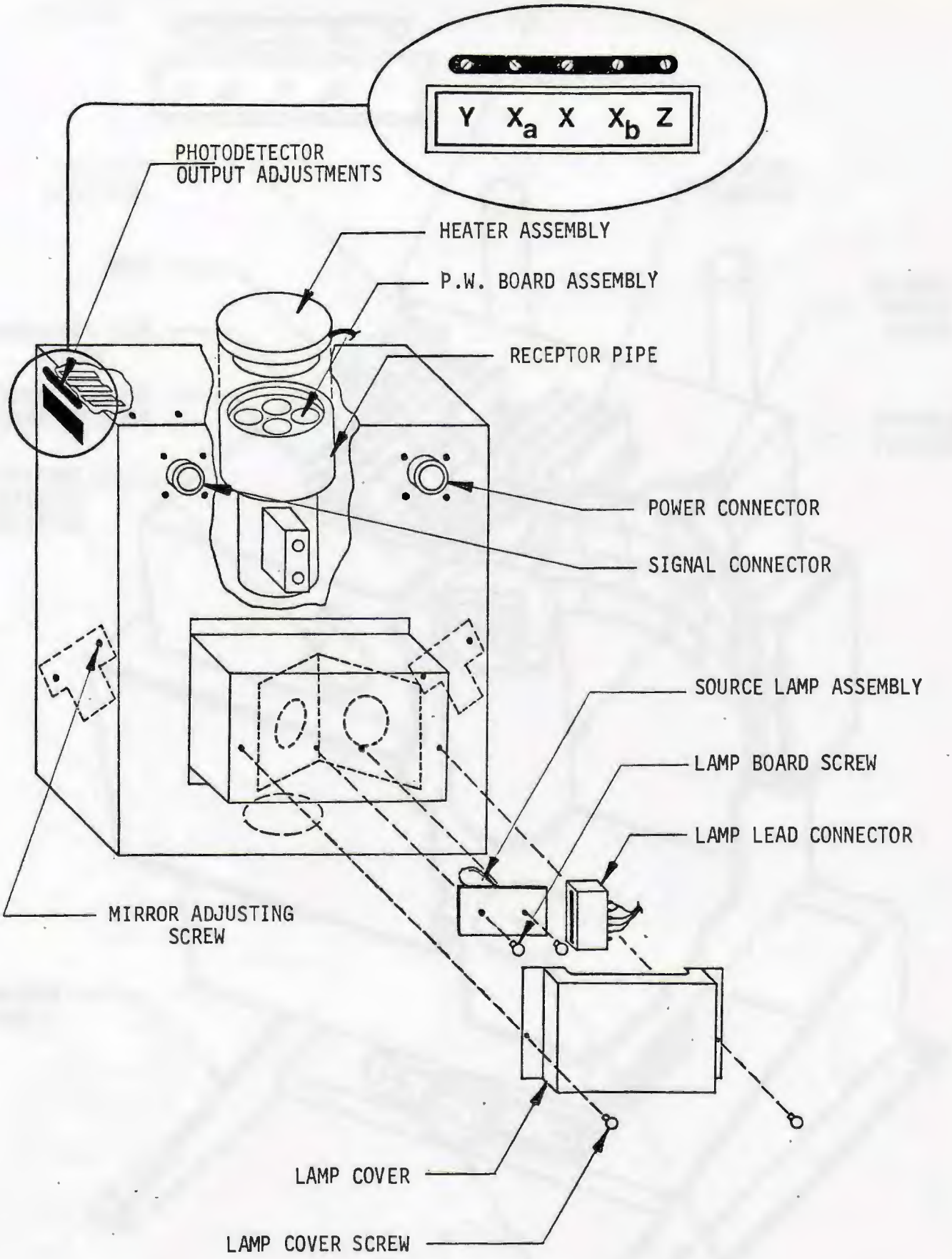


FIGURE 1 D25A OPTICAL SENSOR, EXPLODED REAR VIEW.

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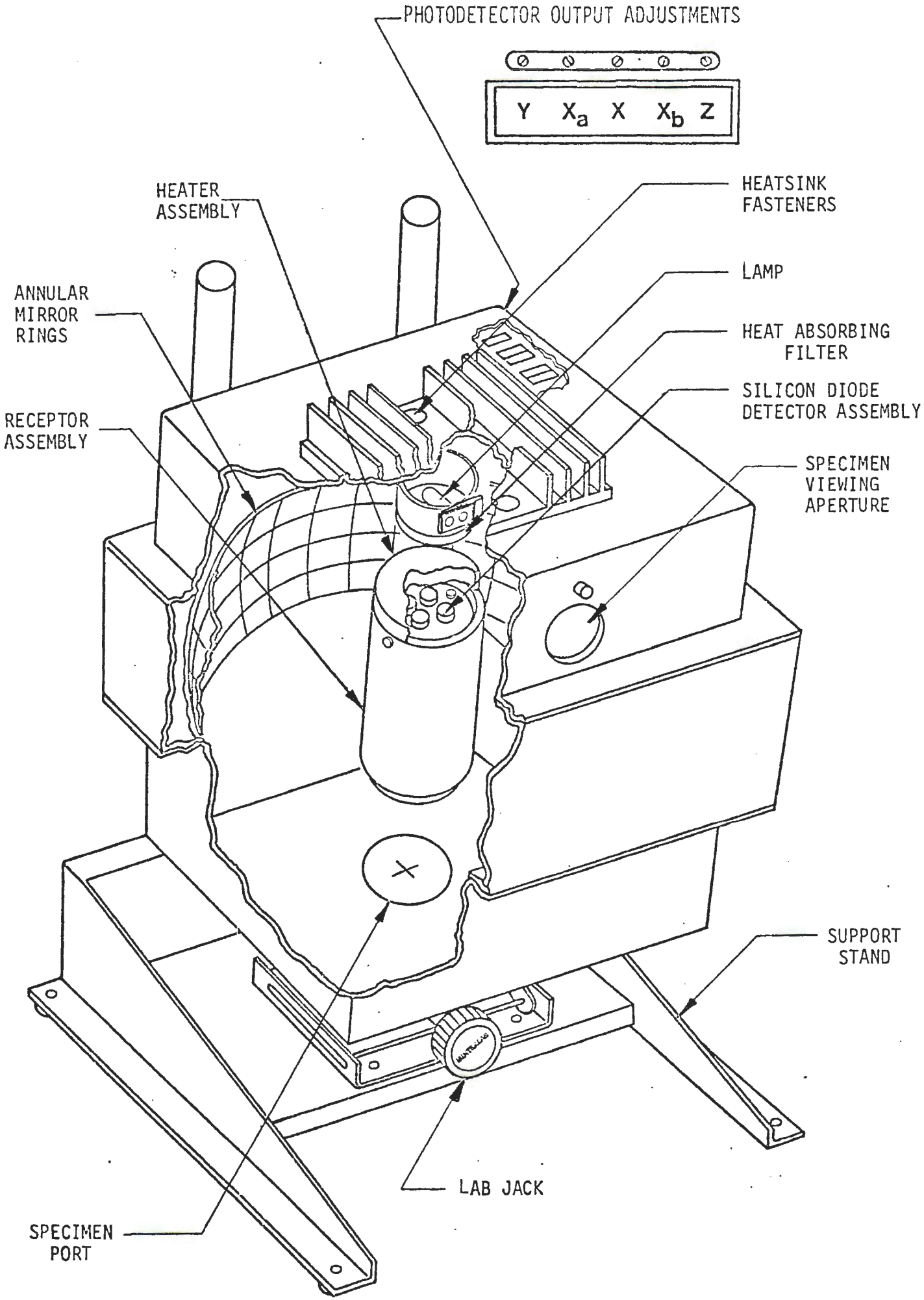


FIGURE 2 D25M/L OPTICAL SENSOR

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Therefore, if, when replacing a lamp, the beam positions have shifted, it may be due to one of the following:

a) Lamp is not within tolerance
b) Lamp improperly installed
c) Damaged lamp or annular rings

For A and AA optical sensors: To check and adjust the light beams, remove the front cover of the optical sensor and block off one incident beam with a piece of cardboard or dark paper. The beam should be centered in the sample port and surrounded by a uniform dark annulus about 1/8 inch wide. If this is not the case, adjust (using an allen wrench) the mirror angle by use of the mirror adjusting screws from the outside of the optical sensor. Repeat this procedure with the other light beam.

Alignment of the incident beams is controlled by the position of the condenser lenses and the beam deflecting mirrors. A change of the position or size of the light beam at the sample port may affect the calibration of the instrument is in question.

For L and M optical sensors: To gain access to the interior of the optical sensor, you may remove the sample port by pressing the two push-to-release/push-to-fasten fasteners at opposite corners of the sample block.

Alignment of the incident beams is controlled by the position of the lamp. A change of the position or size of the light beam at the sample port may affect the color calibration of the instrument.

7.1.3 Photodetector Temperature

Experiments with photodetectors prove that there are spectral characteristic changes as well as total response changes with change of temperature. To prevent these changes, the photodetectors are imbedded in a temperature controlled aluminum block. When shipped, the thermostat in this instrument was operating at the temperature shown in Sec. 2. The temperature control element should maintain this temperature within 2°F (1°C).

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7.2 Diagnostics

<DIAG> 1. Press <DIAG> to display a menu which includes diagnostic routines and viewing instrument standards:

```
                ADDITIONAL CAPABILITIES

          PRESS <1> DIAGNOSTICS
                <2> VIEW STANDARD
                <3> TOP OF SCALE STANDARD
                <ESC> EXIT
```

<1> 2. Press <1> to display a menu of five self diagnostics:

```
                        DIAGNOSTICS MENU

          PRESS <1> LAMP VOLTAGE    <4> PROM CRC
                <2> LAMP ADJUST     <5> RAM TEST
                <3> A/D COUNTS      <6> PORT SETUP
                                    <ESC> EXIT
```

3. Press the numeric key that corresponds to the desired diagnostic routine.

7.2.1 Lamp

<1> 1. While in the diagnostics menu, press <1> to continuously display the lamp voltage in the following format:

```
          LAMP VOLTAGE =

          PRESS <ESC> TO EXIT
```

<ESC> 2. Press <ESC> to return to the diagnostic menu.

<ESC> 3. Press <ESC> to return to the additional capabilities menu.

<ESC> 4. Press <ESC> to exit to measurements.

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7.2.2 Lamp Adjustment

The lamp voltage diagnostics described in Sec. 7.2.1 is a very rapid and convenient method of daily monitoring the voltage of the source lamp. Long term color balance within the instrument, however, is checked using the yellow and blue standard Y values. If the yellow and blue standard readings have shifted in opposite directions by more than a total of 0.3 units, the source voltage should be increased or decreased to compensate. For example, if the Y reading of the yellow tile is 0.3 too high in reference to the calibrated values and the Y reading of the blue tile is 0.1 too low, the total shift difference is 0.4 and the source voltage should be increased. If the yellow standard had read too low, and the blue standard had read too high, a decrease in source voltage would be necessary. If the source voltage has to be changed by an amount greater than the adjustment range available, the lamp circuit should be checked and the lamp replaced, if necessary.

<2>

1. While in the diagnostics menu, press <2> to initiate the routine to determine the instrument color balance. After selecting this choice, the following prompt will be displayed:

```
PLACE YELLOW STANDARD
  AT SENSOR PORT AND
     PRESS <READ>
```

Yellow tile at port

2. Place the yellow standard at the sample port.

<READ>

3. Press <READ>. The following prompt will be displayed:

```
PLACE BLUE STANDARD
 AT SENSOR PORT AND
    PRESS <READ>
```

Blue tile at port

4. Place the blue standard at the sample port.

<READ>

5. Press <READ>. The instrument calculates the delta blue and yellow values, compares them, determines if the lamp voltage is within the 0.3 tolerance range and displays the data in the following format:

```
LAMP ADJUST DIAGNOSTIC

DYY=          DYB=
 LAMP VOLTAGE =
  LAMP VOLTAGE OK

 PRESS <ESC> TO EXIT
```


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The DYY and the DYB values are the delta Y values of the yellow and the blue standards respectively.

If the color balance is not correct, the voltage will be either too low or too high and the corresponding message will be displayed. Turn the adjusting trimpot clockwise on the SIU, labelled LAMP ADJUST to increase the voltage (or counterclockwise to decrease the voltage). Press <ESC> and <2> to repeat the test after changing the voltage. The operator will then be prompted through the calibration routine, plus reading the yellow and blue standards to recalculate the color balance of the instrument.

<ESC> 6. Press <ESC> to return to the diagnostic menu.

<ESC> 7. Press <ESC> to return to the additional capabilities menu.

<ESC> 8. Press <ESC> to exit to measurements.

7.2.3 A/D Count

This routine causes the display of the signal level output from the A/D converter for each of the functions, Xa, Xb, Y and Z, continuously updating. The level for one volt is 3276 counts. The normal counts with the black glass at the port may be ± 300 around zero. The normal readings for the white standard are around 10,000 to 12,000 for all functions except Xb, which will be around 4,000. However, any value below 16383 for the white tile will permit the instrument to function properly.

NOTE: If the instrument is equipped with the Reduced Area Option, the above levels may not apply.

The A/D Count diagnostic routine is used when it is necessary to adjust the signal level for one or more of the four functions as might be the case when the sample measurement is reduced in size.

<3> 1. While in the diagnostics menu, press <3> to continuously display the Xa, Xb, Y and Z raw data counts in the following format:

A/D COUNTS DIAGNOSTIC

Xa= Y=
Xb= Z=

PRESS <ESC> TO EXIT

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Black glass at port

2. Place the black glass at the sample port. The values displayed should all be within the range of ± 300 counts around zero and of approximately the same magnitude. If the difference between any two of the values gets to be as large as 400, it is an indication that the instrument is approaching a state where an additional correction is advisable to bring it into better adjustment. A call to the HunterLab Service Department would be advisable at this point, even though the instrument could perform satisfactorily for some time.

White tile at port

3. Place the white calibrated tile at the sample port. If one of the values equals or exceeds 16383 the value will be '0'. Adjust the appropriate trimpot in the optical sensor, using the trimpot adjusting tool or a small screwdriver, until the value displayed falls below 16383.

<ESC>

4. Press <ESC> to return to the diagnostic menu.

<ESC>

5. Press <ESC> to return to the additional capabilities menu.

<ESC>

6. Press <ESC> to exit to measurements.

7.2.4 PROM CRC

<4>

1. While in the diagnostics menu, press <4> to display the Cyclic Redundancy Check of the SIU program in the following format:

   CRC =

   PRESS <ESC> TO EXIT

   Note: If the CRC value is not the same as listed in Sec. 2.7, call HunterLab Service Department.

<ESC>

2. Press <ESC> to return to the diagnostic menu.

<ESC>

3. Press <ESC> to return to the additional capabilities menu.

<ESC>

4. Press <ESC> to exit to measurements.

7.2.5 RAM

<5>

1. While in the diagnostics menu, press <5> to run the RAM test for the SIU in the following format:

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```
RAM TEST
AREA 1  PASSED
AREA 2  PASSED
AREA 3  PASSED
PRESS <ESC>TO EXIT
```

NOTE: If an area of RAM does not pass the test, call HunterLab Service Department.

<ESC> 2. Press <ESC> to return to the diagnostic menu.

<ESC> 3. Press <ESC> to return to the additional capabilities menu.

<ESC> 4. Press <ESC> to exit to measurements.

7.3 Error Messages

Contact HunterLab Service Department if any error message can not be found or the problem persists.

1. A/D SATURATED - when your D25-PC2A left the factory, it was adjusted to accommodate reflectance values of up to 130%. However, due to changing the lamp or aging of the other optical components the signal level may become too large for the range of the internal A/D converter, particularly when reading fluorescing samples. If this message is displayed, see Sec. 7.2.5.

2. BREAK IN ## - displayed when there is a break in the program where ## is the line the HX-40 was about to execute when the program stopped. Type RUN when the '>' prompt is displayed.

3. BUFFER OVERFLOW ERROR, RESTARTING SYSTEM - displayed when the RS-232 input buffer has received data faster than the HX-40 could process it.

4. NO A/D READINGS - displayed when the A/D converter is not functioning correctly. Contact the HunterLab Service Department.

5. STANDBY - displayed when the OPERATE/STANDBY switch on the SIU is not in the OPERATE position.

6. INTERRUPT ERROR - displayed when a transient interrupt occurs. After message is displayed, processing will continue.

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7.4 Troubleshooting

7.4.1 Possible Effects of Environment

1. Vibration

Vibration and shock have to be fairly severe before they will cause operating problems. The items most sensitive to extreme vibration are the lamp filament, the mirror supports, and the photodetector support. Movements of these components relative to the sample will appear as fluctuation in the digital display. A permanent shift of position will, of course, result in misalignment of the optical beams.

2. Temperature

Large changes of temperature during operation can cause structural changes in the optics, resistance changes in the signal processing circuit, and (if the room temperature is outside the control range of the thermostatically controlled photodetector block) changes in the output of the photodetectors. Any of these will appear as drift in scale calibration. Return to normal room temperature after exposure to low temperature will cause drift and, particularly in areas of relatively high humidity, can also cause moisture to condense on critical surfaces. This moisture can create current leakage problems in photodetector circuits. Always operate the instrument on STANDBY for a period of several hours after it has been exposed to low temperatures.

3. Drafts

Air currents, especially if the air is at a temperature other than that of the instrument, can cause problems similar to those of temperature change. The effects will probably be more rapid and variable.

4. Electrical Power Fluctuations

Since constancy of source light output and detector sensitivity are of prime importance to accuracy and repeatability of measurements, the colorimeter uses highly regulated power supplied for the lamp, and the photodetector-amplifier circuits. Normal variations of power line voltage can be accommodated with a negligible shift in instrument calibration. However, large, rapid fluctuations, even of temporary nature, can cause unbalance, which may appear as momentary fluctuations in the digital readout. The power line must be properly grounded for proper instrument operation.

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7.4.2 Failure to Initialize

1. If the initialization menu is not displayed at all, unplug and replug the power cord from the SIU and reinitialize the system by following the procedures outlined in Sec. 4.3.

2. If at any time the prompt '>' appears, type RUN and press <RETURN>.

3. If the initialization sequence can not be completed because of a communications failure between the Epson and the SIU, no error messages can be displayed, and the display will remain at the initializing message without continuing to the calibration prompts. If this occurs make sure the SIU power is connected and turned on and properly connected at both ends. If this recurs, run the SIU loopback test as follows:

   a) Remove the RS-232 cable which connects the SIU to the Epson from the SIU.

   b) Plug in the SIU test plug into the RS-232 port on the SIU.

   c) Turn the SIU on its side and look inside the fifth air vent at the bottom of the SIU (indicated by a green dot) to ascertain if a green LED is flashing. If it is, this indicates that the RS-232 port is communicating. If it is not flashing, contact HunterLab Service Department.

   d) Remove the SIU test plug and replug the RS-232 cable.

   e) Recycle the power and reinitialize.

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7.4.3 General Rules for Troubleshooting

1. Before attempting trouble diagnosis, refer to maintenance and diagnostics, Secs. 7.1 and 7.2, especially those portions covering the lamp and optical alignment.

2. Turn the SIU on its side and look in the air vents indicated by red dots at the bottom of the SIU. Three red LED's should be lit. If they are not, contact the HunterLab Service Department. The red LED inside the first air vent indicates + 5V while the two LED's in the last air vent indicates ± 12V.

3. DO NOT REMOVE either the photodetectors or the optical filters. The photodetectors have been fully tested and selected for proper response and stability. The filters have been individually manufactured and matched to a particular detector to give accurate spectral response.

4. Disconnect the SIU from the power line before opening the optical sensing unit (except when only changing the lamp).

5. If normal troubleshooting (Secs. 7.4.4 and 7.4.5) does not result in correction of the difficulty, you may have to call the HunterLab Service Department. Telephone advice can be much more accurate if you have the following information available:

   a) Model and serial number of the instrument.

   b) AC power line voltage together with meter brand and type.

   c) Operating environmental conditions under which the instrument is normally used (temperature, humidity, dust, fumes, etc.).

   d) Measured DC voltage at the lamp board, using the lamp diagnostics.

   e) Readings of all standards (if readable) for both Values Read At Factory and the present values.

   f) Output from running the diagnostics routines.

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7.4.4 Symptoms Made Evident by Digital Readout

PROBLEM:	PROBABLE CAUSE:	CHECKS AND CORRECTIONS:
1. Instability of readings-rapid change of values around a stable	a) Signals too low from optical sensor. Voltage change for one bit count is too high. Instrument is stretching the voltage to achieve standardization.	a) For additional proof, run A/D COUNT diagnostics. If the counts (except X_B) on a white tile are below 10000, the signals are too low. Check and clean the optical system. Adjust appropriate trimpots in optical sensor to obtain bit counts over 10000 in the A/D COUNT diagnostics for each function.
2. Digital readout remains at one number of scale	a) No lamp voltage or defective lamp	a) Check lamp voltage per Sec. 7.2.1. Ascertain that lamp is lit
	b) Loss of low voltage	b) Check power supply
3. Readout erratic or wandering during operation	a) Lamp overaged and ready to fail	a) Replace lamp.
	b) Loose connection in the lamp circuit	b) Check for tightness of lamp lead connector. Check the lamp power circuit from the regulator
	c) Power line voltage transients more rapid and/or greater than regulator's specified range.	c) Move the instrument and connect to a power line that is not shared by motors or other heavy load devices
	d) Defective or dirty trimpot slider in sensor.	d) Turn trimpot adjustments back and forth to establish firm contact.

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7.4.4 Symptoms Made Evident by Digital Readout (cont.)

PROBLEM:	PROBABLE CAUSE:	CHECKS AND CORRECTIONS:
	e) Defective ground (electrical case bonding) circuit to the optical sensor	e) Check the ground wires and cable shielding between the optical sensor case and signal processor chassis.
	f) Loose connections or defective connectors	f) Check all cable connectors to ascertain that they are seated properly.
	g) Sensor temperature too high	g) Provide air below 95°F in vicinity of instrumen sensor. Clean dust filters.
4. Loss of instrument standard or program data due to power failure	a) Loss of battery back-up power	a) Contact the HunterLab Service Department for assistance
5. Loss of standardization	a) Loss of power	a) Rezero and restandardize the instrument
6. Screen goes blank	a) Loss of battery back-up power	a) Recharge battery (can be left 'on charge' continually)
	b) Screen contrast too low	b) Adjust screen contrast

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7.4.5 Symptoms Involving Calibration Errors

PROBLEM:	PROBABLE CAUSE:	CHECKS AND CORRECTIONS:
EXAMPLE: When reading standards an error in value of more than 0.3 units from VALUE READ AT FACTORY appears on any one scale	(See Checks and Corrections)	GENERAL RULES: a) Make certain that the standards are clean and undamaged b) Check lamp. Check alignment and clean the optical beam components. See Secs. 7.1.1 and 7.1.2 c) Check lamp voltage. See Sec. 7.2.1
1. The Lightness (Y)scale values of all standards read high or low after standardizing on the white standard	a) Dirty or damaged white standard b) Bottom of scale calibration incorrect	a) Refer to General Rules above b) Check the readings of the gray standard and black glass standard. See Secs. 4.5.5 and 5.2.
2. Gray standard 'a' or 'b' values are incorrect by more than 0.3 units after standardizing on white standard	a) Damaged or dirty standards. b) Bottom of scale calibration incorrect	a) Refer to General Rules above. b) Refer to Secs. 4.5.5 and 5.2.
3. All standard readings have changed in a plus or minus direction by more than 0.3 units from VALUES READ AT FACTORY	a) White standard damaged or has changed values b) Bottom of scale calibration incorrect	a) Standardize instrument on the yellow standard using the VALUES READ AT FACTORY and determine if the rest of the standards are within tolerances for VALUES READ AT FACTORY. If so the white standard values have changed and recalibration would be necessary. Contact the HunterLab Service Dept. for assistance. b) Refer to Secs. 4.5.5 and 5.2.

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SECTION 8 - WARRANTY AND SERVICE

8.1 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 of this warranty is one year from date of shipment of new instruments and two months from the date of shipment of repaired instruments. The Epson personal computer is NOT covered under HunterLab Warranty. It is covered by Epson Corporation.

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 by the HunterLab Service Department with complete information on exact equipment purchased. Questions concerning operation, maintenance or repair of our equipment directed to the Field Service Department can then be knowledgeably handled.

HunterLab Warranty does not cover expendable items such as lamps, fuses, batteries, etc.

The Warranty is void if the user has made unauthorized repairs, or improper use of the instrument.

8.2 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.

8.2.1 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.

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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. Contact local Post Office regarding damage and insurance 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.

2. Retain container and packing.

3. Each UPS office has a different method of handling these occurrences and will advise you of procedure.

4. Notify HunterLab at once for replacement.

8.2.2 Shortage

1. Check packing list notations. The apparent shortage may be marked as an intentional backorder.

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.

8.2.3 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.

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8.3 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.

8.4 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, however, HunterLab offers two means of servicing:

a) Instruments may be returned to a HunterLab service facility for repair,

or

b) A HunterLab service department technician can go to your facility for on-site repair.

8.4.1 Return of Instrument 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:

Service Department
Hunter Associates Laboratory, Inc.
11495 Sunset Hills Road
Reston, Virginia 22090

CUSTOMER IS LIABLE FOR INCOMING AND OUTGOING FREIGHT CHARGES FOR INSTRUMENTS BEING RETURNED TO HUNTERLAB FOR ALL REPAIRS, INCLUDING WARRANTY.

8.4.2 On-Site Repair

For schedule and terms for on-site repairs by our trained service technicians, our Service Department should be called.

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SECTION 9 - OPTIONS

When an instrument is equipped with optional software capability the selection will be displayed in the SCALE or INDEX menu. When two optical sensors are supplied for use alternatively with the D25-PC2A processor, any installed software option can be accessed by either sensor.

See Sec. 2 to verify options included with this instrument.

Total Color Difference (D25-2AE,AC) is described in the basic operating sections.

The following options are described in this section:

9.1 Reduced Area Illumination and Small Area Measurement
9.2 Reduced Area Viewing
9.3 L Sensor Reduced Area Viewing
9.4 Ultraviolet Absorbing Filter
9.5 Whiteness Index
9.6 Yellowness Index
9.7 Opacity (Contrast Ratio)
9.8 Tomato Score
9.9 TAPPI Brightness
9.10 Z% Brightness
9.11 Transfer Standardization
9.12 Averaging
9.13 Product Standard Storage
9.14 External Communications
9.15 IBM Interface

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9.1 Reduced Area Illumination (D25-2RAI) and Small Area Measurement (D25-2SAA)

9.1.1 Description

~1/2" 12MM. VS STD 57MM

The Reduced Area Illumination modification to the A or AA optical sensors consists of a pair of turnable lenses (which are factory installed) and a sample port insert with a 1/2 inch (12mm) diameter aperture (not factory installed, but shipped with the instrument).

The Small Area Measurement option includes a choice of a 3/8 inch (10mm) or 1/4 inch (6mm) port insert, extended standardizing range and External Photodetector Output Adjustment (D25-LS).

This attachment makes it possible to reduce the area illuminated and viewed for those samples too small to be measured using the standard 2 inch port.

CAVEAT

NOTE: PERFORMANCE SPECIFICATIONS (i.e. FACTORY SUPPLIED COLOR VALUES, STABILITY, ACCURACY, ETC.) ARE BASED ON THE STANDARD 2 INCH DIAMETER APERTURE, AND MAY NOT BE MET WITH A SMALLER SIZE APERTURE.

9.1.2 Operation

Samples should be measured as quickly as possible to reduce the chance of fading due to the increased intensity of illumination when using reducing lenses.

1. Turn the two pointer knobs on the front of the optical sensor so that both reducing lenses are rotated into the beams (both knobs pointing toward center of sensor). Use the sample viewing aperture to observe the change.

2. Remove the standard 2 inch diameter sample port insert by pressing it out of the sample port insert retainer. Replace it with the desired port insert. Make sure the flat portion of the insert is facing outward and the beveled portion toward the sensor interior.

3. Restandardize the instrument, as outlined in Section 5.1, before beginning measurements using the reduced area illumination attachment. When the instrument is returned to normal 2 inch viewing condition, it must be restandardized. Any change in port size must be followed by restandardization both on the black glass and on the white calibrated standard.

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All regular calibration checks of the instrument, as described in Sec. 4.5.5 should be done using the normal beam size and 2 inch diameter viewing aperture. The change of geometry that occurs when the reducing lenses are placed in the beams will cause a slight shift in the color values of the calibration standards. Also, the reducing lenses make the instrument more sensitive to any nonuniformity in standards or samples. To insure repeatability of measurements, extra care should be taken when using the reducing lenses to measure the same spot on the sample or standard.

9.1.3 Maintenance

The surfaces of the reducing lenses should be cleaned by brush or lens cleaner just as are the other optical components (Sec. 7.1). Any lubrication of the mechanism should be done sparingly since oil film (caused by vaporization of lubricant inside the optical sensor) on optical component surfaces increases the rate of dust contamination.

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9.2 Reduced Area Viewing (D25-2RAV)

9.2.1 Description

This attachment to the A, AA or M optical sensor consists of one port insert, which may be 1-1/2 inch (38mm), 1-1/4 inch (32mm) or 1 inch (25mm) in diameter. Extended standardizing range and external photodetector output adjustments (Option D25-LS) are provided to allow easy adjustment of the signal levels for proper standardization.

This attachment makes it possible to reduce the area viewed from the standard 2 inch diameter to as small as 1 inch diameter without the use of light beam reducing lenses.

NOTE: PERFORMANCE SPECIFICATIONS (i.e., FACTORY SUPPLIED COLOR VALUES, STABILITY, ACCURACY, ETC.) ARE BASED ON THE STANDARD 2 INCH DIAMETER APERTURE, AND MAY NOT BE MET WITH A SMALLER SIZE APERTURE.

9.2.2 Operation

1. Remove the standard 2 inch sample port insert by pulling it out of the sample port insert retainer. Place the desired port insert in position with the beveled side toward the sensor interior.

2. Restandardize the instrument, as outlined in Sec. 5.1, before beginning measurements using the reduced sample area viewing attachment. Any change in port size MUST be followed by restandardization both on the black glass and on the white calibrated standard. When the instrument is returned to normal 2 inch viewing condition, for example, it must be restandardized.

   All regular calibration checks of the instrument as described in Sec. 4.5.5 should be done using the normal 2 inch viewing aperture.

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9.3 L Sensor Reduced Area Viewing (D25-2RAL)

9.3.1 Description

This attachment to the L optical sensor consists of a sample port insert retainer and a 2 inch (51mm) diameter sample port insert. Extended standardizing range and external photodetector output adjustments (option D25-LS) are provided to allow easy adjustment of the signal levels for proper standardization.

This attachment makes it possible to reduce the area viewed from the standard 3-3/4 inch (95mm) to 2 inch (51mm) diameter without the use of light beam reducing lenses.

NOTE: PERFORMANCE SPECIFICATIONS (i.e., FACTORY SUPPLIED COLOR VALUES, STABILITY, ACCURACY, ETC.) ARE BASED ON THE STANDARD 3-3/4 INCH DIAMETER APERTURE, AND MAY NOT BE BET WITH THE 2 INCH DIAMETER APERTURE.

9.3.2 Operation

1. Remove the standard 3-3/4 inch sample block by pressing the two push button fasteners to release the block.

2. Install the sample port insert retainer block by pressing the two push button fasteners to secure the block in position. Snap in the 2 inch diameter specimen port insert.

3. Restandardize the instrument, as outlined in Section 5.1, before beginning measurements using the reduced sample area viewing attachment, Any change in the size of the port MUST be followed by restandardization both on the black glass and on the white calibrated standard. When the instrument is returned to normal 3-3/4 inch viewing condition, for example, it must be restandardized.

   All regular calibration checks of the instrument as described in Sec. 4.5.5 should be done using the normal 3-3/4 inch viewing aperture.

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9.4 Ultraviolet Absorbing Filter (D25-2UVAfor A and AA Sensors and D25-2UVM for L and M Sensors)

9.4.1 Description

This attachment to the optical sensor consists of one or two (depending on the type of sensor) pale yellow ultraviolet (UV) absorbing filters on a rotatable mount. It is gear driven from a shaft and operates by means of a knob which on the front panel of the optical sensor housing.

The UV filter make possible the measurement of color excluding fluorescence excited by ultraviolet light which normally strikes the sample. The filters are IN the light beams when the pointer indicates UV EXCLUDED, and are rotated 90° OUT of the beams when the pointer is switched to UV INCLUDED position. With the filter out of the beams (UV INCLUDED position), the measurements would include this fluorescence. With the filter in the beam (UV EXCLUDED position), the ultraviolet in the light is absorbed before it reaches the sample, and thus eliminates UV induced fluorescence.

NOTE: IT IS NECESSARY TO KNOW WHAT TYPE OF FLUORESCENCE IS INVOLVED IN THE SAMPLES BEING MEASURED. SOME MATERIALS (OFTEN SCARLET OR GREEN) FLUORESCE DUE TO EXCITATION BY VISIBLE RATHER THAN ULTRAVIOLET WAVELENGTHS. AN ULTRAVIOLET ABSORBING FILTER WOULD NOT ELIMINATE THIS TYPE OF FLUORESCENCE.

9.4.2 Operation

If the measurements of samples are to be made with UV included, the instrument should be calibrated on the white standard with the filter out of the light beam (UV INCLUDED position). If the measurement of samples is to be made excluding the UV, the filter should be rotated into the light beam (UV EXCLUDED position), and allowed to stabilize for 10 minutes before calibrating on the black glass and white standard and proceeding with sample measurements.

9.4.3 Maintenance

The surface of the UV filter may be cleaned by brush. Any lubrication of the mechanism should be done sparingly since oil film (caused by vaporization of lubricant inside the optical sensor) on optical component surface increases the rate of dust contamination.

THE UV FILTER SHOULD BE LEFT IN THE UV INCLUDED POSITION AT ALL TIMES WHEN NOT IN USE. THIS WILL REDUCE THE CHANCE OF FADING OF THE FILTER MATERIAL DUE TO LONG TERM EXPOSURE TO THE HIGH LEVEL SOURCE ILLUMINATION.

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9.5 Whiteness Index (D25-2WI)

9.5.1 Description

When the instrument is equipped with whiteness, it will give a readout of Whiteness per ASTM Method E 313 and AATCC Test Method 110 according to the following formula:

$$WI = 4\left(\frac{Z_{CIE}}{1.18103}\right) - 3Y = 4Z\% - 3Y$$

Whiteness is the attribute by which an object is judged to approach the preferred white. Ideal white is bluish, and departures from this ideal white toward yellow reduce whiteness ratings about four times as much as departures toward gray. Whiteness indices can be used to provide correlation with visual whiteness rankings of 'product whiteness' for a number of product applications; whereby, blue whites will be evaluated higher than neutral or yellow whites of the same lightness.

9.5.2 Operation

1. Standardize the instrument as described in Sec. 5.1.

2. Press <INDEX>. A menu of the optional indices installed in the instrument will be displayed.

3. Press the numeric key that corresponds to WI to display the whiteness index values. The WI value of the previously read sample will be displayed in the following format:

   WI =

4. To check the values, place the calibrated white standard at the sample port.

5. Press <READ>. If the WI value displayed on the readout is within 0.4 unit of the WI value of the white standard (Sec. 2.5), proceed with measurement of samples. If it is not within this tolerance, call the HunterLab Service Department for assistance.

6. Place a sample at the sample port.

7. Press <READ>. The whiteness index of the sample will be displayed.

8. Press <DELTA> to set the delta mode. The WI values will be displayed as the standard.

9. Place a sample at the sample port.

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10. Press <READ>. The values for that sample and delta values will be updated.

11. Press <INDEX> to display the index menu.

12. Select another index by pressing the desired key.

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9.6 Yellowness Index (D25-2YI)

9.6.1 Description

When the instrument is equipped with Yellowness Index (YI), it will give a readout of Yellowness Index per ASTM Method D1925-70*, according to the following equation*:

YI D1925 = [100(1.274976795X - 1.058398178Z)]/Y

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

YI1925 = [100(1.28X - 1.06Z)]/Y

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 will give YI = 0.303 for clear air, because the factors were truncated in three significant figures when the method was written. 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, in terms of visual appearance, is caused by absorption in the blue part of the spectrum. Visually, yellowness can be associated with scorching, soiling, and general product degradation by light, chemical exposure or processing variables. Yellowness Index (ASTM D 1925) is used to measure these types of degradation for the plastics and paint industries.

9.6.2 Operation

1. Standardize the instrument as described in Sec. 5.1.

2. Press <INDEX>. A menu of the optional indices installed in the instrument will be displayed.

3. Press the numeric key that corresponds to YI to display the yellowness index values. The YI value of the previously read sample will be displayed in the following format:

   YI =

4. To check the values, place the calibrated white standard at the sample port.

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5. Press <READ>. If the YI value displayed on the readout is within 0.3 unit of the YI value of the white standard (Sec. 2.5), proceed with measurement of samples. If it is not within this tolerance, call the HunterLab Service Department for assistance.

6. Place a sample at the sample port.

7. Press <READ>. The yellowness index of the sample will be displayed.

8. Press <DELTA> to set the delta mode. The YI values will be displayed as the standard.

9. Place a second sample at the sample port.

10. Press <READ>. The values for that sample and delta values will be updated.

11. Press <INDEX> to display the index menu.

12. Select another index by pressing the desired key.

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9.7 Opacity (Contrast Ratio) (D25-2CR)

9.7.1 Description

When the instrument is equipped with opacity, it will give a readout for measuring contrast ratio of a paint and opacity of paper according to the following ratio:

$$\text{Opacity} = \frac{\text{diffuse reflectance factor (black backing)} \times 100}{\text{diffuse reflectance factor (white backing)}}$$

The Contrast Ratio option makes it possible to read opacity (contrast ratio) directly. Opacity (contrast ratio) is a ratio of the diffuse reflectance factor (CIE Y) of the sample backed with black to the diffuse reflectance factor of the same sample backed with white.

9.7.2 Operation

1. Standardize the instrument as described in Sec. 5.1.

2. Press <INDEX>. A menu of the optional indices installed in the instrument will be displayed.

3. Press the numeric key that corresponds to OPACITY. The following message will be displayed:

   PLACE SAMPLE WITH WHITE BACKING
   AT PORT AND PRESS <READ>

   PRESS <ESC> TO EXIT

4. Place sample with a white backing at the sample port. (For paints: white section of black-white drawdown chart with uncalibrated white tile as backing. For paper: uncalibrated white tile as backing.)

5. Press <READ>. The following message will be displayed:

   PLACE SAMPLE WITH BLACK BACKING
   AT PORT AND PRESS <READ>

   PRESS <ESC> TO EXIT

6. Place the same sample with black backing at the sample port. (For paints: black section of black-white drawdown chart with uncalibrated white tile as backing. For paper: black glass as backing.)

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7. Press <READ>. The opacity measurement and the CIE Y value of the sample backed with white will be displayed in the following format:

   Op= Y=

   PRESS <READ> TO REDO

   PRESS <ESC> TO EXIT

8. Press <PRINT> to print the opacity values.

9. Press <READ> to cycle through another opacity measurement.

10. Press <ESC> to display the index menu.

11. Select another index by pressing the desired key.

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9.8 Tomato Product Scores (D25-2TPS)

9.8.1 Description

This modification for the A or AA optical sensor consists of a 2.5 in. (64mm) diameter round sample cell with optically clear glass bottom, sample cup port holder assembly and a tomato color standard calibrated for Hunter Lab and CIE XYZ.

When the instrument is equipped with this modification, it will give a readout of tomato juice scores (TJS), tomato paste scores (TPS), tomato sauce scores (TSS), tomato catsup scores (TCS), and an a/b ratio per USDA calculations. The scores are defined as:

$$TJS = 29.600 + 0.88354a - 1.8553b$$

$$TPS = -46.383 + 1.0211a + 10.607b - 0.42198b^2$$

$$TSS = -154.39 + 1.1142a + 22.596b - 0.86736b^2$$

$$TCS = -74.937 + 7.5172a - 0.127a^2 - 0.8051b$$

TABR = Ratio of the Hunter a value divided by the Hunter b value.

9.8.2 Operation

1. Standardize the instrument as described in Sec. 5.1.

2. Enter the XYZ values of the tomato standard into the transfer standard register and standardize the instrument using the tomato standard as a transfer standard as described in Sec. 9.11.

3. Press <INDEX>. A menu of the optional indices installed in the instrument will be displayed.

4. Press the numeric key that corresponds to desired index. The tomato scores of the previously read sample will be displayed in one of the following formats:

   TJS=
   TPS=
   TSS=
   TCS=
   TABR=

5. Pour tomato product sample (pureed for whole tomatoes) into sample cup and place at port.

6. Press <READ>. The tomato score values of the sample will be displayed.

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7. Press <DELTA> to set the delta mode. The tomato values will be displayed as the standard.

8. Place a sample at the sample port.

9. Press <READ>. The values for that sample and delta values will be updated.

10. Press <INDEX> to display the index menu.

11. Select another index by pressing the desired key.

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9.9 TAPPI Brightness (D25-2BT)

9.9.1 Description

This attachment to the A or AA optical sensor consists of two source correction filters on a rotatable mount. It is gear driven from a shaft and operates by means of a pointer knob labelled TAPPI FILTER on the front cover of the optical sensor housing. The filters can be rotated IN (TAPPI Brightness measurements) or OUT (normal color measurements) of the source beams by turning the pointer knob. Included with this option is the Reduced Area Illumination (D25-RAI).

In the rotated IN position, the filters do not completely intercept the source beams, for reasons of optimal instrument adjustment.

This attachment makes possible the measurement of TAPPI Brightness, the reflecting power of an infinitely thick stack of material measured in blue light with a centroid wavelength of 457nm under spectral and geometric conditions of measurement as specified in TAPPI Method T-452.

9.9.2 Operation

1. Turn the two pointer knobs on the front of the optical sensor so that both reducing lenses are rotated into the beams (both knobs pointing toward center of sensor). Use the sample viewing aperture to observe the change.

2. Remove the standard 2 inch (51mm) diameter sample port insert by pressing it out of the sample port insert retainer. Replace it with the 1/2 inch (13mm) port insert. Make sure the flat portion of the insert is facing outward and the beveled portion toward the sensor interior.

3. Turn the TAPPI FILTER knob to the OUT position and standardize the instrument as described in Sec. 5.1.

4. Press ‹INDEX›. A menu of the optional indices installed in the instrument will be displayed.

5. Press the numeric key that corresponds to BRIGHTNESS. The following prompt will be displayed:

   INSERT TAPPI FILTER AND PLACE
   WHITE STANDARD AT SPECIMEN PORT
   PRESS ‹READ›

6. Turn the TAPPI FILTER knob to the IN position and allow it to stabilize for 10 minutes.

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7. Place the calibrated white instrument tile at the sample port.

8. Press <READ> to standardize the instrument with the TAPPI filter in position. The TAPPI brightness value of the white tile will be displayed in the following format:

   Br =

9. Place a standard at the sample port.

10. Press <READ>. The TAPPI brightness value of the standard will be displayed.

11. Press <DELTA> to set the delta mode. The TAPPI Brightness value will be displayed as the standard.

12. Place a sample at the sample port.

13. Press <READ>. The values for that sample and delta values will be updated.

14. Return the TAPPI FILTER to the OUT position at the completion of TAPPI Brightness measurements.

    NOTE: Once the instrument is standardized for TAPPI Brightness, it will not be forced through another standardization, when the option is enabled, UNTIL a normal standardization is performed. Therefore, the operation can read samples, with and without the TAPPI filter, without standardization. One word of caution: When the filter is turned to the ON position, it should stabilize for 10 minutes. If the measurements are critical, restandardize for black glass and white tile and then TAPPI, before any readings, if the filter has been rotated.

9.9.3 Maintenance

The surfaces of the TAPPI Brightness source correction filters should be cleaned by brush or lens cleaner just as are the other optical components. any lubrication of the mechanism should be done sparingly since oil film (caused by vaporization of lubricant inside the optical sensor) on optical component surfaces increases the rate of dust contamination.

The TAPPI FILTER should be left in the OUT position at all times when not in use.

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9.10 Brightness - Z% (D25-2Z)

9.10.1 Description

When the instrument is equipped with this option, it will give a readout of brightness (Z%) according to the following equation:

$$Z\% = \frac{Z \text{ CIE}}{1.18103}$$

Z% brightness is used in the evaluation of the degradation (yellowing) of white materials. It can also be a measure of the effectiveness of bleaching. A comparison of the amount of blue reflectance that results from a light source containing ultraviolet energy with that resulting when ultraviolet is absent gives a measure of the contribution of FWA (fluorescent whitening agents) to the whiteness of textiles and paper. A specific spectral blue reflectance is used for the industry-wide measurement of paper brightness but Z% is widely used as an indicator of paper brightness.

9.10.2 Operation

1. Standardize the instrument as described in Sec. 5.1.
2. Press <INDEX>. A menu of the optional indices installed in the instrument will be displayed.
3. Press the numeric key that corresponds to BRIGHTNESS. The Z% brightness value of the previously read sample will be displayed in the following format:

   Br =

4. Place a standard at the sample port.
5. Press <READ>. The Z% brightness value of the standard will be displayed.
6. Press <DELTA> to set the delta mode. The Z% brightness values will be displayed as the standard.
7. Place a sample at the sample port.
8. Press <READ>. The values for that sample and delta values will be updated.
9. Press <INDEX> to display the index menu.
10. Select another index by pressing the desired key.

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9.11 Transfer Standardization (D25-2TS1 and D25-2TS2)

9.11.1 Description

When samples are all similar in color and it is important to achieve the most accurate absolute color values, long-term accuracy and interinstrument agreement may be increased by standardizing the instrument on a calibrated standard of color as close as possible to that of the samples to be measured.

Values for standards other than the white standard can be entered and used for alternate standardization of the instrument. This method uses the current instrument white tile standardization (including the B/A ratio) to correct the raw tile readings and then calculates multiplication factors using the entered tristimulus values.

NOTE: Calculations are carried out to a higher precision internally than is displayed. When entering data, up to five significant figures may be entered.

9.11.2 Standardizing on a Transfer Standard

‹STDZ›

1. Press ‹STDZ› to display the following menu:

```
SELECT STANDARDIZATION METHOD:

PRESS ‹1› ZERO AND STANDARDIZE
      ‹2› TRANSFER STANDARDIZE
      ‹ESC› EXIT
```

Standardize instrument

2. Press ‹1› and standardize instrument as described in Sec. 5.1.

‹STDZ›

3. Press ‹STDZ› to display the standardization menu.

‹2›

4. Press ‹2› to display the following screen. The color scale will be the current one.

```
CURRENT TRANSFER STANDARD VALUES

  X=
  Y=
  Z=
PRESS ‹1› STORE      ‹4› USE CURRENT
      ‹2› RECALL     ‹ESC› EXIT
      ‹3› ENTER
```

5. If the current values displayed are not the desired values, either enter new values (see Sec. 9.11.3) or recall standard (see Sec. 9.11.4).

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<4>

6. Press <4> to place the displayed current values into the standard register. The following prompts are displayed.

PLACE THE TRANSFER STANDARD AT THE
SPECIMEN PORT AND
PRESS <READ>

Standard at port

7. Place the transfer standard at the sample port.

<READ>

8. Press <READ>. The instrument will return the operator to the measurement screen. The instrument is standardized on the values entered through the keyboard and on the blue/amber ratio of the calibrated white standard. These values will remain in the transfer standard register until new values are entered into that register or the instrument is reinitialized.

NOTE: If the instrument was in the delta mode prior to initializing transfer standardization, the values displayed for the standard are still relative to the prior standardization, not the transfer standard. To display the values relative to the transfer standard, reread the product standard and press <DELTA> twice (i.e., once to disable the delta mode and once to enable it again).

9.11.3 Entering and Storing a Transfer Standard

<STDZ>

1. Press <STDZ> to display the following menu:

SELECT STANDARDIZATION METHOD:

PRESS <1> ZERO AND STANDARDIZE
<2> TRANSFER STANDARDIZE
<ESC> EXIT

<2>

2. Press <2> to display the transfer standard values screen. The color scale displayed is the current one.

<3>

3. Press <3>. The following prompt will be displayed.

ENTER TRANSFER STD
X=

'28.8'

4. Key in the X value for the standard, 28.8 for example. If an incorrect value is entered, press the HOME/BS key to delete the mistaken number. Correct the entry by keying in the correct value.

NOTE: If an entry is six characters (including '-' and '.'), do not press <RETURN>.

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<RETURN>	5.	Press <RETURN>. Prompting for the Y value will be added to the display.
'44.3' <RETURN>	6.	Key in the Y value for the standard, 44.3 for example, and press <RETURN>. That value, plus prompting for the Z value, will be added to the display.
'7.8' <RETURN>	7.	Key in the Z value for the standard, 7.8 for example, and press <RETURN>. The screen will return to the transfer standard values screen.
<1>	8.	Press <1> to store the entered values, if option D25-2TS2 (10 transfer standard storage) is installed. The prompt 'STORE TRANSFER STANDARD NUMBER (0-9)?' will be displayed.
'1' for example	9.	Enter a register number where the entered values will be stored, '1' for example.
<ESC>	10.	Press <ESC> to exit the program.

9.11.4 Recalling a Transfer Standard

This section applies only if option D25-2TS2 (10 transfer standard storage) is installed.

<STDZ>	1.	Press <STDZ> to display the following menu:

```
SELECT STANDARDIZATION METHOD:

PRESS <1> ZERO AND STANDARDIZE
      <2> TRANSFER STANDARDIZE
      <ESC> EXIT
```

<2>	2.	Press <2> to display the transfer standard values screen. The color scale displayed will be the current one.
<2>	3.	Press <2> to recall a previously saved transfer standard. The prompt 'RECALL TRANSFER STANDARD NUMBER (0-9)?' will be displayed.
'1' for example	4.	Enter in the register number where the desired values are stored, 1 for example.
<ESC>	5.	Press <ESC> to exit the program.

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9.12 Averaging (D25-2AVG)

9.12.1 Description

When the instrument is equipped with averaging, it will display the averaged sample readings.

9.12.2 Operation

1. Standardize the instrument as described in Section 5.1.
2. Select the desired color scale and index.
3. Press <AVG>. The message 'AVG CNT = 0' will be displayed.
4. Place a sample at the sample port.
5. Press <READ>. The values of the sample will be updated, and the average counter will be incremented by one.
6. Place a second sample at the port.
7. Press <READ>. The values for that sample will be updated, and the average counter will be incremented by one.
8. Repeat steps 6 and 7 for all the samples to be averaged.
9. Press <AVG>. The averaged sample values will be displayed, and the heading will change to 'AVG SAM'.
10. Press <DELTA> to set the delta mode and place the averaged values in the standard register.
11. Repeat steps 3 through 9 to average sample readings. The values for both the sample and delta readings will be updated to display the averaged readings.

    NOTE: Once the average mode has been turned off, the average counter will be reset to zero.

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9.13 Product Standard Storage (D25-2PS)

9.13.1 Description

The values of as many as ten product standards can be stored in the ten nonvolatile product standard registers. Then, as specimens are read, the values for the particular product standard to which they are to be compared are recalled into the Delta Register from the Product Standard Register, where they have been stored and compared with specimen readings. Color differences are calculated.

Product standard values can be read from the sensor or entered into a Product Standard Register through the keyboard into a Product Standard Register. Sec. 9.13.3 describes the procedure for entering values into a Product Standard Register through the keyboard.

After the values are stored, it may be desirable to recall color values of one or more product standards and then use the stored values, rather than the product standards, themselves, in the calculation of color differences between the standard and the specimens. Sec. 9.13.4 describes the procedure for retrieving values from storage.

9.13.2 Reading and Storing Product Standard Values

1. Standardize the sensor as described in Section 5.1.

Sample at port

2. Place the sample which is to be used as the product standard at the port.

<READ>

3. Press <READ>. The values for the sample will be displayed in the current color scale.

<DELTA>

4. Press <DELTA>. The current reading will be set as the working product standard and will display the initial delta values as zeros.

<PSTD>

5. Press <PSTD> to display the following screen. The color scale displayed is the current one.

```
          CURRENT PRODUCT STANDARD VALUES

            L=
            a
            b=

PRESS <1> STORE      <3> ENTER
      <2> RECALL     <ESC> EXIT
```


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<1> 6. Press <1> to store the displayed values. The prompt 'STORE PRODUCT STANDARD NUMBER (0-9)?' will be displayed.

'3' for example 7. Enter a register number where the values will be stored, 3 for example.

<ESC> 8. Press <ESC> to exit. The instrument will be set in the delta mode automatically with the values as the standard values.

9. Continue with color difference measurements, as described in Sec. 5.4, starting with step 9.

9.13.3 Entering and Storing Product Standard Values

The product standard may be available in any color scale. They can be entered into a Product Standard Register as follows:

<PSTD> 1. Press <PSTD> to display the following screen. The color scale displayed is the current one.

```
CURRENT PRODUCT STANDARD VALUES

L=
a=
b=

PRESS <1> STORE      <3> ENTER
      <2> RECALL     <ESC> EXIT
```

<3> 2. Press <3>. The following prompt will be displayed:

```
ENTER PRODUCT STANDARD

L=
```

'36.1' 3. Key in the L values for the standard, 36.1 for example. If an incorrect value is entered, press the HOME/BS key to delete the mistaken number. Correct the entry by keying in the correct value.

NOTE: If an entry is six characters (including '-' and '.'), do not press <RETURN>.

<RETURN> 4. Press <RETURN>. Prompting for the a value will be added to the display.

'-8.4' <RETURN> 5. Key in the a value for the standard, -8.4 for example, and press <RETURN>. That value, plus prompting for the b value, will be added to the display.

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'21.9' <RETURN>

6. Key in the b value for the standard, 21.9 for example, and press <RETURN>. The screen will return to the product standard screen.

<1>

7. Press <1> to store the entered values. The prompt 'STORE PRODUCT STANDARD NUMBER (0-9)?' will be displayed.

'3' for example

8. Enter a register number where the entered values will be stored, 3 for example.

<ESC>

9. Press <ESC> to exit. The instrument will be set in the delta mode automatically with the newly entered values as the standard values.

10. Continue with color difference measurements, as described in Sec. 5.4, starting with step 9.

9.13.4 Recalling Product Standards

<PSTD>

1. Press <PSTD> to display the product standard values screen.

<2>

2. Press <2>. The prompt 'RECALL PRODUCT STANDARD NUMBER (0-9)?' will be displayed.

'6' for example

3. Enter the register number where the values are stored that are to be recalled, 6 for example. The values will be updated on the screen.

<ESC>

4. Press <ESC> to exit. The instrument will be set in the delta mode automatically with the recalled values as the standard values.

5. Continue with color difference measurements, as described in Sec. 5.4, starting with step 9.

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9.14 External Communications (D25-2EXC)

9.14.1 Description

This option consists of software to transmit data displayed on the screen to the RS-232C communications port on the rear of the Epson HX-40. It provides for output from the Epson to a peripheral device.

9.14.2 Setup Parameters

<DIAG> 1. Press <DIAG> to display a menu which includes diagnostic routines and viewing instrument standards:

```
ADDITIONAL CAPABILITIES

PRESS <1> DIAGNOSTICS
      <2> VIEW STANDARD
      <3> TOP OF SCALE STANDARD
      <ESC> EXIT
```

<1> 2. Press <1> to display the following menu of five self-diagnostics and a port setup routine:

```
DIAGNOSTICS MENU

PRESS <1> LAMP VOLTAGE  <4> PROM CRC
      <2> LAMP ADJUST   <5> RAM TEST
      <3> A/D COUNTS    <6> PORT SETUP
                        <ESC> EXIT
```

<6> 3. Press <6> to initiate the external communications port setup routine. The following screen will be displayed:

```
PORT SETUP PROCEDURE
CURRENT SETUP:  4800    8    1    N

SELECT: <1> 9600  <4> 1200  <7> 200
        <2> 4800  <5>  600  <8> 150
        <3> 2400  <6>  300  <9> 110

PRESS <0> TO CONTINUE, <ESC> TO EXIT
```

4. Press the number that corresponds to the desired baud rate, if the current setup is incorrect.

<0> 5. Press <0> to continue the program. The following screen will be displayed.

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```
                    PORT SETUP PROCEDURE
CURRENT SETUP:  4800     8     1     N

SELECT: <1> 7 DATA BITS   <5> NO PARITY
        <2> 8 DATA BITS   <6> ODD PARITY
        <3> 1 STOP BIT    <7> EVEN PARITY
        <4> 2 STOP BITS   <ESC> EXIT
```

6. Press the number that corresponds to the desired number of data bits (<1> or <2>), number of stop bits (<3> or <4>) and/or type of parity (<5>, <6> or <7>), if the current setup is incorrect. The current setup is displayed in the top row.

<ESC> 7. Press <ESC> to return to the diagnostics menu.

<ESC> 8. Press <ESC> to return to the additional capabilities menu.

<ESC> 9. Press <ESC> to return to measurements.

9.14.3 Operations

1. After setting up the external communications port (Sec 9.14.2), standardize the instrument, as described in Sec. 5.1.

2. Proceed with measurements of samples, as described in Secs. 5.3 and 5.4.

<SEND> 3. Press <SEND> to transmit displayed data through the RS-232C communications port. The first line is transmitted in the following format:

D25-PC2d mm/dd/yy hh/mm/ss Carriage return, Line feed

The following eight lines are transmitted exactly as they appear on the screen, with leading and internal spaces and a carriage return and line feed at the end of each line. All letter and numbers are sent in standard ASCII codes.

NOTE: The Δ sign is transmitted as 7F.

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9.15 IBM Interface (D25-2 IBM)

9.15.1 Description

This instrument is equipped with optional software capability by means of a diskette which allows software interface of the D25-PC2Δ system to an IBM PC. The diskette includes the BASIC version of the interface program, D25DELTA.BAS, and the compiled version, PC2D.EXE. The compiled version runs much faster, as it does not need the BASIC interpreter to run. The slower BASIC version (D25DELTA.BAS) is the version which can be modified, if desired.

NOTE: IBM Communications hardware is NOT included.

9.15.2 Installation

Assemble the D25-PC2Δ with the IBM PC, following the instructions in Sec. 4.2 of the operating manual (substituting the IBM PC for the Epson).

To copy the option diskette onto a working diskette, do the following:

SINGLE FLOPPY DRIVE

1. Start the computer with the DOS diskette which must contain the files FORMAT and BASIC.COM.
2. Type 'FORMAT A:/S' and press <RETURN>.
3. Insert a blank diskette into the drive when prompted.
4. When finished, press <N> and <RETURN> to exit the format program.
5. Remove the newly formatted diskette.
6. Reinsert the DOS diskette.
7. Type 'COPY A:COMMAND.COM B:' and press <RETURN> and change diskettes when prompted.
8. When the copying is completed, type 'COPY A:BASIC.COM B:' and press <RETURN> and change diskettes when prompted.
9. When completed, insert option diskette.
10. Type 'COPY A:*.* B:' and press <RETURN> and change diskettes when prompted.

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11. When completed, the new diskette will contain all files necessary to run the program.

12. Use DISKCOPY to copy this diskette onto a new blank diskette.

DUAL FLOPPY DRIVES

1. Start the computer with the DOS diskette which must contain the files FORMAT and BASIC.COM.

2. Type 'FORMAT B:/S' and press <RETURN>.

3. Insert a blank diskette in Drive B.

4. When finished, press <N> and <RETURN> to exit the format program.

5. Type 'COPY A:COMMAND.COM B:' and press <RETURN>.

6. When copying is completed, type 'COPY A:BASIC.COM B:' and press <RETURN>.

7. Remove the DOS diskette and insert option diskette in Drive A.

8. Type 'COPY A:*.* B:' and press <RETURN>.

9. When completed, the new diskette will contain all files necessary to run the program.

10. Use DISKCOPY to copy this diskette onto a new blank diskette.

NOTE: For a more complete description of FORMAT, COPY and DISKCOPY, see the DOS manual.

9.15.3 Operations

1. Place the OPERATE/STANDBY switch on the top of the SIU in the OPERATE position.

2. Press the CRT power switch.

3. Open door on Drive A.

4. Insert the diskette into Drive A and close the door.

5. Turn on the IBM system by placing the red switch on the right side of the system unit to the ON position.

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6. When the system prompt appears, type 'PC2DELTA' and press <RETURN> to run the D25DELTA.BAS program or type 'PC2D' and press <RETURN> to run the compiled version. The system will start, and the following menu will be displayed:

F1	READ	F6	AVG
F2	DELTA	F7	PSTD
F3	SCALE	F8	INDEX
F4	STDZ	F9	DIAG
F5	PRINT		

7. Follow the instructions in Sec. 5 for standardizing and operating the instrument, substituting the appropriate 'F' key for the named key in the text.

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SECTION 10 - APPENDIX

10.1 Key Function Chart

READ

Initiates measurement of samples resulting in the display of the currently selected scale values. It is also used in the standardization routine to set the top and bottom of scale.

DELTA

Sets the instrument to the delta mode, saves the current reading as a reference and displays the initial delta as zeros. Each successive update will display the delta between the current reading and the reference reading.

A second press of the delta will toggle the delta mode off.

SCALE

Displays a menu of scales which may be selected. Upon selection of a scale, the display will update.

1. XYZ - Displays the X,Y,Z values.
2. Lab - Displays the L,a,b values.
3. L*a*b* - Displays the L*a*b* values.
4. Yxy - Displays the Yxy values.
5. Rdab - Displays the Rdab values.

STDZ

Displays a menu for selection of standardization procedures. The operator presses the numeric key which corresponds to the desired procedure.

SELECT STANDARDIZATION METHOD:

PRESS <1> ZERO AND STANDARDIZE
<2> TRANSFER STANDARDIZE
<ESC> EXIT

1. ZERO AND STANDARDIZE - Prompts the operator to first set the bottom of the scale based upon a reading of the black glass. It then will set the top of the scale to the preset white tile XYZ values.

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2. TRANSFER STANDARDIZE - Prompts the operator through the standardization routine based on the operator entered values. THIS ROUTINE SHOULD BE USED JUDICIOUSLY.

PRINT — Prints the contents of the display to the printer.

AVG — Computes and displays the average of the data in the Average Register.

PSTD — Displays the values for the current product standard, plus a menu for selection of product standard procedures.

INDEX — Displays a menu of indices which may be selected. Upon selection of an index, the display will update or a procedure will be initiated. The first entry, plus up to nine of the following indices will be available.

0. None.

1. YI D1925 - Displays the yellowness index.

2. WI E313 - Displays the whiteness index.

3. ΔE Lab - Displays ΔE, ΔC if in Lab color scale.

4. ΔE CIELAB - Displays ΔE*, ΔC*, ΔH* if in CIELAB color scale.

5. ΔE Rdab - Displays ΔE, ΔC if in Rdab color scale.

6. Contrast Ratio - Prompts the operator through an opacity measurement. It will display the Y value of the sample with white backing with the opacity value.

7. Brightness - Displays the Z% scale or the TAPPI Brightness in conjunction with the TAPPI filter.

8. TJS - Displays tomato juice score.

9. TPS - Displays tomato paste score.

10. TSS - Displays tomato sauce score.

11. TCS - Displays tomato catsup score.

12. TABR - Displays tomato a/b ratio.

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DIAG

Displays a menu of additional capabilities. The operator presses the numeric key corresponding to the desired capability.

ADDITIONAL CAPABILITIES

PRESS ‹1› DIAGNOSTICS
‹2› VIEW STANDARD
‹3› TOP OF SCALE STANDARD
‹ESC› EXIT

1. DIAGNOSTICS - Displays a menu of five self diagnostics, plus the optional communications port setup.

DIAGNOSTICS MENU

PRESS ‹1› LAMP VOLTAGE ‹4› PROM CRC
‹2› LAMP ADJUST ‹5› RAM TEST
‹3› A/D COUNTS ‹6› PORT SETUP
‹ESC› EXIT

2. VIEW STANDARD - Displays a menu of three standards.

VIEW STANDARD MENU

PRESS ‹1› WHITE STANDARD
‹2› BLUE STANDARD
‹3› YELLOW STANDARD
‹ESC› EXIT

3. TOP OF SCALE STANDARD - Displays the values and the b/a ratio of the current top-of-scale standard. If there are values other than zero for the b/a ratio, these values will be used upon standardization rather than the white instrument standard values.

SEND

Sends data displayed on the screen to the RS-232C communications port. Note that the port setup may be selected through the diagnostic routine.

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10.2 Pinout Connections

The following is a list of the connector pinout for the DB-25P connector:

2	Transmit Data
3	Receive Data
4	Request to Send (RTS)
5	Clear to Send (CTS)
6	Data Set Ready (DSR)
7	Signal Ground
8	Tied to pin 20
12	Tied to pin 20
14	Test output*
18	Test input*
20	Data Terminal Ready (DTR)
22	Tied to pin 20

* Do not connect to these pins. They are for test purposes only.

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Calibration and Use of Colorimeter

I. Purpose

To establish a standard procedure for calibration and use of the Hunter Colorimeter.

II. Scope

This procedure is applicable to the D25-PC2 model Hunter Colorimeter located in the Physical Inspection Lab, Mt. Prospect.

III. Materials

A. HunterLab Instruction Manual, revision 1.7 (7/87)

B. Calibrated standard tiles

C. Lens brush

D. Trimpot adjusting tool

E. Log book

F. Colorimeter calibration and testing forms (Attachments I and II)

IV. General

A. Warm-up period for a "cool" instrument may take as long as two hours. Once warm-up has been achieved, the colorimeter may be left on with the standby/operate switch on "standby".

B. The instrument should be placed in a draft-free area with medium or subdued lighting. When not in use, the instrument should be stored with sample viewing area door closed and uncalibrated white tile placed at the sample port.

C. The calibrated tile standards should be stored in the standards box when not in use. Always handle standards carefully to avoid chipping the porcelain finish. Keep tiles clean and handle only at edges to prevent fingerprints. Tiles may be dusted with a soft nylon brush or cleaned by running warm water over them and wiping dry with a soft lint-free wipe.

D. To obtain information not specified in this procedure, refer to the HunterLab Manual.

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V. Procedure

A. Standardize equipment. This entails setting the top and bottom of the scale using the black glass and calibrated white tiles.

1. Install 2" aperture at sample port.
2. Turn switch on interface unit from "standby" to "operate".
3. Press "STDZ" button and wait for prompt.
4. Place black glass at sample port so that silver taped edge of tile is flush with front of sensor unit and the markings on the tile and the sensor unit are aligned.
5. Press "READ" button.
6. Place calibrated white tile at the sample port as described in A.4. above.
7. Press "READ" button. If values displayed are not expressed as "X", "Y" and "Z", press "SCALE" button. Check values against values read at factory (see attachment III) and document on calibration form. Values should be within +/-0.3 units of factory-read values.

B. Calibrate using the 2" aperture. Calibration involves reading of 5 standard colored tiles and comparing with factory-read values to verify correct functioning of equipment.

1. Align all tiles as described in section A.4.
2. Read tiles in the following order: pink, green, yellow, blue, and grey.
3. Document X, Y, and Z values for each tile read. Most values should read within +/-0.3 units of factory-read values. The pink tile may be as much as +/-0.4 units off.
4. Check lamp voltage every day that unit is calibrated. Follow instructions in HunterLab Manual section 7.2.2. Document information displayed on calibration form.

    a. If display indicates that lamp voltage is too high or low, adjust voltage using trimpot adjusting tool as described in section 7.2.2. of manual.
    b. Check calibration again after lamp voltage adjustment.

5. Obtain a photocopy of calibration form and file away. Original calibration form should remain with test data.

6. If samples to be tested require use of 1" aperture, install 1" aperture and repeat standardization procedure. Recalibration using 1" aperture is not necessary.

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C. Non-opaque materials require use of uncalibrated white tile to back-up samples. All foam samples should be tested with uncalibrated white tile back-up.

D. Some samples may have a texture which is directional in nature. Such materials should be tested by taking readings in four different spots per sample, rotating each sample 90° between readings. Report average values. Test foam samples in this manner.

E. Test unprinted portion of foam using 1" aperture, taking care not to include any of the printing in the sample area. Check sample placement by looking through the sample viewing area.

F. Test printed portion of foam by aligning printing within the 1" aperture so that the "N" in "Nitrodisc" and the first digit of the dosage are at the edge of the aperture, as shown in attachment IV. Check sample placement by looking through the sample viewing area.

G. Document all test data in both X, Y, Z and L, a, b, scales.

H. Enter the following information into the logbook each time the colorimeter is used: Date, technician intials, description, part and lot numbers of items tested, aperture size used, use of white back-up tile, adjustments/cleaning, and comments.

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Attachment I

Colorimeter Calibration Form

Colorimeter Calibration

Color	X	Y	Z
White			
Pink			
Green			
Yellow			
Blue			
Grey			

Comments/Adjustments made

_____

_____

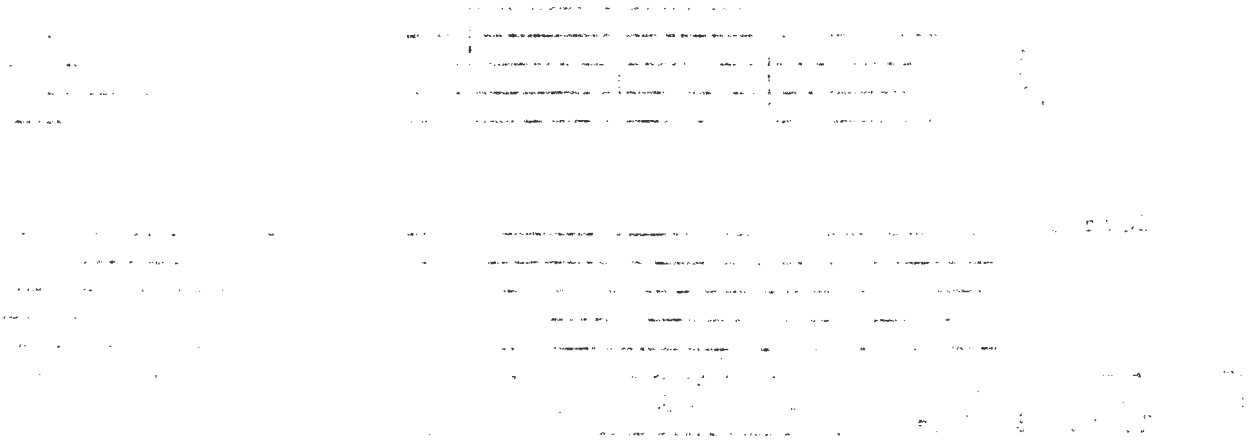
_____

_____

Calibrated by/Date _____

Part #/ Lot # of material tested _____

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Attachment II
Colorimeter Testing Form

Colorimeter Testing

Description _____
Part Number _____ Lot Number _____

Sample Number	X	Y	Z	L	a	b
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						

Comments _____

Tested By / Date _____

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Attachment III

Values Read at Factory for Colored
Calibration Tiles
(From HunterLab Manual)

STANDARDS	CALIBRATED VALUES			VALUES READ AT FACTORY			
ILLUMINANT C	X	Y	Z	X	Y	Z	Xa / Xb
1931 CIE 2° Observer							
White C2-27282	84.08	86.08	101.51	84.1	86.1	101.5	.2225
YI = -0.3	W = 85.6			Z% = NA		B_T = NA	
Pink C2-27283	46.5	41.7	39.3	46.8	42.0	39.5	
Green C2-27284	37.1	44.0	44.5	37.7	44.5	45.1	
Yellow C2-27285	60.2	61.8	41.3	60.8	62.1	41.9	
Blue C2-27286	38.7	42.1	62.8	38.9	42.5	63.1	
Gray C2-27287	10.9	11.0	13.6	11.0	11.1	13.7	

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