



SMART 2 SOIL
.....
Operator's Manual
Code 1985-04



TABLE OF CONTENTS

GENERAL INFORMATION

Packaging & Delivery	5
General Precautions	5
Safety Precautions	5
Limits of Liability	5
Specifications	6
Contents and Accessories	7
CE Compliance	8

CHEMICAL TESTING

An Introduction to Colorimetric Analysis	9
Reagent Blank	10
Colorimeter Tubes	10
Sample Dilution Techniques & Volumetric Measurements	11
Interferences	11

OPERATION OF THE SMART 2 COLORIMETER

Overview	13
Power Source	13
Components	14
Quick Start	15

GENERAL OPERATING PROCEDURES

The Keypad	17
The Display & the Menus	18
Looping Menus	20

TESTING

Testing Menu	21
Sequences of Tests	22
General Testing Procedures	23
Testing With the LaMotte Pre-Programmed Tests	23

EDITING MENU

Edit a Sequence	25
Adding or Deleting Tests	26
Creating a Soil Test Sequence	29
Calibrating LaMotte Pre-Programmed Tests	33
Setting the Clock	36
Turning the Data Logger On and Off	37
Factory Setup	38
Setting the Power Saver Function	38

TABLE OF CONTENTS (cont.)

PC LINK

Output	39
Computer Connection	39

BATTERY OPERATION

Replacing the Battery	39
-----------------------------	----

MAINTENANCE

Cleaning	40
----------------	----

TROUBLESHOOTING GUIDE

Error Messages	40
Helpful Hints	40

SMART 2 REAGENT SYSTEMS

Reagent Systems List	41
----------------------------	----

SOIL TEST INSTRUCTIONS

Electronic Test Methods	
pH	47
Lime Requirement - Woodruff Method	47
Soluble Salts (Total Dissolved Salts)	49
Extraction Procedures	
Multiple Test Procedure	49
Single Test Procedure	49
Neutralization of Soil Extract	50
Ammonia-Nitrogen	51
Calcium & Magnesium	53
Chloride	57
Copper	59
Iron	61
Manganese	63
Nitrate-Nitrogen	65
Nitrite-Nitrogen	69
Phosphorus	71
Potassium	75
Sulfur	77
Zinc	79

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	$\pm 0.001A$
Sample Chamber	Accepts 25 mm diameter flat-bottomed 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
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

■ CONTENTS

SMART 2 Colorimeter
Test Tubes, with Caps
Sample Cell Holder, Universal
Power Supply, 110/220V
Battery Charger
SMART 2 Colorimeter Quick Start Guide
SMART 2 Soil Manual

■ ACCESSORIES

Cigarette Lighter Adapter	Code
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

■ 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



Signature

Scott H. Steffen

Name

VP New Products & Quality

Position

CHEMICAL TESTING

■ AN INTRODUCTION TO COLORIMETRIC ANALYSIS

Most test substances in water or soil extract 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 photodetector 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.

■ SAMPLE DILUTION TECHNIQUES & VOLUMETRIC MEASUREMENTS

If a test result using the SMART 2 Colorimeter gives an **OVERRRANGE** 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 soil extract 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 soil extract 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 soil extract 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 11).

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

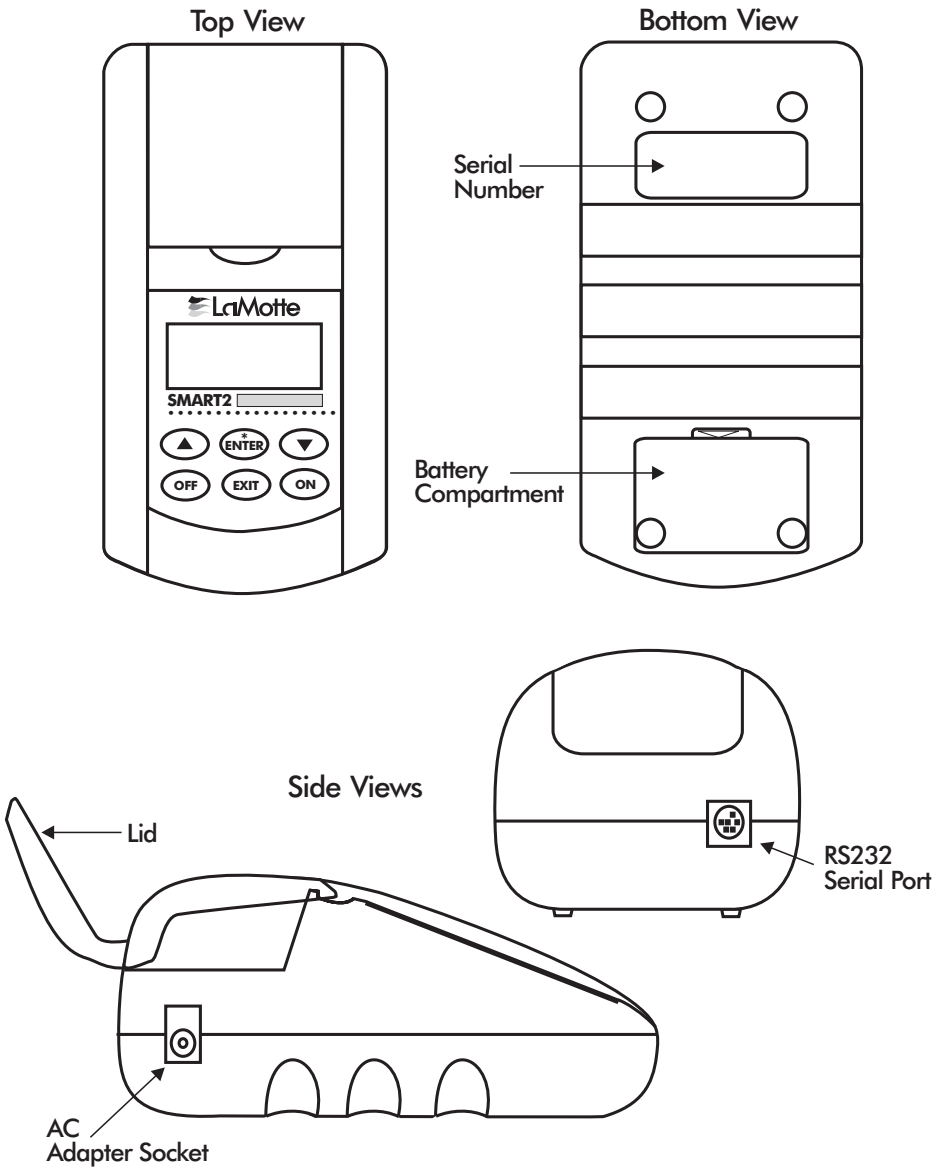
The SMART 2 Colorimeter uses a 6V 500 mA AC adapter. Please refer to the Parts List for the code number for the correct adapter.

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.



■ QUICK START

Some quick instructions to get into testing.

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

VER 1.0
Smart 2
* Start

The MAIN MENU will appear. Press ***/ENTER** to select TESTING MENU.

MAIN MENU
*Testing Menu
Editing Menu
PC Link

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

TESTING MENU
*All Tests
Sequence 1
Sequence 2

Press **▼** or **▲** to move the * to the desired test.

ALL TESTS
*001 Alk - UDV
002 Aluminum
003 Ammonia - N LF

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

ALL TESTS
*015 Chlorine
016 C1 F-UDV
017 C1 Liq-DPD

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

015 Chlorine
* Scan Blank

Continued...

The screen will display Blank Done for about 1 second.

015 Chlorine
Blank Done
* Scan Blank

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

015 Chlorine
* Scan Sample

After recording test result, scroll with ▼ or ▲ and make another selection with ***/ENTER**. Press **EXIT** to escape to previous menus.

015 Chlorine
1.28 ppm
* Scan Sample

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.
▼	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.
▲	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 *	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.

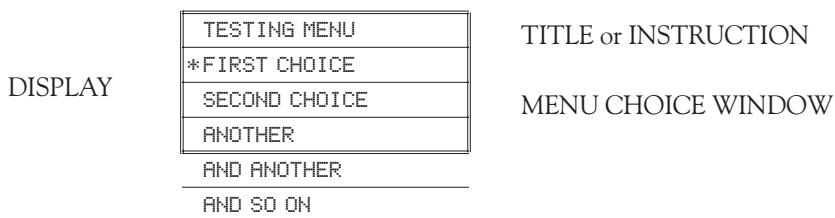
■ SAMPLE HOLDERS

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.

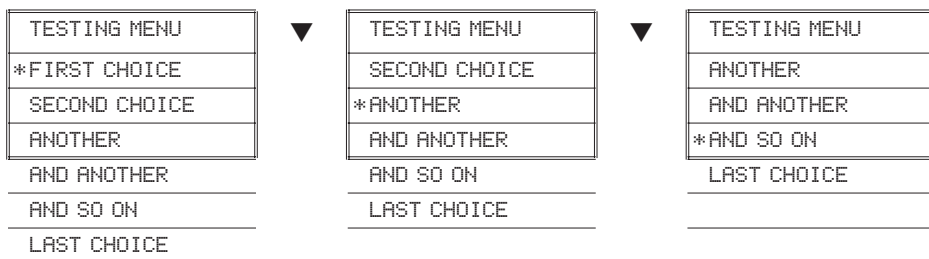
■ THE DISPLAY & THE MENUS

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.

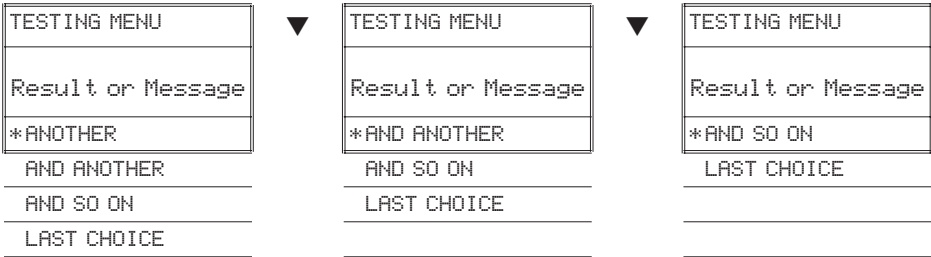


Think of the menu choices as a vertical list in the display which moves up or down each time an arrow button is pressed. This list or menu is viewed through a window, the menu choice window, in the display. The menu choice window is the lower 2 or 3 lines of the display. Pushing the arrow buttons brings 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 ***/ENTER** button. Pushing the ***/ENTER** button selects the menu choice which is adjacent to the “*” in the menu choice window.

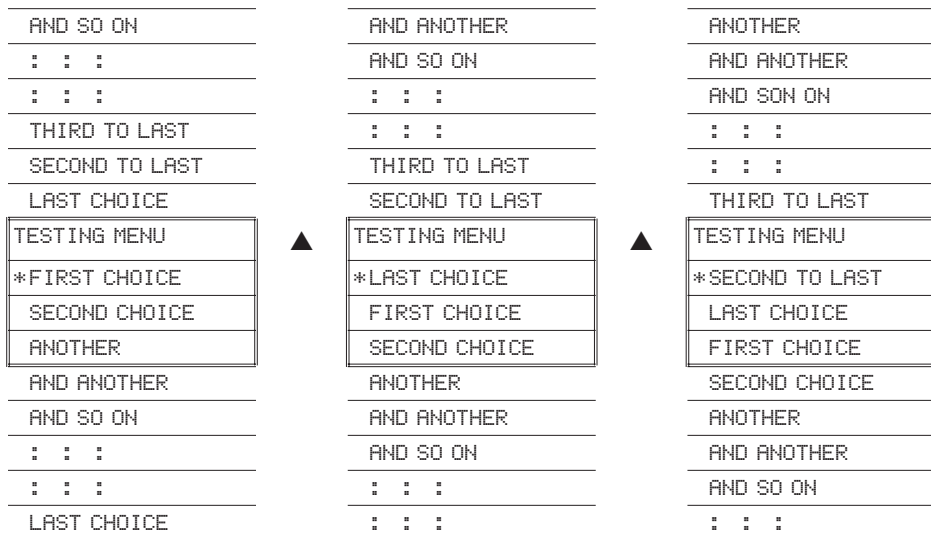
The second general format of the display takes advantage of the graphics capabilities of the display. The top line of the display is still a title line. The middle two lines of the display are used to display important messages, results or graphics in a large, easy to read format. The menus work in the 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.

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

VER 1.0
Smart 2
* Start

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

MAIN MENU
*Testing Menu
Editing Menu
PC Link

Scroll with **▼** or **▲** and make a selection with ***/ENTER**. **All Tests** lists all the available tests. The three sequences have selected tests and **Absorbance** lists %T/ABS tests.

TESTING MENU
*All Tests
Sequence 1
Sequence 2
Sequence 3
Absorbance

■ 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	SEQUENCE 2	SEQUENCE 3
*015 Chlorine	*002 Aluminum	*003 Ammonia-N LF
079 Phosphate H	035 Cyanide	032 Cu-DDC
009 Bromine-LR	041 Fluoride	064 Nitrate-N L
076 pH TB	053 Iron Phen	067 Nitrite-N L
061 Moly-HR	055 Manganese L	074 pH CPR
086 Silica Hi	064 Nitrate-N L	078 Phosphate L
045 Hydrazine	067 Nitrite-N L	085 Silica Lo
032 Cu-DDC	077 Phenol	
051 Iron Bipyr	078 Phosphate L	
	090 Sulfide-LR	

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 ▼ to scroll to the next test and press ***/ENTER** 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. 25).

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 ***/ENTER** to start testing.

VER 1.0
Smart2
*Start

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

MAIN MENU
*Testing Menu
Editing Menu
PC Link

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

TESTING MENU
*All Tests
Sequence 1
Sequence 2

Press **▼** to scroll to 002 Aluminum.

ALL TESTS
*001 Alk - UDU
002 Aluminum
003 Ammonia-N LF

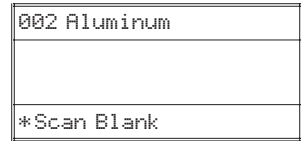
Press ***/ENTER** to select 002 Aluminum.

ALL TESTS
*002 Aluminum
003 Ammonia-N LF
004 Ammonia-N LS

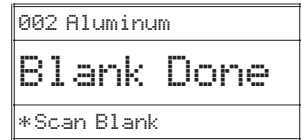
Continued...

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

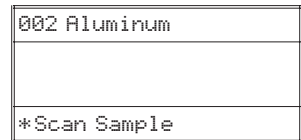
NOTE: Do not keep the button depressed.



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

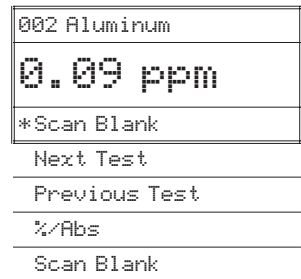


Place the reacted sample in the chamber, close the lid and press ***/ENTER** to scan sample. The colorimeter will scan the sample and the results screen will appear.



Record test result. To repeat the test, press ***/ENTER** 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 **▲** to scroll back to **Scan Blank** and then scanning another blank. Scroll with the **▼** or **▲** buttons and make another selection with the ***/ENTER** button. 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 the **▲** or **▼** buttons 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 ***/ENTER** to start testing.

VER 1.0
Smart2
*START

The Main Menu will appear. Press ▼ to scroll to Editing Menu.

MAIN MENU
Testing Menu
*Editing Menu
PC Link

Press ***/ENTER** to select Editing Menu.

MAIN MENU
*Editing Menu
PC Link

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

EDITING MENU
*Edit Sequence
Edit User Test
Set Clock

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

EDIT SEQUENCE
*Edit Sequence 1
Edit Sequence 2
Edit Sequence 3

Continued...

Sequence 1 appears.

EDIT SEQUENCE 1
*015 Chlorine
079 Phosphate H
009 Bromine-LR

■ 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 ▼ to scroll to 009 Bromine-LR.

EDIT SEQUENCE 1
015 Chlorine
079 Phosphate H
*009 Bromine-LR

Press ***/ENTER** to select 009 Bromine-LR.

EDIT SEQUENCE 1
*009 Bromine-LR
076 pH TB
060 Moly-LR

Press ***/ENTER** to select *Insert Before*.

EDIT SEQUENCE 1
*Insert Before
Insert After
Delete

The *ALL TESTS* menu appears. Press ▼ to move to 002 Aluminum.

ALL TESTS
*002 Aluminum
003 Ammonia-N LF
004 Ammonia-N LS

Press ***/ENTER** to select 002 Aluminum.

ALL TESTS
*002 Aluminum
003 Ammonia-N LF
004 Ammonia-N LS

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.

EDIT SEQUENCE 1
*015 Chlorine
079 Phosphate H
002 Aluminum
009 Bromine-LR
076 pH TB
060 Moly-LR

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

EDIT SEQUENCE 1
*Edit Sequence 1
Edit Sequence 2
Edit Sequence 3

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 **▼** to scroll to 002 Aluminum.

EDIT SEQUENCE 1
*015 Chlorine
079 Phosphate H
002 Aluminum
009 Bromine-LR
076 pH TB
060 Moly-LR

Press ***/ENTER** to select 002 Aluminum.

EDIT SEQUENCE 1
*002 Aluminum
009 Bromine-LR
076 pH TB

Press ▼ to scroll to Delete.

EDIT SEQUENCE 1
*Insert Before
Insert After
Delete

Press */**ENTER** to select Delete.

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

EDIT SEQUENCE 1
*015 Chlorine
079 Phosphate H
009 Bromine-LR
076 pH TB
060 Moly-LR

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

EDIT SEQUENCE 1
*Edit Sequence 1
Edit Sequence 2
Edit Sequence 3

■ CREATING A SOIL TEST SEQUENCE

To create a testing sequence specifically for the reagent systems in the SMART 2 Soil Manual follow the step by step example below. After current stored sequence has been cleared of previous tests, the soil tests will be entered. Tests in the soil sequence will appear in the order that they are listed in the manual.

Start from the EDIT SEQUENCE 1 menu and delete all of the existing tests in the menu by following the example below.

Press ***/ENTER** to select 015 Chlorine.

EDIT SEQUENCE 1
*015 Chlorine
079 Phosphate H
009 Bromine-LR
076 pH-TB
060 Moly-LR

Press ▼ to scroll to Delete.

EDIT SEQUENCE 1
*Insert Before
Insert After
Delete

Press ***/ENTER** to select Delete.

ALL TESTS
*Delete

Sequence 1 appears in the EDIT SEQUENCE 1 menu and 015 Chlorine has been deleted. All changes to Sequence 1 are automatically saved. Press ***/ENTER** to select 079 Phosphate H.

EDIT SEQUENCE 1
*079 Phosphate H
009 Bromine-LR
076 pH TB
060 Moly-LR
086 Silica Hi

Continued....

Press ▼ to scroll to Delete.

EDIT SEQUENCE 1
*Insert Before
Insert After
Delete

Press */**ENTER** to select Delete.

ALL TESTS
*Delete

Sequence 1 appears in the EDIT SEQUENCE 1 menu and 079 Phosphate H has been deleted. All changes to Sequence 1 are automatically saved. Press */**ENTER** to select 009 Bromine-LR. Delete 009 Bromine-LR and all other tests in Sequence 1. When all tests have been deleted the ADD TEST TO SEQ menu will be displayed.

EDIT SEQUENCE 1
*009 Bromine-LR
076 pH TB
060 Moly-LR
086 Silica Hi
045 Hydrazine

Add a test to Sequence 1 as follows.

Press */**ENTER** to select Continue.

ADD TEST TO SEQ
*Continue

The ALL TESTS menu appears. Press ▲ to move to 099 Zinc-LR.

ALL TESTS
*001 Alk - UDV
002 Aluminum
003 Ammonia-N LF

Press */**ENTER** to select 099 Zinc-LR.

ALL TESTS
*099 Zinc-LR
100 Zinc-HR
101 Abs 430

Sequence 1 appears in the EDIT SEQUENCE 1 menu and 099 Zinc-LR is now in Sequence 1. All changes to Sequence 1 are automatically saved. Press ***/ENTER** to select 099 Zinc-LR.

ALL TESTS
*099 Zinc-LR

Press ***/ENTER** to select Insert Before.

EDIT SEQUENCE 1
*Insert Before
Insert After
Delete

The ALL TESTS menu appears. Press ▲ to move to 089 Sulfate-HR.

ALL TESTS
*001 Alk - UDV
002 Aluminum
003 Ammonia-N LF

Press ***/ENTER** to select 089 Sulfate-HR.

ALL TESTS
*089 Sulfate-HR
090 Sulfate-LR
091 Sulfide-HR

Sequence 1 appears in the EDIT SEQUENCE 1 menu and 089 Sulfate-HR is now in Sequence 1. Press ***/ENTER** to select 089 Sulfate-HR.

EDIT SEQUENCE 1
*089 Sulfate-HR
099 Zinc-LR

Press ***/ENTER** to select Insert Before.

EDIT SEQUENCE 1
*Insert Before
Insert After
Delete

Continued....

The ALL TESTS menu appears. Press ▲ to move to 081 Potassium.

ALL TESTS
*001 Alk - UDV
002 Aluminum
003 Ammonia-N LF

Press */**ENTER** to select 081 Potassium.

ALL TESTS
*081 Potassium
082 QAC
083 SDMBT

Continue following this procedure to insert the remaining tests in this order: 089 Phosphate L, 064 Nitrate-N L, 067 Nitrite-N L, 056 Manganese L, 051 Iron Bipyr, 032 Cu DDC, and 005 Ammonia-N H.

Sequence 1 appears in the EDIT SEQUENCE 1 menu and all the tests have been added. All changes to Sequence 1 are automatically saved.

Press **EXIT** to exit the EDIT SEQUENCE 1 menu and return to the EDIT SEQUENCE menu.

EDIT SEQUENCE 1
*005 Ammonia-N H
032 Cu DDC
051 Iron Bipyr
056 Manganese
064 Nitrate-N L
067 Nitrite-N L
078 Phosphate L
081 Potassium
089 Sulfate - HR
099 Zinc - LR

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

EDIT SEQUENCE
*Edit Sequence 1
Edit Sequence 2
Edit Sequence 3

■ CALIBRATING LaMOTTE PRE-PROGRAMMED TESTS

The LaMotte Pre-Programmed Tests have been pre-calibrated. Recalibration of the pre-programmed tests by the user is not possible. However, a procedure to standardize the calibration can be performed to obtain the most accurate readings or to meet regulatory requirements.

The LaMotte Pre-Programmed tests are standardized with one standard solution. To standardize over the full range of the test, the concentration of the standard should be chosen from the high end of the range. Alternatively, if samples do not cover the full range of the test, a standard should be chosen that is close to the concentration of the samples.

For the SMART 2 Soil colorimeter, the standard should be prepared in distilled or deionized water for the range of the reagent system before the multiplication factor has been applied to the reading on the display. The following standards are recommended to standardize over the full range of the tests:

Ammonia Nitrogen	3.00 ppm Ammonia Nitrogen
Copper	4.00 ppm Copper
Iron	4.00 ppm Iron
Manganese	11.00 ppm Manganese
Nitrate Nitrogen	2.00 ppm Nitrate Nitrogen
Nitrite Nitrogen	0.60 ppm Nitrite Nitrogen
Phosphorus	2.00 ppm Phosphate
Potassium	7.00 ppm Potassium
Sulfur	75 ppm Sulfate
Zinc	2.00 ppm Zinc

The standardization procedure should be followed as often as required by regulations and laws for compliance monitoring.

In the example below the Aluminum calibration will be standardized.

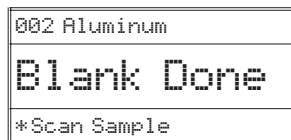
Prepare a standard solution to be tested. Use 0.10 ppm aluminum.

Use the ▲ or ▼ button to scroll to 002 Aluminum.
Follow instructions in the SMART2 Manual for testing the aluminum standard. Scan the blank.

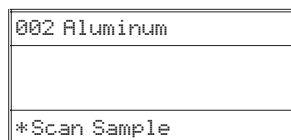
002 Aluminum
SEQUENCE 3
*Scan Blank

Continued...

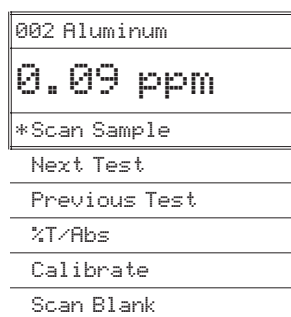
The screen will display **Blank Done** for about 1 second. **Scan Sample** will be positioned next to *****.



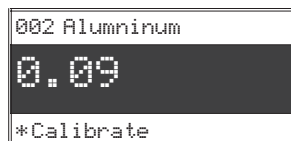
Place the reacted sample in the chamber, close the lid and press ***/ENTER** to scan sample. The result will be displayed.



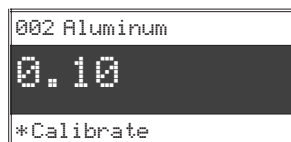
The displayed result can now be standardized. Use the **▲** or **▼** buttons to scroll to **Calibrate**. Press ***/ENTER** to select.



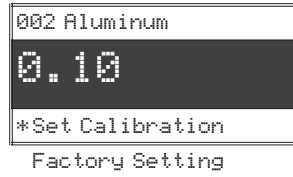
A reverse font (dark background with light characters) will appear to indicate that the reading can be adjusted. Use **▲** or **▼** to scroll to the concentration of the sample, 0.10 ppm in this example.



Set the calibration by pressing ***/ENTER** to select **Calibrate**.



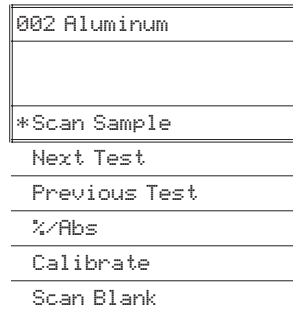
Two menu choices will be offered, Set Calibration and Factory Setting. Set the calibration by pressing ***/ENTER** to select Set Calibration; or use ▲ or ▼ to scroll to and select Factory Setting to revert to the factory calibration.



The meter will display the message “Storing” and return to 002 Aluminum test.



The calibration for 002 Aluminum has now been standardized and can be used for testing. The standardization can be removed by repeating the calibration and selecting Factory Setting.



■ 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 ▼ to scroll to Set Clock. Press ***/ENTER** to select.

EDITING MENU
*Edit Sequences
Edit User Test
Set Clock
Editing Logging
Factory Setup
Set PWR Save

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 ▼ and ▲ to scroll to the appropriate number and press ***/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.

SET TIME
MM - DD - YY
HH : MM : SS

EDITING MENU
*Set Clock
Editing Logging
Factory Setup
Set PWR Save

■ TURNING THE DATA LOGGER ON AND OFF

The default setting for the datalogger is “Enabled” 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 ▼ to scroll to Edit Logging. Press ***/ENTER** to select.

EDITING MENU
*Edit Sequences
Edit User Test
Set Clock
Editing Logging
Factory Setup
Set PWR Save

The current setting is always displayed next to the *. To change the setting, use ▼ or ▲ to scroll to the other setting. Press ***/ENTER** to select.

EDIT LOGGING
*Enabled
Disabled

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

Storing

EDITING MENU
*Editing Logging
Factory Setup
Set PWR Save

■ 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 ▼ to scroll to Set PWR Save. Press ***/ENTER** to select.

EDITING MENU
*Edit Sequences
Edit User Test
Set Clock
Editing Logging
Factory Setup
Set PWR Save

The current setting is always displayed next to the *. To change the setting, use ▼ or ▲ to scroll to the appropriate setting. Press ***/ENTER** to select.

Disabled
AUTO SHUTOFF
*5 Minutes
15 Minutes
30 Minutes
60 Minutes

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

Storing

EDITING MENU
*Set PWR Save

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.

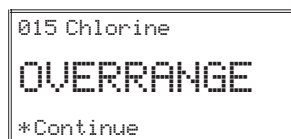
TROUBLESHOOTING GUIDE

■ 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, p. 11).

If **OVERRANGE** is displayed, press ***/ENTER** 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.

SMART2 COLORIMETER REAGENT SYSTEMS

This SMART2 Colorimeter contains calibrations for pre-programmed LaMotte SMART reagent systems for water testing as well as the pre-programmed soil tests included in this lab. A SMART2 manual (Code 1919-MN) and appropriate reagent systems and chamber adapters are required to perform the water test procedures. Call LaMotte Technical Services at 800-344-3100 (410-778-3100 outside the USA) or email tech@lamotte.com for a current list of available calibrations.

■ REAGENT SYSTEMS LIST

Test #	Test Factor	Range(ppm)	Test Method (# of Reagents)	# of Tests
1	Alkalinity-UDV	0-200	Unit Dose Vials (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	0.00-1.00	Salicylate (3)	25
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)	25
9	Bromine-Low Range	0.00-9.00	DPD (3)	100
10	Bromine-High Range			
11	Bromine-UDV	0.0-22.0	DPD (1)	
12	Cadmium	0.00-1.00	PAN (4)	50
13	Ca & Mg Hardness-UDV	0-400	Unit Dose Vials (1)	50
14	Carbohydrazide	0.000-0.900	Iron Reduction (3)	100
15	Chlorine	0.00-4.00	DPD (3)	100
16	Chlorine-Free-UDV	0.00-10.00	DPD (1)	50
17	Chlorine-Liquid DPD	0.00-4.00	DPD (3)	144
18	Chlorine-Total-UDV	0.00-10.00	DPD (1)	50
19	Chlorine-Total-UDV, High Range			
20	Chlorine Dioxide	0.00-8.00	DPD (2)	100
21	Chloride-TesTab	0.0-30.0	Argentometric (1)	50
22	Chromium	0.00-1.00	Diphenylcarbohydrazide (1) or (5)	100
23	Chromium-TesTab			
24	Cobalt	0.00-2.00	PAN (3)	50
25	COD-Low Range	5-150	Digestion (1)	25

Test #	Test Factor	Range(ppm)	Test Method (# of Reagents)	# of Tests
26	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			
31	Copper-Cuprizone	0.00-2.00	Cuprizone (2)	50
32	Copper-DDC	0.00-6.00	Diethyldithiocarbamate (1)	50
33	Copper-UDV	0.0-4.0	Bicinchoninic Acid (1)	50
34	Copper-Zincon-High Range	0-4.0		
35	Cyanide	0.00-0.50	Pyridine-Barbituric Acid (5)	50
36	Cyanuric Acid	5-200	Melamine (1)	100
37	Cyanuric Acid-UDV	5-150	Melamine (1)	50
38	DEHA	0.000-0.700	Iron Reduction (3)	100
39	Dissolved Oxygen	0.0-11.0	Winkler Colorimetric (3)	100
40	Erythorbic Acid	0.00-3.00	Iron Reduction (3)	100
41	Fluoride	0.00-2.00	SPADNS (2)	50
42	Formaldehyde-Low Range			
43	Formaldehyde-High Range			
44	Hardness-Tes Tab			
45	Hydrazine	0.00-1.00	P-dimethylaminobenzaldehyde (2)	25
46	Hydrogen Peroxide-Low Range	0.00-1.50	DPD (2)	100
47	Hydrogen Peroxide-High Range			
48	Hydrogen Peroxide-UDV			
49	Hydroquinone	0.00-2.00	Iron Reduction (3)	100
50	Iodine	0.00-14.00	DPD (3)	100
51	Iron-Bipyridyl	0.00-6.00	Bipyridyl (2)	50
52	Iron-UDV	0.00-10.00	Bipyridyl (1)	50
53	Iron-Phenanthroline	0.00-5.00	1,10 Phenanthroline (2)	50
54	Lead	0.00-5.00	PAR (5)	50
55	Manganese-Low Range	0.00-0.70	PAN (3)	50
56	Manganese-High Range	0.0-15.0	Periodate (2)	50
57	Mercury	0.00-1.50	TMK (3)	50
58	Methylethylketoxime	0.00-3.00	Iron Reduction (3)	100
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

Test #	Test Factor	Range (ppm)	Test Method (# of Reagents)	# of Tests
64	Nitrate Nitrogen-Low Range	0.00-3.00	Cadmium Reduction (2)	20
65	Nitrate Nitrogen-High Range			
66	Nitrate-TesTab	0.0-60.0	Zinc Reduction (1)	50
67	Nitrite Nitrogen-Low Range	0.00-0.80	Diazotization (2)	20
68	Nitrite Nitrogen-High Range			
69	Nitrite-TesTab			
70	Oil/Grease			
71	Ozone-Low Range	0.00-0.40	Indigo (3)	100
72	Ozone-High Range	0.00-2.50	Indigo (3)	25
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	8.0-9.6	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	0.0-4.0	Heteropoly Blue (4)	50
86	Silica-High Range	0-75	Silicomolybdate (3)	50
87	Silver			
88	Sulfate-Low Range			
89	Sulfate-High Range	0-100	Barium Chloride (1)	50
90	Sulfide-Low Range	0.00-1.50	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-molybdphosphoric Acid (2)	50
97	TMIO			
98	Turbidity	0-400 FTU	Absorption (0)	∞
99	Zinc-Low Range	0.00-3.00	Zincon (6)	50
100	Zinc-High Range			

SMART²SOIL

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SOIL TEST INSTRUCTIONS



ELECTRONIC TEST METHODS

pH

PROCEDURE

1. Use the 10 g Soil Measure (1164) to add one level measure of the soil sample to a 50 mL beaker (0944). Use the graduated cylinder (0416) to add 10 mL of deionized water. Stir thoroughly.
2. Let stand for at least 30 minutes, stirring two or three times.
3. Stir mixture just prior to making the pH reading. Determine the pH reading of the sample by following the instructions for the pH Meter.

LIME REQUIREMENT - WOODRUFF METHOD

PROCEDURE

1. Use the 10 g Soil Measure (1164) to add one level measure of the soil sample to a 50 mL beaker (0944). Use the graduated cylinder (0416) to add 10 mL of deionized water. Stir thoroughly.
2. Let stand for at least 15 minutes.
3. Add 20 mL of Woodruff Buffer Solution (5272). Mix well, and let stand for at least 20 minutes, stirring two or three times.
4. Take reading using the pH meter. Stir mixture just prior to making reading.
5. Each 0.1 pH unit drop from pH 7.0 indicates a lime requirement equivalent to 1000 lbs calcium carbonate (CaCO_3).

SOLUBLE SALTS (TOTAL DISSOLVED SALTS)

Most plants will get along well at soluble salts concentrations of below 1000 parts per million. However, greenhouse and many sensitive garden plants may be damaged if the soluble salts are over 500 parts per million of chlorides, particularly some of the most sensitive legumes. If the soluble salts are greater than 1000 parts per million, the chlorides and sulfates should be determined to learn whether the soluble salts are chlorides or sulfates. In calcareous soils, the sulfates represent gypsum and have little effect on the production of plants.

PROCEDURE

1. Fill a 50 mL beaker (0944) with the soil to be tested, tapping it lightly to eliminate any trapped air and then strike off the surface.
2. Empty the contents of the beaker into the 300 mL bottle (0991). Add 100 mL of deionized water.
3. Cap the bottle and shake vigorously. Allow to stand for thirty minutes. During the thirty minute waiting period the bottle should be shaken vigorously three or four times.
4. Filter the contents of the bottle using funnel (0459) and filter paper (0463) and collect the filtrate in a 100 mL bottle (0990) which is then used as a conductivity chamber.
5. Determine the TDS reading of the sample by following the instructions for the TDS 5 Meter.
6. To convert conductivity to Soluble Salts (Total Dissolved Solids), use the following formula.

$$\text{ppm Soluble Solids (Total Dissolved Solids)} = \text{Micromhos/cm @ 25}^\circ\text{C} \times 0.7$$

EXTRACTION PROCEDURE

The following method of extraction is employed for obtaining the soil filtrate for the tests for Nitrate Nitrogen, Phosphorous, Potassium, Calcium, Magnesium, Ammonia Nitrogen, Nitrite Nitrogen, Manganese, Copper, Zinc, and Iron. Separate extractions are required for the Chloride and Sulfate tests. Consult the *LaMotte Soil Handbook* (1504) for information on sampling and preparation of sample for testing.

■ MULTIPLE TEST PROCEDURE

1. Use the 1 mL pipet (0354) to add 5 mL of *Acid Extracting Solution (6361) to the 100 mL graduated cylinder (0419). Add deionized water to 75 mL graduation.
2. Pour this solution into the 100 mL bottle (0990).
3. Use the Soil Measure (1165) to add 15 g (one level measure) of the soil sample to the bottle.
4. Cap the bottle and shake for 5 minutes.
5. Use the funnel (0459) and filter paper (0463) to filter and collect all of the soil extract in a 100 mL bottle (0990).
6. The soil extract is used for all of the tests listed above, except Chloride and Sulfate.

■ SINGLE TEST PROCEDURE

1. Use the 1 mL pipet (0354) to add 1 mL of *Acid Extracting Solution (6361) to the test tube (0701), then add deionized water to fill to the 15 mL line.
2. Use the 1.0 g spoon (0697) to add 3 measures of soil to the extracting solution in the test tube.
3. Cap the tube and shake for 5 minutes.
4. Filter, using the funnel (0459) and filter paper (0463) and collect all of the soil extract.
5. The soil extract is used for all of the tests listed above except Chloride and Sulfate.

■ NEUTRALIZATION OF SOIL FILTRATE

In the test procedures for Ammonia Nitrogen, Calcium & Magnesium, Copper, Iron, Manganese and Zinc require that the acidity of the soil extract be neutralized before the test procedure is performed. This is done by adding *Sodium Hydroxide, 15% (7886) to the soil extract until Bromthymol Blue Test Paper (2931) indicates that the pH is in the proper range.

1. Add one drop of *Sodium Hydroxide, 15% (7886) to the soil extract. Stir with the stirring rod.
2. Touch the stirring rod to the Bromthymol Blue Test Paper (2931).
3. If the test paper does not change from yellow to blue or green, continue adding *Sodium Hydroxide, 15% to the soil extract, one drop at a time. Stir and test the pH after the addition of each drop until the test paper changes from yellow to green or blue.

AMMONIA-NITROGEN

NESSLERIZATION METHOD

CODE 3642-SC

QUANTITY	CONTENTS	CODE
30 mL	Ammonia Nitrogen Reagent #1	V-4797-G
2 x 30 mL	*Ammonia Nitrogen Reagent #2	*V-4798-G
1	Pipet, 1 mL, plastic	0354

***WARNING:** Reagents marked with a * are considered hazardous substances. Material Safety Data Sheets (MSDS) are supplied for these reagents. For your safety read label and MSDS before using.

A fertile soil may be expected to give a low ammonia nitrogen test reading, unless there has been a recent application of nitrogenous fertilizer in forms other than the nitrate. The rapid disappearance of ammonia after fertilizer application indicates the desired transformation of the ammonia to the more available nitrate compounds. In forest soils, ammonia is the most abundant available form of nitrogen. If there is a satisfactory rate of nitrogen transformation, the humus layers of a forest soil will produce very high concentrations of ammonia nitrogen.

RANGE: 0.00-200.00 lb/acre Ammonia-Nitrogen

METHOD: Ammonia forms a colored complex with Nessler's Reagent in proportion to the amount of ammonia present in the sample. Rochelle salt is added to prevent precipitation of calcium or magnesium in undistilled samples.

INTERFERENCES: Sample turbidity and color may interfere. Turbidity may be removed by filtration procedure. Color interferences may be eliminated by blanking the instrument with a sample blank.

PROCEDURE

1. Press and hold **ON** button until colorimeter turns on.
2. Press **ENTER** to start.
3. Press **ENTER** to select TESTING MENU.
4. Scroll to and select ALL TESTS (or another sequence containing 5 Ammonia-N H) from TESTING MENU.
5. Scroll to and select 5 Ammonia-N H from menu.
6. Use the 1 mL pipet (0354) to transfer 2 mL of soil extract into a clean tube (0290). Dilute to the 10 mL line with deionized water. Mix and neutralize according to the procedure on page 50.
7. Insert tube into chamber, close lid and select SCAN BLANK. (See Note)
8. Remove tube from colorimeter. Add 12 drops of Ammonia Nitrogen Reagent #1 (V-4797). Cap and mix. Wait 1 minute.
9. Use the 1.0 mL pipet (0354) to add 1.0 mL of *Ammonia Nitrogen Reagent #2 (V-4798). Cap and mix. Allow 5 minutes for maximum color development.
10. At end of the 5 minute waiting period, immediately mix, insert tube into chamber, close lid and select SCAN SAMPLE. Multiply the result by 50 to determine the ammonia-nitrogen concentration in lb/acre.
11. Press **OFF** button to turn the colorimeter off or press the **EXIT** button exit to a previous menu or make another menu selection.

NOTE: For the best possible results, a reagent blank should be determined to account for any contribution to the test result by the reagent system. To determine the reagent blank, follow the above test procedure to scan a distilled or deionized water blank. Then follow the above procedure to perform the test on a distilled or deionized water sample. This test result is the reagent blank. Subtract the reagent blank from all subsequent test results of unknown samples. It is necessary to determine the reagent blank only when a new lot number of reagents are obtained.

■ AMMONIA NITROGEN CONCENTRATION CHART

POUNDS PER ACRE	RANGE
0-24 lb/acre	Low
25-68 lb/acre	Medium
Over 71 lb/acre	High

CALCIUM & MAGNESIUM

SCHWARZENBACH EDTA METHOD

CODE M-CAL-MAG

QUANTITY	CONTENTS	CODE
30 mL	*Calcium & Magnesium Buffer	*5126-G
60 mL	Standard EDTA Reagent	5254-H
100	Calcium Hardness Indicator Tablets	T-5250-J
30 mL	Calcium Magnesium Inhibitor Reagent	3922-G
30 mL	*CM Indicator Reagent	*6522WT-G
30 mL	*Sodium Hydroxide w/Metal Inhibitors	*4259-G
15 mL	*Inhibitor Solution	*9258-E
15 mL	*TEA Reagent	*3921-E
2	Direct Reading Titrators, 0-1000 Range	0384
1	Pipet, transfer, plastic	0364
1	Test tube, 5-10-15 mL, glass, w/cap	0778

***WARNING:** Reagents marked with a * are considered hazardous substances. Material Safety Data Sheets (MSDS) are supplied for these reagents. For your safety read label and MSDS before using.

The amount of total calcium in soils may range from as little as 0.1% to as much 25%. A calcium deficiency is rarely a problem due to widely accepted practice of applying lime to soil to raise the pH to the proper range for optimum plant growth. As an important mineral nutrient, calcium is a component of cell walls in plants and is known to stimulate root and leaf development as well as activate several enzyme reactions involved in plant metabolism. Indirectly, calcium influences crop yields by reducing soils acidity and by reducing the toxicity of several other soil minerals such as manganese, zinc, and aluminum.

The Schwarzenbach EDTA titration method, used to determine calcium and magnesium, involves two titrations. The first titration gives the calcium and magnesium content, the second only calcium. Magnesium is calculated from the difference between the titration values.

RANGE: 0-800 lb/acre Calcium
0-480 lb/acre Magnesium

METHOD: Titration with Schwarzenbach EDTA

INTERFERENCE: Sample color and turbidity may interfere with endpoint.

PROCEDURE

I. DILUTION OF SOIL EXTRACT

Use the 30 mL graduated cylinder (0418) to measure 10 mL of the soil extract and transfer it to a 50 mL beaker (0944). Add 10 mL of deionized water, mix and neutralize according to the procedure on page 50.

II. TITRATION A, CALCIUM & MAGNESIUM

Carefully read the LaMotte Direct Reading Titrator Manual (1649) before performing the titrations described below.

1. Fill the test tube (0778) to the 5 mL line with the soil extract from above. Dilute to the 10 mL line with deionized water.
2. Add 5 drops of Calcium Magnesium Inhibitor Reagent (3922).
3. Wait 5 minutes.
4. Use a pipet (0364) to add 5 drops of *Calcium & Magnesium Buffer (5126).
5. Add 10 drops of *CM Indicator (6522WT).
6. Fill the Direct Reading Titrator (0384) with the Standard EDTA Reagent (5254). Insert the tip of the Titrator into the center hole of the test tube cap.
7. While gently swirling the tube, slowly press the plunger to titrate until the color changes from red to blue.
8. Read the Titrator scale at the tip of the plunger and multiply by 5.16. This is Titration Value A.

III. TITRATION B, CALCIUM

1. Fill the test tube (0778) to the 5 mL line with the diluted soil extract. Dilute to 10 mL with deionized water.
2. Add 2 drops of *Inhibitor Solution (9258).
3. Add 2 drops of *TEA Reagent (3921).
4. Add 8 drops of *Sodium Hydroxide w/Metal Inhibitors (4259).
5. Add one Calcium-Hardness Indicator Tablet (T-5250) to the test sample. Cap and shake to dissolve the tablet. A red color will develop.
6. Immediately titrate the sample. Fill the Direct Reading Titrator with Standard EDTA Reagent (5254). Insert the tip of the Titrator into the hole in the cap of the test tube.
7. While gently shaking the tube, slowly press the plunger to titrate until the red color changes to a clear blue and does not revert to red upon standing 1-2 minutes.
8. Read the Titrator scale at the tip of the plunger and multiply by 5.16. This is Titration Value B.

IV. FINAL RESULTS

Calcium Content = $0.4 \times \text{Titration Value B} = \text{ppm Ca}$

Magnesium Content = $0.24 (\text{Value A} - \text{Value B}) = \text{ppm Mg}$

Multiply the results by 2 to obtain the content in pounds per acre.

EXAMPLE:

Titration Value A is 640 ppm CaCO_3

Titration Value B is 520 ppm CaCO_3

$$\begin{aligned}\text{Calcium} &= 0.4 \times 520 = 208 \text{ ppm Ca} \\ &= 208 \times 2 = 416 \text{ lb/acre Ca}\end{aligned}$$

$$\begin{aligned}\text{Magnesium} &= 0.24 (640 - 520) \\ &= 0.24 \times 120 = 29 \text{ ppm Mg} \\ &= 29 \times 2 = 58 \text{ lb/acre Mg}\end{aligned}$$

CHLORIDE

DIRECT READING TITRATOR METHOD

CODE M7241

QUANTITY	CONTENTS	CODE
15 mL	*Chloride Reagent #1	*4504-E
60 mL	*Silver Nitrate, 0.141N	*3062DR-H
1	Test Tube, 5-10-15 mL, plastic, w/cap	0701
1	Spoon, 1g	0697
1	Test Tube, 5-10-15 mL, glass, w/cap	0778
1	Direct Reading Titrator, 0-1000 Range	0384

***WARNING:** Reagents marked with a * are considered hazardous substances. Material Safety Data Sheets (MSDS) are supplied for these reagents. For your safety, read label and accompanying MSDS before using.

Chlorides are present in practically all soils. Application of fertilizer may increase chloride levels. Chlorides are removed from soil by leaching. Excessive concentrations are toxic to plants. A high test reading, particularly where stunted growth has been observed, may indicate poisoning due to high chloride levels in the soil. This test is valuable on saline soils or when contamination from sea water or sea spray is suspected. Normal soils of humid regions rarely give readable tests, except when recently receiving liberal amounts of fertilizers containing chlorides.

RANGE: 0-1000 lb/acre Chloride

METHOD: In a neutral or slightly alkaline solution, potassium dichromate indicates the endpoint of the silver nitrate titration.

INTERFERENCES: Bromine, iodide and cyanide register as equivalent chloride concentrations.

PROCEDURE

Carefully read the LaMotte Direct Reading Titrator Manual (1649) before performing the titration procedure described below. The Titrator is calibrated in terms of parts per million chloride and each minor division on the Titrator scale equals 20 ppm.

1. Fill a clean test tube (0701) to the 15 mL line with deionized water.
2. Add 3 measures of soil using the 1 g spoon (0697). Cap tube and shake for five minutes.
3. Filter and collect all of the soil filtrate using the funnel (0459) and filter paper (0463). The extract does not have to be clear since a slight turbidity does not interfere in the test.
4. Fill the test tube (0778) to the 10 mL line with the filtrate.
5. Add three drops of *Chloride Reagent #1 (4504) to the sample. Cap and shake to mix. A yellow color will result.
6. Fill the Direct Reading Titrator (0384) with *Silver Nitrate, 0.141 (3062DR) in the manner described in the instruction manual.
7. Titrate the test sample with *Silver Nitrate, 0.141 (3062DR) until the yellow color changes permanently to pink. Record the Titrator reading. If the plunger reaches the bottom mark (1000 ppm) on the Titrator scale before the endpoint color change occurs, refill the Titrator and continue the titration procedure. Be sure to include the value of the original amount added (1000 ppm) when recording the final result.

COPPER

DIETHYLDITHIOCARBAMATE METHOD CODE M3639-46-65-SC

QUANTITY	CONTENTS	CODE
15 mL	*Copper 1	*6446-E

***WARNING:** Reagents marked with a * are considered hazardous substances. Material Safety Data Sheets (MSDS) are supplied for these reagents. For your safety, read label and accompanying MSDS before using.

Like many other micronutrients, the amount of available copper varies considerably with the type of soil. Well drained sandy soils are usually low in copper while heavily clay-type soils contain an abundant supply of copper. Like manganese, copper may be unavailable in soils that have a high organic make-up because it readily forms insoluble complexes with organic compounds.

Generally from 0.2-25 lb/acre of copper is added to the soil to correct a deficient level. Copper is another metal that is necessary in the formation of the chlorophyll molecule and like other metals, e.g. iron, manganese and zinc acts as a catalyst.

RANGE: 0.00-30.00 ppm Copper

METHOD: Cupric ions form a yellow colored chelate with Diethyldithiocarbamate around pH 9-10, in proportion to the concentration of copper in the sample.

INTERFERENCES: Bismuth, cobalt, mercury, nickel and silver ions and chlorine (6 ppm or greater) interfere seriously and must be absent.

PROCEDURE

1. Press and hold **ON** button until colorimeter turns on.
2. Press **ENTER** to start.
3. Press **ENTER** to select TESTING MENU.
4. Select ALL TESTS (or another sequence containing 32 Cu DDC) from TESTING MENU.
5. Scroll to and select 32 Cu DDC from menu.
6. Fill a clean tube (0290) to the 10 mL line with the soil extract then neutralize according to the procedure on page 50.
7. Insert tube into chamber, close lid and select SCAN BLANK.
8. Remove tube from colorimeter and add 5 drops of *Copper 1 (6446). Cap and mix. Solution will turn yellow if copper is present.
9. Insert tube into chamber, close lid and select SCAN SAMPLE. Multiply the result by 5 to determine the copper concentration in ppm.
10. Press **OFF** button to turn colorimeter off or press **EXIT** button to exit to a previous menu or make another menu selection.

NOTE: The reaction may stain the tubes. Scrub the tubes thoroughly after each use.

■ COPPER CONCENTRATION CHART

PARTS PER MILLION	RANGE
0-1 ppm	Low
1-3 ppm	Marginal
3-4 ppm	Adequate

IRON

BIPYRIDYL METHOD

3648-SC

QUANTITY	CONTENTS	CODE
30 mL	*Iron Reagent #1	*V-4450-G
5 g	*Iron Reagent #2 Powder	*V-4451-C
1	Pipet, 0.5 mL	0353
1	Spoon, 0.1 g	0699

***WARNING:** Reagents marked with a * are considered hazardous substances. Material Safety Data Sheets (MSDS) are supplied for these reagents. For your safety, read label and accompanying MSDS before using.

Iron is essential to the formation of chlorophyll, and iron deficiency causes chlorosis. While most soils contain abundant iron, only a fraction is soluble and readily available to the growing plant. This is particularly true in neutral or alkaline soils. Acid soils contain higher levels of available iron.

RANGE: 0.00-30.00 ppm Iron

METHOD: Ferric iron is reduced to ferrous iron and subsequently forms a colored complex with bipyridyl for a quantitative measure of total iron.

INTERFERENCES: Strong oxidizing agents interfere, as well as copper and cobalt in excess of 5.0 mg/L

PROCEDURE

1. Press and hold **ON** button until colorimeter turns on.
2. Press **ENTER** to start.
3. Press **ENTER** to select TESTING MENU.
4. Select ALL TESTS (or another sequence containing 51 Iron Bipyr) from TESTING MENU.
5. Scroll to and select 51 Iron Bipyr from menu.
6. Fill a clean tube (0290) to the 10 mL line with the soil extract then neutralize according to the procedure on page 50.
7. Insert tube into chamber, close lid and select SCAN BLANK.
8. Remove tube from colorimeter. Use the 0.5 mL pipet (0353) to add one measure of *Iron Reagent #1 (V-4450). Cap and mix.
9. Use the 0.1 g spoon (0699) to add 0.1 g of *Iron Reagent #2 Powder (V-4451). Cap and shake vigorously for 30 seconds. Wait three minutes for maximum color development.
10. At the end of 3 minute waiting period, do not mix. Insert tube into chamber, close lid and select SCAN SAMPLE. Multiply the result by 5 to determine the iron concentration in ppm.
11. Press **OFF** button to turn colorimeter off or press **EXIT** button to exit to a previous menu or make another menu selection.

NOTE: For best possible results, a reagent blank should be determined to account for any contribution to the test result by the reagent system. To determine the reagent blank, follow the above test procedure to scan a distilled or deionized water blank. Then follow the above procedure to perform the test on a distilled or deionized water sample. This test result is the reagent blank. Subtract the reagent blank from all subsequent test results of unknown samples. It is necessary to determine the reagent blank only when a new lot number of reagents are obtained.

■ IRON CONCENTRATION CHART

PARTS PER MILLION	RANGE
0.0-1.3 ppm	Very Low
1.4-3.0 ppm	Low
3.0-5.0 ppm	Medium
5.0-10.0 ppm	Medium High
Above 10.0-25.0 ppm	High

MANGANESE

PERIODATE METHOD

CODE 3669-SC

QUANTITY	CONTENTS	CODE
10 g	Manganese Buffer Reagent	6310-D
15 g	*Manganese Periodate Reagent	*6311-E
1	Spoon, 0.1 g	0699
1	Spoon, 0.15 g	0727

***WARNING:** Reagents marked with a * are considered hazardous substances. Material Safety Data Sheets (MSDS) are supplied for these reagents. For your safety, read label and accompanying MSDS before using.

The amount of manganese available to the plant is dependant upon the soil pH, the quantity of organic matter present, and the degree of aeration. Manganese deficiency is most likely to occur in neutral or alkaline soils because it is less soluble at elevated pH levels. In extremely acid soils, where manganese is more soluble, toxic levels may exist which may reduce crop yields. In slightly acid sandy soils, manganese may leach past the root zone and not be able for utilization by the plant. Also, it is believed that manganese may form insoluble organic complexes in some soils that have high humus content. All of the factors contribute to the availability of this essential element. Only soil or tissue tests can determine whether deficient or toxic levels of manganese exist.

Although manganese is known to play an important role in many of the metabolic processes in the plant, little is known about its function other than it is required in some enzyme reactions and is required for the formation of chlorophyll in the plant.

RANGE: 0.00-75.00 ppm Manganese

METHOD: Periodate method

INTERFERENCES: Reducing substances capable of reacting with periodate or permanganate must be eliminated. Chlorine in small amounts can be oxidized by periodate.

PROCEDURE

1. Press and hold **ON** button until colorimeter turns on.
2. Press **ENTER** to start.
3. Press **ENTER** to select TESTING MENU.
4. Select ALL TESTS (or another sequence containing 56 Manganese H) from TESTING MENU.
5. Scroll to and select 56 Manganese H from menu.
6. Fill a clean tube (0290) to the 10 mL line with the soil extract then neutralize according to the procedure on page 50.
7. Insert tube into chamber, close lid and select SCAN BLANK.
8. Remove tube from colorimeter. Use the 0.1 g spoon (0699) to add two measures of Manganese Buffer Reagent (6310). Cap and mix until powder dissolves.
9. Use the 0.15 g spoon (0727) to add one measure of *Manganese Periodate Reagent (6311). Cap and shake for one minute. An undissolved portion of the reagent may remain in the bottom of the tube without adversely affecting the test results. Wait two minutes for maximum color development. Solution will turn pink if manganese is present.
10. At the end of the two minute waiting period, mix, insert tube into chamber, close lid and select SCAN SAMPLE. Multiply the result by 5 to determine the manganese concentration in ppm.
11. Press **OFF** button to turn colorimeter off or press **EXIT** button to exit to a previous menu or make another menu selection.

■ MANGANESE CONCENTRATION CHART

PARTS PER MILLION	RANGE
0-5 ppm	Low
5-12 ppm	Medium
13-24 ppm	Medium High
25-40 ppm	High
Over 40 ppm	Very High

NITRATE-NITROGEN

CADMIUM REDUCTION METHOD

CODE 3649-SC

QUANTITY	CONTENTS	CODE
2 x 60 mL	*Mixed Acid Reagent	*V-6278-H
5 g	*Nitrate Reducing Reagent	*V-6279-C
1	Spoon, 0.1g	0699
1	Dispenser cap	0692

***WARNING:** Reagents marked with a * are considered hazardous substances. Material Safety Data Sheets (MSDS) are supplied for these reagents. For your safety, read label and accompanying MSDS before using.

Nitrogen is a component of the chlorophyll (green color) in plants, thus giving plants the rich green color characteristic of a healthy plant. Nitrogen promotes succulence in forage crops and leafy vegetables. When used at the recommended rates, nitrogen improves the quality of leaf crops. It also simulates the utilization of phosphorus, potassium and other essential nutrient elements. The above-ground growth of plants is enhanced with nitrogen. Nitrogen hastens crop maturity (assuming all other nutrients are adequately supplied and excessive nitrogen rates are not applied). Nitrogen is very influential in fruit sizing.

RANGE: 0.00-300.00 lb/acre Nitrate-Nitrogen

METHOD: Powdered cadmium is used to reduce nitrate to nitrite. The nitrite that is originally present plus reduced nitrate is determined by diazotizing sulfanilamide and coupling with N-(1 naphthyl)-ethylenediamine dihydrochloride to form a highly colored azo dye which is measured colorimetrically.

INTERFERENCES: Strong oxidizing and reducing substances interfere. Low results might be obtained for samples that contain high concentrations of iron and copper.

PROCEDURE

NOTE: Place Dispenser Cap (0692) on *Mixed Acid Reagent (V-6278). Save this cap for refill reagents.

1. Press and hold **ON** button until colorimeter turns on.
2. Press **ENTER** to start.
3. Press **ENTER** to select TESTING MENU.
4. Select ALL TESTS (or another sequence containing 64 Nitrate-N LR) from TESTING MENU.
5. Scroll to and select 64 Nitrate-N LR from menu.
6. Use the 1 mL pipet (0354) to add 1 mL of soil extract to a clean tube (0290) and dilute to the line with deionized water. Cap tube and mix.
7. Insert tube into chamber, close lid and select SCAN BLANK.
8. Remove tube from colorimeter and pour off 5 mL into graduated cylinder or similar. Discard the remaining diluted extract.
9. Pour the 5 mL diluted extract from a graduated cylinder or similar into the tube. Use the graduated cylinder or similar to measure 5 mL of *Mixed Acid Reagent (V-6278) and add to tube. Cap and mix. Wait 2 minutes before proceeding to Step 10.
10. Use the 0.1 g spoon (0699) to add two measures of *Nitrate Reducing Reagent (V-6279). Cap.
11. Hold tube by index finger and thumb and mix by inverting approximately 60 times a minute for four minutes. Wait 10 minutes for maximum color development.

NOTE: At end of waiting period an undissolved portion of Nitrate Reducing Reagent may remain in bottom of the tube without affecting results.
12. At the end of the 10 minute waiting period, mix, insert tube into chamber, close lid and select SCAN SAMPLE. Multiply the result by 100 to determine the nitrate-nitrogen concentration in lb/acre.
13. Press **OFF** to turn colorimeter off or press **EXIT** to exit to a previous menu or make another selection.

NOTES:

- For best possible results, a reagent blank should be determined to account for any contribution to the test result by the reagent system. To determine the reagent blank, follow the above test procedure to scan a distilled or deionized water blank. Then follow the above procedure to perform the test on a distilled or deionized water sample. This test result is the reagent blank. Subtract the reagent blank from all subsequent test results of unknown samples. It is necessary to determine the reagent blank only when a new lot number of reagents are obtained.
- To convert Nitrate Nitrogen (NO₃-N) results to ppm Nitrate (NO₃), multiply by 4.4.

■ NITRATE-NITROGEN CONCENTRATION CHART

POUNDS PER ACRE	RANGE
0-9.0 lb/acre	Low
11-29 lb/acre	Medium
33-51 lb/acre	Medium High
53-100 lb/acre	High
Over 100 lb/acre	Very High

NITRITE-NITROGEN

DIAZOTIZATION METHOD

CODE 3650-SC

QUANTITY	CONTENTS	CODE
2 x 60 mL	*Mixed Acid Reagent	*V-6278-H
5 g	*Color Developing Reagent	*V-6281-C
1	Spoon, 0.1g	0699
1	Dispenser cap	0692

***WARNING:** Reagents marked with a * are considered hazardous substances. Material Safety Data Sheets (MSDS) are supplied for these reagents. For your safety, read label and accompanying MSDS before using.

Nitrites are formed as an intermediate step in the production of nitrate. Soils that are well drained and aerated contain only small amounts of nitrite nitrogen. Excessive nitrites, which are toxic to plants, may result from soil conditions unfavorable to the formation of nitrate, such as inadequate aeration. High nitrite readings may also be encountered in soils with large amounts of nitrates, where a portion of the nitrate nitrogen decomposes to form nitrites.

RANGE: 0.00-40.00 lb/acre Nitrate-Nitrogen

METHOD: The diazonium compound formed by diazotization of sulfanilamide by nitrite in water under acid conditions is coupled with N-(1-naphthyl)-ethylenediamine to produce a reddish-purple color which is read colorimetrically.

INTERFERENCES: There are few known interferences of substances at concentrations less than 1000 times that of nitrite; however, the presence of strong oxidants or reductants may readily affect the nitrite concentrations. High alkalinity (above 600 mg/L) will give low results due to a shift in pH.

PROCEDURE

NOTE: Place Dispenser Cap (0692) on *Mixed Acid Reagent (V-6278). Save this cap for refill reagents.

1. Press and hold **ON** button until colorimeter turns on.
2. Press **ENTER** to start.
3. Press **ENTER** to select TESTING MENU.
4. Select ALL TESTS (or another sequence containing 67 Nitrite-N LR) from TESTING MENU.
5. Scroll to and select 67 Nitrite-N LR from menu.
6. Use the 1 mL pipet (0354) to add 2 mL of soil extract to a clean tube (0290) and dilute to the line with deionized water. Cap tube and mix.
7. Insert tube into chamber, close lid and select SCAN BLANK.
8. Remove tube from colorimeter and pour off 5 mL into a graduated cylinder or similar. Discard the remaining diluted extract.
9. Pour the 5 mL diluted extract from the graduated cylinder or similar into the colorimeter tube. Use graduated cylinder or similar to measure 5 mL of *Mixed Acid Reagent (V-6278) and add to tube. Cap and mix.
10. Use the 0.1 g spoon (0699) to add two measures of *Color Developing Reagent (V-6281). Cap and mix by gently inverting for 1 minute. Wait 5 minutes for maximum color development.
11. At the end of the 5 minute waiting period, mix, insert tube into chamber, close lid and select SCAN SAMPLE. Multiply the result by 50 to determine the nitrite-nitrogen concentration in lb/acre.
12. Press **OFF** button to turn colorimeter off or press **EXIT** button to exit to a previous menu or make another menu selection.

NOTE: To convert nitrite-nitrogen ($\text{NO}_2\text{-N}$) results to ppm nitrite (NO_2), multiply results by 3.3.

■ NITRITE-NITROGEN CONCENTRATION CHART

POUNDS PER ACRE	RANGE
0.0-2.0 lb/acre	Low
2.5-4.0 lb/acre	Medium
4.5-10.0 lb/acre	High
Over 10 lb/acre	Very High

PHOSPHORUS

ASCORBIC ACID REDUCTION METHOD

CODE 3653-SC

QUANTITY	CONTENTS	CODE
60 mL	*Phosphate Acid Reagent	*V-6282-H
5 g	*Phosphate Reducing Reagent	*V-6283-C
1	Pipet, 1 mL, plastic	0354
1	Spoon, 0.1 g	0699

***WARNING:** Reagents marked with a * are considered hazardous substances. Material Safety Data Sheets (MSDS) are supplied for these reagents. For your safety read label and accompanying MSDS before using.

Phosphorus is necessary for the hardy growth of the plant and activity of the cells. It encourages root development, and by hastening the maturity of the plant, it increases the ratio of grain to straw, as well as the total yield. It plays an important part in increasing the palatability of plants and simulates the formation of fats, convertible starches and healthy seed. By stimulating rapid cell development in the plant, phosphorus naturally increases the resistance to disease. An excess of phosphorus does not cause the harmful effect of excessive nitrogen and has an important balancing effect upon the plant.

RANGE: 0.00-99.00 lb/acre Phosphorus

METHOD: Ammonium molybdate and antimony potassium tartrate react in a filtered acid medium with dilute solution of PO_4^{2-} to form an antimony-phosphomolybdate complex. This complex is reduced to an intense blue colored complex by ascorbic acid. The color is proportionate to the amount of phosphate present. (Only orthophosphate forms a blue color in this test.) Polyphosphates (and some organic phosphorus compounds) may be converted to the orthophosphate form by sulfuric acid digestion. Organic phosphorus compounds may be converted to the orthophosphate form by persulfate digestion.

INTERFERENCES: High iron concentrations can cause precipitation of and subsequent loss of phosphorus.

PROCEDURE

1. Press and hold **ON** button until colorimeter turns on.
2. Press **ENTER** to start.
3. Press **ENTER** to select TESTING MENU.
4. Select ALL TESTS (or another sequence containing 78 Phosphate L) from TESTING MENU.
5. Scroll to and select 78 Phosphate L from menu.
6. Use the 1 mL pipet (0354) to add 1 mL of the soil extract to a clean tube (0290) and dilute to the 10 mL line with deionized water.
7. Insert tube into chamber, close lid and select SCAN BLANK.
8. Remove tube from colorimeter. Use 1.0 mL pipet (0354) to add 1.0 mL of *Phosphate Acid Reagent (V-6282). Cap and mix.
9. Use the 0.1 g spoon (0699) to add one measure of *Phosphate Reducing Reagent (V-6283). Cap and shake until powder dissolves. Wait 5 minutes for full color development. Solution will turn blue if phosphorus is present.
10. At end of 5 minute waiting period, mix, insert tube into chamber, close lid and select SCAN SAMPLE. Multiply the result by 32 to determine the phosphorus concentration in lb/acre.
11. Press **OFF** button to turn colorimeter off or press **EXIT** button to exit to a previous menu or make another menu selection.

PHOSPHORUS IN ALKALINE SOILS

A special extraction procedure is used for determining the available phosphorus content of Western U.S. alkaline soils where the pH value is above 7.0.

EXTRACTION PROCEDURE

1. Use the 1 mL pipet (0354) to add 1 mL of the *Special NF Extracting Solution (6362) to the test tube (0701) then add deionized water to the graduation.
2. Add 3 one gram measures of soil using the 1 g spoon (0697) to the extracting solution in the vial.
3. Cap the vial and shake for a period of 5 minutes.
4. Filter using the funnel (0459) and filter paper (0463). Collect all of the filtrate.
5. Perform the Phosphorus test according to the Phosphorus procedure given above.

■ PHOSPHORUS CONCENTRATION CHART

POUNDS PER ACRE	RANGE
0-14 lb/acre	Very Low
16-34 lb/acre	Low
35-67 lb/acre	Medium
Over 70 lb/acre	High

POTASSIUM

TETRAPHENYLBORON METHOD

CODE M3639-46-65-SC

QUANTITY	CONTENTS	CODE
30 mL	*Sodium Hydroxide, 0.1N	*4004WT-G
5g	*Tetraphenylboron Powder	*6364-C
1	Spoon, 0.05g	0696

***WARNING:** Reagents marked with a * are considered hazardous substances. Material Safety Data Sheets (MSDS) are supplied for these reagents. For your safety, read label and accompanying MSDS before using.

Potassium is not a component of the structural makeup of plants, yet it plays a vital role in the physiological and biochemical functions of plants. The exact function of potassium in plants is not clearly understood, but many beneficial factors, implicating the involvement and necessity of potassium in plant nutrition have been demonstrated. Some of these factors are: it enhances disease resistance by strengthening stalks and stems; activates various enzyme systems within plants; contributes to a thicker cuticle (waxy layer) which guards against disease and water loss; controls the turgor pressure within plants to prevent wilting; enhances fruit size, flavor, texture and development and is involved in the production of amino acids (the building blocks for protein), chlorophyll formation (green-color), starch formation and sugar transport from leaves to roots.

When present in large amounts, ammonia salts will produce a precipitate similar to that produced by potassium. If fertilizer containing ammonia salts has recently been applied, or if the soil pH is below pH 5.0, perform the ammonia test before performing the potassium test. A high ammonia nitrogen test result will alert the operator to a probable false high reading in the potassium test; actual potassium tests will be somewhat lower.

RANGE: 0.0-500.0 lb/acre Potassium

METHOD: Potassium reacts with sodium tetraphenylboron to form a colloidal white precipitate in quantities proportional to the potassium concentration measured as turbidity.

INTERFERENCES: Calcium and Magnesium at very high concentrations.

PROCEDURE

1. Press and hold **ON** button until colorimeter turns on.
2. Press **ENTER** to start.
3. Press **ENTER** to select TESTING MENU.
4. Select ALL TESTS (or another sequence containing 81 Potassium) from TESTING MENU.
5. Scroll to and select 81 Potassium from menu.
6. Use the 1 mL pipet (0354) to add 2 ml of the soil extract to a clean tube (0290) and dilute to the 10 mL line with deionized water.
7. Insert tube into chamber, close lid and select SCAN BLANK.
8. Remove tube from colorimeter. Add 4 drops of *Sodium Hydroxide, 1.0N (4004WT). Cap and mix.
9. Use the 0.05 g spoon (0696) to add one measure of *Tetraphenylboron Powder (6364). Cap and shake vigorously until all of the powder has dissolved. Wait 5 minutes.
10. At end of 5 minute waiting period, mix tube again to suspend any settled precipitate. Insert tube into chamber, close lid and select SCAN SAMPLE. Multiply the result by 50 to determine the potassium concentration in lb/acre.
11. Press **OFF** button to turn colorimeter off or press **EXIT** button to exit to a previous menu or make another menu selection.

NOTES:

- For best possible results, a reagent blank should be determined to account for any contribution to the test result by the reagent system. To determine the reagent blank, follow the above test procedure to scan a distilled or deionized water blank. Then follow the above procedure to perform the test on a distilled or deionized water sample. This test result is the reagent blank. Subtract the reagent blank from all subsequent test results of unknown samples. It is necessary to determine the reagent blank only when a new lot number of reagents are obtained.
- For the most accurate results, the sample and reagents should be at $25 \pm 4^{\circ}\text{C}$.

■ POTASSIUM CONCENTRATION CHART

POUNDS PER ACRE	RANGE
0-44 lb/acre	Very Low
50-76 lb/acre	Low
82-143 lb/acre	Medium
144-281 lb/acre	High
Over 294 lb/acre	Very High

SULFUR

BARIUM CHLORIDE METHOD

CODE 3639-45-65-SC

QUANTITY	CONTENTS	CODE
10 g	*Sulfate Reagent	*V-6277-D
1	Spoon, 0.1 g	0699

***WARNING:** Reagents marked with a * are considered hazardous substances. Material Safety Data Sheets (MSDS) are supplied for these reagents. For your safety, read label and accompanying MSDS before using.

Sulfur is essential to the formation of protein and affects various aspects of plant metabolism. Sulfur-deficient plants are pale green in color with thin, reedy stems. Negatively charged sulfate ions are easily leached. The major sources of soil sulfate are fertilizer containing sulfate compounds and atmospheric sulfur dioxide carried into the soil by precipitation.

RANGE: 3-94 ppm Sulfur

METHOD: Sulfate ion is precipitated in an acid medium with barium chloride to form barium sulfate crystals in proportion to the amount of sulfate present.

INTERFERENCE: Suspended matter and color interference may be removed by a filtration step. Silica in excess of 500 mg/L will interfere.

PROCEDURE

1. Press and hold **ON** button until colorimeter turns on.
2. Press **ENTER** to start.
3. Press **ENTER** to select TESTING MENU.
4. Select ALL TESTS (or another sequence containing 89 Sulfate-HR) from TESTING MENU.
5. Scroll to and select 89 Sulfate-HR from menu.
6. Use the 1 mL pipet (0354) to add 1 mL of *Sulfate Extracting Solution (6363) to the test tube (0701) then add deionized water to the 15 mL line.
7. Add 3 one gram measures of soil using the 1 g spoon (0697). Cap vial and shake for five minutes.
8. Filter and collect all of the soil filtrate using the funnel (0459) and filter paper (0463). If the filtrate is not clear, filter a second time.
9. Fill a clean tube (0290) to the 10 mL line with the soil extract.
10. Insert tube into chamber, close lid and select SCAN BLANK..
11. Remove tube from colorimeter. Use the 0.1 g spoon (0699) to add one measure of *Sulfate Reagent (V-6277). Cap and shake until powder dissolves. A white precipitate will develop if sulfates are present. Wait 5 minutes.
12. Mix tube again. Insert tube into chamber, close lid and select SCAN SAMPLE. Multiply the result by 1.65 to determine the sulfur concentration in ppm.
13. Press **OFF** button to turn colorimeter off or press **EXIT** button to exit to a previous menu or make another menu selection.

NOTES:

- If the sulfate concentration of the test sample is greater than 100 ppm, it is recommended that a dilution be made with deionized water and the results multiplied by the dilution factor.
- A white film is deposited on the inside of test tubes as a result of the sulfate test. Thoroughly clean and rinse test tubes after each test.
- For the most accurate results, samples and reactions should be at $25 \pm 4^{\circ}\text{C}$.

■ SULFUR CONCENTRATION CHART

PARTS PER MILLION	RANGE
0-16 ppm	Low
17-30 ppm	Medium Low
31-50 ppm	Medium
52-75 ppm	High

ZINC

ZINCON METHOD

CODE 3667-SC

QUANTITY	CONTENTS	CODE
30 mL	*Zinc Indicator Solution	*6314-G
120 mL	*Methyl Alcohol	*6319-J
10 g	Sodium Ascorbate	6316-D
25 g	*Zinc Buffer Powder	*6315-G
15 mL	*Sodium Cyanide, 10%	*6565-E
30 mL	*Formaldehyde Solution, 37%	*5128-G
1	"Diluted Zinc Indicator Solution" Bottle, w/1 mL pipet assembly	0128-MT
1	Graduated Cylinder, 10 mL, glass	0416
1	Spoon, 0.5 g	0698
2	Pipets, plain, plastic	0352
1	Spoon, 0.1 g	0699

***WARNING:** Reagents marked with a * are considered hazardous substances. Material Safety Data Sheets (MSDS) are supplied for these reagents. For your safety read label and accompanying MSDS before using.

The availability of zinc in soils decreases with an increase in soil pH. Some soils that are limited above pH 6.0 may show a zinc deficiency especially in well drained sandy soils. A nutrient interaction exists between soils that have a high phosphorous level and show a zinc deficiency even though zinc levels were sufficient. This interaction is due to the preferential uptake of phosphorus instead of zinc and the possible formation of insoluble zinc phosphates. Once zinc is applied to the soil, it is relatively immobile because it is readily absorbed by organic matter in the soil.

Zinc is essential in promoting certain enzyme reactions in the soil and is required for the production of chlorophyll and the formation of carbohydrates in plants.

APPLICATION: Drinking and surface waters, domestic and industrial waste water.

RANGE: 0.00 - 15.00 ppm Zinc

METHOD: Zinc forms a blue colored complex with Zincon in a solution buffered at pH 9.0. Other heavy metals are complexed by cyanide and the zinc cyanide complex is released by the addition of formaldehyde before the other metal cyanide complexes are destroyed. Sodium ascorbate is added to reduce the interference of manganese.

**SAMPLE
HANDLING &
PRESERVATION:**

Sample should be analyzed within 6 hours after collection. The addition of HCl will help preserve the metal ion content, however the acid should be neutralized before analysis.

INTERFERENCES:

The following ions interfere in concentrations greater than those listed.

ION	mg/L	ION	mg/L
Cd(II)	1	Cr(III)	10
Al (III)	5	Ni(II)	20
Mn (II)	5	Cn (II)	30
Fe (III)	7	Co (II)	30
Fe (II)	9	CrO4(II)	50

PROCEDURE

A. PREPARATION OF DILUTE ZINC INDICATOR SOLUTION

1. Use a pipet (0352) to measure exactly 5.0 mL of *Zinc Indicator Solution (6314) into 10 mL graduated cylinder (0416). The bottom of the curved surface (the meniscus) of liquid should be at 5.0 mL mark. Pour this into the bottle labeled "Dilute Zinc Indicator Solution".
2. Use unrinsed graduated cylinder to add 10.0 mL and then 7.8 mL (total of 17.8 mL) of *Methyl Alcohol (6319) to bottle labeled "Dilute Zinc Indicator Solution". Cap and mix ingredients in this bottle. Do not leave this bottle uncapped.

B. DETERMINATION OF ZINC

1. Press and hold **ON** button until colorimeter turns on.
2. Press **ENTER** to start.
3. Press **ENTER** to select TESTING MENU.
4. Select ALL TESTS (or another sequence containing 99 Zinc-LR) from TESTING MENU.
5. Scroll to and select 99 Zinc-LR from menu.
6. Fill a clean tube (0290) to the 10 mL line with the soil extract then neutralize according to the procedure on page 40.
7. Insert tube into chamber, close lid and select SCAN BLANK. (See Note)
8. Remove tube from colorimeter. Use 0.1 g spoon (0699) to add one measure of Sodium Ascorbate Powder (6316). Use 0.5 g spoon (0698) to add one measure of *Zinc Buffer Powder (6315). Cap and shake vigorously for 1 minute. Some undissolved buffer may remain in the bottom of the tube.
9. Add 3 drops of *Sodium Cyanide, 10% (6565). Cap and mix.
10. Use the 1 mL pipet assembly to add 1 mL of "Dilute Zinc Indicator Solution". Cap and mix.
11. Use a second plain pipet (0352) to add 4 drops of *Formaldehyde Solution, 37% (5128). Cap and mix by inverting 15 times.
12. Insert tube into chamber, close lid and select SCAN SAMPLE. Multiply result by 5 to determine the zinc concentration in ppm.
13. Press **OFF** button to turn colorimeter off or press **EXIT** button to exit to a previous menu or make another menu selection.

NOTE: For best possible results, a reagent blank should be determined to account for any contribution to the test result by the reagent system. To determine the reagent blank, follow the above test procedure to scan a distilled or deionized water blank. Then follow the above procedure to perform the test on a distilled or deionized water sample. This test result is the reagent blank. Subtract the reagent blank from all subsequent test results of unknown samples. It is necessary to determine the reagent blank only when a new lot number of reagents are obtained.

■ ZINC CONCENTRATION CHART

PARTS PER MILLION	RANGE
0-0.5 ppm	Low
0.6-1.0 ppm	Marginal
1.1-2 ppm	Adequate