



OPERATOR'S MANUAL



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SMART SPECTRO TEST INSTRUCTIONS

APPENDIX

GENERAL INFORMATION

■ PACKAGING & DELIVERY

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

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

■ GENERAL PRECAUTIONS

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

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

NEVER PUT WET TUBES IN SPECTROPHOTOMETER.

■ SAFETY PRECAUTIONS

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

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

Protect Yourself and Equipment: Use Proper Analytical Technique

■ 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 their products.

■ SPECIFICATIONS

■ INSTRUMENT TYPE: Single beam spectrophotometer

Readout	4 line, 20 character per line LCD
Wavelength Range	350-1000 nm
Wavelength Accuracy	± 2 nm
Wavelength Resolution	1 nm
Wavelength Bandwidth	5 nm (max)
Photometric Range	0-125%T, -0.1-2.5A
Photometric Accuracy	$\pm 0.005A$
Photometric Stray Light	$<0.5\%T$
Dispersive Device	1200 lines/mm ruled grating
Sample Chamber	Accepts 25 mm diameter flat-bottomed test tubes, 10 mm square cuvettes, 16 mm COD test tubes
Source Lamp	Quartz halogen
Modes	%/T, ABS, pre-programmed tests
Pre-Programmed Tests	YES, with automatic wavelength selection
User Defined Tests	Up to 25 user tests can be input
RS232 Port	8 pin mDIN
Power Requirements	Battery Operation (optional): Ni-Metal Hydride battery pack Line Operation: 110/220V, 50/60 Hz
Dimensions	36 cm (wide) x 28 cm (deep) x 17 cm (tall)
Weight	10.3 lbs, 4.65 kgs

■ STATISTICAL AND 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

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.

Precision: Precision is the numerical agreement between two or more measurements.³ The precision can be reported as a range for a measurement (difference between the min and max). It can also be reported as the standard deviation or the relative standard deviation. It is a measure of how close together the measurements are, not how close they are to the correct or true value. The precision can be very good and the accuracy very bad. This is a useful measure of the performance of a test method.

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

Accuracy: Accuracy is the nearness of a measurement to the accepted or true value.⁴ 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 know amount of analyte in a determination of the analyte (i.e. 103.5 %). This is a useful measure and what most customers are interested in when they want to know about the performance of a test method.

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

Resolution: Resolution is the smallest discernible difference between any two measurements that can be made.⁵ For meters this is usually how many decimal places are displayed. (i.e. 0.01). For titrations and various comparators it is the smallest interval the device is calibrated or marked to (i.e. 1 drop = 10 ppm, 0.2 ppm for a DRT, or \pm half a unit difference for an octaslide or color chart). 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. This is often done with various comparators. One caveat is, 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, very bad! This is not a useful measure of the performance of a test method.

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

Sensitivity: Sensitivity is the resolution based on how this term is used in LaMotte catalogs. This term is not listed in any of the references. Sometimes it is used for detection limit. It is a confusing term and should be avoided.

Repeatability: Repeatability is the within-run precision.⁶ 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.

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.

Reproducibility: Reproducibility is the between-run precision.⁷

7. 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

■ CONTENTS

SMART Spectro Spectrophotometer

Test Tubes, with Caps

Sample Cell Holder, Universal

Sample Cell Holder, 10 mm Square

Power Cable

Battery Charger

Power Supply, 110/220V

SMART Spectro Quick Start Guide

SMART Spectro Manual

NOTE: The battery pack is not included and must be purchased separately. An empty slot is placed in the foam packing material for the original shipment.

■ ACCESSORIES

Battery Pack with Holder (rechargeable)	Code 2000-BP
Cigarette Lighter Adapter	Code 1917
Carrying Case	Code 2000-CS
SMARTLink 2 Software with Cable (3.5 disk)	Code 1912-3
SMARTLink 2 Software with Cable (compact disk)	Code 1912-CD

■ EPA COMPLIANCE

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

■ CE COMPLIANCE

The SMART Spectrophotometer has been independently tested and has earned the European CE Mark of Compliance for electromagnetic compatibility and safety.

DECLARATION OF CONFORMITY

Application of Council Directives: 89/336/EEC

Standards to which Conformity Declared: EN61326-1:97, EN61000-3-2:1995,
EN61000-3-3:1995

Manufacturer's Name: LaMotte Company

Manufacturer's Address: 802 Washington Avenue
PO Box 329
Chestertown, MD 21620

Type of Equipment: Spectrophotometer

Model Name: SMART Spectro

Year of Manufacture: 2000

Testing Performed By: Intertek Testing Services
40 B Commerce Way
Totowa, NJ 07512

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

Chestertown, Maryland

Place

12/01/00

Date



Signature

Scott H. Steffen

Name

Director of Product Development

Position

CHEMICAL TESTING

■ WATER SAMPLING FOR CHEMICAL ANALYSIS

■ Taking Representative Samples

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

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

■ Sampling of Open Water Systems

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

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

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

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

For dissolved oxygen studies, or for tests requiring small sample sizes, a Water Sampler (LaMotte Code 1060) will serve as a subsurface or in-depth sampler. This weighted device is lowered to the sampling depth and allowed to rest at

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

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

▪ **Sampling of Closed System**

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

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

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

■ **FILTRATION**

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

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

■ AN INTRODUCTION TO COLORIMETRIC ANALYSIS & SPECTROSCOPY

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 LaMotte SMART Spectro 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 or spectrophotometer can be used to photoelectrically measure the amount of colored light absorbed by a colored sample in reference to a colorless sample (blank).

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

The SMART Spectro uses a quartz halogen lamp as the source of white light. The white light passes through an entrance slit and is focused on a ruled grating consisting of 1200 lines/mm. The grating causes the light to be dispersed into its various component wavelengths. The monochromator design allows the user to select which specific wavelength of interest will be passed through the exit slit and into the sample. The use of mirrors and additional filters prevents light of undesired wavelengths (overtones, stray light) from making it to the sample. A photodetector measures the amount of light which passes through the sample.

The difference in the amount of monochromatic light transmitted through a colorless sample (blank) and the amount of monochromatic light transmitted through a test sample is a measurement of the amount of monochromatic light absorbed by the sample. In most colorimetric tests the amount of monochromatic light absorbed is directly proportional to the concentration of the test factor producing the color and the path length through the sample. However, for a few tests the relationship is reversed and the amount of monochromatic light absorbed is inversely proportional to the concentration of the test factor.

The choice of the correct wavelength for testing is important. It is interesting to note that the wavelength that gives the most sensitivity (lower detection limit)

for a test factor is the complementary color of the test sample. For example the Nitrate-Nitrogen test produces a pink color proportional to the nitrate concentration in the sample (the greater the nitrate concentration, the darker the pink color). A wavelength in the green region should be selected to analyze this sample since a pinkish-red solution absorbs mostly green light.

■ REAGENT BLANK

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

NOTE: Some tests require a reagent blank to be used to **SCAN BLANK**.

■ SPECTROPHOTOMETER TUBES

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

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

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

■ SELECTING AN APPROPRIATE WAVELENGTH

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

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

Sample Color	Wavelength Range
Yellow	350-450
Yellow-Orange	450-490
Orange	490-510
Pink	510-570
Red	570-600
Green and Blue	600-750

■ CALIBRATION CURVES

The SMART Spectro contains over 40 precalibrated tests for the LaMotte reagent systems (see page 49). The first step in using a non-LaMotte reagent system with your SMART Spectro is to create a calibration curve for the reagent system. To create a calibration curve, prepare standard solutions of the test factor and use the reagent system to test the standard solutions with the SMART Spectro.

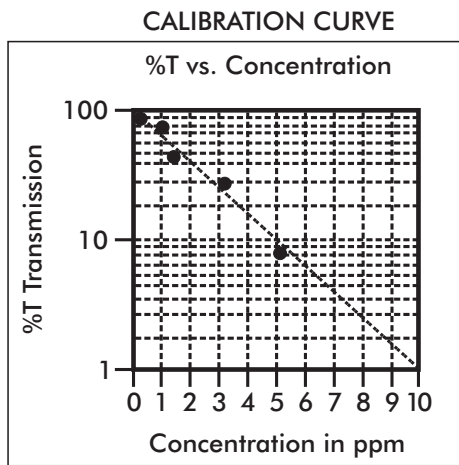
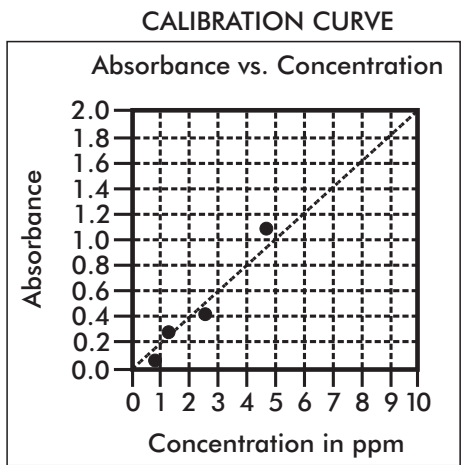
Plot the results (in ABS or %Transmittance) versus concentration to create a calibration curve. The calibration curve may then be used to identify the concentration of an unknown sample by testing the unknown, reading Absorbance or %T, and finding the corresponding concentration from the curve. The linear range of the reagent system can be determined and this information can be used to input a User Test into the SMART Spectro (see EDIT USER TESTS, page 33).

■ PROCEDURE

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

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

A sample of each type of graph appears below:



■ PREPARING DILUTE STANDARD SOLUTIONS

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

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

A sample chart appears below:

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

■ STANDARD ADDITIONS

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

For example, a 10.0 mL water sample was determined to contain 0.3 ppm iron. To a second 10.0 mL sample, 0.1 mL of 50 ppm iron standard was added. The concentration of iron due to the “spike” was $(0.10 \text{ mL} \times 50 \text{ ppm})/10.0 \text{ mL} = 0.50 \text{ ppm}$. The concentration of iron determined in the spiked sample should be $0.3 + 0.5 = 0.8 \text{ ppm}$ iron.

(Note: any error due to the increased volume from the “spike” is negligible).

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

■ SAMPLE DILUTION TECHNIQUES & VOLUMETRIC MEASUREMENTS

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

Example:

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

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

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

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

Example:

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

■ INTERFERENCES

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

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

Chlorine interference can be removed with the use of glycine. Very high levels of chloramines may interfere if the test result is not read immediately. Oxidized manganese interferences but can be removed with arsenite. Bromine and iodine interferes but can be removed with a thioacetamide blank correction.

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

■ STRAY LIGHT INTERFERENCE

Normal indoor lighting causes no interference with the SMART. Always be sure the sample chamber lid is closed when scanning blanks or samples.

OPERATION OF THE SMART SPECTRO

■ OVERVIEW

The SMART Spectro is a portable, microprocessor controlled, direct reading, single beam spectrophotometer. It has a 4 line, 20 character liquid crystal display for alphabetical and numerical messages. The operation is controlled with the keypad through menu driven software in response to selections shown on the display.

The test library consists of 100 LaMotte tests (not all 100 may be available at present) and 25 "User Tests". The spectrophotometer is also capable of running %T/Absorbance tests over the entire wavelength range of 350 - 1000 nm. The LaMotte tests are precalibrated for LaMotte reagent systems. The spectrophotometer displays the results 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 a quartz halogen bulb as a light source with a minimum life expectancy of 1000 hours. The incident white light is dispersed into its component wavelengths by a 1200 lines/mm ruled grating. The microprocessor controls the positioning of the grating, automatically positioning the grating to the correct wavelength for the test that has been selected. The monochromatic light is passed through the sample cell and is detected by a silicon photodiode.

The SMART Spectro is powered by an AC adapter that automatically recognizes the input voltage (110/220V) and converts it to the 12V needed to run the instrument. An optional battery pack is available for use where portability is important. To save power an automatic shut-off feature can be utilized (Energy Savings Mode).

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

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

■ POWER SOURCE

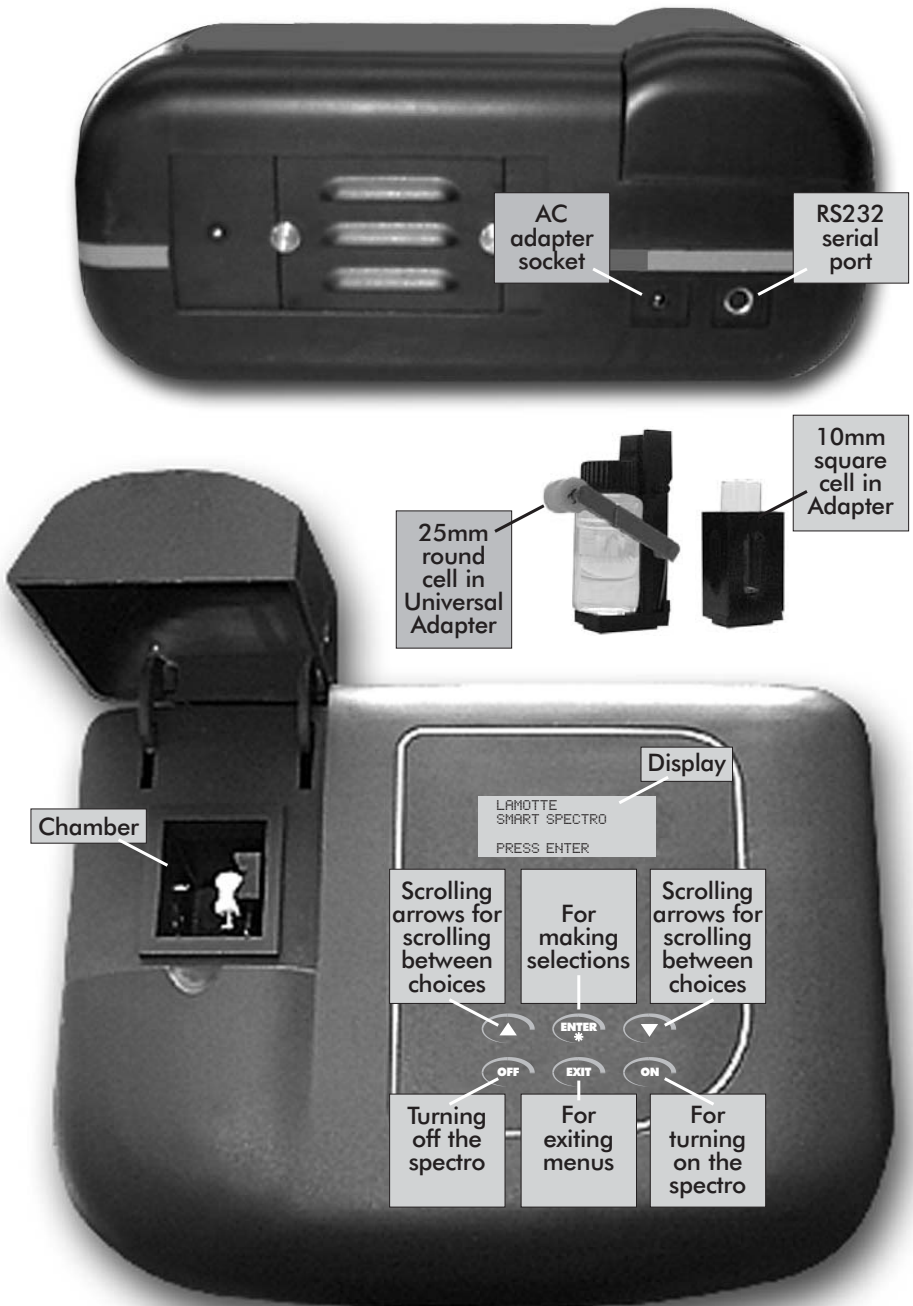
To use the SMART Spectro with an AC power supply:

1. Plug the Power Supply into the AC Adapter socket on the back of the SMART Spectro.
2. Connect the Power Cable to the Power Supply and an electrical outlet.

To use the Battery Pack, see page 45.

■ COMPONENTS

Figure 1 shows a diagram of the SMART Spectro and the components.



■ QUICK START

Some quick instructions to get into testing.

1. Press **ON** to turn on the SMART Spectro. The WELCOME screen will appear for about 2 seconds.

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2. The MAIN MENU screen will appear automatically.

MAIN MENU 12:45
*CALIBRATE WL
PROGRAMMED TESTS
%T/ABS

3. Press ▼ until the * is next to PROGRAMMED TESTS.

MAIN MENU 00:00
CALIBRATE WL
*PROGRAMMED TESTS
%T/ABS

4. Press **ENTER/*** to select PROGRAMMED TESTS. PROGRAMMED TESTS menu will appear.

PROGRAMMED TESTS
*SEQUENCE 1
SEQUENCE 2
SEQUENCE 3

5. Press ▼ until the * is next to ALL TESTS. Press **ENTER/***.

PROGRAMMED TESTS
SEQUENCE 2
SEQUENCE 3
*ALL TESTS

6. The ALL TESTS menu will appear.

ALL TESTS
*1 Aluminum
2 Alkalinity-TT
3 Ammonia-N-L F

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

ALL TESTS
13 CA Hard - UDU
14 Carbohydrazine
*15 Chlorine

Continued next page...

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

15 Chlorine
*SCAN BLANK
SCAN SAMPLE
END 515 NM

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

15 Chlorine
*SCAN BLANK
SCAN SAMPLE
END 515 NM

10. Insert reacted sample. Press **ENTER/*** to scan sample.

15 Chlorine
16.5%T @.7834 A
1.28 PPM
PRINT PRESS ENTER

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

GENERAL OPERATING PROCEDURES

The operation of the SMART Spectro 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 spectrophotometer 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 eight selections accessible from the MAIN MENU - CALIBRATE WL, PROGRAMMED TESTS, %T/ABS, PC LINK, EDIT CLOCK, ENERGY MODE, STORE METHOD, and TEST MODE.

■ THE KEYPAD

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

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

■ SAMPLE HOLDERS

The SMART Spectro Spectrophotometer is supplied with two removable sample cell holders. Each holder is secured in the chamber with a single screw. The square sample holder should be positioned so the arrow on the top is pointing toward the left. The square sample holder will hold 10 mm square cuvettes. The universal sample holder should be positioned with the V-channel toward the right side of the chamber. The universal sample holder will hold round tubes of varying diameters. When using the universal adapter, the tube should be placed between the white roller on the spring-loaded arm and the v-channel on the right-hand side of the adapter. Press the tube down on the white roller to retract the arm.

■ THE DISPLAY & THE MENUS

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

There are four lines in the display. The top line in each menu is a title or pertinent instruction. The top line does not change unless a new menu is selected. The second line is used in two ways. One way is to display additional information if the top line is insufficient. For example, test results are displayed on the second line. The second line is also used to display menu choices. The third and fourth line are also used for menu choices.

DISPLAY	TESTING MENU	TITLE or INSTRUCTION
	*FIRST CHOICE	MENU CHOICE WINDOW
	SECOND CHOICE	
	ANOTHER	
	AND ANOTHER	
	AND SO ON	
END OF LIST		

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

TESTING MENU	▼	TESTING MENU	▼	TESTING MENU
*FIRST CHOICE		SECOND CHOICE		ANOTHER
SECOND CHOICE		*ANOTHER		AND ANOTHER
ANOTHER		AND ANOTHER		*AND SO ON
AND ANOTHER		AND SO ON		END OF LIST
AND SO ON		END OF LIST		
END OF LIST				

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

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

CALIBRATION

■ CALIBRATE WAVELENGTH

The Calibrate Wavelength (CALIBRATE WL) mode is used to establish or re-establish the accuracy of the wavelength selection process. Normally, the Calibrate Wavelength procedure should be run after the SMART Spectro is turned **ON** and allowed to warm up for 15 minutes or if operating conditions (temperature, humidity, etc.) change significantly.

For field use, when operating with the battery, calibrate wavelength prior to going into the field using AC power. This will increase battery life in the field. Alternatively calibrate wavelength in the field immediately before testing. Turn Spectro on immediately before scanning blank. Calibrate wavelength just before scanning blank.

Press **ON** to turn on the SMART Spectro. The Welcome screen will appear for about 2 seconds.

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The MAIN MENU will appear.

MAIN MENU 12:45
*CALIBRATE WL
PROGRAMMED TESTS
%T/ABS

The * should be to the left of the Calibrate Wavelength listing. If it is, press **ENTER/*** to run the wavelength calibration procedure. If the * needs to be moved, use the **▲** or **▼** buttons to position it.

CALIBRATE WL
WAIT...
31696 37674

The Calibrate Wavelength procedure takes about 1-2 minutes to be completed. During the calibration, the Spectro will display two numbers at the bottom of the screen. The first number is fixed. The second number will change and can have a range of values. The microprocessor will move the grating in search of the position that gives a very specific maximum light intensity. The microprocessor will then move the grating a precise predetermined amount from this position. This precise movement will cause the grating to be positioned at 546 nm every time. Once calibrated the wavelength displayed during testing is accurate to ± 2 nm. When the wavelength calibration is complete the display will go back to the Main Menu.

PROGRAMMED TESTS

■ INTRODUCTION

The PROGRAMMED TESTS mode is used to run all LaMotte pre-programmed tests and USER TESTS. This is also where USER TESTS and SEQUENCES are set-up and edited.

Press **ON** to turn on the SMART Spectro.
The WELCOME screen will appear.

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The MAIN MENU will appear.

MAIN MENU 12:45
*CALIBRATE WL
PROGRAMMED TESTS
%T/ABS

Using the **▲** or **▼** buttons move the * to the left of the Programmed Tests line. Press **ENTER/***. The PROGRAMMED TESTS menu will appear. In the PROGRAMMED TESTS menu, there are 3 alterable sequences and 1 fixed sequence, as well as the Edit function.

PROGRAMMED TESTS
*SEQUENCE 1
SEQUENCE 2
SEQUENCE 3
ALL TESTS
EDIT
END OF LIST

■ SEQUENCES OF TESTS

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

SEQUENCE 1
*60 Molybdenum LR
79 Phosphate H
9 Bromine LR
76 pH TB
15 Chlorine
86 Silica HI
45 Hydrazine
32 Copper DDC
51 Iron Bipyr
END OF LIST

SEQUENCE 2
*1 Aluminum
35 Cyanide
41 Fluoride
53 Iron Phen
55 Manganese L
64 Nitrate N LR
26 COD Low
77 Phenols
78 Phosphate L
90 Sulfide LR
END OF LIST

SEQUENCE 3
*3 Ammonia-N L F
32 Copper DDC
64 Nitrate-N LR
67 Nitrite-N LR
74 pH CPR
78 Phosphate L
85 Silica Lo
END OF LIST

NOTE: Sequences always end with END OF LIST to indicate that there are no more tests in the sequence.

These alterable sequences allow a series of tests to be setup that are run frequently. The order of the individual tests in the sequence is determined by the user. After running a test, press **EXIT** to escape back to the Sequence menu. Move the ▼ down to the next test listed and press **ENTER/***. Continue this pattern until the entire sequence has been completed.

ALL TESTS is a fixed sequence containing the LaMotte pre-programmed tests and User Tests.

Modification of the alterable sequence is accomplished through the **EDIT** function. This function is explained in detail in the section titled EDIT.

It should be noted that if a %T/ABS test is to be included in a sequence, the %T/ABS test must first be setup as a User Test (but no actual calibration needs to be performed, only select a name and wavelength).

Pressing the **EXIT** button while in a sequence menu will escape back to the PROGRAMMED TESTS menu.

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

■ GENERAL TESTING PROCEDURES

The following are some step by step examples of how to run tests from the PROGRAMMED TESTS menu. These test procedures are designed to be used with LaMotte SMART Spectro reagent systems.

■ TESTING WITH THE LaMOTTE PROGRAMMED TESTS

Scroll to ALL TESTS with the ▼ button in the PROGRAMMED TESTS menu.

PROGRAMMED TESTS
SEQUENCE 2
SEQUENCE 3
*ALL TESTS

Press the **ENTER/*** button to select ALL TESTS.

Press **ENTER/*** button to select 1 Aluminum.

ALL TESTS
*1. Aluminum
2. Alkalinity-TT
3. Ammonia-N L F
:
:
125 User Test 25
END OF LIST

The SMART Spectrophotometer is ready to scan; the correct wavelength has been selected. Place the blank in the sample chamber and press the **ENTER/*** button one time to scan blank (Note: do not keep the button depressed). The spectrophotometer will scan and store the blank and the * will be positioned next to SCAN SAMPLE.

1 Aluminum
*SCAN BLANK
SCAN SAMPLE
END 535NM

Place the reacted sample in the chamber and press the **ENTER/*** button to scan the sample. The spectrophotometer will scan the sample and the results screen will appear.

1 Aluminum
SCAN BLANK
*SCAN SAMPLE
END 535NM

Continued on next page ...

The spectrophotometer will scan the sample and the results screen will appear.

1 Aluminum
99.8%T 0.0015A
0.01 PPM
PRINT PRESS ENTER

Press **ENTER/*** to print the result when connected to a printer or computer. To repeat the test, press **EXIT** to escape to the test screen, then press the **ENTER/*** button to scan the sample again. The last blank scanned is used to zero the spectrophotometer for repeat scans. A different blank can be used by pressing the **▲** button to scroll back to **SCAN BLANK** and then scanning another blank.

1 Aluminum
99.8%T 0.0015A
0.01 PPM
PRINT PRESS ENTER

Press the **EXIT** button to escape back to the **PROGRAMMED TESTS** menu, if no more samples are to be scanned for this test.

1 Aluminum
SCAN BLANK
*SCAN SAMPLE
END 535NM

SETUP & EDIT SEQUENCES & USER TESTS

The EDIT menu allows any of the three alterable test sequences (SEQUENCE 1, SEQUENCE 2, and SEQUENCE 3) and any of the 25 User Tests in the ALL TESTS fixed sequence to be edited. This feature allows a sequence or test which is used frequently to be set-up for easy access. The order of the sequence can be arranged to suit the needs of the user. Any combination, and any order of tests from ALL TESTS (including User Tests), may be placed into these sequences.

■ EDIT A SEQUENCE

Go to the PROGRAMMED TESTS menu. Move the * down using ▼ button until the * is to the left of EDIT. Press the **ENTER/*** button

PROGRAMMED TESTS
SEQUENCE 3
ALL TESTS
*EDIT

The EDIT menu appears.

EDIT
*EDIT SEQUENCE 1
EDIT SEQUENCE 2
EDIT SEQUENCE 3

■ ADDING OR DELETING TESTS

There are two ways to alter a sequence - INSERT and DELETE.

INSERT is used to add a new test to a sequence and to place the new test before an existing test in a sequence.

DELETE is used to remove an existing test from a sequence.

- **Below is a step by step example of how to add a test to SEQUENCE 3 starting from the EDIT menu.**

Use the ▼ button to scroll to EDIT SEQUENCE 3 in the EDIT menu. Press **ENTER/*** button to select EDIT SEQUENCE 3.

EDIT
EDIT SEQUENCE 1
EDIT SEQUENCE 2
*EDIT SEQUENCE 3

Press **ENTER/*** button to select END OF LIST.

EDIT SEQUENCE 3
*END OF LIST

Press **ENTER/*** button to insert a test before END OF LIST menu.

EDIT SEQUENCE
*INSERT
DELETE
END OF LIST

Press the ▼ button to scroll to 78 Phosphate L test. Press **ENTER/*** button to select 78 Phosphate L from the list and insert it before END OF LIST. The display will automatically return to EDIT SEQUENCES menu.

INSERT
76 pH TB
77 Phenol
*78 Phosphate L
79 Phosphate H
:
:
END OF LIST

Continued on next page...

Press **ENTER/*** button to select Phosphate L.

EDIT SEQUENCE 3
*78 Phosphate L
END OF LIST

Press **ENTER/*** to insert a test before PHOSPHATE L.

EDIT SEQUENCE 3
*INSERT
DELETE
78 Phosphate L

Press **ENTER/*** to select 1 Aluminum from the list and insert it before Phosphate L. The display will automatically return to EDIT SEQUENCE 3 menu.

INSERT BEFORE
*1 Aluminum
2 Alkalinity-TT
3 Ammonia-N L F
:
:
:
END OF LIST

SEQUENCE 3 has now been modified and will remain until it is edited again. To run a test in SEQUENCE 3 go to the PROGRAMMED TESTS menu.

Press the **EXIT** button to exit the EDIT SEQUENCE 3 menu and return to the EDIT menu.

EDIT SEQUENCE 3
*1 Aluminum
78 Phosphate L
END OF LIST

Press the **EXIT** button to exit the EDIT menu. The SMART Spectro will automatically save any changes and go to the PROGRAMMED TESTS menu.

EDIT
*EDIT SEQUENCE 1
EDIT SEQUENCE 2
EDIT SEQUENCE 3
EDIT USER TESTS
END OF LIST

- **Below is an example of how to delete a test from SEQUENCE 3, which was just created, starting from the EDIT menu.**

Use the ▼ button to scroll to EDIT SEQUENCE 3 in the EDIT menu. Press **ENTER/*** button to select EDIT SEQUENCE 3.

EDIT
EDIT SEQUENCE 1
EDIT SEQUENCE 2
*EDIT SEQUENCE 3

Press **ENTER/*** button to select 1 Aluminum for deletion.

EDIT SEQUENCE 3
* 1 Aluminum
78 Phosphate L
END OF LIST

Use the ▼ button to scroll to DELETE.

EDIT SEQUENCES
INSERT BEFORE
*DELETE
1 Aluminum

Press **ENTER/*** button to delete 1 Aluminum and return to EDIT SEQUENCE 3 in menu.

EDIT SEQUENCES
INSERT BEFORE
*DELETE
1 Aluminum

1 Aluminum is no longer in SEQUENCE 3. Press **EXIT** button to exit EDIT SEQUENCE 3 menu and return to EDIT menu.

EDIT SEQUENCE 3
*78 Phosphate L
END OF LIST

Press the **EXIT** button to exit the EDIT menu. The SMART Spectro will automatically save any changes and go to the PROGRAMMED TESTS menu.

EDIT
*EDIT SEQUENCE 1
EDIT SEQUENCE 2
EDIT SEQUENCE 3
EDIT USER TESTS
END OF LIST

■ 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 and select the number of decimal places used to display the results. 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 between 1 and 8 data points. The curve fitting options of linear least squares or linear least squares through zero are available. This requires that the test have a linear calibration, if accurate results are expected. The spectrophotometer 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 lowest concentration and finishing with the highest concentration (for more information about this, see CALIBRATION CURVES, page 13). Prepare these solutions prior to entering a new calibration.

NOTE: A calibration procedure must be performed before using any of the User Tests. If a User Test is selected before a calibration has been entered the message `not yet available press exit please` will appear.

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

To edit a User Test, go to the PROGRAMMED TESTS menu. Move the * down using the ▼ button until the * is to the left of EDIT. Press the **ENTER/*** button to access the EDIT menu

PROGRAMMED TESTS
SEQUENCE 3
ALL TESTS
*EDIT

Scroll down to EDIT USER TESTS. Press **ENTER/*** to select the EDIT USER TESTS options.

EDIT
EDIT SEQUENCE 2
EDIT SEQUENCE 3
*EDIT USER TESTS

Continued on next page...

From the EDIT USER TESTS menu, select the User Test to be entered or changed. In this example, choose 101 User Test 1. Use the ▼ and ▲ buttons to scroll to other User Tests if desired. Select the USER TEST by pressing the **ENTER/*** button.

EDIT USER TESTS
*101 User Test 1
102 User Test 2
103 User Test 3
104 User Test 4
:
END OF LIST

NOTE: This menu allows a test to be renamed, a wavelength to be selected, reacted standards to be scanned and the numerical format of the displayed test result to be selected. After editing any one of these menu choices the display will return to this menu. Any menu choice can be edited at any time by selecting it. The normal procedure would be to start with NAME THE TEST, then SELECT WAVELENGTH, then NEW CALIBRATION, and then FORMAT RESULT.

101 User Test 1
*NAME THE TEST
SELECT WL
NEW CALIBRATION
FORMAT RESULT
END OF LIST

■ NAMING THE TEST

A NAME can be up to 14 characters long. The menu choices for each character are 26 letters A to Z, ten numerals 0 to 9, a space, a dash, a decimal point, and a ! as a terminator. Selecting the terminator indicates the end of the name and stores the name. The terminator, !, is the first menu choice since it is the one character that will always have to be selected. It is before the letter A. DO NOT CHOOSE THE ! UNTIL THE NAMING OF THE TEST HAS BEEN COMPLETED. The terminator should be selected following the end of the name. It must be the last character selected.

From 101 User-Test 1 menu press the **ENTER/*** button to select NAME THE TEST and change the name of User-Test 1.

101 User-Test 1
*NAME THE TEST
SELECT WAVELENGTH
NEW CALIBRATION
FORMAT RESULT
END OF LIST

Scroll to CHANGE and press **ENTER/*** to select CHANGE. In this example the new test name will be H2O. The characters of the name will be selected one at a time, from left to right.

NAME THE TEST
KEEP
*CHANGE
END OF LIST

NOTE: Select KEEP to go back to 101 User-Test 1 menu. Select CHANGE to change the name of test 101.

Press the ▼ button to scroll right to the letter H. Selection of characters is controlled by moving the blinking cursor over top of the letter to be chosen. The ▲ button scrolls left. The ▼ button scrolls right. Press **ENTER/*** with the blinking cursor over the letter H to select it. The letter H will appear now in line next to 101. Continue in this fashion until entire H2O is entered. Press **EXIT** to delete/erase any incorrect entry and start over. Select ! at the end of the name to save the name. The display will return to the KEEP CHANGE menu. Select KEEP to save the name and return to 101 H2O menu. Note that test 101 is named H2O.

NAME THE TEST
101
!ABCDEFGHIJKLMNPOQR
STUVWXYZ

NAME THE TEST
*KEEP
CHANGE
END OF LIST

Continued on next page...

■ SELECTING THE WAVELENGTH

Scroll to **SELECT WL**. Press **ENTER/*** to choose **SELECT WL**.

101 H2O
NAME THE TEST
*SELECT WL
NEW CALIBRATION
FORM AT RESULT

Use ▲ and ▼ to scroll to the appropriate **WAVELENGTH**.

SELECT WAVELENGTH
600 NM
SET PRESS ENTER

Press **ENTER/*** to select the wavelength. Display goes back to 101 H2O screen.

101 H2O
*NAME THE TEST
SELECT WAVELENGTH
NEW CALIBRATION
FORMAT RESULT

■ ENTERING A NEW CALIBRATION

Scroll to **NEW CALIBRATION**. Press the **ENTER/*** button.

101 H20
NAME THE TEST
SELECT WAVELENGTH
*NEW CALIBRATION
FORMAT RESULT

The **INPUT DATA NUMBERS** menu appears. Using the ▲ and ▼ buttons set the number of data points to be used. When finished press the **ENTER/*** button. The **NEW CALIBRATION** menu appears.

INPUT DATA NUMBERS
DATA NUMBERS = 8
SET PRESS ENTER

The **NEW CALIBRATION** menu allows the entry of the data points. Select **ENTER STD. 1** by pressing **ENTER/*** button while the * is adjacent to **ENTER STD. 1** in the display.

NEW CALIBRATION
*ENTER STD. 1
ENTER STD. 2
ENTER STD. 3

ENTER STD. 8

CALCULATE

Place a blank in the sample chamber. Press the **ENTER/*** button to **SCAN BLANK**. This is the only choice.

ENTER STD. 1
*SCAN BLANK
STD. 1=
!0123456789.

The menu will indicate the Spectro is blanking.

ENTER STD. 1
BLANKING
STD. 1=
!123456789.

When **BLANKING** is finished the display will indicate **BLANKED** and a blinking cursor will appear on the character selection line.

ENTER STD. 1
BLANKED
*STD. 1=
!0123456789.

Continued on next page ...

The * moves automatically to the STD 1.= line. Place the reacted standard into sample chamber beginning with the lowest concentration. Use the ▲ and ▼ buttons to enter the concentration of the standard by selecting the characters with the blinking cursor.

ENTER STD.1
BLANKED
*STD.1. = 1.0
!0123456789.

After entering the concentration, select the ! terminator. The standard will then be scanned. The absorbance will be displayed.

NOTE: Sample must be in chamber when ! is selected.

ENTER STD.1
BLANKED
STD.1 = 1.0
A=0.0016A

Press the **EXIT** button to go back to the NEW CALIBRATION menu. The * will be next to ENTER STD. 2. Press **ENTER/*** button to input the next standard into the calibration.

NEW CALIBRATION
ENTER STD.1
*ENTER STD.2
ENTER .3

Press **ENTER/*** to SCAN BLANK, enter the concentration and scan the standard for standard 2. Repeat this procedure until all standards are input into the calibration.

NOTE: Input standards for the number of data points previously selected.

For example:

When inputting 7 standards, ignore request for ENTER STD. 8.

ENTER STD.2
*SCAN BLANK
STD.2=
!0123456789.

When finished inputting standards scroll down (in the NEW CALIBRATION menu) to the CALCULATE selection. Select CALCULATE.

NEW CALIBRATION
ENTER STD.7
ENTER STD.8
*CALCULATE

Continued on next page...

When finished inputting standards scroll down (in the NEW CALIBRATION menu) to the CALCULATE selection. Select CALCULATE.

NEW CALIBRATION
ENTER STD.7
ENTER STD.8
*CALCULATE

From the SELECT DEGREES menu scroll to and select either 1 DEGREE THRU.0 or 1 DEGREE.

SELECT DEGREES
*1 DEGREE THRU.0
1 DEGREE

NOTE: 1 DEGREE THRU.0 calculates the best straight line fit through the data points and intersects with the origin at 0 ppm, 0 absorbance. This is a classical Beers Law calibration. 1 DEGREE calculates the best straight line fit but without forcing the line through the origin. The minimum number of standards needed for a calibration is one for 1 DEGREE THRU.0 and two for 1 DEGREE.

Press **ENTER/*** button to select the curve fit type. The display will show the constants for the best fit line.

K0=0.0000 E+00
K1=1.0000 E+00
K2=0.0000 E+00
K3=0.0000 E+00

Press **EXIT** button to escape back to SELECT DEGREES menu. Press **EXIT** button again to escape back to Input Data Numbers menu. Press **EXIT** button to escape back to 101 H20 menu.

101 H20
*NAME THE TEST
SELECT WAVELENGTH
NEW CALIBRATION
FORMAT RESULT

■ SELECTING THE NUMERICAL FORMAT OF THE RESULT

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

Scroll to **FORMAT RESULTS** and press **ENTER/*** button to select **FORMAT RESULTS** while in the **101 H2O** menu.

101 H2O
SELECT WAVELENGTH
NEW CALIBRATION
*FORMAT RESULT
END OF LIST

Scroll to the number of decimal places to be shown. Press **ENTER/*** button to select that number format.

DECIMAL PLACES?
*0 PLACES
1 PLACES
2 PLACES
3 PLACES
END OF LIST

The **101 H2O** menu will appear:

Since no more editing needs to be done press **EXIT** button to escape to **EDIT USER TESTS** menu.

101 H2O
NAME THE TEST
SELECT WAVELENGTH
NEW CALIBRATION

Continued on next page ...

Press **EXIT** button again to escape to EDIT menu and once again to escape to PROGRAMMED TESTS menu.

NOTE: Test 101 was USER TEST 1 and now is H2O. It is still a USER TEST because its calibration can be changed but it has a different name.

EDIT
*EDIT SEQUENCE 1
EDIT SEQUENCE 2
EDIT SEQUENCE 3

PROGRAMMED TESTS
*SEQUENCE 1
SEQUENCE 2
SEQUENCE 3

ALL TESTS

EDIT

END OF LIST

MEASURING IN THE %T/ABS MODE

Scroll to %T/ABS with the ▼ button in the MAIN MENU. Press **ENTER/*** button to select %T/ABS.

MAIN MENU 00:00
CALIBRATE WL
PROGRAMMED TESTS
*%T/ABS

The wavelength appears at the top right of the display. Press **ENTER/*** button while * is next to SELECT WL in display to change the wavelength.

%T/ABS 604 NM
*SELECT WL
SCAN BLANK
SCAN SAMPLE
END OF LIST

Use the ▼ ▲ buttons to display the appropriate wavelength. Push **ENTER/*** button to select that wavelength. (Here 530 is selected as an example.)
The SMART Spectro is ready to scan.

SELECT WL
WL=530

Insert blank into sample chamber and push **ENTER/*** button to scan blank.

%T/ABS 530NM
SELECT WL
*SCAN BLANK
SCAN SAMPLE
END OF LIST

NOTE: For most %T/ABS tests, a clear colorless water blank should be used.

Insert a reacted sample in the sample chamber and push **ENTER/*** button to scan sample.

%T/ABS 530NM
SELECT WL
SCAN BLANK
*SCAN SAMPLE
END OF LIST

Continued on next page ...

At this point, it is possible to scan another sample, scan another blank, or select another wavelength. To print the results to a connected computer or serial printer, press **ENTER/*** and return to previous menu. Press **EXIT** to escape to previous menu.

%T/ABS 530NM
T=90.7%T
A=0.0424A
PRINT PRESS ENTER

If no more samples are to be scanned, press **EXIT** to return to the MAIN MENU or press the **OFF** button to turn off the spectrophotometer.

%T/ABS 530NM
SELECT WAVELENGTH
SCAN BLANK
*SCAN SAMPLE

PC LINK

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

The spectrophotometer may also be interfaced with an RS-232 serial printer, using an interface cable (Code 1772) and setting the printer configuration to the Output below (see Computer Connection, below).

Choose **PC LINK** from the Main Menu. The user has the option to download the last 25 results or the entire datalogging buffer (500 results). Downloading does not delete or empty the datalogger.

■ OUTPUT

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

■ COMPUTER CONNECTION

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

EDIT CLOCK

Select **EDIT CLOCK** from the Main Menu. The user can enter the year/month/day/hour/minute/second. This information is used to time stamp the results for the datalogger.

ENERGY MODE

Select **ENERGY MODE** from the Main Menu. There are two selections, **NORMAL** and **SAVE**. **NORMAL** is the default setting. The unit will stay on all of the time. **SAVE** activates the energy savings mode. This mode helps conserve battery and lamp life. With **SAVE** activated the unit will shut off after 10 minutes of inactivity. Pressing any button during the 10 minutes causes the 10 minute shut down time to start over.

STORE METHOD

Select **STORE METHOD** from the Main Menu. There are two selections, **AUTO** and **MANUAL**. **AUTO** is the default setting. All results are automatically stored into the datalogger. **MANUAL** allows the user to determine whether they want to store the result or not. If **MANUAL** is selected the user is prompted after each test to **STORE RESULT PRESS ENTER**.

TEST MODE

Select **TEST MODE** from the Main Menu. Test Mode allows the user to change the way that blanking and reading of results is carried out during the %T/ABS testing. It does not affect any of the Pre-programmed tests. **REGULAR** is the default test mode and should be used whenever the blank is clear or has less absorbance than the samples. This will be the case most of the time. In the rare instances where the blank will be darker or have more absorbance than the samples the Test Mode must be switched to **REVERSE** to avoid error messages and incorrect readings.

The Test Mode should always be returned to **REGULAR** at the end of any testing session.

BATTERY OPERATION

The SMART Spectro can be run using battery power. The battery pack consists of a rechargeable Ni-metal hydride battery pack. The battery pack is not included in the standard meter package and must be purchased as an accessory (Code 2000-BP). The battery charger comes standard with each SMART Spectro.

■ CHARGING THE BATTERY PACK

1. Connect the Power Supply to the Battery Charger.
2. Connect the Battery Charger to the Battery Pack.
3. The battery pack will automatically charge. (For older battery packs with a switch, move the switch to the **CHARGING** position.) A full charge will require about 5 hours.

■ RUNNING THE SMART SPECTRO USING BATTERIES

Connect the Battery Pack to the SMART Spectro.

CAUTION: Do not connect the Power Supply directly to the Battery Pack. The connectors will not fit. Don't force them.

MAINTENANCE

■ CLEANING

Clean with a damp, lint-free cloth.

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

■ LIGHT BULB

The quartz halogen bulb in the SMART has an approximate life of 1000 hours. If a test is performed and there is no response and the unit is receiving adequate power, the light bulb may need to be replaced. With the meter power ON check the rear lamp access panel to see if any light can be observed through the vents. If the lamp is not ON please contact LaMotte Technical Services Department by phone at 800-344-3100 or 410-778-3100, fax 410-778-6394, or e-mail LaMotte.com for assistance.

■ CLOCK BATTERY

The SMART date/clock function is powered by its own battery. This battery should be replaced about every 3 years. If the date or clock function stops running please contact LaMotte Technical Services Department by phone at 800-344-3100, fax 410-778-6394, or e-mail lamotte.com for assistance.

TROUBLESHOOTING GUIDE

■ ERROR MESSAGES

▪ OUT OF RANGE

If the message OUT OF RANGE 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 & Volumetric Measurements, page 14).

▪ BATTERY

If the symbol **BAT** appears in the upper left corner of the display when using the battery pack, the battery needs to be charged. The SMART Spectro will turn off if the battery power becomes too low.

▪ ERROR 1 TROUBLE WITH FILTER

There is a problem with filter positioning. This could be due to a dead motor, bad connection to the motor, or a bad positioning detector. Contact LaMotte Technical Service for help.

▪ **ERROR 2 TROUBLE WITH SWITCH**

There is a problem with the grating positioning. This could be due to a dead stepping motor, bad connection to stepping motor, or a bad micro switch. Contact LaMotte Technical Service for help.

▪ **ERROR 3 TROUBLE WITH LIGHT**

There is a problem locating the zero order light during wavelength calibration. Contact LaMotte Technical Service for help.

▪ **WARNING SIGNAL TOO WEAK**

Not enough light is getting to the detector. Check light path for blockage. Check lamp position. Try recalibrating wavelength.

▪ **WARNING SIGNAL TOO STRONG**

This can be an indication that the meter was accidentally shut-off during wavelength calibration. Shut meter off and restart.

▪ **WARNING RAM BATTERY LOW**

Clock battery needs to be replaced soon. If it fails all user tests and Datalog Data will be lost. Unit can be run without this battery. Just use line power and leave unit on.

■ **HELPFUL HINTS**

▪ **POWER**

The power supply has an internal switch that handles both 110V and 220V input.

▪ **STRAY LIGHT**

The SMART Spectro should have no problems with stray light. Make sure that the sample compartment lid is always fully closed.

▪ **ACCIDENTAL LOSS OF POWER**

If for any reason the meter experiences a loss of power during wavelength calibration, the next time the meter is powered up a wavelength calibration will automatically be performed.