

OREGON HEALTH & SCIENCE UNIVERSITY  
Hospitals and Clinics  
Point of Care

**Blood Gas, Electrolytes, Hemoglobin,  
And Oxygen Saturation by ABL 80 Flex**

Principle

The ABL 80 analyzer is used for measurement of pH, blood gas, electrolytes, oxygen saturation, and measured hemoglobin status in arterial, venous, and capillary blood samples.

There are four measuring principles employed in sensors in the ABL 80 Flex analyzer: Potentiometry (pH, pCO<sub>2</sub>, and electrolytes), amperometry (pO<sub>2</sub>), conductometry (air-in-sample detection), and spectrophotometry (hemoglobin and oximetry).

Blood gases and oximetry are obtained to determine if the patient is well oxygenated and to determine the acid base status of the patient. The pH determines if the patient is in an acidic or alkali state, the pO<sub>2</sub> refers to the pressure or tension exerted by dissolved O<sub>2</sub> gas in the blood. The pCO<sub>2</sub> is influenced by respiratory causes only. The O<sub>2</sub> measurement indicates how well the tissues are oxygenated. The oxygenation of blood from the lungs and the circulation of the blood from the heart contribute to the amount of pO<sub>2</sub> measured and renal compensation to the acid/base disturbance. The O<sub>2</sub> saturation is calculated as a ratio and shows the percentage of the volume of oxygen carried to the maximum volume which is possible to carry.

Electrolytes help maintain osmotic pressure, regulation of heart and other muscular contraction, oxidation-reduction potential, and participate as catalysts for enzymes. Disturbance of K<sup>+</sup> homeostasis causes muscle weakness and affects heart rate. Sodium maintains normal distribution of water through osmotic pressure. Ionized calcium is the active form of calcium and is useful in the evaluation of renal function and endocrine disorders.

Hemoglobin is the main chemical substance within red blood cells and is the compound which transports the major portion of oxygen to the tissues. The ABL 80 Flex optical system is designed to measure total hemoglobin, oxygen saturation, and hemoglobin derivatives in human blood.

Blood gases, electrolytes, and hemoglobin are analyzed in the operating rooms in order to monitor patient status during surgery.

## Specimen Requirements

1. Thoroughly mixed whole blood collected in a standardized hospital Lithium or Sodium Heparin syringe. Do not use other heparin solutions.
2. Perform tests immediately.
3. Minimum volume is 105  $\mu\text{L}$ .

Interferences:

<b>Causes of Error</b>	<b>Parameters Most Affected</b>	<b>Preventative Measure</b>
Air Bubbles in Sample	pO <sub>2</sub>	Expel all air bubbles from sample immediately
Cell sedimentation	Hgb, pO <sub>2</sub> , pCO <sub>2</sub>	Mix sample thoroughly prior to sample aspiration
Hemolysis	Na <sup>+</sup> , K <sup>+</sup> , Ca <sup>2+</sup> , Cl <sup>-</sup> , Hgb	<ul style="list-style-type: none"> <li>• Avoid using sampling needles with a narrow inner diameter</li> <li>• Avoid squeezing the tissue surrounding the patient sampling site during capillary sample collection</li> <li>• Avoid mixing the sample too vigorously</li> <li>• See section <i>Storage and preparation prior to analysis</i> further in this chapter</li> </ul>
Liquid heparin dilution	Na <sup>+</sup> , K <sup>+</sup> , Ca <sup>2+</sup> , Cl <sup>-</sup> , pCO <sub>2</sub> , cHCO <sub>3</sub> <sup>-</sup> , pO <sub>2</sub> , Hgb	Use only pre-heparinized blood gas syringes with dry heparin
Heparin interference	Na <sup>+</sup> , K <sup>+</sup> , Ca <sup>2+</sup> , Cl <sup>-</sup> , Hgb	Use only electrolyte-balanced heparin
Arterial blood mixed with venous blood	pO <sub>2</sub> , pCO <sub>2</sub> , pH	Use proper sampling technique (an unexpectedly low pO <sub>2</sub> can often be verified using pulse oximetry).
Red blood cell leakage	K <sup>+</sup>	Store glass (not plastic) capillary samples for no more than 30 minutes in cold (0-4 °C) conditions
Dilution of sample with flush solution	Na <sup>+</sup> , K <sup>+</sup> , Ca <sup>2+</sup> , Cl <sup>-</sup>	Discard a sufficient volume of flush from the catheter prior to blood sampling
Infusion solution being introduced in the same arm	Na <sup>+</sup> , K <sup>+</sup> , Ca <sup>2+</sup> , Cl <sup>-</sup>	Stop the infusion during sampling or use another sample site

Analytical Measurement Range (Linearity)

Analyte	AMR
pH	6.75-7.86
pCO <sub>2</sub>	5.0-117.0 mmHg
pO <sub>2</sub>	0-700 mmHg
tHb	4.5-24.0 g/dL
sO <sub>2</sub>	0.0-100.0%

Analyte	AMR
K <sup>+</sup>	0.7-12.7 mmol/L
Na <sup>++</sup>	78.0-168.0 mmol/L
Cl <sup>-</sup>	21.0-137.0 mmol/L
Ca <sup>++</sup>	0.18-4.02 mmol/L
Hct	13.5-72.0 %

Reference Range

Analyte	Age	Arterial	Venous
pH	0-2 months	7.30-7.50	7.35-7.45
pH	>2 months	7.37-7.44	7.35-7.45
pCO <sub>2</sub> (mmHg)	0-2 months	30-65	35-50
pCO <sub>2</sub> (mmHg)	>2 months	32-43	35-50
pO <sub>2</sub> (mmHg)	0-2 months	50-75	30-55
pO <sub>2</sub> (mmHg)	2mo-40 yrs	83-108	30-55
pO <sub>2</sub> (mmHg)	>40 years	72-104	30-55
HCO <sub>3</sub> (mMol/L)	No age limit	21-28	22-28
Total CO <sub>2</sub> (mMol/L)	0-150 yrs	22-29	23-29
O2 Sat (%)	0-1 Month	40-90	
	1 Mo- 150 yr	92-98	
Na <sup>+</sup> (mMol/L)	No age limit	134-143	134-143
K <sup>+</sup> (mMol/L)	No age limit	3.4-5.0	3.4-5.0
Cl <sup>-</sup> (mMol/L)	No age limit	97-108	97-108
iCa <sup>++</sup> , meas. (mMol/L)	No age limit	1.14-1.32	1.14-1.32
Hemoglobin (g/dL)		<b>Male</b>	<b>Female</b>
	0-6 months	9.5-14.0	9.5-14.0
	6 mos-1 yr	10.5-13.5	10.5-13.5
	1-12 yrs	11.5-13-.5	11.5-13.5
	12-18 yrs	13.0-16.0	13.0-16.0
	18-150 yrs	13.5-17.5	12.2-15.0

Analyte	Age	Cord Blood Arterial	Cord Blood Venous
pH	Birth	7.17-7.31	7.21-7.37
pCO <sub>2</sub> (mmHg)	Birth	41-59	33-53
pO <sub>2</sub> (mmHg)	Birth	10-26	18-38
HCO <sub>3</sub> (mMol/L)	Birth	20.5-25.5	N/A

## Alert Values

Critical alert values are only applicable with the measured results. Temperature corrected results do not contain critical values. Alert values are those results demonstrating such variance from normal as to represent a pathophysiological state with potential of being life threatening unless action is taken quickly. These results must be immediately reported to the care provider and be documented in the test record as to who was contacted, the time of contact, the person making contact, and if relevant, that the results were read back.

Test (Arterial)	Low	High
PH	≤7.25	≥7.55
pCO <sub>2</sub> (mmHg)	≤20	≥70
pO <sub>2</sub> (mmHg)	≤50	NA
Na <sup>+</sup> (mmol/L)	≤120	≥160
K <sup>+</sup> (mmol/L)	<2.5	>6.0
Hemoglobin (mg/dL)	<6.6	>18.9

## Calibration

The calibration process includes the measurement of three solutions with different analyte concentrations. These three measured values are used in different combinations of two points each to establish three two-point calibration lines for each analyte. One calibration line is consistently used to report sample results. The other two calibration lines are used to evaluate the system linearity.

1. Calibrations will be scheduled every eight hours.
2. One-point calibration must be:
  - a. Scheduled every thirty minutes.
  - b. Scheduled after each patient sample is run.
3. One or two-point calibrations can be requested during instrument troubleshooting.

### tHb calibration (for Co-Ox users only)

tHb calibration is performed every 3 months, when recommended by the manufacturer, or when indicated by the Quality Control Data.

- a. Select Menu ► Utilities ► tHb Calibration.
- b. Press the scan button and scan the ctHb Calibration Solution barcode located on the package insert.
- c. The system will complete a blank calibration then prompt the user to aspirate the calibration solution.
- d. Open an ampoule of the ctHb Calibration Solution, raise the inlet handle, guide the sample onto the inlet probe, and press aspirate.
- e. When completed, the system displays a value for the cuvette factor ( $F_{cuv}$ ).

**The  $F_{cuv}$  acceptable range is 0.80-1.20**

- f. Following a successful tHb calibration, the system will automatically initiate a System Cycle.

### Calibration verification and correlations

1. Calibration verification is performed by POCT every 6 months to validate the AMR.
2. Patient correlations are performed every 6 months.

### Quality Control Using the QC<sup>3</sup> Control Solutions

1. Perform three levels of automatic Quality Control (QC) every 24 hours of patient testing following the posted QC schedule. At least one level of automatic control must be run every eight hours of patient testing.

Check AutoCheck Status by viewing the quality controls results from each System Cycle.

2. The assigned value and acceptable range for each parameter and level is entered automatically into the analyzer each time a new solution pack is installed. These values can be viewed and printed from the system Information/Solution Pack tab.
3. The table of QC results provided with each System Cycle includes the following information: Solution ID, Lot Number, Cycle Numbers, Parameter values and QC#.

### Manual QC Run

1. Three levels of liquid QC must be run when a new sensor cassette or solution pack is installed.
2. To run the liquid QC: Select Menu►Manual QC.
3. Vigorously shake the QC vial for 15 seconds.
4. Tap the vial so solution goes into bottom of vial.
5. While holding the tip of the vial (wrapped in gauze) with thumb and forefinger snap off the tip.
6. Instantly slide the inlet handle up and insert the vial into the sample probe and hit aspirate.
7. After the beeps remove the vial and slide the handle down. Throw the QC vials in a sharps container.
8. If the QC passes run next control.
9. If all levels of QC pass, patient testing can resume. If any of the QC fails, rerun the failed QC. If the rerun fails, call the troubleshooting hotline for assistance 1-800-736-0600. Refrain from patient testing until both levels of QC

### Patient Testing Procedure

1. Ensure the analyzer is ready to accept a patient sample.
  - Ready is displayed in the upper left corner of the main menu
  - Traffic light is displaying a green or yellow light

- The desired parameters are available (appear in the parameter bar and are either green or yellow)

Color	Status	Action
Green	Analyzer okay to use.	None.
Yellow	Error and/or reminder.	The parameter is active, but at least one manual QC measurement result fell outside the acceptable range and QC warning is enabled. Exercise caution when using results from this parameter.
Red	Critical error. Analyzer cannot perform measurement.	The parameter failed the last system cycle. The parameter was inactivated or locked out for the current cassette or a manual QC lockout condition exists.

2. *Select Analysis button on right side of screen.*

**Ensure the blood sample is thoroughly mixed then, at the prompt, lift the sample inlet handle.**

3. Slide the handle up to the first position. This raises the probe for aspiration.
4. Guide the inlet probe into the sample.
5. Ensure the tip of the inlet probe is fully immersed in the sample.

*NOTE: Do not press the tip of the inlet probe against the syringe plunger. This can produce an airtight seal and prevent sample aspiration.*

7. Press *Aspirate*.

8. The analyzer will beep twice when aspiration is complete. The screen will provide instructions on removing the sample and lowering the handle.

9. Enter/ scan patient's CSN when prompted.

10. When finished, press *OK*.

11. A progress bar will be displayed until the analysis is complete.

12. Final results will be displayed on the screen and be available for printouts.

13. Hit close button to access main screen.

## Results Reporting

1. Examine the PATIENT RESULT screen for results that are flagged.
2. The following table explains the flags that may appear next to a parameter result:

Marking	Definition
↓ or ↑	The final result is outside the reference range but not beyond the critical limits. On the screen this result is also highlighted in yellow.
↓↓ or ↑↑	The final result is beyond the critical limits. On the screen this result is also highlighted in red.
↓↓↓ or ↑↑↑	The final result is outside the test range of the analyzer. On the screen this result is also highlighted in red.
R/R or *	The final result is outside the user-defined reportable range. The final result can either be replaced by the acronym R/R or flagged with an asterisk.
***	The final result is outside the measuring range of the analyzer.
###	The final result is beyond the electrical range of the analyzer.
!!	Possible air was identified in either the sample or the flush during analysis.
?	One or more errors have been identified related to oximetry results. All related results are flagged with a question mark. <b>Do Not Report These Results.</b>
ℓ	The last manual QC sample run on this parameter was outside the acceptable range. Rerun QC with a fresh sample.

3. The PATIENT RESULT MESSAGE screen also provides an explanation of flags or errors associated with a patient result. Press NOTES to enter a note associated with a particular patient result.
4. Refer to Operator's Manual, Chapter 10, Troubleshooting, for a detailed description and possible corrective actions related to messages.
5. Patient results are recorded in the patient chart.
6. Report all critical results to provider and document the following in EPIC:
  - a. Who was notified.
  - b. Time of notification.
  - c. Was the result read back.

## Troubleshooting:

Please consult Appendix A for troubleshooting the ABL 80 Flex. Call the Radiometer hotline for other troubleshooting at 1-800-736-0600.

## Consumables:

The ABL80 FLEX consists of the analyzer, a sensor cassette, and a solution pack. Each component is described below:

### A. Solution pack:

1. Quality management of the system is accomplished using a solution pack that contains multiple levels of precision tonometered electrolyte solutions packaged in gas tight disposable pouches. The solution pack provides the necessary fluids for the calibration and quality control of pH,  $p\text{CO}_2$ ,  $p\text{O}_2$ ,  $c\text{Na}^+$ ,  $c\text{K}^+$ ,  $c\text{Ca}^{2+}$ ,  $c\text{Cl}^-$ , (cGlu and ctHb for Co-Ox only).
2. Each solution pack contains a smart chip that provides information to the system regarding the status of the solution pack. The analyzer automatically reads this information when the solution pack is installed onto the analyzer and writes additional information to the smart chip during use. This information includes the following:
  - Serial number of the pack
  - Lot number for each of four solution pouches
  - Install by date (the last day this solution pack can be installed onto an analyzer)
  - Installation date (the date this solution pack was installed onto an analyzer)
  - Analyzer serial number (the analyzer onto which this pack was installed)
  - Number of allowable days in use
  - True values for each parameter
  - Quality control assigned values and acceptable ranges for each parameter
  - Number of cycles for each pouch
  - Version
3. The solution pack contains five pouches:
  - Four pouches contain NIST traceable solutions with various concentrations of tonometered gases, electrolytes, and metabolites, as well as dyes required for oximetry measurements.
  - The fifth pouch collects all liquid waste, both from the internal solutions and all external solutions including the biohazardous bodily fluids from patient samples. The waste pouch contains an additive, which combines with the liquid waste to form a gel. This gel limits spillage and provides an added level of safety. **All used reagent packs should be placed in biohazard bags.**

### B. Sensor cassette:

1. The sensor cassette is designed for use with whole blood or quality control solutions. The sensor cassette contains a low volume, flow-through cell. All the measuring sensors are contained in a multi-use disposable cassette assembly. The cassette flow

cell also contains a reference electrode for the potentiometric sensors and an integral temperature sensor and heating element for precise temperature control.

2. Each sensor cassette contains a smart chip that provides information to the system regarding the type and status of each sensor cassette. The analyzer automatically reads this information when the cassette is installed onto the analyzer. While in-use the analyzer also records additional information on the smart chip. Information recorded in the smart chip includes:
  - Lot number
  - Serial number
  - Parameter panel
  - Number of tests allowed
  - Number of tests remaining
  - Install by date (the last day this sensor cassette can be installed onto an analyzer)
  - Installation date (the date this cassette was first installed onto an analyzer)
  - Analyzer serial number (the analyzer onto which this cassette is currently installed)
  - Expiration date (date this sensor cassette will expire once installed).

#### Installation of consumables:

##### 1. Sensor Cassette (Process takes 15 minutes)”:

The ABL80 FLEX provides step-by-step screen instructions for installing or replacing the sensor cassette. The allowable tests remaining for each cassette is automatically monitored and the user notified when replacement is necessary.

a. Select *Menu* > *Utilities* > *Install* > *SC80*.

b. If a sensor cassette is not currently installed on the analyzer, proceed to step d. If a sensor cassette is currently installed on the analyzer, the system will first remove all fluid from the current cassette. On the screen the status message will state: *Please wait, removing excess fluid from sensor cassette...* The screen will then prompt the user to remove the old sensor cassette.

c. To remove a sensor cassette, perform the following steps:

- Press up on the cassette latch at the bottom of the cassette, grasp the cassette body, and pull the cassette straight off the analyzer

**Clean the sensor cassette nest and waste port with a clean, lint-free cloth moistened with water.**

d. To install a new sensor cassette perform the following steps:

- Tear open the foil pouch containing the new cassette and remove the cassette.
- Lift the cassette from the shipping tray.
- Align the cassette to the front of the analyzer and push the cassette straight onto the analyzer.

- Press on the raised circle at the center of the cassette body until a snap is heard. This signifies a complete connection has been made.

e. Press *OK* on the screen to proceed to the sensor initialization phase.

a. When the installation is complete, the system will display a message on the screen. Return to the main menu.

## 2. Solution Pack (Process takes 5 minutes)

The ABL80 FLEX provides step-by-step instructions for installing or replacing the solution pack. The fluid levels in each pouch are automatically monitored and the user notified when replacement is necessary.

*CAUTION: The solution pack contains four solution pouches and a waste pouch. With use, the waste pouch will contain blood and other biohazardous fluids. Avoid contact with the waste inlet port and clean any spillage. Handling and disposal of a used solution pack should comply with all required biohazardous regulations per your institutional guidelines.*

a. Select *Menu* ➤ *Utilities* ➤ *Install* ➤ *Solution Pack*

- If a solution pack is not currently installed on the analyzer, proceed to Step d

b. Follow the instructions on the screen to remove the old solution pack.

- Press down on the solution pack door latch

- Lower the door completely. This will release the solution pack.

- Remove the old solution pack and discard per your institution's biohazardous guidelines

c. Press *Continue*.

d. Remove the foil tape from the new solution pack.

e. Slide the new solution pack fully into the solution pack cavity.

f. Raise the door and press near the top of the latch until a snap is heard. This signifies the door is completely latched closed.

g. Press *OK* on the screen to complete the installation.

**NOTE: The analyzer will automatically initiate a solution pack verification check following solution pack replacement when there is a sensor cassette installed. This check verifies the integrity of the new solution pack.**


















## Reagents:

1. Sensor cassette: Stable at temperature range of 12-28°C (54-82°F) until expiration date. Once installed on machine, the pack expires in 30 days.
2. Solution pack: Stable at temperature range of 12-28°C (54-82°F) until expiration date. Once installed on machine, the pack expires in 30 days.
3. Liquid Controls: Stable at 2°C- 25°C until the expiration date on the vials. Avoid storing controls in direct sunlight. Use immediately after opening the ampoule.

## References

1. ABL 80 Flex Operator Manual.
2. ABL 80 Flex Reference Manual.
3. Kotaska K, et al. Re-evaluatio of cord blood arterial and venous reference ranges for pH, pO<sub>2</sub>, pCO<sub>2</sub> according to spontaneous or cesarean delivery. J Clin Lab Anal. 2010;24:300-304.
4. Thorp JA, et al. Umbilical cord blood gas analysis. Obstet Gynecol Clin. 1999;26:695-710.
5. Tietz, Norbert, Ph. D.: Fundamentals of Clinical Chemistry, 2001.

## APPENDIX A

ABL80 FLEX Troubleshooting Guidance				
Parameter	Failure Mode (Same readings on consecutive System Cycles)	Step 1	 Evaluate Step 1	Step 2
pH	Any type (Sensitivity or QC out-of-range)	Replace SC80 	If Step 1 did not resolve issue, move to Step 2	Replace SP 
pCO <sub>2</sub>	Sensitivity low	Allow sensor to re-hydrate (if time allows)		Replace SC80 
	Sensitivity high	Replace SC80 		Replace SP 
	QC out-of-range	Replace SC80 		Replace SP 
pO <sub>2</sub>	Sensitivity out-of-range	Replace SC80 		
	QC out-of-range	Replace SP 		Replace SC80 
Electrolytes K <sup>+</sup> , Na <sup>+</sup> , Ca <sup>++</sup> , Cl <sup>-</sup>	Any type (Sensitivity or QC out-of-range)	Replace SC80 		Replace SP 
Glu	1. Sensitivity low 2. QC out-of-range at installation	Allow sensor to re-hydrate (if time allows)		Replace SC80 
	Sensitivity high	Replace SC80 		Replace SP 
	QC out-of-range during use	Replace SC80 		Replace SP 