MEDICAL INSTRUMENTS

9180 Electrolyte Analyzer
Operator's Manual

2nd Edition
June 1996

For information contact:

AVL Scientific Corporation
50 Mansell Court
P.O. Box 337
Roswell, Georgia USA 30077
1-800-526-2272

AVL MEDICAL INSTRUMENTS AG
Stettemerstrasse 28
CH-8207 Schaffhausen
Switzerland
41-848-800-885

AVL LIST GmbH
Kleiststrasse 48
A-8020 Graz
Austria
43-316-987

Printed in USA

PD5006 REV B

Important Information!

This Operator´s Manual contains important warnings and safety information to be observed by the user.

This instrument is only intended for one area of application which is described in the instructions. The most important prerequisites for application, operation and safety, are explained to ensure smooth operation. No warranty or liability claims will be covered if the instrument is applied in areas other than those described or if the necessary prerequisites and safety measures are not observed.

The instrument is only to be operated by qualified personnel capable of observing these prerequisites.

Only accessories and supplies either delivered by or approved by AVL are to be used with the instrument.

Due to this instrument operating principle, analytical accuracy not only depends on correct operation and function, but also upon a variety of external influences beyond the manufacturers control. Therefore, the test results from this instrument must be carefully examined by an expert, before further measures are taken based on the analytical results.

Instrument adjustment and maintenance with removed covers and connected power mains are only to be performed by a qualified technician who is aware of the dangers involved.

Instrument repairs are only to be performed by the manufacturer or qualified service personnel.

Symbol	Explanation
	Attention symbol - Refer to the Operator's Manual or Service Manual for further instructions. This symbol is located on the inside of the instrument.
	Type B instrument symbol - An instrument of the B type falls under safety categories I, II, or III, or has an internal power supply providing the required insulation against discharge current and reliable ground connections.

Important Information!

Operating Safety Information

- This instrument falls under Safety Category I.
- This instrument is a Class B instrument.

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

Warning: Changes or modifications to this unit not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communication. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does not cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna
- Increase the separation between the equipment and receiver
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio TV technician for help

Caution:

- The instrument is designed as a conventional device (closed, not waterproof type).
- Do not operate the instrument in an explosive environment or in the vicinity of explosive anesthetic mixtures containing oxygen or nitrous oxide.
- This instrument is suitable for continuous operation.
- The power plug is to be plugged into a ground socket only. When using an extension cord, make sure that it is of the proper size and is properly grounded.
- Any breakage of the ground lead inside or outside the instrument or a loose ground connection can cause a hazardous condition when operating the instrument. Intentional disconnection of the grounding is not permitted.
- When replacing the fuses, make sure that they are of the same type and rating as the original fuses. Never use repaired fuses or short-circuit the fuse holders.

Operating Safety Information

METHOD SHEET

Intended Use

The AVL 9180 Electrolyte Analyzer is intended to be used for the measurement of sodium, potassium, chloride, ionized calcium and lithium in samples of whole blood, serum, plasma, urine, dialysate and aqueous standard solutions.

Clinical Significance[1,2]

Sodium

Sodium is the major cation of extracellular fluid. Its primary functions in the body are to chemically maintain osmotic pressure and acid-base balance and to transmit nerve impulses. Sodium functions at the cell membrane level by creating an electrical potential between different cell membranes causing the transmission of nerve impulses and neuromuscular excitability to be maintained. Sodium is involved in some enzyme catalyzed reactions as a cofactor. The body has a strong tendency to maintain a total base content, and only slight changes are found even under pathologic conditions.

Low sodium values, *hyponatremia*, usually reflect a relative excess of body water rather than a low total body sodium. Reduced sodium levels may be associated with: low sodium intake; sodium losses due to vomiting or diarrhea with adequate water and inadequate salt replacement, diuretics abuse, or salt-losing nephropathy; osmotic diuresis, metabolic acidosis; adrenocortical insufficiency; congenital adrenal hyperplasia; dilution type due to edema, cardiac failure, hepatic failure; and hypothyroidism.

Elevated sodium values, *hypernatremia*, are associated with conditions with water loss in excess of salt loss through profuse sweating, prolonged hyperpnea, severe vomiting or diarrhea, diabetes insipidus or diabetic acidosis; increased renal sodium conservation in hyperaldosteronism, Cushing's syndrome; inadequate water intake because of coma or hypothalamic diseases; dehydration; or excessive saline therapy.

The sodium value obtained may be used in the diagnosis or monitoring of all disturbances of the water balance, infusion therapies, vomiting, diarrhea, burns, heart and kidney insufficiencies, central or renal diabetes insipidus, endocrine disturbances and primary or secondary cortex insufficiency of the adrenal gland or other diseases involving electrolyte imbalance.

---

[1] Tietz, Norbert W., Ed., Clinical Guide to Laboratory Tests, 2nd Ed., (Philadelphia: W.B.Saunders, Co., 1990) p.98-99, 118-119, 456-459, 510-511, 720-721.

[2] Burtis C, Ashwood E (Eds.), Tietz Textbook of Clinical Chemistry, 2nd Ed., (Philadelphia: W.B.Saunders, Co., 1994) pp.1354-1370.

Potassium

Potassium is the major cation in the intracellular fluid and functions as the primary buffer within the cell itself. Ninety percent of potassium is concentrated within the cell, and damaged cells release potassium into the blood. Potassium plays an important role in nerve conduction, muscle function, and helps maintain acid-base balance and osmotic pressure.

Elevated potassium levels, *hyperkalemia*, can be found in oliguria, anemia, urinary obstruction, renal failure due to nephritis or shock, metabolic or respiratory acidosis, renal tubular acidosis with the K^+/H^+ exchange and hemolysis of the blood. Low potassium levels, *hypokalemia*, can be found in excessive loss of potassium through diarrhea or vomiting, inadequate intake of potassium, malabsorption, severe burns and increased secretion of aldosterone. High or low potassium levels may cause changes in muscle irritability, respiration and myocardial function.

The potassium value obtained may be used to monitor electrolyte imbalance in the diagnosis and treatment of infusion therapies, shock, heart or circulatory insufficiency, acid-base imbalance, therapy with diuretics, all kinds of kidney problems, diarrhea and hyper- and hypo-function of adrenal cortex and other diseases involving electrolyte imbalance.

Chloride

Chloride is an anion that exists predominantly in extracellular spaces. It maintains cellular integrity through its influence on osmotic pressure. It is also significant in monitoring acid-base balance and water balance. In metabolic acidosis, there is a reciprocal rise in chloride concentration when the bicarbonate concentration drops.

Decreased levels are found in severe vomiting, severe diarrhea, ulcerative colitis, pyloric obstruction, severe burns, heat exhaustion, diabetic acidosis, Addison's disease, fever and acute infections such as pneumonia.

Increased levels are found in dehydration, Cushing's syndrome, hyperventilation, eclampsia, anemia, cardiac decompensation.

Ionized Calcium

Calcium in blood is distributed as free calcium ions (50 %), bound to protein, mostly albumin (40 %) and 10 % bound to anions such as bicarbonate, citrate, phosphate and lactate. However, only ionized calcium can be used by the body in such vital processes as muscular contraction, cardiac function, transmission of nerve impulses and blood clotting. The AVL 9180 Analyzer measures the ionized portion of the total calcium. In certain disorders such as pancreatitis and hyperparathyroidism, ionized calcium is a better indicator for diagnosis than total calcium.

Elevated calcium, *hypercalcemia*, may be present in various types of malignancy, and calcium measurements may serve as biochemical markers. In general, while ionized calcium may be slightly more sensitive, either ionized or total calcium measurements have about equal utility in the detection of occult malignancy. Hypercalcemia occurs commonly in critically ill patients with abnormalities in acid-base regulation and losses of protein and albumin, which gives a clear advantage to monitoring calcium status by ionized calcium measurements.

Patients with renal disease caused by glomular failure often have altered concentrations of calcium, phosphate, albumin, magnesium and pH. Since these conditions tend to change ionized calcium independently of total calcium, ionized calcium is the preferred method for accurately monitoring calcium status in renal disease[3] .

Ionized calcium is important for diagnosis or monitoring of: hypertension management, parathyroidism, renal diseases, inadequate calcium intake, vitamin D monitoring, dialysis patients, cancer, pancreatitis, effect of diuretics, malnutrition, kidney stones, multiple myeloma and diabetes mellitus.

Lithium

Lithium is a monovalent alkali metal which is usually absent in the human body. It is used in the treatment of manic depression psychosis. The drug has proven highly effective in its intended use but some clinically significant complications have been associated with its use. Lithium binding to the plasma proteins is less than 10% and its half life is 7 - 35 hrs. It is mainly eliminated from the body by urine (95%).

Lithium has a very narrow therapeutic range. Initial dosing is aimed at between 0.80 to 1.20 mmol/L and the long-term maintenance level is 0.60 to 0.80 mmol/L. The concentration of lithium in serum during therapy is closely monitored, because lithium is acutely toxic with concentrations that are slightly higher than the above therapeutic range.

Urine Electrolytes

The electrolytes present in the human body and also ingested daily from food are excreted from the body in a natural circulation via the renal system, into the urine. Measurement of electrolytes in excreted urine gives important information about the efficiency of the kidneys and other pathological situations. Urine examinations can be made on a random urine sample or for a quantitative determination on a 24 hour collected urine sample. The quantity of electrolytes excreted per day can be determined by multiplying the measured concentration (mmol/L) with the total quantity of urine excreted in one day.

---

[3] Burritt MF, Pierides AM, Offord KP: Comparative studies of total and ionized serum calcium values in normal subjects and in patients with renal disorders. Mayo Clinic Proc. 55:606, 1980.

Dialysate Electrolytes

In the dialyzer, arterial blood and suitable dialysate liquids are led to a dialysis membrane in opposite directions. The structure of the membrane is such that it prevents the diffusion of proteins and red blood cells through the membrane. Since the composition of the blood and the dialysate are different, a gradient will be formed at the membrane and thus smaller molecules are activated to diffuse through the membrane. This method is effectively used to remove substances like urea, uric acid which are unable to excrete from the blood because of renal insufficiency.

When the concentration of the electrolytes between the blood and dialysate liquid deviates significantly, the electrolytes diffuse in the direction towards the lower concentration (i.e. from blood into the dialysis liquid or vice versa). Analysis of electrolytes in dialysis is of immense clinical significance and provides useful information to the clinician. The use of ISE's in dialysis are:

- To control the patient's electrolyte balance before, during and after the dialysis for fast recognition of deviations and also for making early corrections.
- To control the electrolyte concentrations in the dialysis liquid. Normally they are prepared by mixing appropriate concentrations of the substances with a defined quantity of distilled water.

Principles of Procedures

The AVL 9180 Analyzer methodology is based on the ion-selective electrode (ISE) measurement principle to precisely determine the measurement values.

There are six different electrodes used in the AVL 9180 Electrolyte Analyzer: sodium, potassium, chloride, ionized calcium, lithium and a reference electrode. Each electrode has an ion-selective membrane that undergoes a specific reaction with the corresponding ions contained in the sample being analyzed. The membrane is an ion exchanger, reacting to the electrical charge of the ion causing a change in the membrane potential, or measuring voltage, which is built up in the film between the sample and the membrane.

A galvanic measuring chain within the electrode determines the difference between the two potential values on either side of the membrane. The galvanic chain is closed through the sample on one side by the reference electrode, reference electrolyte and the "open terminal". The membrane, inner electrolyte and inner electrode close the other side.

A difference in ion concentrations between the inner electrolyte and the sample causes an electrochemical potential to form across the membrane of the active electrode. The potential is conducted by a highly conductive, inner electrode to an amplifier. The reference electrode is connected to ground as well as to the amplifier.

The ion concentration in the sample is then determined by using a calibration curve determined by measured points of standard solutions with precisely known ion concentrations.

Specimen Collection and Handling

Safety

Universal precautions must be observed when collecting blood specimens. It is recommended that all blood specimens be handled as potentially infectious specimens capable of transmitting human immunodeficiency virus (HIV), hepatitis B virus (HBV), or other bloodborne pathogens. Proper blood collection technique must be followed in order to minimize risk to the laboratory staff. Gloves should always be worn when handling blood and other body fluids.

Please refer to NCCLS document, M29-T2, *Protection of Laboratory Workers from Infectious Disease Transmitted by Blood, Body Fluids, and Tissue - Second Edition;* Tentative Guideline for further information on safe handling of these specimens.

Sample Requirements

Refer to NCCLS document, H11-A2, *Percutaneous Collection of Arterial Blood for Laboratory Analysis - Second Edition;* Approved Standard, May 1992, for detailed information on sample collection, storage and handling.

Blood sampling for analysis must be performed under proper supervision with details of collection, including sampling devices, site selection, sample handling and documentation approved by the personnel responsible. Specific procedures used should follow NCCLS guidelines.

Anticoagulants and Sample Collection Devices

The AVL 9180 Electrolyte Analyzer will accept samples directly from syringes, collection tubes, samples cups and, with the use of an adapter, from capillary tubes or the AVL Microsampler.

For whole blood and plasma samples, a balanced heparin that does not affect the electrolyte values is the recommended anticoagulant of choice. Sodium heparin is also an acceptable anticoagulant for electrolyte analysis, however, heparin binds ionized calcium to a certain extent falsely decreasing the measurement values.

Other anticoagulants such as EDTA, citrate, oxalate and fluoride have a significant effect on blood electrolytes and should not be used.

For serum samples, containers without additives are recommended.

Handling and Storage of Samples

For ionized calcium values, anaerobic conditions should be followed for all sample types. Contact with ambient air will cause a loss of CO_2 in the sample and the subsequent rise in pH will cause a reduction in ionized calcium.

Whole Blood

Whole blood samples should be collected in a heparinized syringe, AVL Microsampler or capillary and analyzed as soon as possible after collection. The sample container should be filled as much as possible, leaving minimal residual air space. If brief storage is required, do not cool the sample, as the erythrocytes could burst and release the intracellular potassium, creating an inaccurate potassium value in the sample.

Plasma

Plasma samples should be obtained by immediately centrifuging heparinized whole blood, separating the plasma from red cells and capping the sample tube. Analyze as soon as possible. If storage is required, the samples should be capped and refrigerated at 4 to 8 °C. Refrigerated samples should be allowed to warm to room temperature (15 to 30 °C) prior to analysis. If storage exceeds one hour, the plasma sample must be recentrifuged to remove additional fibrin clots.

Serum

Serum samples should be obtained by collecting blood in an untreated blood collecting tube. The sample should stand for 30 minutes to allow the clot to form prior to centrifugation. After centrifugation, remove the serum from the clot, and cap or seal the sample tube. If storage is required, the sample should be stored, tightly capped, under refrigeration at 4 to 8 °C, and allowed to return to room temperature, 15 to 30 °C, prior to analysis.

Each laboratory should determine the acceptability of its own blood collection syringes, capillaries and tubes and the serum or plasma separation products. Variations in these products exist between manufacturers, and at times, from lot to lot.

Reagents

ISE SnapPak™ (BP5186) containing the following reagents:

Standard A

Use:	For calibration of sodium, potassium, chloride, ionized calcium and lithium in the AVL 9180 Electrolyte Analyzer		
Contents:	350 mL		
Active Ingredients:	Na^+	150	mmol/L
	K^+	5.0	mmol/L
	Cl^-	115	mmol/L
	Ca^{++}	0.9	mmol/L
	Li^+	0.3	mmol/L
Additives:	Germicides		
Storage:	Temperature: 5 - 30 °C (41 - 86 °F)		
Stability:	Expiration Date & Lot Number are printed on each container label.		

Standard B

Use:	For calibration of sodium, potassium, chloride, ionized calcium and lithium in the AVL 9180 Electrolyte Analyzer		
Contents:	85 mL		
Active Ingredients:	Na^+	100	mmol/L
	K^+	1.8	mmol/L
	Cl^-	72	mmol/L
	Ca^{++}	1.5	mmol/L
	Li^+	0.3	mmol/L
Additives:	Germicides		
Storage:	Temperature: 5 - 30 °C (41 - 86 °F)		
Stability:	Expiration Date & Lot Number are printed on each container label.		

Standard C

Use:	For calibration of sodium, potassium, chloride, ionized calcium and lithium in the AVL 9180 Electrolyte Analyzer		
Contents:	85 mL		
Active Ingredients:	Na^+	150	mmol/L
	K^+	5.0	mmol/L
	Cl^-	115	mmol/L
	Ca^{++}	0.9	mmol/L
	Li^+	1.4	mmol/L
Additives:	Germicides		
Storage:	Temperature: 5 - 30 °C (41 - 86 °F)		
Stability:	Expiration Date & Lot Number are printed on each container label.		

Reference Solution

Use:	A salt bridge for calibration and measurement in the AVL 9180 Electrolyte Analyzer
Contents:	85 mL
Active Ingredients:	Potassium chloride 1.2 mol/L
Additives:	Germicides
Storage:	Temperature: 5 - 30 °C (41 - 86 °F)
Stability:	Expiration Date & Lot Number are printed on each container label.

Separately Packaged Reagents:

Cleaning Solution A (BP1025)

Use:	For cleaning the AVL 9180 Analyzer measuring system.
Contents:	Each dispensing bottle contains 100 mL of solution
Active Ingredients:	Neodisher MA (detergent) 3.5 g/L
Additives:	none
Storage:	Temperature: 5 - 30 °C (41 - 86 °F)
Stability:	Expiration Date & Lot Number are printed on each container label.

Conditioning Solution (BP0380)

Use:	For daily conditioning of the sodium electrode and sample sensor in the AVL 9180 Analyzer.
Contents:	Each dispensing bottle contains 100 mL of solution (U.S. market)
Active Ingredients:	Ammonium bifluoride 100 mmol/L
Additives:	none
Storage:	Temperature: 5 - 30 °C (41 - 86 °F)
Stability:	Expiration Date & Lot Number are printed on each container label.

Urine Diluent (BP0344)

Use:	For use as a diluent for the measurement of urine samples in AVL electrolyte system.
Contents:	Each bottle contains 500 mL of solution
Active Ingredients:	Sodium chloride 120 mmol/L
Additives:	germicides
Storage:	Temperature: 5 - 30 °C (41 - 86 °F)
Stability:	Expiration Date & Lot Number are printed on each container label.

PRECAUTIONS:
Use of calibration solutions or electrodes not manufactured for AVL could void the warranty.

A waste container is provided with the ISE SnapPak™ which, when used, holds human body fluids which may be potentially infectious; handle with appropriate care to avoid skin contact or ingestion.

FOR IN-VITRO DIAGNOSTIC USE.

Procedure

Materials Needed

Description	Part Number
ISE SnapPak™	BP5186
Cleaning Solution A	BP1025
Conditioning Solution	BP0380
Urine Diluent	BP0344
Printer Paper (5 rolls)	HP5025

The AVL 9180 Analyzer allows the operator to select one of the following measuring modes: whole blood, serum, urine, standard, Q.C. material, acetate or bicarbonate depending on the sample type to be analyzed. The analyzer automatically processes the sample through the necessary steps, then prints and displays the results.

In the blood, serum and Q.C. measuring modes, the results for sodium and potassium are reported by default as flame photometry equivalent values; chloride, ionized calcium, and lithium are reported as ISE direct potentiometry values. The urine mode allows for the measurement of prediluted urine samples for sodium, potassium and chloride. The acetate, bicarbonate and standard mode allows for the measurement of aqueous solutions and reports as ISE direct potentiometry values. For details of this operation, please refer to the Operator's Manual.

Test Conditions

Sample Size:	95 µL
Sample Types:	Whole blood, serum, plasma, urine, acetate and bicarbonate dialysate solutions
Sample Container:	capillary, AVL Microsampler, syringe, collection tube, sample cup.
Ambient Temperature:	+15 to +32 °C (60 to 90 °F)
Relative Humidity:	5% to 85% (non-condensing)
Type of Measurement:	direct potentiometry

Measured Parameters

Parameter	Measurement Range	Display Resolution	
Whole blood, serum, plasma, dialysate and aqueous solutions:			
Sodium	40 - 205 mmol/L	1 or 0.1	mmol/L
Potassium	1.5 - 15 mmol/L (0.8 - 15 mmol/L dialysate)	0.1 or 0.01	mmol/L
Chloride	50 - 200 mmol/L	1 or 0.1	mmol/L
ionized Calcium	0.2 - 5.0 mmol/L	0.01 or 0.001	mmol/L
Lithium	0.1 - 6.0 mmol/L	0.01 or 0.001	mmol/L
(Lithium is not measured in dialysate samples)			
Urine			
Sodium	1 - 300 mmol/L	1	mmol/L
Potassium	4.5 - 120 mmol/L (60-120 with additional dilution)	0.1	mmol/L
Chloride	1 - 300 mmol/L	1	mmol/L
(Calcium and Lithium are not measured in urine samples)			

Calibration

The analyzer contains software which permits one of six parameter configurations: $Na^+/K^+/Ca^{++}$, $Na^+/K^+/Cl^-$, $Na^+/K^+/Li^+$, Na^+/K^+, Na^+/Li^+, Li^+. Each of these configurations uses the same calibration solutions.

A 2-point calibration is performed automatically every 4 hours in READY mode and a 1-point calibration is automatically performed with every measurement.

An automatic calibration procedure is also performed shortly after power-on or reset. A calibration cycle can also be initiated manually at times when no sample measurements are performed.

Quality Control

AVL recommends that at least once daily or in accordance with local regulations, quality control solutions with known Na^+, K^+, Cl^-, Ca^{++} and Li^+ values should be analyzed at two levels (normal and low or high). For further details, please review the Quality Control section of the Operator's Manual. Results obtained should fall within limits defined by the day-to-day variability of the system as measured in the user's laboratory. If the results fall outside the laboratory's acceptable limits, refer to the Troubleshooting Section of the Operator's Manual.

Reference Interval

Specimen	Reference Ranges				
	Na^+ (mmol/l)	K^+ (mmol/L)	Ca^{++} (mmol/L)	Cl^- (mmol/L)	Li^+ (mmol/L)
serum, plasma, whole blood	136-145[1]	3.5-5.1[1]	1.12-1.32[1]	97-111[4]	0.6-1.20[1]
urine (mmol/24hrs)	40-220[1]	25-125[1]	N/A	110-250[1]	N/A

The ranges are provided for reference only. Each laboratory should establish its own reference interval for Na^+, K^+ , Cl^-, Ca^{++} and Li^+ as performed on the AVL 9180 Electrolyte Analyzer.

---

[4] Henry, R.J., Clinical Chemistry - Principles and Technics, (New York: Harper and Row, 1974)

Limitations of the Procedure

A number of substances have been reported to cause physiological changes in blood, serum, and plasma analyte concentrations. A comprehensive discussion concerning these and other interfering substances, their blood, serum or plasma concentrations and their possible physiological involvement is beyond the scope of this method sheet. No significant effect on serum and urine has been demonstrated from bromide, ammonium and iodide.

As with any clinical reaction, users must be alert to the possible effect on results due to unknown interference from medications or endogenous substances. All patient results must be evaluated by the laboratory and the physician in light of the total clinical status of the patient.

Opening and closing the fist with a tourniquet in place results in an increase in potassium levels by as much as 10 to 20%. It is recommended that the blood sample be obtained without a tourniquet, or that the tourniquet be released after the needle has entered the vein and 2 minutes elapsed before the sample is drawn.

Since the concentration of potassium inside erythrocytes is much greater than that in extracellular fluid, hemolysis should be avoided, and the serum should be separated from the cells as soon as possible after collection.

The lithium electrode response is dependent on the actual sodium concentration of the sample. The AVL 9180 Analyzer reports lithium in the range of 105 - 180 mmol/L Na^+.

Interferences

Salicylate, in extremely high levels, is known to interfere with the chloride electrode and results in a positive bias of the chloride result. At therapeutic levels of salicylate concentration, the influence on chloride is clinically insignificant.

The lithium electrode shows a slight sensitivity to the ionized calcium present in the sample and results in a negative bias of the lithium result. At normal physiological ionized calcium concentrations, the influence of ionized calcium is clinically insignificant.

---

[5] Kost GJ.Arch.Path.Lab.Med., Vol.117, Sep.1993, p.890-95

Relationship of ionized Calcium to total Calcium

The ratio of ionized calcium to total calcium in a healthy population is around 0.50 or 50% [1,5]. These relationships may be altered when using citrate in blood, or when the acid-base metabolism is disturbed.

Specific Performance Characteristics

Reproducibility

Typical Within-Run (S_{wr}) Between-Day (S_{dd}) and Total (S_T) Precision is determined from 2 runs per day with 2 replicates per run for 20 days on two AVL 9180 analyzers in each of its three configurations. Values for sodium and potassium are average of all six instruments, while values for chloride, ionized calcium and lithium are determined from the measurement of two of each respective unit configuration. All values are reported in mmol/L.

Material: ISE-trol Protein Based Aqueous Control Material - Level 1

Parameter	mean	S_{wr}	(CV%)	S_{dd}	(CV%)	S_T	(CV%)
Sodium	114.6	0.48	0.42%	0.76	0.66%	0.89	0.78%
Potassium	2.82	0.025	0.87%	0.035	1.24%	0.041	1.44%
Chloride	76.7	0.29	0.38%	0.52	0.67%	0.72	0.94%
ionized Calcium	2.07	0.015	0.72%	0.024	1.18%	0.034	1.66%
Lithium	0.40	0.010	2.40%	0.018	4.57%	0.026	6.41%

Material: ISE-trol Protein Based Aqueous Control Material - Level 2

Parameter	mean	S_{wr}	(CV%)	S_{dd}	(CV%)	S_T	(CV%)
Sodium	141.2	0.40	0.28%	0.30	0.21%	0.46	0.33%
Potassium	4.35	0.024	0.55%	0.023	0.53%	0.036	0.82%
Chloride	102.4	0.18	0.18%	0.20	0.20%	0.32	0.31%
ionized Calcium	1.35	0.016	1.21%	0.021	1.55%	0.042	3.10%
Lithium	1.04	0.012	1.19%	0.035	3.36%	0.045	4.31%

Material: ISE-trol Protein Based Aqueous Control Material - Level 3

Parameter	mean	S_{wr}	(CV%)	S_{dd}	(CV%)	S_T	(CV%)
Sodium	158.8	0.51	0.32%	0.76	0.48%	0.90	0.56%
Potassium	5.74	0.027	0.48%	0.026	0.45%	0.036	0.62%
Chloride	123.2	0.36	0.29%	0.89	0.72%	1.17	0.95%
ionized Calcium	0.63	0.010	1.52%	0.007	1.07%	0.014	2.29%
Lithium	2.59	0.025	0.97%	0.063	2.44%	0.082	3.18%

Material: RNA EQUIL Reduced Bovine Hemoglobin Solution - Level 2

Parameter	mean	S_{wr}	(CV%)	S_{dd}	(CV%)	S_T	(CV%)
Sodium	134.8	0.53	0.40%	0.45	0.33%	0.63	0.47%
Potassium	4.89	0.039	0.79%	0.021	0.42%	0.043	0.88%
Chloride	100.4	0.43	0.43%	0.42	0.41%	0.58	0.57%
ionized Calcium	1.10	0.008	0.75%	0.004	0.40%	0.011	0.95%
Lithium	N/A						

Material: Aqueous Standard Solution - Level 1

Parameter	mean	S_{wr}	(CV%)	S_{dd}	(CV%)	S_T	(CV%)
Sodium	150.0	0.55	0.37%	0.34	0.23%	0.57	0.38%
Potassium	4.97	0.022	0.44%	0.018	0.36%	0.029	0.57%
Chloride	115.0	0.11	0.09%	0.08	0.07%	0.16	0.14%
ionized Calcium	0.96	0.004	0.41%	0.004	0.39%	0.007	0.76%
Lithium	0.30	0.004	1.27%	0.005	1.60%	0.008	2.48%

Material: Aqueous Standard Solution - Level 2

Parameter	mean	S_{wr}	(CV%)	S_{dd}	(CV%)	S_T	(CV%)
Sodium	113.2	0.51	0.45%	0.96	0.85%	1.07	0.95%
Potassium	1.82	0.033	1.88%	0.043	2.36%	0.053	2.92%
Chloride	82.9	0.27	0.33%	0.67	0.80%	0.87	1.05%
ionized Calcium	2.43	0.014	0.56%	0.032	1.33%	0.043	1.76%
Lithium	5.42	0.043	0.78%	0.155	2.86%	0.196	3.62%

Material: Pooled Human Serum

Parameter	mean	S_{wr}	(CV%)	S_{dd}	(CV%)	S_T	(CV%)
Sodium	138.8	0.30	0.22%	0.36	0.28%	0.47	0.34%
Potassium	4.49	0.034	0.75%	0.041	0.92%	0.051	1.13%
Chloride	106.8	0.18	0.17%	1.00	0.93%	1.24	1.16%
ionized Calcium	1.19	0.007	0.55%	0.031	2.64%	0.039	3.29%
Lithium	0.17	0.011	6.19%	0.015	8.40%	0.023	13.28%

Material: Acetate Dialysate Solution

Parameter	mean	S_{wr}	(CV%)	S_{dd}	(CV%)	S_T	(CV%)
Sodium	86.1	0.85	0.98%	1.81	2.10%	1.78	2.07%
Potassium	2.09	0.029	1.41%	0.041	1.94%	0.049	2.32%
Chloride	107.8	0.25	0.24%	0.23	0.21%	0.40	0.37%
ionized Calcium	1.77	0.020	1.13%	0.092	5.20%	0.115	6.50%
Lithium	N/A						

Material: Bicarbonate Dialysate Solution

Parameter	mean	S_{wr}	(CV%)	S_{dd}	(CV%)	S_T	(CV%)
Sodium	135.2	0.45	0.33%	0.59	0.44%	0.72	0.54%
Potassium	1.58	0.023	1.46%	0.031	1.95%	0.037	2.37%
Chloride	107.3	0.37	0.35%	0.63	0.59%	0.86	0.80%
ionized Calcium	1.68	0.012	0.72%	0.016	0.96%	0.027	1.63%
Lithium	N/A						

Material: Urine

Parameter	mean	S_{wr}	(CV%)	S_{dd}	(CV%)	S_T	(CV%)
Sodium	51.5	1.98	3.84%	3.06	5.94%	3.65	7.08%
Potassium	48.4	0.65	1.34%	0.97	2.00%	1.11	2.29%
Chloride	85.9	0.53	0.62%	0.66	0.76%	0.99	1.16%
ionized Calcium	N/A						
Lithium	N/A						

Linearity in Aqueous Standard Solutions

Aqueous linearity standards were gravimetrically prepared from N.I.S.T. traceable salts and measured on each of six AVL 9180 instruments, two of each configuration: Na/K/Cl, Na/K/iCa and Na/K/Li.

Parameter	Slope	Intercept	Correlation Coefficient	Sy*x	Range	n
Sodium	0.99993	0.0128	0.99995	0.666	51-196	300
Potassium	0.99838	0.0119	0.99919	0.194	2.0-12.6	300
Chloride	0.97556	-0.1775	0.99994	0.674	56-194	100
ionized Calcium	1.01552	-0.0078	0.99980	0.037	0.4-3.3	100
Lithium	0.99850	0.0087	0.99985	0.038	0.3-5.3	100

Linearity in Serum

Linearity in serum was established with the analysis of two specimen sets in non-clinical tests: commercially prepared serum linearity standards for sodium, chloride and potassium with normal protein content, and a group of random patient serum samples. All samples were analyzed in pairs on each of two of AVL 9180 instruments in each configuration: Na/K/Cl, Na/K/iCa and Na/K/Li. and in pairs on each of the following instrument types for comparision to various methods:

Direct ISE, not flame correlated (listed as 98X)	AVL 983 Na/K/Cl Analyzer AVL 984 Na/K/iCa Analyzer AVL 985 Na/K/Li Analyzer
Direct ISE, flame correlated (listed as 91XX)	AVL 9130 Na/K/Cl Analyzer AVL 9140 Na/K/iCa Analyzer
Flame Absorbance Emission Spectroscopy	IL 943 Flame Photometer
Chloridometry	Labconco Digital Chloridometer

Correlation to Flame

IL 943 Flame Photometer

Parameter	Slope	Intercept	Correlation Coefficient	Sy*x	Range	n
Sodium	0.9617	5.83	0.9908	2.04	104-178	50
normalized to Na = 140		0.47				
Potassium	1.0249	0.015	0.9991	0.075	1.8-11.5	50
normalized to K = 4.0		0.11				
Lithium	0.9803	0.011	0.9822	0.028	0.11-0.71	15
	0.9720	0.016	0.9957	0.019	0.23-1.13	15

Correlation to Direct ISE - not flame correlated

AVL 98X Electrolyte Analyzers

Parameter	Slope	Intercept	Correlation Coefficient	Sy*x	Range	n
Sodium	0.9895	-6.35	0.9992	0.61	110-186	50
normalized to Na = 140		-7.83				
Potassium	1.0223	-0.25	0.9996	0.05	2.0-11.6	50
normalized to K = 4.0		-0.164				
Chloride	0.9631	-1.01	0.9995	0.51	70-152	50
normalized to Cl = 105		-4.88				
ionized Calcium	0.8898	0.107	0.9960	0.021	0.67-1.66	50
normalized to iCa = 1.1		-0.014				
Lithium	0.9923	0.008	0.9985	0.010	0.11-0.71	15

Correlation to Direct ISE - flame correlated

AVL 91XX Electrolyte Analyzers

Parameter	Slope	Intercept	Correlation Coefficient	Sy*x	Range	n
Sodium	0.9856	-2.02	0.9856	1.21	104-179	50
normalized to Na = 140		0.006				
Potassium	0.9992	0.02	0.9994	0.05	1.9-11.8	50
normalized to K = 4.0		0.02				
Chloride	1.0026	-5.31	0.9989	0.73	70-152	50
normalized to Cl = 105		-5.04				
ionized Calcium	1.0023	0.040	0.9954	0.022	0.62-1.54	50
normalized to iCa = 1.1		0.042				

Correlation to Chloridometry

Labconco Digital Chloridometer

Parameter	Slope	Intercept	Correlation Coefficient	Sy*x	Range	n
Chloride	1.0222	2.75	0.9923	2.03	66-145	50
normalized to Cl = 105		0.00				

Bibliography

Bishop ML, Duben-Engelkirk JL, Fody EP. Clinical Chemistry Principles Procedures Correlations, 2nd Ed., (Philadelphia: J.B.Lippincott Co.),1992,p.281.

Burritt MF, Pierides AM, Offord KP: Comparative studies of total and ionized serum calcium values in normal subjects and in patients with renal disorders. Mayo Clinic Proc. 55:606, 1980.

Burtis C, Ashwood E (Eds.), Tietz Textbook of Clinical Chemistry, 2nd Ed., (Philadelphia: W.B. Saunders, Co.,1994) pp.1354-1360,2180-2206.

Calbreath, Donald F., Clinical Chemistry A Fundamental Textbook, (Philadelphia: W.B. Saunders Co., 1992) pp.371, 376, 390-395.

Henry, R.J., Clinical Chemistry - Principles and Technics, (New York, Harper and Row, 1974)

Kost GJ.Arch.Path.Lab.Med., Vol.117, Sep.1993, p.890-95

National Committee for Clinical Laboratory Standards. Protection of Laboratory Workers from Infectious Disease Transmitted by Blood, Body Fluids and Tissue, Second Edition; Tentative Guideline. NCCLS Document M29-T2, (1992).

National Committee for Clinical Laboratory Standards. Additives for Blood Collection Devices: Heparin; Tentative Standard; NCCLS Document H24-T, (1988).

National Committee for Clinical Laboratory Standards. Evaluation of Precision Performance of Clinical Chemistry Devices, Second Edition; Tentative Guideline. NCCLS Document EP5-T2, (1992).

Rose, Burton David, Clinical Physiology of Acid-Base and Electrolyte Disorders, 4th Ed., (New York: McGraw-Hill, Inc., 1993) pp. 346-348, 432, 797-798.

Schoeff, Larry E & Williams, Robert H. (Eds.) Principles of Laboratory Instruments, (St. Louis: Mosby Year Book Inc., 1993) pp. 150-157, 161-164.

Snyder John R., Senhauser Donald A, (Eds.), Administration and Supervision in Laboratory Medicine, 2nd Ed, (Philadelphia: J.B.Lippincott Co., 1989) pp.262-284.

Tietz, Norbert W.,Ed.,Clinical Guide to Laboratory Tests, 2nd Ed., (Philadelphia: W.B. Saunders Co., 1990), pp.98-99, 118-119, 456-459, 510-511, 720-721

Tietz, Norbert W.,Ed., Textbook of Clinical Chemistry, 2nd Ed., (Philadelphia: W.B. Saunders, Co.,1986), pp.1816, 1837, 1840-1842, 1845.

Toffaletti J, Gitelman JH, Savory J: Separation and quantification of serum constituents associated with calcium by gel filtration. Clin Chem 22: 1968-72, 1976.

Preface

Welcome

Your AVL Electrolyte Analyzer is a powerful tool designed to help you quickly, accurately and efficiently conduct basic electrolyte testing in the convenience of your own laboratory.

This manual will help guide you through setting up your analyzer and will help you start analyzing samples. As you become familiar with the operation of the unit, you may use the manual as a reference for day-to-day routines and as a guide for maintenance and troubleshooting.

How to use this manual

If you have an analyzer that is not yet set up, you should begin by reading Chapters 1 and 2. For programming and quality control functions, read Chapters 3 and 4. Information on analyzer operation and maintenance is contained in Chapters 5 and 6. Detailed service information and operating principles can be found in Chapters 7 and 8.

Contents

Chapter 1: Getting to Know Your AVL Electrolyte Analyzer 1

Chapter 2: Installation 11

Chapter 3: Programming 25

Chapter 4: Quality Control 41

Chapter 5: Operation 47

Chapter 6: Maintenance 55

Chapter 7: Troubleshooting and Service Functions 75

Chapter 8: Principles of Operation 95

Chapter 9: Supplies, Service, and Warranty Registration 109

Appendix A: Technical Specifications 114

Appendix B: Program Flow Chart 116

Appendix C: Maintenance Log Master 117

Appendix D: Correlation Factor Worksheet Master 118

1

Chapter 1

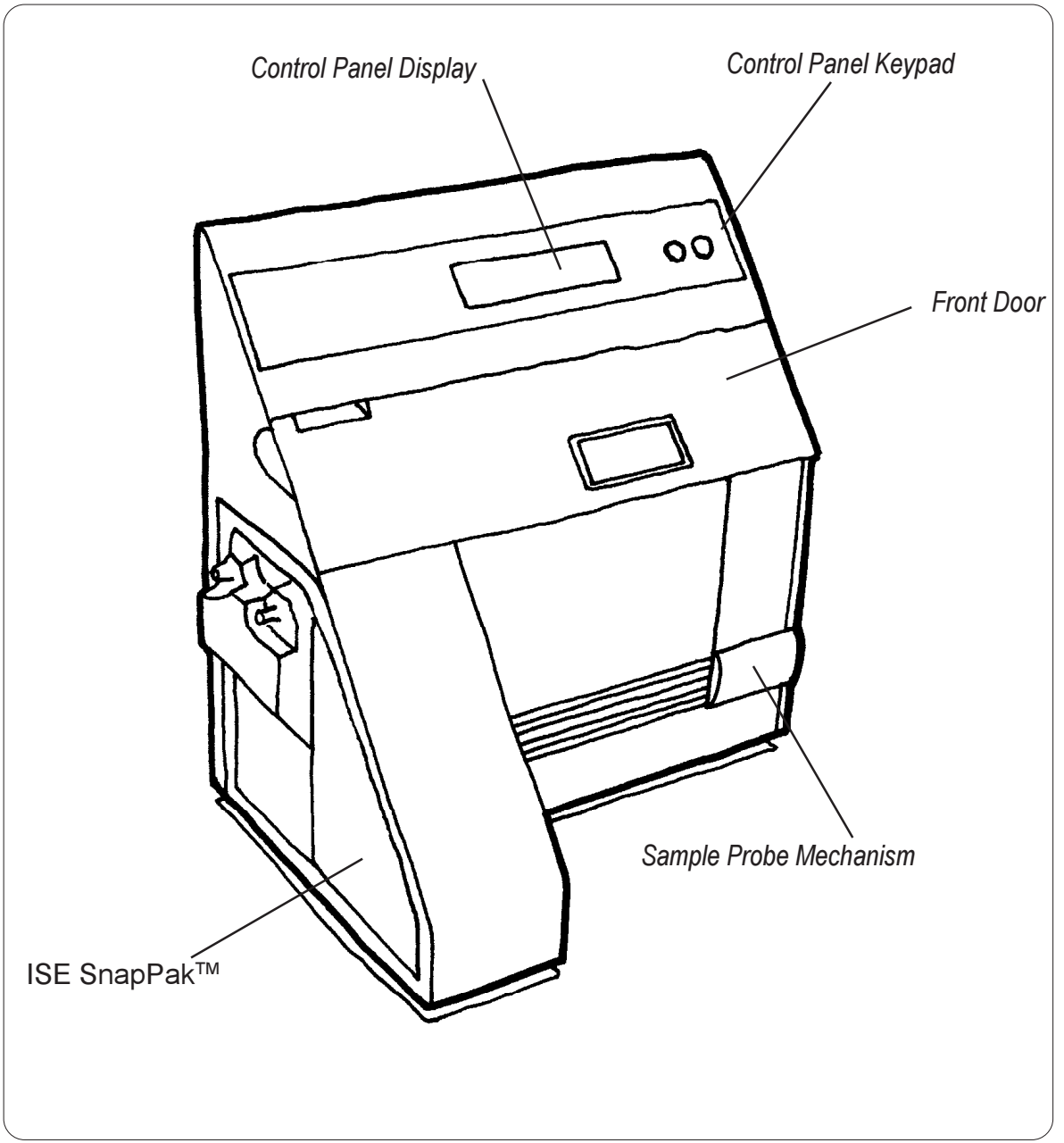
Getting to Know Your AVL Electrolyte Analyzer

Important safety instructions

Before you begin installing your AVL Electrolyte Analyzer, carefully read the overview information in this chapter.

For your own safety and the proper operation of your equipment, always follow these precautions when working with your AVL Electrolyte Analyzer:

- Keep the analyzer away from all sources of liquids such as sinks and wash basins.
- Don't use ammonia-based or alcohol-based cleaners, which can chemically react with plastic, on or around the analyzer.
- Always handle blood samples and collection devices with care.
- Use approved protective gloves to avoid direct contact with sample.
- Aseptic procedures are required when cleaning the sampling probe to avoid contamination.
- Dispose of ISE SnapPak™ according to local regulations.



1-1. 9180 Electrolyte Analyzer Major Components (external)

Analyzer components

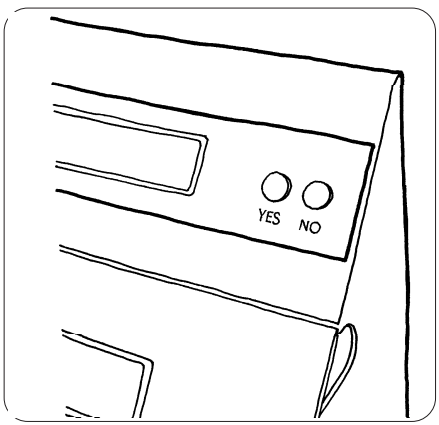
The AVL Electrolyte Analyzer is a fully automatic, microprocessor-controlled medical instrument that measures:

Na^+ : Sodium
K^+ : Potassium

plus one of the following:

Cl^- : Chloride
Ca^{++} : Calcium
Li^+ : Lithium

The analyzer consists of several major components that are important for you to know and understand while becoming familiar with the unit.
See Illustration 1-1.

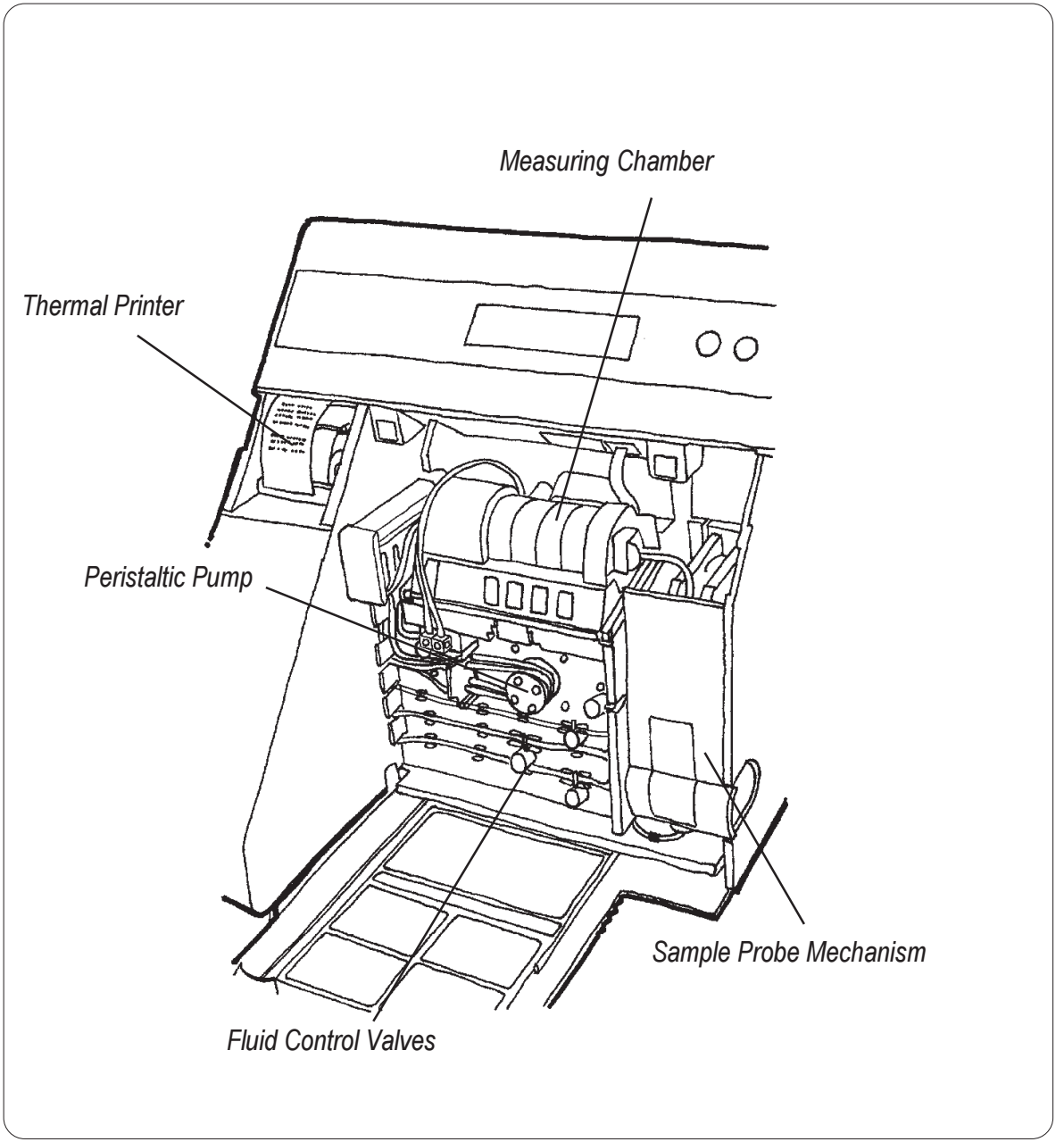


1-2. Control panel keypad

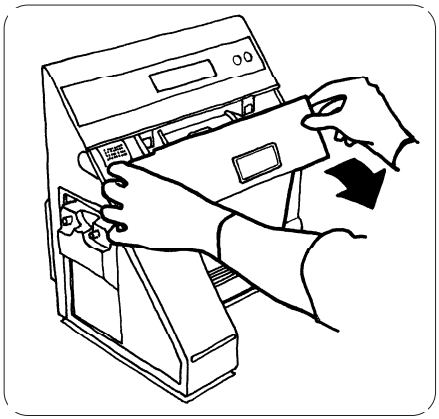
You communicate with the analyzer through a **keypad** with **YES** and **NO** keys. With these keys you can perform all analyzer functions, including: sample measurement, data input, programming and quality control testing.
See Illustration 1-2.

1-3. Control panel display

The analyzer communicates to you through a dot matrix **display**. This two line, alpha-numeric read-out allows up to 16 characters per line, displaying the activities of the analyzer, sample results and other programmed information.
See Illustration 1-3.

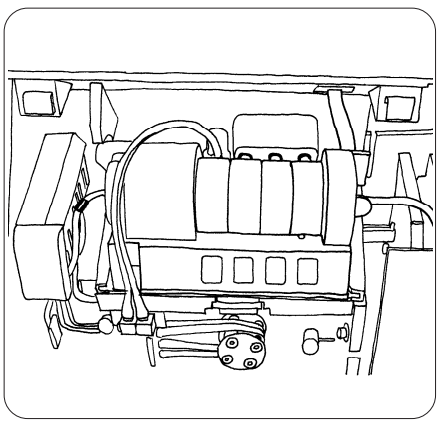


1-4. 9180 Electrolyte Analyzer Major Components (internal)



1-5. Opening the main door

Inside the unit are other components which are accessible by opening the main door.
See illustration 1-4 and 1-5.

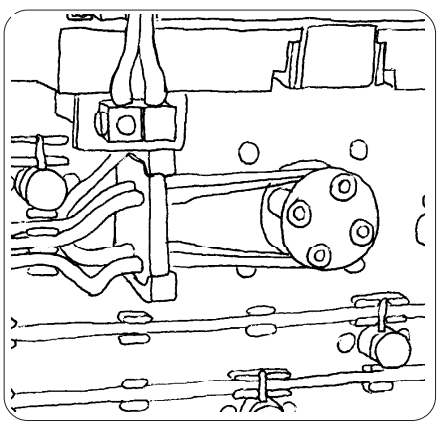


1-6. Measuring chamber

The **measuring chamber** consists of the movable left locking device that holds the electrodes in place, the electrodes, the right electrode holder with sample sensor connector, and the measuring chamber base. Electrodes are labeled:

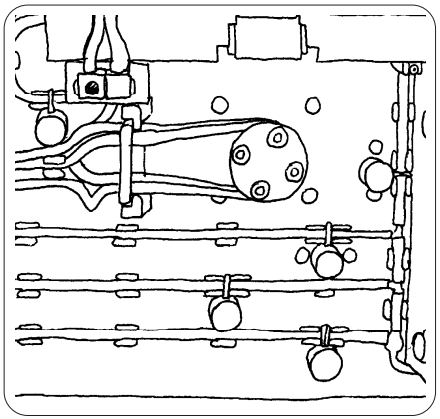
Ref : Reference
Na^{+} : Sodium
K^{+} : Potassium
Cl^{-} : Chloride
Ca^{++} : Calcium
Li^{+} : Lithium

See illustration 1-6.



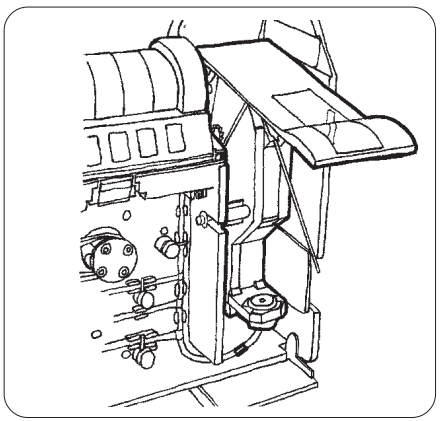
1-7. Peristaltic pump

A **peristaltic pump** is used to transport all liquids within the analyzer.
See illustration 1-7.



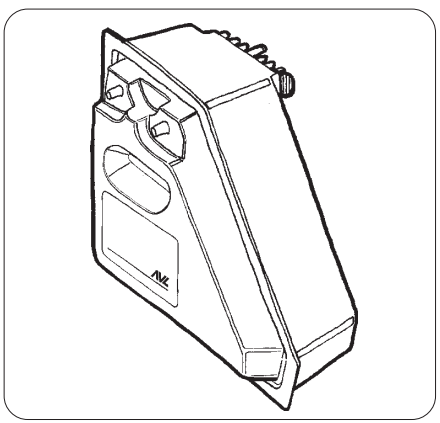
1-8. Fluid control valves

Valves control the movement of the liquid within the analyzer.
See illustration 1-8.



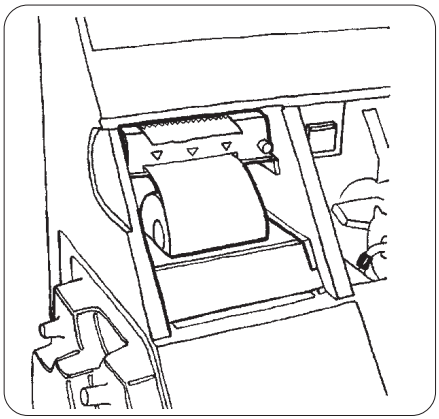
1-9. Sample probe mechanism

The **sample probe mechanism** is located behind the small door at the front of the unit.
See illustration 1-9.



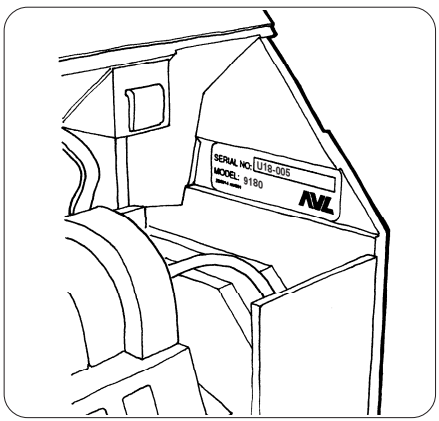
1-10. ISE SnapPak™

The self-contained ISE SnapPak™ uses an integral check-valve to ensure that waste cannot spill out of the package.
See illustration 1-10.



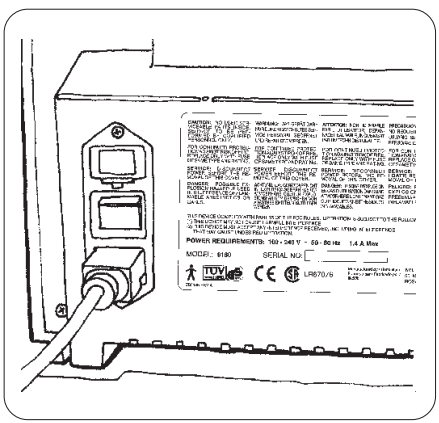
1-11. Thermal printer

The **thermal printer** uses heat-sensitive paper to output information in 16 columns. The analyzer will print measured values, calibration values, electrode voltages, and amount of liquid remaining in the ISE SnapPak™ as well as cleaning and maintenance information. The unit is configured to allow convenient storage of a second roll of paper in the paper tray.
See illustration 1-11.



1-12. Model - Serial No. plate

The model and serial number is located on an **identification plate** above the probe mechanism.
See illustration 1-12.



1-13. Rear panel

The rear panel of the unit contains a serial number plate, as well as the power switch/power receptacle module and an RS232 interface port.
See illustration 1-13.

Congratulations

You've just learned the basic components of the analyzer and are now ready to install your system.

2

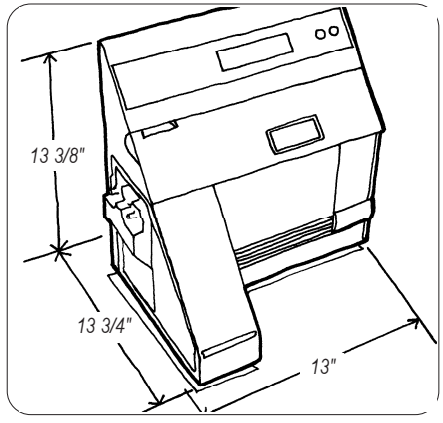
Chapter 2

Installation

Choosing a location for the AVL Electrolyte Analyzer

Location is important for trouble-free operation of your analyzer. Before you begin setup, choose a site that is convenient for your sampling needs and meets the following physical requirements of the unit:

- Grounded electrical outlet
- Away from direct sunlight
- Room temperature between 15° C and 32° C (60° F and 90° F)
- Maximum relative humidity of 85%
- Ample room to allow air to circulate freely around the unit. See illustration 2-1.
- Away from strong electromagnetic fields, such as those created by electric motors and x-ray equipment.
- Away from explosive gases or vapors.



2-1. Space requirements

Now it's time to unpack your AVL Electrolyte Analyzer. Carefully remove the unit from the box. DO NOT lift the analyzer by the foam packaging materials, which are provided for shipping only.

Before you begin installing your system, take a moment to look over the contents to ensure that you have everything you need to get your analyzer up and running.

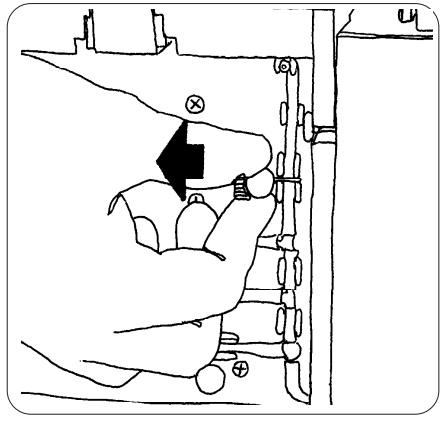
Check for these items:

Power cord
Electrodes
Printer paper
ISE SnapPak™
Cleaning Solution A
Electrode Conditioning Solution
ISE-trol Electrolyte Control

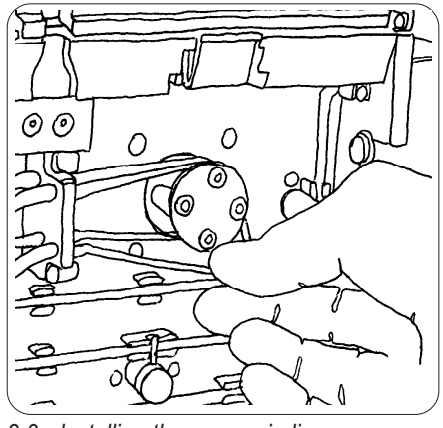
You will also need a supply of lint-free tissues and disposable sample cups, which should be kept in a location convenient to the analyzer.

Setting up

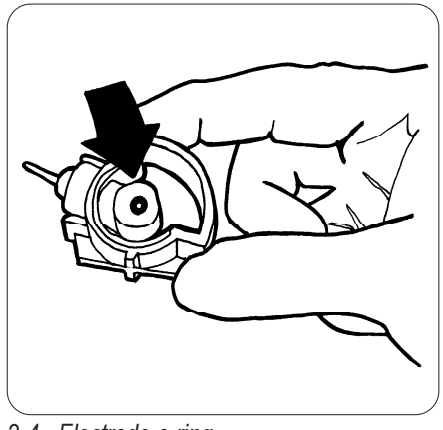
Now you're ready to get your AVL Electrolyte Analyzer prepared to operate. Prior to beginning the actual installation, it is a good idea to completely read through this chapter to develop an understanding of the procedures that are required.



2-2. Removing relief clamps



2-3. Installing the pump windings



2-4. Electrode o-ring

Begin by placing the analyzer on a secure table top that allows plenty of working space and is convenient to a power connection.

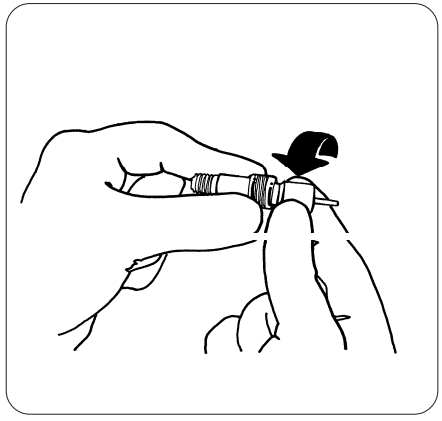
Open the analyzer main door. Locate and carefully remove the five red relief clamps from the valves by sliding out the clamps. Save the clamps for reuse to prevent damaging the tubes in the event the analyzer is later shut down for any reason.
See illustration 2-2.

Slip the two pump windings around the analyzer pump rollers, making sure not to overstretch the tubing.
See illustration 2-3.

Electrodes and measuring chamber

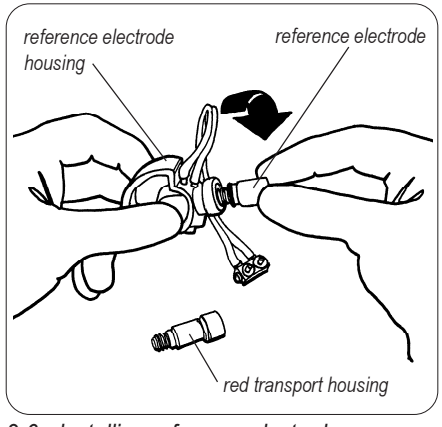
The next procedure involves preparing and installing the electrodes in the measuring chamber.

Remove the reference housing and electrodes from their protective boxes and place them on a soft, clean surface. Check that each electrode has an o-ring in the left side of the electrode.
See illustration 2-4.



2-5. Transport housing removal

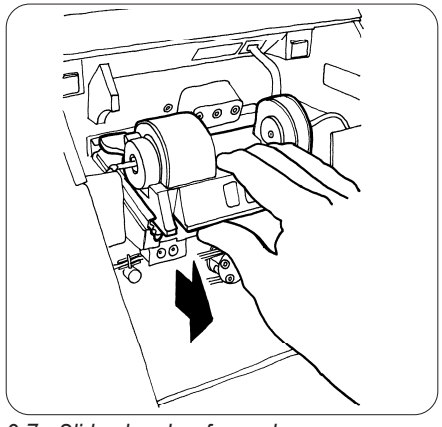
Unscrew the red transport housing from the reference electrode and check that the o-ring on the electrode is properly seated. Save the transport housing for storage of the reference electrode in the event the analyzer is turned off or taken out of service for any reason.
See illustration 2-5.



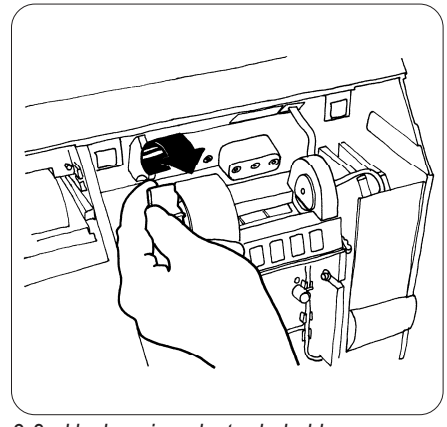
2-6. Installing reference electrode

Carefully screw the reference electrode into the reference electrode housing and place it with the other electrodes.
See illustration 2-6.

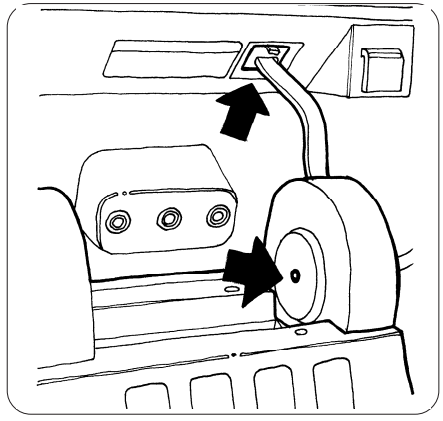
Slide the measuring chamber forward until it locks in the front position. Unclamp the left electrode holder by moving the clamp forward.
See illustrations 2-7 and 2-8.



2-7. Slide chamber forward

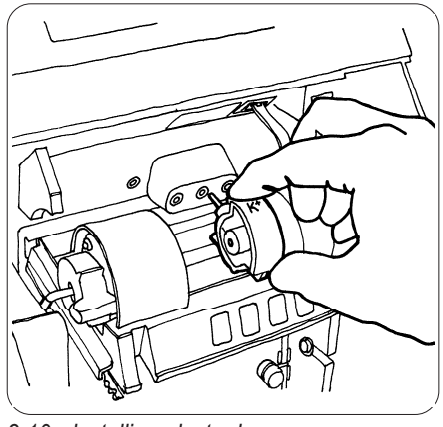


2-8. Unclamping electrode holder



2-9. Sample sensor cable & o-ring

Locate the sample sensor cable and ensure that it is securely inserted into the receptacle above the measuring chamber. Check that an o-ring is present in the right electrode holder.
See illustration 2-9.

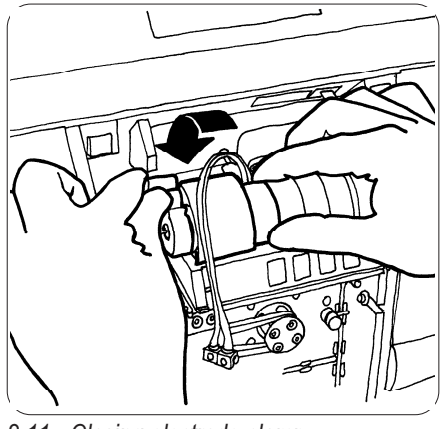


2-10. Installing electrodes

Now install the electrodes in the measuring chamber, beginning on the right and working to the left (the reference electrode will be installed last).

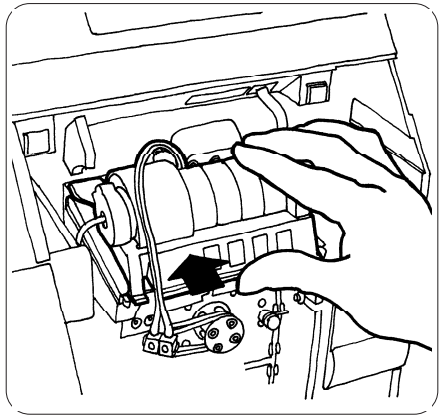
Note: The electrode on the right may be one of the following: chloride, ionized calcium, lithium or a dummy electrode, if no third test is needed. If sodium and lithium are selected, the K^+ electrode is replaced by a dummy electrode.

Check to make sure that the lettering on the measuring chamber matches the lettering on the electrode. Also, note that all electrodes have a lip on the bottom that rests on the flat edge of the measuring chamber to aid in proper positioning.
See illustration 2-10.



2-11. Closing electrode clamp

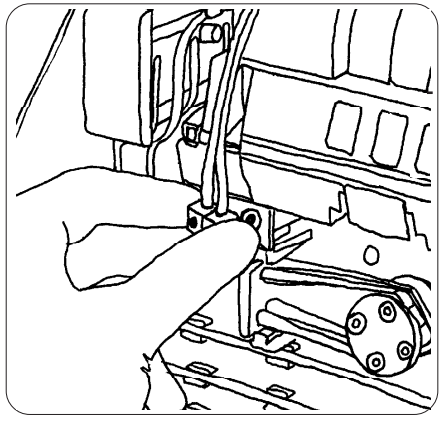
Close the clamp on the left electrode holder by lifting it upward until it locks in the back position, and ensure that the electrodes are properly seated.
See illustration 2-11.



2-12. Slide chamber backward

Slide the measuring chamber back until it snaps into position.
See illustration 2-12.

Plug the tubing connector of the reference housing assembly into the receptacle below the left side of the measuring chamber.
See illustration 2-13.

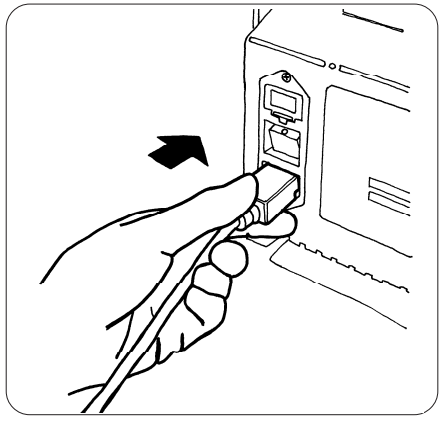


2-13. Reference connector

Preparing the analyzer for operation

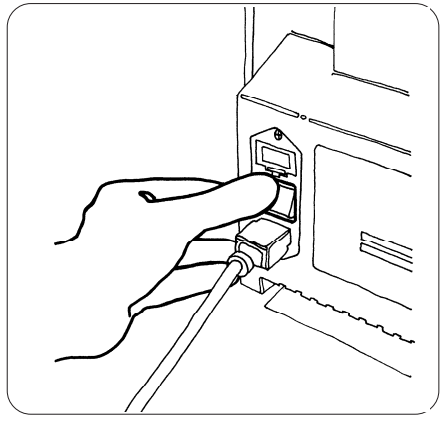
Before the analyzer is powered on, the language setting must be selected. The factory-set language is English; to select a different language setting, remove the paper tray and use a pen to set the switch to the desired language position as indicated on the label.

Now, locate the power switch on the back of the unit and make sure that it is in the **OFF (O)** position. Next, plug the power cord into the power receptacle module on the back of the unit, then plug the cord into a grounded electrical outlet.
See illustration 2-14.



2-14. Power cord installation

Note: If you decide to change the language after the unit is powered on, you must cycle the power to activate the new language.



2-15. Turning power on

Push the power switch to the **ON (I)** position. The unit will automatically begin to operate.
See illustration 2-15.

Now that the AVL Electrolyte Analyzer is functioning, you will begin using the keypad interface to communicate with the instrument. Use the **NO** key to make changes, the **YES** key to accept the displayed values or information.

The analyzer will display a default date and time and will allow you to input the correct date and time.

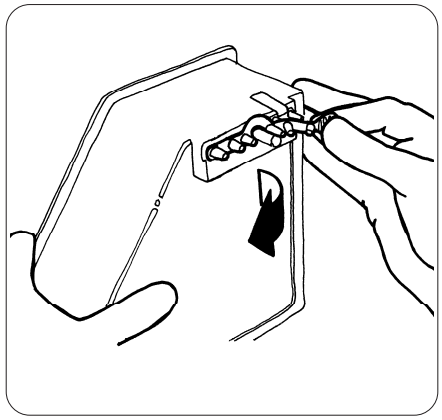
Date: 01-JAN -80
Time: 00:00

Enter the correct date as follows:

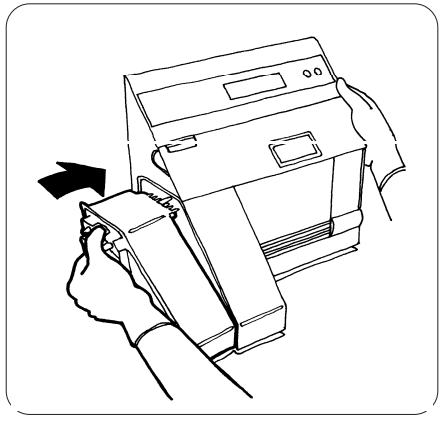
1. Press the **NO** key until the correct day is displayed. Press **YES**. The cursor will move to the month.

Note: By keeping the NO *key depressed, the analyzer will automatically scroll through the numbers, first slowly, then fast.*

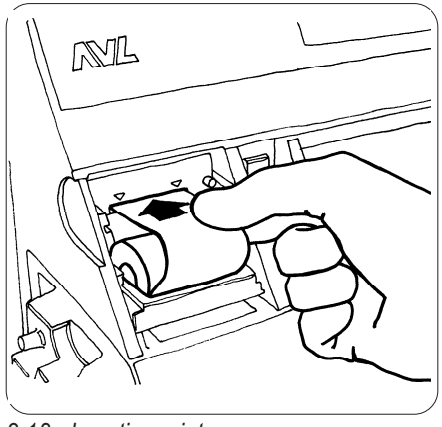
2. Press **NO** until the correct month is displayed. Press **YES**.
3. Press **NO** until the correct year is displayed. Press **YES**. The correct date should now be displayed.
4. Follow the same procedure to enter the correct time.



2-16. Removing protective strip



2-17. Installing ISE SnapPak™



2-18. Inserting printer paper

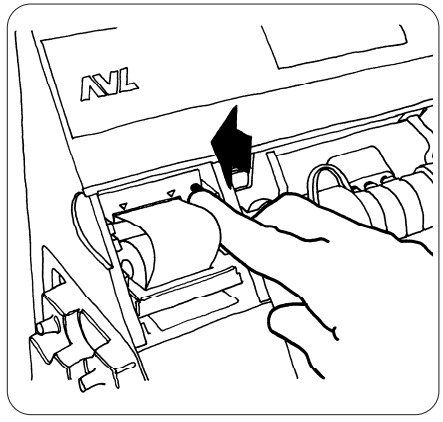
5. After entering the time, the analyzer will prompt: **OK?** Press **YES,** if the date and time you entered is correct, or press **NO** to make a change.
6. After entering **YES**, the following prompt appears in the display : **STATUS: NO SnapPak**.

Install the ISE SnapPak™. Record the installation date on the label on the pack. Remove the protective strip and slide the ISE SnapPak™ into position on the left side of the analyzer.
See illustration 2-16 and 2-17.

Note: Once the protective strip is removed, be sure to keep the ISE SnapPak™ *upright to avoid spillage. Save the protective strip to use to close the nipples on the pack prior to disposing.*

At the prompt **New SnapPak Installed?**, press **YES**. Press **YES** again to the question **Are you sure?**

Install the thermal printer paper into the printer by placing the printer paper into the paper tray and threading it into the feeder slot, as shown in the diagram underneath the paper holder on the analyzer. See illustration 2-18.



2-19. Paper advance button

Press the paper advance button to bring the paper completely through the feeder.
See illustration 2-19.

Note: By pressing and releasing the paper advance button, the paper will automatically advance 10 lines.

Your AVL Electrolyte Analyzer is now prepared for initial daily maintenance.

Initial daily maintenance

Prior to performing your first calibration or running your first sample, the AVL Electrolyte Analyzer needs to undergo a simple cleaning and conditioning procedure that helps ensure that the unit will perform properly. This procedure is called daily maintenance, because it must be performed each day the analyzer is used to conduct sampling.

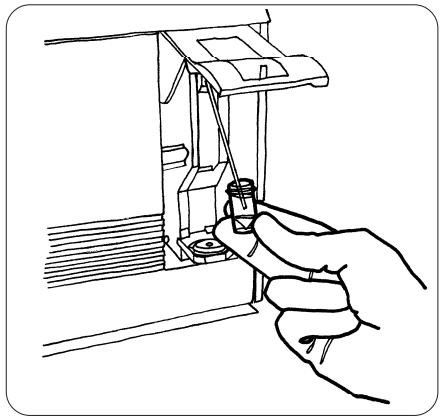
The process involves cleaning and conditioning the sample path and electrodes, which prepares the AVL analyzer for calibration. You should have ready the bottles containing Cleaning Solution A and Electrolyte Conditioning Solution, along with a package of lint-free tissues that will be used to dry the probe.

Note: Check expiration date on bottles.

Note: In some cases, when the unit prompts you for an action and you do not respond within a set period of time, an alarm will sound and the unit will discontinue its current operation.

To perform daily cleaning, you will communicate through the keypad interface. The prompt **Perform Daily Cleaning?** will be displayed. Press **YES** to accept.

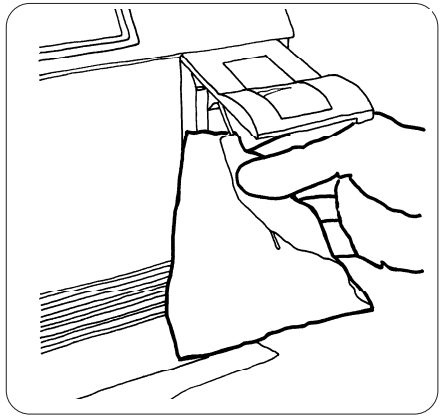
The prompt **Open Sample Door Introduce Sample** will be displayed. Pour a small amount of AVL Cleaning Solution A into a clean sampling container.



2-20. Introducing cleaning solution

Lift the sample door. The prompt **Introduce Sample** will be displayed and the pump will begin to aspirate. Introduce the cleaning solution to the probe. See illustration 2-20.

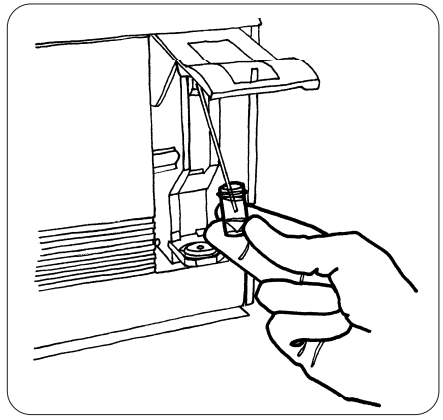
Hold the solution under the probe until the prompt **Wipe Probe Close Sample Door** is displayed. Use a lint-free tissue to remove the cleaning solution from the probe, then close the door.
See illustration 2-21.



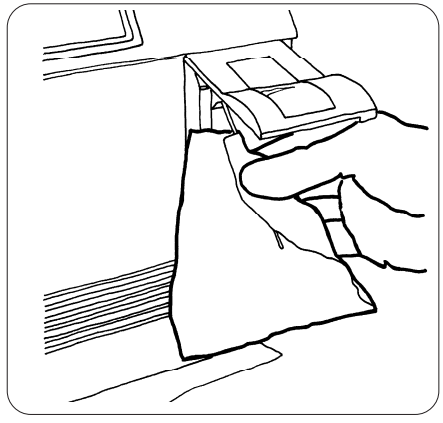
2-21. Cleaning probe

The analyzer will now display **Thank You!** and a brief countdown will begin, indicated by the clock in the lower right of the display. While the countdown is running, open the bottle of AVL Electrode Conditioning Solution and pour a small amount into a clean container.

After the countdown is completed, the system will prompt **Perform Daily Conditioning?** Press **YES.**



2-22. Introducing conditioner



2-23. Cleaning probe

The prompt **Open Sample Door Introduce Sample** will be displayed. Lift the sample door. The prompt **Introduce Sample** will be displayed and the pump will begin to aspirate. Now, introduce the conditioning solution to the probe.
See illustration 2-22.

Hold the solution under the probe until the prompt **Wipe Probe Close Sample Door** is displayed. Use a lint-free tissue to remove the conditioning solution from the probe and close the door.
See illustration 2-23.

The analyzer will now display **Thank You!** and a brief countdown will begin. Upon completion of the countdown, the prompt **Remain in Daily Maintenance?** will be displayed. Press **NO**.

The unit will display **Calibration in Process** while the analyzer prepares for automatic calibration. A countdown will be displayed as soon as the actual calibration cycle starts.

Note: Calibration is an automatic process. During this time, the analyzer is conducting measurement operations to ensure the accuracy of the instrument. Occasionally, extended calibration is required.

Note: It is very important that the main door is closed during calibration, since it provides shielding from sources of electromagnetic interference.

When calibration is completed, the analyzer will display **READY**, indicating that the instrument is now prepared for quality control sampling.

Selecting Parameter Configuration

After completion of the daily maintenance procedure, the analyzer starts an automatic calibration for sodium and potassium.

To select a different parameter configuration, interrupt the calibration by pressing **NO**. Continue pressing **NO**, until **OPERATOR FUNCTIONS** is displayed. Press **YES** followed by **NO**, until the analyzer displays **Select Parameter Configuration?** Press **YES** to display the current configuration. The default configuration is displayed:

Selected Param.:
[Na] [K] [ ] ok?

Press **NO** until the desired configuration is displayed, then press **YES** to accept your selection.

Note: If ([Na]) [ ] [Li] *is selected, only lithium is reported. Install the Na electrode and calibrate for lithium.*

Congratulations! Your AVL Electrolyte Analyzer is ready for operation.

3

Chapter 3

Programming

Your AVL Electrolyte Analyzer comes preset to easily and accurately perform sampling operations. Through the programming menu, you have the capability to input additional information or parameters to tailor the instrument's performance to match the particular needs of your lab.

Programming the analyzer allows you to select the third testing channel and to modify quality control ranges, normal values and correlation factors. You can also program the operation of the printer.

Note: For safety and security, the analyzer can only be programmed or have existing parameters changed by entering the correct password via the control panel keypad.

Accessing programming functions

From the **READY** display, press **NO** until the prompt **PROGRAM INSTRUMENT?** is displayed. Press **YES**.

The analyzer will display **Enter Code: AAA**. To program your AVL Electrolyte Analyzer, you must now enter the code **K-E-Y** as follows:

1. Press **NO** until the character **K** is displayed.
2. Press **YES** and the cursor will advance to the second position.
3. Press **NO** until **E** is displayed, then press **YES**. The cursor will advance to the last character.
4. Press **NO** until **Y** is displayed.

Note: If you pass the desired letter, continue pressing NO *until the letter is displayed again.*

If you have entered the code correctly, press **YES**. The analyzer is prepared for operator programming and will display **Program QC Level 1 Ranges?**

Note: If you inadvertently enter an incorrect code, the analyzer will display CODE ERROR! RETRY? *Enter* YES *and you will be returned to the* Enter Code *prompt. To exit this menu, press* NO.

Programming QC Level ranges

When you open a new box of AVL ISE-trol Electrolyte Controls, the lot number should be entered into the analyzer, along with the target ranges. Each level has its own lot number, which is printed on the informational sheet contained inside the ISE-trol box.

Note: AVL ISE-trol Electrolyte Controls are specially designed for your AVL Electrolyte Analyzer and should be used exclusively to ensure absolute quality and consistency of your patient samples.

To enter the lot number, proceed from the display **Program QC Level 1 Ranges?** Enter **YES** and the analyzer will prompt **Current Lot: 0000 Change Lot#?**

Note: The first time QC lot number information is entered, the AVL Electrolyte Analyzer will display a default lot number. Thereafter, the current lot number will appear.

Note: If you do not desire to change current lot information, but wish to verify current programmed QC ranges, press NO.

Press **YES** and **Print old Values and Statistics?** will be displayed. Select **YES** to receive a printout that contains information including the mean, standard deviation (SD) and coefficient of variation (CV) of stored data, or press **NO** to decline.

The analyzer will display **New Lot! Delete Old Data?** Select **YES** to continue entering new lot number information or press **NO**, if you decide to keep the current lot number and data.

Note: If you enter YES, *all stored statistics for this QC level will automatically be deleted from memory.*

To enter a new lot number, press **NO** until the correct number is displayed above the cursor, and **YES** to accept. Repeat until all four digits have been entered.

After entering the new lot number, the analyzer will ask you to confirm that the entry is correct. To proceed with QC programming, press **YES**.

Note: If you have entered an incorrect lot number, enter NO *and you will return to the* Enter Lot Number *prompt.*

The analyzer will now sequentially display high and low ranges for the electrolytes that correspond with the QC level and lot number, such as:

Na low = 040
Na high = 205

Note: You may find this information printed on the data sheet contained inside the box of ISE-trol.

Press **YES** and the next electrolyte range will be displayed. After all activated parameters have been programmed, the display prompts: **Additional Parameters?**. Pressing **YES** will allow you to program the deactivated parameters as well.

After each range has been displayed, QC Level 1 programming will be completed. The AVL Electrolyte Analyzer will prompt **Program QC Level 2 Ranges?**

To continue programming, repeat the above procedure for QC Level 2 and QC Level 3.

At the completion of QC Level 3 programming, the analyzer will prompt **Program Normal Ranges?** This programming feature allows you to customize the normal ranges that the AVL Electrolyte Analyzer will use to flag abnormal patient measurement values on both the display and printed report.

Programming normal ranges

The AVL Electrolyte Analyzer is preset to standard direct normal ranges (Na^+/K^+ - flame photometry):

Na^+	:	136 - 145 mmol/L[1]
K^+	:	3.5 - 5.1 mmol/L[1]
Cl^-	:	97 - 111 mmol/L[2]
Ca^{++}	:	1.12 - 1.32 mmol/L[1]
Li^+	:	0.6 - 1.20 mmol/L[1]

These parameters can be changed through the programming menu to tailor the normal ranges to your lab specifications. To change the normal ranges, follow the steps at the beginning of this chapter that explain the **PROGRAM INSTRUMENT?** display.

1. Tietz, Norbert W., Ed. Clinical Guide to Laboratory Tests, 2nd edition (Philadelphia: W.B. Saunders Company, 1990), pp. 98, 456, 510, 720.
2. Henry, R.J., Clinical Chemistry - Principles and Technics, (New York: Harper and Row, 1974).

Press **NO** until **Program Normal Ranges?** is displayed. Press **YES** and the current Na^+ low and high values will be displayed as such:

Na low = 136
Na high = 145 ok?

If the standard Na^+ ranges are acceptable for your lab, press **YES**. If you wish to change the ranges to conform to your specific requirements, press **NO**. You may now adjust the high and low values by using the **NO** key to change the number, the **YES** key to accept the number.

The analyzer will now display the current K^+ low and high values as such:

K low = 3.5
K high = 5.1 ok?

If the standard K^+ ranges are acceptable for your lab, press **YES**. If you wish to change the ranges to conform to your specific requirements, press **NO**. You may now adjust the high and low values by using the **NO** key to change the number, the **YES** key to accept the number.

The analyzer will now display the current Cl^- (if activated) low and high values as such:

Cl low = 97
Cl high = 111 ok?

If the standard Cl^- ranges are acceptable for your lab, press **YES**. If you wish to change the ranges to conform to your specific requirements, press **NO**.

You may now adjust the high and low values by using the **NO** key to change the number, the **YES** key to accept the number.

The analyzer will now display the current Ca^{++} (if activated) low and high values as such:

Ca low = 1.12
Ca high = 1.32 ok?

If the standard Ca^{++} ranges are acceptable for your lab, press **YES**. If you wish to change the ranges to conform to your specific requirements, press **NO**. You may now adjust the high and low values by using the **NO** key to change the number, the **YES** key to accept the number.

Note: If the units for Ca^{++} were switched to mg/dL (for MGL Code, see 'Service Codes'), the low and high values are displayed in mg/dL units.

The analyzer will now display the current Li^{+} (if activated) low and high values as such:

Li low = 0.60
Li high = 1.20 ok?

If the standard Li^{+} ranges are acceptable for your lab, press **YES**. If you wish to change the ranges to conform to your specific requirements, press **NO**. You may now adjust the high and low values by using the **NO** key to change the number, the **YES** key to accept the number.

Programming correlation factors

Correlation factors allow you to correlate results from your AVL Electrolyte Analyzer to other electrolyte analyzers. Activated correlation values are taken into consideration when sampling whole blood, serum, plasma and QC samples. They are not used for standard samples analyzed in the **QC/STD/DIALYSATE/URINE SAMPLE** mode. A separate set of correlation factors is available for dialysate and urine samples.

Note: In case the QC samples were switched to report direct ISE values (Code QCC, see 'Service Codes'), the values are NOT affected by correlation factors.

Note: The measurement range as well as normal and QC ranges are ALWAYS checked against the DISPLAYED values. Therefore, you may have to adjust the QC and normal ranges to your correlation factors.

The correlation factors can be changed through the programming menu. Follow the steps at the beginning of this chapter that explain the **PROGRAM INSTRUMENT?** display and enter the password.

Press **NO** until **Program Corr. Factors?** is displayed. Press **YES** and the analyzer will prompt **Reset Corr. Factors (Default)?**. Pressing **YES** to this prompt will cancel all correlation factors programmed and will return to the default values. The analyzer will then advance to the printer programming functions.

Press **NO** to the prompt **Reset Corr. Factors (default)?** and the analyzer will display **Input/Verify Corr Factors?** Pressing **NO** will allow you to exit the correlation factor section and proceed to the printer programming functions.

Pressing **YES** to the prompt **Input / Verify Corr Factors?** will allow you to input your own correlation factors or to verify or change correlation factors already programmed.

The current values will be displayed, such as:

Na(b) = +00.0
Na(m) = 1.000 ok?

If the Na^+ intercept (b) and the slope (m) are correct, press **YES**. If you wish to change the values, press **NO**. You may now adjust the intercept and slope values by using the **NO** key to change the number, the **YES** key to accept the number.

The programmed factors are automatically applied to blood/serum and QC samples.

Follow the same procedure for the intercept (b) and slope (m) for K^+, Cl^-, Ca^{++} , and Li^+ .

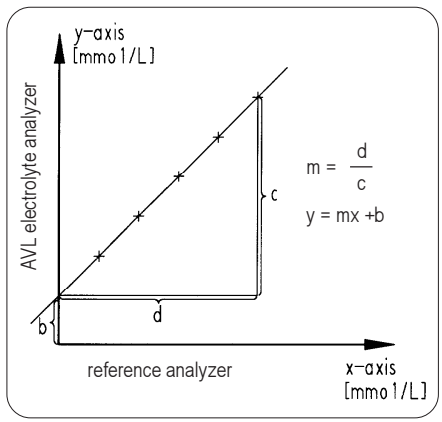
Note: Only activated parameters can be programmed.

If Na^+/K^+, $Na^+/K^+/Cl^-$ or $Na^+/K^+/Ca^{++}$ are activated, a separate set of bicarbonate and acetate correlation factors can be programmed. Press **YES** to **Program Bicarb.Corr Factors?** and/or **Program Acetate Corr Factors?**. Program these factors as described above. The programmed factors are automatically applied to acetate and bicarbonate measurements.

A separate set of correlation factors is availabe for urine samples. Press **YES** to **Program Urine Corr Factors?** Note that there are no urine correlation factors available for Ca^{++} and Li^+ since these parameters are not measured in urine mode.

Calculating correlation factors

If the analyzer you wish to correlate with does not compare to flame photometer values, you may need to determine correlation factors. This may be done using one of the following two methods:



3-1. Regression diagram

a) Correlation Factor Worksheet.

1. Measure the AVL ISE-trol level 1 and level 3, three times each on the AVL Electrolyte Analyzer and the reference analyzer. The three measured values for each device should not differ by more than 2.0 mml/L for Na^+, 0.2 mmol/L for K^+, and 2.0 mmol/L for Cl^-, 0.04 mmol/L for Ca^{++}, and 0.04 mmol/L for Li^+.

2. Fill out a Correlation Factor Worksheet for each parameter. Follow the arrows and calculations to determine the intercept (b) and slope (m). (See appendix for blank worksheets.)

b) Calculator with Regression Function.

1. Analyze at least 20 lipid-free serum samples or samples with normal lipids on the AVL Electrolyte Analyzer and on the reference analyzer. Select samples with different concentrations in order to provide determination points from the lowest point to the highest point of the measurement range. See illustration 3-1.

2. Use a calculator with a linear regression function to determine the intercept (b) and slope(m).

Programming the printer

The AVL Electrolyte Analyzer allows convenient operator programming of the printing functions for automatic printing of patient sample reports, printing two copies of the sample report, and automatic calibration reports.

The analyzer printing default is set to automatically print one sample report after conducting an analysis, but not to automatically print the calibration reports. To change the default setting, enter the programming menu. Follow the steps at the beginning of this chapter that explain the **PROGRAM INSTRUMENT?** display and enter the operator code.

Press **NO** until **Program Printer Setup?** appears. Press **YES** and the analyzer will prompt **Patient Report Off?**. Select **NO** if you want the analyzer to automatically print a sample report after each analysis, or **YES** if an automatic report is not required.

Note: If you select YES*, you will advance to the* Automatic Cal Report? *prompt.*

If you select **NO**, the analyzer will display **Print two Patient Reports?**. Press **YES** if you want the AVL Electrolyte Analyzer to automatically produce two reports, **NO** to decline.

The analyzer will display **Automatic Cal Report?** Select **YES** if you want a printed calibration report after each calibration, or **NO** if an automatic report is not required.

Note: The PRINT FUNCTIONS *menu allows you to print a copy of the last sample report as well as the last calibration report.*

The analyzer displays **Program Comment Line?** In this menu, a comment (up to 16 characters) can be programmed which will be printed after the header on each report. After pressing **YES** to the **Program Comment Line?** display, the prompt **Enter Comment** appears. Press **NO** to scroll through the letters of the alphabet and numbers 0 - 9, press **YES** to accept your selection. Press **NO** to move the cursor to the next character.

After completing printing programming functions, the menu **Program Interface?** will be displayed. Press **YES** and the prompt **Activate Data link?** appears. Press **YES** if you wish to interface the AVL 9180 with an AVL Compact 2 blood gas analyzer. The data link with the AVL Compact 2 blood gas analyzer allows you to combine ISE results with pH/blood gas results on one printout. If Ca^{++} is activated on the 9180, a pH-corrected Ca^{++} value will be calculated and printed on the combined sample report.

For connection of the 9180 analyzer to the Compact 2 analyzer, the optional Interface Kit (BP5202) is required. To install the kit, first turn both instruments off. Connect the interface filter provided in the kit to the RS232 port on the 9180. Then connect one end of the cable to the interface filter, the other end to the **COM 2** port on the Compact 2. On the Compact 2, select **9180** under the COM2 interface options. See Compact 2 Operator's Manual for Details.

The analyzer will then display **Remain in Program Func?** Pressing **YES** will return you to the **Program QC Level 1 Ranges?** menu, while **NO** will return the analyzer to **READY**.

4

Chapter 4

Quality Control

Running a QC sample

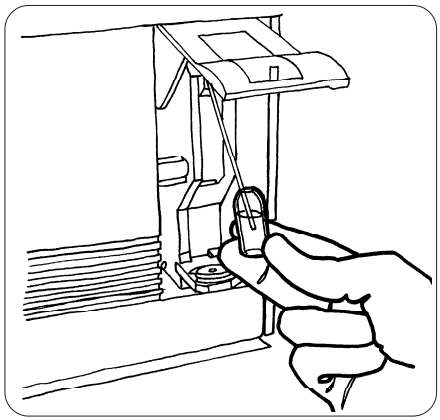
To monitor the performance of your AVL Electrolyte Analyzer, you should run daily quality control samples using AVL ISE-trol Electrolyte Control (HC0033). These protein-based ISE controls allow you to monitor the analysis of sodium, potassium, chloride, ionized calcium and lithium, and have been specially formulated for use with your AVL Electrolyte Analyzer.

Note: You can store in memory up to 35 QC measurements per level. You can print the values stored and view the statistics at any time.

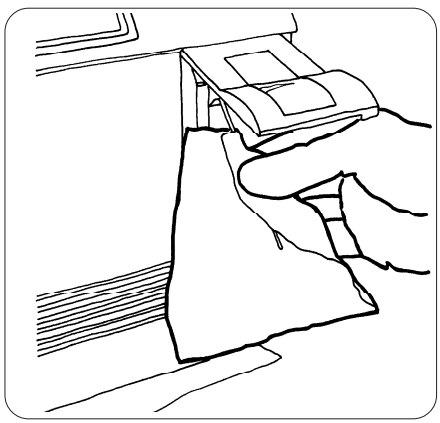
ISE-trol is provided in three levels to produce expected values that are low, normal and high, allowing thorough evaluation of the analyzer's performance. Whenever a new box of ISE-trol is opened, be sure to enter the lot number information into the analyzer as detailed in Chapter 3.

Note: ISE-trol should be stored in the refrigerator at 2-8° C and brought to room temperature before use.

From the **READY** display, press **NO** until the prompt **QC / STD / DIALYSATE / URINE SAMPLE?** appears. Press **YES**. The prompt **QC Level 1 Sample?** will be displayed.



4-1. Introducing Level 1 control



4-2. Cleaning probe

Press **YES**. The prompt **Open Sample Door Introduce Sample** will be displayed.

Remove a Level 1 ampule from the box of ISE-trol and mix carefully. Gently tap the head of the ampule with your fingernail to remove any liquid.

Carefully open the ampule by breaking off the top.

Note: Protect your fingers by using gloves or tissue while breaking ampule.

Lift the sample door and the prompt **Introduce Sample** will be displayed. Introduce the control to the sample probe.
See illustration 4-1.

Note: It is very important that the main door is closed during sampling, since it provides shielding from sources of electromagnetic interference.

Hold the ampule under the probe until the prompt **Wipe Probe Close Sample Door** is displayed. Use a lint-free tissue to remove the control from the probe, then close the door.
See illustration 4-2.

Note: It is very important that the sample probe is carefully cleaned each time following a sample introduction.

The instrument will display **QC Level 1 in process** and a countdown will begin, during which the control will be analyzed. Upon completion, the results will briefly be displayed, such as:

Na	K	↓ Cl
125.1	3.05	77.8

Note: The AVL Electrolyte Analyzer "flags" values that are above or below the programmed target ranges by using an "up" or "down" arrow.

The analyzer will automatically prompt **Store Values in Memory?** To save the values in memory, press **YES**. To reject the values, press **NO**. If the values are rejected, the analyzer will return to the **QC Level 1 Sample?** display, allowing you to repeat level 1 by pressing **YES** and repeating the sampling procedure, or to skip to level 2 by pressing **NO.**

Note: In case the value is outside the measurement range (↑↑↑↑, ↓↓↓↓ *or* ERR*.), it will automatically be rejected.*

If the values have been saved, the analyzer will display **VALUES ACCEPTED!**, followed by the prompt **QC Level 2 Sample?** To continue with QC measurement, press **YES** and follow the instructions as outlined for QC Level 1 Sample, being sure to use a Level 2 ISE-trol.

After storing values for QC Level 2, the analyzer will display **VALUES ACCEPTED**!, followed by the prompt **QC Level 3 Sample?** To continue with QC measurement, press **YES** and follow the instructions as outlined for QC Level 1 Sample, being sure to use a Level 3 ISE-trol.

Note: If you wish to discontinue QC testing, press NO *until* READY *is displayed.*

At the completion of QC Level 3 testing, the analyzer will prompt, **Remain in QC/Std/ Urine Sample?** If all level testing has been completed, press **NO** and the analyzer will return to **READY**.

Note: Responding YES *to the* Remain in QC / Std/ Urine Sample? *prompt will return the analyzer to the* QC Level 1 Sample? *display.*

Printing a QC report

The analyzer will store in memory the last 35 measurement values for each of the three levels of control. To print a report of these values along with their mean, standard deviation (1SD) and coefficient of variation (CV), press the **NO** key until **PRINT FUNCTIONS?** is displayed.

Press **YES** and the prompt **Print last Sample Report?** will be displayed. Press **NO**.

The analyzer will now display **Print Cal Report?** Press **NO** and **Print QC Values and Statistics?** will appear. Press **YES** and instrument will begin printing all values grouped by configuration. For the statistics, all values available for each parameter are used.

After printing, the AVL Electrolyte Analyzer will return to **READY**.

Note: If correlation factors are changed or QC values switched to direct ISE, ALL values in memory are recalculated and printed in the new setting.

5

Chapter 5

Operation

The AVL Electrolyte Analyzer provides fast, convenient analysis of whole blood, serum, plasma, aqueous solutions, dialysate solutions and urine for:

Na^+	Sodium
K^+	Potassium
Cl^-	Chloride
Ca^{++}	Calcium
Li^+	Lithium
	(Ca^{++} and Li^+ are not measured in urine samples)

The analyzer will accept specimens directly from most common containers, including collection tubes, syringes, sample cups and capillary tubes.

Note: Always follow proper safety procedures when handling biological samples.

All parameters are reported in mmol/L. However, Ca^{++} (if activated) can be switched to mg/dL (see 'Service Codes').

Whole blood samples

Collect the blood in a green top tube or heparinized syringe, preferably with sodium heparin anticoagulant.

Note: Lithium heparin may also be used, if lithium is not installed.

Whole blood samples should be analyzed as soon as possible within one hour after collecting the sample. If a brief storage is required, do not cool the sample as the erythrocytes could burst and release the intracellular potassium, creating an inaccurate value of potassium in the sample.

Plasma samples

Collect the blood in a green top tube, preferably with lithium or sodium heparin anticoagulant.

Note: Lithium heparin may be used, if lithium is not installed.

Centrifuge the sample and separate plasma into a different test tube or sample cup as soon as possible.

Plasma can be stored longer than whole blood samples. If storage is required, plasma samples should be capped and placed in the refrigerator. Prior to analysis, always allow sample to warm to room temperature.

Note: For whole blood and plasma samples, the proper amount of anticoagulant must be used to prevent the sample from clotting. DO NOT use anticoagulants such as EDTA, citrate, oxalate, etc.

Serum samples

Collect the blood in a red top tube containing no anticoagulant. Allow the blood to clot and then centrifuge. Separate the serum into a different test tube or sample cup as soon as possible.
Serum can be stored longer than whole blood, though preferably capped and placed in the refrigerator.

Prior to measurement, always bring the sample to room temperature.

Aqueous Samples

Aqueous samples, such as Standard A, have to be measured in the Standard Mode.

Note: The Standard Mode ALWAYS reports direct ISE values and is not affected by correlation factors or the setting of QCC (see 'Service Codes').

Dialysate Samples

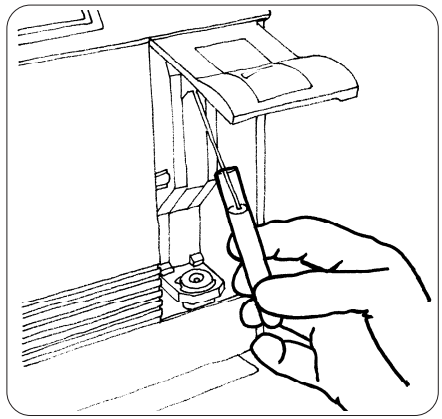
Either acetate or bicarbonate dialysate fluids may be analyzed. Dialysate samples can be stored longer than whole blood, though preferably capped and placed in the refrigerator.
Prior to measurement, always bring the sample to room temperature.

Note: If lithium is activated, the dialysate mode is not available.

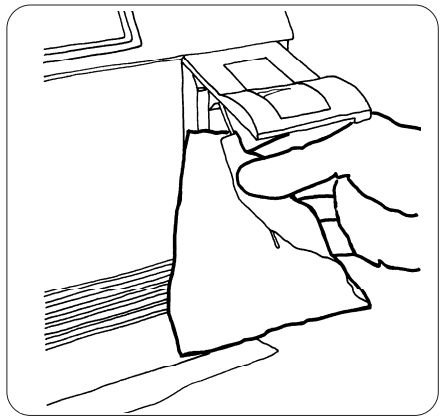
Running a sample with the AVL Electrolyte Analyzer

The AVL Electrolyte Analyzer provides fast, easy operation. Whenever **READY** appears on the display, the unit is prepared to conduct sampling measurements. To analyze a Standard Sample, press **NO** to get to **QC/STD/DIALYSATE/URINE SAMPLE?**. Press **YES**. Then press **NO** until the prompt **Standard Sample?** appears. Press **YES**.

Note: Urine samples require dilution, and must be analyzed in the urine mode. Instructions for analyzing urine samples are provided later in this chapter.



5-1. Introducing a sample



5-2. Cleaning probe

```
*      AVL 9180     *
ELECTROLYTE ISE
      NA - K - LI
01MAR96     07:20

Name: . . . . . .
      . . . . . .

Sample: SERUM

Sample No. 4

Na  =  190 ↑ mmol/L
K   =  5.2    mmol/L
Li  =  ***    mmol/L

*** Li calculation
    not possible
```

5-3. Sample report

To analyze a sample, lift the sample door. The prompt, **Introduce Sample** will be displayed and the pump will begin to aspirate. Introduce the sample to the probe.
See illustration 5-1.

Note: It is very important that the main door is closed during sampling, since it provides shielding from sources of electromagnetic interference.

Hold the sample under the probe until **Wipe Probe Close Sample Door** is displayed. Use a lint-free tissue to clean the probe, then close the sample door when prompted.
See illustration 5-2.

Note: It is very important that the sample probe is carefully cleaned each time following a sample introduction.

The analyzer will display **Thank You!** and a brief countdown will begin. Upon completion of analysis, the test results will be displayed and printed.
See illustration 5-3.

Note: Values that are higher or lower than the programmed normal range will be indicated by an arrow pointing up or down.

Note: If the Na^+ result is above 180 mmol/L (above 169.5 mmol/L for blood/serum) or below 95 mmol/L (below 89.6 mmol/L for blood/serum), the Li^+ value cannot be derived.

If an additional sample report is desired or the automatic sample report is turned off, the results may be printed by following these steps:

1. Press **NO**.
2. The prompt **PRINT FUNCTIONS?** will be displayed.
3. Press **YES** to accept.
4. **Print Last Sample Report?** will be displayed.
5. Press **YES** to accept.
6. The test results will be displayed, and the report will print.
7. The analyzer will return to **READY**.

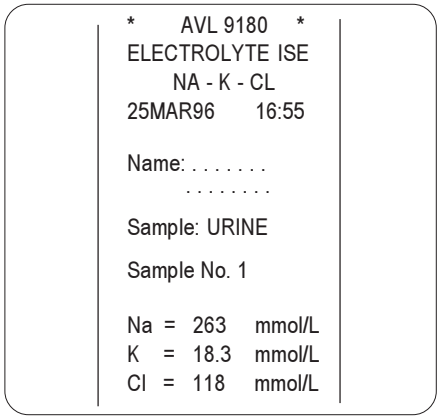
Dialysate samples

Dialysate samples are measured in the dialysate mode. In the default analyzer setting, the dialysate mode provides measurements identical to those performed in the standard mode. Separate correlation factors for bicarbonate and acetate permit optimization of absolute measurement, which may be necessary for certain dialysate compositions (see Chapter 3, Correlation Factors).

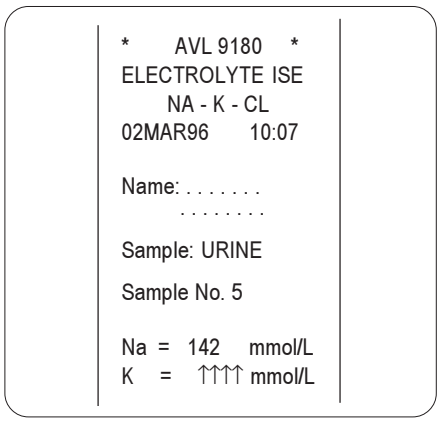
To access the dialysate mode, press **NO** until **QC/STD/DIALYSATE/URINE SAMPLE?** appears. Press **YES**, then **NO** until **Bicarbonate Sample?** or **Acetate Sample?** appears.

Note: If lithium is selected, the dialysate mode is not available.

Due to interfering substances inherent in some dialysate solutions, you may need to establish correlation factors to obtain correct results.



5-4. Urine sample report (no additional dilution required).



5-5. Urine sample report (additional dilution required).

Urine samples

Before measuring urine, accurately dilute the sample with AVL Urine Diluent (BP0344) in the ratio of 1 part urine to 2 parts diluent (e.g., 1 mL urine and 2 mL urine diluent). Thoroughly mix the sample, and analyze in the urine mode.

Whenever **READY** appears on the display, the unit is prepared to conduct sampling measurements. However, urine samples, diluted with urine diluent, are analyzed in the urine mode. To access this mode, press **NO** until **QC / STD / DIALYSATE / URINE SAMPLE?** appears on the display.

Press **YES** and then **NO** until **Urine Sample?** appears. Press **YES** and follow the prompts. Upon completion of analysis, the analyzer will calculate the final test results which will be displayed and printed. See illustration 5-4.

Note: Ca^{++} and Li^{+} are not measured in urine.

Note: If the result of the urine sample is given with ↑↑↑↑, the K^{+} value of the sample is higher than 45 mmol/L, and outside the measurement range of the analyzer. The measurement must be repeated using the following procedure.

1. Record the value of Na (and Cl^{-}, if activated) of the first urine measurement.
2. Redilute the diluted urine (already diluted 1:2 with urine diluent) with distilled water in the ratio of 1:2 (e.g., 1 mL of diluted urine and 2 mL distilled water).
3. Thoroughly mix the sample.
4. Run a second urine measurement with the twice-diluted urine sample.
5. Ignore the Na^{+} value (and Cl^{-}, if activated).
6. Multiply the K^{+} value by 3 and record.

6

Chapter 6

Maintenance and Operator Functions

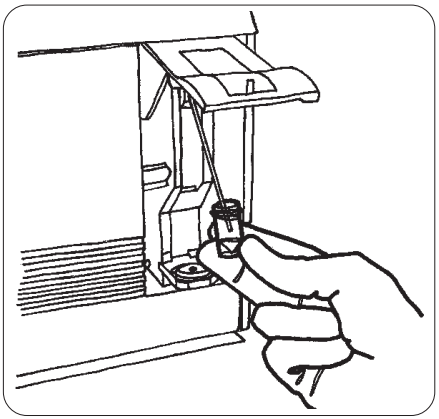
Scheduled Maintenance:
Performing daily maintenance

Prior to running your first sample of the day, the AVL Electrolyte Analyzer needs to undergo a simple cleaning and conditioning procedure that helps ensure the unit will perform properly. This procedure is called daily maintenance, because it must be performed once each day the analyzer is used to conduct sampling.

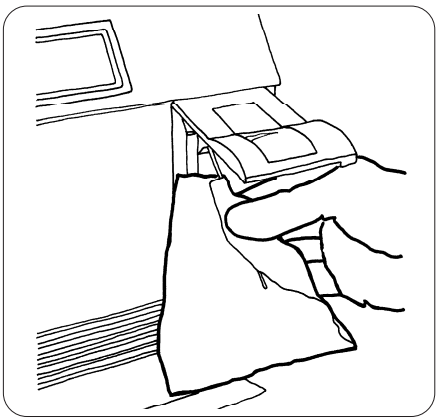
Note: In case cleaning and/or conditioning has not been performed within the last 24 hours, the analyzer will automatically print on each sample report Perform Daily Maintenance.

The process involves cleaning and conditioning the sampling path, including the probe and electrodes. You will need to have ready the bottles of Cleaning Solution A and Electrolyte Conditioning Solution, and a package of lint-free tissues to use in drying the sample probe. Check the bottles to ensure that the expiration date has not been reached.

Note: If fewer than 5 samples are analyzed each day, cleaning should be performed once a week instead of daily (see weekly maintenance).



6-1. Introducing Cleaning Solution A



6-2. Cleaning probe

To begin daily maintenance, press **NO** until the prompt **DAILY MAINTENANCE?** is displayed. Press **YES** to accept. **Perform Cleaning?** will be displayed. Press **YES** to start the cleaning procedure.

The prompt **Open Sample Door Introduce Sample** will appear. At this time, pour a small amount of AVL Cleaning Solution A into a clean container.

Lift the sample door and the pump will begin to aspirate. Introduce the cleaning solution to the sample probe.
See illustration 6-1.

Continue holding the solution under the sample probe until the prompt **Wipe Probe and Close Sample Door** is displayed. Use a lint-free tissue to remove the cleaning solution from the probe and close the door.
See illustration 6-2.

The analyzer will now display **Thank You!**, and a brief countdown will begin. While the countdown is running, open the bottle of AVL Electrode Conditioning Solution and pour a small amount into a clean container.

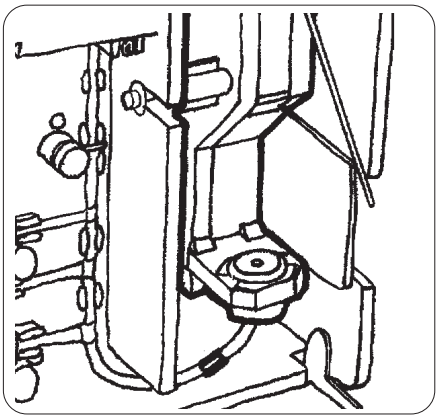
After the countdown is completed, the system will prompt, **Perform Daily Conditioning?** To continue with the procedure, press **YES.**

The prompt **Open Sample Door Introduce Sample** will be displayed. Lift the sample door and the pump will begin to aspirate. Introduce the conditioning solution to the sample probe.

Continue holding the solution under the sample probe until the prompt **Wipe Probe and Close Sample Door** is displayed. After wiping the probe and closing the sample door, the analyzer will display **Thank You!** . Upon completion of the countdown, the prompt **Remain in Daily Maintenance?** will be displayed. Press **NO**, and the AVL Electrolyte Analyzer will automatically initiate a calibration cycle.

Note: It is very important that the main door is closed during calibration, since it provides shielding from sources of electromagnetic interference.

When calibration is completed, the analyzer will display **READY**, indicating that the instrument is prepared to conduct electrolyte sampling.



6-3. Fill port

Performing weekly maintenance

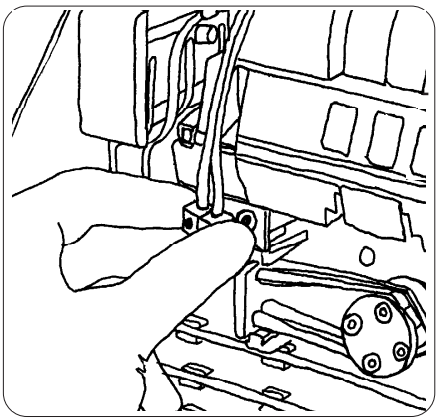
On a weekly basis, or whenever necessary, you should clean the sample fill port and sample probe (illustration 6-3), as well as the exterior analyzer surfaces. Cleaning should also be performed on a weekly basis, if fewer than five samples are analyzed a day.

To clean the sample fill port and probe, open the sample door and clean the fill port, probe and surrounding area with a damp cotton swab. When finished, close the sample door. If the analyzer attempts to perform a sample analysis, **NO Sample** will be briefly displayed, and the unit will return to **READY**. The exterior surfaces should be wiped clean with a soft, damp cloth.

Note: Never use strong or abrasive cleaners on the AVL Electrolyte Analyzer. Use a slightly damp cloth to avoid getting fluid inside the analyzer.

Performing monthly maintenance

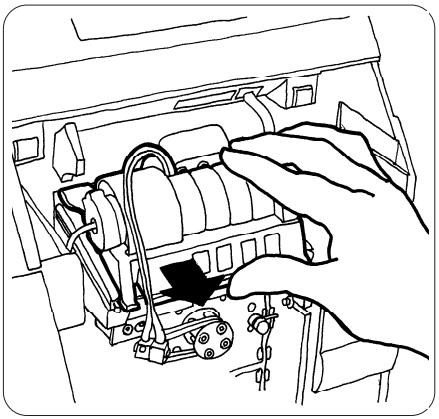
Monthly maintenance involves cleaning the reference electrode housing, and should be performed prior to daily maintenance. To complete this procedure, you will need a small amount of household bleach.



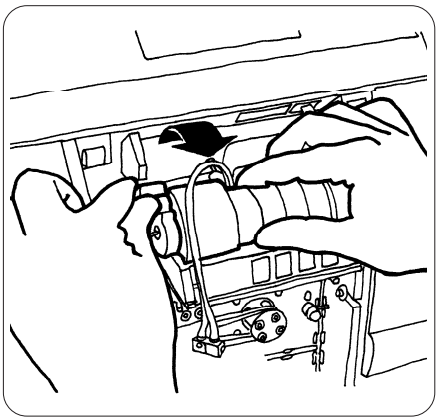
6-4. Removing reference connector

Begin monthly maintenance by pressing **NO** until **DAILY MAINTENANCE?** is displayed. Press **YES** and **Perform Daily Cleaning?** will appear. Do not press any keys.

Open the front cover of the analyzer. Unplug the tubing of the reference electrode from the receptacle below the left side of the measuring chamber. See illustration 6-4.



6-5. Sliding measuring chamber to front locked position



6-6. Unclamping left electrode holder

Slide the measuring chamber forward until it locks in the front position.
See illustration 6-5.

Unclamp the left electrode holder by moving the clamp forward.
See illustration 6-6.

Remove the reference electrode assembly from the analyzer. Unscrew the reference electrode from the reference housing. Store the reference electrode in the red transport housing filled with reference solution that has been poured from the electrode housing.

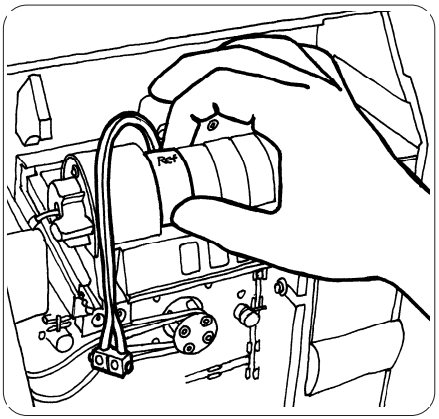
Note: It is important that reference electrode always be stored in reference solution and never allowed to become dry.

Pour some bleach into a small container, and submerge the reference housing into the bleach, ensuring that no air bubbles remain in the housing.

Note: The reference connector and tubing do not need to be submerged.

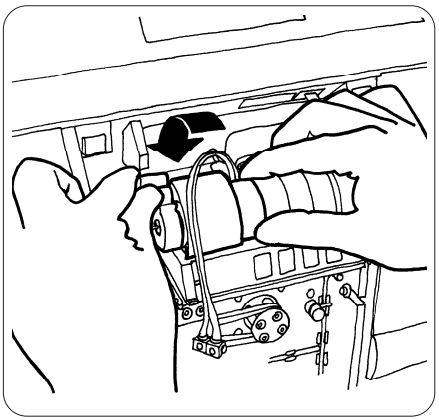
After a period of 15 minutes, remove the reference housing from the bleach, thoroughly rinse the housing with tap water and dry.

Unscrew the red transport housing from the reference electrode and check that the o-ring on the electrode is properly seated. Save the transport housing.



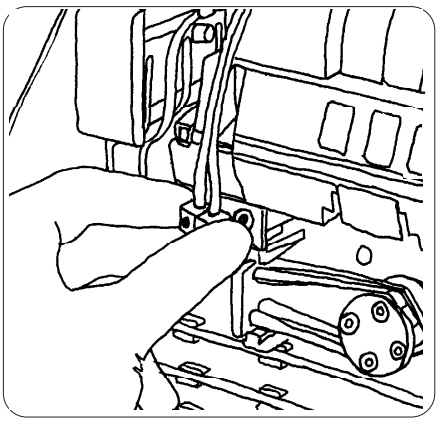
6-7. Installing reference electrode

Carefully screw the reference electrode into the reference electrode housing and place the assembly into the left side of the measuring chamber. Note that the reference electrode has a lip on the bottom that rests on the flat edge of the measuring chamber.
See illustration 6-7.



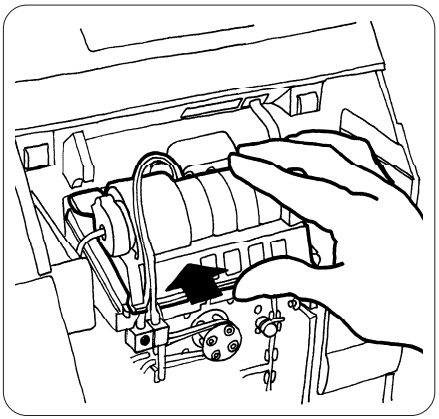
6-8. Closing electrode holder clamp

Close the clamp on the left electrode holder by lifting it upward until it locks in the back position. Ensure the electrodes are seated properly.
See illustration 6-8.

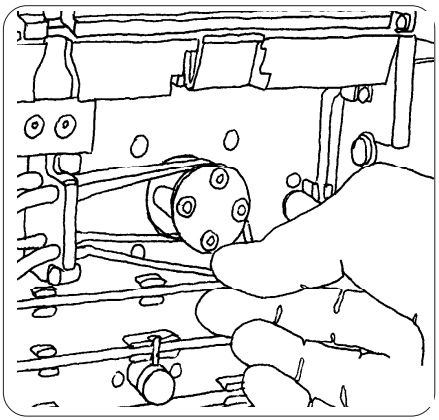


6-9. Installing ref. electrode connector

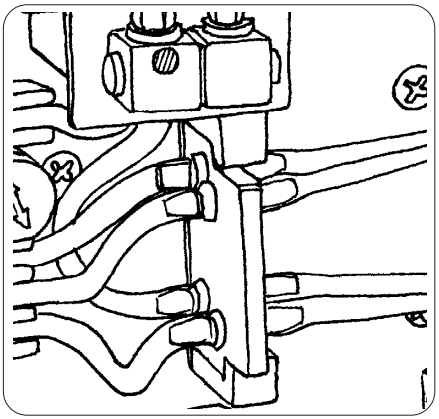
Plug the tubing of the reference electrode into the receptacle below the left side of the measuring chamber.
See illustration 6-9.



6-10. Installing measuring chamber



6-11. Removing pump windings



6-12. Pump winding plate

Slide the measuring chamber back until it snaps into position, and close the front cover of the analyzer.
See illustration 6-10.

At this time, you may perform daily maintenance by pressing **YES**. If daily maintenance is not needed, press **NO** until **CALIBRATION?** is displayed. Press **YES** and a complete calibration cycle will be performed.

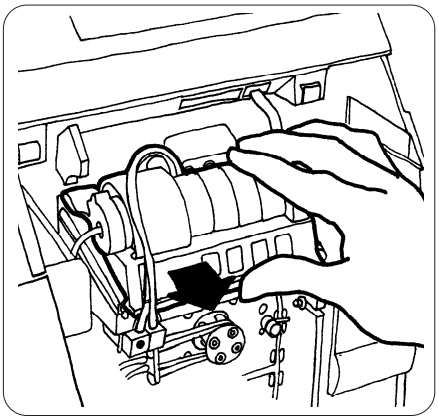
Performing 6-month maintenance

Every six months, the peristaltic pump tubing needs to be replaced.

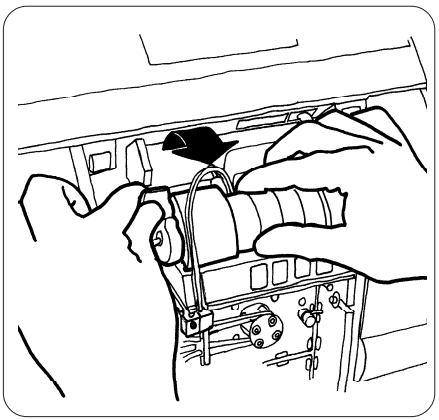
Note: To make sure that the pump does not turn on during this procedure, press NO *until* DAILY MAINTENANCE? *is displayed. Press* YES *and* Perform Daily Cleaning? *will appear. Then, do not press any keys.*

To change the tubing, open the analyzer front cover and slip the two pump windings from the analyzer pump rollers.
See illustration 6-11.

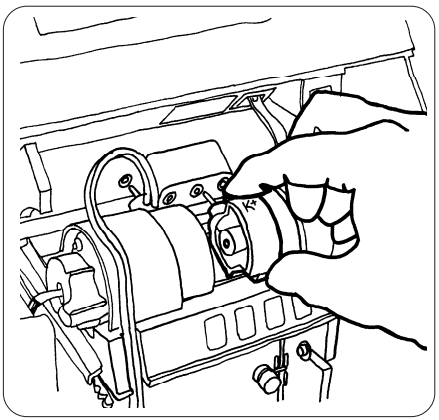
Next, disconnect one tube at a time from the old pump winding plate and reconnect to the same place on the new pump winding plate.
See illustration 6-12.



6-13. Slide chamber forward



6-14. Unclamp electrodes



6-15. Remove used electrode

Install the new pump winding plate and slip the new pump windings over the analyzer pump rollers, being careful not to cross the tubes.

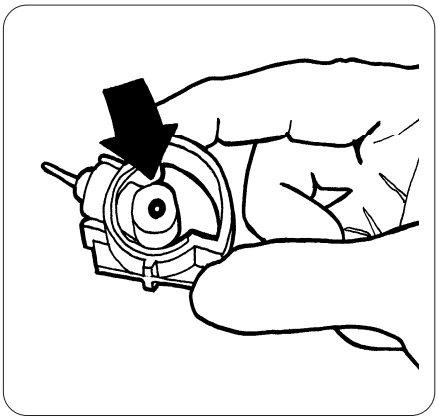
Press **NO** until **CALIBRATION?** is displayed. Press **YES** to initiate a calibration cycle.

Unscheduled Maintenance:
Changing electrodes

Slide the measuring chamber forward until it locks in the front position.
See illustration 6-13.

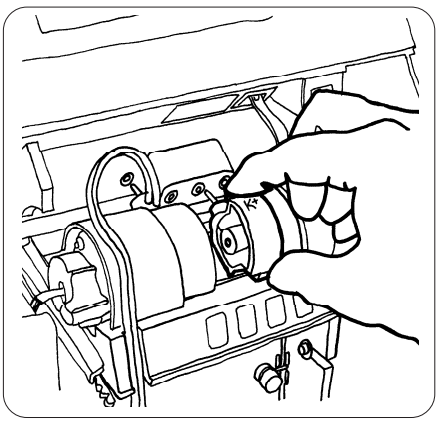
Unclamp the left electrode holder by moving the clamp forward.
See illustration 6-14.

Remove the used electrode from the measuring chamber.
See illustration 6-15.



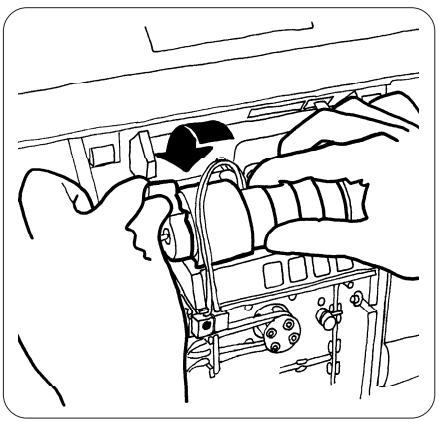
6-16. Electrode o-ring

Remove the new electrode from its protective box and check for the presence of an o-ring in the left side of the electrode.
See illustration 6-16.



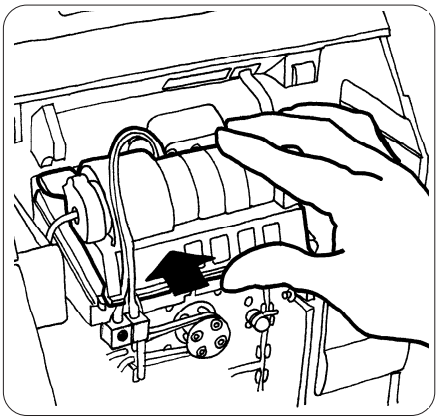
6-17. Installing new electrode

Install electrode in its labeled position in the measuring chamber. Note that the electrode has a lip on the bottom that rests on the flat edge of the measuring chamber to aid in proper positioning.
See illustration 6-17.



6-18. Closing electrode clamp

Close the clamp on the left electrode holder by lifting it upward until it locks in the back position. Ensure that the electrodes are seated properly.
See illustration 6-18.



6-19. Slide measuring chamber back

Slide the measuring chamber back until it snaps into position.
See illustration 6-19.

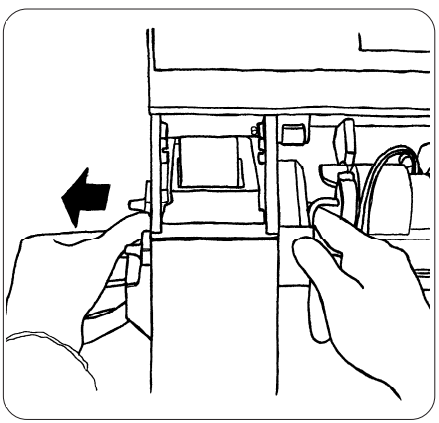
After installing a new electrode, the AVL Electrolyte Analyzer needs to undergo Daily Maintenance, Calibration and QC Measurement to verify the performance of the electrode.

Operator Functions

Checking reagent fluid level and changing the ISE SnapPak™

The AVL Electrolyte Analyzer monitors the level of solutions in the ISE SnapPak™ and displays the amount remaining. To check the status of fluid remaining in the pack:

1. Press **NO** until the prompt, **OPERATOR FUNCTIONS?** is displayed. Press **YES**.
2. The prompt **Change SnapPak?** will be displayed.
3. Press **YES**. The analyzer will display the amount of fluid remaining.
4. To change the ISE SnapPak™, it is not necessary to go to a special menu, just grasp the extended portion of the pack and slide it out. If removal is difficult, press on the end of the ISE SnapPak™ guide pin (protruding from the connector located to the left of the measuring chamber inside the front door).
   See illustration 6-20.



6-20. Removal of used ISE SnapPak™

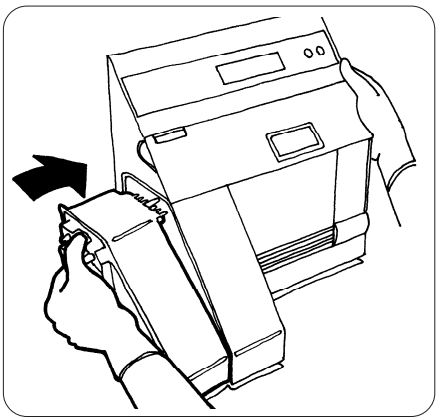
As soon as the analyzer detects that the pack has been removed, the display prompts **Status: No SnapPak**. In addition, the printer will print the current status of the ISE SnapPak™.

Note: Do not remove the pack during a calibration or measurement procedure.

Note: The ISE SnapPak™ *must be treated as medical waste and disposed of in accordance with local regulations.*

5. Prepare the new ISE SnapPak™ by carefully removing the protective strip. Save this cover to close the connectors prior to disposal of the used pack. Write the installation date on the label of the new pack.

Note: Once the protective strip is removed, be sure to keep the pack upright to avoid spillage.



6-21. Installing ISE SnapPak™

6. Slide the new ISE SnapPak™ into position on the left side of the analyzer. The analyzer will prompt **New SnapPak installed?** See illustration 6-21.

7. Press **YES** to indicate that a new ISE SnapPak™ is installed. Press **NO** if you reinstall the pack that was removed.

8. Press **YES**, and the AVL Electrolyte Analyzer will automatically reset the fluid pack counter to 100% and commence system calibration.

Standby mode

The AVL Electrolyte Analyzer is designed to calibrate automatically every four hours during normal operation. If sampling will be delayed for an extended period of time, such as evenings and weekends, you may place the analyzer into Standby mode to suspend automatic calibration.

Note: Your analyzer can be programmed to automatically enter Standby mode. For instructions see "Service Codes" in Chapter 7.

To access this mode, follow the steps below:

1. Press **NO** until the prompt, **OPERATOR FUNCTIONS?** is displayed. Press **YES**.
2. Press **NO** until the prompt **Go to Standby Mode?** is displayed and press **YES.**
3. The analyzer will display **STANDBY! YES -> READY** to confirm that it has entered Standby mode.

To leave Standby and resume normal operation:

1. Press **NO**. The prompt **Leave Standby Mode?** will be displayed.
2. Press **YES**.

Note: If less than four hours have elapsed since the last calibration, the analyzer will return to READY. *If more than four hours have elapsed, the analyzer will exit to the daily maintenance menu. If cleaning / conditioning has not occurred in the past 24 hours perform the daily maintenance now. If cleaning / conditioning is not needed, press* NO *to start calibration.*

Setting date and time

The date and time of the AVL Electrolyte Analyzer can be easily changed as necessary. To change the date and time, enter the **OPERATOR FUNCTIONS?** menu and press **NO** until **Set Time / Date?** is displayed.

1. Press **YES** to enter the time/date setting menu.
2. The current time/date is displayed with the question **OK?** Respond with **NO**, if you want to change the time/date. Press **YES** to exit.
3. Press **NO** until the correct day is displayed. Press **YES**. The cursor will move to the month.
4. Press **NO** until the correct month is displayed. Press **YES**.
5. Press **NO** until the correct year is displayed. Press **YES**. The correct date should now be displayed.
6. Follow the same procedure to enter the correct time. The analyzer will prompt: **OK?** Press **YES** if the date and time you entered is correct, or press **NO** to continue making changes.

Changing Parameter Configuration

Your analyzer is designed to allow easy change of parameter configuration. To change the current parameter configuration, enter the **OPERATOR FUNCTIONS?** menu. Press **YES** followed by **NO** until **Select Parameter Configuration?** appears. Press **NO**, until the desired configuration is displayed.

Note: The ([Na]) *in parenthesis indicates that the Na^+ result is not displayed, the Na^+ parameter, however, has to be present to allow for lithium calibration.*

After confirming the desired parameter configuration by pressing **YES**, the instrument returns to **READY**, if no new parameter has been activated. If one or several new parameters have been selected, the analyzer will enter the maintenance menu, where a cleaning and conditioning routine has to be performed followed by an automatic calibration.

Resetting the sample number

Each time a sample is analyzed, the analyzer will automatically advance the sample counter. If for any reason you wish to reset the counter, you can do so by entering the **OPERATOR FUNCTIONS?** menu and press **NO** until **Reset Sample Number?** is displayed.

To reset the sample number to zero (0), press **YES**. The analyzer will prompt **Are you sure?** Press **YES** and the sample number will be reset to zero. Press **NO** to decline.

Take out of operation

The take-out-of-operation routine assists you in performing a complete shutdown of the analyzer. A complete shutdown may be indicated to prepare the analyzer for shipping or in case the analyzer is not being used for an extended period of time. For this procedure, you will need a special shutdown kit BP5014 (not supplied with the analyzer).

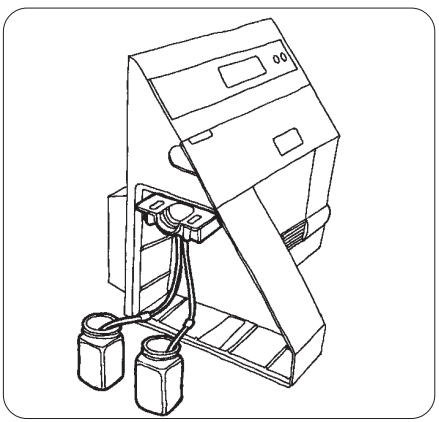
Note: Never attempt to turn the power off for an extended period of time without performing a complete shutdown of the analyzer.

Note: In case the analyzer is not being used for several days only, it is not recommended to perform a complete shutdown, but to put the analyzer in Standby Mode.

To perform the shutdown, you will need the following items:

- Two containers, one filled with at least 100 mL of water, the other one empty.
- Five solenoid relief clamps (supplied with analyzer and shutdown kit)
- Two reference electrode transport housings (supplied with shutdown kit)
- One shutdown plug (supplied with shutdown kit)
- Protective strip for ISE SnapPak™ (supplied with shutdown kit)

To get started, go to **OPERATOR FUNCTIONS**. Press **YES**, then **NO** until **Take Out of Operation?** appears. Press **YES**.

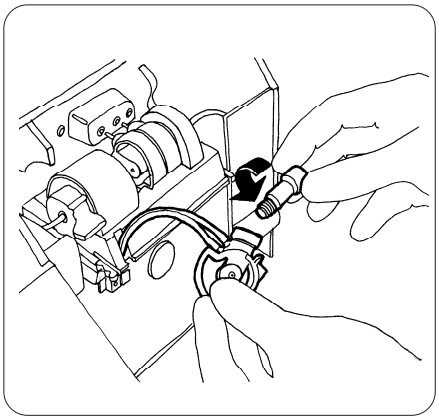


6-22. Shutdown plug and containers installed

Next the analyzer prompts **Shutdown Plug and Water Installed?**. First remove the ISE SnapPak™ and push the protective strip firmly onto the fluid pack connector. Insert the shutdown plug carefully into the fluid pack receptacle. Next, place the blue marked line into the disposable container filled with water. The line with the red mark is inserted into the empty container. Press **YES**.
See illustration 6-22.

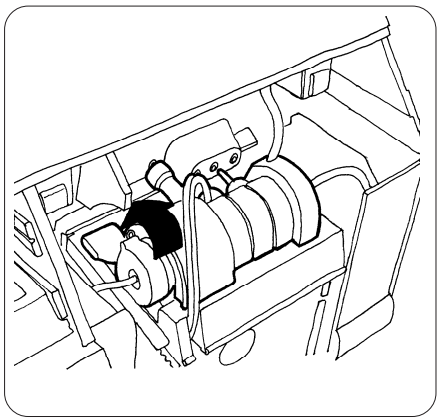
The analyzer will prompt **Transport Ref Housing Installed?** Pull the electrode holder forward and remove the reference electrode assembly.

Carefully unscrew the reference electrode from the reference electrode housing. Temporarily place the reference electrode on a clean, soft cloth. Next, pour the remaining reference solution in the reference housing into a transport housing. Then carefully screw the reference electrode into the filled transport housing.



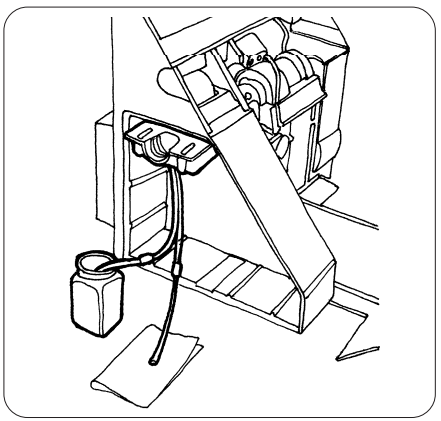
6-23. Installing the second transport housing

Now the second transport housing is screwed into the reference housing. Place the reference housing back into the electrode holder and move the lever backwards, making sure all electrodes are seated properly. The electrode holder remains in the forward position. Press **YES**.
See illustration 6-23 and 6-24.



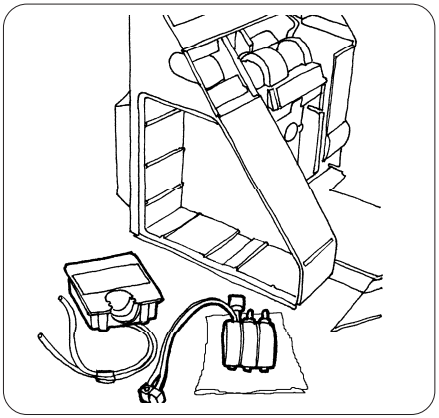
6-24. Reclamp electrode assembly

The analyzer will take approximately one minute to flush all lines with water. Upon completion, you will receive the prompt **Remove Water and Press Yes**. Remove the line with the blue mark from the water and place it on a cloth, making sure it is not obstructed. The line with the red mark remains in its container. Press **YES**. During this cycle, all lines are purged of water. Upon completion, the prompt **All Electrodes & Plug Removed?** will appear.
See illustration 6-25.

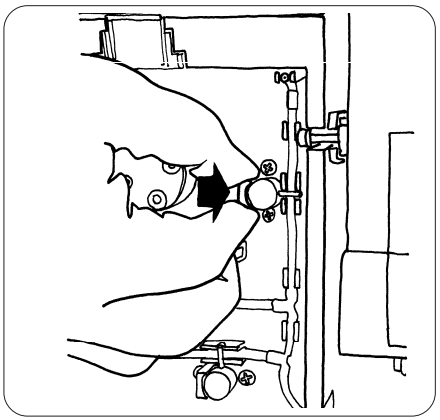


6-25. Blue line removed for purge cycle

Unplug the reference connector below the left side of the electrode holder. Then move the lever on the left side forward and remove all electrodes, placing them on a soft cloth. Next, move the lever back and push the empty electrode holder into its back position.



6-26. Shutdown plug and electrodes removed



6-27. Installing red relief clamps

Unscrew the transport housing from the reference housing. Empty the reference housing and place all electrodes in their protective boxes. Remove the line with the red mark from its container. Now the shut-down plug can be removed. Press **YES**.
See illustration 6-26.

The display will prompt **All 5 Relief Clamps Inserted?** Install the red relief clamps making sure that they are snapped securely into position.
Press **YES**.
See illustration 6-27.

Note: Never insert the solenoid relief clamps with the ISE SnapPak™ *in place.*

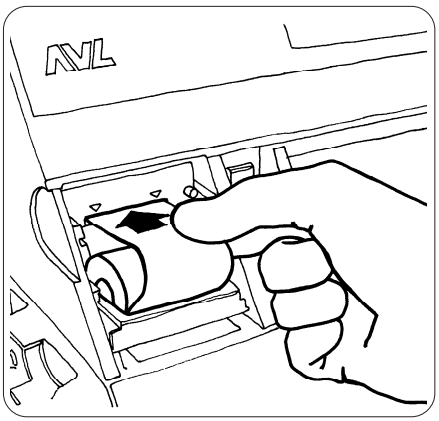
The prompt **Pump Windings Relieved?** appears. First, grasp the front winding close to the pump roller and gently pull it off the roller. Repeat the same procedure for the rear pump winding. Press **YES**.
The analyzer will ask **Do You Wish to DELETE All Data?**.

If you press **YES**, all QC values and statistics will be deleted and the sample number is reset to 0. QC and normal ranges as well as correlation factors, printer settings, date/time and ISE SnapPak™ volume are reset to default. Also, all service codes are deactivated. A deletion of all data is recommended in case the analyzer is operated by different personnel later on.

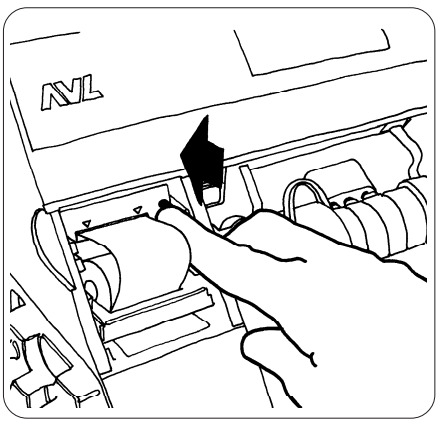
Press **NO** if you wish to retain all data.

Then the analyzer will prompt **Shutdown Complete Turn Power Off**. After the power has been turned off, unplug the power cord from the receptacle and close the main door. Clean all external surfaces of the analyzer as well as the areas accessible through the main door and the sample door.

For putting the analyzer back into operation, see Chapter 2.



6-28. Inserting printer paper



6-29. Paper feed button

Changing printer paper

The thermal printer paper supplied by AVL contains an indicator strip to alert you when the paper roll should be changed. To change the roll:

1. Open the front cover of the analyzer.
2. Press the paper feed button to eject any remaining paper.
3. Place a new roll in the chamber and thread it into the feeder.
4. Press the paper feed button to bring the paper completely through the feeder.
   See illustration 6-28 and 6-29.

Note: By pressing and releasing the paper feed button, the paper will automatically advance 10 lines.

5. Close the front cover of the analyzer and tear off any excess paper.
6. Cut the end of the roll to make a square edge.

Note: Do not pull paper backwards.

7

Chapter 7

Troubleshooting and service functions

Your AVL Electrolyte Analyzer is designed to provide long, trouble-free service. However, any scientific measuring device may occasionally malfunction, requiring the operator to identify the cause of the problem.

The following information lists displayed messages and recommends steps that should help you return your AVL Electrolyte Analyzer to operation. This chapter includes two sections, troubleshooting and service functions. If your AVL Electrolyte Analyzer does not perform correctly after conducting the basic steps outlined in this chapter, you should contact AVL for technical assistance.

STATUS: NOT CALIBRATED

This message will be displayed when calibration has been interrupted.

Possible remedies:

- Perform system calibration to return the instrument to the **READY** mode.

STANDARD A NOT DETECTED

As the analyzer aspirates a sample of Standard A, the solution is detected by the sample sensor, which must detect its presence without encountering any air bubbles. If the sample sensor is unable to properly detect the presence of Standard A solution in a programmed time period, above error message will be displayed.

Possible remedies:

- Check the fluid remaining in the ISE SnapPak™. If less than 5% remains, replace the ISE SnapPak™.
- Check for clots or crystals that may have formed in the Standard A tubing or the electrode chamber.
- Replace the ISE SnapPak™.
- Ensure the sample sensor is securely plugged in and perform the sample sensor test to ensure that the sensor is operating correctly. If necessary, clean the sample sensor.
- Replace the peristaltic pump tube set to ensure correct aspiration of Standard A.

STANDARD B NOT DETECTED

Detection of Standard B aspiration is the same as for Standard A. If Standard A is aspirated properly, but Standard B is not detected, check Standard B tubing for crystallization. If no crystallization or leaks are found, replace the ISE SnapPak™.

STANDARD C NOT DETECTED (Li^+ activated)

Detection of Standard C aspiration is the same as for Standard B. See remedy for Standard B.

CHECK SAMPLE SENSOR

The sample sensor is calibrated with air during each calibration. For proper functioning, the sensor must provide a reading of 80 - 120 units when air is detected. To check sample sensor response, perform **Test Sample Sensor**. Open the sample door and press the **YES** key to aspirate various fluids through the sensor. For transparent fluids (e.g. water), the reading should increase by at least 40 units. For blood samples (not transparent), the reading should decrease by at least 40 units. The pump can be stopped at any time by pressing **NO**. After troubleshooting, perform a calibration to remove the error message.

Possible remedies:

- Clean sample sensor by using the Daily Maintenance procedure.
- Check for correct drying of the measuring chamber during the wash cycle.
- Replace the peristaltic pump tube set.

CHECK REFERENCE HOUSING

When the analyzer fails to detect a flow of Reference Solution into the measuring chamber, **CHECK REFERENCE HOUSING** will be displayed. This test is performed at the beginning of each calibration cycle.
Possible remedies:

- Check for proper filling of the reference housing.
- Ensure that the reference tubing is securely connected to the receptacle.
- Since this test utilizes Standard A, make sure that it is aspirated properly into the measuring chamber. If not, replace the ISE SnapPak™.
- Clean the reference housing. (See Performing Monthly Maintenance in Chapter 6)

PLEASE CLOSE SAMPLE DOOR

This message occurs when the sample door is not closed within 20 seconds after the sample is in place, or when the door has been opened and no sample is detected.
Possible remedy:

- Close the sample door within time allowed.

NO SAMPLE

Under certain conditions, the analyzer may not detect the presence of a sample and an error message will occur. This could be caused by the sample door remaining open more than 20 seconds after samples are in place, air bubbles in the sample, a sample volume too small to analyze, or no sample being aspirated through the sampling mechanism.
If you wish to abort a sample, you can do so by closing the sample door during sample aspiration.

Possible remedies:

- First, repeat the sample to see if it is detected properly on a second trial.
- Close the sample door within time allowed.
- Check sample aspiration and look for the presence of clots in the sampling system.
- Check for the presence of o-rings and for proper sealing of the electrodes.
- Ensure that the sample sensor is plugged in and perform **TEST SAMPLE SENSOR** to verify that it is operating correctly.
- Replace pump windings.

CLEANING FLUID NOT DETECTED

Under certain conditions, the analyzer may not detect the presence of cleaning solution. This could be caused by air bubbles in the cleaning solution, too small a volume of cleaning solution, or the cleaning solution not being aspirated properly through the sampling mechanism.

Possible remedies:

- Check for the presence of o-rings and for proper sealing of the electrodes.
- Check for aspiration of cleaning solution and look for presence of clots in the sampling system.
- Check for the proper sealing of the pump windings.
- Ensure that the sample sensor is plugged in and perform **Test Sample Sensor** to verify that it is operating correctly.

CONDITIONING FLUID NOT DETECTED

Under certain conditions, the analyzer may not detect the presence of conditioning solution. This could be caused by air bubbles in the conditioning solution, too small a volume of conditioning solution, or the conditioning solution not being aspirated properly through the sampling mechanism.

Possible remedies:

- Check for the presence of o-rings and for proper sealing of the electrodes.
- Check for aspiration of conditioning solution and look for presence of clots in the sampling system.
- Check for the proper sealing of the pump windings.
- Ensure that the sample sensor is plugged in and perform **Test Sample Sensor** to verify that it is operating correctly.

INTERFACE ERROR

This message will only be displayed during the **TEST INTERFACE?** function. Testing the interface requires jumping pins 2 and 3 of the interface receptacle. During the test, the analyzer sends out the characters A, V, L, and checks if they are received within a set time period.

Possible remedies:

- Check to see if pins 2 and 3 are jumped correctly. Make sure jumper does not touch ground.
- Contact AVL for technical assistance.

PAPER JAM OR PRINTER DEFECT

If the printer attempts to print to the paper and the paper jams in the feeder, **PAPER JAM OR PRINTER DEFECT** will be displayed briefly, then the sample results will appear on the display.
Possible remedy :

- First turn analyzer off, then remove the printer by placing your index finger behind the back edge of the printer module and pull it forward. Remove the jammed paper and reinsert the printer into the analyzer. Turn analyzer back on.

Note: To ease removal of jammed paper, the printer head can be moved by turning the spindle gear on the left side.

Note: Paper jams should be cleared as soon as possible to avoid damaging the printer.

CHECK ELECTRODES

If none of the electrodes passes the calibration, the **CHECK ELECTRODES** message will be displayed. There are several possible reasons for an electrode not passing calibration. Either a stable reading of Standard A could not be obtained within 6 aspirations of Standard A, or the slope A-B or A-C is outside of the limits.
Possible remedies:

- Ensure that electrodes are properly plugged in.
- Check for proper operation of the reference electrode assembly. If necessary, clean the reference electrode housing or replace the reference electrode.
- Perform daily maintenance.
- Replace the ISE SnapPak™.

NA NOT CAL'D
K NOT CAL'D
CL NOT CAL'D
CA NOT CAL'D
LI NOT CAL'D

These messages will be displayed in the event a specific electrode does not pass calibration. There are several possible reasons for an electrode not to pass calibration. Either a stable reading of Standard A could not be obtained within 6 aspirations of Standard A, or the slope A-B or A-C is outside the limits.
Possible remedies:

- Perform daily maintenance.
- Ensure that the electrode is properly plugged in.
- Check for leaks, blockages, bubbles, or improper flow of calibration reagents.
- Clean or replace the electrode.
- Check and/or replace the ISE SnapPak™.

CLOG CHECK FLUID PATH

If the unit is unable to clear the sample path or to aspirate any of the 3 Standards at the beginning of a calibration, the message **CLOG CHECK FLUID PATH** will be displayed. Please note that a defective reference housing may cause this message (increased discharge of KCl).
Possible remedies:

- Make sure that the electrode o-rings are present and seated properly. Make sure there are no leaks in the fluid path.
- Check for a clog or crystallization in the fluid path: especially in the sample probe, the tubing to the sample sensor and in the sample sensor.

- Ensure that the sample sensor is securely plugged in and perform a sample sensor test to ensure the sensor is operating correctly. If necessary, clean the sample sensor.
- Replace reference electrode housing.

↑↑↑↑ ↓↓↓↓

In case the unit displays arrows up or arrows down instead of the sample results, the concentration of the sample is outside of the measurement range (see specifications).
Possible remedies:

- In the case of a urine sample, arrows up instead of the K-result indicate that further dilution of the sample is necessary (see Urine Sample).
- Check for proper sample preparation (see Chapter 5).
- Check for small air bubbles in the sample after aspiration into the sample chamber.
- Check for proper aspiration of Standard A.

↑ ↓

With Ca^{++} activated, the calibration report will print an arrow up or down instead of the actual temperature, if the temperature measured is out of range (Range 10.0°C - 40°C). The temperature sensor is located in the right side electrode holder.
Possible remedies:

- Ensure the sample sensor cable is securely plugged in.
- Make sure room temperature is within specified limits (15°C to 32°C / 60°F to 90°F).
- Perform **TEST AMPLIFIER** (see Service Functions) to measure the actual temperature. With the front door opened, the temperature displayed should be approx. 5°C above the actual room temperature.

ERR.

If the unit displays **ERR.** instead of the sample results, no valid voltage reading could be obtained from the electrode.

Possible remedies:

- Check for proper sample preparation (see Chapter 5).
- Check for proper connection of the electrodes.
- Check for proper filling of the reference housing.
- Check for air bubbles in the sample.

PERFORM DAILY MAINTENANCE

This message will be printed at the end of a sample report when cleaning or conditioning have not been performed within the last 24 hours. This message is printed only.

Possible remedy:

- Perform daily maintenance.

CHANGE FLUID PACK

When the monitored fluid level in the ISE SnapPak™ reaches 5% remaining, the analyzer will automatically print **CHANGE FLUID PACK** at the end of each sample report. This message is printed only.

Possible remedy:

- Replace the ISE SnapPak™ (See Checking Reagent Fluid Level and Changing the ISE SnapPak™ in Chapter 6).

*** LI CALCULATION NOT POSSIBLE

The lithium result can only be calculated for a Na^+ range of 95 - 180 mmol/L (89.6 - 169.5 mmol/L for blood/serum). If the Na^+ value of the sample is outside of this range, *** will be displayed and printed instead of the Li^+ value.

CHECK TEMP (Ca^{++} activated)

This message is printed at the end of the sample report and displayed while the measurement is in process in case the temperature of the sample is outside the range (Range: 10°C - 40°C).
The sample result is then calculated using a default temperature of 25°C.
Possible remedies:

- Check for proper sample preparation (see Chapter 5).
- Ensure the sample sensor cable is securely plugged in.
- Make sure room temperature is within specified limits (15°C to 32°C / 60°F to 90°F).
- Perform **Test Amplifier** (Service Functions) to measure the actual temperature.
  With the front door opened, the temperature displayed should be approx. 5°C above the actual room temperature.

Service Functions

To aid in testing and troubleshooting your AVL Electrolyte Analyzer, there are various built-in functions that you can access to evaluate the performance of the instrument. From the **READY** display, press **NO** until the prompt **SERVICE FUNCTIONS?** appears. Press **YES**.

Testing the electrodes

You can test the voltage levels of the electrodes by using standard solutions or an external sample. Press **NO** until the prompt **Test Electrodes?** is displayed. Press **YES** and the prompt **Test Standard A?** will be displayed. Press **YES** and the voltages for each electrolyte will appear. Record these values. Press **NO** to exit.

The prompt **Test Standard B?** will now be displayed. Press **YES** and the voltages for each electrolyte will appear. Record these values. Press **NO** to exit.

The prompt **Test Standard C?** will now be displayed. Press **YES** and the voltages for each electrolyte will appear. Record these values and compare in this manner:

Electrode	*Standard A*	*Standard B*	*Standard C*	*Allowable Difference*	
				A-B	*A-C*
Na^+	-600 to +2400	-1600 to +2000	-600 to +2400	+250 to +680	-50 to +50
K^+	-700 to +1000	-2500 to +500	-700 to +1000	+470 to +1200	-40 to +40
Cl^-	-3100 to -100	-1000 to +3000	-3100 to -100	-370 to -860	not used
Ca^{++}	-3100 to +1000	-2300 to +2500	-3100 to +1000	-350 to -660	-150 to +150
Li^+	-3100 to +1900	-3600 to +1400	-2600 to +3400	+1 to +760	-1730 to -285

Note: If the voltage difference A-B or A-C is outside the allowable difference, perform daily maintenance or replace the electrode.

After testing the electrodes against the standard solutions, the AVL Electrolyte Analyzer will prompt **Test External Sample?** Press **YES**. The instrument will prompt **Open Sample Door Introduce Sample.**

Introduce the sample to the probe until the prompt **Remove Sample and Wipe Probe** is received. After closing the sample door, the voltages will automatically appear. Check for stable readings. Press **NO** to exit and after a short **Please Wait** message, the prompt **Remain in Test Electrodes?** will appear. Press **NO** to exit or to perform other service functions.

Testing the sample sensor

The sample sensor must provide a reading of 80 - 120 when air is detected, and should indicate at least 40 higher when clear liquid is passed through the sensor. To check the sample sensor, from the **SERVICE FUNCTIONS?** display, press **NO** until **Test Sample Sensor?** appears. Press **YES.**

The analyzer will display the normal range and the measured value. Press **YES** and open the sample door to pump liquid through the sensor for measurement; press **NO** to stop the pump, press **NO** again to exit or to perform other service functions.

Testing the sample door

To check the positioning of the sample door from the **SERVICE FUNCTIONS?** display, press **NO** until **Test Sample Door?** appears. Press **YES.**

Raise the sample door and the display should indicate that the door is open with an **"O"** in the upper right corner of the display. Close the door and the **"O"** should change to a **"C"** indicating the door is closed.

Testing SnapPak Sensor

Press **YES** to the prompt **Test SnapPak Sensor? "I"** indicates that the pack is in place, **"O"** indicates that the pack is either not present or not completely seated. If the ISE SnapPak™ has been removed during this test, a calibration should be performed to prime all fluid lines.

Testing the language switch

To check the current position and the performance of the language switch, press **YES** in the **Test Language Switch?** menu. The language switch is located behind the paper tray. Remove the paper tray and use a pen to change the setting of the language switch. The selected language will be displayed.

Note: To activate a new language, turn the analyzer off and back on.

Testing the peristaltic pump

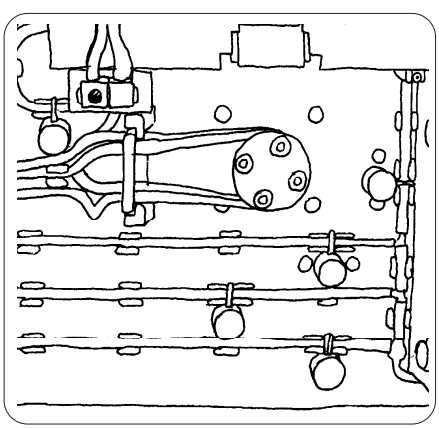
The peristaltic pump has four speeds of operation, that can be automatically checked. From the **SERVICE FUNCTIONS?** display, press **NO** until **Test Pump?** appears. Open the front cover and press **YES**.

The pump will progressively display **Very Slow Speed, Slow Speed, Medium Speed** and **Fast Speed**, and an audible change should be heard in the pump's speed of operation. Close the front cover and press **NO** to exit or perform other service functions.

Note: The pump speed is electronically controlled and does not require any adjustment.

Testing the valves

The AVL Electrolyte Analyzer has five valves that function automatically during the operation of the instrument.
See illustration 7-1.



7-1. Fluid control valves

Open the analyzer front cover. From the **SERVICE FUNCTIONS?** display, press **NO** until **Test Pinch Valves?** appears. Press **YES**.

Test Valve A: YES/NO = ON/OFF will appear. When you press the **YES** button, you should see the valve move into the open position. Pressing **NO** will close the valve. Pressing **NO** again will move to the next successive valve. After testing all valves, close the front cover and press **NO** to exit or perform other service functions.

Testing the interface

Testing the serial interface allows you to verify the proper operation of the interface circuit. From the **SERVICE FUNCTIONS?** display, press **NO** until **Test Interface? Jump Pins 2 and 3** appears. Jump pins 2 and 3 making sure not to short the jumper to ground. Press **YES**.

During the interface test, the instrument sends out the characters A, V, L, and checks if they are received within a set time period. Press **NO** to exit or to perform other service functions.

Testing the amplifier

The amplifier voltage can be checked from the **SERVICE FUNCTIONS?** display. Press **NO** until **Test Amplifier?** appears. Press **YES**.

The analyzer will automatically test and display the voltage levels of the electrode channels. Press **NO** and the ground and offset voltage will be displayed. If Ca^{++} is activated, press **NO** to view the temperature voltage and the temperature in degrees C. Press **NO** to exit or to perform other service functions.

Service Codes

The **Enter Service Code?** menu allows the programming of various functions into the unit. To enter a service code, go to the **SERVICE FUNCTIONS?** display, press **NO** until **Enter Service Code?** appears. Press **YES**.

The instrument will display **Enter Code**. Enter the desired service code by pressing **NO** to each letter, until the correct letter is displayed, then press **YES**. After entering the code, the analyzer will prompt **Code Accepted**, then it will display **Enter another Service Code?** Press **YES** to do so, **NO** to exit.

Note: If an incorrect code is entered during the process, the analyzer will prompt Code Error Retry? *Press* YES *to correct the code or* NO *to exit.*

To remove a service code, enter the reversed sequence of the code letters (example: DEC becomes CED, ECO becomes OCE, MGL becomes LGM, etc.). To clear all service codes at one time, enter CDC.

DEC

This service code will increase the resolution by one digit for all parameters in blood and serum samples. QC and standard samples are always shown in high resolution, urine samples in low resolution.

ECO

This service code will automatically put the instrument into Standby Mode, if no samples are run between two calibrations (4 hrs.). This feature mainly helps to conserve reagents. When the unit automatically enters the Standby Mode, it is always necessary to perform a calibration to get back to the **READY** prompt.

FIF

This service code will automatically print the voltage levels of the electrodes on sample- and calibration reports.
This code should only be used by trained service technicians. To disable this code, either enter **IFI** or turn the power off and back on.

LEM

This service code will print the last 20 error messages with the date and time of occurrence. **MEL** will erase all error messages stored.

MGL (Ca^{++} activated)

This service code allows you to report Ca^{++} values in mg/dL instead of mmol/L. When this code is set, the unit automatically converts the current high and low values of the normal ranges to mg/dL. Note that QC and standard measurements are always reported in mmol/L independent of the **MGL** setting. This allows you to compare the Ca^{++} values to the ISE-trol assay ranges.

NOB

This service code disables the beep.

SLC

When this code is set, the current setting of the leasing counter, which cannot be reset by the operator, is printed on the calibration report.

SFC

This code allows the input of a percentage for the ISE SnapPak™ counter. When this code is activated, the analyzer displays:

SnapPak Counter:
xxx% ok?

If this percentage is not correct, press **NO** and enter the correct percentage between 0 and 100% using the **NO** and **YES** keys. Pressing **YES** to **ok?** will return the analyzer to the ready screen.

QCC

When this code is enabled, the QC measurements will be reported in direct ISE instead of flame equivalent values.
Note that no correlation factors are applied to the measurement values, if **QCC** is set.

With the exception of **FIF**, all service codes are permanently stored in memory and will be retained during power failures. The service codes currently set can be printed on the calibration report.

8

Chapter 8

Principles of Operation

The measurement principle

Your AVL Electrolyte Analyzer is a sophisticated medical instrument that uses the Ion Selective Electrode (ISE) measurement principle to precisely determine electrolyte values. Although the technology itself is quite complicated, understanding how the instrument performs sampling analysis is relatively simple. Basically, the analyzer compares an *unknown* value against a *known* value to compute the sample's electrolyte level.

An ion-selective membrane undergoes a specific reaction with the type of electrolyte contained in the sample. The membrane is an ion exchanger, reacting to the electrical change of the ion causing a change in the membrane potential, or measuring voltage, which is built up in the film between the sample and the membrane.

A galvanic measuring chain within the electrode determines the difference between the two potential values on either side of the membrane. The galvanic

chain is closed through the sample on one side by the reference electrode, the reference electrolyte and the "open terminal." The membrane, inner electrolyte and inner electrode close the other side.
See illustration 8-1.

The different ion concentrations between the inner electrolyte and the sample causes an electro-chemical potential to form on the membrane of the active electrode. The potential is conducted by the inner electrode to the input of an amplifier. The reference electrode is connected to ground as well as the second input of the amplifier.

Since the reference electrode is on ground, amplification of the electrode potential allows further signal processing.

The ion concentration in the sample is then determined and displayed by using a calibration curve determined by two measured points of standard solutions with precisely known ion concentrations (two-point calibration), and by using the measured voltage of the sample and the Standard-A (one-point calibration).

Physical principle

An ion-selective electrode is connected with a reference electrode to form a measuring system. When immersed in a solution that contains the relative ion, the Nernst equation applies:

1. $$E = E' \pm \frac{R \cdot T}{n \cdot F} \cdot \ln a_i$$

or

2. $$E = E' \pm \frac{R \cdot T}{n \cdot F} \cdot \ln (f_i \cdot c_i)$$ (+) for cations, (-) for anions

The equation can also be written:

3. $$E = E' \pm S \cdot \log (f_i \cdot c_i)$$

E	the measured electric potential
E'	the e.m.f. of the system in a standard solution
a_i	activity of the ion measured
R	the general gas constant (8.31 J/Kmol)
T	temperature
n	valence of the measured ion
F	Faraday constant 96.496 A.s/g equivalent
f_i	the activity coefficient
c_i	the concentration of the measured ion
S	the slope of the electrode

See illustration 8-2.

If the ion concentration of one measuring solution is known, the ion concentration of the sample can be determined on the basis of the difference of two measured potentials.

4. $E_{sample} = E' + S \cdot \log (f_i \cdot c_{i\ sample})$

5. $E_{standard} = E' + S \cdot \log (f_i \cdot c_{i\ standard})$

6. $$\Delta E = E_{sample} - E_{standard} = S \cdot \log \frac{c_{i\ sample}}{c_{i\ standard}}$$

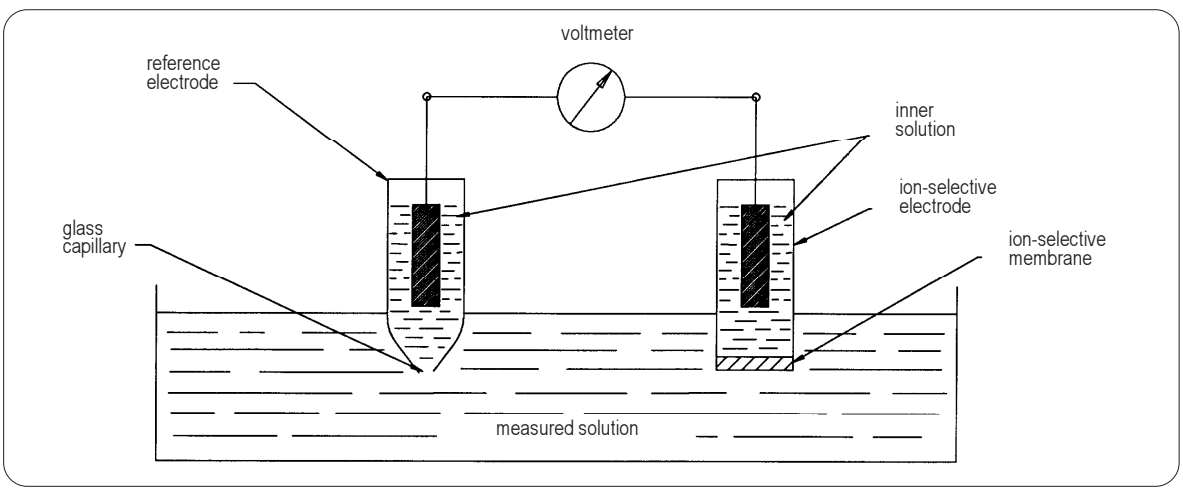
ΔE	the difference between the measured potentials of the sample and the standard
S	the potential difference of the electrode, determined from the potential difference of two measured standard solutions
$c_{i\ sample}$	concentration of the measured ions in the sample
$c_{i\ standard}$	concentration of the measured ions in the standard solutions

The unknown ion concentration in the sample can now be determined by:

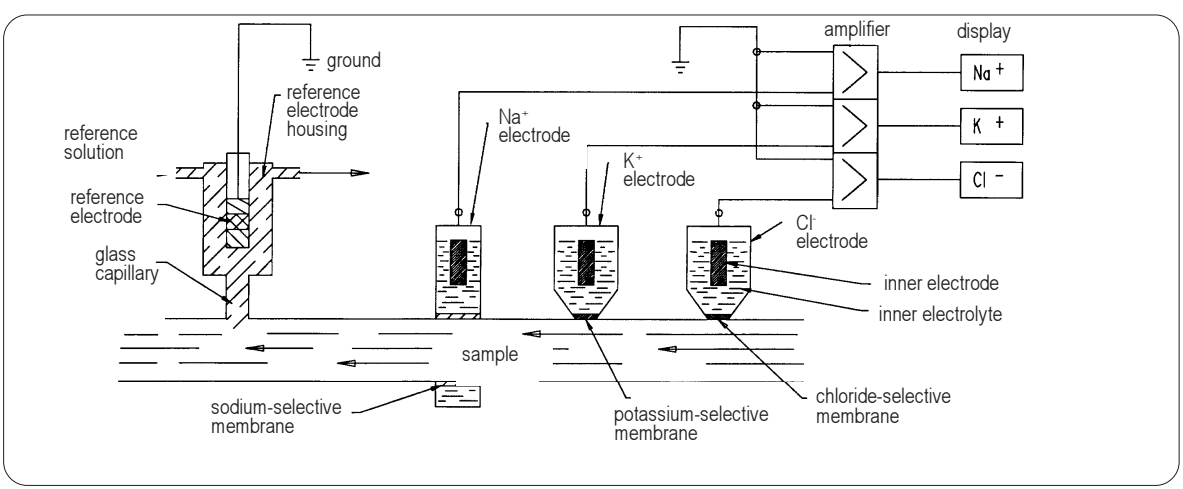
7. $c_{i\ sample} = c_{i\ standard} \cdot 10^{(\Delta E / S)}$

As demonstrated by these equations, the ion selective electrodes do not measure the ion concentration but the activity of the ions concerned. This activity is a criterion of the ion's ability to interact with other ions, in which each ion binds a proportion of its energy.

The ion concentration is calculated on the basis of the ion activity. The correlation is affected by the total number of ions in the solution. Because sodium in whole blood and serum is the predominant ion, the known value of the sodium concentration makes it possible to ascertain and adjust for total ion effect and strength.



8-1. Measurement principle



8-2. Measurement system

Sodium Electrode Specifications

The Sodium Electrode is a glass capillary electrode used for in-vitro diagnostic measurement of sodium ions present in fluid samples. It is designated with a Na^+ marking on the top surface of the housing.

Construction

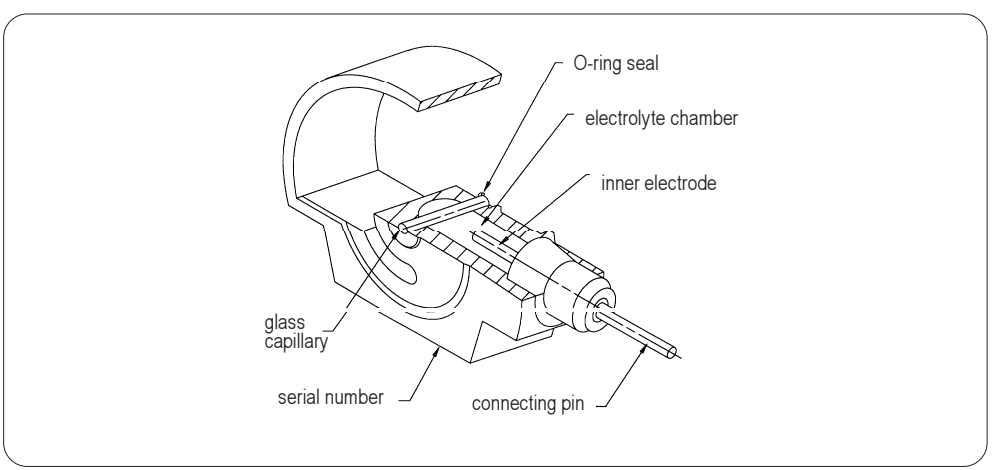
Electrode housing:	transparent acrylic plastic
Measuring capillary:	sodium selective glass
Electrolyte chamber:	airtight, filled with electrolyte solution for Na^+ electrodes
Pin connector:	silver, silver chloride (Ag / AgCl)

Use and Care

AVL Sodium Electrodes are manufactured for use in AVL 9180 Electrolyte Analyzers.

Proper care should be used in handling and storage of the electrode. Never use strong or abrasive cleaners such as alcohol or amphyl on the electrode since these will attack the plastic housing.

Store the electrode in a clean, dry place only after the electrode has been cleaned and rinsed with distilled water and dried with a lint-free cloth. The o-ring seal should be installed in the electrode during storage.



8-3. Sodium electrode construction

Potassium Electrode Specifications

The Potassium Electrode is a membrane electrode used for in-vitro diagnostic measurement of potassium ions present in fluid samples. It is designated with a K^+ marking on the top surface of the housing.

Construction

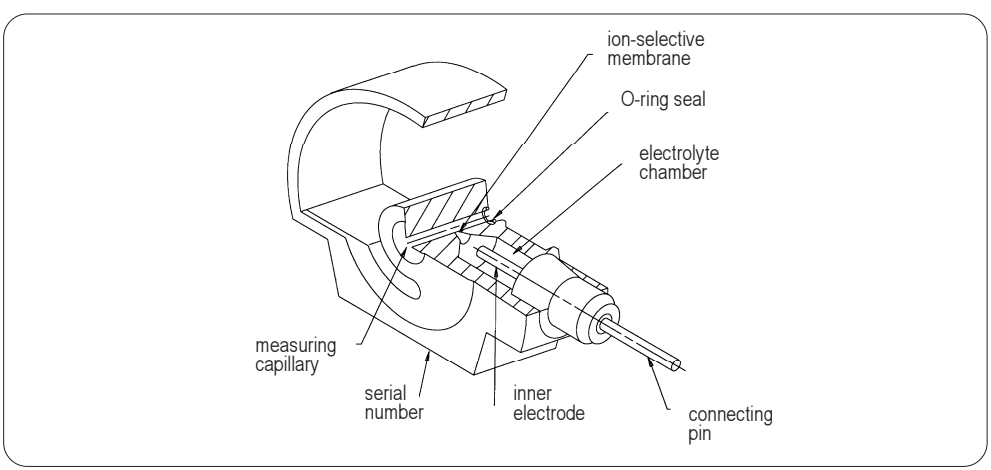
Electrode housing:	transparent acrylic plastic
Measuring membrane:	potassium ion selective
Electrolyte chamber:	airtight, filled with electrolyte solution for K^+ electrodes
Pin connector:	silver, silver chloride (Ag / AgCl)

Use and Care

AVL Potassium Electrodes are manufactured for use in AVL 9180 Electrolyte Analyzers.

Proper care should be used in handling and storage of the electrode. Never use strong or abrasive cleaners such as alcohol or amphyl on the electrode since these will attack the plastic housing.

Store the electrode in a clean, dry place only after the electrode has been cleaned and rinsed with distilled water and dried with a lint-free cloth. The o-ring seal should be installed in the electrode during storage.



8-4. Potassium electrode construction

Chloride Electrode Specifications

The Chloride Electrode is a membrane electrode used for in-vitro diagnostic measurement of chloride ions present in fluid samples. It is designated with a Cl^- marking on the top surface of the housing.

Construction

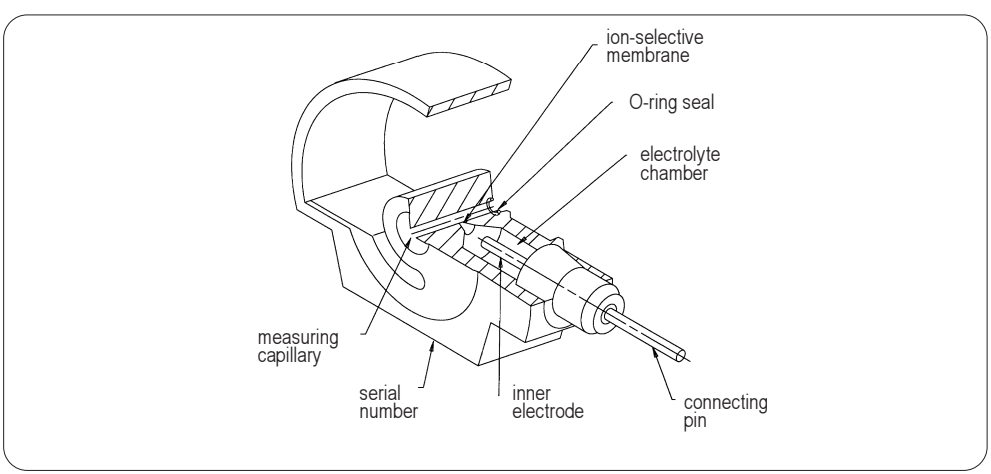
Electrode housing:	transparent acrylic plastic
Measuring membrane:	chloride ion selective
Electrolyte chamber:	airtight, filled with electrolyte solution for Cl^- electrodes
Pin connector:	silver, silver chloride (Ag / AgCl)

Use and Care

AVL Chloride Electrodes are manufactured for use in AVL 9180 Electrolyte Analyzers.

Proper care should be used in handling and storage of the electrode. Never use strong or abrasive cleaners such as alcohol or amphyl on the electrode since these will attack the plastic housing.

Store the electrode in a clean, dry place only after the electrode has been cleaned and rinsed with distilled water and dried with a lint-free cloth. The o-ring seal should be installed in the electrode during storage.



8-5. Chloride electrode construction

Calcium Electrode Specifications

The Calcium Electrode is a membrane electrode used for in-vitro diagnostic measurement of calcium ions present in fluid samples. It is designated with a Ca^{++} marking on the top surface of the housing.

Construction

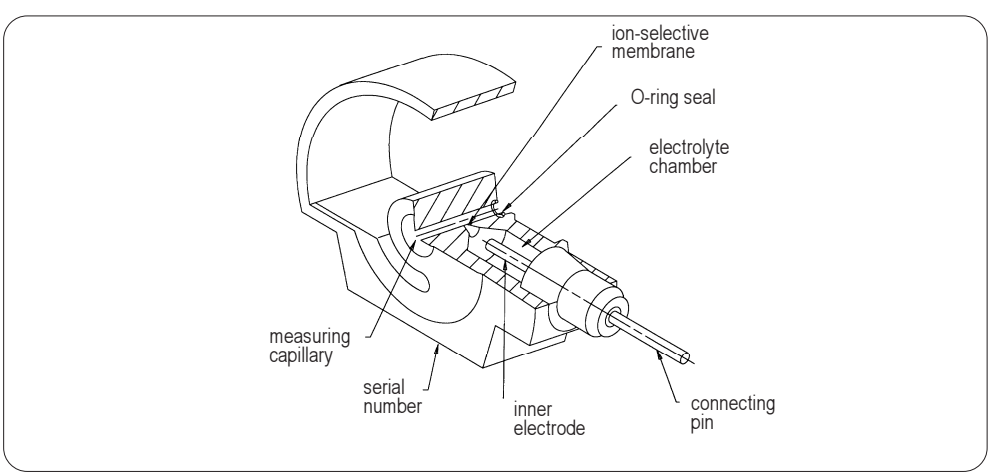
Electrode housing:	transparent acrylic plastic
Measuring membrane:	calcium ion selective
Electrolyte chamber:	airtight, filled with electrolyte solution for Ca^{++} electrodes
Pin connector:	silver, silver chloride (Ag / AgCl)

Use and Care

AVL Calcium Electrodes are manufactured for use in AVL 9180 Electrolyte Analyzers.

Proper care should be used in handling and storage of the electrode. Never use strong or abrasive cleaners such as alcohol or amphyl on the electrode since these will attack the plastic housing.

Store the electrode in a clean, dry place only after the electrode has been cleaned and rinsed with distilled water and dried with a lint-free cloth. The o-ring seal should be installed in the electrode during storage.



8-6. Calcium electrode construction

Lithium Electrode Specifications

The Lithium Electrode is a membrane electrode used for in-vitro diagnostic measurement of lithium ions present in fluid samples. It is designated with a Li^+ marking on the top surface of the housing.

Construction

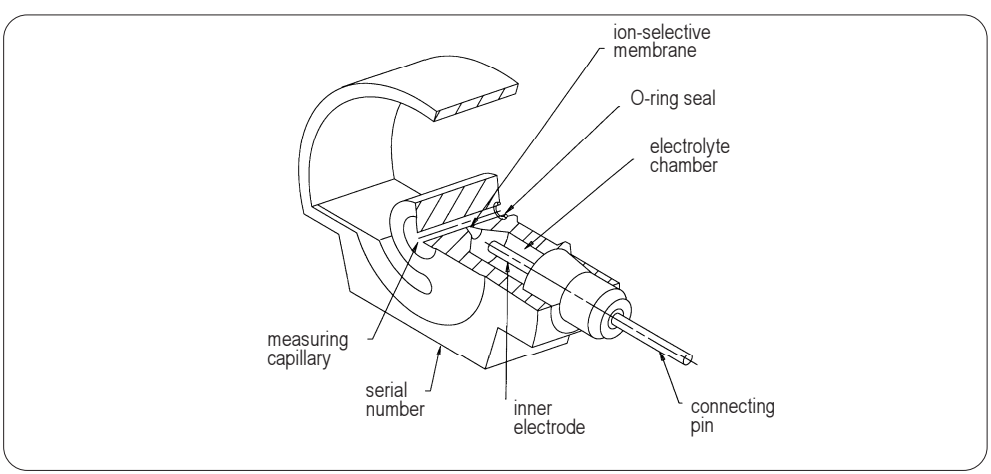
Electrode housing:	transparent acrylic plastic
Measuring membrane:	lithium ion selective
Electrolyte chamber:	airtight, filled with electrolyte solution for Li^+ electrodes
Pin connector:	silver, silver chloride (Ag / AgCl)

Use and Care

AVL Lithium Electrodes are manufactured for use in AVL 9180 Electrolyte Analyzers.

Proper care should be used in handling and storage of the electrode. Never use strong or abrasive cleaners such as alcohol or amphyl on the electrode since these will attack the plastic housing.

Store the electrode in a clean, dry place only after the electrode has been cleaned and rinsed with distilled water and dried with a lint-free cloth. The o-ring seal should be installed in the electrode during storage.



8-7. Lithium electrode construction

Reference Electrode Assembly Specifications

The Reference Electrode Assembly is a device used as an electrical junction between the sample and electrical ground.

Construction

The Reference Electrode Assembly consists of two parts: the Reference Electrode Housing and the Reference Electrode.

Reference Electrode Housing

In the Reference Electrode Housing, reference electrolyte solution establishes the electrical contact between the Reference Electrode and the sample. At the beginning of each measurement, reference electrolyte is pumped into the housing. At the same time a glass capillary allows a small amount of reference electrolyte to pass into the measuring capillary, thus establishing electrical contact between the sample and the Reference Electrode.
See illustration 8-8.

Use and Care

AVL Reference Electrode Housings are manufactured for use in AVL 9180 Electrolyte Analyzers.

Proper care should be used in handling and storage of the electrode housing. Never use strong or abrasive cleaners such as alcohol or amphyl on the housing.

Store the Reference Electrode Housing in a clean, dry place only after the Reference Electrode has been removed and the housing cleaned and rinsed with distilled water and dried with a lint-free cloth.
The o-ring seals should be installed in the housing during storage.

Reference Electrode

The Reference Electrode completes the electrical circuit between the reference electrolyte and electrical ground. This is accomplished by a cotton wool (saturated with reference electrolyte)-calomel (Hg_2Cl_2)- mercury (Hg)-platinum wire-connecting pin junction.
See illustration 8-9.

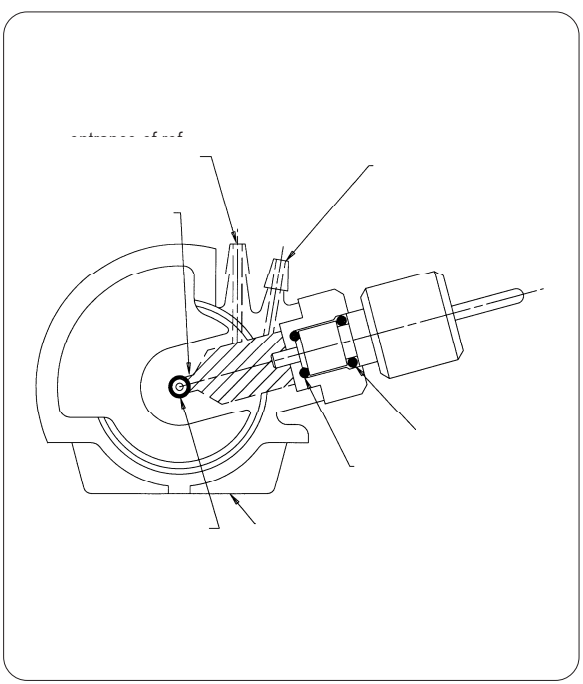
Use and Care

AVL Reference Electrodes are manufactured for use in AVL 9180 Electrolyte Analyzers.

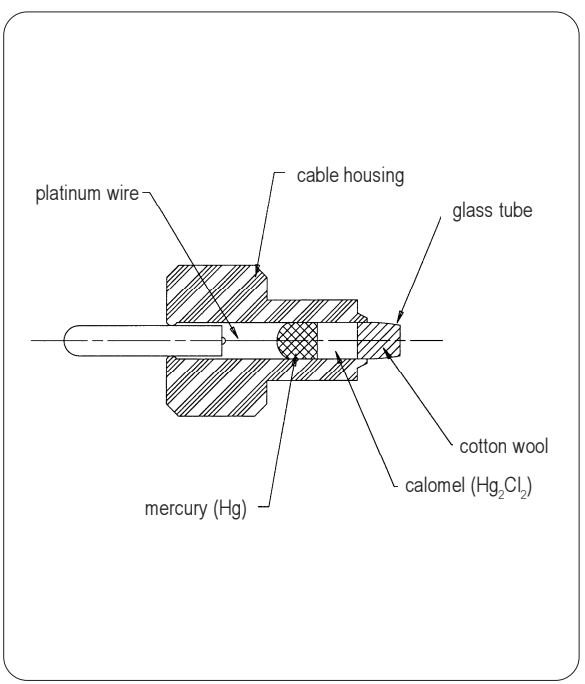
Proper care should be used in handling and storage of the Reference Electrode. Never use strong or abrasive cleaners such as alcohol or amphyl on the electrode.

Store the Reference Electrode in the transport housing provided with the electrode at the time of purchase. Make sure that the transport housing is filled with reference electrolyte solution (you may use the reference electrolyte solution remaining in the Reference Electrode Housing at the time of disassembly).

Note: Never rinse the Reference Electrode with distilled water.
Never allow the Reference Electrode to become dry.



8-8. Reference electrode housing



8-9. Reference electrode

9

Chapter 9

Supplies

Each AVL Electrolyte Analyzer is shipped with an initial supply of calibrating and operating solutions, ISE-trol Electrolyte Control, accessories, and maintenance supplies.

Below is a listing of all necessary supplies and accessories which you may need to replace during the use of your analyzer.

To order replacement supplies and accessories, contact your local Authorized AVL Distributor or, in the U.S., call AVL's Order Entry Department at 1-800-421-4646 Monday through Friday, 8 AM to 5 PM eastern time. Our Order Entry representative will gladly provide any assistance you may require.

Electrodes

Potassium Electrode	BP0359
Sodium Electrode	BP0413
Chloride Electrode	BP0570
Calcium Electrode	BP0360
Lithium Electrode	BP0962
Reference Electrode	BP5026
Reference Housing with Tubing Assembly	BP5019

Solutions

ISE SnapPak™ (9180)	BP5186
Cleaning Solution A	BP1025
Electrode Conditioning Solution	BP0380
Urine Diluent	BP0344
ISE-trol Quality Control Kit (Tri-level, 36 x 1mL)	HC0033

Supplies

Printer Paper (5 rolls)	BP5025
Pump Tubing Set	BP5027
Complete Valve Tubing Set / Interconnectors	BP5193

Spare Parts

Sample Probe with Tubing	BP5006
Reference Solution Interconnector	BP5020
Fill Port Tubing (with red tag)	BP5029
Fill Port Complete	BP9043
Reference Electrode O-ring	DA0111
Electrode Interconnect O-ring (Quad Ring)	DA0156
Fuse, 0.3 amp, slow-blow	EV5000
Fuse, 1.25 amp, slow-blow	EV0082
Fuse, 1.6 amp, slow-blow	EV0044
Fuse, 2.0 amp, slow-blow	EV0045
Reference Electrode Transport Housing (for storage)	HV0294
Service Syringe, 12 mL	MC0007
Printer Paper Tray	RE5016
Reference Solution Double Tubing	SS5000
Solenoid Relief Clamp	YA0111
Stylet for Cleaning Sample Probe	YA0836
Operators Manual for 9180 - English	PD5006
Operators Manual for 9180 - International	PD5008
Service Manual for 9180	US0285
Shut Down Kit	BP5014
Interface Kit, 9180 to Compact 2	BP5202

Technical Assistance

Most often, problems can be resolved over the telephone, getting the analyzer back in service within minutes. Our technicians have the training and experience you can rely on for dependable technical assistance.

AVL's STATService Hotline (U.S.Market only) is staffed to provide immediate troubleshooting assistance seven (7) days per week, twenty four (24) hours per day.

Should you need troubleshooting assistance or application information regarding your AVL Electrolyte Analyzer just contact AVL's STATService Hotline. In the U.S., call **1-800-526-2272**.

Should you require additional service support, our STATService Hotline can provide complete details on all available service options and ensure that any instrument down time is minimized.

Warranty Registration (U.S. market only)

After successful completion of the installation of your new AVL Electrolyte Analyzer, it will be necessary to complete the Installation and Instrument Warranty Report form enclosed. It is necessary for this document to be completed and returned to AVL to ensure proper warranty support should you require warranty assistance. The model and serial numbers can be found directly behind the front cover on the right hand side, above the sample probe mechanism.

Please read the Instrument Warranty Terms and Conditions to become familiar with the agreement.

Each new analyzer purchased is provided with a one year warranty from the date the analyzer is placed into service. Electrodes are provided with product warranties as indicated on AVL's price list. The warranty period for electrodes varies depending on the specific type of electrode. Electrode warranties begin from the date of shipment.

Contact AVL's STATService Hotline for any assistance regarding warranty assistance or support.

Appendix A

Technical specifications

Electrodes

Sodium (Na^+) Sensor	ion selective, flow-through, glass capillary electrode
Potassium (K^+)Sensor	ion selective, flow-through, liquid membrane electrode
Chloride (Cl^-) Sensor	ion selective, flow-through, liquid membrane electrode
Calcium (Ca^{++}) Sensor	ion selective, flow-through, liquid membrane electrode
Lithium (Li^+) Sensor	ion selective, flow-through, liquid membrane electrode
Reference System	open liquid junction, flow-through, electrode

Measuring Ranges (mmol/L)

Parameter	Measurement Range	Display Resolution
Whole blood, serum, plasma, dialysate and aqueous solutions:		
Sodium	40 - 205 mmol/L	1 or 0.1 mmol/L
Potassium	1.5 - 15 mmol/L	0.1 or 0.01 mmol/L
	(0.8 - 15 mmol/L dialysate)	
Chloride	50 - 200 mmol/L	1 or 0.1 mmol/L
ionized Calcium	0.2 - 5.0 mmol/L	0.01 or 0.001 mmol/L
Lithium	0.1 - 6.0 mmol/L	0.01 or 0.001 mmol/L
(Lithium is not measured in dialysate samples)		

Reproducibility (within run)	Na^+	CV ≤ 1.0% @ 140 - 160 mmol/L
	K^+	CV ≤ 1.5% @ 4 - 6 mmol/L
	Cl^-	CV ≤ 1.0% @ 90 - 130 mmol/L
	Ca^{++}	SD ≤ 0.02 mmol/L @ 0.8-1.5mmol/L
	Li^+	SD ≤ 0.02 mmol/L @ 0.4-1.3mmol/L

Urine

Sodium	1 - 300 mmol/L	1 mmol/L
Potassium	4.5 - 120 mmol/L	0.1 mmol/L
	(60-120 with additional dilution)	
Chloride	1 - 300 mmol/L	1 mmol/L
(Calcium and Lithium are not measured in urine samples)		

Reproducibility (within run)	Na^+	CV ≤ 5% @ 100 - 250 mmol/L
	K^+	CV ≤ 5% @ 10 - 60 mmol/L
	Cl^-	CV ≤ 5% @ 100 - 250 mmol/L

Operating Parameters

Sample size	95 µL
Sample type	whole blood, serum, plasma, dialysate, urine
Sample application	syringe, sample cup, collection tube, capillary
Analysis time	(approx.) 50 sec.
Sample rate	60 per hr. without printout 45 per hr. with printout
Calibration	fully automatic 1- and 2-point calibrations
Data management	quality control memory storage, 3 levels, 35 days calculation of mean, std. deviation and coefficient of variation (CV)
Diagnostic programs	user-controlled diagnostics, plain language display
Electronics	microprocessor-controlled
Display	dot-matrix, 2 lines, 16 characters per line
Printout	built-in, thermal paper roll printer, 16-character width
Computer interface	RS232C serial port
Data link	Data link to Compact 2
Power requirements	100 - 240 V~, 50/60 Hz (self-adjusting) 1.4 A max.,375 watts max.
Nominal power consumption	30 watts
Temperature	room temperature, 15° - 32° C; 60° - 90° F
Humidity	< 85% relative humidity, non-condensing
Dimensions	(HxWxD) 13.2 x 12.4 x 12.0"; 335 x 315 x 295 mm
Weight	(approx.) 13 lbs.; 6 kg

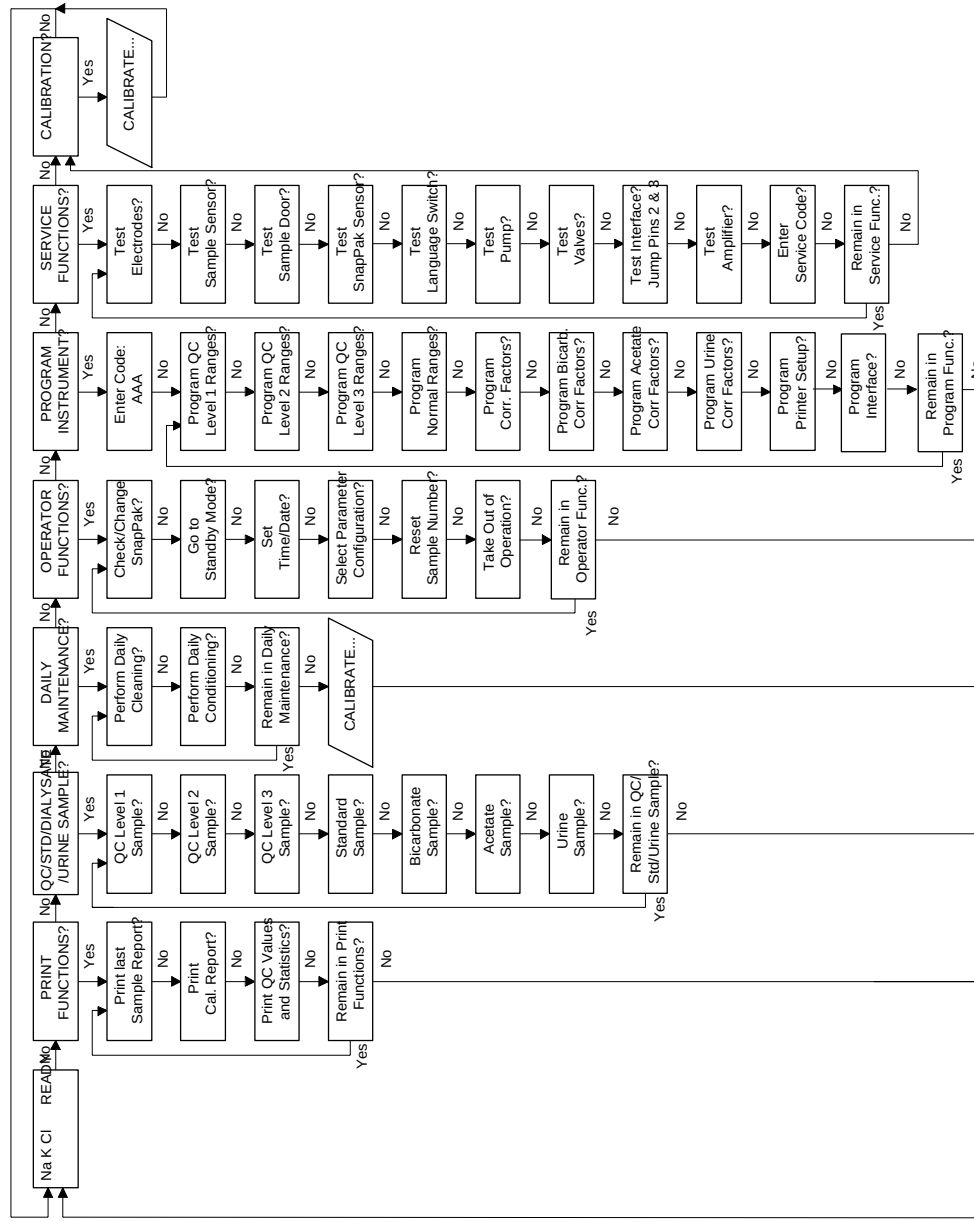
Classifications

Safety category	I
Device type	B (according to ÖVE-MG/EN 60601-1, IEC 601-1)
Mode of operation	continuous operation
Protection classification	IP 20
Explosion protection	the device is not designed for operation in explosive environments.
Approvals	CSA, IEC 1010 (TÜV/GS), CE, FCC Class B

Data subject to change without notice. Technical information is supplied for general informational purposes only.

Appendix B

Program flow chart



Appendix C

Maintenance log master

Note: You may use this page as a master for duplicating.

AVL 9180 ELECTROLYTE ANALYZER
MAINTENANCE SCHEDULE

MONTH OF _____

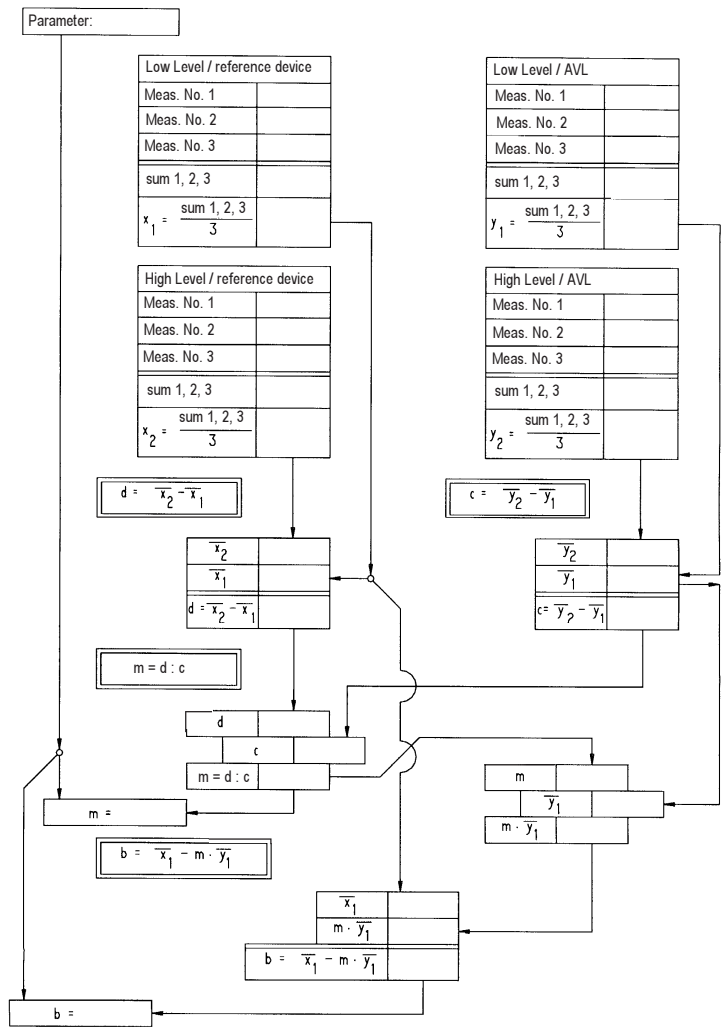
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
DAILY																															
Perform Cleaning Cycle																															
Perform Conditioning Cycle																															
WEEKLY																															
Clean Sample Probe/Fill Port																															
Clean Analyzer Surfaces																															
MONTHLY																															
Clean Ref. Electrode Housing																															
SEMIANNUALLY																															
Replace Peristaltic Pump Tubing																															

UNSCHEDULED MAINTENANCE

Appendix D

Correlation factor worksheet master

Note: You may use this page as a master for duplicating.



AVL 9180 Electrolyte Analyzer Operator's Manual

Written by Gerri Priest, Barbara Smith and Bernie Heitz of AVL.

Edited by Randy Byrd, Tom McNulty and Steve Wickiser.

Designed, illustrated and produced by Rick Burns and Drew Meincke.