

YSI MODEL 23L LACTATE ANALYZER INSTRUCTION MANUAL



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PRICE INCLUDING HANDLING \$20.00

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GENERAL INFORMATION

INTENDED USE OF THE YSI MODEL 23L LACTATE ANALYZER

The YSI Model 23L Lactate Analyzer (Figure 1) is a quantitative device for the discrete measurement of L-Lactate in whole blood, lysed whole blood, plasma and cerebrospinal fluid. In sports medicine, metabolic studies, critical care situations, or the like, whole blood lactate* can be assayed from a sample of only 25 μ l within 45 seconds after the sample has been drawn from the patient. Forty-two samples may be assayed every hour.

Extracellular lactate in the plasma is measured when a sample of whole blood is injected into the Model 23L. The intercellular lactate remains in the erythrocytes and is not measured; because of the isotonicity of the instrument buffer, no measurable transport across the erythrocyte membrane takes place during the brief assay.

If it is desirable to determine total blood lactate (plasma and erythrocyte lactate), whole blood can be placed in a YSI 2372 Total Blood Lactate Tube, whereby the lactate will be released from the erythrocytes and then can be immediately assayed. Results of YSI Total Blood Lactate assays show excellent correlation with methods using perchloric acid.

Although deproteinizing agents also release lactate from the erythrocytes, they must not be used with the 23L since these agents will completely and irreversibly destroy the lactate oxidase in the lactate membrane.



Figure 1. The YSI 23L Lactate Analyzer

Plasma lactate can be determined directly from erythrocyte-free samples containing typical anticoagulants such as oxalates, or heparin and sodium fluoride to inhibit lactate formation.

Cerebrospinal fluid (CSF) may be analyzed immediately after withdrawal from the subject with no further preparation of the sample.

The analyzer is linear within the range of 0-15.0 millimoles per liter (mmol/l). Concentrations above 15.0 mmol/l may be diluted for assay.

*Throughout this manual, "lactate" will always mean L-Lactate.

Biochemical and drug interferences are minimal with this device. The results of our tests for interference are tabulated in **Effects of Selected Substances**.

PRINCIPLES OF OPERATION

In the discussion that follows, chemical and electrochemical reactions are simplified for clarity.

The tip of the lactate probe (Figure 2) is covered by a three-layer membrane which serves to protect the electrodes and to define a diffusion path to them. The outer layer is a polycarbonate material with a nominal pore size of 0.03 micrometers, which is large enough to readily pass oxygen, hydrogen peroxide, water, and salt, but small enough to restrict the diffusion of enzymes. The inner layer is a cellulose acetate material with a much smaller pore size which excludes ascorbic acid and most other potentially interfering substances from the electrodes while still allowing hydrogen peroxide, oxygen, water, salts, etc. to pass through. Between these membranes is a layer of glutaraldehyde-crosslinked L-Lactate oxidase.

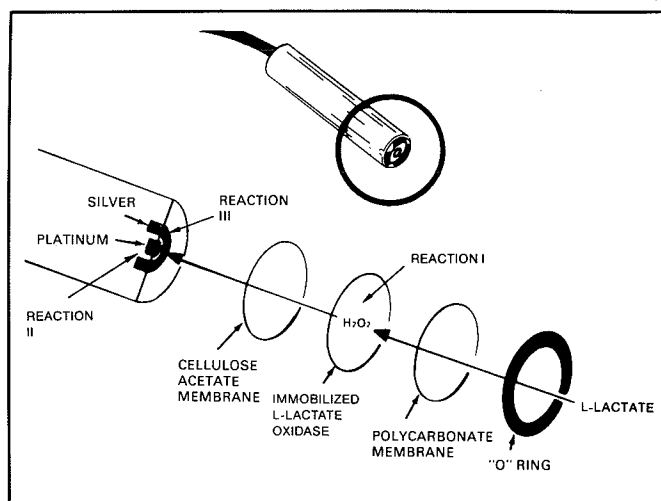
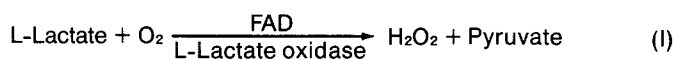


Figure 2. The Lactate Probe and Membrane.

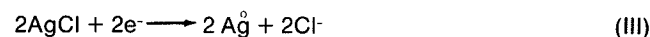
When the L-Lactate in an injected sample diffuses through the outer membrane, Reaction 1 (below) occurs: the catalytic action of L-Lactate oxidase and flavin adenine dinucleotide (FAD) on oxygen and L-Lactate produces hydrogen peroxide and Pyruvate.



The hydrogen peroxide produced in Reaction 1 diffuses through the inner layer of cellulose acetate and comes into contact with the platinum anode which is held at a potential of +0.700 volt with respect to the silver reference cathode. Reaction 2 now takes place at the platinum anode, yielding a current which is linearly proportional to the concentration of lactate in the sample.



The circuit is completed by the silver reference cathode, Reaction 3.



At constant chloride concentration, the potential of this reaction is practically independent of current.

Both the lactate probe and a temperature probe (see Figure 3) are mounted in a sample measurement chamber controlled nominally at 37°C and filled with pre-warmed buffer solution. Since enzyme reaction rate and membrane permeability are temperature-dependent, the temperature probe is provided to enable the instrument to compensate automatically for variations in sample temperature.

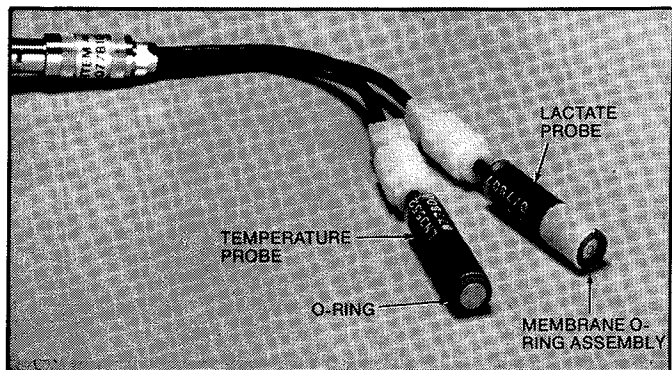


Figure 3. The Lactate Probe and Temperature Probe assembly.

Chamber contents are stirred by an air-driven silicone diaphragm (see Figure 4) which ensures adequate mixing of the buffer and sample. Atmospheric oxygen diffuses freely through this diaphragm to the buffer, providing a supply for the enzyme reactions. Although a great amount of oxygen is present in this process, the instrument does not measure oxygen and does not respond measurably to normal changes in atmospheric pressure.

THE MEASUREMENT CYCLE

Standards, controls and samples are injected into the chamber with a 25 μ l YSI Syringepet. Pressure of the Syringepet against the injection port starts a timer. The numerical display blanks and the word WAIT appears on the screen. After 40 to 45 seconds, WAIT goes out and the word READ appears. The lactate reading in millimoles per liter appears on the display, locked at the number to be read or recorded. (If the CALIBRATE button is pressed at this point, the numerical display is unlocked and continuously shows probe response.) When the CLEAR button is pressed, READ goes off, WAIT comes on again, and the sample chamber is flushed with 3 to 4 milliliters of buffer solution. After 35 to 40 seconds, WAIT goes off and the legend ZERO/INJECT is displayed, indicating that the instrument is ready for another cycle.

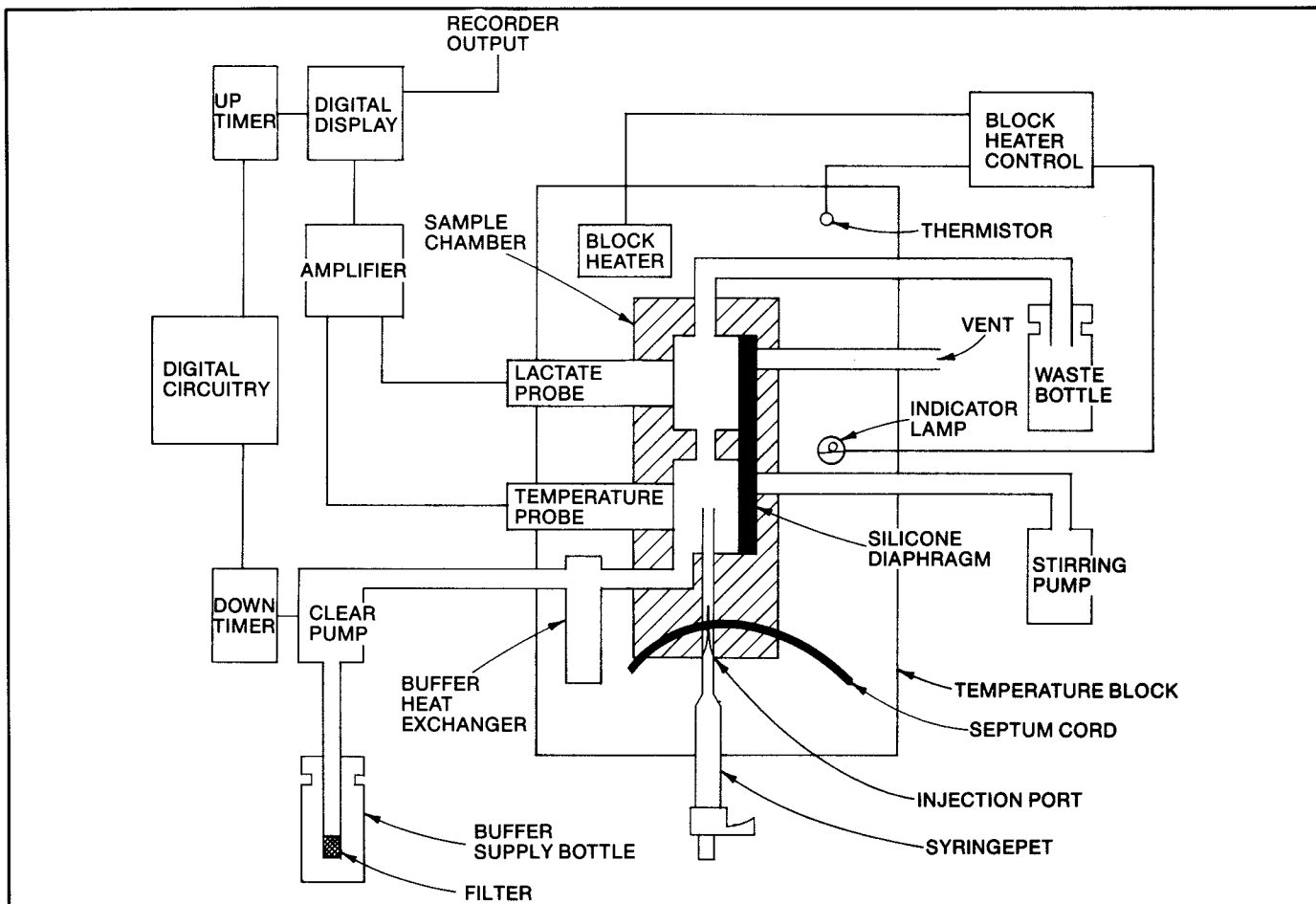


Figure 4. Flow chart of the 23L mechanical and electronic systems.

SPECIFICATIONS

Measurement Performance

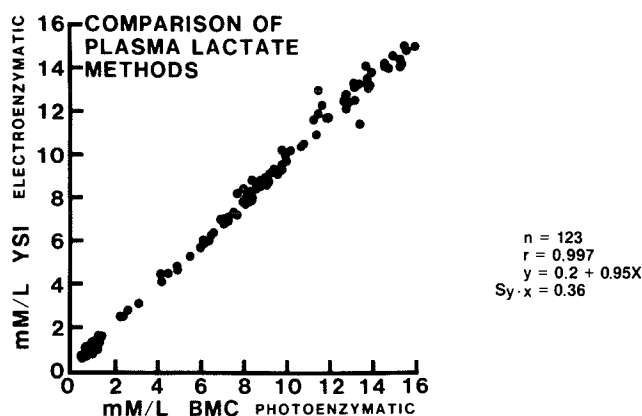
Accuracy: See mean bias and bias standard deviation, below.

Precision: See the pooled estimate of the standard deviation, below.

PLASMA — Comparison of the YSI 23L versus a photoenzymatic LDH-NAD method.

Lactate Concentration mmol/l	Pooled Estimate Std. Deviation mmol/l	Mean Bias mmol/l	Std. Deviation of Bias mmol/l
0.0- 5.0	≤0.07	0.10 < X < 0.17	≤0.16
5.1-10.0*	≤0.15	-0.27 < X < 0.13	≤0.32
10.1-15.0*	≤0.25	-0.49 < X < 0.17	≤0.73

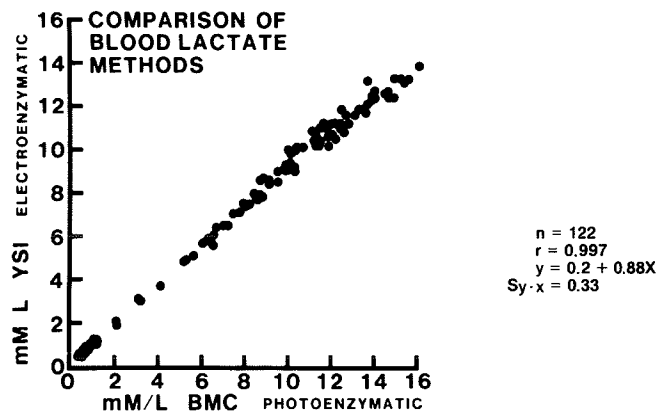
The following figure illustrates graphically all plasma samples (n) which were used to compute the 95% confidence limits in the above table. Correlation coefficient (r), linear regression, and standard error of estimate ($S_{y \cdot x}$) were calculated and appear next to the graph.



WHOLE BLOOD — Comparison of the YSI 23L versus a photoenzymatic LDH-NAD method. This photoenzymatic method requires precipitation of the whole blood sample by perchloric acid.

Lactate Concentration mmol/l	Pooled Estimate Std. Deviation mmol/l	Mean Bias mmol/l	Std. Deviation of Bias mmol/l
0.0- 5.0	≤0.07	-0.04 < X < 0.03	≤0.17
5.1-10.0*	≤0.16	-0.79 < X < 0.65	≤0.32
10.1-15.0*	≤0.34	-1.61 < X < 1.3	≤0.73

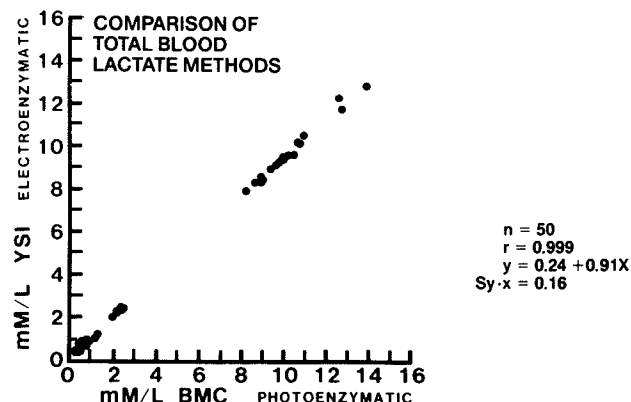
The following figure represents graphically the results of all samples (n) which were used to compute the 95% confidence limits in the above table. Correlation coefficient (r), linear regression, and standard error of estimate ($S_{y \cdot x}$) were calculated and appear next to the graph.



TOTAL BLOOD LACTATE — Comparison of the YSI method for total lactate versus a photoenzymatic LDH-NAD method. This photoenzymatic method requires precipitation of the whole blood sample by perchloric acid, which releases the lactate from the erythrocytes. In the YSI method, lactate is released from the erythrocytes by cetrimonium bromide. Thus, these two methods can be compared directly because all the lactate is quantifiable.

Lactate Concentration mmol/l	Pooled Estimate Std. Deviation mmol/l	Mean Bias mmol/l	Std. Deviation of Bias mmol/l
0.0-15.0	≤0.07	-0.33 ≤ X ≤ -0.11	≤0.56

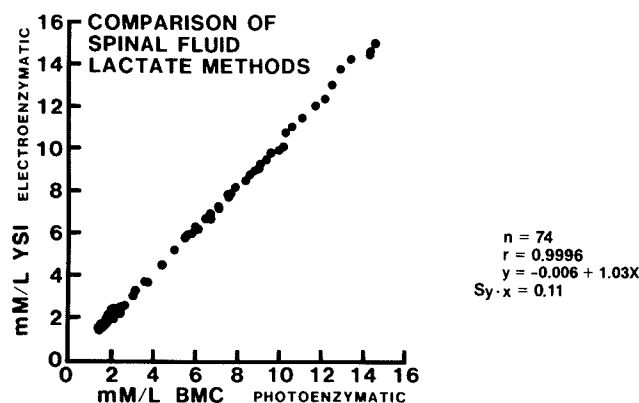
The figure below represents graphically the results of all samples (n) which were used to compute the 95% confidence limits in the table above. Correlation coefficient (r), linear regression, and standard error of estimate ($S_{y \cdot x}$) were calculated and appear next to the graph.



CEREBROSPINAL FLUID — Comparison of the YSI 23L versus a photoenzymatic LDH-NAD method.

Lactate Concentration mmol/l	Pooled Estimate Std. Deviation mmol/l	Mean Bias mmol/l	Std. Deviation of Bias mmol/l
0.0- 5.0	≤0.08	-0.03 < X < 0.08	≤0.098
5.1-10.0*	≤0.10	-0.15 < X < 0.19	≤0.093
10.1-15.0*	≤0.26	-0.24 < X < 0.48	≤0.35

The following figure represents graphically the results of all CSF samples (n) which were used to compute the 95% confidence limits in the above table. Correlation coefficient (r), linear regression, and standard error of estimate ($S_{y \cdot x}$) were calculated and appear next to the graph.



*These concentrations were achieved by spiking with lactate.

Electrical and Mechanical

Range: 0-15 millimoles per liter (mmol/l); higher ranges can be achieved by dilution of sample.

Display Resolution: 0.1 mmol/l

Sample Volume: 25 μ l, nominal

Sample Type: Whole blood, plasma, or cerebrospinal fluid

Sample Chamber Volume: ~350 μ l
Power: 115 \pm 15 VAC or 230 \pm 30 VAC, 50-60 Hz, 70 watts
Environment: 15 to 35°C; below 90% RH, non-condensing
Recorder Output: 1 mV/0.1 mmol/l on the readout display.
 Recorder must have input impedance of at least 50K Ω .
Dimensions: 33 x 21 x 31 cm (13" x 8¼" x 12½").
Weight: 6.8 kg (15 lbs.).

Supplies

YSI 2327 L-Lactate Standard, 5 mmol/l
 YSI 2328 L-Lactate Standard, 15 mmol/l
 YSI 2329 Lactate MembraneKit (or YSI 2357)

YSI 2357 Buffer Kit, concentrate
 YSI 2363 Potassium Ferrocyanide
 YSI 2372 Total Blood Lactate Kit
 YSI 2392 NaCl Solution

The Food and Drug Administration has not established a product class standard for lactate measurement. L-Lactate levels for plasma and cerebrospinal fluid were determined with the YSI 23L and compared with a referee method employing lactate dehydrogenase (LDH) and NAD. Claims for precision and accuracy for use with whole blood and plasma are based on EDTA-preserved specimens.

INSTALLATION

INSTALLATION POLICY

We recommend that your dealer or YSI representative help you with the initial installation and setup and with instruction prior to first use. However, YSI warranty and product claims are not dependent on installation by dealer or factory personnel.

UNPACKING PRECAUTIONS

When you remove the 23L from the shipping container, take care not to discard any parts or supplies that have been packaged with it.

Check the Packing List and cross off each item as you remove it from the shipping container. A plastic box is provided for storing the various small parts and supplies. Examine each component or assembly for damage.

In the event of damage or missing parts, contact your dealer immediately and provide a list of these items. The

dealer will arrange for direct factory shipment of the parts to your laboratory.

POWER REQUIREMENTS

The YSI Model 23L requires 0.6 amp current at 115 \pm 15 VAC, 60 Hz. The YSI Model 23L-230 requires 0.3 amp current at 230 \pm 30 VAC, 50 Hz. Power consumption is approximately 70 watts. The line cord contains a ground conductor, and should be connected to a properly grounded circuit.

ENVIRONMENTAL REQUIREMENTS

The YSI Model 23L occupies about two square feet of table top or laboratory bench work space. The instrument is designed to operate in ambient temperatures between 15 and 35°C and in relative humidity below 90% noncondensing. Electricity is the only utility required.

INITIAL SETUP

This section deals with setting up the instrument after it has been unpacked, checked for missing or damaged parts and supplies, and placed in the work area.

INSTALLATION OF MEMBRANE

1. The YSI Model 23L normally comes with the probe sample chamber and plumbing assemblies as shown in

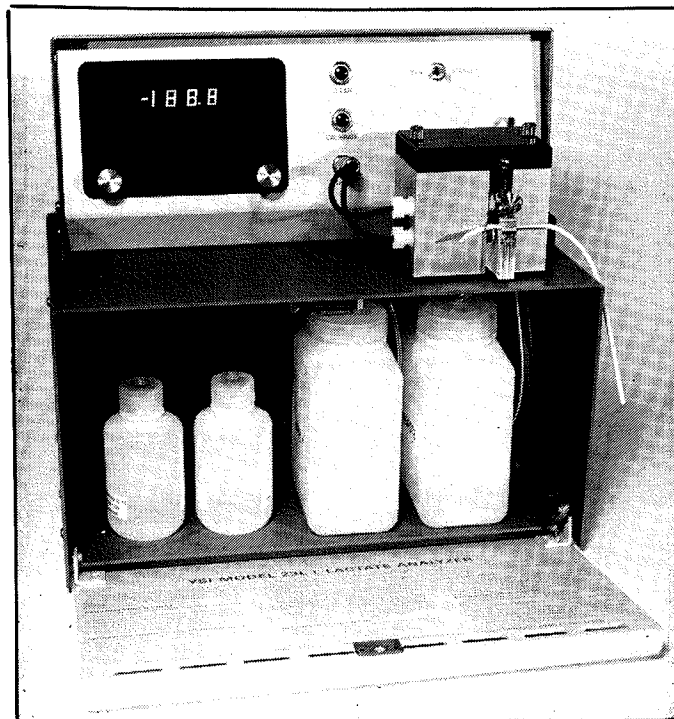


Figure 5. The 23L, showing storage compartment.

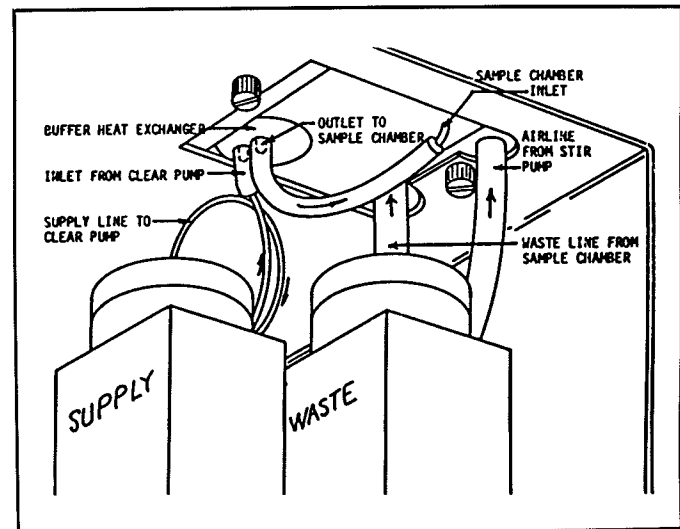


Figure 6. Plumbing Assembly. Arrows show direction of flow.

Figures 5, 6 and 7. Check to see that everything on the instrument agrees with these illustrations.

Then install a new membrane. (See **Maintenance**, procedures, 30 and Figure 13.)

2. Prepare and install the buffer supply as follows:
 - Detach the 500 ml SUPPLY bottle provided, and empty into it the contents of one vial of dry buffer material.
 - Fill the SUPPLY bottle with 450 ml of distilled water (or equivalent) and agitate it until the buffer material dissolves.
 - Uncap the bottle and re-attach it to the supply line in the 23L.
3. Flip the RUN/STANDBY switch on the front panel of the instrument to STANDBY. (See Figure 7.)

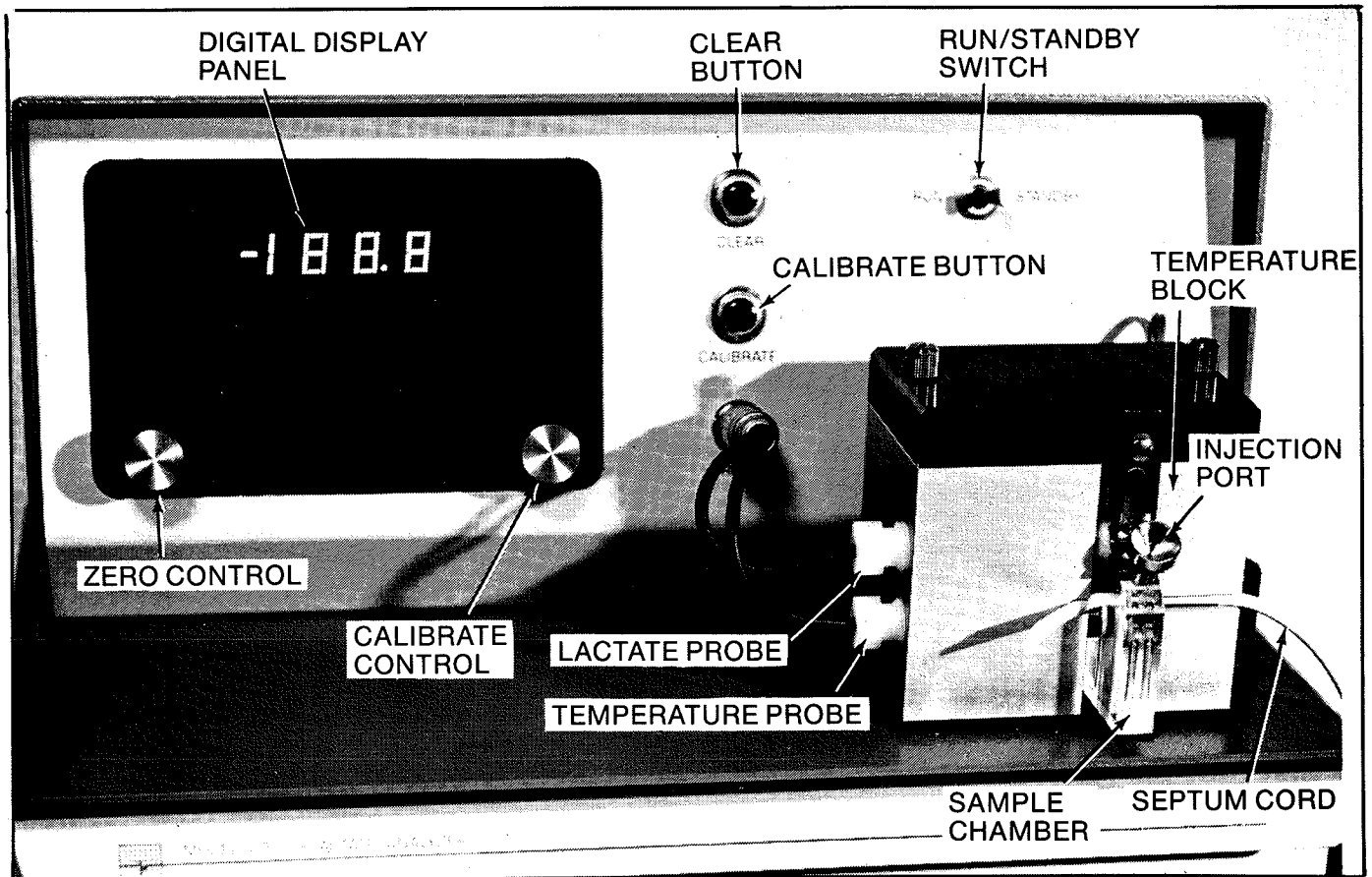


Figure 7. Front panel controls and components.

4. Plug the instrument's power cord into a wall receptacle. Note that the instrument is always powered "on," whether the switch is in the RUN or the STANDBY position. The RUN/STANDBY switch should always be in the STANDBY position unless the instrument is being used for lactate determinations. In the STANDBY position:
 - The stirring pump is turned down but not off. You can operate the clear pump at high speed by pushing and holding the CLEAR button.
 - A timer circuit pulses the clear pump every 45 minutes. The volume of one pulse is 65 μ l of buffer. This keeps the sample chamber and probes wet with fresh buffer when the instrument is not used for long periods.
 - The display panel shows "188.8". In some cases, a minus sign may flash. (If anything other than 188.8, the minus sign, or the one are on the display panel, one of the 23L's systems is inoperative. Contact your dealer Service Representative.)
5. Carefully plug the probe assembly connector into the PROBE outlet on the front panel.
6. Press the CLEAR button to start the clear pump and fill the system with buffer. The system is full when buffer starts to drain into the WASTE bottle. Release the CLEAR button. (If the pump fails to prime, see **Troubleshooting**, 13.)
7. Check the system for leaks and correct if found.
8. Allow the 23L to warm up. After 15-20 minutes, a light behind the sample chamber will come on and begin to cycle on and off. As the block temperature equilibrates, the light will be on for about 45 seconds and off for 15. As soon as the light comes on the first time, the block temperature has equilibrated sufficiently to permit sample measurements. However, probe polarization may require up to two hours.
9. The 23L is now ready to operate. Before running any samples, be sure you are familiar with the following sections of this Instruction Manual:
 - **The Measurement Cycle**
 - **Sample Handling and Collection**
 - **Syringepet Operating Techniques**
 - **Daily Operational Check**
 - **Daily Calibration**
 - **Operating Precautions and Limitations**

RECORDING AND PRINTING

The YSI Model 23L comes with recorder output jacks from which an analog signal can be taken to operate recording and printing devices. The output is 1 mV/digit relative to the meter display. The recorder or printer must have a minimum input impedance of 50K ohms.

A BCD (binary code decimal) output can be added to the 23L by means of a factory modification. Contact the YSI Service Department for details.

OPERATING INFORMATION

SAMPLE COLLECTION AND HANDLING

The Model 23L Lactate Analyzer can be used whenever there is an appropriate power source. Equipment for specimen storage and processing is not necessary because the instrument will immediately accept whole blood samples as drawn from the patient. However, if immediate analysis is not practical, the sample must be preserved until it can be evaluated. Suitable preservatives which will not interfere are listed in **Effects of Selected Substances**. Use aseptic techniques in handling the sample from collection through assay.

Whole Blood

If more than five minutes will elapse between the time a specimen is drawn and the time it is analyzed, mix the blood with an anticoagulant and a glycolytic inhibitor during or immediately after collection and refrigerate at 4°C. This should preserve the whole blood sample up to five hours with no change in lactate concentration.

One method of preservation which may be used with the 23L is to draw blood with a vacuum collecting tube containing sodium fluoride (12.5 mg) and potassium oxalate (10 mg) per 5 ml of whole blood. Potassium oxalate may have a tendency to shrink the red blood cells.

Before taking a sample from a whole blood specimen, any cells which have settled out must be resuspended. Just before sampling with the Syringejet, invert the collection tube three times. Do this gently to prevent frothing. Samples which have settled for more than an hour (particularly if they've been refrigerated) should be placed on a blood rotator for five minutes to break up clumps of cells.

Air bubbles or froth drawn into the Syringejet can cause significant errors in the form of low lactate readings. Because it is difficult to detect bubbles visually in whole blood specimens, great care is necessary when taking a sample with the Syringejet. Operate the plunger slowly and steadily to minimize the likelihood of bubble formation. Avoid repeated expulsion of the blood from the Syringejet back into the collection tube as this can both cause bubbles and produce hemolysis, which will result in a low hematocrit reading. If bubbles are suspected, repeat the assay. With a little practice, users quickly learn to avoid these problems.

After sampling whole blood, immediately rinse the Syringejet twice with water to prevent clogging.

Blood Plasma

During or immediately after collection, mix the specimen with an anticoagulant. Separate the red blood cells from plasma with a refrigerated centrifuge. Use a glycolytic inhibitor if centrifugation cannot be performed immediately. Do not allow the plasma to stand on the red cells because a change in the lactate concentration will result. When filling the Syringejet with plasma, draw from near the top of the sample to avoid aspirating red blood cells.

If delays between collection and assay are unavoidable, you may refrigerate the plasma at 4°C for up to five hours with glycolytic inhibitor present.

Several common anticoagulants and antiglycolitics are suitable for use with specimens being prepared for 23L assay. See **Effects of Selected Substances**.

Cerebrospinal Fluid

The CSF sample may be assayed immediately after withdrawal from the patient with no further preparation. If a delay is unavoidable, the sample may be stored at 4°C for no more than one hour, or it may be frozen until it is to be analyzed.

NOTE: Lactate concentration may vary with time due to the presence of abnormalities in the sample (bacteria, cancer cells, white cells, etc.).

SYRINGEPET OPERATING TECHNIQUES

The Syringejet provided with the 23L gives the user the precision of a positive displacement microsyringe along with the convenience and ease of use of the popular air-displacement pipets (See Figure 8).

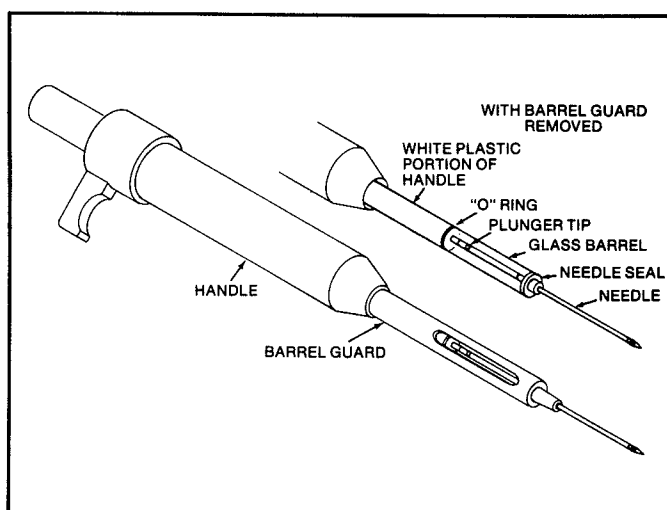


Figure 8. The Syringejet

The heart of the Syringejet system is a precision 25 μ l glass syringe with a Teflon-tip plunger. The plunger is spring-loaded to return automatically to the withdrawn position. A needle especially selected for maximum durability and minimum sample carryover is included with the Syringejet. (But, because some carryover, typically $\sim 1.5 \mu$ l, is unavoidable, it is necessary to rinse the Syringejet at least twice before drawing sample or standard for injection into the 23L.)

Correct Syringejet technique is essential for accurate readings. The user is advised to practice bubble-free filling of the Syringejet, and injecting samples with a firm yet gentle stroke. Violent plunger strokes can lead to leaks and consequent loss of accuracy; hesitant plunger motions may fail to deliver the sample completely. Use only sharp Syringejet needles; a badly bent point will tear ragged holes in the septum cord, permitting leakage from the sample chamber.

- **Filling.** To operate the Syringejet, depress the plunger and hold it down, insert the needle into the sample, and release the plunger. The sample will be drawn into the barrel. The sample is dispensed by depressing the plunger again as far as it will go. A small amount of sample remains in the needle after dispensing. Before refilling the Syringejet, this must be rinsed out at least twice with the next sample or calibration solution. Sample or standard should only then be drawn for assay. After the last use, the Syringejet should be rinsed at least twice with distilled water to prevent solids from drying in the barrel.

Failure to keep the needle tip below the liquid level while the barrel is filling with cause air to be drawn into the Syringejet. If air is drawn into the Syringejet when the needle tip is below the liquid level, then the barrel guard may be loose, the needle plugged, or the plunger tip or needle seal worn and in need of service. See **Semi-Annual Maintenance**.

- **Dispensing.** To inject a solution into the Model 23L, place the needle in the injection port and push it through the rubber septum until the barrel guard fully depresses the funnel. (See Figure 9.) Depress the plunger firmly and completely and hold it down. Remove the Syringejet from the injection port and then release the plunger. Failure to keep the plunger completely depressed while the needle is in the Model 23L sample chamber will cause the withdrawal of some of the contents of the sample chamber; this will lead to an error in the reading.

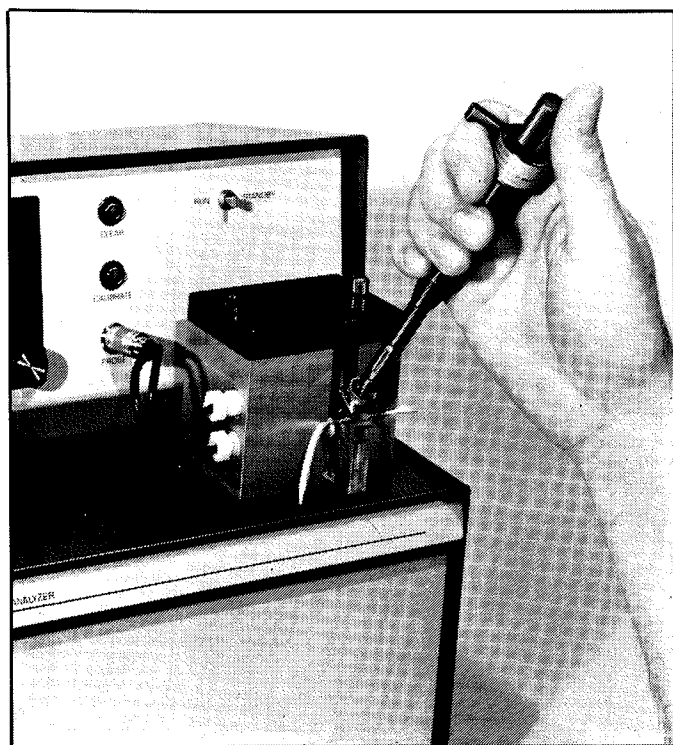


Figure 9. Injecting a sample into the 23L. The Syringejet needle has been placed in the injection port and pushed through the septum cord. The barrel guard is depressing the injection port. Next, the plunger is depressed to inject the sample, and the Syringejet is removed from the injection port before the plunger is released.

After you've mastered Syringejet operation, and you may test yourself by actually injecting and measuring samples of the 5.0 mmol/l standard. The best way to do this is to perform operations 4 through 11 of **Daily Calibration** several times. You should be able to reproduce the 5.0 mmol/l value within ± 0.1 mmol/l every time.

DAILY OPERATIONAL CHECK

At least once each day, preferably at the start of the work day, a three-part maintenance and inspection routine should be performed: the Daily Operational Check, the Daily Calibration (including the Linearity Check), and the Daily Membrane Integrity Check, in the sequence listed. If power has been shut off, or if probes have been unplugged or removed from the block, allow time for the system to restabilize before attempting these procedures.

1. Set the RUN/STANDBY switch to STANDBY. The digital display should read 188.8. In some cases, a minus sign will show or flash (Figure 10).

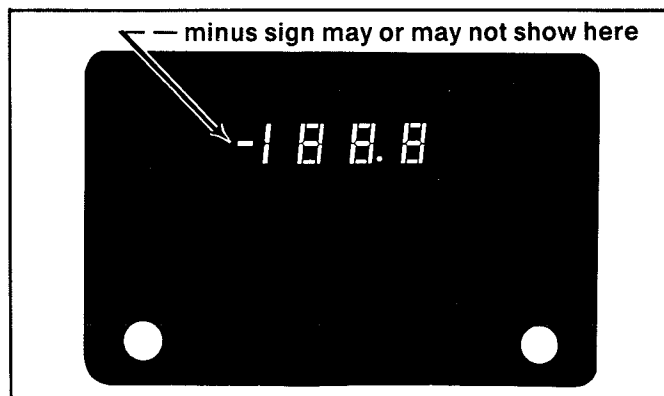


Figure 10. Correct digital display when the 23L is in the STANDBY mode.

2. Check to see that the operating temperature indication light behind the sample chamber, is cycling on and off.
3. Check to see that all tubing is properly connected. (See Figure 6.) Check the air line from the stir pump to see whether any moisture has accumulated in it. If moisture can be seen, disconnect the air line and remove the moisture with a cotton swab. Reconnect the air line.
4. Depress CLEAR button and hold until no bubbles can be observed in the sample chamber, then release.
5. Advance the septum cord if fluid is leaking out or if excessive injections have been made since the last advance.

The septum cord must be advanced $\sim 1/4$ " to the left every 10 to 20 injections, or whenever it begins to leak or to feel "mushy." The cord is advanced by pulling it to the *left*. If it is too tight to pull smoothly, it may be slightly stretched in *both* directions as it is pulled to the left. It should also be rotated slightly with each advance. When the end of the cord is reached, it may be pulled all the way back to the right and started over. Cords which have been recycled three or four times in this manner should be replaced. The operator will find it easier to thread the septum cord into the instrument if one end is "sharpened" with a scissors or razor blade, and if tweezers are used to help start the cord through.

6. Make sure that the buffer's expiration date has not passed, and that there is a sufficient quantity in the SUPPLY bottle for the day's operation. Prepare fresh buffer if necessary. Rinse buffer supply bottle with distilled or deionized water before refilling.
7. Empty the WASTE bottle, then replace it in position.
8. Fill a plastic cup with 5.0 mmol/l standard. Keep the cup covered when not using and do not use standard that has been in the cup for more than two hours; evaporation will change the lactate concentration of the standard solution.
9. Fill a plastic cup with distilled or deionized water for rinsing. Place the standard and water cups in the holder provided.
10. Place an empty cup in the waste position of the holder.

DAILY CALIBRATION

1. Set the RUN/STANDBY switch to STANDBY.
2. Hold in the CLEAR button for five seconds.
3. Set the RUN/STANDBY switch to RUN.
4. Press and release the CLEAR button. When ZERO/INJECT is lit, zero the numerical display if necessary. Values between -0.1 and 0.2 are acceptable zeros.
5. Rinse the Syringepet twice with water and once with 5.0 mmol/l standard.
6. Fill the Syringepet with standard and inject.
7. When a numerical value is displayed, press the CALIBRATE button and adjust the reading to 5.0 mmol/l. Watch the display for 30 seconds to be sure there is no drift. If the value drifts more than 0.1 mmol/l in 10 seconds, check stirring and leakback (see **Troubleshooting**, 2 and 4). If there is no stirring or leakback problem, change the membrane, wait 15 minutes, and start calibration again.
8. Repeat steps 4 and 6.
9. The calibration reading should be 5.0 ± 0.1 mmol/l. If it is not, press and release the CALIBRATE button and adjust value to 5.0 mmol/l.
10. Repeat steps 4, 6 and 9 if necessary until the zero value is between -0.1 and 0.2, and the calibration value is 5.0 ± 0.1 mmol/l.
11. Press CLEAR button and release.

Linearity Check. Complete the remaining steps to confirm that the instrument is functioning properly through its entire range of 0 to 15.0 mmol/l.

12. Fill a plastic cup with 15 mmol/l standard. Keep the cup covered when not in use, and do not use standard that has been in the cup for more than two hours; evaporation will change the lactate concentration.
13. Rinse the Syringepet twice with water and once with 15.0 mmol/l standard.
14. Fill the Syringepet with 15 mmol/l standard and inject.
15. The numerical value displayed should be between 14.4 and 15.6 mmol/l. If it is, press and release the CLEAR button. If it is not, try again to get the correct reading with the 15.0 mmol/l standard. If you succeed in obtaining a reading between 14.4 and 15.6 mmol/l by the *fourth* attempt, repeat calibration procedures from step 8, above. If the 15.0 mmol/l test fails a fourth time, replace the membrane, wait 15 minutes, and begin the Daily Calibration procedure again.

DAILY MEMBRANE INTEGRITY CHECK

1. Pour a small amount of Potassium Ferrocyanide (FCN) into a plastic cup.
2. Rinse the Syringepet twice with water and once with FCN.
3. Fill the Syringepet with FCN. When ZERO/INJECT is lit, re-zero if necessary and inject the FCN into the sample chamber, keeping the plunger depressed until the Syringepet is withdrawn.
4. After 40 to 45 seconds, the WAIT light should go off and the word READ and a numerical value should be displayed. This number should be between -0.1 and 0.3. If it is not, repeat calibration procedures. If the FCN test fails a second time, replace the probe membrane and wait 15 minutes or until the background reading stabilizes. Begin the Daily Check and Calibration Procedures again, then repeat the FCN Membrane Integrity test.
5. Press the CLEAR button and release.

OPERATING PRECAUTIONS AND LIMITATIONS

1. If you need to unplug the YSI Model 23L, be sure to unplug the probe cable connector from the receptacle in the instrument panel first. Probes left plugged into an unpowered instrument have unusually long startup times.
2. Whenever the 23L is started up after having all power to it shut off, time for thorough warmup must be allowed. After 15-20 minutes, a light behind the sample chamber will come on and begin to cycle on and off; this indicates the sample chamber has reached the proper operating temperature. However, the lactate probe may require up to two hours to stabilize.
3. When the 23L is not being used, set the RUN/STANDBY switch to STANDBY.
4. Do not allow air to enter the Syringepet when filling.
5. Do not allow the buffer SUPPLY to run empty. This will allow the sample chamber to fill with air and cause rapid deterioration of the lactate probe membrane. Rinse out the SUPPLY bottle thoroughly with distilled water before adding fresh buffer.
6. When air bubbles are observed in the sample chamber, do not make any lactate determinations until the problem is corrected.
7. Do not accept readings greater than 15.0 mmol/l without rerunning the sample according to the instructions in **Measuring Samples Above 15.0 mmol/l Lactate**.
8. Do not allow samples or standard solutions to remain in the sample chamber any longer than necessary. Clear the instrument promptly after making assays to avoid problems with lactate carryover.
9. Be sure to follow **Sample Handling and Collection** instructions for the type of sample being measured.

FAIL-SAFE MODES

The YSI Model 23L Lactate Analyzer is equipped with several features to alert the operator that an error in operation has taken place. These are called Fail-Safe Modes:

- After the ZERO/INJECT light comes on, a sample can be injected into the 23L's sample chamber. However, once the Syringepet is inserted into the injection port, a 10-second timer starts. The sample must be injected and the Syringepet removed within this 10-second period, or the instrument will automatically bring up the CLEAR command. The instrument must then be cleared before attempting to inject the sample.
 - If a second sample is injected into the sample chamber while the first sample is still being analyzed, the instrument will automatically go to the CLEAR command, thus aborting the measurement in progress.
- NOTE:** The CLEAR command will not appear if a second injection is made before the 10-second allowance has "timed out." In such a case, the 23L would give a false reading.
- If after the CLEAR button is pushed, a sample is injected before the ZERO/INJECT light comes on, the cycle aborts. The clear pump stops and the instrument automatically brings up the CLEAR command.

SAMPLE MEASUREMENT

Before running any samples on the Model 23L, be sure that you are familiar with all the information in this manual, that the instrument has had the Daily Operational Check, Daily Calibration and Daily Membrane Check, and that the Monthly and Semi-Annual Maintenance has been performed as needed. Be sure an adequate supply of buffer is in the SUPPLY bottle, and that none of the reagents are past their expiration dates.

If you are not familiar with how to obtain blood samples, we refer you to two publications:

Approved Standard Procedures for the Collection of Diagnostic Blood Specimens by Skin Puncture, edited by Jean M. Slockbower. National Committee for Clinical Laboratory Standards, Volume 2 Number 5, pages 132-149, 1982.

Collection and Handling of Laboratory Specimens. A Practical Guide, edited by Jean M. Slockbower and Thomas A. Blumenfield. J. B. Lippincott Company, Philadelphia, 1983. ISBN 0-397-50520-5.

ROUTINE SAMPLE MEASUREMENT PROCEDURE

1. Set to RUN, press and release the CLEAR button, zero as needed. (-0.1 to 0.2 are acceptable zero values.)
 2. Rinse Syringepet twice with water, twice with 5.0 mmol/l standard.
 3. Fill Syringepet with 5.0 mmol/l standard and inject.
 4. Adjust calibration value to 5.0 mmol/l, if necessary.
 5. Press and release CLEAR button.
 6. Rinse the Syringepet twice with water and twice with the sample.
 7. Fill Syringepet with sample and inject.
 8. When the word READ is illuminated, record the sample value.
- NOTE:** The sample value will stay on the control panel until the CLEAR or the CALIBRATE button is pushed. If the CLEAR button is not pressed, the CLEAR command will light up in about 60 to 80 seconds; but the sample value will continue to be displayed, as will the word READ.
9. Press and release the CLEAR button.
 10. Start again at step 2 if you have more samples to measure; if not, set the RUN/STANDBY switch to STANDBY.

NOTE: In routine sample measurement, calibration may be performed at intervals of several samples, depending on the frequency of use and the spread of assayed values. Trial and experiment within each likely set of measurement circumstances will enable the operator to estimate the necessary frequency of calibration for achieving specified accuracy. We recommend calibration at 2 to 5 sample intervals.

WHOLE BLOOD MEASUREMENT

The non-liquid or "solid" parts of the cells in whole blood are responsible for a liquid volume difference between a whole blood sample and the standard solution used for calibrating the instrument. The difference will affect the reading, and will vary as the volume of solids in the sample vary.

TOTAL BLOOD LACTATE MEASUREMENT

To determine the total lactate content in any given whole blood specimen, 100 to 200 microliters of blood is placed into

a YSI 2372 Total Blood Lactate Tube. Cetrimonium bromide, a surfactant in the tube, will immediately lyse all erythrocytes and release the lactate and intracellular fluid. Sodium fluoride is also present to preserve the lactate reading when samples cannot be assayed immediately.

Treated samples will keep for two days at temperatures under 25°C, and for seven days at 4°C. Prepared samples are similar to specimens treated with perchloric acid, with the exception that the erythrocyte cellular material is still present.

Procedure:

1. Place 100 to 200 microliters of whole blood into a YSI 2372 Total Blood Lactate Tube. 200 microliters will just fill the lower, conical section of the Lactate Tube. Do not exceed this amount of specimen.
2. Dissolve dry contents into the whole blood specimen in a vortex mixer, or by gently tapping with your fingers near the bottom of the tube.
3. When dry contents have dissolved, you may store the specimen for two days at 25°C, or for up to seven days at 4°C.
4. Assay in Model 23L.
5. If dilution is necessary, use the procedure described under MEASURING PLASMA SAMPLES ABOVE 15 mmol/l LACTATE. Do not store diluted samples.

CAUTION: Do not allow the dry contents of the tube or the prepared sample to come into contact with the skin or other parts of the body. Keep the tube capped at all times when not in use. Ascertain that the cap is securely seated so that its lip is in complete contact with the shoulder of the tube.

MEASURING PLASMA SAMPLES ABOVE 15.0 mmol/l LACTATE

When a plasma sample with a lactate value greater than 15.0 mmol/l is injected into the Model 23L, flashing numbers from 15.0 to 199.9 may be displayed. This flashing display, a visual reminder of an overrange reading, will commence in the region of 15.0 to 15.3 mmol/l.

To assay a sample which has more than 15.0 mmol/l of lactate, it is necessary to dilute it.

1. Use a 250 μ l pipet and transfer 250 μ l of sample into a test tube.
2. Rinse the pipet twice with distilled water.
3. Pipet 250 μ l of distilled water into the test tube.
4. Swirl the tube to thoroughly mix the sample. (Use of a test tube vortex mixer is recommended.)
5. Assay the sample according to instructions in Routine Sample Measurement.
6. Multiply the indicated lactate value times two to calculate the true lactate value.

Should a plasma sample with a lactate value greater than 30.0 mmol/l be encountered, it would of course be necessary to dilute it even more than 1:1 with distilled water. Be sure to make the appropriate correction to the indicated lactate value.

Lactate values obtained through the dilution process may have slightly less accuracy due to the additional error introduced in pipeting.

MAXIMUM ACCURACY ANALYSIS

Operation of the YSI Model 23L Lactate Analyzer as described in this manual will provide results in accordance with the stated performance specifications. This level of accuracy will generally meet or exceed most laboratory requirements. However, you may occasionally need to make a measurement or series of measurements at the best possible accuracy. In such cases, follow these additional guidelines:

- Use fresh buffer solution.
- Use fresh standards of known quality. Do not allow the standard in the plastic cup to be exposed to air any longer than necessary, and replace the standard every hour.
- Run the entire Daily Calibration procedure twice each day.
- Calibrate with 5.0 mmol/l standard before and after each sample determination. If all samples are known to have values grouped closely together, use a calibration standard of similar value in place of the 5.0 mmol/l standard.
- Rinse Syringe pet twice with sample before injecting.

EFFECTS OF SELECTED SUBSTANCES

The endogenous substances listed below were all tested at levels far higher than can be found in the body, and all were found to be noninterfering at the highest naturally occurring levels. The column headed "Interfering Level" indicates the concentration at which each substance might be expected to cause an error of 1 mmol/l in the lactate reading. NI designates No Interference even at levels as high as 500 mg/dl.

Certain exogenous substances can interfere with 23L measurements, and nothing should be added to the specimens except those anticoagulants and antiglycolytics recommended in the section on **Sample Collection and Handling**.

CAUTION: The following preservatives interfere with lactate measurements on the 23L and should not be used:

- Benzalkonium Chloride
- Methyl Paraben
- Phenol
- Perchloric Acid
- Sodium Azide
- Thymol
- Trichloroacetic Acid

Recent information indicates that some of the exogenous substances listed are now drugs of abuse, ingested at levels much higher than the usually recommended therapeutic doses. In patients with higher than therapeutic levels, there is hazard of gross masking of lactate concentration by the interfering substance.

The Model 23L should not be used to analyze specimens containing any of these substances at or above the listed Interfering Level.

Endogenous Substances	Formula Weight	Interfering Level, mmol/l	Exogenous Substances	Formula Weight	Interfering Level, mmol/l
DL- α -Glycerophosphate, Disodium salt	216.1	NI	DRUGS AND OTHER CHEMICALS		
Glyceric Acid	106.08	9.4	Acetaminophen	151.16	0.8
Glycolic Acid	76.05	3.4	Metaphosphoric Acid	79.98	NI
β -Hydroxypyruvic Acid, Lithium salt	111.0	NI	Ethanol	46.07	NI
DL- β -Hydroxybutyric Acid, Sodium salt	126.1	NI	Acetylsalicylic Acid	180.16	NI
4-Hydroxybutyric Acid, Sodium salt	126.1	NI	Formaldehyde	30.03	208.1
DL-Malic Acid	134.1	NI	Hydrogen Peroxide	34.01	1.0
DL- α -Hydroxybutyric Acid	126.1	19.8	D-Penicillamine	149.2	167.5
L- β -Phenyllactic Acid	166.2	3.1	Salicylamide	137.14	2.2
β -Chlorolactic Acid	124.5	33.5	Sodium Nitrite	69.01	145.0
DL- α -Hydroxycaproic Acid	132.2	23.6	Sodium Salicylate	160.10	1.7
Oxalacetic Acid	132.07	NI	ANTICOAGULANTS		
DL- α -Hydroxycaproic Acid	132.2	13.5	Sodium Oxalate	134.01	NI
Pyruvic Acid	88.06	NI	Ammonium Oxalate	124.10	NI
Uric Acid	168.11	NI	Potassium Oxalate	184.23	NI
DL- α -Hydroxyisovaleric Acid	118.13	NI	Sodium Heparin	—	NI
L- α -Glycerophosphate, Di (monocyclohexyl-ammonium) salt	370.4	NI	GLYCOLYTIC INHIBITORS		
L- α -Hydroxyisocaproic Acid	132.16	7.3	Sodium Fluoride	41.98	NI
α -Hydroxyisobutyric Acid	104.10	NI	Iodoacetic Acid	185.96	NI
Glycerol	92.09	NI			

TROUBLESHOOTING

This section contains information for identifying and/or correcting these malfunctions in the YSI 23L Lactate Analyzer:

1. Instrument is slow in coming back to zero.
2. Zero control will not adjust to zero.
3. Zero control has no effect.
4. ZERO/INJECT light stays on constantly.
5. Instrument is difficult to calibrate.
6. Instrument will not repeat 5.0 mmol/l with successive injections of standard.
7. Calibration control will not adjust to 5.0 mmol/l.
8. Instrument will not read 14.4-15.6 with 15.0 mmol/l standard.
9. Unstable or jumpy readings.
10. Bubbles in the sample chamber or sample chamber is dried out.
11. Membrane requires changing too often.
12. Fluid leaks past plunger tip of the Syringejet.
13. Clear pump fails to self-prime.

If you are unable to correct the problem following the information in this section, contact your dealer Service Representative.

1. Instrument is slow in coming back to zero.
 - 1.1. Check for leaks in or around the buffer heat exchanger and the sample chamber. (See note at 21, **Monthly Maintenance**, Perform 1-49 if there is a leak.)
 - 1.2. Check the clear pump system's flow rate. (**Semi-Annual Maintenance**, 5.)
 - 1.3. Clean the temperature block and probe assembly. (**Monthly Maintenance**, 1-49.)
2. ZERO control will not adjust to zero.
 - 2.1. After the instrument has just been plugged in or after a new membrane has been installed on the probe, from 15 minutes to two hours must be allowed for the system to stabilize.
 - 2.2. The membrane and electrode surfaces *must* be kept free from contamination and there *must not* be any foreign substances between the membrane and electrode. If there is any question about the presence of contamination or foreign substances, clean the electrodes and replace the membrane. (**Monthly Maintenance**, 1, 3, 8, 9, 27-35, and 45.)
 - 2.3. If cleaning the probe and changing the membrane or replacing the probe assembly doesn't correct the problem, the electronics may be out of alignment. This is a rare problem, and you'll need the dealer Service Representative's help to correct it. To confirm that the electronics need alignment, follow this procedure:
 - Remove the lactate probe from the temperature block.
 - Remove the membrane, wash to probe tip with distilled water, and dry it carefully with a lint-free tissue.
 - Turn the ZERO and CALIBRATE controls full clockwise.
 - Set the RUN/STANDBY switch to RUN.
 - Check to see that there is buffer solution in the lower part of the sample chamber.
 - Push the CALIBRATE button and release.
 - At this point, with a properly operating instrument, the reading on the numerical display

would be 0.2 ± 0.2 . If it is not, contact your dealer Service Representative.

3. ZERO control has no effect.
 - 3.1. Check the pins in the PROBE plug and receptacle to see if they are slightly bent and therefore not mating properly.
 - 3.2. Be sure the probe connector is screwed together tightly.
4. ZERO/INJECT light or WAIT light stays on constantly.
 - 4.1. Check to see that when you insert the Syringejet needle into the sample chamber, the Syringejet barrel guard depressed the injection port far enough to activate the analyzer's circuitry.
 - 4.2. If that isn't the problem, remove the screw holding the injection port funnel bracket in place, and remove the bracket and the O-ring. Install an orange 006 size O-ring from the 23L Preventive Maintenance Kit and re-install the bracket and the screw.
 - 4.3. If replacing the O-ring does not solve the problem, the injection port switch will need to be adjusted or replaced. Contact your dealer Service Representative.
5. Instrument is difficult to calibrate.
 - 5.1. Check to see that you are delivering a constant, standard volume to the sample chamber with the Syringejet. Review the section on **Syringejet Operating Techniques**.
 - 5.2. Perform the Syringejet maintenance procedures. (**Semi-Annual Maintenance**, 1.)
 - 5.3. Clean the temperature block and probe assembly. (**Monthly Maintenance**, 1-49.) Pay particular attention to cleaning and disinfection.
 - 5.4. Check the stirring pump system. (**Semi-Annual Maintenance**, 2.)
 - 5.5. Check the clear pump system. (**Semi-Annual Maintenance**, 4 and 5.)
 - 5.6. Check temperature probe thermistor stability. (See 2.3, above.)
6. Instrument will not repeat 5.0 mmol/l with successive injections of standard.
 - 6.1. Check to see that you are delivering a constant, standard volume to the sample chamber with the Syringejet. Review the section on **Syringejet Operating Techniques**.
 - 6.2. Perform the Syringejet maintenance procedures. (**Semi-Annual Maintenance**, 1.)
 - 6.3. Clean the temperature block and probe assembly. (**Monthly Maintenance**, 1-49.) Pay particular attention to cleaning and disinfection.
 - 6.4. Check the stirring pump system. (**Semi-Annual Maintenance**, 2.)
 - 6.5. Check the clear pump system. (**Semi-Annual Maintenance**, 4 and 5.)
 - 6.6. Check temperature probe thermistor stability. (See 2.3, above.)
7. CALIBRATE control will not adjust to 5.0 mmol/l.
 - 7.1. Check the stirring pump system. (**Semi-Annual Maintenance**, 2.)
 - 7.2. Clean the lactate probe and replace the membrane. (**Monthly Maintenance**, 1, 3, 8, 9, 27-35, and 45.) The membrane and electrode surfaces *must* be kept free from contamination and there *must*

not be any foreign substances between the membrane and electrode.

- 7.3. If the stirring pump system is functioning properly, and if cleaning the probe and changing the membrane doesn't correct the problem, the electronics may be at fault or else the temperature probe may be malfunctioning. To identify the specific problem, follow this procedure:
 - Set the RUN/STANDBY switch to RUN.
 - Press the CLEAR button and release.
 - When the ZERO/INJECT light comes on, turn the CALIBRATE and ZERO controls full clockwise.
 - Record the reading from the numerical display.
 - Turn the ZERO control full counterclockwise.
 - Record the reading from the numerical display.
 - If the first reading was positive and the second negative, the thermistor probe is good. If both numbers were negative, the signal conditioning circuit needs repair, contact your dealer Service Representative.
8. Instrument will not read between 14.4 and 15.6 with 15.0 mmol/l standard.
 - 8.1. Repeat the 15.0 mmol/l test using fresh standards.
 - 8.2. Check to see that you are delivering a constant, standard volume to the sample chamber with the Syringejet. Review the section on **Syringejet Operating Techniques**.
 - 8.3. Perform the Syringejet maintenance procedures. (**Semi-Annual Maintenance, 1.**)
 - 8.4. Replace the buffer.
 - 8.5. Clean the temperature block and probe assembly. (**Monthly Maintenance, 1-46.**) Pay particular attention to cleaning and disinfection.
 - 8.6. Check the stirring pump system. (**Semi-Annual Maintenance, 2.**)
 - 8.7. Check the clear pump system. (**Semi-Annual Maintenance, 4 and 5.**)
 - 8.8. Check temperature probe thermistor stability. (See 7.3, above.)
9. Unstable or "jumpy" readings.
 - 9.1. Check to see if you are touching the temperature block during measurement as this can cause the numerical display to jump as a result of static discharge.
 - 9.2. Clean the temperature block and probe assembly. (**Monthly Maintenance, 1-49.**) Pay particular attention to leaks around the buffer heat exchanger and the sample chamber. Also see note in Item 21.
 - 9.3. Check temperature probe thermistor stability. (See 7.3, above.)
10. Bubbles in the sample chamber or sample chamber is dried out.
 - 10.1. Check for leaks in and around the buffer heat exchanger, the sample chamber, and all plumbing junctions. (See note at 21 in **Monthly Maintenance**. If there is a leak, perform steps 1-49.)
 - 10.2. Check the clear pump's leak-back rate. (**Semi-Annual Maintenance, 5.**)
11. Membrane requires changing too often.
 - 11.1. The sample chamber may be drying out when the instrument is not in use. Check for leaks in and around the buffer heat exchanger, the sample chamber, and all plumbing connections. (See note in step 21 of **Monthly Maintenance**. If there is a leak, perform steps 1-49.)
 - 11.2. Check the clear pump's leak-back rate. (**Semi-Annual Maintenance, 5.**)
 - 11.3. The lactate probe and the sample chamber may be contaminated. Clean the temperature block and probe assembly. (**Monthly Maintenance, 1-49.**) Pay particular attention to cleaning and disinfection. Do not re-perform steps 1-49 if they were just done.
12. Fluid leaks past the plunger tip of the Syringejet.
 - 12.1. Disassemble the Syringejet. (**Semi-Annual Maintenance, 1.1 and 1.2.**)
 - 12.2. Thoroughly clean the plunger tip and the glass barrel with acetone or isopropyl alcohol.
 - 12.3. Reassemble the Syringejet.
 - 12.4. Remove the barrel guard, needle, and needle seal.
 - 12.5. Hold the barrel and Syringejet as shown in Figure 11. Place the barrel end flat against a glass plate. Depress the plunger several times so that the tip strikes the glass. This helps assure a correct fit between the plunger tip and the barrel.
- 12.6. Replace the needle and seal assembly. Screw the barrel guard back on.
- 12.7. Insert the needle tip into colored water or blood and depress and release the plunger several times.
- 12.8. Examine to see if any fluid is leaking past the plunger tip. If it is not, the Syringejet is ready for use again. If there is a leak, replace the plunger rod and tip assembly. (**Semi-Annual Maintenance, 1.**)
13. Clear pump fails to self-prime.
 - 13.1. Failure to self-prime may be due to dirt lodged under the check valve, or because the valve is sticking after the system has dried out or been stored.
 - 13.2. Try to force prime. Completely fill the SUPPLY bottle. Keeping one finger over the vent hole in the top, switch to RUN and press the CLEAR button. Squeeze the bottle to force fluid into the pump.
 - 13.3. Alternately, it is possible to force prime by connecting a buffer-filled syringe to the inlet tubing and squeezing while running the pump.
 - 13.4. If these methods fail, replace the clear pump head assembly (Replacement Part 110351).

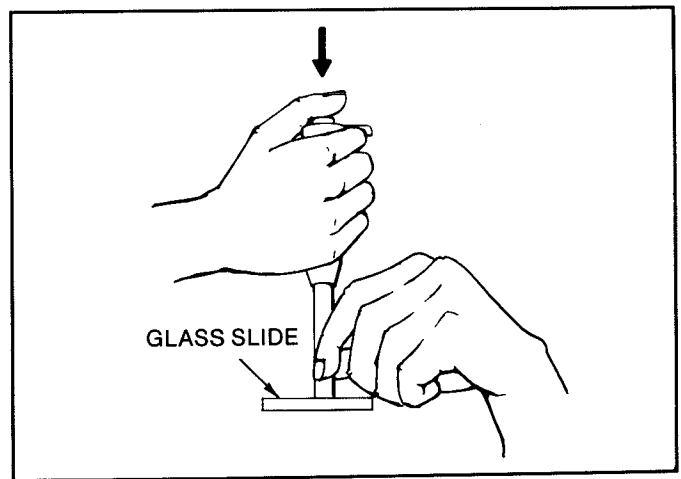


Figure 11. Striking the plunger tip against a glass slide.

MAINTENANCE

There are three maintenance cycles for the Model 23L: Daily, Monthly, and Semi-Annual. All can be performed by the user.

The Daily Operational Check and Monthly Maintenance procedures for the first six months do not require any parts or supplies other than those supplied with the 23L and associated with the normal operation of the instrument. Because the Daily Operational Check is one of the required daily routines, the procedures are described in the section on **General Operating Information**.

The Semi-Annual Maintenance procedures require the YSI Model 23L Preventive Maintenance Kit, which is available from your dealer. If you prefer, your dealer will perform the Semi-Annual Maintenance for you.

You should keep a complete record of all maintenance and service performed on the 23L. This record should include date of service, service performed, parts replaced (include serial numbers if there are any), and name of the person doing the servicing.

DAILY OPERATIONAL CHECK

Because the Daily Operational Check is one of the required daily routines, the procedures are described in the **General Operating Information** section along with the procedures for the Daily Calibration.

MONTHLY MAINTENANCE

In addition to the normal Daily Operational Check and the Daily Calibration, the Model 23L should receive the following maintenance procedure every month. Special attention is given to the temperature block, sample chamber, probe, the Up Timer, and the Down Timer.

1. Set the RUN/STANDBY switch to STANDBY.
2. Check the temperature block temperature. It should be just warm to the touch.
3. Unplug the probe from the PROBE receptacle.
4. Unplug the power line from the wall receptacle.
5. Unplug the heater assembly/injection port switch connector. (See Figure 12.) Be sure no buffer solution spills into the receptacle.
6. Open the front door of the instrument. Disconnect and remove the WASTE bottle.
7. Disconnect the stirring pump and clear pump connections from the temperature block assembly.
8. Remove the white plastic bolts holding the temperature and lactate probes in place.
9. Remove both probes from the temperature block assembly and remove the temperature probe O-ring if damaged.
10. Loosen the two thumb screws holding the temperature block in place and lift the block free of the instrument.

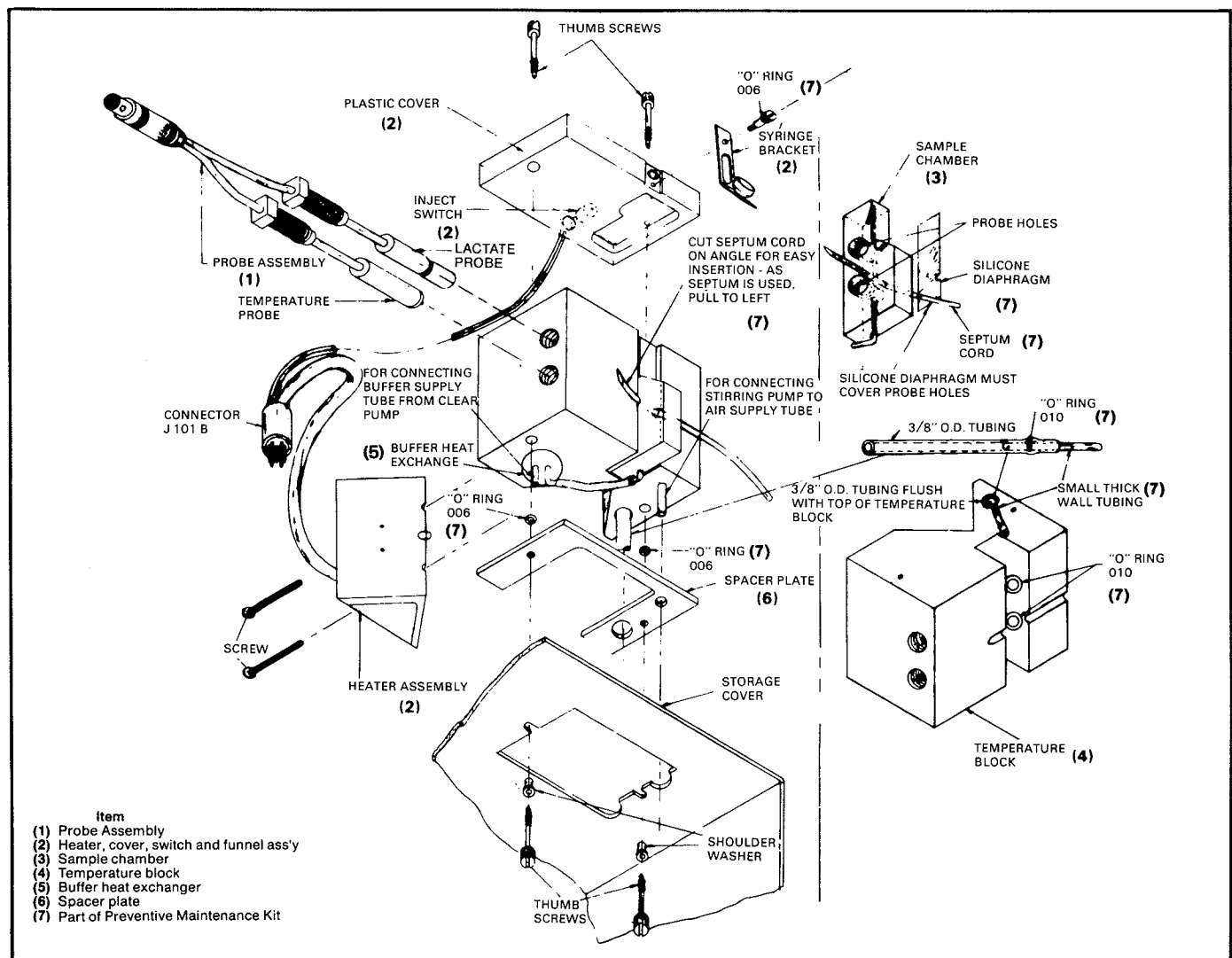


Figure 12. Exploded view of the temperature block.

11. Loosen the two thumb screws holding the black plastic cover on top of the temperature block and remove the cover.
12. Remove the septum cord from the sample chamber.
13. Remove the tubing at the top and bottom of the sample chamber. Rinse tubing in distilled water. (THIS TUBING SHOULD BE REPLACED EVERY THREE MONTHS.)
14. Pull the buffer heat exchanger from the temperature block. (If the heat exchanger is difficult to remove, it is probably being held in place by dried buffer. Do not use the steel tubes as levers to remove the exchanger; soak the assembly in water and carefully use a screwdriver to pry between the two tubes if necessary. Don't let the temperature block top or connector get wet.) Examine the heat exchanger for leaks.
15. Remove the plastic waste tube from the temperature block. Rinse in distilled water.
16. Lift the sample chamber out of the temperature block. (The sample chamber is positioned and retained by the probes, which have already been removed. However, it still may be difficult to remove the sample chamber because it has a tendency to stick to the temperature block. It may require a lot of sideways pressure to break it loose.)
17. Pull the silicone diaphragm off the sample chamber (or temperature block) and discard.
18. Soak the sample chamber in a 1% solution of a mild detergent (such as Alconox, Liqui-nox, or Sparkleen) and distilled water for five minutes. Then remove the chamber, scrub it thoroughly with a medium-soft-bristle brush, and rinse thoroughly in distilled water.
19. Soak the sample chamber for 2-5 minutes in a solution of 1% sodium hypochlorite or a 1:4 dilution of household bleach with distilled water. Rinse thoroughly with distilled water.
20. Remove the O-rings from the temperature block.
21. Wash the temperature block thoroughly in warm, running tap water. Don't let the black plastic cover or connector get wet.

NOTE: The surface of the temperature block where the silicone diaphragm and sample chamber seat must be free of dried buffer. If they are not, leakage will occur and cause salt bridges that result in drift and erratic readings. Extreme cases have caused the air tube in the block to clog up enough to restrict the stirring action. If the temperature block appears to need cleaning more than once a month, it's because the silicone diaphragm was installed improperly, the probes were not tightened sufficiently, or the temperature block surface was not cleaned adequately during Monthly Maintenance.

The temperature block must be replaced if its surface becomes corroded or has dried buffer so firmly attached that normal cleaning will not remove it. In some cases, a temporary remedy is to scrape the surface while it is wet. Take care not to injure the surface while scraping. Use a metal straightedge, such as a single-edge razor blade. Any tool which would gouge or groove the surface is unacceptable.

22. Blow the temperature block air line free of water. Be sure there are no buffer deposits inside.
23. Trim a new septum cord to a point and insert it into the sample chamber cord opening.
24. Rinse a new silicone diaphragm in distilled water. Position the diaphragm on the sample chamber.

25. Install the O-rings in the temperature block.
26. Place the sample chamber in the temperature block.
27. Clean the temperature probe tip with a lint-free tissue moistened with isopropyl alcohol.
28. Thoroughly flush the temperature probe tip with distilled water.
29. Place a new O-ring on the temperature probe if necessary.
30. Install a new membrane on the lactate probe. (See Figure 13.)
 - 30.1. Remove the old membrane assembly. Check to be sure there are no pieces of delaminated membrane material left on the electrode surface. If there are, use distilled water to loosen them and gently wipe clean the lactate probe with a lint-free tissue. (Do not use microscope tissue.) Be careful not to gouge or scratch the electrode surface.

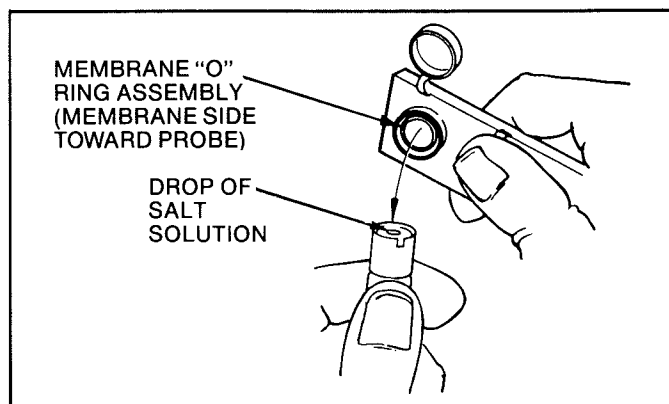


Figure 13. Installing a new membrane on the lactate probe.

- 30.2. Flush the electrode with distilled water. Gently dry with a lint-free tissue.
- 30.3. Place a small drop of YSI 2392 NaCl Salt Solution on the center of the probe.
- 30.4. Place a new membrane assembly on the probe tip.
- 30.5. Gently press the membrane assembly to seat it snugly in the probe.
- 30.6. Visually inspect the membrane assembly for dirt, large wrinkles, tears, etc. If there are any, replace the membrane assembly. Tiny wrinkles are not a problem.
31. Insert the probe into the upper hole in the temperature block and carefully seat it in the sample chamber.
32. Move the white plastic retainer up to the temperature block and carefully screw it in finger tight.
33. Insert the temperature probe into the lower hole in the temperature block and carefully seat it in the sample chamber.
34. Move the retainer up to the temperature block and carefully screw it in finger tight.
35. Alternately tighten the sensor and temperature probe retainers so the two probes are properly aligned and held in place with about the same pressure.
36. Insert the plastic waste tube through the temperature block, being sure there is a secure, leak-proof connection where the large and small tubes join. A black 007 O-ring is used to join the two tubes.
37. Place the buffer heat exchanger in the temperature block.
38. Attach the plastic tubing at the top and bottom of the sample chamber. Be sure the silicone tube does not make a sharp bend which would restrict the proper flow of buffer.
39. Position the cover on the temperature block and fasten in place with two thumb screws.

40. Position the temperature block assembly on the instrument and fasten in place with the two thumb screws.
41. Attach the stirring pump and clear pump connections to the temperature block assembly.
42. Replace the WASTE bottle and insert the waste tube.
43. Plug in the heater assembly/injection port switch connector.
44. Plug the power line into the wall receptacle.
45. Plug the probe assembly connector into the PROBE receptacle.
46. Hold in the CLEAR button long enough to recharge the system with buffer. The system is full when buffer starts to drain into the WASTE bottle.
47. Check the system for leaks and correct any if found.
48. Allow the instrument to warm up for two hours.
49. After the two-hour warmup, check to see that the indicator light behind the sample chamber, comes on and begins to cycle on and off.
50. Set the RUN/STANDBY switch to RUN.
51. Check the Down Timer cycle. Push and release the CLEAR button and at the same time start a stop-watch or similar timer when the ZERO/INJECT light comes on, stop the watch. Elapsed time should be 35-40 seconds; if it is less than 35 seconds, consult your dealer Service Representative.
52. Check the Up Timer cycle. Inject a sample of blood or standard and start a stop-watch or similar timer just as the WAIT light comes on. Stop the watch when the READ light comes on. Elapsed time should be 40-45 seconds; if it is less than 40 seconds, consult your dealer Service Representative.
53. Perform the Daily Operational Check.

SEMI-ANNUAL MAINTENANCE

The Monthly Maintenance procedures are part of the six-month check. In addition to the temperature block, sample chamber, probes, Up Timer, and Down Timer, the Semi-

and the stirring and clear pump systems.

In order to perform the Semi-Annual Maintenance procedures, you will need the YSI Model 23L Preventive Maintenance Kit (2353), and the Syringejet Preventive Maintenance Kit (2395), which are available from your dealer. If you prefer, your dealer will conduct the Semi-Annual Maintenance for you.

1. Replace the Syringejet plunger rod and tip assembly. (See Figure 14.)
 - 1.1. Unscrew the barrel guard and remove it, the needle and seal assembly and the glass barrel, and the O-ring. Do not separate the needle and seal assembly from the glass barrel.
 - 1.2. Unscrew the plunger retainer and remove it, the plunger, the plunger rod and tip assembly, the washer, the spring, and the eyelet.
 - 1.3. Clean the tip of a new plunger rod and tip assembly in isopropyl alcohol and acetone. It must be *absolutely* free of dirt, oil, etc., or it will not operate properly.
 - 1.4. Carefully reassemble the plunger rod and tip assembly with the washer, spring, eyelet, plunger and handle. Take care not to damage the plunger tip.
 - 1.5. Screw on the plunger retainer.
 - 1.6. Install the new 007 black O-ring on the barrel adapter.
 - 1.7. Slide the glass barrel over the plunger tip and seat it against the O-ring. It should be a tight fit; take care not to damage the plunger tip. Fit the plunger tip to the barrel as instructed in **Troubleshooting 12.5**.
 - 1.8. Install the needle and seal assembly onto the barrel and screw on the barrel guard.
 - 1.9. Insert the needle tip into isopropyl alcohol and depress and release the plunger several times until the plunger returns freely.
 - 1.10. Insert the needle tip into colored water or blood and depress and release the plunger several times.

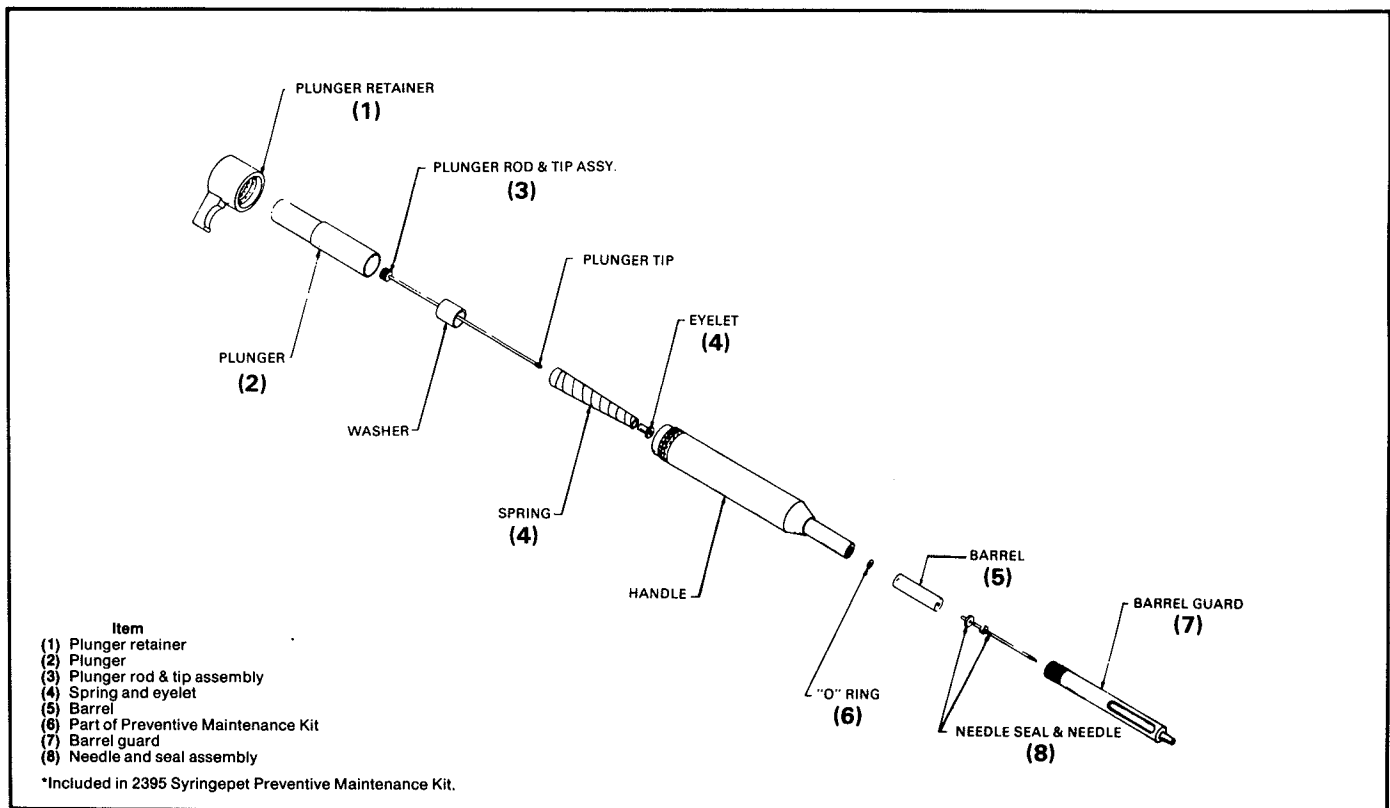


Figure 14. Exploded view of the Syringejet.

- 1.11. Insert the needle tip into distilled water and depress and release the plunger several times.
- 1.12. Be sure the plunger returns to its positive stop position and that the fluid drawn into the barrel is free of air bubbles. The Syringejet is now ready for use.
2. Examine the stirring pump system.
 - 2.1. Open the front door of the instrument and check that the air line is properly connected to the temperature block and the air pump. If it is not, connect it before proceeding.
 - 2.2. Check that there is no fluid in the air line. If there is, remove the tube at the temperature block and tip the instrument forward to allow the fluid to run out. Replace the tube at the temperature block. (Also, when there's fluid in the air line, it is possible that the silicone diaphragm has ruptured or been installed improperly; it should be checked.)
 - 2.3. Set the RUN/STANDBY switch to RUN.
 - 2.4. Inject a sample of air into the sample chamber and observe the reaction. If the stirring action is adequate, considerable froth (an homogenous mixture of air and buffer) will form in the sample chamber. If the froth forms, go to step 3. If not, go to 2.5.
 - 2.5. If froth did not form in the sample chamber, the air pump probably needs to be replaced. Consult your dealer Service Representative. (Also see note at item 21 in **Monthly Maintenance**.)
3. Check the clear pump's self-priming ability.
 - 3.1. Press and hold the CLEAR button until the supply tubing is pumped nearly dry. You'll hear a distinct change in the pumping sound when the tubing is dry enough.
 - 3.2. Rinse out the SUPPLY bottle and fill it with fresh buffer solution.
 - 3.3. Screw the SUPPLY bottle back into place.
 - 3.4. Press the CLEAR button and hold it until buffer flows into the WASTE bottle. If after a reasonable length of time no buffer goes into the WASTE bottle, the clear pump may be malfunctioning. Try to force prime as described in **Troubleshooting**, 13. If the clear pump continues to malfunction, consult your dealer Service Representative.
4. Check the clear pump system's flow rate.
 - 4.1. Remove the WASTE bottle.
 - 4.2. Run the waste tube to a graduated cylinder. (See Figure 15.)

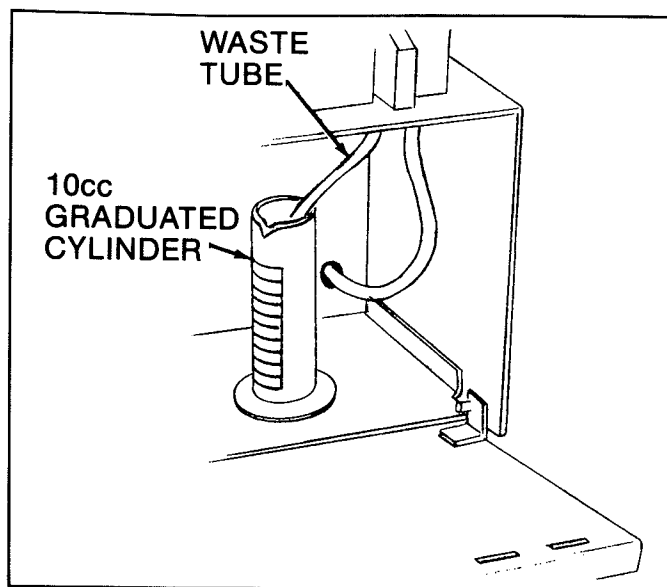


Figure 15. Flow-rate check setup.

- 4.3. Set the RUN/STANDBY switch to run.
- 4.4. Press and release the CLEAR button.
- 4.5. After the ZERO/INJECT light comes on, measure the amount of buffer in the graduated cylinder. There should be 3-4 cc. If not, there is a problem in the clear pump system. Consult your dealer Service Representative.
- 4.6. Reinstall the WASTE bottle.
5. Check the clear pump's leak-back rate.
 - 5.1. Flip the RUN/STANDBY switch to STANDBY.
 - 5.2. Disconnect the buffer supply tubing from the temperature block connection. (See Figure 6.)
 - 5.3. Insert the micro-bore tubing from the Preventive Maintenance Kit into the end of the supply tubing.
 - 5.4. Tape the micro-bore tubing vertically to the instrument so that the open end is about 0.5 in. above the temperature block's black plastic cover. (See Figure 16.)

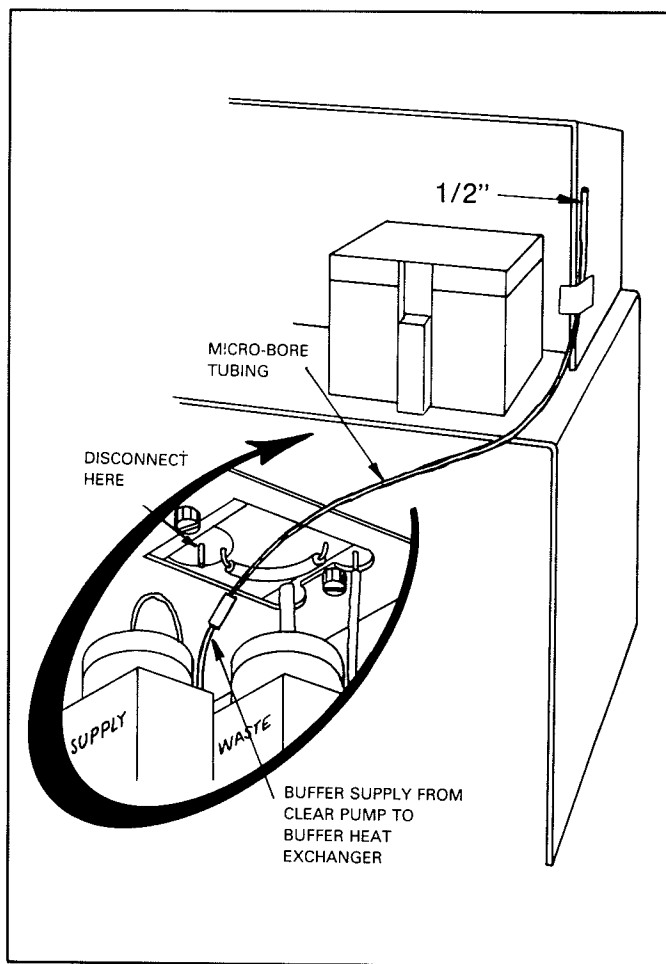


Figure 16. Leak-back rate setup.

- 5.5. Press and hold in the CLEAR button until buffer flows out of the tube.
- 5.6. Set the RUN/STANDBY switch to RUN and wait 30 minutes.
- 5.7. Check to see that the fluid level in the micro-bore tubing has not dropped more than 4mm. If it has, and if you have ascertained that there are no tubing leaks, replace the clear pump head assembly, or consult your dealer Service Representative.
- 5.8. Remove the micro-bore tubing and reattach the supply tubing to the temperature block connection.
6. Perform all steps in the Monthly Maintenance section, including the Daily Operational Check.

SUPPLEMENTARY INFORMATION

MODEL 23L SUPPLIES

YSI REORDER NO.	ITEM
24232	Instruction Manual
2361	Syringepet Syringepet Needle & Seal Assembly
2362	Sample Cups, 1000
2353	Preventive Maintenance Kit 1 Plastic Box 1 Silicone Tubing, 8 inches 1 length micro-bore tubing 2 O-Ring, 006 (orange) 2 O-Ring, 006 (black) 6 O-Ring, 007 (black) 2 O-Ring, 009 (black) 4 O-Ring, 010 (orange) 6 Septum Cord 1 Silicone Diaphragm 2 Bottles and Lids, 500 ml 1 SUPPLY Label 1 WASTE Label
2395	Syringepet Preventive Maintenance Kit 2 Plunger Rod and Tip Assembly 4 Needle and Seal Assembly
2327	L-Lactate Standard, 5 mmol/l
2328	L-Lactate Standard, 15 mmol/l
2357	Buffer Kit, 23L
2329	Lactate Membrane Kit
2363	Potassium Ferrocyanide
2392	NaCl Solution

Contact your dealer to order any of these supplies.

STORAGE AND SHIPMENT

Before storing or shipping this instrument, flush and drain its fluid lines by the following procedure:

1. Replace the buffer in the SUPPLY bottle with approximately 100 ml distilled water, and then hold in the CLEAR button until this water has all been pumped through.
2. Empty the WASTE and SUPPLY bottles.
3. Disconnect the tubing line from the inlet to the buffer heat exchanger, then press and hold in the CLEAR button until the tubing line is clear.
4. Blow a little air into the end of the waste line (as with a rubber bulb); the fluid in the buffer heat exchanger will siphon out. Clean up any spills.

When shipping this instrument, be sure it is properly packaged for complete protection.

WARRANTY

All YSI instruments are warranted for one year against defects in workmanship and materials when used for their intended purpose and maintained according to instructions. Damage from accidents, misuse, tampering or lack of prescribed maintenance is not covered. Shelf life for reagents, membranes, and other supplies in the original unopened package is warranted for the period of time indicated by their expiration dates. This warranty is limited to repair or replacement at no charge.

Return Instructions

Contact the dealer from whom you bought the instrument. Report the date of purchase, model and serial numbers. Instructions for return will be furnished as necessary. If the repair is not covered by the warranty, you will be notified of the charge for repair or replacement.

If Service is Needed

Contact your dealer's service department and report the date of purchase, model, serial number and nature of the failure. Arrange for on-site service, pick-up or shipment (see **STORAGE AND SHIPMENT**).

If Factory assistance is needed, call the YSI Service Department at 513/767-7241.

You will be notified of any charge for repairs not covered by warranty.



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