SMART 2

Colorimeter

OPERATOR'S MANUAL

LaMotte

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GENERAL INFORMATION

PACKAGING & DELIVERY

Experienced packaging personnel at LaMotte Company assure adequate protection against normal hazards encountered in transportation of shipments. After the product leaves the manufacturer, all responsibility for its safe delivery is assured by the transportation company. Damage claims must be filed immediately with the transportation company to receive compensation for damaged goods.

Should it be necessary to return the instrument for repair or servicing, pack instrument carefully in suitable container with adequate packing material. A return authorization number must be obtained from LaMotte Company by calling 1-800-344-3100. Attach a letter with the authorization number to the shipping carton which describes the kind of trouble experienced. This valuable information will enable the service department to make the required repairs more efficiently.

GENERAL PRECAUTIONS

Before attempting to set up or operate this instrument it is important to read the instruction manual. Failure to do so could result in personal injury or damage to the equipment.

The SMART 2 Colorimeter should not be stored or used in a wet or corrosive environment. Care should be taken to prevent water or reagent chemicals from wet colorimeter tubes from entering the colorimeter chamber.

NEVER PUT WET TUBES IN COLORIMETER.

SAFETY PRECAUTIONS

Read the labels on all LaMotte reagent containers prior to use. Some containers include precautionary notices and first aid information. Certain reagents are considered hazardous substances and are designated with a * in the instruction manual. Material Safety Data Sheets (MSDS) are supplied for these reagents. Read the accompanying MSDS before using these reagents. Additional emergency information for all LaMotte reagents is available 24 hours a day from the Poison Control Center listed in the front of the phone book. Be prepared to supply the name and four-digit LaMotte code number found on the container label or at the top of the MSDS. LaMotte reagents are registered with a computerized poison control information system available to all local poison control centers.

Keep equipment and reagent chemicals out of the reach of young children.

Protect Yourself and Equipment: Use Proper Analytical Techniques

LIMITS OF LIABILITY

Under no circumstances shall LaMotte Company be liable for loss of life, property, profits, or other damages incurred through the use or misuse of its products.

SPECIFICATIONS

INSTRUMENT TYPE: Colorimeter

Readout	Graphical 4 line, 16 character per line LCD
Wavelengths	430nm, 520 nm, 570 nm, 620 nm
Wavelength Accuracy	± 2 nm
Readable Resolution	Determined by reagent system
Wavelength Bandwidth	10 nm typical
Photometric Range	–2 to +2A
Photometric Precision	± 0.001A
Sample Chamber	Accepts 25 mm diameter flat-bottomed test tubes, 10 mm square cuvettes, 16 mm COD test tubes
Light Sources	4 LEDs
Detectors	4 silicon photodiodes with integrated interference filters
Modes	Absorbance, pre-programmed tests
Pre-Programmed Tests	YES, with automatic wavelength selection
User Defined Tests	Up to 10 user tests can be input
RS232 Port	8 pin mini-DIN, 9600b, 8, 1, n
Power Requirements	*Battery Operation:* 9 volt alkaline *Line Operation:* 110/220V AC; 50/60 Hz with adapter, 6V 500 mA DC
Dimensions (LxWxH)	8.5 x 16.2 x 16.7 cm, 3.4 x 6.4 x 2.6 inches
Weight	312 g, 11 oz (meter only)
Data Logger	350 test results stored for download to a PC

CONTENTS AND ACCESSORIES

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SMART 2 Colorimeter

Test Tubes, with Caps

Power Supply, 110/220V

SMART 2 Colorimeter Quick Start Guide

SMART 2 Colorimeter Manual

ACCESSORIES

COD Adapter	Code 5-0087
UDV Adapter	Code 5-0086
Small Field Carrying Case	Code 1919-GCS150
Large Field Carrying Case	Code 1919-BCS440
SMARTLink 2 Program & Interface Cable (3.5 disk)	Code 1912-3
SMARTLink 2 Program & Interface Cable (CD)	Code 1912-CD

EPA COMPLIANCE

The SMART 2 Colorimeter is an EPA-Accepted instrument. EPA-Accepted means that the instrument meets the requirements for instrumentation as found in test procedures that are approved for the National Primary Drinking Water Regulations (NPDWR) or National Pollutant Discharge Elimination System (NPDES) compliance monitoring programs. EPA-Accepted instruments may be used with approved test procedures without additional approval.

CE COMPLIANCE

The SMART 2 Colorimeter has earned the European CE Mark of Compliance for electromagnetic compatibility and safety.

DECLARATION OF CONFORMITY

Standards to which Conformity Declared:	EN61326:1998, IEC61326:1997, IEC61000-4-2:1995, IEC61000-4-3:1995 IEC61000-4-4:1995, IEC61000-4-5:1995 IEC61000-4-6:1996, IEC61000-4-11:1994, EN61000-3-2:1995, EN61000-3-3:1994-12, EN55011/CISPR11, FCCCFR47 Part 15, EN61558
Manufacturer's Name:	LaMotte Company
Manufacturer's Address:	802 Washington Avenue PO Box 329 Chestertown, MD 21620
Type of Equipment:	Colorimeter
Model Name:	SMART 2
Year of Manufacture:	2001
Testing Performed By:	Windermere 2000 Windermere Court Annapolis, MD 21401

I, the undersigned, hereby declare that the equipment specified above conforms to the above Directive and Standards.

Chestertown, Maryland
Place

1/15/02
Date

Scott H. Steffen
Signature

Scott H. Steffen
Name

VP New Products & Quality
Position

WATER SAMPLING FOR CHEMICAL ANALYSIS

Taking Representative Samples

The underlying factor to be considered for any type of water sampling is whether or not the sample is truly representative of the source. To properly collect a representative sample:

- Sample as frequently as possible.
- Collect a large sample or at least enough to conduct whatever tests are necessary.
- Make a composite sample for the same sampling area.
- Handle the sample in such a way as to prevent deterioration or contamination before the analysis is performed.
- Perform analysis for dissolved gases such as dissolved oxygen, carbon dioxide, and hydrogen sulfide immediately at the site of sampling. These factors, as well as samples for pH, cannot be stored for later examination.
- Make a list of conditions or observations which may affect the sample. Other considerations for taking representative samples are dependent upon the source of the sample. Taking samples from surface waters involves different considerations than taking samples from impounded and sub-surface waters.

Sampling of Open Water Systems

Surface waters, such as those found in streams and rivers, are usually well mixed. The sample should be taken downstream from any tributary, industrial or sewage pollution source. For comparison purposes samples may be taken upstream and at the source of the pollution before mixing.

In ponds, lakes, and reservoirs with restricted flow, it is necessary to collect a number of samples in a cross section of the body of water, and where possible composite samples should be made to ensure representative samples.

To collect samples from surface waters, select a suitable plastic container with a tight fitting screw cap. Rinse the container several times with the sample to be tested, then immerse the container below the surface until it is filled to overflowing and replace the cap. If the sample is not to be tested immediately, pour a small part of the sample out and reseal. This will allow for any expansion. Any condition which might affect the sample should be listed.

Sub-surface sampling is required to obtain a vertical profile of streams, lakes, ponds, and reservoirs at specific depths. This type of sampling requires more sophisticated sampling equipment.

For dissolved oxygen studies, or for tests requiring small sample sizes, a Water Sampler (LaMotte Code 1060) will serve as a subsurface or in-depth sampler.

This weighted device is lowered to the sampling depth and allowed to rest at this depth for a few minutes. The water percolates into the sample chamber displacing the air which bubbles to the surface. When the bubbles cease to rise, the device has flushed itself approximately five times and it may be raised to the surface for examination. The inner chamber of the sampling device is lifted out and portions of the water sample are carefully dispensed for subsequent chemical analysis.

A Snap-Plunger Water Sampler (LaMotte Code 1077) is another "in-depth" sampling device which is designed to collect large samples which can be used for a multitude of tests. Basically, this collection apparatus is a hollow cylinder with a spring loaded plunger attached to each end. The device is cocked above the surface of the water and lowered to the desired depth. A weighted messenger is sent down the calibrated line to trip the closing mechanism and the plungers seal the sample from mixing with intermediate layers as it is brought to the surface. A special drain outlet is provided to draw off samples for chemical analysis.

▪ Sampling of Closed System

To obtain representative samples from confined water systems, such as pipe lines, tanks, vats, filters, water softeners, evaporators and condensers, different considerations are required because of chemical changes which occur between the inlet and outlet water. One must have a basic understanding of the type of chemical changes which occur for the type of equipment used. Also, consideration should be given to the rate of passage and retaining time for the process water.

Temperature changes play an important part in deciding exactly what test should be performed. Process water should be allowed to come to room temperature, 20–25°C, before conducting any tests.

When drawing off samples from an outlet pipe such as a tap, allow sample to run for several minutes, rinsing the container several times before taking the final sample. Avoid splashing and introduction of any contaminating material.

FILTRATION

When testing natural waters that contain significant turbidity due to suspended solids and algae, filtration is an option. Reagent systems, whether EPA, Standard Methods, LaMotte or any others, will generally only determine dissolved constituents. Both EPA and Standard Methods suggest filtration through a 0.45 micron filter membrane, to remove turbidity, for the determination of dissolved constituents.** To test for total constituents, organically bound and suspended or colloidal materials, a rigorous high temperature acid digestion is necessary.

**LaMotte offers a filtering apparatus: syringe assembly (Code 1050) and membrane filters, 0.45 micron, (Code 1103).

AN INTRODUCTION TO COLORIMETRIC ANALYSIS

Most test substances in water are colorless and undetectable to the human eye. To test for their presence we must find a way to "see" them. The SMART 2 Colorimeter can be used to measure any test substance that is itself colored or can be reacted to produce a color. In fact a simple definition of colorimetry is "the measurement of color" and a colorimetric method is "any technique used to evaluate an unknown color in reference to known colors". In a colorimetric chemical test the intensity of the color from the reaction must be proportional to the concentration of the substance being tested. Some reactions have limitations or variances inherent to them that may give misleading results. Many such interferences are discussed with each particular test instruction. In the most basic colorimetric method the reacted test sample is visually compared to a known color standard. However, accurate and reproducible results are limited by the eyesight of the analyst, inconsistencies in the light sources, and the fading of color standards.

To avoid these sources of error, a colorimeter can be used to photoelectrically measure the amount of colored light absorbed by a colored sample in reference to a colorless sample (blank).

White light is made up of many different colors or wavelengths of light. A colored sample typically absorbs only one color or one band of wavelengths from the white light. Only a small difference would be measured between white light before it passes through a colored sample versus after it passes through a colored sample. The reason for this is that the one color absorbed by the sample is only a small portion of the total amount of light passing through the sample. However, if we could select only that one color or band of wavelengths of light to which the test sample is most sensitive, we would see a large difference between the light before it passes through the sample and after it passes through the sample.

The SMART 2 Colorimeter passes one of four colored light beams through one of four optical filters which transmits only one particular color or band of wavelengths of light to the photodectector where it is measured. The difference in the amount of colored light transmitted by a colored sample is a measurement of the amount of colored light absorbed by the sample. In most colorimetric tests the amount of colored light absorbed is directly proportional to the concentration of the test factor producing the color and the path length through the sample. However, for some tests the amount of colored light absorbed is inversely proportional to the concentration.

The choice of the correct wavelength for testing is important. It is interesting to note that the wavelength that gives the most sensitivity (lower detection limit) for a test factor is the complementary color of the test sample. For example the Nitrate-Nitrogen test produces a pink color proportional to the nitrate concentration in the sample (the greater the nitrate concentration, the darker the pink color). A wavelength in the green region should be selected to analyze this sample since a pinkish-red solution absorbs mostly green light.

REAGENT BLANK

Some tests will provide greater accuracy if a reagent blank is determined to compensate for any color or turbidity resulting from the reagents themselves. A reagent blank is performed by running the test procedure on 10 mL of demineralized water. Use sample water to SCAN BLANK. Insert the reagent blank in the colorimeter chamber and select SCAN SAMPLE. Note result of reagent blank. Perform the tests on the sample water as described. Subtract results of reagent blank from all subsequent test results. NOTE: Some tests require a reagent blank to be used to SCAN BLANK.

COLORIMETER TUBES

Colorimeter tubes which have been scratched through excessive use should be discarded and replaced with new ones. Dirty tubes should be cleaned on both the inside and outside. Fingerprints on the exterior of the tubes can cause excessive light scattering and result in errors. Handle the tubes carefully, making sure the bottom half of the tube is not handled.

LaMotte Company makes every effort to provide high quality colorimeter tubes. However, wall thicknesses and diameter of tubes may still vary slightly. This may lead to slight variations in results (e.g. if a tube is turned while in the sample chamber, the reading will likely change slightly). To eliminate this error put the tubes into the sample chamber with the same orientation every time.

The tubes that are included with the colorimeter have an index mark to facilitate this. If possible, use the same tube to SCAN BLANK and SCAN SAMPLE.

SELECTING AN APPROPRIATE WAVELENGTH

The most appropriate wavelength to use when creating a calibration curve is usually the one which gives the greatest change from the lowest reacted standard concentration to the highest reacted standard concentration. However, the absorbance of the highest reacted standard concentration should never be greater than 2.0 absorbance units. Scan the lowest and highest reacted standards at different wavelengths using the absorbance mode to find the wavelength which gives the greatest change in absorbance without exceeding 2.0 absorbance units. Use this wavelength to create a calibration curve.

Below is a list of suggested wavelengths for the color of the reacted samples. Use these as a starting point.

Sample Color	Wavelength Range
Yellow	430
Pink	520
Red	570
Green and Blue	620

CALIBRATION CURVES

The SMART 2 Colorimeter contains precalibrated tests for the LaMotte reagent systems (see Page 49). The first step in using a non-LaMotte reagent system with your SMART 2 Colorimeter is to create a calibration curve for the reagent system. To create a calibration curve, prepare standard solutions of the test factor and use the reagent system to test the standard solutions with the SMART 2 Colorimeter. Select a wavelength for the test as described above.

Plot the results (in ABS or %Transmittance) versus concentration to create a calibration curve. The calibration curve may then be used to identify the concentration of an unknown sample by testing the unknown, reading Absorbance or %T, and finding the corresponding concentration from the curve. The linear range of the reagent system can be determined and this information can be used to input a User Test into the SMART 2 Colorimeter (see EDIT USER TESTS, page 36).

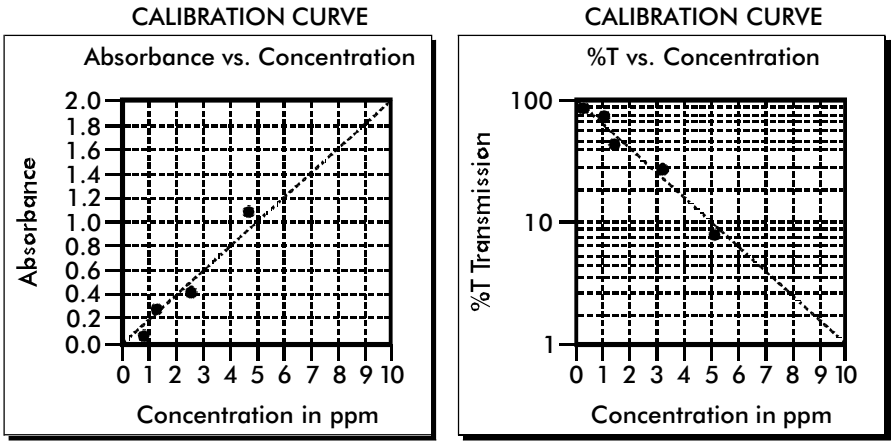
PROCEDURE

1. Prepare 5 or 6 standard solutions of the factor being tested. The concentration of these standards should be evenly distributed throughout the range of the reagent system, and should include a 0 ppm standard (distilled water). For instance, the solutions could measure 0, 10%, 30%, 50%, 70%, and 90% of the system's maximum range.
2. Turn on the SMART 2 Colorimeter. Select the appropriate wavelength from the absorbance mode. Be sure to select the appropriate wavelength for the color produced by the reagent system.
3. Use the unreacted 0 ppm standard to standardize the colorimeter by using it to scan blank.
4. Following the individual reagent system instructions, react each standard solution beginning with 0 ppm. Continue with standards in increasing concentration. Record the reading and the standard solution concentration on a chart. Readings can be recorded as percent transmittance (%T) or absorbance (A).

5. Plot results on graph paper or computer using any available plotting program. If results are as %T versus concentration, semilog graph paper must be used. Plot the standard solution concentrations on the horizontal, linear axis, and the %T on the vertical, logarithmic axis. If results are as absorbance versus standard solution concentration, simple linear graph paper can be used. Plot the standard solution concentration on the horizontal axis, and the absorbance on the vertical axis.
6. After plotting the results, draw a line, or curve, of best fit through the plotted points. The best fit may not connect the points. There should be approximately an equal number of points above the curve as below the curve. Some reagent systems will produce a straight line, while others produce a curve. Many computer spreadsheet programs can produce the curve of best fit by regression analysis of the standard solution data.

NOTE: Only reagent systems which produce a straight line can be used for a User Test.

A sample of each type of graph appears below:



▪ PREPARING DILUTE STANDARD SOLUTIONS

Standard solutions should be prepared to create a calibration curve. Standard solutions can be prepared by diluting a known concentrated standard by specified amounts. A chart or computer spreadsheet can be created to determine the proper dilutions. Use volumetric flasks and volumetric pipets for all dilutions.

1. In Column A – Record the maximum concentration of test as determined by the range and path length.
2. In Column B – Record the percent of the maximum concentration the standard solution will be.
3. In Column C – Calculate the final concentration of the diluted standard solutions by multiplying the maximum concentration (In Column A) by the % of maximum concentration divided by 100. ($C = A \times {}^{B}/_{100}$).
4. In Column D – Record the final volume of the diluted sample (i.e. volume of volumetric flask).
5. In Column E – Record the concentration of the original standard.
6. In Column F – Calculate the milliliters of original standard required ($C \times {}^{D}/_{E} = F$).

A sample chart appears below:

A	B	$C = A \times {}^{B}/_{100}$	D	E	$F = C \times {}^{D}/_{E}$
Maximum concentration of test	% of Maximum concentration	Final concentration of Diluted Standard	Volume of Standard	Concentration of Original Standard	mL of Original Standard Required
10.0 ppm	90	9.0 ppm	100 mL	1000 ppm	0.90 mL
10.0 ppm	70	7.0 ppm	100 mL	1000 ppm	0.70 mL
10.0 ppm	50	5.0 ppm	100 mL	1000 ppm	0.50 mL
10.0 ppm	30	3.0 ppm	100 mL	1000 ppm	0.30 mL
10.0 ppm	10	1.0 ppm	100 mL	1000 ppm	0.10 mL
10.0 ppm	0	0 ppm	100 mL	1000 ppm	0 mL

■ STANDARD ADDITIONS

A common method to check the accuracy and precision of a test is by standard additions. In this method a sample is tested to determine the concentration of the test substance. A second sample is then "spiked" by the addition of a known quantity of the test substance. The second sample is then tested. The determined concentration of the spiked sample should equal the concentration of the first plus the amount added with the spike. The procedure can be repeated with larger and larger "spikes." If the determined concentrations do not equal the concentration of the sample plus that added with the "spike", then an interference may exist.

For example, a 10.0 mL water sample was determined to contain 0.3 ppm iron. To a second 10.0 mL sample, 0.1 mL of 50 ppm iron standard was added. The concentration of iron due to the "spike" was (0.10 mL x 50 ppm)/10.0 mL = 0.50 ppm. The concentration of iron determined in the spiked sample should be 0.3 + 0.5 = 0.8 ppm iron. (Note: any error due to the increased volume from the "spike" is negligible).

LaMotte offers a line of calibration standards which can be used to generate calibration curves and perform standard additions.

SAMPLE DILUTION TECHNIQUES & VOLUMETRIC MEASUREMENTS

If a test result using the SMART 2 Colorimeter gives an OVERRANGE message then the sample concentration could be over range or under range. If it is over range, the sample must be diluted. Then the test should be repeated on the diluted sample to obtain a reading which is in the concentration range for the test. (Note: This is not true for colorimetric determination of pH.)

Example:

Measure 5 mL of the water sample into a graduated cylinder. Add demineralized water until the cylinder is filled to the 10 mL line. The sample has been diluted by one-half, and the dilution factor is therefore 2. Perform the test procedure, then multiply the resulting concentration by 2 to obtain the test result.

The following table gives quick reference guidelines on dilutions of various proportions. All dilutions are based on a 10 mL volume, so several dilutions will require small volumes of the water sample. Graduated pipets should be used for all dilutions.

Size of Sample	Deionized Water to Bring Volume to 10 mL	Multiplication Factor
10 mL	0 mL	1
5 mL	5 mL	2
2.5 mL	7.5 mL	4
1 mL	9 mL	10
0.5 mL	9.5 mL	20

If the above glassware is not available, dilutions can be made with the colorimeter tube. Fill the tube to the 10 mL line with the sample then transfer it to another container. Add 10 mL volumes of demineralized water to the container and mix. Transfer back 10 mL of the diluted sample to the tube and follow the test procedure. Continue diluting and testing until a reading, which is in the concentration range for the test, is obtained. Be sure to multiply the concentration found by the dilution factor (the number of total 10 mL volumes used).

Example:

10 mL of sample is diluted with three 10 mL volumes of demineralized water; the dilution factor is four.

INTERFERENCES

LaMotte reagent systems are designed to minimize most common interferences. Each individual test instruction discusses interferences unique to that test. Be aware of possible interferences in the water being tested.

The reagent systems also contain buffers to adjust the water sample to the ideal pH for the reaction. It is possible that the buffer capacity of the water sample may exceed the buffer capacity of the reagent system and the ideal pH will not be obtained. If this is suspected, measure the pH of a reacted distilled water reagent blank using a pH meter. This is the ideal pH for the test. Measure the pH of a reacted water sample using the pH meter. If the pH is significantly different from the ideal value, the pH of the sample should be adjusted before testing.

Interferences due to high concentration of the substance being tested, can be overcome by sample dilution (see page 16).

STRAY LIGHT INTERFERENCE

When scanning samples in 16 mm tubes, such as COD, the sample chamber lid can not be closed. The COD adapter minimizes stray light. To further reduce stray light interference, do not scan sample in direct sunlight.

OPERATION OF THE SMART 2 COLORIMETER

OVERVIEW

The SMART 2 Colorimeter is a portable, microprocessor controlled, direct reading colorimeter. It has a graphical 4 line, 16 character liquid crystal display for graphical, alphabetical and numerical messages. The operation is controlled with the keypad through menu driven software in response to selections shown on the display.

The test library consists of 100 LaMotte tests (not all 100 may be available at present) and 10 "User Tests". The LaMotte tests are precalibrated for LaMotte reagent systems. The colorimeter displays the results of these tests directly in units of concentration. The 10 "User Tests" may be used to enter additional calibrations. All of these tests may be arranged in any of 3 sequences. These sequences can be modified a limitless number of times to meet changing testing needs.

The optics feature 4 different colored LEDs. Each LED has a corresponding silicon photodiode with an integrated interference filter. The interference filters select a narrow band of light from the corresponding LED for the colorimetric measurements. The microprocessor automatically selects the correct LED/photodiode combination for a test.

A RS-232 serial port on the back of the colorimeter, and optional software, allows the SMART 2 to be interfaced with an IBM compatible personal computer for real time data acquisition and data storage. This port also allows an interface with a RS-232 serial printer.

Due to its portability, alternate power sources, and rugged construction, the SMART 2 Colorimeter is ideal for lab and field use.

POWER SOURCE

The SMART 2 Colorimeter uses a 6V 500 mA AC adapter. Please refer to the Parts List for the code number for the correct adapter.

USE OF ANY AC ADAPTER OTHER THAN THE ONE SPECIFIED FOR USE WITH THE SMART 2 COLORIMETER MAY DAMAGE THE METER AND WILL VOID THE WARRANTY. Do not use the adapter sold with the original SMART Colorimeter.

To use the adapter, slide the connector pin from the AC adapter into the small hole on the left side of the meter. Plug the AC adapter into an appropriate wall socket or power source.

COMPONENTS

Figure 1 shows a diagram of the SMART 2 Colorimeter and its components.

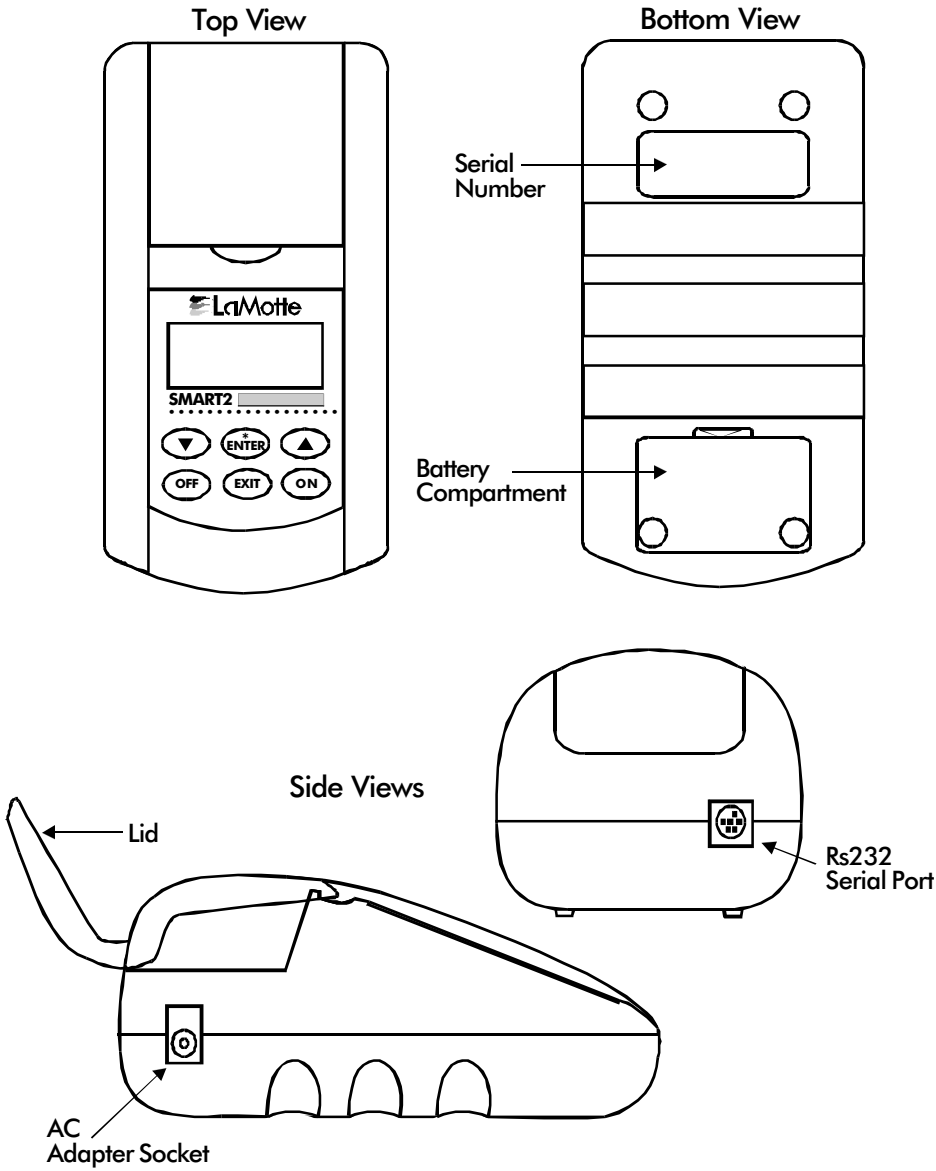


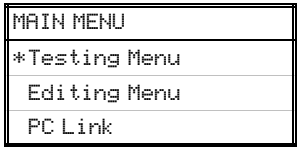
Figure 1

QUICK START

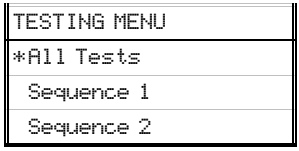
Some quick instructions to get into testing.

1. Press **ON** to turn on the SMART 2. The LaMotte logo screen will appear for about 2 seconds and then the Start screen appears. Press **Q/ENTER** to start testing.

2. The Main Menu will appear. Press **Q/ENTER** to select TESTING MENU.

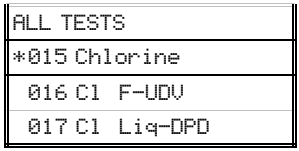


3. Press **Q/ENTER** to select All Tests.

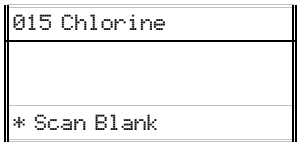


4. Press **t** or **s** to move the * to the desired test.

5. Press **Q/ENTER** to select test.

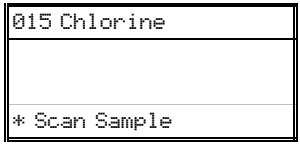


6. Insert blank, press **Q/ENTER** to scan blank.

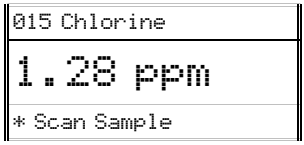


7. The screen will display Blank Done for about 1 second.

8. Insert the reacted sample. Press **Q/ENTER** to scan sample. The SMART 2 will scan the sample and display the concentration.



9. After recording test result, scroll with **t** or **s** and make another selection with **Q/ENTER**. Press **EXIT** to escape to previous menus.



GENERAL OPERATING PROCEDURES

The operation of the SMART 2 Colorimeter is controlled by a microprocessor. The microprocessor is programmed with menu driven software. A menu is a list of choices. This allows a selection of various tasks for the colorimeter to perform, such as, scan blank, scan sample, and edit test sequences. The keypad is used to make menu selections which are viewed in the display. There are three selections accessible from the MAIN MENU: Testing Menu, Editing Menu and PC Link.

THE KEYPAD

The keypad has 6 buttons which are used to perform specific tasks.

ON	This button is used to turn the colorimeter on.
t	This button will cause the display to scroll down through a list of menu choices. It will move through a list viewed in the display. It will auto scroll when held down.
s	This button will cause the display to scroll up in a list of menu choices. It will move through a list viewed in the display. It will auto scroll when held down.
ENTER Q	This button is used to select the menu choice adjacent to the "*" in a menu viewed in the display.
EXIT	This button is an exit or escape button. When pressed, the display will exit from the current menu and go to the previous menu.
OFF	This button turns the colorimeter off.

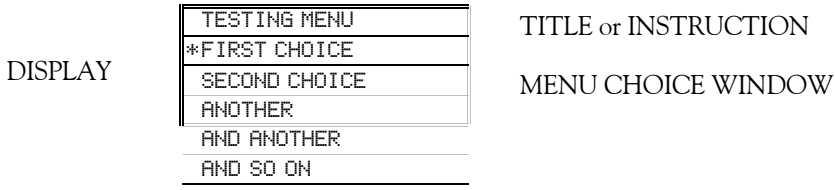
SAMPLE HOLDERS

The sample chamber is designed for 25 mm round tubes. Additional sample holders for 16 mm COD tubes and for 1 cm square UDV cuvettes are available for the SMART 2 Colorimeter.

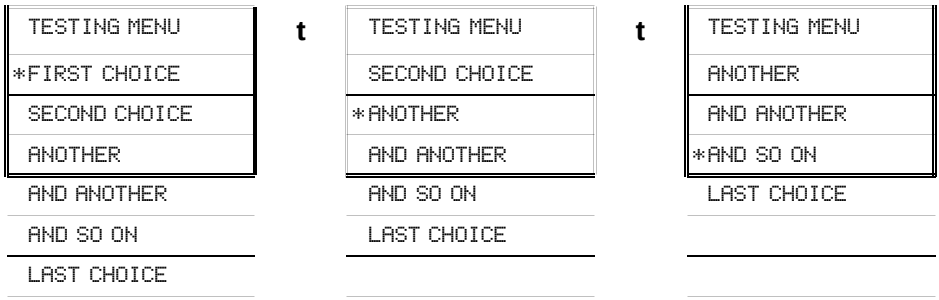
THE DISPLAY & THE MENUS

The display allows menu selections to be viewed and chosen. These choices instruct the colorimeter to perform specific tasks. The menus are viewed in the display using two general formats which are followed from one menu to the next. Each menu is a list of choices or selections.

There are four lines in the display. The top line in each menu is a title or pertinent instruction. The top line does not change unless a new menu is selected. The second and third lines are used in two ways. One way is to display menu choices. The second way takes advantage of the graphical capabilities of the display. Both lines are used to display important messages, such as test results, in a large, easy to read format. The fourth line is used for menu choices.

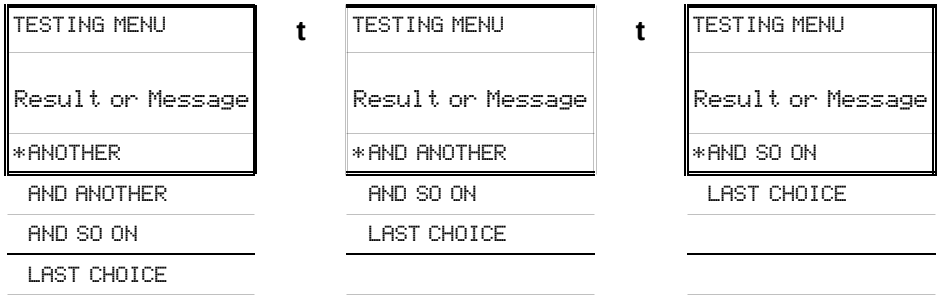


Think of the menu choices as a vertical list in the display which moves up or down each time an arrow button is pressed. This list or menu is viewed through a window, the menu choice window, in the display. The menu choice window is the lower 2 or 3 lines of the display. Pushing the arrow buttons brings another portion of the menu into menu choice window. This is referred to as scrolling through the menu.



An asterisk, "*", will start in the far left position of the top line in the menu choice window. As the menu is scrolled through, different choices appear next to the "*". The "*" in the display corresponds with the **Q/ENTER** button. Pushing the **Q/ENTER** button selects the menu choice which is adjacent to the "*" in the menu choice window.

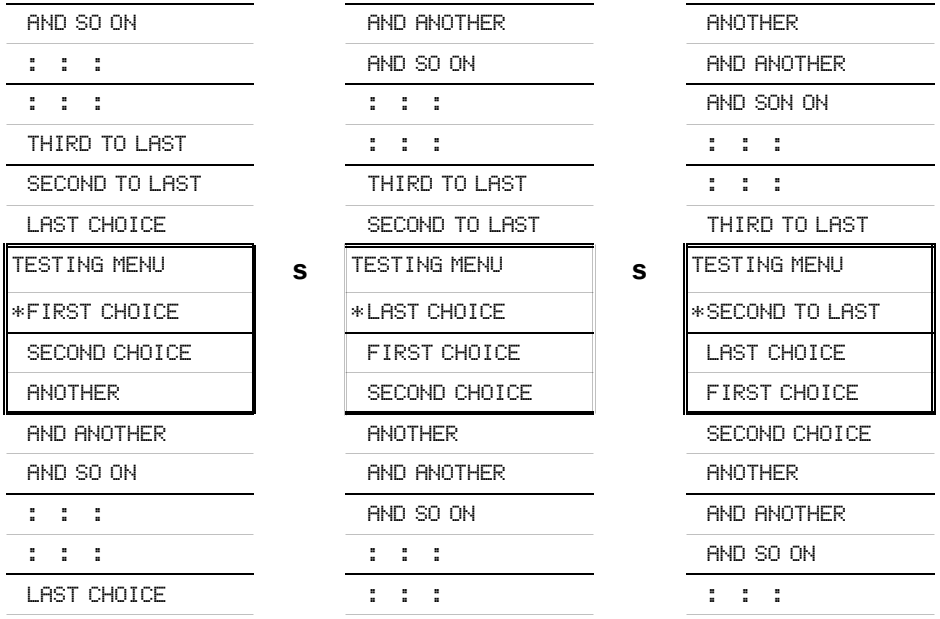
The second general format of the display takes advantage of the graphics capabilities of the display. The top line of the display is still a title line. The middle two lines of the display are used to display important messages, results or graphics in a large, easy to read format. The menus work in the same way as described previously but only one line of the menu is visible at the bottom of the display.



As described previously, the **EXIT** button allows an exit or escape from the current menu and a return to the previous menu. This allows a rapid exit from an inner menu to the main menu by repeatedly pushing the **EXIT** button. Pushing **OFF** at any time will turn the colorimeter off.

LOOPING MENUS

Long menus, such as `All Tests`, incorporate a looping feature which allow the user to quickly reach the last choice in the menu from the first choice. In a looping menu the last choices in the menu are above the first choice and scrolling upward moves through the menu in reverse order. Scrolling downward moves through the menu from first choice to last but the menu starts over following the last choice. So all menu choices can be reached by scrolling in either direction. The diagrams below demonstrate a looping menu.

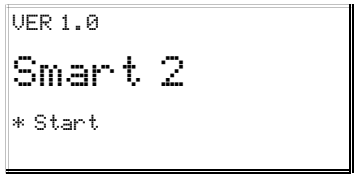


TESTING

TESTING MENU

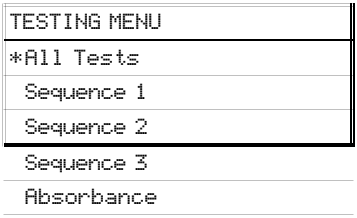
The Testing Menu is used to run all LaMotte pre-programmed tests, USER TESTS and Absorbance test at one of four wavelengths. Testing from any of three sequences can also be done.

1. Press the **ON** button to turn on the SMART 2 Colorimeter. The LaMotte logo will appear for about 2 seconds and the the Start screen appears. Press the **Q/ENTER** button to begin testing.



2. The MAIN MENU will appear. Press the **Q/ENTER** button to select Testing Menu.

3. Scroll with the **t** or **s** buttons and make a selection with the **Q/ENTER** button. All Tests has all the available tests. The three sequences have selected tests and Absorbance has %T/ABS tests.



SEQUENCES OF TESTS

SEQUENCE 1, SEQUENCE 2, and SEQUENCE 3 are alterable sequences. They may be edited using the Editing Menu. Any of the LaMotte pre-programmed tests or User Tests may be placed in these sequences in whatever testing order that is preferred. Some examples of typical sequences are given below.

SEQUENCE 1
*015 Chlorine
079 Phosphate H
009 Bromine - LR
076 pH TB
061 Moly - HR
086 Silica Hi
045 Hydrazine
032 Cu - DDC
051 Iron Bipyr

SEQUENCE 2
*002 Aluminum
035 Cyanide
041 Fluoride
053 Iron Phen
055 Manganese L
064 Nitrate-N L
067 Nitrite-N L
077 Phenol
078 Phosphate L
090 Sulfide - LR

SEQUENCE 3
*003 Ammonia-N L F
032 Cu - DDC
064 Nitrate-N L
067 Nitrite-N L
074 pH CPR
078 Phosphate L
085 Silica Lo

These alterable sequences allow a series of tests to be setup that are run frequently. The order of the individual tests in the sequence is determined by the user. After running a test, use the **t** button to scroll to the next test and press the **Q/ENTER** button to select the next test in the sequence. Continue this pattern until the entire sequence has been completed.

All Tests is a fixed sequence containing the LaMotte pre-programmed tests, User Tests, and Absorbance tests.

Modification of the alterable sequences is accomplished through the Editing Menu. This menu is explained in greater detail in EDITING MENU (p. 32).

Pressing the **EXIT** button while in a sequence menu will escape back to the Testing Menu.

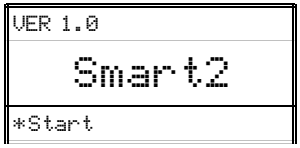
Pressing the **OFF** button at any time will turn the colorimeter off.

GENERAL TESTING PROCEDURES

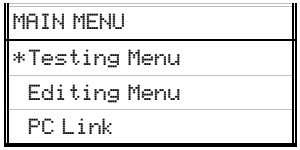
The following are some step by step examples of how to run tests from the `Testing Menu.` These test procedures are designed to be used with LaMotte SMART Reagent Systems.

TESTING WITH THE LaMOTTE PRE-PROGRAMMED TESTS

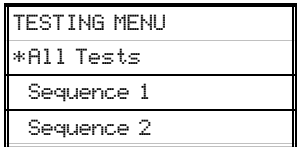
Press ON to turn on the SMART 2 Colorimeter. The LaMotte logo will appear for about 2 seconds and then the Start screen appears. Press the **Q/ENTER** button to start testing.



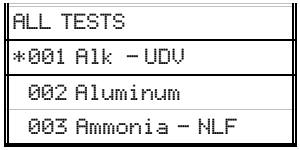
The `MAIN MENU` will appear. Press the **Q/ENTER** button to select `Testing Menu`.



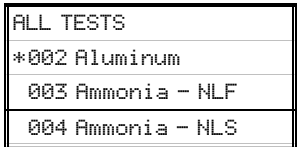
Press the **Q/ENTER** button to select `All Tests`.



Press the **t** button to move to the `002 Aluminum` to *.

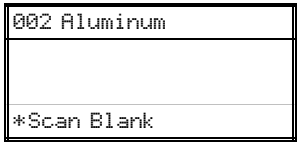


Press the **Q/ENTER** button to select `002 Aluminum`.

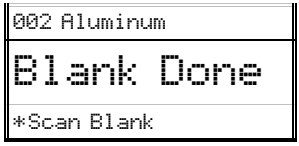


The SMART 2 Colorimeter is ready to scan at the correct wavelength. Place the blank in the sample chamber, close the lid and press the **Q/ENTER** button to scan blank.

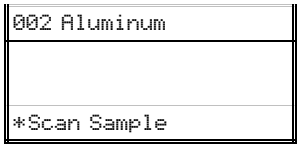
NOTE: Do not keep the button depressed.



The screen will display `Blank Done` for about 1 second. `Scan Sample` will be positioned next to *.

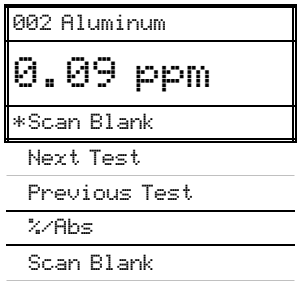


Place the reacted sample in the chamber, close the lid and press the **Q/ENTER** button to scan sample. The colorimeter will scan the sample and the results screen will appear.



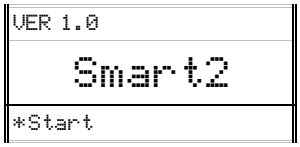
Record test result. To repeat the test, press the **Q/ENTER** button to scan the sample again. The last blank scanned is used to zero the colorimeter for repeated scans. A different blank can be used by pressing the **s** button to scroll back to `Scan Blank` and then scanning another blank. Scroll with the **t** or **s** buttons and make another selection with the **Q/ENTER** button. The %T or Absorbance of the last test can be viewed by choosing `%T/Abs`. Press the **EXIT** button to escape to previous menus.

NOTE: The menus loop in this screen so either the **s** or **t** buttons will lead to the menu selection needed.

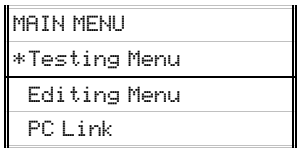


MEASURING IN THE ABSORBANCE MODE

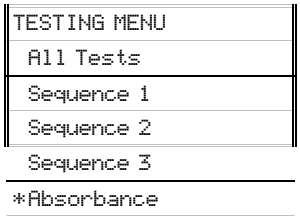
Press **ON** to turn on the SMART 2 Colorimeter. The LaMotte logo will appear for about 2 seconds and then the Start screen appears. Press the **Q/ENTER** button to start testing.



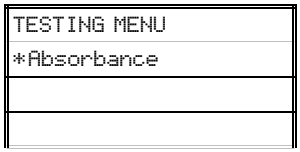
The MAIN MENU will appear. Press the **Q/ENTER** button to select Testing Menu.



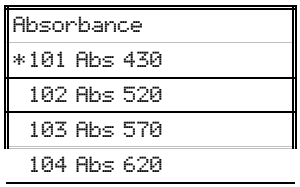
Press the **t** button to scroll to Absorbance.



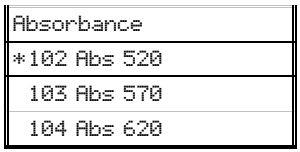
Press the **Q/ENTER** button to select Absorbance.



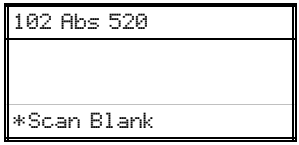
Press the **t** or **s** buttons to move to the desired test.



Press the **Q/ENTER** button to select test.



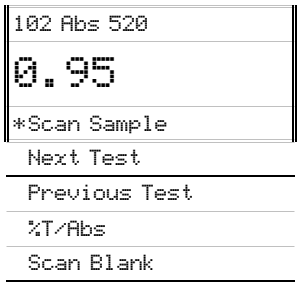
Insert blank, press the **Q/ENTER** button to scan blank.



The screen will display `Blank Done` for about 1 second.

Insert the reacted sample. Press the **Q/ENTER** button to scan the sample.

Record test result. To repeat the test, press the **Q/ENTER** button to scan the sample again. The last blank scanned is used to zero the colorimeter for repeated scans. A different blank can be used by pressing the **s** button to scroll back to `Scan Blank` and then scanning another blank. Scroll with **t** or **s** and make another selection with **Q/ENTER**. The %T or Absorbance of the last test can be viewed by choosing `%T/Abs`. Press **EXIT** to escape to previous menus.



NOTE: The menus loop in this screen so either **t** or **s** will lead to the menu selection needed.

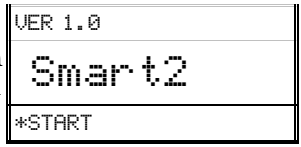
EDITING MENU

The EDITING MENU allows the user to edit sequences, edit user tests, set the clock, edit the logging function, and set the power saving function.

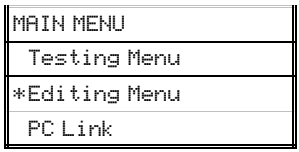
EDIT A SEQUENCE

The EDIT SEQUENCE menu allows three alterable test sequences (SEQUENCE 1, SEQUENCE 2, and SEQUENCE 3) to be edited.

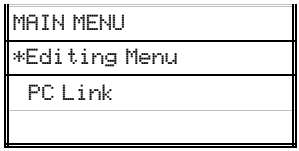
Press ON to turn on the SMART 2 Colorimeter. The LaMotte logo will appear for about 2 seconds and then the Start screen appears. Press the **Q/ENTER** button to start testing.



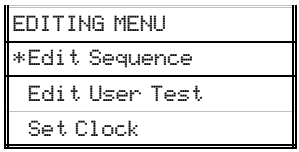
The Main Menu will appear. Press the **t** button to scroll to Editing Menu.



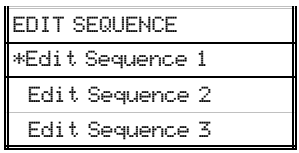
Press the **Q/ENTER** button to select Editing Menu.



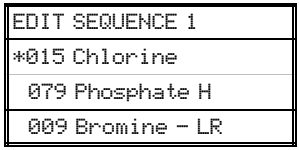
The Editing Menu appears. Press the **Q/ENTER** button to select Editing Sequence.



The Edit Sequence menu appears. Press the **Q/ENTER** button to scroll to select Edit Sequence 1.



Sequence 1 appears.

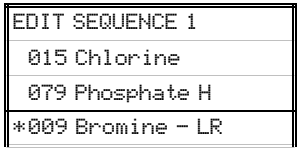


ADDING OR DELETING TESTS

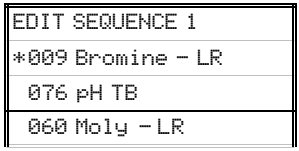
There are three ways to alter a sequence: `Insert Before`, `Insert After`, and `Delete`. `Insert Before` adds a new test to the sequence before the selected test. `Insert After` adds a new test to the sequence after the selected test. `Delete` is used to remove an existing test from a sequence.

Below is a step by step example of how to add a test to `SEQUENCE 1` starting from the `EDIT SEQUENCE 1` menu.

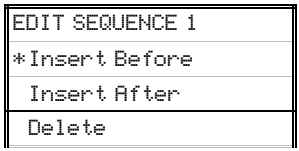
Press the **t** button to scroll to `009 Bromine - LR`.



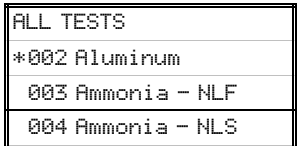
Press the **Q/ENTER** button to select `009 Bromine - LR`.



Press the **Q/ENTER** button to select `Insert Before`.

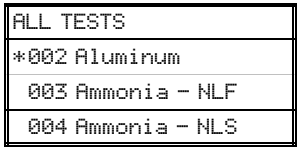


The `ALL TESTS` menu appears. Press the **t** button to move the `002 Aluminum` to *.

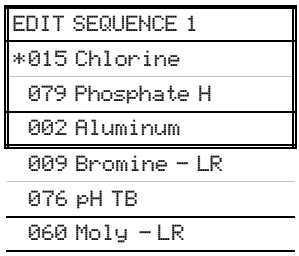


Continued...

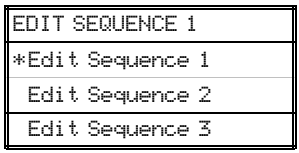
Press the **Q/ENTER** button to select 002 Aluminum.



Sequence 1 appears in EDIT SEQUENCE 1 menu and 002 Aluminum is now before Bromine - LR in the sequence. All changes to Sequence 1 are automatically saved. Press the **EXIT** button to exit the EDIT SEQUENCE 1 menu and return to the EDIT SEQUENCE menu or continue editing.

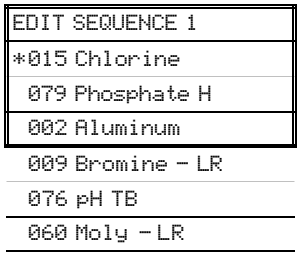


The EDIT SEQUENCE menu appears. Select another sequence to edit or press the **EXIT** button to return to the EDITING MENU. Press the **EXIT** button again to return the the MAIN MENU.

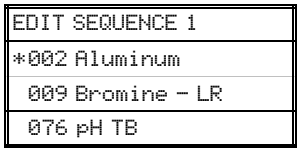


Below is a step by step example of how to delete a test from SEQUENCE 1 starting from the EDIT SEQUENCE 1 menu. The test 002 Aluminum, added in the previous example, will be deleted.

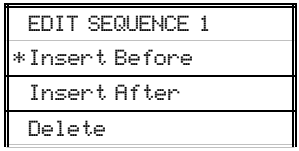
Press the **t** button to scroll to 002 Aluminum.



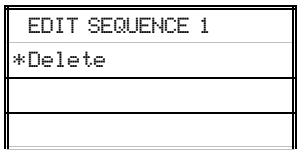
Press the **Q/ENTER** button to select 002 Aluminum.



Press the **t** button to scroll to Delete.

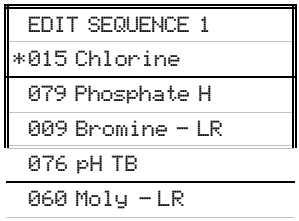


Press the **Q/ENTER** button to select Delete.

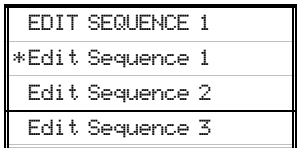


Sequence 1 appears in the EDIT SEQUENCE 1 menu and 002 Aluminum has been deleted. All changes to SEQUENCE 1 are automatically saved.

Press the **EXIT** button to exit the EDIT SEQUENCE 1 menu and return to the EDIT SEQUENCE menu or continue editing.



The EDIT SEQUENCE menu appears. Select another sequence to edit or press the **EXIT** button to return to the EDITING MENU. Press the **EXIT** button again to return the the MAIN MENU.



EDIT USER TESTS

If a test other than the LaMotte programmed tests is performed regularly, a calibration for it may be entered in one of the 10 User Tests. These tests are originally named "User Test 1 – 10". It will be possible to rename the test, select a wavelength, enter a new calibration, select the number of decimal places used to display the results, and select the units. A User Test may be added for a reagent system for which no precalibrated test exists. A calibration of a LaMotte reagent system may also be entered. The calibration of a User Test can be changed at any time.

The User Tests have the ability to handle 2 data points. The colorimeter will determine the absorbance of the standards and calculate a response that will be stored to determine the concentration of future samples of unknown concentration. These standards should cover all the concentrations for the range of the test being performed and be scanned beginning with the low concentration and finishing with the high concentration (for more information about this, see CALIBRATION CURVES, page 13). Prepare these solutions prior to entering a new calibration.

NOTE: A calibration procedure must be performed before using any of the User Tests.

The User Tests can be placed in any of the alterable sequences using EDIT SEQUENCES.

To edit a User Test, start at the EDITING MENU. Scroll down to Edit User Test.

EDITING MENU
*Edit Sequences
Edit User Test
Set Clock

Press the **Q/ENTER** button to select the Edit User Test.

EDITING MENU
*Edit User Test
Set Clock
Edit Logging

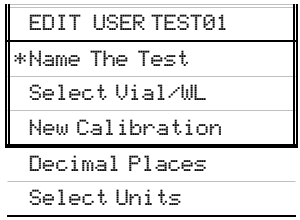
From the EDIT USER TEST menu, select the User Test to be entered or changed. In this example, choose 105 User Test 01. Use the **t** and **s** buttons to scroll to other User Tests if desired. Select the User Test by pressing the **Q/ENTER** button.

EDIT USER TEST
*105 User Test 01
106 User Test 02
107 User Test 03
108 User Test 04
: : :
114 User Test 10

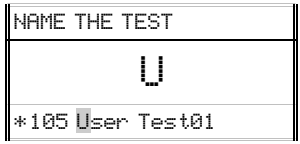
NAMING THE TEST

A User Test can be up to 11 characters long. The menu choices for each character are 26 upper case letters A to Z, 26 lower case letters a to z, ten numerals 0 to 9, a space (SP), a dash (-) and a decimal point (.). The existing name is displayed on the bottom line of the display. A cursor will be over the character which is to be edited and that character is also displayed in the center of the display. The character can be changed by using the **t** and **s** buttons to scroll to other characters. Use the **Q/ENTER** button to select a character. The edited name is saved at any time by pressing **EXIT** or by pressing the **Q/ENTER** button after selecting the eleventh character.

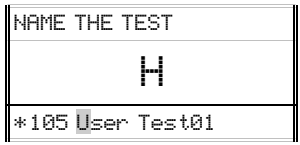
From the Edit User Test01 menu press the **Q/ENTER** button to select Name The Test and change the name of User Test 01.



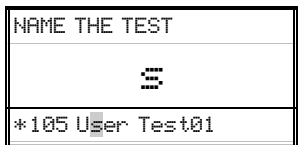
The cursor is over the letter "U" in 105 User Test01 and the letter "U" is displayed in the large font in the center of the display.



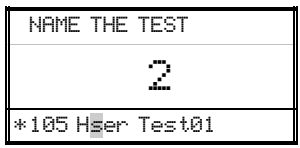
Change the name to H2O. Use the **t** and **s** buttons to scroll to the letter "H" into the center of the display. Press the **Q/ENTER** button to select the letter "H".



The letter "H" has been entered in the first position of the name and the cursor has moved to the second letter "s".

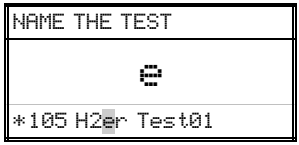


Use the **t** and **s** buttons to scroll to the number "2" into the center of the display. Press the **Q/ENTER** button to select the number "2".

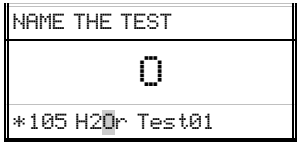


Continued...

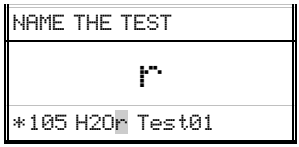
The number "2" has been entered in the second position of the name and the cursor has moved to the third letter "e".



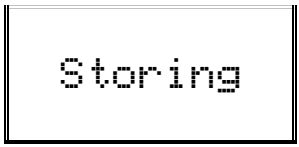
Use the **t** and **s** buttons to scroll to the letter "0" into the center of the display. Press the **Q/ENTER** button to select the letter "0".

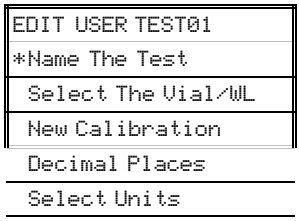


The letter "0" has been entered in the third position of the name and the cursor has moved to the fourth letter "r". Press the **EXIT** button to save the name entered up to this point.



The meter will display the message "Storing" and return to the EDIT USER TEST01 menu.

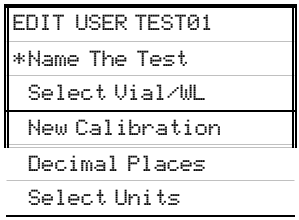




SELECTING THE VIAL AND WAVELENGTH

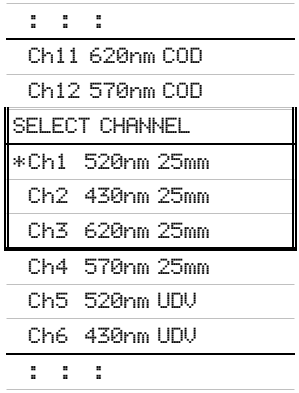
The Smart 2 Colorimeter has three different vials (the 25 mm 0290 tube, UDVs and COD tubes) and 4 different wavelengths (430, 520, 570, and 620 nm). The colorimeter uses different settings for each of the twelve combinations of vial and wavelength. These twelve settings are called channels. Choose the channel with the correct wavelength and vial for the test.

Use the **t** button to scroll to `Select Vial/WL` and press **Q/ENTER** button to select.

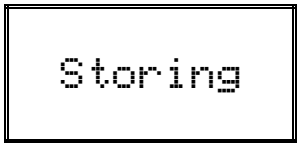


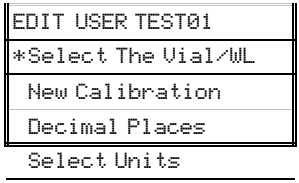
Use the **t** and **s** buttons to scroll to the appropriate channel and press **Q/ENTER** button to select.

NOTE: This is a looping menu.



The meter will display the message "`Storing`" and return to the `EDIT USER TEST01` menu.

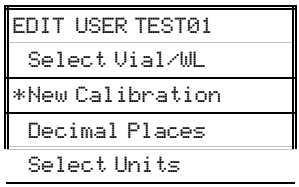




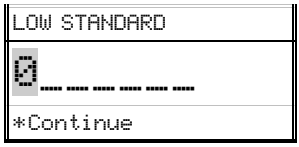
ENTERING A NEW CALIBRATION

To enter a new calibration two reacted standards solutions of known concentration are required: a “low standard” and a “high standard”. These should be ready to use.

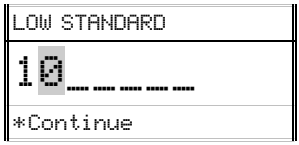
Use the **t** button to scroll to `New Calibration` and press **Q/ENTER** button to select.



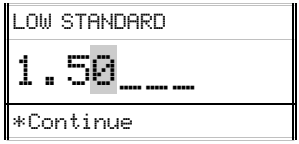
Input the concentration of the `LOW STANDARD` by using the **t** and **s** buttons to scroll the first digit of the concentration into the first position on the display. Press **Q/ENTER** button to select that digit (`1` for this example).



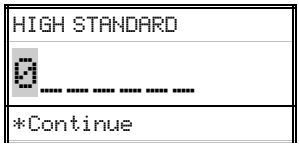
The number “`0`” is always the starting point for the next digit. Continue selecting digits or a decimal point to enter the concentration (up to seven characters).



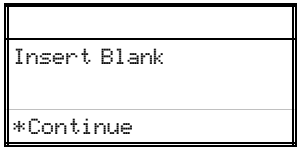
“`1.5`” has been entered in this example. Press **Q/ENTER** button four times to input “`0`” as the last four digits. Pressing **Q/ENTER** after selecting the last digit saves the concentration.



Input the concentration of the `HIGH STANDARD` by using the same method as for the low standard.

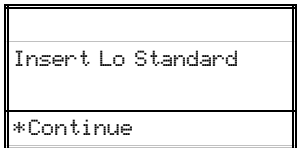


Place a clear blank in the sample chamber. Press the **Q/ENTER** button to scan the blank.

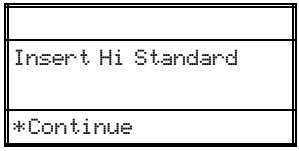


The screen will display `Blank Done` for about 1 second.

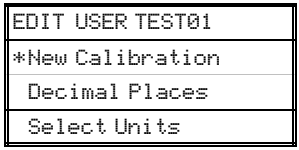
Place the reacted low standard in the sample chamber. Press **Q/ENTER** to scan the low standard.



Place the reacted high standard in the sample chamber. Press **Q/ENTER** to scan the high standard.



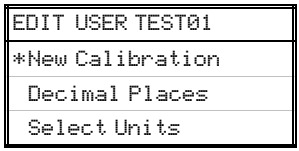
The meter will display the message "`Storing`" and return to the `EDIT USER TEST01` menu.



SELECTING THE NUMERICAL FORMAT OF THE RESULT

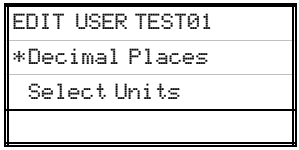
To input tests with very different ranges, the number of decimal places displayed for a result can be selected. A test which ranges from 20 to 1000 ppm should not be displayed with three decimal places. A test with a range from 0.010 to 0.500 needs three decimal places (the microprocessor will always calculate the concentration to many more significant figures than will be displayed). Menu choices of 0, 1, 2, or 3 decimal places will be given for the display.

Use the **t** button to scroll to `Decimal Places` and press **Q/ENTER** button to select.



Use the **t** button to scroll to the number of decimal places to be shown and press **Q/ENTER** to select.

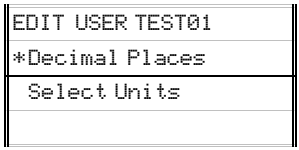
The meter will display the message "`Storing`" and return to the `EDIT USER TEST01` menu.



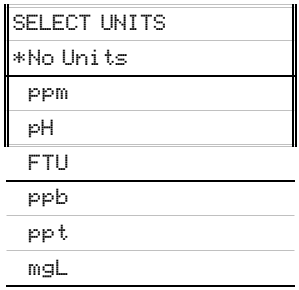
SELECTING THE UNITS OF CONCENTRATION

The SMART 2 Colorimeter has seven options for units of concentration. They are No Units, ppm, pH, FTU, ppb, ppt and mgL.

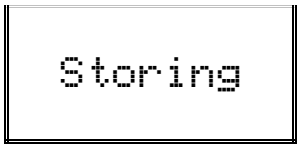
Use the **t** button to scroll to `Select Units` and press **Q/ENTER** to select.

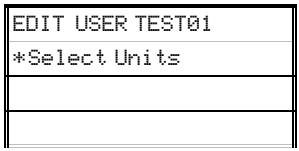


Use the **t** button to scroll to the appropriate unit and press **Q/ENTER** to select.



The meter will display the message "`Storing`" and return to the `EDIT USER TEST01` menu.

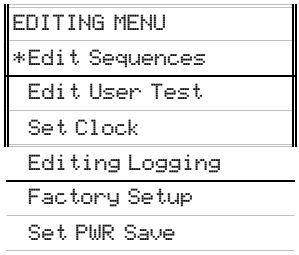




SETTING THE CLOCK

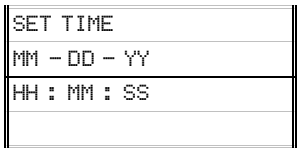
Setting the clock allows the correct time and date stamp to be stored with each reading in the data logger and with each reading sent out the serial port.

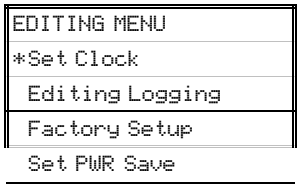
From the EDITING MENU use the **t** button to scroll to Set Clock. Press **Q/ENTER** to select.



The current date and time are displayed as month - day - year on the first line and as hours : minutes : seconds on the second line. A two-digit number is displayed for each setting. Use the **t** and **s** buttons to scroll to the appropriate number and press **Q/ENTER** to select. The cursor will move to the next digit. Set all subsequent numbers in the same manner. Selecting the final digit in the seconds field stores the date and time and returns to the EDITING MENU.

NOTE: These are looping menus.

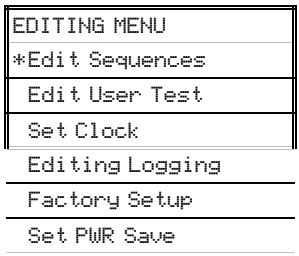




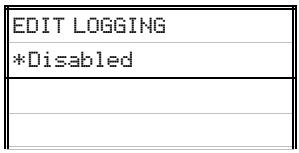
TURNING THE DATA LOGGER ON AND OFF

The default setting for the datalogger is “Disabled” or turned off. If there is no need for data logging, this setting is suggested. If data logging is needed, the data logger can be “Enabled” or turned on.

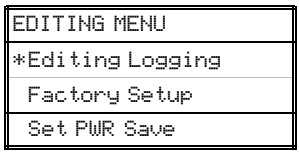
From the EDITING MENU use the **t** button to scroll to Edit Logging. Press **Q/ENTER** to select.



The current setting is always displayed next to the *. To change the setting, use the **t** or **s** buttons to scroll to the other setting. Press **Q/ENTER** to select.



The meter will display the message “Storing” and return to the EDITING MENU.



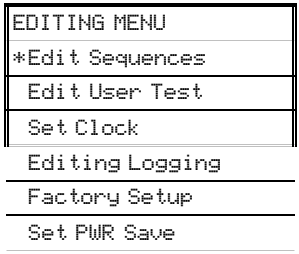
FACTORY SETUP

The Factory Setup menu is used in the manufacturing of the SMART 2 Colorimeter. This menu is not for use by the operator in the field.

SETTING THE POWER SAVING FUNCTION

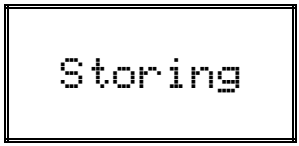
The SMART 2 Colorimeter has a power saving function that turns the meter off after an interval of inactivity. If no buttons have been pressed during that interval the meter will turn itself off. This interval can be disabled or set for 5, 15, 30 or 60 minutes. The default setting is 5 minutes.

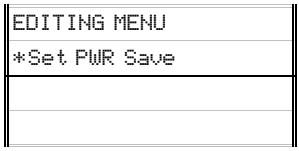
From the EDITING MENU use the **t** button to scroll to Set PWR Save. Press **Q/ENTER** to select.



The current setting is always displayed next to the *. To change the setting, use the **t** or **s** buttons to scroll to the appropriate setting. Press **Q/ENTER** to select.

The meter will display the message "Storing" and return to the EDITING MENU.





PC LINK

The SMART 2 Colorimeter may be interfaced with any Windows-based computer by using the LaMotte SMARTLink2 Program and Interface Cable (Order Code 1912-3 [3.5 disk] or 1912-CD [compact disk]). The program stores customer information and test data in a database. It can be used to download data stored in the SMART 2 datalogger for each test site.

The colorimeter may also be interfaced with an RS-232 serial printer, using an interface cable (Order Code 1772) and setting the printer configuration to the Output as described below.

Choose PC Link from the Main Menu. The user can download the entire datalogging buffer. Downloading does not delete or empty the datalogger.

OUTPUT

RS-232 compatible, asynchronous serial, 9600 baud, no parity, 8 data bits, 1 stop bit.

COMPUTER CONNECTION

RS-232 interface connection, 8 pin mini-DIN/9 pin F D-submin. (Order Code 1772).

BATTERY OPERATION

The colorimeter may be run on battery power or AC using the AC adapter. If using the meter as a benchtop unit, keep it plugged in if possible. If used on only battery power, always have a spare battery on hand.

If the battery power is low, the SMART 2 will display "LOW BATT" and turn off.

REPLACING THE BATTERY

The SMART 2 Colorimeter uses a standard 9-volt alkaline battery that is available worldwide. The battery compartment is located on the bottom of the the case.

To replace the battery:

1. Open the battery compartment lid.
2. Remove the battery and disconnect the battery from the polarized plug.
3. Carefully connect the new battery to the polarized plug and insert it into the compartment.
4. Close the battery compartment lid.

MAINTENANCE

CLEANING

Clean with a damp, lint-free cloth.

DO NOT ALLOW WATER TO ENTER THE COLORIMETER CHAMBER OR ANY OTHER PARTS OF THE METER.

TROUBLESHOOTING GUIDE

ERROR MESSAGES

OVER RANGE

If the message OVERRANGE is displayed when scanning a sample, the sample may be over range or under range. If the sample is over range the sample should be diluted and tested again (see Sample Dilution Techniques and Volumetric Measurements, page 16).

If OVERRANGE is displayed, press the **Q/ENTER** button to continue testing on diluted samples.

HELPFUL HINTS

STRAY LIGHT

The SMART 2 Colorimeter should have no problems with stray light. Make sure that the sample compartment lid is always fully closed, except when testing COD with the adapter.

SMART2 COLORIMETER REAGENT SYSTEMS

SMART2 REAGENT SYSTEMS LIST

Test #	Test Factor	Range (ppm)	Test Method (# of Reagents)	# of Tests
1	Alkalinity	0-200	UDV (1)	50
2	Aluminum	0.00-0.30	Eriochrome Cyanine R (4)	50
3	Ammonia Nitrogen-Low Range, Fresh Water	0.00-1.00	Salicylate (3)	25
4	Ammonia Nitrogen-Low Range, Salt Water	0.00-4.00	Salicylate (3)	
5	Ammonia Nitrogen-High Range	0.00-4.00	Nesslerization (2)	50
6	Arsenic			
7	Barium			
8	Boron	0.00-0.80	Azomethine-H (2)	50
9	Bromine-Low Range	0.00-9.00	DPD Tablets (3)	100
10	Bromine-High Range		DPD (3)	
11	Bromine-UDV		DPD (3)	
12	Cadmium	0.00-1.00	PAN (4)	50
13	Ca & Mg Hardness-UDV	10-500	UDV (1)	50
14	Carbohydrazide			
15	Chlorine	0.00-4.00	DPD (3)	100
16	Chlorine-Free-UDV		UDV (1)	
17	Chlorine-Liquid DPD		UDV (1)	
18	Chlorine-Total-UDV, Low Range		UDV (1)	
19	Chlorine-Total-UDV, High Range		UDV (1)	
20	Chlorine Dioxide	0.00-7.00	DPD (3)	50
21	Chloride-TesTab			
22	Chromium	0.00-1.00	Diphenylcarbohydrazide (1)	100
23	Chromium-TesTab			
24	Cobalt	0.00-2.00	PAN (3)	50
25	COD-Low Range	5-150	Digestion (1)	25
25	COD-Standard Range	0-1500	Digestion (1)	25
27	COD-High Range	0-15000	Digestion (1)	25
28	Color	0-1000	Platinum Cobalt (0)	∞
29	Copper-BCA-Low Range	0.00-3.50	Bicinchoninic Acid (1)	50
30	Copper-BCA-High Range		Bicinchoninic Acid (1)	
31	Copper-Cuprizone	0.00-2.00	Cuprizone (2)	50
32	Copper-DDC	0.00-6.00	Diethyldithiocarbamate (1)	100
33	Copper-UDV	0.00-3.50	Bicinchoninic Acid, UDV (1)	50

Test #	Test Factor	Range(ppm)	Test Method (# of Reagents)	# of Tests
34	Copper-Zincon-High Range			
35	Cyanide	0.00-0.50	Pyridine-Barbituric Acid (5)	50
36	Cyanuric Acid	0-200	Melamine (1)	50
37	Cyanuric Acid-UDV	0-200	Melamine, UDV (1)	50
38	Diethylhydroxylamine			
39	Dissolved Oxygen	0.0-12.0	Winkler colorimetric	300
40	Erythorbic Acid			
41	Fluoride	0.00-2.00	SPADNS (2)	50
42	Formaldehyde-Low Range			
43	Formaldehyde-High Range			
44	Hardness-TesTab			
45	Hydrazine	0.00-1.00	P-dimethylaminobenzaldehyde (2)	50
46	Hydrogen Peroxide-Low Range	0.00-1.50	DPD (2)	100
47	Hydrogen Peroxide-High Range			
48	Hydrogen Peroxide-UDV			
49	Hydroquinone			
50	Iodine	0.00-14.00	DPD (2)	100
51	Iron-Bipyridyl	0.00-6.00	Bipyridyl (2)	50
52	Iron-UDV	0.00-10.00	Bipyridyl (2)	50
53	Iron-Phenanthroline	0.00-4.50	1,10 Phenanthroline (2)	50
54	Lead	0.00-5.00	PAR (5)	50
55	Manganese-Low Range	0.00-0.50	PAN (3)	50
56	Manganese-High Range	0.0-15.0	Periodate (2)	50
57	Mercury	0.00-1.50	TMK (3)	50
58	Methylethylketone			
59	Molybdenum-Very Low Range			
60	Molybdenum-Low Range			
61	Molybdenum-High Range	0.0-50.0	Thioglycolate (3)	50
62	Morpholine			
63	Nickel	0.00-8.00	Dimethylglyoxime (6)	50
64	Nitrate Nitrogen-Low Range	0.00-3.00	Cadmium Reduction (2)	20
65	Nitrate Nitrogen-High Range			
66	Nitrate-TesTab			
67	Nitrite Nitrogen-Low Range	0.00-0.80	Diazotization (2)	20
68	Nitrite Nitrogen-High Range			
69	Nitrite-TesTab			
70	Oil/Grease			

Test #	Test Factor	Range (ppm)	Test Method (# of Reagents)	# of Tests
71	Ozone-Low Range	0.00-0.40	Indigo (3)	100
72	Ozone-High Range			
73	Palladium			
74	pH-Chlorophenol Red	5.0-6.8	Chlorophenol Red (1)	100
75	pH-Phenol Red	6.6-8.4	Phenol Red (1)	100
76	pH-Thymol Blue	8.0-9.5	Thymol Blue (1)	100
77	Phenol	0.00-6.00	Aminoantipyrine (3)	50
78	Phosphate-Low Range	0.00-3.00	Ascorbic Acid Reduction (2)	50
79	Phosphate-High Range	0.0-70.0	Vanodomolybdphosphoric Acid (1)	50
80	Polyacrylate			
81	Potassium	0.0-10.0	Tetraphenylboron (2)	100
82	QAC			
83	SDMBT			
84	Selenium			
85	Silica-Low Range	0.00-2.50	Heteropoly Blue (4)	50
86	Silica-High Range	0-50	Silicomolybdate (3)	50
87	Silver			
88	Sulfate-Low Range			
89	Sulfate-High Range	5-100	Barium Chloride (1)	50
90	Sulfide-Low Range	0.00-1.00	Methylene Blue (3)	50
91	Sulfide-High Range			
92	Sulfite-Low Range			
93	Sulfite-High Range			
94	Surfactants	0.5-8.0	Bromphenol Blue (3)	50
95	Suspended Solids			
96	Tannin	0.0-10.0	Tungsto-molybdophosphoric Acid (2)	50
97	TMIO			
98	Turbidity	0-400	Absorption (0)	∞
99	Zinc-Low Range	0.00-3.00	Zincon (6)	50
100	Zinc-High Range			