INSTRUCTION MANUAL

ANALOG 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

4. INSERT CLEAR SAMPLE/WATER (BLANK)

5. PUSH TEST BUTTON

6. ADJUST FOR 100% TRANSMITTANCE

7. REPLACE BLANK WITH UNKNOWN AND MEASURE ABSORBANCE OR TRANSMITTANCE.

-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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13.0 LINEARITY CHECK

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

13.1 Turn on colorimeter. Set filter to 490 nm.

13.2 Using a blank, set to 100% transmittance.

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

13.4 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.

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

13.6 Absorbance of each solution, noting the readings.

13.7 Plot absorbance (vertical axis) versus cobalt concentration (mL of cobalt solution values) to check the absolute linearity.

13.8 The line is a "best-fit" straight line. The area of interest is between an abrorbance of 0.1 and 1.0. Many color systems will become non-linear outside of this range.

13.9 Any significant curvature in the "best-fit" line would be an indication of possible light leaks or improper alignment of the optical system.

12.2 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 13.0.

12.3 Unstable Readings

a. Make certain that samples are completely stable. An underdeveloped or deteriorating sample can cause un stable readings.

b. If using a round cuvette, make certain that the cuvette position is optimized and then used with consistent align ment.

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.

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 or 0 - 2.0 absorbance. The instrument is powered by batteries or runs with a 110 or 220 VAC transformer and features a universal cuvette holder along with a colorwheel holding seven filters.

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 > 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.

12.0 TROUBLESHOOTING GUIDE

12.1 Meter exhibits no response when sample is inserted.

a. Adjust % T knob clockwise; if still no response, replace batteries or use on AC power.

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

used are essential in making informed decisions regarding any wavelength change. Keep in mind that reading samples at other than the optimum wavelength will probably result in decreased sensitivity.

9.0 FILTER CARE

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

10.0 STANDARDS

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

11.0 CIRCUIT FUNCTION

11.1 Power

12VDC voltage, from the batteries, is applied to all circuitry by pressing the test button. The 110 or 220 adaptor can be used with the power jack on the back of the instrument. When external power is applied, the batteries are disconnected.

11.2 Light Source

A switching regulator provides a stable, adjustable voltage to the tungsten lamp. The % TRANSMITTANCE knob adjusts this voltage, allowing standardization to 100% T at various filter wavelengths.

11.3 Detection and Metering

A silicon diode photo cell generates a voltage proportional to the light it receives, i.e. the light which passes through the solution. This voltage is amplified and used to drive the meter movement. The meter scale is calibrated in % T (linear with respect to light transmitted, and absorbance (logarithmic with respect to light transmitted).

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 7.0.)

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:	6" Analog meter
Transmission:	0 - 100 %
Absorbance:	0 - 2.0 A
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:	5” H X 8” W X 5” D
Weight:	1.9 lbs (0.86 Kg)
Power:	8 X 1.5 V AA batteries or 110/220 VAC transformer

8.0 WAVELENGHT SELECTION

8.1 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 with this instrument.

8.2 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 interfering compounds. The wavelength chosen should always have a 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.

8.3 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 standards should be used (assuming both standards curves are linear).

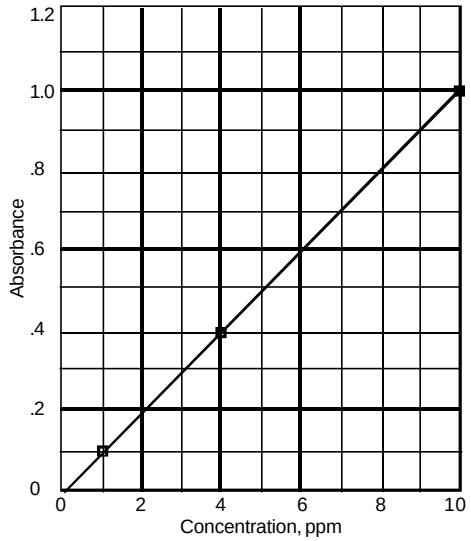
8.4 In most cases, the test method is the best source of information regarding interferences and alternate wavelengths. A thorough understanding of what is being tested and what method is

Example 2

Standard Curve

ppm	Absorbance
1.0	0.1
4.0	0.4
10.0	1.0

An unknown has absorbance of 0.5, therefore concentration is 5 ppm.



6.0 CALIBRATION

6.1 Turn meter on with the colorwheel turned to block the light. (Turn the colorwheel counterclockwise as far as it will go. No filter value will be indicated at this position.)

6.2 Using a flat head screwdriver adjust the zero adjustment screw on the meter (see section 4.6), so the needle indicates zero.

6.3 Instrument is now ready for operation. Refer to section 5.0 for operation instructions.

NOTE: There are no internal adjustments.

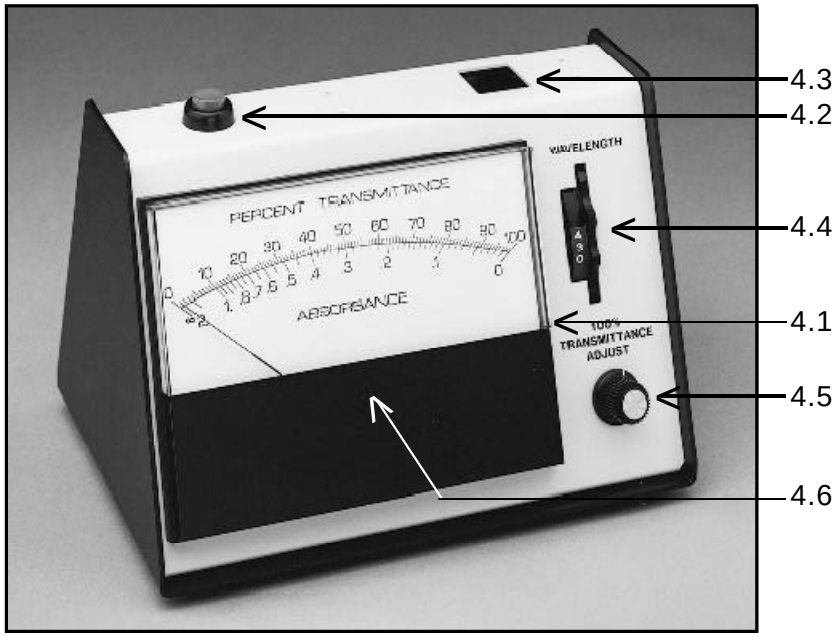
7.0 MEASUREMENT GUIDELINES

7.1 Avoid contamination of the standards and sample solutions.

7.2 Use the same style cuvette for all measurements.

7.3 Orient cuvettes in the same direction for all solutions.

4.0 INSTRUMENT FAMILIARITY



4.1 Analog readout - six inch meter face

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.

4.5 100% Transmittance - knob for adjustment of blank to either 0 absorbance or 100% transmittance depending on scale used.

4.6 Mechanical zero - screw used to adjust meter needle to acceptable starting position when meter is off (0% transmittance or absorbance).

5.0 OPERATION

5.1 Select correct filter. If the wavelenght specified is not one of the available wavelengths or if the correct wavelenght is unknown, then go to section 7.0.

5.2 Decide on a measurement mode: Percent Transmittance (%T) or Absorbance (A)

5.3 The correct solution for the blank should be described in your test procedure. Pour a sample of your reagent into the cuvette. Any of a variety of cuvettes can be used but the same size cuvette should be used throughout the test.

5.4 Insert the cuvette into the instrument. When using rectangular cuvette, make certain the readings windows are properly aligned with the light path.

5.5 Use 100% Transmittance knob to zero the instrument in the Absorbance mode. In the Transmittance mode, the 100% Transmittance knob is used to adjust the mete to 100% T.

5.6 Read and record a set of standards to be used for the standard curve.
Requirements for standards:
a. Should be made at the same time as the unknown samples.
b. Should encompass full concentration range that unknowns are expected to span.
c. Should read at least three standards.

5.7 Read and record the values for the unknown samples.

5.8 Draw and use a standard curve to obtain the concentration from % T readings.

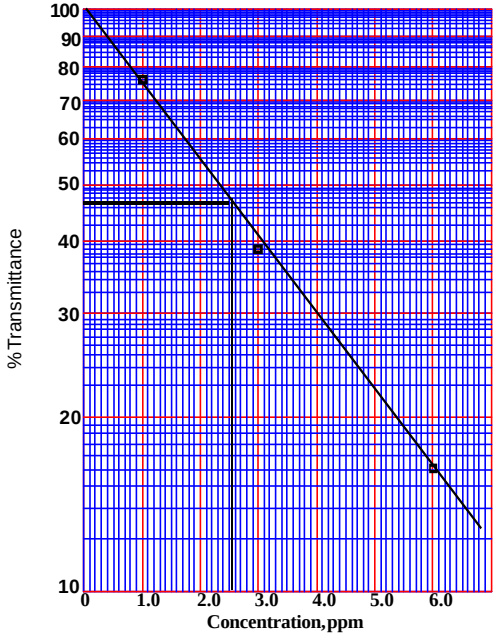
Procedure:
a. Use semi-log graph paper.
b. Plot the % T on the log side (y-axis) and concentration on the x-axis.
c. Plot the % T verses the concentration of the standards.
d. Draw the best-fit straight line. A deviation of ±5% is acceptable.

e. Locate the % T of your unknown on the curve.
f. Determine the corresponding concentration value by dropping a straight line down to the x-axis.
g. % T values of the unknowns should be between 10% and 90% transmittance to assure linearity.
h. Take any previous sample dilution into account when calculating final concentrations.

Example 1
Standard Curve

ppm	%T
1	73
3	38
6	15

An unknown has a %T of 45, therefore concentration is 2.5 ppm.



5.9 To obtain concentration from absorbance readings, draw and use a standard curve.

Procedure:
a. Use linear graph paper.
b. Plot Absorbance versus Concentration.
c. Plot values of standards.
d. Draw best-fit line. A deviation of ±5% is acceptable.
e. Locate the absorbance of your unknown on the best-fit line.
f. Determine the corresponding concentration value.
g. Absorbance values of the unknown should fall between 0.1 and 1.0 A to assure linearity.
h. Take any previous sample dilution into account when calculation final concentration.