

# INSTRUCTION MANUAL

DIGITAL COLORIMETER

## QUICK CHECK/OPERATION

1. OPEN SHIPPING BOX - TAKE OUT INSTRUMENT
2. ANY DAMAGE?
  - REPORT TO FREIGHT COMPANY
  - CALL DISTRIBUTOR/FACTORY
3. SET WAVELENGTH DIAL TO CORRECT POSITION  
(INSERT SINGLE FILTER ON FIELD UNIT)
4. INSERT CLEAR SAMPLE/WATER
5. PUSH TEST BUTTON
6. ADJUST FOR 100% TRANSMITTANCE
7. REPLACE CLEAR SAMPLE WITH KNOWN (REFERENCE)  
SOLUTION
8. SET  $C_1$  OR  $C_2$  FOR KNOWN CONCENTRATION READING.
9. REPLACE KNOWN STANDARD WITH YOUR SOLUTION.  
PUSH TEST BUTTON AND MEASURE CONCENTRATION.

-READ INSTRUCTION MANUAL-

## LIMITED ONE YEAR WARRANTY

Manufacturer warranties all instruments (excluding batteries, damage caused by batteries, probes, standards, buffers) against defects in materials and workmanship for one year from date of original purchase. During this warranty period, the manufacturer will repair or at their option, replace at no charge a product which proves to be defective, provided the product is returned, shipping prepaid to the manufacturer's service center.

This warranty does not apply to damage caused by accident or misuse or as a result of service or modification by other than an authorized service center. No other express warranty is given. Repair or replacement of product is your exclusive remedy. In no event, shall the manufacturer be liable for consequential damages.

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## **12.0 DEVELOPING A COLORIMETRIC PROCEDURE**

When a published method is not available, a colorimetric procedure can be developed as follows:

**12.1** Make a series of standard dilutions, using material to be tested.

**12.2** Place a blank sample (deionized or distilled water) in the universal cuvette holder. Set the filter to 430 nm and the function switch to %T. Adjust for 100% transmittance.

**12.3** Place the most concentrated sample in the meter and note the reading.

**12.4** Repeat steps 2 and 3 for each filter frequency.

**12.5** Select the filter which gives the greatest reduction in transmittance.

**12.6** Measure the absorbance for each standard using the selected filter.

**12.7** Prepare a calibration curve of absorbance versus concentration. See section 11.8.

**12.8** A calibration curve of transmittance versus concentration can be prepared using semi-log graph paper. (See section 2.3.)

## 11.0 LINEARITY CHECK

The following test will demonstrate the relationship between absorbance and concentration as well as check the linearity of the colorimeter.

11.1 Turn on colorimeter. Set filter to 490 nm.

11.2 Using a blank, set to 100% transmittance.

11.3 Prepare a cobaltous chloride solution that is concentrated enough to produce a 10% transmittance reading.

11.4 Make a series of dilutions of the cobaltous chloride solution as follows:

Solution #	1	2	3	4	5
mL of cobalt solution	25	20	15	10	5
mL of water*	0	5	10	15	20

\* Water should be deionized or distilled water.

11.5 Place solution #3 in a cuvette, place in colorimeter.

11.6 Set the concentration ( $C_1$  or  $C_2$  depending on your color concentration) to 60.0. This is an arbitrary setting since we don't know the true concentration. We are only interested in the relative values between samples.

11.7 Check the concentration and absorbance of each solution, noting the readings. If transmittance is desired for each sample, simply turn the function switch %T prior to removing the sample.

11.8 Plot absorbance (vertical axis) versus cobalt concentration to check the absolute linearity.

Note: The line will be a "best fit" straight line. The area of interest is between an absorbance of 0.1 and 1.0. Many color systems will be non-linear outside this region.

## 1.0 INTRODUCTION

Your new digital colorimeter is for general purpose laboratory, field, industrial, or educational use. This meter allows a choice of 0 - 100% transmission, 0 - 2.0 absorbance, 0 - 199.9 concentration or 0 - 1999 concentration. Bench units are battery or AC powered and feature a universal cuvette holder along with a colorwheel holding seven filters. Field units feature batteries, a universal cuvette holder, and filter inserts.

## 2.0 THEORY OF OPERATION

To understand the theory behind colorimetry it is first necessary to define a few basic terms.

### 2.1 Light and Color

**Polychromatic Light** - Light that consists of two or more colors. Examples are visible light and sunlight. Sunlight is actually composed of a continuous spectrum. In the visible range we recognize six colors; violet, blue, green, yellow, orange and red.

**Monochromatic Light** - Light that consists of only one color. Each of the colors seen in a rainbow appears to us as a separate monochromatic light. In reality, a rainbow is a continuous spectrum of light.

**Light Wavelength** - Wavelength is an assigned property of colored light. Each hue of color can be defined by a specific wavelength range.

**Transmitted Color** - When a full spectrum of visible light is available, a sample or solution will transmit specific wavelengths of light. The wavelengths that are transmitted will result in the color that is perceived by the human eye when viewing the sample.

**Absorbed Colors** - When a full spectrum of visible light is available, a sample or solution will absorb specific light wavelengths. An extreme example of the phenomena is a black sample which absorbs all colors and therefore no color is perceived by the human eye.

**Chart 1 - Colors of Different Wavelength Regions**

Wavelength	Absorbed Color	Transmitted Color*
380-450	Violet	Yellow-Green
450-495	Blue	Yellow
495-570	Green	Violet
570-590	Yellow	Blue
590-620	Orange	Green-Blue
620-750	Red	Blue-Green

\* Color of solution

## 2.2 Colorimetry

Colorimetry, simply defined, is the scientific determination of the concentration of a specific compound through a reaction which yield a colored solution. The intensity of the absorbed color is proportional to the compound's concentration. An example of a specific reaction is the test for albumin.

albumin + bromocresol green  $\longrightarrow$  albumin-bromocresol green  
(blue-green color)

The albumin-bromocresol green complex is measured at wavelength 630 nm. It is important to differentiate at this point between a transmitted color (blue-green), and absorbed color (630 nm wavelength or red). The chosen wavelength for a colorimetry measurement is usually the wavelength of greatest absorbance by the sample. Therefore, when a solution appears blue-green, the color which is most absorbed is red (see chart 1), and the wavelength in the range of 620-750 nm is most appropriate. The test procedure will usually specify a wavelength. If you were able to look at the filter you would see that a wavelength of 630 selects a red filter which will allow red light to pass through the sample. If Absorbance is measured, then the amount of light absorbed will be displayed. The darker or more concentrated the sample the higher the absorbance reading.

**IF** percent Transmittance (%T) is measured, then the percent of light transmitted will be displayed. In this mode, the more concentrated sample will transmit less light and the % T will decrease.

4. Unscrew 4 screws holding cuvette holder assembly to top of chassis.
5. Remove cuvette holder assembly.
6. Unscrew 3 screws from lamp wire end of holder assembly, and remove loosened panel.
7. Pull lamp holder off brass slides, discard, and replace with new lamp shuttle.
8. Reassemble holder assembly and instrument.

## 10.2 Non-linear Standard Curve

- a. Check all test solutions for expiration or contamination - remake any suspicious solutions and standards. Recheck with new solutions and standards.
- b. Recheck standard range - a narrower range may be necessary to assure linearity.
- c. Change tungsten lamp - old fading light source can cause non-linearity.
- d. Check the instrument linearity by running a linearity check. See section 11.0.

## 10.3 Unstable Readings

- a. Make certain that samples are completely stable. An underdeveloped or deteriorating sample can cause unstable readings.
- b. If using a round cuvette, make certain that the cuvette position is optimized and then used with consistent alignment.
- c. Check tungsten bulb - if the bulb seems to flicker or waver, it needs to be changed.

**If all corrective actions fail, then the instrument needs to be serviced.**

## 10.0 TROUBLESHOOTING GUIDE

### 10.1 Meter exhibits no response when sample is inserted.

a. Adjust % T knob clockwise; if still no response, replace batteries or use with the AC transformer. In field units, recharge batteries by connecting recharger to unit and plugging into an AC outlet. This unit may also be used while connected to the recharger/power adaptor.

To replace batteries, in bench models:

1. Unscrew 4 feet, remove shroud.
2. Loosen screws on back panel.
3. Disconnect battery snaps.
4. Replace batteries, noting polarity.
5. Reassemble instrument.

To replace batteries, in field models:

1. Loosen screws on front panel.
2. Disconnect battery snaps.
3. Replace batteries, noting polarity.
4. Reassemble instrument.

- b. Check to see if correct wavelength is being used.
- c. If using rectangular cuvettes - make certain that cuvette is aligned so that the clear windows are in the light path.
- d. Check tungsten bulb - the tungsten bulb provided has a calibrated 2000 hour lifetime at maximum intensity. You may need to replace the light holder assembly.

Replacing light holder procedure:

1. Unscrew 4 feet, remove shroud. On field unit, unscrew 4 screws and remove shroud.
2. Unscrew photo diode holder from cuvette holder assembly.
3. Unscrew 2 terminals on circuit card and remove 2 wires which go to cuvette holder assembly.

This relationship between Absorbance or Transmittance and Concentration is illustrated mathematically by Beers Law:

$$A = - \text{Log } T = ebc$$

A = Absorbance  
T = % Transmittance

e = a constant  
b = length of light path  
c = Concentration

If b is kept constant by use of the same size cuvette throughout the test measurement then the Concentration is directly proportional to the Absorbance and proportional to the negative log of the Transmittance. This is why the Transmittance standard curve is graphed on semi-log paper and the Absorbance standard curve is graphed on linear paper. (See section 6.0.)

## 2.4 Theory of Instrumentation

The basic set-up of the colorimeter is:

- a. Tungsten light source - Produces polychromatic light over the entire visible region.
- b. Broad spectrum filter - the colorwheel has eight different filters. The filter employed is selected by wavelength. Each filter will produce monochromatic light at a specified peak wavelength with a bandpass of 30 nm. The filters enable the user to perform tests from 430 to 660 nm.
- c. Cuvette Holder - holds the inserted cuvette during testing. It is imperative the cuvette be consistently oriented in the holder. Square cuvettes usually have two clear and two frosted window. The light should pass through the two clear windows. Round cells usually have orientation markings to correctly position the cuvette.
- d. Detector - a silicon photo diode is used as the detector. The photo detector current will change as a function of light energy.
- e. Display - the current signal from the detector is converted to a numerical value, either absorbance, percent transmittance, or concentration, depending upon the scale chosen.

### 3.0 SPECIFICATIONS

Wavelength Range:	430 - 660 nm
Readout:	3 1/2 digit LCD
Transmission:	0 - 100 %
Absorbance:	0 - 2.0 A
Concentration:	0-1999
Recorder output:	0-2 V nominal
Repeatability:	± 0.5% T
Test time:	10-15 sec. / test
Operating temperature range:	+15°C to +35°C
Storage temperature range:	-20°C to +50°C
Operating relative humidity:	20% to 70%
Storage relative humidity:	0% to 90% non-condensing
Operating filter life:	2 - 3 years under normal operating conditions
Bandwidth:	25 - 40 nm (standard)
Wavelength Peak:	±5 nm (standard)
Sample Holder:	Universal, rectangular or 9 - 19 mm round
Size:	
Bench	5" H X 8" W X 5" D
Field	4" H X 12" W X 5" D
Weight:	
Bench	1.9 lbs (0.86 Kg)
Field	3 lbs (1.36 Kg)
Power:	8 X 1.5 V AA batteries or 110/220 transformer

**7.3** If the test method wavelength falls between two wavelengths available, the decision to go to the higher or lower wavelength should be decided by the following procedure:

- a. If there are interferences at one end of the spectrum, then the wavelength chosen should be toward the opposite end of the spectrum.
- b. If interferences are not a problem, then a series of standards should be made up and read at both the higher and lower wavelength. The wavelength that gives the highest absorbance for the most concentrated standard should be used (assuming both standard curves are linear).

### 8.0 FILTER CARE

The multi-wavelength colorwheel consist of 7 gelatin filters. After two years of a high temperature, high humidity environment, some degradation of the filters can be expected.

The single wavelength insert holds one glass filter. If finger prints or dirt buildup are noticed, use a cotton swab and alcohol to clean the filter.

### 9.0 STANDARDS

Colorimeter standards are available to test the linearity of your instrument. They are not required for calibration, contact your dealer/distributor.

## 6.0 MEASUREMENT GUIDELINES

- 6.1 Avoid contaminating the standard and sample solutions.
- 6.2 Use the same style cuvette for all solutions.
- 6.3 Orient cuvettes in the same direction for all solutions.

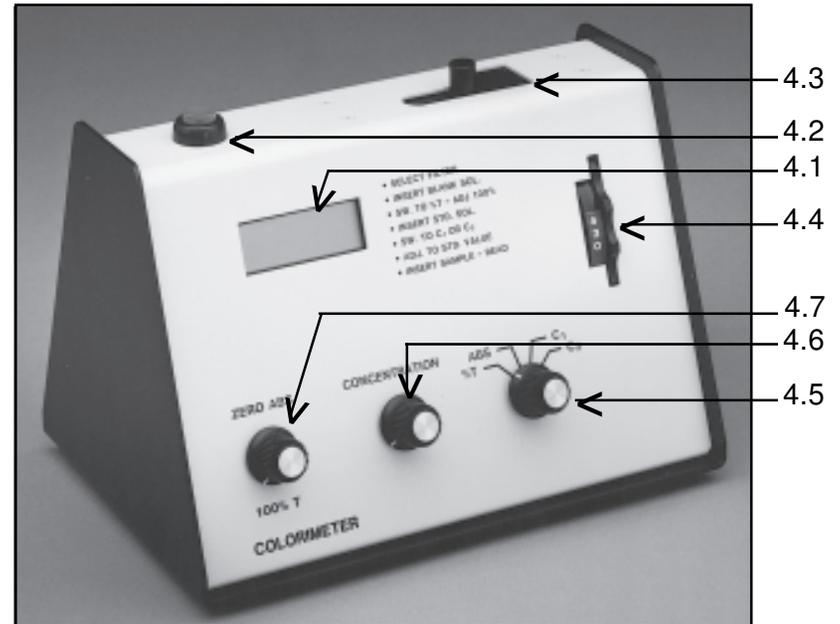
## 7.0 WAVELENGTH SELECTION

**7.1** This colorimeter is not designed to be an instrument for methodology research and should not be used for that purpose. There are circumstances, however, where a method can be adapted for use.

**7.2** If the wavelength specified in the test method is not one of the available wavelengths, the decision to use another wavelength should be decided by the following procedure:

- a. Check for other test methods. Often there are several test methods for a particular compound requiring different wavelengths.
- b. Know what compounds could interfere with the test and where in the spectrum they absorb. The decision to read a test at a wavelength other than that specified in the test method depends on the absorbance spectrum of any interfering compounds. The wavelength chosen should always be one that has minimum overlap with the spectrum of interfering compounds.
- c. If no other test methods are available, and interfering compounds are not a problem, then many tests can be read at wavelengths other than that mentioned by the method.

## 4.0 INSTRUMENT FAMILIARITY



- 4.1 Digital readout** - 3 1/2 digit LCD display
- 4.2 Test button** - push to test sample. Applies power to instrument.
- 4.3 Universal cuvette holder** - holds a standard rectangular cuvette or a round cuvette up to 19 mm in diameter.
- 4.4 Filter Selector** (Colorwheel) - allows selection of correct filter corresponding to the available wavelengths of 430, 460, 490, 530, 570, 610, and 660 nm. 8th position blocks light for zero calibration. Available on bench units only.
- Filter Inserts** - removeable narrow bandwidth filters, available at select frequencies from 430 to 660 nm. Filter inserts are available on field models only.
- 4.5 Function Selector Switch** - selects reading of transmittance, absorbance, concentration (x1) or concentration (x 10).
- 4.6 Concentration** - calibrates unit to a "standard" solution for direct reading.
- 4.7 Percent Transmittance** - Adjusts for 100% T (0 Absorbance) against clear water sample.

NOTE: Binding posts on rear panel provide RECORDER output signal.

## 5.0 OPERATION

### 5.1 General

5.1.1 Select correct filter. If the wavelength desired is not one of the available wavelengths, or if the correct wavelength is unknown, then read section 5.0.

5.1.2 Any 9 to 20 mm round or square cuvette may be used.

However:

a) If a square cuvette is used, be sure the flat surface is against the flat surface on the right side of the universal cuvette holder.

b) If a round cuvette is used, and precision readings are desired, mark the cuvette so orientation is always the same.

### 5.2 Transmittance

5.2.1 Turn unit on.

5.2.1 Set function switch to %T.

5.2.2 Put blank (distilled or deionized water) in a test cuvette and place in universal holder.

5.2.3 Adjust **100% T** for a reading of 100.0%.

5.2.4 Place sample to be measured in holder, readout will display transmittance of sample in direct %.

### 5.3 Absorbance

5.3.1 Set function switch to **ABS**.

5.3.2 Put blank (distilled or deionized water) in a test cuvette and place in universal holder.

5.3.3 Adjust **ZERO ABS (100% T)** for a reading of 00.0 absorbance (same as setting transmittance to 100%).

5.3.4 Place sample to be measured in cuvette, place in universal holder; readout will display absorbance of sample in direct units.

### 5.4 Concentration

5.4.1 Set function switch to % **T**.

5.4.2 Put blank (distilled or deionized water) in a test cuvette and place in universal holder.

5.4.3 Adjust %**T** for a reading of 100.0.

5.4.4 Set function switch to either **C<sub>1</sub>** or **C<sub>2</sub>** (depending on intensity of concentration or resolution desired).

5.4.5 Place a standard solution of known concentration in the holder and adjust concentration to correct reading. Colorimeter is now calibrated to the concentration units desired.

5.4.6 Replace standard solution with sample to be tested and read concentration in direct units.

### 5.5 Concentration via Transmittance or Absorbance

Concentration can be determined from either transmittance or absorbance readings by constructing a calibration curve.

5.5.1 Make a series of standard dilutions for test sample.

5.5.2 Following either section 5.2 or 5.3, take readings of all the dilutions and record the results.

5.5.3 Prepare a calibration curve of absorbance vs concentration or transmittance vs concentration.

For additional information, contact your dealer or the manufacturer for a booklet on the subject.