SMART3 Soil
Colorimeter

Operator's Manual

Firmware Version 2.10

1985-05-MN-V3

10/19

Warning! This set contains chemicals that may be harmful if misused. Read cautions on individual containers carefully. Not to be used by children except under adult supervision.

LaMotte®

1985-05-MN-V3.indd

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SMART3 COLORIMETER SOIL TEST PROCEDURES

APPENDIX

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GENERAL INFORMATION

■ PACKAGING & DELIVERY

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

Should it be necessary to return the instrument for repair or servicing, pack instrument carefully in a suitable container with adequate packing material. A return authorization number must be obtained from LaMotte Company by calling 1-800-344-3100 or emailing tech@lamotte.com. 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 Smart3 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 potentially hazardous substances and are designated with a * in the instruction manual. Safety Data Sheets (SDS) can be found at www.lamotte.com. Read the SDS before using these reagents. Additional emergency information for all LaMotte reagents is available 24 hours a day from the National Poison Control Center 1-800-222-1222 or by contacting the 24 hour emergency line for ChemTel 1-800-255-3924 (USA, Canada, Puerto Rico); locations outside the North American Continent 813-248-0585 (call collect). Be prepared to supply the name and four-digit LaMotte code number found on the container label or at the top of the SDS or in the contents list of the procedure. 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.

Ensure that the protection provided by this equipment is not impaired. Do not intall or use this equipment in a manner that is not indicated in this manual.

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■ 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.

■ WARRANTY

LaMotte Company warrants this instrument to be free of defects in parts and workmanship for 2 years from the date of shipment. If it should become necessary to return the instrument for service during or beyond the warranty period, contact our Technical Service Department at 1-800-344-3100 or tech@lamotte.com for a return authorization number or visit www.lamotte.com for troubleshooting help. The sender is responsible for shipping charges, freight, insurance and proper packaging to prevent damage in transit. This warranty does not apply to defects resulting from action of the user such as misuse, improper wiring, operation outside of specification, improper maintenance or repair, or unauthorized modification. LaMotte Company specifically disclaims any implied warranties or merchantability or fitness for a specific purpose and will not be liable for any direct, indirect, incidental or consequential damages. LaMotte Company's total liability is limited to repair or replacement of the product. The warranty set forth above is inclusive and no other warranty, whether written or oral, is expressed or implied.

■ REGISTER YOUR METER

To register your meter with the LaMotte Service Department, go to www.lamotte.com and choose SUPPORT on the top navigation bar.

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■ SPECIFICATIONS

INSTRUMENT TYPE: Colorimeter	
Readout	160 x 100 backlit LCD, 20 x 6 line graphical display
Wavelengths	428 nm, 525 nm, 568 nm, 635 nm
Wavelength Accuracy	±2% FS
Readable Resolution	Determined by reagent system
Wavelength Bandwidth	10 nm typical
Photometric Range	–2 to +2 AU
Photometric Precision	± 0.001 AU at 1.0 AU
Photometric Accuracy	±0.005 AU at 1.0 AU
Sample Chamber	Accepts 25 mm diameter flat-bottomed test tubes, 10 mm square cuvettes†, 16 mm COD test tubes
Light Sources	4 LEDs
Detectors	4 silicon photodiodes
Modes	Pre-programmed tests, absorbance, %T
Pre-Programmed Tests	YES, with automatic wavelength selection
User Defined Tests	Up to 25 user tests can be input
Languages	English, Spanish, French, Portuguese, Italian, Chinese, Japanese
Temperature	Operation: 0-50 °C; Storage: -40-60 °C
Operation Humidity Range	0-90 % RH, non-condensing
USB Port	Mini B
Power Requirements	USB wall adapter, USB computer connection or lithium ion rechargeable battery
Battery	Charge Life: Approximately 380 tests with backlight on to 1000 tests with backlight off. (Signal averaging disabled). Battery Life: Approximately 500 charges.
Electrical Rating	Rated voltage (5V), Rated power of input current (1.0A) at mini-USB input port
Data Logger	500 test results stored for download to a PC
Waterproof	IP67 with USB port plug in place

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Certifications	BT Radio	FCC ID:	T9J-RN42
		Cert#	6514A-RN42
		BQB LISTED	B014867-SPP and DUN profiles
	CE Mark	Safety	EN61610-1:2010 +Corrigendum 1:2011
		EMC	EN 301 489-17 and EN 301 489
	US	EMC	FCC CFR 47, Part 15, subpart B
	Canada	EMC	CAN ICES-3(A)/NMB-3(A)
	AU/NZ	EMC	AS/NZS CISPR 22
Dimensions (LxWxH)	3.5 x 7.5 x 2.5 inches, 8.84 x 19.05 x 6.35 cm		
Weight	13 oz, 362 g (meter only)		

†525 nm and 568 nm only

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■ STATISTICAL & TECHNICAL DEFINITIONS RELATED TO PRODUCT SPECIFICATIONS

Method Detection Limit (MDL): "The method detection limit (MDL) is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte."[1] Note that, "As Dr. William Horwitz once stated, 'In almost all cases when dealing with a limit of detection or limit of determination, the primary purpose of determining that limit is to stay away from it.'"[2]

Accuracy: Accuracy is the nearness of a measurement to the accepted or true value.[3] The accuracy can be expressed as a range, about the true value, in which a measurement occurs (i.e. ±0.5 ppm). It can also be expressed as the % recovery of a known amount of analyte in a determination of the analyte (i.e. 103.5 %).

Resolution: Resolution is the smallest discernible difference between any two measurements that can be made.[4] For meters this is usually how many decimal places are displayed. (i.e. 0.01). Note that the resolution many change with concentration or range. In some cases the resolution may be less than the smallest interval, if it is possible to make a reading that falls between calibration marks. A word of caution, that resolution has very little relationship to accuracy or precision. The resolution will always be less than the accuracy or precision but it is not a statistical measure of how well a method of analysis works. The resolution can be very, very good and the accuracy and precision can be very bad! This is not a useful measure of the performance of a test method.

Repeatability: Repeatability is the within-run precision.[5] A run is a single data set, from set up to clean up. Generally, one run occurs on one day. However, for meter calibrations, a single calibration is considered a single run or data set, even though it may take 2 or 3 days.

Reproducibility: Reproducibility is the between-run precision.[6]

Detection Limit (DL): The detection limit (DL) for the 2020we/wi is defined as the minimum value or concentration that can be determined by the meter, which is greater than zero, independent of matrix, glassware, and other sample handling sources of error. It is the detection limit for the optical system of the meter.

[1] CFR 40, part 136, appendix B

[2] Statistics in Analytical Chemistry: Part 7 – A Review, D. Coleman and L Vanatta, American Laboratory, Sept 2003, P. 31.

[3] Skoog, D.A., West, D. M., Fundamental of Analytical Chemistry, 2nd ed., Holt Rinehart and Winston, Inc, 1969, p. 26.

[4] Statistics in Analytical Chemistry: Part 7 – A Review, D. Coleman and L Vanatta, American Laboratory, Sept 2003, P. 34.

[5] Jeffery G. H., Basset J., Mendham J., Denney R. C., Vogel's Textbook of Quantitative Chemical Analysis, 5th ed., Longman Scientific & Technical, 1989, p. 130.

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[6] Jeffery G. H., Basset J., Mendham J., Denney R. C., Vogel's Textbook of Quantitative Chemical Analysis, 5th ed., Longman Scientific & Technical, 1989, p. 130

■ CONTENTS AND ACCESSORIES

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Smart3 Colorimeter	
Test Tubes, with Caps	Code 0290
COD/UDV Adapter	Code 1724
USB Wall Adapter	Code 1721
USB Cable	Code 1720-01
Smart3 Colorimeter Quick Start Guide	
Smart3 Colorimeter Manual	

Accessories

Test Tubes, with Caps	Code 0290-6
Replacement Chamber	Code 3-0038
USB Cable	Code 1720-01
USB Wall Adapter	Code 1721
COD/UDV Adapter	Code 1724
Bluetooth Mobile Printer	Code 3-0066
Car Charger	Code 5-0132
Small Field Carrying Case (37.5 27.5 x 13.75 cm)	Code 1910-GCS150
Large Field Carrying Case (45 x 32.5 x 20 cm)	Code 1910-GCS440

WARNING: Only use the USB Cable (1720-01) that is supplied with the kit. Make no substitutions.

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■ EPA COMPLIANCE

The Smart3 Colorimeter is an EPA-Accepted instrument. EPA-Accepted means that the instrument meets the requirements for instrumentation as found in test procedures that are approved for the National Primary Drinking Water Regulations (NPDWR) or National Pollutant Discharge Elimination System (NPDES) compliance monitoring programs. EPA-Accepted instruments may be used with approved test procedures without additional approval.

■ CE COMPLIANCE

The Smart3 Colorimeter has earned the European CE Mark of Compliance for electromagnetic compatibility and safety. The Declaration of Conformity for the Smart3 colorimeter is available at www.lamotte.com.

This device complies with Part 15 of the FCC rules. Operation is subject to the following two conditions (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interferences in which case the user will be required to correct the interference at his own expense.

■ IP67 CERTIFICATION

The Smart3 meets IP67 standards for protection against dust and immersion only when the USB port plug is in place. Documentation is available at www.lamotte.com.

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■ AN INTRODUCTION TO COLORIMETRIC ANALYSIS

Most test substances in water are colorless and undetectable to the human eye. To test for their presence we must find a way to "see" them. The Smart3 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 Smart3 Colorimeter passes one of four colored light beams through one of four optical filters which transmits only one particular color or band of wavelengths of light to the photodectector where it is measured. The difference in the amount of colored light transmitted by a colored sample is a measurement of the amount of colored light absorbed by the sample. In most colorimetric tests the amount of colored light absorbed is directly proportional to the concentration of the test factor producing the color and the path length through the sample. However, for some tests the amount of colored light absorbed is inversely proportional to the concentration.

The choice of the correct wavelength for testing is important. It is interesting to note that the wavelength that gives the most sensitivity (lower detection limit) for a test factor is the complementary color of the test sample. For example the Nitrate-Nitrogen test produces a pink color proportional to the nitrate-nitrogen concentration in the sample (the greater the nitrate-nitrogen 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.

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■ 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 demineralized or deionized water. Use sample water to **Scan Blank**. Insert the reacted 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 AND CHAMBER

The colorimeter uses one type of tube (Code 0290) for all test factors.

The handling of the tubes is of utmost importance. Tubes must be clean and free from lint, fingerprints, dried spills and significant scratches, especially the central zone between the bottom and the sample line.

Scratches, fingerprints and water droplets on the tube can cause stray light interference leading to inaccurate results. Tubes that have been scratched in the light zone through excessive use should be discarded and replaced with new ones.

Tubes should always be washed on the inside and outside with mild detergent prior to use to remove dirt or fingerprints. The tubes should be allowed to air-dry in an inverted position to prevent dust from entering the tubes. Dry tubes should be stored with the caps on to prevent contamination.

After a tube has been filled and capped, it should be held by the cap and the outside surface should be wiped with a clean, lint-free absorbent cloth until it is dry and smudge-free. Handling the tube only by the cap will avoid problems from fingerprints. Always set the clean tube aside on a clean surface that will not contaminate the tube. It is imperative that the tubes and light chamber be clean and dry. The outside of the tubes should be dried with a clean, lint-free cloth or disposable wipe before they are placed in the meter chamber.

Tubes should be emptied and cleaned as soon as possible after reading a sample to prevent deposition of particulates on the inside of the tubes.

Variability in the geometry of the glassware and technique is the predominate cause of variability in results. Slight variations in wall thickness and the diameter of the tubes may lead to slight variations in the test results. To eliminate this error the tubes should be placed in the chamber with the same orientation each time.

Chambers which have been scratched through excessive use should be discarded and replaced with a new one.

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METER CARE

The optical system of the Smart3 must be kept clean and dry for optimal performance. Dry the colorimeter tubes before placing them in the chamber to avoid introducing moisture. For best results store the instrument in a area that is dry and free from aggressive chemical vapors.

CALIBRATION

As with all pre-calibrated meters, it is highly recommended, even if not required by regulations, that the user periodically verify the performance of the meter by running standards with a predetermined concentration. Results outside of specification are an indication that the meter needs to be adjusted. This can be done following the user calibration described on page 29. If the user calibration fails to properly adjust the meter then the meter should be returned to LaMotte Company for recalibration. (See page 74).

SAMPLE DILUTION TECHNIQUES & VOLUMETRIC MEASUREMENTS

If a test result using the Smart3 Colorimeter gives an over range message then the the sample must be diluted. 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 volumetric 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

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the test, is obtained. Be sure to multiply the concentration found by the dilution factor (the number of total 10 mL volumes used).

Example:

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

■ INTERFERENCES

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

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

Interferences due to high concentration of the substance being tested, can be overcome by sample dilution (see page 14)

■ STRAY LIGHT INTERFERENCE

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

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OPERATION OF THE SMART3 COLORIMETER

■ OVERVIEW

The Smart3 is a portable, microprocessor controlled, direct reading colorimeter. It has a graphical liquid crystal display and 6 button keypad. These allow the user to select options from the menu driven software, to directly read test results or to review stored results of previous tests in the data logger. The menus can be displayed in seven different languages.

The test library consists of over 80 LaMotte tests and 25 "User Tests". The LaMotte tests are precalibrated for LaMotte reagent systems.The colorimeter displays the result of these tests directly in units of concentration. The 25 "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 photoiode with an integrated interference filter. The interference filters select a narrow band of light from the corresponding LED for the colorimetric measurements. The microporcessor automatically selects the correct LED/photodiode combination for the test.

A USB wall adapter, USB computer connection or lithium battery powers the Smart3.

Bluetooth wireless technology allows communication between the colorimeter and the Bluetooth Mobile Printer (Code 3-0066 only).

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■ COMPONENTS

Figure 1 shows a diagram of the Smart3 Colorimeter and its components.

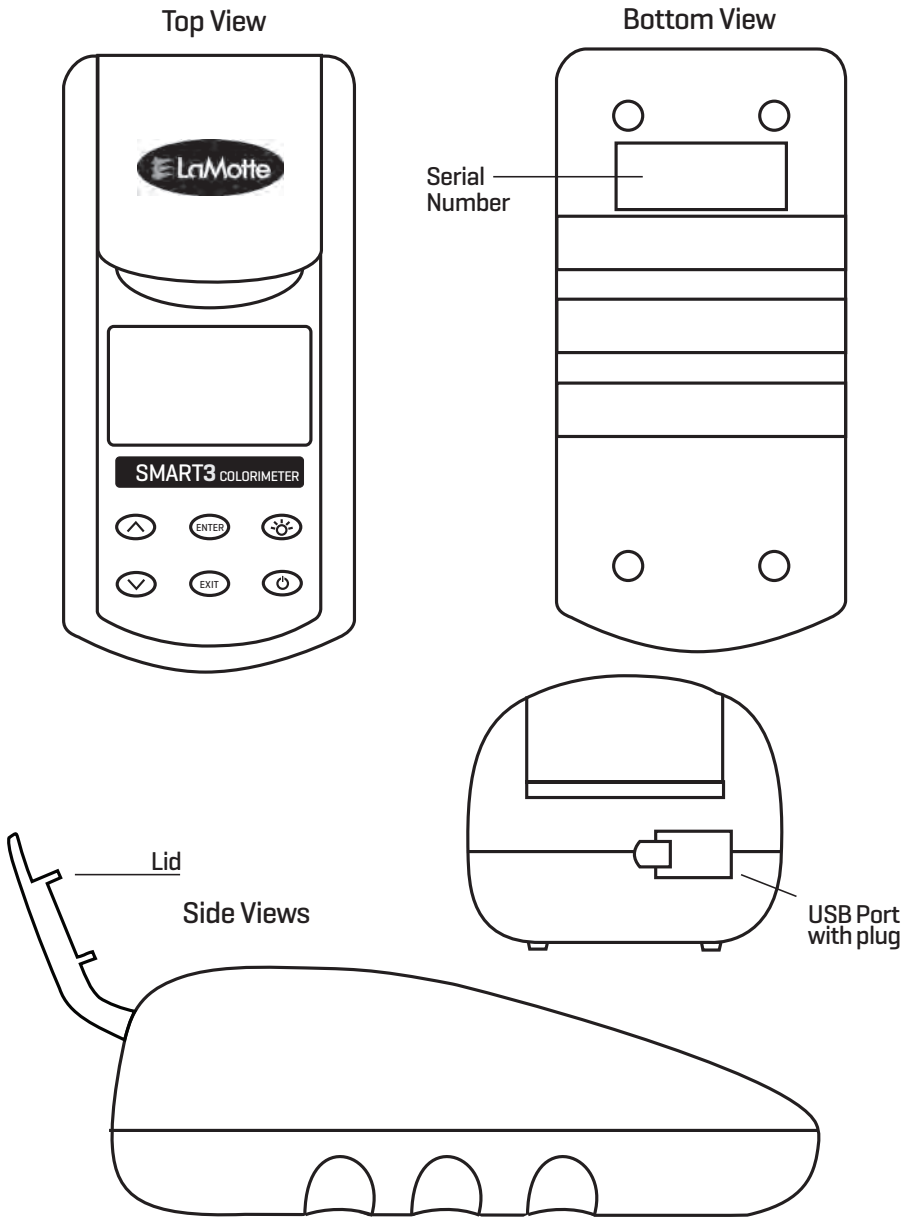

Figure 1

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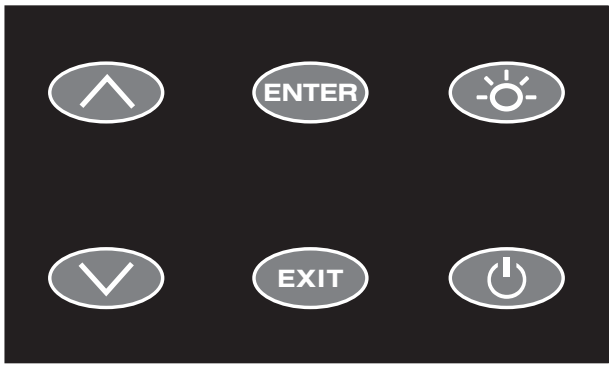
GENERAL OPERATING PROCEDURES

The operation of the Smart3 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 two selections accessible from the Main Menu: Testing Menu and Editing Menu.

■ THE KEYPAD

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

^	This button will scroll up through a list of menu selections or go to the next character on a character selection line.
ENTER	The button is used to select choices in a menu viewed in the display and to add the selected character to the name and advance one character.
☼	This button controls the backlight on the display.
v	This button will scroll down through a list of menu selections or go to the previous character selection line.
EXIT	This button exits to the previous menu on the name edit screen, the name will not be saved.
⏻	This button turns the meter on or off.



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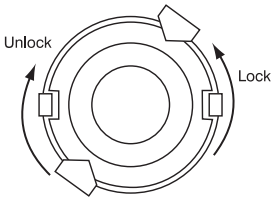
■ SAMPLE HOLDERS

The sample chamber is designed for 25 mm round tubes. An adapter to hold 16 mm COD tubes and 10 mm square UDV cuvettes is included. 10 cm cuvettes can be scanned only at 525 nm and 568 nm. The light path is blocked at 428 nm and 635 nm with the use of the adapter. COD tubes can be scanned at all wavelengths.

Position the COD/UDV Adapter (Code 1724) so that the notches in the adapter fit around the posts on the chamber. Turn the adapter counterclockwise until the arrows are at the top and bottom of the chamber and the adapter is locked into place. Turn the adapter clockwise to unlock the adapter and remove it from the chamber.

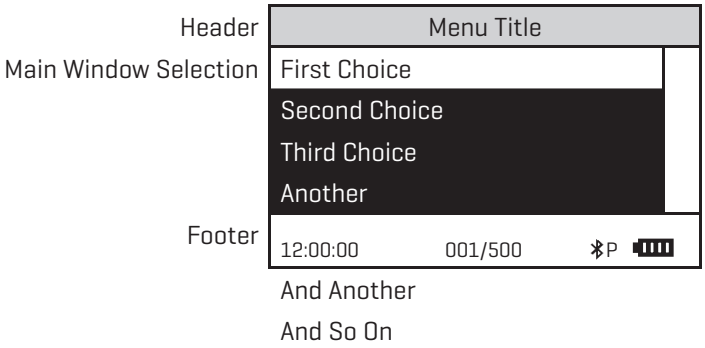


■ THE DISPLAY & THE MENUS

The display allows menu selections to be viewed and selected. These selections instruct the SMART3 to perform specific tasks. The menus are viewed in the display using two general formats that are followed from one menu to the next. Each menu is a list of choices or selections.

The display has a header line at the top and a footer line at the bottom. The header displays the title of the current menu. The footer line displays the time and the date, the data logger status, the bluetooth/printer status and the battery status. The menu selection window is in the middle of the display between the header and the footer.

The menu selection window displays information in two general formats. In the first format only menu selections are displayed. Up to 4 lines of menu selections may be displayed. If more selections are available they can be viewed by pressing the arrow buttons ⌃ ⌄ to scroll the other menu selections into the menu selection window. Think of the menu selections as a vertical list in the display that moves up or down each time an arrow button ⌃ ⌄ is pressed. Some menus in the Smart3 are looping menus. The top and bottom menu choices are connected in a loop. Scrolling down past the bottom of the menu will lead to the top of the menu. Scrolling up past the top of the menu will lead to the bottom of the menu.



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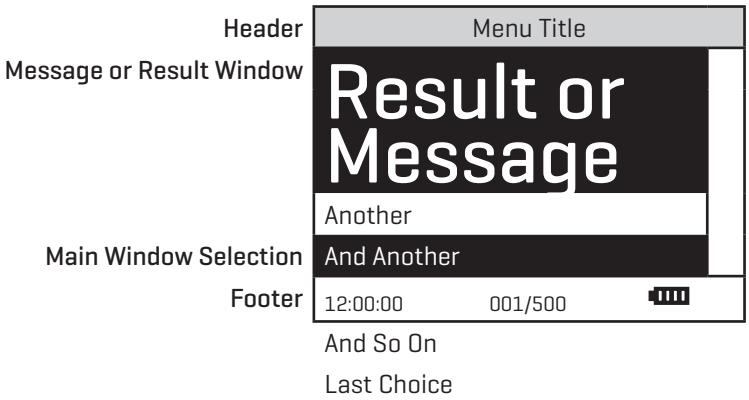
A light bar will indicate the menu choice. As the menu is scrolled through, the light bar will highlight different menu choices. Pressing the ENTER button will select the menu choice that is indicated by the light bar.

In the second format the menu choice window takes advantage of the graphical capabilities of the display. Large format graphic information, such as test results or error messages or the LaMotte logo is displayed. The top two lines of the display are used to display information in a large, easy to read format. The menus work in the same way as previously described but two lines of the menu are 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 ⏻ at any time will turn the Smart3 off.

The display may show the following messages:

	Battery Status
↑ ↓	More choices are available and can be viewed by scrolling up and/or down through the display.
Header	Identifies the current menu and information on units and reagent systems if applicable.
Footer	In the data logging mode the number of the data point is displayed and the total number of data points in the memory will be shown. The footer also shows current time and battery status

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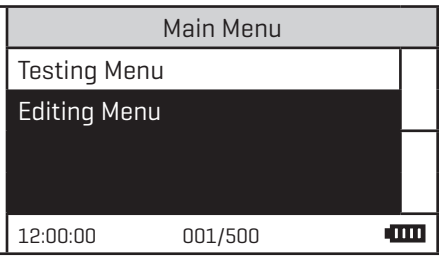
TESTING

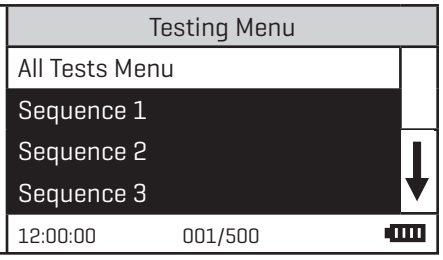
■ TESTING MENU

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

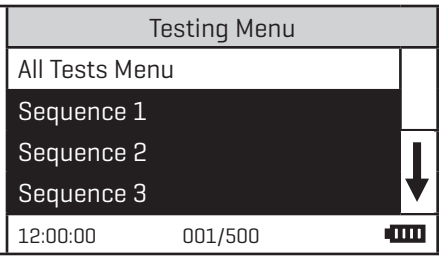
1. Press and briefly hold ⏻ to turn the meter on. The LaMotte logo screen will appear for about 3 seconds and the **Main Menu** will appear.



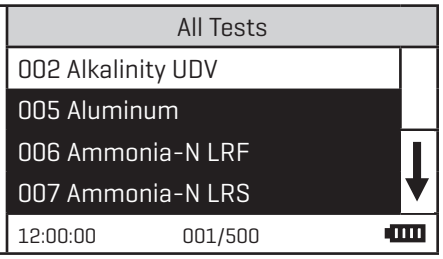
2. Press ENTER to select **Testing Menu**.



3. Press ^ or v to scroll to desired option. **All Tests** contains all of the available pre-programmed tests. The three sequences have user selected tests. Absorbance has %T/ABS tests.



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



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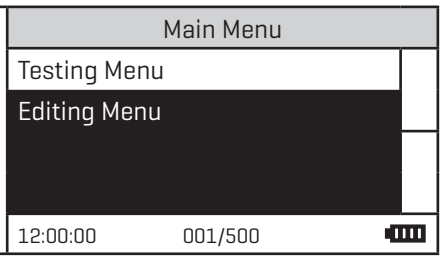
■ GENERAL TESTING PROCEDURES

The following is a step-by-step example of how to run tests from the Testing Menu. These test procedures are designed to be used with LaMotte SMART Reagent Systems.

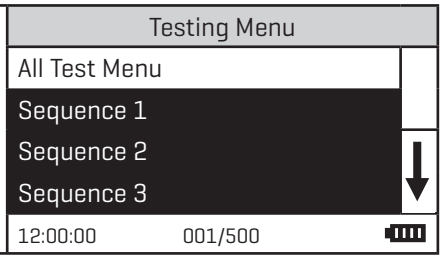
LaMotte Company continuously updates the list of pre-programmed tests as the calibrations become available. Call LaMotte Technical Services at 1-800-344-3100 (410-778-3100 outside the USA) or email at tech@lamotte.com for a current list of available calibrations.

■ TESTING WITH LaMOTTE PRE-PROGRAMMED TESTS

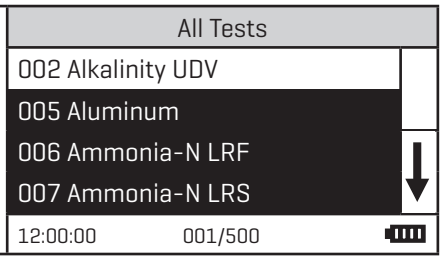
1. Press and briefly hold ⏻ to turn the meter on. The LaMotte logo screen will appear for about 3 seconds and the **Main Menu** will appear.



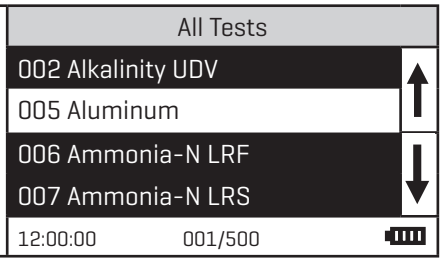
2. Press ENTER to select **Testing Menu**.



3. Press ENTER to select **All Tests Menu**.



4. Press ∧ or ∨ to scroll to the desired test.



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5. Press ENTER to select the test.	005 Aluminum Scan Bank Scan Sample 12:00:00 001/500
6. Insert the blank into the chamber. Close the lid.Press ENTER to scan the blank. The screen wil display **Scan Blank Blank Done** for about 1 second and then return to the test menu.	005 Aluminum Scan Blank Scan Sample 12:00:00 001/500
7. Insert the reacted sample into the chamber. Close the lid. Press ENTER to scan the sample. The screen will display **Scan Sample Sample Done** for about 1 second. The result will appear on the screen.	005 Aluminum 1.00 ppm Scan Blank Scan Sample 12:00:00 001/500
8. To repeat the test, press ENTER to scan the sample again. The last blank scanned is used by the colorimeter for repeated scans. A different blank can be used by pressing ^ or v to scroll to Scan Blank and then scanning another blank. Scroll with ^ or v and make another selection with ENTER. The %T or Absorbance of the last test can be viewed by scrolling down and choosing %T/Abs. Press EXIT to escape to previous menus. NOTE: The menus loop in this screen so either ^ or v will lead to the menu selection needed.	005 Aluminum 1.00 ppm Scan Bank Scan Sample 12:00:00 001/500 To Use the Print Test Function, See the Bluetooth Menu Selection, (page 63).

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■ 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 SMART3 Soil colorimeter, the standard should be used instead of the soil extract and 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

In the example below, the Aluminum calibration will be standardized.

Prepare a standard solution to be tested. In this example, 0.30 ppm aluminum.

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1. Press and briefly hold ⏻ to turn the meter on. The LaMotte logo screen will appear for about 3 seconds and the **Main Menu** will appear.	Main Menu Testing Menu Editing Menu 12:00:00 001/500
2. Press ENTER to select **Testing Menu**.	Testing Menu All Test Menu Sequence 1 Sequence 2 Sequence 3 12:00:00 001/500
3. Press ENTER to select **All Tests Menu**.	All Tests 002 Alkalinity UDV 005 Aluminum 006 Ammonia-N LRF 007 Ammonia-N LRS 12:00:00 001/500
4. Press ^ or v to scroll to the desired test factor.	All Tests 002 Alkalinity UDV 005 Aluminum 006 Ammonia-N LRF 007 Ammonia-N LRS 12:00:00 001/500
5. Press ENTER to select the test.	005 Aluminum Scan Blank Scan Sample 12:00:00 001/500

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6. Follow the test procedure in the manual to test the prepared standard. Insert the blank into the chamber. Close the lid. Press ENTER to scan the blank. The screen will display **Scan Blank Blank Done** for about 1 second and then return to the **Test Menu**.	005 Aluminum Scan Blank Scan Sample 12:00:00 001/500
7. Insert the reacted standard solution into the chamber. Close the lid. Press ENTER to scan the sample. The screen will display **Scan Sample Sample Done** for about 1 second. The result will appear on the screen.	005 Aluminum 0.28 ppm Scan Blank Scan Sample 12:00:00 001/500
8. The displayed result can now be standardized. Press ∧ or ∨ to scroll to **Calibrate**.	005 Aluminum 0.28 ppm %T/Abs Calibrate 12:00:00 001/500
9. Press ENTER to select **Calibrate**. A reverse font (light background with dark characters) will appear to indicate that the reading can be adjusted.	005 Aluminum 0.28 ppm ∧, ∨=Edit, ENTER=Save ∧ +ENTER=Default 12:00:00 001/500

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10. Press ∧ or ∨ to adjust the value shown to the concentration of the prepared standard, 0.30 in this example. NOTE: A maximum adjustment of 25% is possible.	005 Aluminum 0.30 ppm ∧, ∨=Edit, ENTER=Save ∧ +ENTER=Default 12:00:00 001/500

11. Press ENTER to save the value. To leave the Calibration procedure without saving the adjustment, press EXIT. Press ∧ and ENTER at any time to return to the default value. The calibration has now been standardized and can be used for testing. Scroll to **Scan Blank** and begin testing.	005 Aluminum 0.30 ppm %T/Abs Calibrate 12:00:00 001/500

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■ MEASURING IN THE ABSORBANCE MODE

1. Press and briefly hold ⏻ to turn the meter on. The LaMotte logo screen will appear for about 3 seconds and the **Main Menu** will appear.	Main Menu Testing Menu Editing Menu 12:00:00 001/500
2. Press ENTER to select **Testing Menu**.	Testing Menu All Test Menu Sequence 1 Sequence 2 Sequence 3 12:00:00 001/500
3. Press ∧ or ∨ to scroll to **Absorbance**.	Testing Menu Sequence 1 Sequence 2 Sequence 3 Absorbance 12:00:00 001/500
4. Press ENTER to select **Absorbance**.	Absorbance 101 Absorbance 428 102 Absorbance 525 103 Absorbance 568 104 Absorbance 635 12:00:00 001/500
5. Press ∧ or ∨ to scroll to desired wavelength.	Absorbance 101 Absorbance 428 102 Absorbance 525 103 Absorbance 568 104 Absorbance 635 12:00:00 001/500

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6. Press ENTER to select the wavelength.	102 Absorbance 525 Scan Blank Scan Sample 12:00:00 001/500
7. Insert the blank. Close the lid. Press ENTER to scan the blank. The screen wil display **Scan Blank Blank Done** for about 1 second and return to the Absorbance menu.	102 Absorbance 525 Scan Blank Scan Sample 12:00:00 001/500
8. Insert the reacted sample. Press ENTER to scan the sample. The screen will display **Scan Sample Sample Done** for about 1 second. The result will appear on the screen.	102 Absorbance 525 0.425 Scan Sample Next Test 12:00:00 001/500

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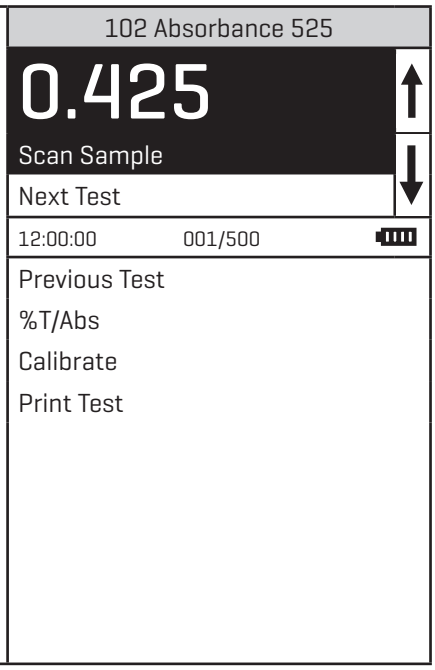
9. To repeat the test, scroll to **Scan Sample** and press ENTER to scan the sample again. The last blank scanned is used by the colorimeter for repeated scans. A different blank can be used by pressing ^ or v to scroll to **Scan Blank** and then scanning another blank. Scroll with ^ or v and make another selection with ENTER. The %T or Absorbance of the last test can be viewed by choosing %T/Abs. Press EXIT to escape to previous menus.
NOTE: The menus loop in this screen so either ^ or v will lead to the menu selection needed.
NOTE: The calibrate function does not work in the Absorbance mode.



EDITING MENU

The Editing Menu allows the user to edit sequences, edit user tests, set the clock, edit the logging function, access factory setting, set the power saving function, set the backlight time, and select a language.

The default factory settings are:

Date Format	MM-DD-YYYY
Logging	Enabled
Power Save	5 minutes
Backlight	10 seconds
Language	English

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■ TEST SEQUENCES

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. There are three intial sequences in the Smart3 that can be customized by adding or deleting tests:

Sequence 1	Sequence 2	Sequence 3
025 Chlorine T DPD	005 Aluminum	006 Ammonia-N LF
080 Phosphate HR	025 Chlorine T DPD	036 Cu Thiocarbamate
010 Benzotriazole	056 Iron Phenanthro	065 Nitrate-N LR
075 pH UDV	060 Manganese LR	068 Nitrite-N LR
12:00:00 001/500	12:00:00 001/500	12:00:00 001/500
063 Molybdenum HR	065 Nitrate-N LR	075 pH PR
086 Silica HR	068 Nitrite-N LR	081 Phosphate LR
036 Cu Thicarbamate	079 Phenol	087 Silica LR
055 Iron Bipyridyl	081 Phosphate LR	
	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 can be determined by the user. After running a test, 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 (page 36).

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

Pressing ⏻ the at any time will turn the colorimeter off.

NOTE: A sequence must contain at least one test.

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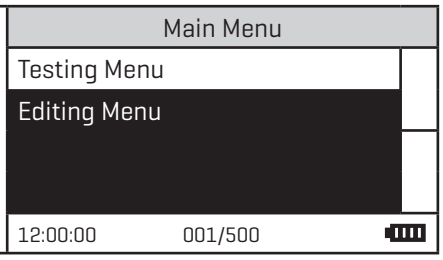
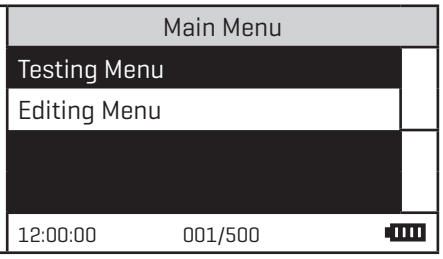
■ EDITING A SEQUENCE

The Edit Sequence menu allows three alterable test sequences (Sequence 1, Sequence 2, Sequence 3) to be edited.

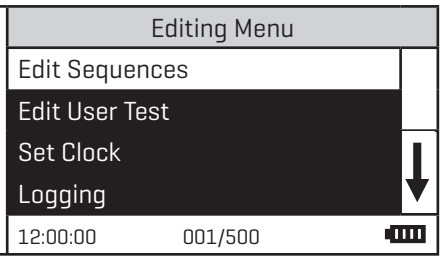
1. Press and briefly hold ⏻ to turn the meter on. The LaMotte logo screen will appear for about 3 seconds and the **Main Menu** will appear.



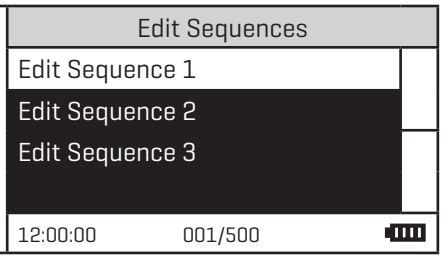
2. Press ∧ or ∨ to scroll to the **Editing Menu.**



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



4. Press ENTER to select **Edit Sequences**.



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5. Press ^ or v to scroll to the desired sequence.	Edit Sequences Edit Sequence 1 Edit Sequence 2 Edit Sequence 3 12:00:00 001/500

6. Press ENTER to select the sequence to be edited.	EDIT SEQUENCE 2 005 Aluminum 025 Chlorine T DPD 056 Iron Phenanthro 060 Manganese LR 12:00:00 001/500

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ADDING OR DELETING A TEST

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.

ADDING A TEST

Below is a step-by-step example of how to add a test to SEQUENCE 2 starting from the EDIT SEQUENCE 2 menu.

1. To add a test before or after an existing test, press ^ or v to scroll to the existing test.	EDIT SEQUENCE 2 005 Aluminum 025 Chlorine T DPD 056 Iron Phenanthro 060 Manganese LR 12:00:00 001/500
2. Press ENTER to select the existing test.	Add or Delete Insert Before Insert After Delete 12:00:00 001/500
3. Press ^ or v to scroll to **Insert Before** or **Insert After**.	Add or Delete Insert Before Insert After Delete 12:00:00 001/500
4. Press ENTER to select the option, **Insert Before**, in this example. The **All Test Menu** will appear.	All Tests 002 Alkalinity UDV 005 Aluminum 006 Ammonia-N LRF 007 Ammonia-N LRS 12:00:00 001/500

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5. Press ^ or v to scroll to the test that will be added to the sequence. In this example, 006 Ammonia-N LRS.	All Tests 002 Alkalinity UDV 005 Aluminum 006 Ammonia-N LRF 007 Ammonia-N LRS 12:00:00 001/500

6. Press ENTER to select the test. The sequence will appear in the Edit Sequence menu and the new test will be added to the sequence. All changes in the sequence will be automatically saved.	EDIT SEQUENCE 2 005 Aluminum 025 Chlorine T DPD 006 Ammonia-N LF 056 Iron Phenanthro 12:00:00 001/500

7. Press EXIT to exit the **Edit Sequence** menu and return to the **Editing Sequences Menu**.	Edit Sequences Edit Sequence 1 Edit Sequence 2 Edit Sequence 3 12:00:00 001/500

8. Press ENTER to select **Edit Sequences** to continue editing the sequences or press EXIT twice to return to the **Main Menu**.	Main Menu Testing Menu Editing Menu 12:00:00 001/500

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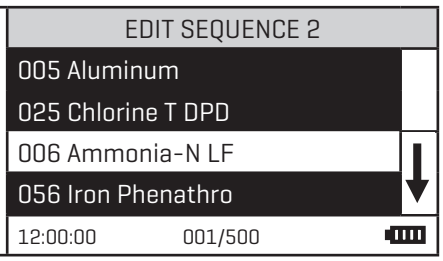
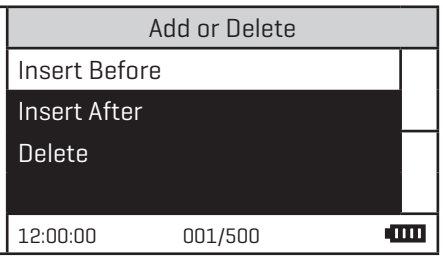
DELETING A TEST

Below is a step-by-step example of how to delete a test in SEQUENCE 2 starting from the EDIT SEQUENCE 2 menu.

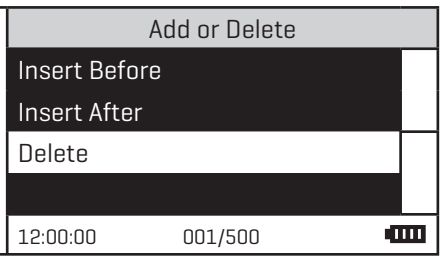
1. To delete a test, press ^ or v to scroll to the test in the sequence.



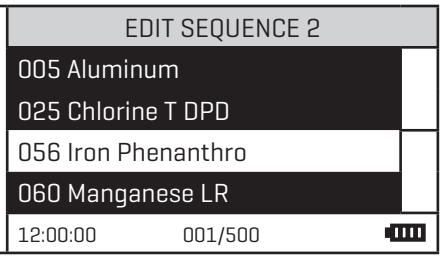
2. Press ENTER to select the test.



3. Press ^ or v to scroll to **Delete**.



4. Press ENTER to select **Delete**. The sequence will appear in the **Edit Sequences** menu and the selected test will have been deleted. All changes to the sequence will automatically have been saved.



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5. Press EXIT to exit the **Edit Sequence** menu and return to the **Edit Sequences Menu**.	Edit Sequences Edit Sequence 1 Edit Sequences 2 Edit Sequences 3 12:00:00 001/500

6. Press EXIT to exit the **Edit Sequences** menu and return to the **Editing Menu**.	Editing Menu Edit Sequences Edit User Test Set Clock Logging 12:00:00 001/500

7. Press ENTER to select **Edit Sequences** to continue editing the sequences or press EXIT to return to the **Main Menu**.	Main Menu Testing Menu Editing Menu 12:00:00 001/500

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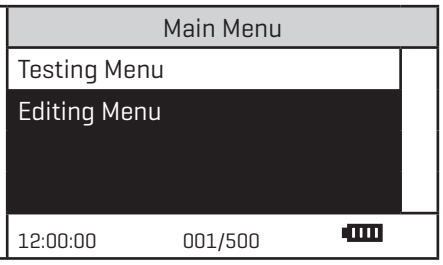
■ CREATING A SOIL TEST SEQUENCE

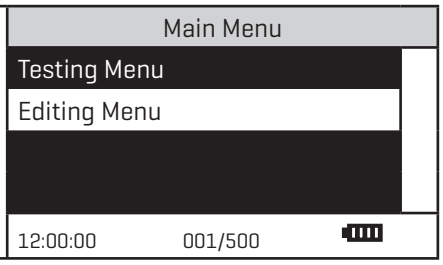
To create a soil testing sequence specifically for the reagent systems in this SMART3 Soil Manual follow the step by step procedure below. The test sequence currently in the meter will be cleared and then the soil tests will be added to Sequence 1. Tests in the soil sequence will be arranged in the order in which they appear in the manual.

008 Ammonia-N HR
036 Cu Thiocarbamate
055 Iron Bipyridyl
059 Manganese HR
065 Nitrate-N LR
068 Nitrite-N LR
081 Phosphate LR
085 Potassium
089 Sulfate HR
097 Zinc LR

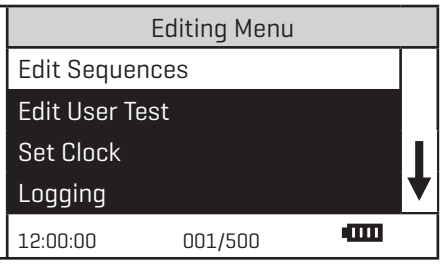
1. Press and briefly hold ⏻ to turn the meter on. The LaMotte logo screen will appear for about 3 seconds and the **Main Menu** will appear.



2. Press ∧ or ∨ to scroll to the **Editing Menu.**



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



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4. Press ENTER to select **Edit Sequences**.	Edit Sequences Edit Sequence 1 Edit Sequence 2 Edit Sequence 3 12:00:00 001/500
5. Press ^ or v to scroll to the desired sequence. In this exmple, Edit Sequence 1.	Edit Sequences Edit Sequence 1 Edit Sequence 2 Edit Sequence 3 12:00:00 001/500
6. Press ENTER to select the sequence to be edited.	Edit Sequence 1 025 Chlorine T DPD 080 Phosphate HR 010 Benzotriazole 075 pH PR 12:00:00 001/500
7. Press ENTER to select the test to be edited. In this example, 025 Chlorine T DPD.	Add or Delete Insert Before Insert After Delete 12:00:00 001/500
8. Press ^ or v to scroll to **Delete**.	Add or Delete Insert Before Insert After Delete 12:00:00 001/500

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9. Press ENTER to select **Delete**.

Edit Sequence 1
080 Phosphate HR
010 Benzotriazole
075 pH UDV
063 Molybdenum HR
12:00:00 001/500

10. Press ^ or v and ENTER to select the next test to be edited. In this example, 080 Phosphate HR.

Add or Delete
Insert Before
Insert After
Delete
12:00:00 001/500

11. Press ^ or v to scroll to **Delete**.

Add or Delete
Insert Before
Insert After
Delete
12:00:00 001/500

12. Press ENTER to select **Delete**. Repeat the procedure to delete the tests in the series except for 055 Iron Bipyridal which will remain. Tests will be added to the sequence.

NOTE: It is not possible to empty a test sequence completely. One test will remain. To remove the remaining test, add a new test and then delete the unwanted test. In creating the soil sequence, the last test—055 Iron Biryridal—will be included in the sequence and will not be deleted.

Edit Sequence 1
055 Iron Bipyridyl
12:00:00 001/500

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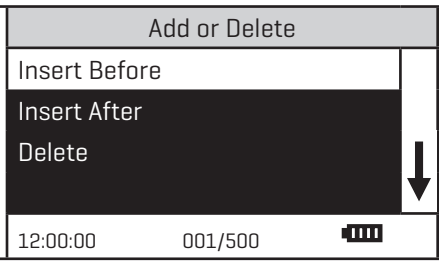
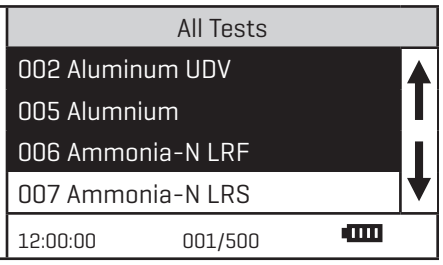
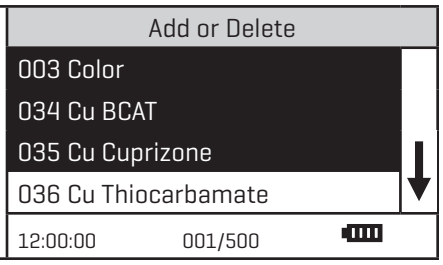
13. Press ENTER to begin adding tests to the sequence.



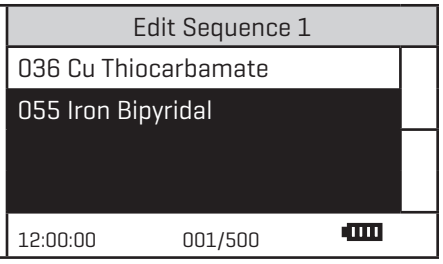
14. Press ENTER to select **Insert Before**.



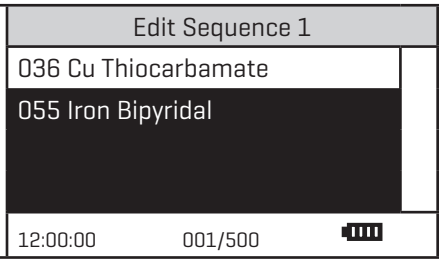
15. Press ^ or v to scroll to the first test to be added to the sequence. In this example, 036 Cu Thiocarbamate because the tests will be added in the order that they appear in the manual.



16. Press ENTER to select the test to be added.



17. Press ENTER to select **036 Cu Thiocarbamate**.



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18. Press ^ or v to scroll to **Insert Before**.

Add or Delete
Insert Before
Insert After
Delete
12:00:00 001/500

19. Press ENTER to select **Insert Before**. Press ^ or v to scroll to the next test to be added. In this example, 008 Ammonia-N HR.

Add or Delete
006 Ammonia-N LRF
007 Ammonia-N LRS
008 Ammonia-N HR
009 Barium
12:00:00 001/500

20. Press ENTER to select 008 **Ammonia-N HR** test to be added.

Edit Sequence 1
008 Ammonia-N HR
036 Cu Thiocarbamate
055 Iron Bipyridal
12:00:00 001/500

21. Press v to scroll to the last test in the sequence. In this example, 055 Iron Bipyridal.

Edit Sequence 1
008 Ammonia-N HR
036 Cu Thiocarbamate
055 Iron Bipyridal
12:00:00 001/500

22. Press ENTER to select **055 Iron Bipyridal**. Press ^ or v to scroll to **Insert After**.

Add or Delete
Insert Before
Insert After
Delete
12:00:00 001/500

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23. Press ENTER to select **Insert Before**.	All Tests 002 Aluminum UDV 005 Alumnium 006 Ammonia-N LRF 007 Ammonia-N LRS 12:00:00 001/500
24. Press ENTER to select the test to be added.	Edit Sequence 1 008 Ammonia-N HR 036 Cu Thiocarbamate 055 Iron Bipyridal 059 Manganese HR 12:00:00 001/500
25. Press ∨ to scroll to the last test in the sequence. In this example, 059 Manganese HR.	All Tests 008 Ammonia-N HR 036 Cu Thiocarbamate 055 Iron Bipyridal 059 Manganese HR 12:00:00 001/500
26. Press ENTER to **059 Manganese HR**. Press ∧ or ∨ to scroll to **Insert After**.	Add or Delete Insert Before Insert After Delete 12:00:00 001/500

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27. Press ENTER to select **Insert After**. Repeat the procedure to add the remaining tests to the sequence.

    059 Manganese HR
    065 Nitrate-N LR
    068 Nitrate-N LR
    081 Phosphate LR
    085 Potassium
    089 Sulfate HR
    097 Zinc LR

All Tests
081 Phosphate LR
285 Potassium
089 Sulfate LR
099 Zinc LR
12:00:00 001/500

28. Press EXIT to escape the **Sequences Menu**.

Editing Menu
Edit Sequence 1
Edit Sequence 2
Edit Sequence 3
12:00:00 001/500

29. Press EXIT to escape the **Editing Menu**.

Editing Menu
Edit Sequences
Edit User Test
Set Clock
Logging
12:00:00 001/500

30. Press EXIT to escape to the **Main Menu**. Press ^ or v to scroll to the **Testing Menu**.

Main Menu
Testing Menu
Editing Menu
12:00:00 001/500

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31. Press ENTER to select **Testing Menu**. Press ^ or v to scroll to **Sequence 1** to begin testing.	Testing Menu All Test Menu Sequence 1 Sequence 2 Sequence 3 12:00:00 001/500

■ EDIT USER TESTS

If a test other than the LaMotte programmed tests is performed regularly, a calibration for it may be entered in one of the 25 User Tests. These tests are originally named "User Test 1 - 25". It will be possible to rename the test, select a wavelength, enter a new calibration, select the number of decimal places used to display the results, and select the units. A User Test may be added for a reagent system for which no precalibrated test exists. A calibration of a LaMotte reagent system may also be entered. The calibration of a User Test can be changed at any time.

The User Tests have the ability to handle 2 data points. The colorimeter will determine the absorbance of the standards and calculate a response that will be stored to determine the concentration of future samples of unknown concentration. These standards should cover all the concentrations for the range of the test being performed and be scanned beginning with the low concentration and finishing with the high concentration (for more information about this, see CALIBRATION CURVES, page 16). Prepare these standards prior to entering a new calibration.

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

The User Tests can be placed in any of the alterable sequences using Edit Sequences.

1. Press and briefly hold ⏻ to turn the meter on. The LaMotte logo screen will appear for about 3 seconds and the **Main Menu** will appear.	Main Menu Testing Menu Editing Menu 12:00:00 001/500

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2. Press ^ or v to scroll to the **Editing Menu.**	Main Menu Testing Menu Editing Menu 12:00:00 001/500
3. Press ENTER to select **Editing Menu**. Press v to scroll to **Edit User Test**.	Editing Menu Edit Sequences Edit User Test Set Clock Logging 12:00:00 001/500
4. Press ENTER to select **Edit User Test**.	Edit User Test 105 USER TEST 01 106 USER TEST 02 107 USER TEST 03 108 USER TEST 04 12:00:00 001/500
5. Press ^ or v to scroll to the desired user test.	Edit User Test 108 USER TEST 04 109 USER TEST 05 110 USER TEST 06 111 USER TEST 07 12:00:00 001/500
6. Press ENTER to select the **User Test**.	111 USER TEST 07 Name the Test Select Vial/WL STD Calibration Enter Constants 12:00:00 001/500

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■ NAMING THE TEST

A User Test can be up to 16 characters long. The menu choices for each character are 26 upper case letters A to Z, 26 lower case letters a to z, ten numerals 0 to 9, a space, a dash (-) and a decimal point (.). The existing name is displayed on the bottom line of the display. The character which is to be edited will blink and that character is also displayed in the center of the display. The character can be changed by using ^ or v to scroll to other characters. Use ENTER to select a character. The edited name is saved at any time by pressing EXIT or by pressing ENTER after selecting the sixteenth character.

1. From the User Test menu, press v to scroll to **Name the Test**.	111 USER TEST 07 Name the Test Select Vial/WL STD Calibration Enter Constants 12:00:00 001/500
2. Press ENTER to select **Name the Test**. A blinking reverse font (dark background with a light character) will appear to indicate the character that will be adjusted. The same character will also appear in the center of the display.	Name the Test P Q R S T U V W X Z 111 U SER TEST 07 12:00:00 001/500
3. Press ^ or v to scroll to the desired character. In this example, the test name will be H2O. The character for a blank space is located after the lower case z.	Name the Test C D E F G H I J K L M 111 U SER TEST 07 12:00:00 001/500

Editing/Set Up

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4. Press ENTER to save the character and move to the next character.	Name the Test N O P Q R **S** T U V W X 111 H S ER TEST 07 12:00:00 001/500
5. Press ^ or v to scroll to the desired character.	Name the Test X Y Z . 0 1 **2** 3 4 5 6 7 111 H S ER TEST 07 12:00:00 001/500
6. Press ENTER to save the character and move to the next character.	Name the Test 9 A B C D **E** F G H I J K 111 H2 E R TEST 07 12:00:00 001/500
7. Press ^ or v to scroll to the desired character.	Name the Test J K L M N **O** P Q R S T 111 H2 O R TEST 07 12:00:00 001/500

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8. Press ENTER to save the character. Repeat the procedure until the test name is complete. After selecting the last character in the name: Hold down ∨ and press and release ENTER to save all selected characters and to delete all characters to the right of the cursor and exit the name edit screen. Hold down ∧ and press and release ENTER to save all remaining characters and exit the name edit screen. THe meter will return to the **Edit Test** manu.	111 H20 Name the Test Select Vial/WL STD Calibration Enter Constants 12:00:00 001/500

■ SELECT THE VIAL AND WAVELENGTH

The Smart3 Colorimeter accepts three different vials (the 25 mm 0290 tube, UDVs and COD tubes) at 4 different wavelengths (428, 525, 560, and 635 nm). The colorimeter uses different settings for each of the twelve combinations of vial and wavelength.

1. From the **User Test** menu, press ∧ or ∨ to scroll to **Select Vial/WL**.	111 H20 Name the Test Select Vial/WL STD Calibration Enter Constants 12:00:00 001/500

2. Press ENTER to select **Select Vial/WL**.	Select Vial/WL Ch1 428nm 25mm Ch2 525nm 25mm Ch3 635nm 25mm Ch4 568nm 25mm 12:00:00 001/500

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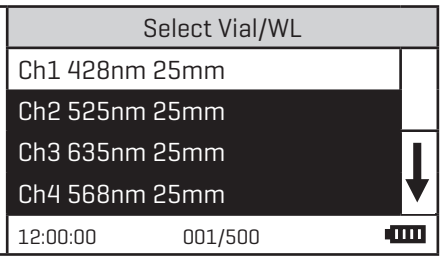
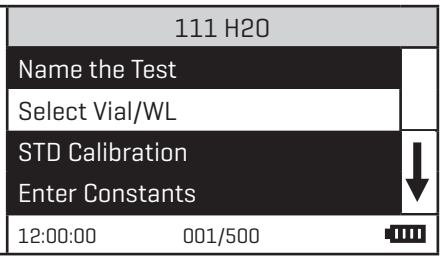
3. Press ^ or v to scroll to the channel with the desired wavelength and vial size combination. The screen will display **storing...** for about 1 second and the meter will return to the **User Test** menu.



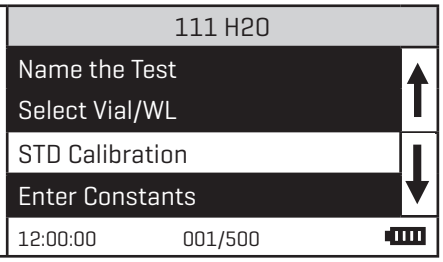
4. Press ENTER to select the Vial/WL option. The screen will display **Storing...** for about 1 second and the meter will return to the **Edit Test** menu.



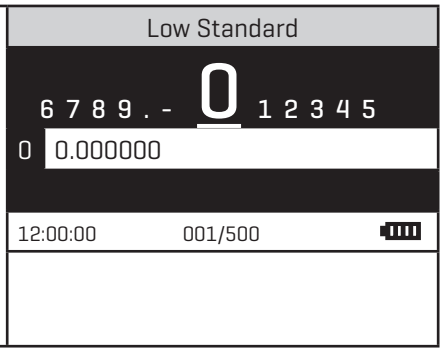
■ ENTERING A TWO POINT CALIBRATION

The Smart3 Colorimeter can scan two reacted standards and create a calibration curve. To create a calibration curve with multiple data points see Entering a Multiple Point Calibration Curve (pg. 54).

1. From the User Test menu, press ^ or v to scroll to STD (Standard) Calibration.



2. Press ENTER to select STD Calibration. The values for the standards will be entered. The screen will display the **Low Standard** screen. A blinking reverse font (dark background with a light character) will appear to indicate the character that will be adjusted. The same character will also appear in the center of the display.



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3. Press ^ or v to scroll to the first character of the low concentration. In this example, 1.00 ppm.	Low Standard 789.-0 1 23456 0 .000000 12:00:00 001/500
4. Press ENTER to save the character and move to the next character.	Low Standard 56789 . -01234 1 . 000000 12:00:00 001/500
5. Press ^ or v to scroll to the desired character.	Low Standard 56789 . -01234 1 . 000000 12:00:00 001/500
6. Press ENTER to save the character and move to the next character.	Low Standard 6789.- 0 12345 1. 0 00000 12:00:00 001/500
7. Press ^ or v to scroll to the desired character.	Low Standard 6789.- 0 12345 1. 0 00000 12:00:00 001/500

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8. Press ENTER to save the character. Repeat the procedure until the low concentration value is complete. (the character for a blank space is located after the 9.) After the final character is complete the meter will save the low concentration value. The screen will display the **High Standard** screen. A blinking reverse font (dark background with a light character) will appear to indicate the character that will be adjusted. The same character will appear in the center of the display.	High Standard 6 7 8 9 . - 0 1 2 3 4 5 0 .0000 12:00:00 001/500
9. Use ^ or v and ENTER to select the characters for the high concentration value. In this example, 7.5 ppm.	High Standard 6 7 8 9 . - 0 1 2 3 4 5 7.50000 0 12:00:00 001/500
10. After the final character is entered the meter will save the high concentration value. The screen will display instructions for completing the calibration procedure.	STD Calibration Insert Blank <Enter> continue 12:00:00 001/500
11. The standards wil be scanned. Insert the blank. Press ENTER and the **Insert Low Standard** screen will appear.	STD Calibration Insert Low Standard <Enter> continue 12:00:00 001/500

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12. Insert the low standard. Press ENTER. The **Insert High Standard** screen will be displayed.	STD Calibration Insert High Standard <Enter> continue 12:00:00 001/500
13. Insert the high standard. Press ENTER. The meter will display the constants for the calibration curve.	K0 = 0.57246 K1 = 7.14547 K2 = 0.00000 K3 = 0.00000 <Enter> Save 12:00:00 001/500
14. Press ENTER to save the calibration curve and return to the **Edit User Test Menu**.	111 H20 Name the Test Select Vial/WL STD Calibration Enter Constants 12:00:00 001/500

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■ ENTERING A MULTIPLE POINT CALIBRATION

The Smart3 can directly create a 2 point calibration curve. (See Entering a Two Point Calibration on page 50.) To create a multiple point calibration curve, constants obtained from a linear regression of multiple data points can be entered into the Smart3.

1. Scan reactions of multiple concentrations at the appropriate wavelength in the absorbance mode on the Smart3.
2. Plot the concentration (y axis) versus absorbance (x axis) in a program capable of linear regression such as Excel.
3. Enter the constants obtained from the linear regression equation into the Smart3.

   For Example:

   $y = 0.001x^3 - 0.017x^2 + 0.181x - 0.049$

   K0 = – 0.049

   K1 = 0.181

   K2 = – 0.017

   K3 = 0.001

   OR (Over Range) = 10

1. From the User Test menu, press ^ or v to scroll to **Enter Constants**.	111 H2O Name the Test Select Vial/WL STD Calibration Enter Constants 12:00:00 001/500

2. Press ENTER to select **Enter Constants**.	K0=0.00000 K1=1.00000 K2=0.00000 K3=0.00000 OR=100.00000 12:00:00 001/500

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3. Press ENTER to begin entering the values for the constants. A reverse font (dark background with a light character) will appear to indicate the character that will be adjusted. The same character will also appear in the center of the display.	Enter Constants K0 6 7 8 9 . - 0 1 2 3 4 5 0 .00000 12:00:00 001/500
4. Press ^ or v to scroll to the first character of K0. In this example, – 0.049.	Enter Constants K0 6 7 8 9 . _ 0 1 2 3 4 5 0 .00000 12:00:00 001/500
5. Press ENTER to save the character and move to the next character.	Enter Constants K0 5 6 7 8 9 . - 0 1 2 3 4 – . 00000 12:00:00 001/500
6. Press ^ or v to scroll to the next character.	Enter Constants K0 6 7 8 9 . - 0 1 2 3 4 5 – . 00000 12:00:00 001/500
7. Press ENTER to save the character and move to the next character. Press ^ or v to scroll to the next character. Note: The character for a blank space is located after the 9.	Enter Constants K0 5 6 7 8 9 . - 0 1 2 3 4 – 0 0 0000 12:00:00 001/500

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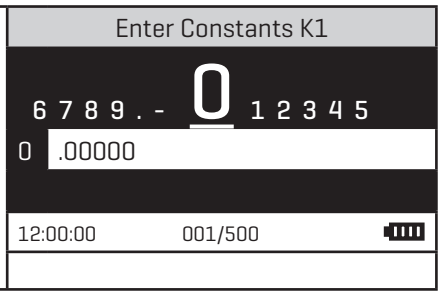
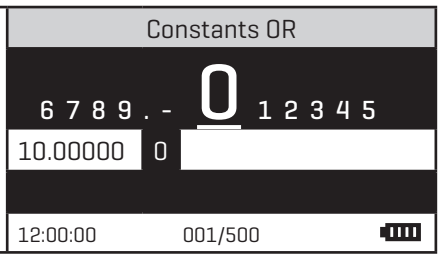
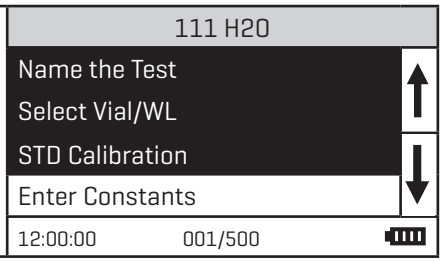
8. Press ENTER to save the character. Repeat the procedure until the K0 value is complete. After the final character is complete the meter will save the K0 value and the meter will display K1 screen.



9. Use ^ , v and ENTER to select the characters for the remaining values: K1, K2, K3, and over range. In this example, 10 ppm.



10. After the final character is entered the meter will save the constants. The screen will display **Storing...** and return to the **Edit Test** menu.



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■ SELECTING THE NUMERICAL FORMAT OF THE RESULT

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

1. From the User Test menu, press ^ or v to scroll to **Decimal Places**.	111 H20 Select Vial/WL STD Calibration Enter Constants Decimal Places 12:00:00 001/500
2. Press ENTER to select **Decimal Places**.	Decimal Places None 0 One 0.0 Two 0.00 Three 0.000 12:00:00 001/500
3. Press ^ or v to scroll to the desired number of decimal places.	Decimal Places None 0 One 0.0 Two 0.00 Three 0.000 12:00:00 001/500
4. Press ENTER to select the decimal places. The screen wil display **Storing...** for about 1 second and the meter will return to the **Edit Test** menu.	111 H20 Select Vial/WL STD Calibration Enter Constants Decimal Places 12:00:00 001/500

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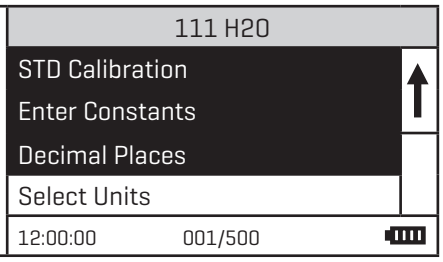
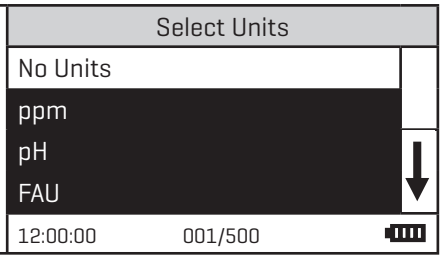
■ SELECTING THE UNITS OF CONCENTRATION

The Smart3 Colorimeter has seven options for units of concentration. They are No Units, ppm, pH, FAU, ppb, ppt and mgL.

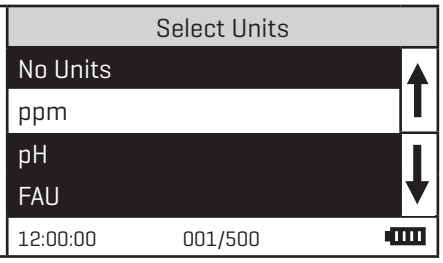
1. From the User Menu, press ^ to scroll to **Select Units**.



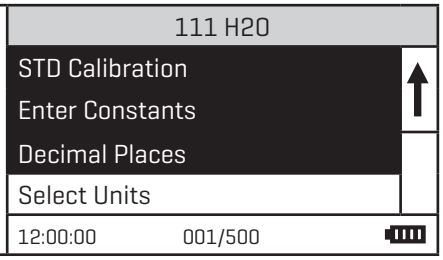
2. Press ENTER to select **Select Units**.



3. Press ^ or v to scroll to the desired units.



4. Press ENTER to select the units. The screen will display **Storing...** for about 1 second and the meter will return to the **Edit Test** menu.



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■ SETTING THE CLOCK

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

1. From the **Editing Menu**, press ^ or v to scroll to **Set Clock**.	Editing Menu Edit Sequences Edit User Test Set Clock Logging 12:00:00 001/500
2. Press ENTER to select **Set Clock**. The year is displayed. Press ^ or v to scroll to the appropriate character. Press ENTER to select the character. The month, day, hour, format hour, minute, second, AM/PM will be dislpayed. Repeat for each.	Set Time Year: 2000 12:00:00 001/500
3. Press ENTER to select the final character. The time and date will be saved and the meter will return to the **Editing Menu**.	Editing Menu Edit Sequences Edit User Test Set Clock Logging 12:00:00 001/500

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■ LOGGING DATA

The default setting for the data logger is enabled. The meter will log the last 500 data points. The counter in the center bottom of the display will show how many data points have been logged. The display will show 500+ when the data logger has exceeded 500 points and the data points are being overwritten.

1. From the **Editing Menu**, press ^ or v to scroll to **Logging**.	Editing Menu Edit Sequences Edit User Test Set Clock Logging 12:00:00 001/500
2. Press ENTER to select **Logging**.	Logging Display Test Log Logging Enabled Logging Disabled Erase Log 12:00:00 001/500
3. Press ^ or v to scroll to desired function.	Logging Display Test Log Logging Enabled Logging Disabled Erase Log 12:00:00 001/500
4. Press ENTER. The screen will display **Storing...** for about 1 second and return to the **Editing Menu**.	Editing Menu Edit Sequences Edit User Test Set Clock Logging 12:00:00 001/500

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■ FACTORY SETUP

The Factory Setup menu is used in manufacturing of the Smart3 Colorimeter. This menu is not for use by the operator in the field.

■ SETTING POWER SAVE

The power saving Auto Shutoff feature will turn the meter off when a button has not been pushed for a set amount of time. The default setting is disabled. To change the setting:

1. From the **Editing Menu**, press ^ or v to scroll to **Set Power Save**.	Editing Menu Set Clock Logging Factory Setup Set Power Save 12:00:00 001/500
2. Press ENTER to select **Set PWR Save**.	Set PWR Save Disable 5 Minutes 15 Minutes 30 Minutes 12:00:00 001/500
3. Press ^ or v to scroll to desired function.	Set PWR Save Disable 5 Minutes 15 Minutes 30 Minutes 12:00:00 001/500
4. Press ENTER. The screen will display **Storing....** for about 1 second and the meter will retun to the **Editing Menu**.	Editing Menu Set Clock Logging Factory Setup Set PWR Save 12:00:00 001/500

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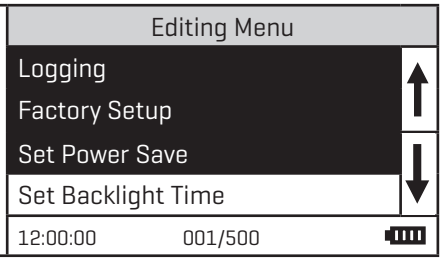
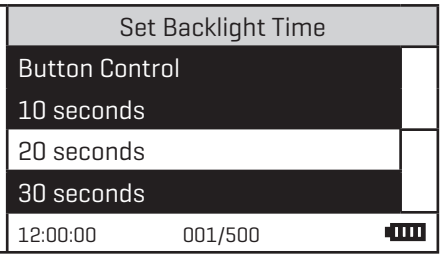
■ SETTING THE BACKLIGHT TIME

The backlight illuminates the display for enhanced viewing. The default setting is 10 seconds. If Button Control is chosen the backlight button on the key pad will act as an on/off switch and the backlight will remain on or off when the meter is being used. When one of the other settings – 10, 20 or 30 seconds – is chosen, the display will be illuminated for the specified amount of time after any button is pressed.
NOTE: The backlight feature uses a significant amount of power. The longer the backlight is on, the more frequently the battery will have to be charged if the USB/Wall Adapter is not being used.

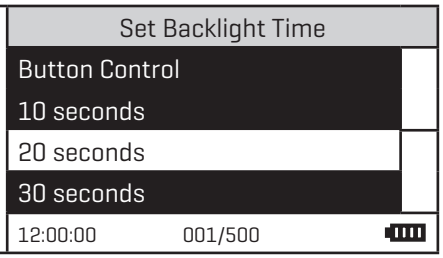
1. From the **Editing Menu**, press ^ or v to scroll to **Backlight Time**.



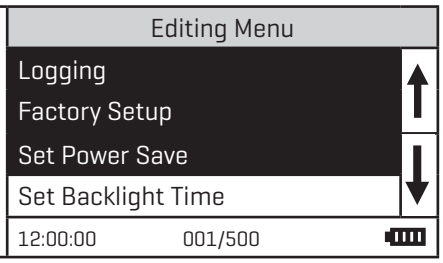
2. Press ENTER to select **Set Backlight Time**.



3. Press ^ or v to scroll to desired option.



4. Press ENTER. The screen will display **Storing...** for about 1 second and the meter will return to the **Editing Menu**.



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■ BLUETOOTH MENU

Enabling Bluetooth Power

Bluetooth wireless technology allows communication between the colorimeter and a Bluetooth Mobile Printer (Code 5-0066 only). Bluetooth Power must be enabled to use the Bluetooth Mobile Printer (Code 5-0066). When Bluetooth Power is enabled, the Bluetooth icon will flash next to the battery icon on the bottom line of the display.

If the Bluetooth feature is not being used to connect to the printer, Bluetooth Power should be disabled to conserve the battery life. The default Bluetooth Power setting is disabled.

1. From the **Editing Menu**, press ^ or v to scroll to **Bluetooth Menu**.	Editing Menu Factory Setup Set Power Save Set Backlight Time Bluetooth Menu 12:00:00 001/500

2. Press ENTER to select **Bluetooth Menu**.	Bluetooth Menu Bluetooth Power Bluetooth Mode Bluetooth Scan Set BT Timeout 12:00:00 001/500

3. Press ^ or v to scroll to **Bluetooth Power**.	Bluetooth Menu Bluetooth Power Bluetooth Mode Bluetooth Scan Set BT Timeout 12:00:00 001/500

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4. Press ENTER to select **Bluetooth Power**.	Bluetooth Power Enable Bluetooth Disable Bluetooth 12:00:00 001/500
5. Press ^ or v to scroll to desired option.	Bluetooth Power Enable Bluetooth Disable Bluetooth 12:00:00 001/500
6. Press ENTER to select the option. Bluetooth Power must be enabled to use the Bluetooth Mobile Printer (Code 5-0066). The screen will display **Storing**... for about 1 second and the meter will return to the **Bluetooth Menu**. A flashing ᛒP symbol will indicate that Bluetooth is enabled.	Bluetooth Menu Bluetooth Power Bluetooth Mode Bluetooth Scan Set BT Timeout 12:00:00 001/500 ᛒP

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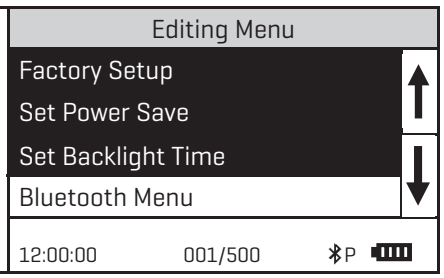
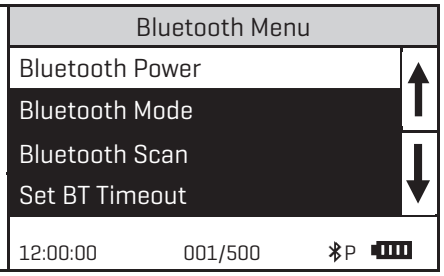
Setting The Bluetooth Mode

A Bluetooth connection is available only for the Bluetooth Mobile Printer (Code 5-0066).

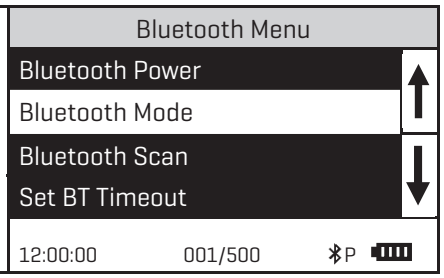
1. From the **Editing Menu**, press ^ or v to scroll to **Bluetooth Menu**.



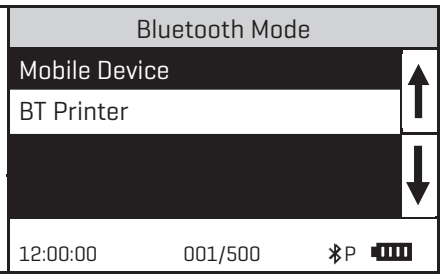
2. Press ENTER to select **Bluetooth Menu**.



3. Press ^ or v to scroll to **Bluetooth Mode**.



4. Press ENTER to select **Bluetooth Mode**.



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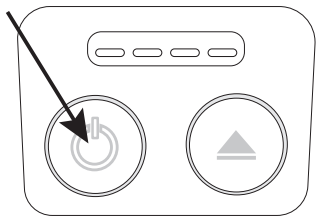
5. Press ⌃ or ⌄ to scroll to **BT Printer**.	Bluetooth Mode Mobile Device BT Printer 12:00:00 001/500 ᛒP

6. Press ENTER . The screen will display **Storing**... for about 1 second and the meter will return to the **Bluetooth Menu**.	Bluetooth Menu Bluetooth Power Bluetooth Mode Bluetooth Scan Set BT Timeout 12:00:00 001/500 ᛒP

Scan For Printers

The Smart3 can only be used with Bluetooth Mobile Printer (Code 5-0066).

1. Turn on the power to the Bluetooth Mobile Printer (Code 5-0066).	

2. From the **Editing Menu**, press ⌃ or ⌄ to scroll to **Bluetooth Menu**.	Editing Menu Factory Setup Set Power Save Set Backlight Time Bluetooth Menu 12:00:00 001/500 ᛒP

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3. Press ENTER to select **Bluetooth Menu**.	Bluetooth Menu Bluetooth Power Bluetooth Mode Bluetooth Scan Set BT Timeout 12:00:00 001/500 P
4. Press ^ or v to scroll to **Bluetooth Scan**.	Bluetooth Menu Bluetooth Power Bluetooth Mode Bluetooth Scan Set BT Timeout 12:00:00 001/500 P
5. Press ENTER to select **Bluetooth Scan**. The meter will begin scanning. A count down timer will begin counting down from 11 seconds. If "No BT Available..." is displayed, Bluetooth is not enabled on the meter. Go to Bluetooth Power to enable it.	Bluetooth Scan Scanning (11)... 12:00:00 001/500 P

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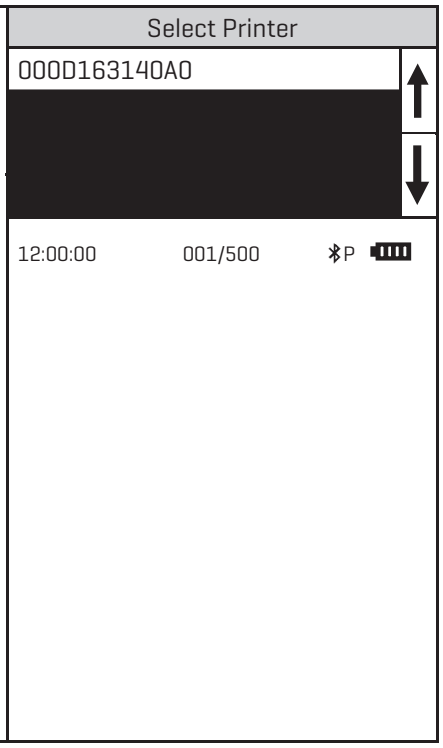
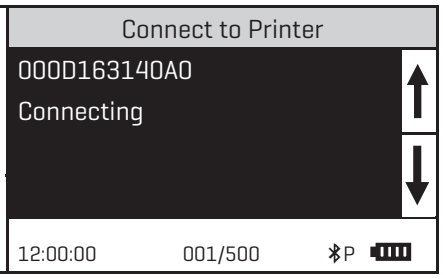
6. The addresses of the available printers will be displayed.

NOTE: The printer address for the Bluetooth Mobile Printer (Code 5-0066) can be determined by turning the power off and then pressing the Power button and the Paper Feed button simultaneously to print the printer specifications. The printer address is designated as Bluetooth: BT Address.



7. Scroll to the desired printer and press ENTER to pair the printer. The screen will display the BT Address and **Working...** for about 1 second. The meter will display a status message when the printer is connected.



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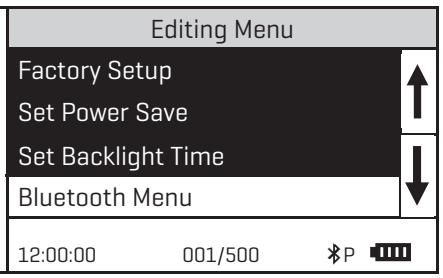
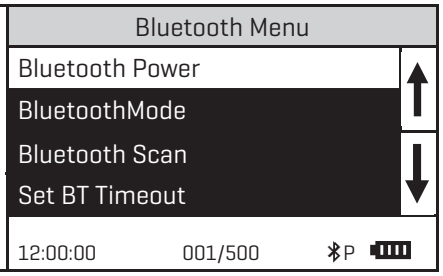
Set BT Timeout

The Bluetooth Timeout can be set to allow the Bluetooth feature to be on to allow data to be sent to the Bluetooth printer and then turn off after a specified amount of time.

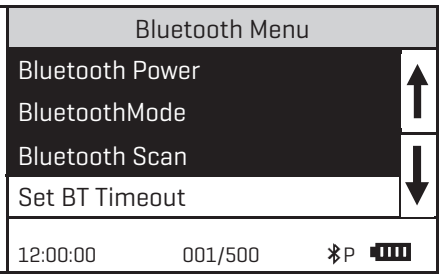
1. From the **Editing Menu**, press ^ or v to scroll to **Bluetooth Menu**.



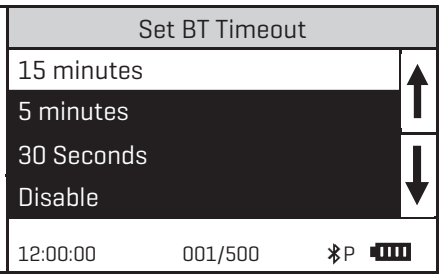
2. Press ENTER to select **Bluetooth Menu**.



3. Press ^ or v to scroll to **Set BT Timeout**.



4. Press ENTER to select **Set BT Timeout**.



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5. Press ^ or v to scroll to desired option.	Set BT Timeout 15 minutes 5 minutes 30 Seconds Disable 12:00:00 001/500 P

6. Press ENTER . The screen will display **Storing**... for about 1 second and the meter will return to the **Bluetooth Menu**.	Bluetooth Menu Bluetooth Power Bluetooth Mode Bluetooth Scan Set BT Timeout 12:00:00 001/500 P

■ SELECTING A LANGUAGE

There are seven languages available in the Smart3: English, Spanish, French, Portuguese, Italian, Chinese, and Japanese.

1. From the **Editing Menu**, press ^ or v to scroll to **Select Language**.	Editing Menu Set Power Save Set Backlight Time Bluetooth Menu Select Language 12:00:00 001/500

2. Press ENTER to select **Select Language**.	Select Language English Spanish French Portugese 12:00:00 001/500

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3. Press ^ or v to scroll to desired language.	Select Language English Spanish French Portugese 12:00:00 001/500

4. Press ENTER. The screen will display **Storing...** for about 1 second and the meter will return to the **Editing Menu**.	Editing Menu Set Power Save Set Backlight Time Bluetooth Menu Select Language 12:00:00 001/500

NOTE: If meter unintentionally switches to another language, use the procedure above to reset the meter to the desired language. For example, to reset the meter to English:

Turn meter on.

1. Press v one time. Press ENTER.
2. Press v eight times. Press ENTER.
3. Press ENTER.

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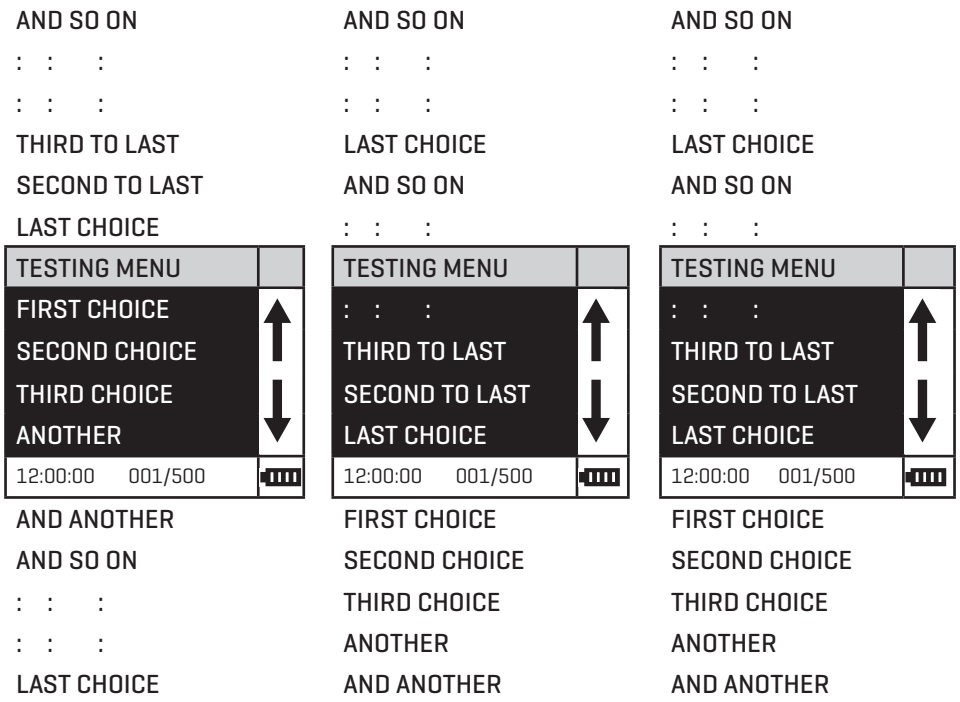
■ LOOPING MENUS

Long menus, such as All Tests, incorporate a looping feature which allows 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.



The feature called **Looping Menu** can be turned on and off in the **Editing Menu**. The default setting is ON.

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COMPUTER CONNECTION

■ OUTPUT

USB

■ COMPUTER CONNECTION

USB Type A, USB mini B, Order Cable Code 1720.

■ BLUETOOTH CONNECTION

Barriers to wireless signals can reduce the range of wireless devices. The Smart3 will work best if there are no walls between it and the receiving device.

The Smart3 colorimeter uses Bluetooth wireless technology to allow communication between the colorimeter and a bluetooth printer (Code 3-0066 only).

■ WATERLINK CONNECT

The meter may be interfaced with any Windows-based 64 bit computer by using the LaMotte WaterLink Connect program and a USB cable. The program will store test information and results in a local database, and allow for exporting this data to a comma separated value (CSV) file. The meter will send the following data: time/date stamp, name of test, sample value, sample units, meter name, and location. To download WaterLink go to http://softwarecenter.lamotte.com/. Select "WaterLink Connect Software for Windows FREE Download".

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BATTERY

■ BATTERY/AC OPERATION

The SMART3 may be operated on battery power using a USB wall adapter or USB computer connection. If using the meter as a bench top unit, use the wall adapter if possible to extend the battery life. The meter will remain on when the USB adapter is used.

To charge the battery with the wall adapter, plug the smaller end of the USB cable (USB mini B connector) into the meter and the larger end of the USB cable (USB type A connector) into the wall adapter. Plug the wall adapter into an AC outlet. Reinsert the rubber USB port plug after charging. To charge the battery from a computer, plug the smaller end of the USB cable (USB mini B connector) into the meter and the larger end of the USB cable (USB Type A connector) into a USB port on a computer. The battery icon will show no bars and flash when the unit first turns on. Then the indicator will indicate the battery status by showing 0, 1, 2, 3, or 4 bars.

It will take 6 hours to fully charge a low battery. The battery icon will flash when the battery is charging. The battery icon will show four bars and stop flashing when it is fully charged. The charging circuit will automatically switch to a float charge when the battery is fully charged. The charger may remain connected. Some computers will NOT supply power to their USB ports during standby operation. The wall adapter will charge the unit continuously.

Storing the meter above ambient room temperature will decrease the battery charge more quickly than storage at room temperature. If the meter does not turn on, it means that the battery is at a very low charge. Charging the battery with the wall adapter in this state may take up to 10 hours. At low temperatures, approaching 0 °C, the battery will charge more slowly. It will not charge at all below 0 °C. The battery icon will show no bars and continuously flash if the battery is getting low but the unit will still operate normally. A "Low Battery" message on the status bar of the display will replace the time when the battery voltage is too low for proper operation and accuracy may be degraded. A "Shutdown Low Batt" message on the display will appear for a few seconds before the power is switched off when the battery is too low to operate the unit. When the battery icon simultaneously flashes bars 1 and 2 followed by bars 3 and 4, it is an indication that the battery is damaged and technical support should be contacted.

To extend the battery life:

- Shut down the unit with the power switch when not taking measurements or use the power save option to have the unit automatically turn off after 5 minutes.
- Store the unit at a moderate temperature.
- Fully charge the battery before storing the unit for extended periods of time.
- Fully charge the battery at least once per year. Failure to do so may result in a permanently drained battery.
- Limit backlight use. The unit consumes 3X normal power with the backlight on. Set the backlight time option to 10 seconds, or select "Button Control" and keep the backlight off.

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■ BATTERY REPLACEMENT

The lithium ion battery used in this unit should last for many years with normal use. When it no longer powers the unit long enough to meet testing requirements it will need to be replaced. Lithium ion batteries that are properly charged and stored do not usually lose all capacity; they just have less capacity after hundreds of charge cycles. This unit uses a custom battery assembly that is only available from LaMotte Company. Battery replacement must be performed at a LaMotte authorized repair facility. The water resistant housing of this meter should not be opened by the user. Contact LaMotte Company by phone (1-800-344-3100) or email (tech@lamotte.com) for a return authorization number.

MAINTENANCE

■ CLEANING

Clean the exterior housing with a damp, lint-free cloth. Do not allow water to enter the light chamber or any other parts of the meter. To clean the light chamber and optics area, point a can of compressed air into the light chamber and blow the pressurized air into the light chamber. Use a cotton swab dampened with Windex® window cleaner to gently swab the interior of the chamber. Do not use alcohol; it will leave a thin residue over the optics when dry.

■ REPAIRS

Should it be necessary to return the meter for repair or servicing, pack the meter carefully in a suitable container with adequate packing material. A return authorization number must be obtained from LaMotte Company by calling 800-344-3100 (US only) or 410-778-3100, faxing 410-778-6394, or emailing tech@lamotte.com. Often a problem can be resolved over the phone or by email. If a return of the meter is necessary, attach a letter with the return authorization number, meter serial number, a brief description of problem and contact information including phone and FAX numbers to the shipping carton. This information will enable the service department to make the required repairs more efficiently.

■ METER DISPOSAL

Waste Electrical and Electronic Equipment (WEEE)

Natural resources were used in the production of this equipment. This equipment may contain materials that are hazardous to health and the environment. To avoid harm to the environment and natural resources, the use of appropriate take-back systems is recommended. The crossed out wheeled bin symbol on the meter encourages the use of these systems when disposing of this equipment.

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Take-back systems will allow the materials to be reused or recycled in a way that will not harm the environment. For more information on approved collection, reuse, and recycling systems contact local or regional waste administration or recycling services.

TROUBLESHOOTING

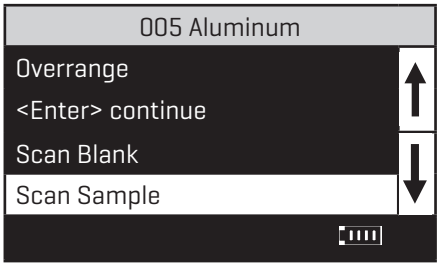
■ ERROR MESSAGES

OVER RANGE

If the message OVERRANGE is displayed when scanning a sample, the sample may be over range or under range. If the sample is over range the sample should be diluted and tested again (see Sample Dilution Techniques and Volumetric Measurements, page 14).

If overrange is displayed, press ENTER to continue testing on diluted samples.

Note: After pressing ENTER, the overrange cncentration will be displayed. This concentration is an **approximation only**.



CALIBRATION

As with all pre-calibrated meters, it is highly recommended, even if not required by regulations, that the user periodically verify the performance of the meter by running standards with a predetermined concentration. Results outside of specification are an indication that the meter needs to be adjusted. This can be done following the user calibration described on page 24. If the user calibration fails to properly adjust the meter then the meter should be returned to LaMotte Company for recalibration. (See page 75).

STRAY LIGHT

The Smart3 Colorimeter should have no problems with stray light. Make sure that the sample compartment lid is always fully closed, except when testing COD with the adapter.

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TROUBLESHOOTING GUIDE

PROBLEM	*REASON*	*SOLUTION*
Flashing	Low battery. Readings are reliable.	Charge battery or use USB wall/computer adapter.
"Low Battery"	Battery voltage is very low. Readings are not reliable.	Charge battery or use USB wall/computer adapter.
"Shut Down Low Batt" Shut Down	Battery is too low to operate the unit.	Charge battery or use USB wall/computer adapter.
"Overrange"	Sample is outside of acceptable range.	Dilute sample and test again.
Unusually large negative or positive readings when performing calibration	Incorrect standards used to calibrate meter.	Use fresh 0.0 standard in clean tube. Reset meter to factory default settings. Recalibrate meter.

SOFTWARE TROUBLESHOOTING

PROBLEM	*REASON*	*SOLUTION*
No printer connected	Colorimeter has not been paired via Bluetooth, or pairing was lost by leaving Bluetooth range.	Re-pair the colorimeter to the printer.
Printer does not appear in the list of Bluetooth devices	Printer in not powered on.	Power on the printer
Connection lost	Bluetooth pairing with the printer was lost.	Re-pair the Printer to the colorimeter

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SMART3 Soil
Colorimeter

Test Procedures

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SMART3 SOIL COLORIMETER REAGENT SYSTEMS

■ SMART3 REAGENT SYSTEMS LIST

LaMotte Company continuously updates the list of pre-programmed tests as the calibrations become available.

Call LaMotte Technical Services at 1-800-344-3100 (410-778-3100 outside the USA) or email at tech@lamotte.com for a current list of available calibrations and more information.

Test Factor (Test #)	Range (ppm)	Test Method (# of Reagents)	# of Tests
Ammonia Nitrogen-High Range (008)	0.00–4.00	Nesslerization (2)	50
Calcium & Magnesium	0-4000 Calcium 0-2400 Magnesium	Schwarzenbach EDTA (8)	50
Chloride	0-1000	Direct Reading Titrator (2)	50
Copper-Thiocarbamate (036)	0.00–6.00	Diethyldithiocarbamate (1)	50
Copper-UDV (037)	0.0–4.0	Bicinchoninic Acid (1)	100
Iron-Bipyridyl (055)	0.00–6.00	Bipyridyl (2)	50
Manganese-High Range (059)	0.0–15.0	Periodate (2)	50
Nitrate Nitrogen-Low Range (065)	0.00–3.00	Cadmium Reduction (2)	20
Nitrite Nitrogen-Low Range (068)	0.00–0.80	Diazotization (2)	20
Phosphate-Low Range (081)	0.00–3.00	Ascorbic Acid Reduction (2)	50
Potassium (085)	0.0-10.0	Tetraphenylboron (2)	100
Sulfur (089)	0–100	Barium Chloride (1)	50
Zinc-Low Range (097)	0.00–3.00	Zincon (6)	50

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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 ($CaCO_3$)/acre.

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■ 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 that 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 Meter.
6. To convert conductivity to Soluble Salts (Total Dissolved Solids), use the following formula.

   ppm Soluble Solids (Total Dissolved Solids) = Micromhos/cm @ 25°C x 0.7

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■ 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.

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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.

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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 an * are considered to be potential health hazards. To view or print a Safety Data Sheet (SDS) for these reagents go to www.lamotte.com. Search for the four digit reagent code number listed on the reagent label, in the contents list or in the test procedures. Omit any letter that follows or precedes the four digit code number. For example, if the code is 4450WT-H, search 4450. To obtain a printed copy, contact LaMotte by email, phone or fax.

Emergency information for all LaMotte reagents is available from Chem-Tel: (US, 1-800-255-3924) (International, call collect, 813-248-0585).

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 a filtration procedure. Color interference may be eliminated by blanking the instrument with a sample blank.

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PROCEDURE

1. Press and hold ⏻ until colorimeter turns on.
2. Press ENTER to select **Testing Menu**.
3. Scroll to and select **All Tests** (or another sequence containing **008 Ammonia-N HR**) from **Testing Menu**.
4. Scroll to and select **008 Ammonia-N HR** from menu.
5. 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 waer. Mix and neutralize according to the procedure on page 84.
6. Insert tube into chamber, close lid and select **Scan Blank**. (See Note)
7. Remove tube from colorimeter. Add 12 drops of Ammonia Nitrogen Reagent #1 (V-4797). Cap and mix. Wait 1 minute.
8. 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.
9. 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.
10. Press ⏻ to turn the colorimeter off or press the EXIT exit to a previous menu or make another menu selection.

NOTE: It is strongly suggested that a reagent blank 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 is obtained.

Ammonia Nitrogen Concentration Chart

Pounds per Acre	Range
0-24 lb/acre	Low
25-68 lb/acre	Medium
Over 71 lb/acre	High

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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
50	Calcium Hardness Indicator Tablets	5250A-H
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	*Triethanolamine 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

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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.

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RANGE:	0-4000 lb/acre Calcium 0-2400 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 84.

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 and does not revert to red upon standing for 1 minute.
8. Read the test result from the scale where the large ring on the Titrator meets the Titrator barrel. 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 *Triethanolamine Reagent (3921).
4. Add 8 drops of *Sodium Hydroxide w/Metal Inhibitors (4259).

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5. Add one Calcium Hardness Indicator Tablet (5250A) 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 for 1 minute. Read the test result from the scale where the large ring on the Titrator meets the Titrator barrel. Multiply by 5.16. This is Titration Value B.

IV. FINAL RESULTS

Calcium Content = 0.4 x Titration Value B = ppm Ca

Magnesium Content = 0.24 (Value A - Value B) = 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 $CaCO_3$

Calcium = 0.4 x 520 = 208 ppm Ca
= 208 x 2 = 416 lb/acre Ca

Magnesium = 0.24 (640 - 520)
= 0.24 x 120 = 29 ppm Mg
= 29 x 2 = 58 lb/acre Mg

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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

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Emergency information for all LaMotte reagents is available from Chem-Tel: (US, 1-800-255-3924) (International, call collect, 813-248-0585).

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.

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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. Read the test result from the scale where the large ring on the Titrator meets the Titrator barrel. 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.

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COPPER

DIETHYLDITHIOCARBAMATE METHOD · CODE M3639-46-65-SC

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

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Emergency information for all LaMotte reagents is available from Chem-Tel: (US, 1-800-255-3924) (International, call collect, 813-248-0585).

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:	0.00–35.00 ppm Copper
METHOD:	Copper 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, mercurous, nickel and silver ions and chlorine (6 ppm or greater) interfere and must be absent.

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PROCEDURE

1. Press and hold ⏻ until colorimeter turns on.
2. Press ENTER to select **Testing Menu**.
3. Select **All Tests** (or another sequence containing **036 Cu Thiocarbamate**) from **Testing Menu**.
4. Scroll to and select **036 Cu Thiocarbamate** from menu.
5. Fill a clean tube (0290) to the 10 mL line with the soil extract then neutralize according to the procedure on page 84.
6. Insert tube into chamber, close lid and select **Scan Blank**.
7. Remove tube from colorimeter and add 5 drops of *Copper 1 (6446). Cap and mix. Solution will turn yellow if copper is present.
8. Insert tube into chamber, close lid and select **Scan Sample**. Multiply the result by 5 to determine the copper concentration in ppm.
9. Press ⏻ to turn colorimeter off or press EXIT 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

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IRON

BIPYRIDYL METHOD · CODE 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, plastic	0353
1	Spoon, 0.1 g, plastic	0699

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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.

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PROCEDURE

1. Press and hold ⏻ until colorimeter turns on.
2. Press ENTER to select **Testing Menu**.
3. Select **All Tests** (or another sequence containing **055 Iron Bipyridyl**) from **Testing Menu**.
4. Scroll to and select **055 Iron Bipyridyl** from menu.
5. Fill a clean tube (0290) to the 10 mL line with the soil extract then neutralize according to the procedure on page 84.
6. Insert tube into chamber, close lid and select **Scan Blank**.
7. Remove tube from colorimeter. Use the 0.5 mL pipet (0353) to add one measure of *Iron Reagent #1 (V-4450). Cap and mix.
8. 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.
9. At the end of 3 minute waiting period, DO NOT MIX. Insert tube into chamber, close lid and select **Scan Sample**. Multiply results by 5 to determine the iron concentration in ppm.
10. Press ⏻ to turn colorimeter off or press EXIT 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 is 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
Over 10.0 ppm	High

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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, plastic	0699
1	Spoon, 0.15 g, plastic	0727

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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 oxidizes soluble manganous compounds into permanganate.
INTERFERENCES:	Reducing substances capable of reacting with periodate or permanganate must be removed or destroyed before the periodate oxidation is attempted.

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PROCEDURE

1. Press and hold ⏻ until colorimeter turns on.
2. Press ENTER to select **Testing Menu**.
3. Select **All Tests** (or another sequence containing **059 Manganese HR**) from **Testing Menu**.
4. Scroll to and select **059 Manganese HR** from menu.
5. Fill a clean tube (0290) to the 10 mL line with the soil extract then neutralize according to the procedure on page 84.
6. Insert tube into chamber, close lid and select **Scan Blank**.
7. 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.
8. 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.
9. 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.
10. Press ⏻ to turn colorimeter off or press EXIT to exit to a previous menu or make another menu selection.

Mangansese 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	Very High

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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, 0.1 g, plastic	0699
1	Dispenser Cap	0692

***WARNING:** Reagents marked with an * are considered to be potential health hazards. To view or print a Safety Data Sheet (SDS) for these reagents go to www.lamotte.com. Search for the four digit reagent code number listed on the reagent label, in the contents list or in the test procedures. Omit any letter that follows or precedes the four digit code number. For example, if the code is 4450WT-H, search 4450. To obtain a printed copy, contact LaMotte by email, phone or fax.

Emergency information for all LaMotte reagents is available from Chem-Tel: (US, 1-800-255-3924) (International, call collect, 813-248-0585).

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 diazotization of sulfanilamide and nitrite followed by coupling with N-(1 naphthyl)-ethylenediamine dihydrochloride to form a highly colored azo dye which is measured colorimetrically.
INTERFERENCES:	Nitrite interferes at all levels. Strong oxidizing and reducing substances interfere. Low results might be obtained for samples that contain high concentrations of iron and copper.

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PROCEDURE

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

1. Press and hold ⏻ until colorimeter turns on.
2. Press ENTER to select **Testing Menu**.
3. Select **All Tests** (or another sequence containing **065 Nitrate-N LR**) from **Testing Menu**.
4. Scroll to and select **065 Nitrate-N LR** from menu.
5. Use the 1 mL pipet (0354) to add 1 mL of soil extract to a clean tube (0290) and dilute to the 10 mL line with deionized water. Cap tube and mix.
6. Insert tube into chamber, close lid and select **Scan Blank**.
7. Remove tube from colorimeter and pour off 5 mL of the diluted extract into graduated cylinder or similar. Discard the remaining diluted extract.
8. Pour the 5mL 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.
9. Use the 0.1 g spoon (0699) to add two measures of *Nitrate Reducing Reagent (V-6279). Cap.
10. 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.
11. 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.
12. Press ⏻ to turn colorimeter off or press EXIT 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.

To convert Nitrate Nitrogen (NO_3–N) results to ppm Nitrate (NO_3^-), multiply by 4.4.

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Nitrate-Nitrogen Concentration Chart

Pounds Per Acre	Range
0.0-9.0 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

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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, 0.1 g, plastic	0699
1	Dispenser Cap	0692

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Emergency information for all LaMotte reagents is available from Chem-Tel: (US, 1-800-255-3924) (International, call collect, 813-248-0585).

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 Nitrite-Nitrogen
METHOD:	The compound formed by diazotization of sulfanilamide and nitrite is coupled with N–(1–naphthyl)–ethylenediamine to produce a reddish-purple color, which is read colorimetrically.
INTERFERENCES:	There are few known interfering substances at concentration less than 1000 times the nitrite-nitrogen concentration; however, the presence of strong oxidants or reductants may readily affect nitrite concentrations. High alkalinity (above 600 mg/L) will give low results due to a shift in pH.

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PROCEDURE

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

1. Press and hold ⏻ until colorimeter turns on.
2. Press ENTER to select **Testing Menu**.
3. Select **All Tests** (or another sequence containing **068 Nitrite-N LR**) from **Testing Menu**.
4. Scroll to and select **068 Nitrite-N LR** from menu.
5. Use the 1 mL pipet (0354) to add 2 mL of soil extract to a clean tube (0290) and dilute to the 10 mL line with deionized water. Cap tube and mix.
6. Insert tube into chamber, close lid and select **Scan Blank**.
7. Remove tube from colorimeter and pour off 5 mL of the diluted extract into a graduated cylinder or similar. Discard the remaining diluted extract.
8. Pour the 5 mL diluted extract from the graduated cylinder 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.
9. 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.
10. 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.
11. Press ⏻ to turn colorimeter off or press EXIT button to exit to a previous menu or make another menu selection.

NOTE: To convert nitrite-nitrogen (NO_2–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	Medium High
Over 10 lb/acre	High

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PHOSPHATE

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, plastic	0699

***WARNING:** Reagents marked with an * are considered to be potential health hazards. To view or print a Safety Data Sheet (SDS) for these reagents go to www.lamotte.com. Search for the four digit reagent code number listed on the reagent label, in the contents list or in the test procedures. Omit any letter that follows or precedes the four digit code number. For example, if the code is 4450WT-H, search 4450. To obtain a printed copy, contact LaMotte by email, phone or fax.

Emergency information for all LaMotte reagents is available from Chem-Tel: (US, 1-800-255-3924) (International, call collect, 813-248-0585).

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.

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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^{-3} to form an antimony-phosphomolybdate complex. This complex is reduced to an intense blue colored complex by ascorbic acid. The color is proportional 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: a. No interference from copper, iron, or silicate at concentrations many times the concentration of sea water. However, high iron concentrations can cause precipitation and subsequent loss of phosphorus.

b. Salt error for samples ranging from 5% to 20% salt content was found to be less than 1%.

c. Mercuric chloride, $HgCl_2$, when used as the preservative, interferes when the chloride levels are low (less than 50 mg/L). This interference is overcome by spiking samples with a minimum of 50 mg/L of sodium chloride.

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PROCEDURE

1. Press and hold ⏻ until colorimeter turns on.
2. Press ENTER to select **Testing Menu**.
3. Select **All Tests** (or another sequence containing **081 Phosphate LR**) from **Testing Menu**.
4. Scroll to and select **081 Phosphate LR** from menu.
5. Use the 1 mL pipet (0354) to add 1 mL of soil extract to a clean tube (0290) and dilute to the 10 mL line with deionized water. Cap tube and mix.
6. Insert tube into chamber, close lid and select **Scan Blank**.
7. Remove tube from colorimeter. Use 1.0 mL pipet (0354) to add 1.0 mL of *Phosphate Acid Reagent (V-6282). Cap and mix.
8. Use the 0.1 g spoon (0699) to add one measure of Phosphate Reducing Reagent (V-6283). Cap and mx until powder dissolves. Wait 5 minutes for full color development. Solution will turn blue if phosphates are present.
9. 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.
10. Press ⏻ to turn colorimeter off or press EXIT 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 15mL 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.

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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

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POTASSIUM

TETRAPHENYLBORON METHOD · CODE M3639-46-65-SC

QUANTITY	CONTENTS	CODE
30 mL	*Sodium Hydroxide, 1.0N	*4004WT-G
5 g	*Tetraphenylboron Powder	*6364-C
1	Spoon, 0.05 g, plastic	0696

***WARNING:** Reagents marked with an * are considered to be potential health hazards. To view or print a Safety Data Sheet (SDS) for these reagents go to www.lamotte.com. Search for the four digit reagent code number listed on the reagent label, in the contents list or in the test procedures. Omit any letter that follows or precedes the four digit code number. For example, if the code is 4450WT-H, search 4450. To obtain a printed copy, contact LaMotte by email, phone or fax.

Emergency information for all LaMotte reagents is available from Chem-Tel: (US, 1-800-255-3924) (International, call collect, 813-248-0585).

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 ppm Potassium
METHOD:	Potassium reacts with sodium tetraphenylborate to form a colloidal white precipitate in quantities proportional to the potassium concentration.
INTERFERENCE:	Calcium and magnesium interfere at very high concentrations. Check for stray light interference (see p. 69).

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PROCEDURE

1. Press and hold ⏻ until colorimeter turns on.
2. Press ENTER to select **Testing Menu**.
3. Select **All Tests** (or another sequence containing **085 Potassium**) from **Testing Menu**.
4. Scroll to and select **085 Potassium** from menu.
5. Use the 1 mL pipet (0354) to add 2 mL of soil extract to a clean tube (0290) and dilute to the 10 mL line with deionized water. Cap tube and mix.
6. Insert tube into chamber, close lid and select **Scan Blank**.
7. Remove tube from colorimeter. Add 4 drops of *Sodium Hydroxide, 1.0N (4004WT). Cap and mix.
8. Use the 0.05 g spoon (0696) to add one measure of *Tetraphenylboron Powder (6364). Cap and shake vigorously for 20 seconds until all of the powder has dissolved. Wait 5 minutes.
9. 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.
10. Press ⏻ to turn colorimeter off or press EXIT 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±4°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

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SULFUR

BARIUM CHLORIDE METHOD · CODE M3639-46-65-SC

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

***WARNING:** Reagents marked with an * are considered to be potential health hazards. To view or print a Safety Data Sheet (SDS) for these reagents go to www.lamotte.com. Search for the four digit reagent code number listed on the reagent label, in the contents list or in the test procedures. Omit any letter that follows or precedes the four digit code number. For example, if the code is 4450WT-H, search 4450. To obtain a printed copy, contact LaMotte by email, phone or fax.

Emergency information for all LaMotte reagents is available from Chem-Tel: (US, 1-800-255-3924) (International, call collect, 813-248-0585).

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 a barium sulfate suspension 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. Check for stray light interference (see page 69).

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PROCEDURE

1. Press and hold ⏻ until colorimeter turns on.
2. Press ENTER to select **Testing Menu**.
3. Select **All Tests** (or another sequence containing **089 Sulfate HR**) from **Testing Menu**.
4. Scroll to and select **089 Sulfate HR** from menu.
5. 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.
6. Add 3 one gram measures of soil using the 1 g spoon (0697). Cap vial and shake for five minutes.
7. 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.
8. Fill a clean tube (0290) to the 10 mL line with the soil extract.
9. Insert tube into chamber, close lid and select **Scan Blank**.
10. 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.
11. Mix tube again. Insert tube into chamber, close lid and select **Scan Sample**. Multiply the results by 1.65 to determine the sulfur concentration in ppm.
12. Press ⏻ to turn colorimeter off or press EXIT to exit to a previous menu or make another menu selection.

NOTE: 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±4°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

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ZINC

ZINCON METHOD · CODE 3667-01-SC

QUANTITY	CONTENTS	CODE
30 mL	*Zinc Indicator Solution	*6314-G
120 mL	*Methyl Alcohol	*6319-J
10 g	Sodium Ascorbate Powder	6316-D
25 g	*Zinc Buffer Powder	*6315-G
15 mL	*Sodium Cyanide, 10%	*6565-E
30 mL	*Formaldehyde Solution, 37%	*5128-G
1	Dilute Zinc Indicator Solution" Bottle, w/1 pipet assembly	6321-MT-G
1	Graduated Cylinder, 10 mL, glass	0416
1	Spoon, 0.5 g, plastic	0698
2	Pipets, plain, plastic	0352
1	Spoon, 0.1 g, plastic	0699

***WARNING:** Reagents marked with an * are considered to be potential health hazards. To view or print a Safety Data Sheet (SDS) for these reagents go to www.lamotte.com. Search for the four digit reagent code number listed on the reagent label, in the contents list or in the test procedures. Omit any letter that follows or precedes the four digit code number. For example, if the code is 4450WT-H, search 4450. To obtain a printed copy, contact LaMotte by email, phone or fax.

Emergency information for all LaMotte reagents is available from Chem-Tel: (US, 1-800-255-3924) (International, call collect, 813-248-0585).

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.

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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.

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	Co (II)	30
Fe (III)	7	CrO4(II)	50
Fe (II)	9		

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PROCEDURE

A. PREPARATION OF DILUTE ZINC INDICATOR SOLUTION

1. Use a pipet (0352) to add exactly 5.0 mL of *Zinc Indicator Solution (6314) to a 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" (6321-MT-G).
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 (6321). Cap and mix ingredients in this bottle. Do not leave this bottle uncapped.

B. DETERMINATION OF ZINC

1. Press and hold ⏻ until colorimeter turns on.
2. Press ENTER to select **Testing Menu**.
3. Select **All Tests** (or another sequence containing **097 Zinc LR**) from **Testing Menu**.
4. Scroll to and select **097 Zinc LR** from menu.
5. Fill a clean tube (0290) to the 10 mL line with the soil extract then neutralize according to the procedure on page 84.
6. Insert tube into chamber, close lid and select **Scan Blank**. (See Note)
7. 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.
8. Add 3 drops of *Sodium Cyanide, 10% (6565). Cap and mix.
9. Use the 1 mL pipet assembly to add 1 mL of *Dilute Zinc Indicator Solution (6321). Cap and mix.
10. Use a second plain pipet (0352) to add 4 drops of *Formaldehyde Solution, 37% (5128). Cap and mix by inverting 15 times.
11. Insert tube into chamber, close lid and select **Scan Sample**. Multiply the result by 5 to determine the zinc concentration in ppm.
12. Press ⏻ to turn colorimeter off or press EXIT 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.

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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 is obtained.

Zinc Concentration Chart

Parts Per Million	Range
0.0-0.5 ppm	Low
0.6-1.0 ppm	Marginal
1.1-2.0 ppm	Adequate

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