



**510(k) SUBSTANTIAL EQUIVALENCE DETERMINATION
DECISION SUMMARY
ASSAY ONLY**

I Background Information:

A 510(k) Number

K241037

B Applicant

Radiometer Medicals ApS

C Proprietary and Established Names

Abl90 FLEX PLUS System

D Regulatory Information

Product Code(s)	Classification	Regulation Section	Panel
CEM	Class II	21 CFR 862.1600 - Potassium Test System	CH - Clinical Chemistry
JGS	Class II	21 CFR 862.1665 - Sodium test system	CH - Clinical Chemistry
JFP	Class II	21 CFR 862.1145 - Calcium test system	CH - Clinical Chemistry
CGA	Class II	21 CFR 862.1345 - Glucose test system	CH - Clinical Chemistry
KHP	Class I, meets the limitations of exemptions per 862.9(c)(9)	21 CFR 862.1450 - Lactic acid test system	CH - Clinical Chemistry

II Submission/Device Overview:

A Purpose for Submission:

Modification to a previously cleared device.

B Measurand:

Potassium (cK⁺), Sodium (cNa⁺), Calcium (cCa²⁺), Glucose (cGlu), Lactate (cLac)

C Type of Test:

Potentiometry: Potassium, Sodium, Calcium

Amperometry: Glucose and Lactate

III Intended Use/Indications for Use:**A Intended Use(s):**

See Indications for Use below.

B Indication(s) for Use:

The ABL90 FLEX PLUS System is an in vitro diagnostic, portable, automated analyzer that quantitatively measures electrolytes (cK⁺, cNa⁺, cCa²⁺), glucose, and lactate in heparinized arterial and venous whole blood.

The ABL90 FLEX PLUS System is intended for use by trained technologists, nurses, physicians and therapists. It is intended for use in a laboratory environment, near patient, or point-of-care setting.

These tests are only performed under a physician's order.

Potassium (cK⁺): Potassium measurements are used to monitor electrolyte balance in the diagnosis and treatment of disease conditions characterized by low or high blood potassium levels.

Sodium (cNa⁺): Sodium measurements are used in the diagnosis and treatment of aldosteronism, diabetes insipidus, adrenal hypertension, Addison's disease, dehydration, inappropriate antidiuretic secretion, or other diseases involving electrolyte imbalance.

Calcium (cCa²⁺): Calcium measurements are used in the diagnosis and treatment of parathyroid disease, a variety of bone diseases, chronic renal disease and tetany.

Glucose (cGlu): Glucose measurements are used in the diagnosis and treatment of carbohydrate metabolism disorders including diabetes mellitus and idiopathic hypoglycemia, and of pancreatic islet cell carcinoma.

Lactate (cLac): The lactate measurements measure the concentration of lactate. Lactate measurements are used to evaluate the acid-base status and are used in the diagnosis and treatment of lactic acidosis (abnormally high acidity of the blood).

C Special Conditions for Use Statement(s):

Rx - For Prescription Use Only

D Special Instrument Requirements:

ABL90 FLEX PLUS System

IV Device/System Characteristics:

A Device Description:

The ABL90 FLEX PLUS System consists of the ABL90 FLEX PLUS analyzer, sensor cassette (SC) and solution pack (SP) consumables, and related accessories for the analyzer. The ABL90 FLEX PLUS is a portable, automated system intended for in vitro testing of samples of balanced heparinized whole blood for the parameters cK⁺, cNa⁺, cCa²⁺, glucose and lactate.

The ABL90 FLEX PLUS Analyzer is a portable analyzer that contains the inlet module, the sample mixer, the fluid transport system, a barcode reader, a printer, and all the electronics and software to control the analyzer and for data management. The ABL90 FLEX PLUS Analyzer has an automated sample inlet mechanism, which can collect the blood through two different measuring modes: the S65 syringe mode and the SP65 short probe mode.

The ABL90 FLEX Sensor Cassette (SC) includes sensors for potentiometric measurements of cK⁺, cNa⁺, and cCa²⁺ and the amperometric measurements of cGlu and cLac. The SC comes in different versions. The versions are the same with respect to physical and chemical characteristics and differ only in a memory chip that encodes the maximum number of tests and availability of sensors for use in each SC.

The ABL90 FLEX PLUS Solution Pack (SP) provides solutions and gas mixtures for calibration, rinse and quality control of the measuring system, and sealed pouches for collection of waste from the analyzer. The SP comes in two versions that differ in the amount of liquid chemicals to support the maximum number of activities, where an “activity” can be a patient sample, QC measurement, a calibration, or a rinse, all of which use liquids from the SP.

This submission addresses modifications in the cGlu, cLac, cK⁺, cNa⁺, and cCa²⁺ electrode manufacturing process that were made to the device cleared in K160153.

The ABL90 FLEX PLUS Analyzer for the quantitative measurement of pH, blood gas (pO₂), Oximetry (sO₂, ctHb, FO₂Hb, FCOHb, FMetHb, and FHHb) was cleared in K240998.

B Principle of Operation:

There are two different measuring principles employed by the ABL90 FLEX PLUS system to measure cGlu, cLac, cK⁺, cNa⁺, and cCa²⁺:

Potentiometry: The potential of an electrode chain is measured by a voltmeter and related to the concentration of the sample (the Nernst equation). The potentiometric measuring principle is applied in cK⁺, cNa⁺, cCa²⁺ sensors.

Amperometry: The magnitude of an electrical current that flows through an electrode chain is proportional to the concentration of the substance that is oxidized or reduced at an electrode in the chain. The amperometric measuring principle is applied in the cGlu and cLac sensors.

V Substantial Equivalence Information:

A Predicate Device Name(s):

ABL90 Flex

B Predicate 510(k) Number(s):

K092686

C Comparison with Predicate(s):

Device & Predicate Device(s):	<u>K241037</u>	<u>K092686</u>
Device Trade Name	ABL90 FLEX PLUS System	ABL90 FLEX
General Device Characteristic Similarities		
Intended Use/Indications For Use	An in vitro diagnostic, portable, automated analyzer that quantitatively measures electrolytes (cK ⁺ , cNa ⁺ , cCa ²⁺), glucose and lactate.	Same
Intended Use environment	Laboratory environment, near patient or point-of-care setting	Same
Reportable Range	cK ⁺ : 2.1 – 10.5 mmol/L	Same
	cNa ⁺ : 116 – 180 mmol/L	Same
	cCa ²⁺ : 2.00 – 9.94 mg/dL	Same
	cLac: 4 – 216 mg/dL	Same
General Device Characteristic Differences		
Reportable Range	cGlu: 18 – 738 mg/dL	cGlu: 9 – 738 mg/dL

VI Standards/Guidance Documents Referenced:

Clinical and Laboratory Standards Institute (CLSI) EP05-A3 – Evaluation of Precision of Quantitative Measurement Procedures

CLSI EP09c 3rd Edition – Measurement Procedure Comparison and Bias Estimation Using Patient Samples

CLSI EP17-A2 2nd Edition – Evaluation of Detection Capability for Clinical Laboratory Measurement Procedures; Approved Guideline

CLSI EP06-2nd Edition – Evaluation of Linearity of Quantitative Measurement Procedures.

CLSI EP07-3rd Edition – Interference Testing in Clinical Chemistry

CLSI EP37 1st Edition – Supplemental Tables for Interference Testing in Clinical Chemistry

CLSI EP39 1st Edition – A Hierarchical Approach to Selecting Surrogate Samples for the Evaluation of In Vitro Medical Laboratory Tests

VII Performance Characteristics (if/when applicable):

A Analytical Performance:

i. Precision/Reproducibility:

Two point-of-care precision (POC) studies were conducted at three sites using at least three POC operators. The first was a multi-day precision study performed using four concentrations of aqueous control solutions and 3 reagent lots. At each site, each level was tested as two replicates per run, two runs per day, for twenty days. The second was a multi-day precision study conducted with balanced heparinized whole blood at levels within the reportable range of each analyte using both the S65 and SP65 sampling modes. The results supported that modifications made to the ABL90 FLEX PLUS did not impact the precision of cGlu, cLac, cK⁺, cNa⁺, and cCa²⁺.

ii. Linearity:

Linearity testing was conducted in general accordance with CLSI EP06-A2. The results supported that modifications made to the ABL90 FLEX PLUS did not impact the linearity of cGlu, cLac, cK⁺, cNa⁺, and cCa²⁺.

iii. Analytical Specificity/Interference:

Interference testing was conducted in two parts: paired-difference testing and dose-response experiments.

- a. The paired-difference testing was conducted on all potential interferents. Matched samples were tested, one with no interferent and the other with the interferent. If no interference was found, no further testing was performed.
- b. The dose-response experiment was only conducted on interferents found to have an effect via the paired-difference testing. This was carried out to determine the concentration at which clinically significant interference occurred.

Freshly drawn heparinized human plasma samples or whole blood samples were used as starting material for all interference studies. Interference testing was conducted at two levels (i.e., low and high) for Ca²⁺, K⁺, Na⁺, Glu and Lac. The results supported that modifications made to the ABL90 FLEX PLUS did not significantly impact the substances that interfere with cGlu, cLac, cK⁺, cNa⁺, and cCa²⁺. The following information is provided in the labeling.

Highest concentration tested at which no significant interference is observed.

Potential interferent for parameter cK ⁺	Concentration
Ascorbate (-sodium)	392 mg/dL
Bilirubin, conjugated	40 mg/dL
Bilirubin, unconjugated	40 mg/dL
Biotin	0.351 mg/dL
Calcium (-chloride)	22.0 mg/dL
Hemolysis	0.25%
Intralipid	2000 mg/dL
Leflunomide	30 mg/dL
Lithium (-nitrate)	3.2 mmol/L
Nortriptyline (hydrochloride)	0.113 mg/dL
Propofol	4.8 mg/dL
Sodium (-chloride)	190.0 mmol/L
Zinc (-chloride)	2.3 mg/dL
Potential interferent for parameter cNa ⁺	Concentration
Ascorbate (-sodium)	392 mg/dL
Bilirubin, conjugated	40 mg/dL
Bilirubin, unconjugated	40 mg/dL
Biotin	0.351 mg/dL
Calcium (-chloride)	22 mg/dL
Hemolysis	2.5%
Leflunomide	30 mg/dL
Lithium (-nitrate)	3.2 mmol/L
Magnesium (-nitrate)	15.0 mmol/L
Nortriptyline (hydrochloride)	0.113 mg/dL
Potassium (-chloride)	17 mmol/L
Propofol	4.8 mg/dL
Thiopental	1.66 mmol/L
Zinc (-chloride)	2.3 mg/dL
Potential interferent for parameter cCa ²⁺	Concentration
Sodium Ascorbate	392 mg/dL
Bilirubin, conjugated	40 mg/dL
Bilirubin, unconjugated	40 mg/dL
Biotin	0.351 mg/dL
Intralipid	2000 mg/dL
Lithium (-nitrate)	22 mg/dL
Nortriptyline (hydrochloride)	0.113 mg/dL
Perchlorate (-potassium)	1.50 mmol/L
Potassium (-chloride)	17 mmol/L
Propofol	4.8 mg/dL
Potential interferent for parameter cGlu	Concentration
Acetaminophen	30 mg/dL
Acetoacetate (lithium-)	22 mg/dL
Acetylsalicylic acid	65 mg/dL

Ascorbate (-sodium)	392 mg/dL
Bilirubin, conjugated	40 mg/dL
Bilirubin, unconjugated	40 mg/dL
Biotin	0.351 mg/dL
Chlorpromazine (HCl)	7.1 mg/dL
Citrate (-trisodium)	1176 mg/dL
Creatinine	34 mg/dL
Dopamine hydrochloride	19 mg/dL
EDTA (edetate disodium 2H ₂ O)	112 mg/dL
Ethanol	599 mg/dL
Formaldehyde	30 mg/dL
Formic acid	115 mg/dL
Glucosamine (HCl)	43 mg/dL
Hemolysis	20%
Heparin (-sodium)	8000 iU/dL
Ibuprofen (-sodium)	50 mg/dL
Intralipid	2000 mg/dL
Lactate (-sodium)	280 mg/dL
Maltose (monohydrate)	180 mg/dL
Mannose	18 mg/dL
Methanol	240 mg/dL
N-acetylcysteine	166 mg/dL
Oxalate (-sodium)	134 mg/dL
Pralidoxime chloride	0.78 mg/dL
Propofol	4.8 mg/dL
Pyruvate (sodium-)	22 mg/dL
Salicylic acid	59 mg/dL
Urea	505 mg/dL
Uric acid	25 mg/dL
Xylose (D-xylose)	15 mg/dL
Potential interferent for parameter cLac	Concentration
2-deoxy glucose	164 mg/dL
Acetaminophen	30 mg/dL
Acetoacetate (-lithium)	22 mg/dL
Acetylsalicylic acid	65 mg/dL
Ascorbate (-sodium)	392 mg/dL
Bilirubin, conjugated	40 mg/dL
Bilirubin, unconjugated	40 mg/dL
Biotin	0.351 mg/dL
Calcium (-chloride)	0.4 mg/dL
Chlorpromazine HCl	7.1 mg/dL
Creatinine	34 mg/dL
D-Glucose	1000 mg/dL
Dopamine hydrochloride	19 mg/dL
Ethanol	599 mg/dL
Formaldehyde	30 mg/dL
Galactose	59 mg/dL

Glucosamine HCl	43 mg/dL
Hemolysis	20%
Heparin (-sodium)	8000 iU/dL
Ibuprofen (-sodium)	50 mg/dL
Intralipid	2000 mg/dL
Lactate (-sodium)	280 mg/dL
Maltose (-monohydrate)	180 mg/dL
Mannose	18 mg/dL
Methanol	240 mg/dL
Oxalate (-sodium)	134 mg/dL
Potassium (-chloride)	1.5 mmol/L
Pralidoxime (-chloride)	0.78 mg/dL
Propofol	4.8 mg/dL
Pyruvate (-sodium)	22 mg/dL
Salicylic acid	59 mg/dL
Sodium (-chloride)	190 mmol/L
Urea	505 mg/dL
Uric acid	25 mg/dL
Xylose (D-xylose)	5 mg/dL

For those substances that on initial screening were found to interfere, dose response testing was conducted to establish the concentration limit below which no significant interference is expected. The results are summarized in the table below:

Interferent	Maximum test concentration	Highest concentration level without interference	Impact on result
cCa²⁺ (test level: 4.6 mg/dL)			
Benzalkonium chloride	2.4 mg/dL	0.6 mg/dL	1.94 mg/dL
Hemolysis	20%	5%	-1.43 mg/dL
Leflunomide	30 mg/dL	15 mg/dL	-0.73 mg/dL
Magnesium (-nitrate)	385 mg/dL	96 mg/dL	1.13 mg/dL
pH @ low level	6.8	Interference for pH ≤ 7.2	1.58 mg/dL
pH @ high level	8.0	Interference for pH ≥ 7.6	-1.20 mg/dL
Teriflunomide	30 mg/dL	No interference	N/A
Zn ⁺ (-chloride)	2.3 mg/dL	1.7 mg/dL	0.58 mg/dL
cCa²⁺ (test level: 6.0 mg/dL)			
Benzalkonium chloride	2.4 mg/dL	0.45 mg/dL	2.54 mg/dL
Hemolysis	20%	5%	-1.69 mg/dL
Leflunomide	30 mg/dL	22.5 mg/dL	-0.85 mg/dL

Interferent	Maximum test concentration	Highest concentration level without interference	Impact on result
Magnesium (-nitrate) (test matrix: Plasma)	385 mg/dL	72 mg/dL	1.53 mg/dL
pH @ low level	6.8	Interference for $\text{pH} \leq 7.2$	2.35 mg/dL
pH @ high level	8.0	Interference for $\text{pH} \geq 7.7$	-0.84 mg/dL
Teriflunomide	30 mg/dL	22.5 mg/dL	-0.79 mg/dL
Zn ⁺ (-chloride)	2.3 mg/dL	No interference	N/A
cK⁺ (test level: 3.5 mmol/L)			
Benzalkonium chloride	2.4 mg/dL	0.6 mg/dL	1.11 mmol/L
Hemolysis	20%	0.25%	13.1 mmol/L
Teriflunomide	30 mg/dL	15 mg/dL	-0.53 mmol/L
cK⁺ (test level: 5.0 mmol/L)			
Benzalkonium chloride	2.4 mg/dL	0.6 mg/dL	1.27 mmol/L
Hemolysis	20%	0.40%	14.3 mmol/L
Teriflunomide	30 mg/dL	15 mg/dL	-0.88 mmol/L
cNa⁺ (test level: 135 mmol/L)			
Benzalkonium chloride	2.4 mg/dL	0.11 mg/dL	28.0 mmol/L
Hemolysis	20%	2.5%	-15.3 mmol/L
Intralipid	2000 mg/dL	1000 mg/dL	5.0 mmol/L
Teriflunomide	30 mg/dL	22.5 mg/dL	-4.3 mmol/L
Thiopental	40 mg/dL	No interference	NA
cNa⁺ (test level: 145 mmol/L)			
Benzalkonium chloride	2.4 mg/dL	0.11 mg/dL	29.6 mmol/L
Hemolysis	20%	2.5%	-14.8 mmol/L
Intralipid	2000 mg/dL	1000 mg/dL	4.8 mmol/L
Teriflunomide	30 mg/dL	22.5 mg/dL	-4.8 mmol/L
Thiopental	40 mg/dL	30 mg/dL	-3.0 mmol/L
cGlu (test level: 39.6 mg/dL)			
2-deoxy glucose	164 mg/dL	3.3 mg/dL	158 mg/dL
Bromide (-sodium)	391 mg/dL	49 mg/dL	-5.81 mg/dL
Fluoride (-sodium)	210 mg/dL	105 mg/dL	-5.6 mg/dL
Galactose	59 mg/dL	44 mg/dL	3.5 mg/dL
Povidone-iodine	1000 mg/dL	500 mg/dL	6.9 mg/dL

Interferent	Maximum test concentration	Highest concentration level without interference	Impact on result
Thiocyanate (-sodium)	195 mg/dL	1.2 mg/dL	94 mg/dL
cGlu (test level: 220 mg/dL)			
2-deoxy glucose	164 mg/dL	25 mg/dL	165 mg/dL
Thiocyanate (-sodium)	195 mg/dL	10 mg/dL	99 mg/dL
cLac (test level: 9.0 mg/dL)			
Bromide (sodium-)	391 mg/dL	49 mg/dL	-3.4 mg/dL
Citrate (trisodium citrate 2H ₂ O)	1176 mg/dL	No interference	-0.37 mg/dL
EDTA (edetate disodium 2H ₂ O)	112 mg/dL	84 mg/dL	-1.67 mg/dL
Fluoride (-sodium)	210 mg/dL	No interference	-0.52 mg/dL
Formic acid	115 mg/dL	29 mg/dL	-1.36 mg/dL
Glycolic acid	7.6 mg/dL	0.2 mg/dL	10 mg/dL
N-acetylcysteine	166 mg/dL	125 mg/dL	-1.07 mg/dL
Thiocyanate (-sodium)	195 mg/dL	1.2 mg/dL	16 mg/dL
cLac (test level: 15.3 mg/dL)			
Citrate (trisodium citrate 2H ₂ O)	1176 mg/dL	882 mg/dL	-1.9 mg/dL
EDTA (edetate disodium 2H ₂ O)	112 mg/dL	56 mg/dL	-1.9 mg/dL
Fluoride (sodium-)	210 mg/dL	52.5 mg/dL	-1.5 mg/dL
Formic acid	115 mg/dL	86 mg/dL	-1.7 mg/dL
Glycolic acid	7.6 mg/dL	0.2 mg/dL	27 mg/dL
N-acetylcysteine	166 mg/dL	83 mg/dL	-1.40 mg/dL
Thiocyanate (-sodium)	195 mg/dL	2.4 mg/dL	21 mg/dL

The sponsor included the following limitations in their labeling:

- Do not use samples collected in fluorinated sampling tubes as exposure to high concentrations of fluoride causes falsely low cGlu and cLac results and may cause falsely low cGlu and cLac results in subsequent sample measurements.
- A change in the pH of blood has the physiological effect of changing the concentrations of ionized calcium. An increase in 1 unit of pH results in a decrease of approximately 2 mg/dL in cCa²⁺.
- Healthy patients have a glycolic acid concentration of 0.034 to 0.093 mg/dL. Ethylene glycol poisoning is a rare condition affecting about 20 people per million annually in the USA. Ethylene glycol poisoning may exhibit very high levels of glycolic acid. Levels up to 289 mg/dL have been reported. A glycolic acid level of 289 mg/dL may interfere with

the lactate sensor for up to 5 minutes. If ethylene glycol poisoning is suspected or confirmed, do not use lactate results for that sample or any subsequent samples measured within 5 minutes.

- Normal physiological levels of bromide do not interfere. Exposure to high concentrations of Bromide causes falsely low cLac results and may cause falsely low cLac results on any subsequent samples measured within 5 minutes.

iv. Assay Reportable Range:

The results from the studies support the claimed measuring ranges:

cCa²⁺: 2.00 – 9.94 mg/dL

cK⁺: 2.1 – 10.5 mmol/L

cNa⁺: 116 – 180 mmol/L

cGlu: 18 – 738 mg/dL

cLac: 4 – 216 216 mg/dL

v. Traceability, Stability, Expected Values (Controls, Calibrators, or Methods):

cCa²⁺ is traceable to SRM915 (NIST) Standard Reference Material.

cNa⁺ is traceable to NIST SRM 84I through a commercially available certified standard.

cK⁺ is traceable to NIST SRM 3141a through a commercially available certified standard.

cGlu is traceable to SRM917 (NIST) Standard Reference Material.

cLac is traceable to a certified reference standard.

vi. Detection Limit:

Detection capability testing was conducted in general accordance with CLSI EP17-A2. The results demonstrate that the detection limits of the ABL90 FLEX PLUS was not significantly impacted by the modifications and support substantial equivalence to the predicate (See Assay Reportable Range above).

vii. Assay Cut-Off:

Not applicable.

B Comparison Studies:

i. Method Comparison with Predicate Device:

Method comparison studies were conducted in general accordance with CLSI EP09c-ED3. Heparinized arterial and venous whole blood specimens from a total of 353 subjects were collected across 4 POC sites with at least two POC operators per site were compared to whole blood specimens tested on a comparative method. Each sample were measured once on the ABL90 FLEX PLUS in both the S65 and SP65 modes and once on the predicate device in the same mode. Less than 10% contrived samples were used for each analyte. Evaluations were performed per each combination of parameter, blood type, and sampling

mode by Deming regression analysis. The regression analysis for these samples are summarized below:

Method Comparison Results for S65 mode

Parameter	n	Blood Type	Slope	Intercept	R2
cK+ (mmol/L)	222	Arterial	0.996	0.018	0.999
	233	Venous	0.996	0.014	0.999
cNa+ (mmol/L)	225	Arterial	1.002	0.039	0.999
	234	Venous	1.004	-0.276	0.999
cCa2+ (mg/dL)	222	Arterial	1.003	-0.014	0.999
	231	Venous	1.004	0.019	0.999
cGlu (mg/dL)	224	Arterial	0.988	0.425	0.999
	232	Venous	0.989	0.184	0.999
cLac (mg/dL)	221	Arterial	1.007	-0.182	0.995
	233	Venous	1.008	-0.333	0.994

Method Comparison Results for SP65 mode

Parameter	n	Blood Type	Slope	Intercept	R2
cK+ (mmol/L)	218	Arterial	0.993	0.033	0.997
	225	Venous	0.992	0.033	0.997
cNa+ (mmol/L)	224	Arterial	1.003	-0.227	0.999
	224	Venous	1.004	-0.276	0.999
cCa2+ (mg/dL)	214	Arterial	1.011	-0.046	0.999
	220	Venous	1.001	-0.049	0.999
cGlu (mg/dL)	215	Arterial	0.990	-0.024	0.999
	219	Venous	0.990	-0.045	0.999
cLac (mg/dL)	216	Arterial	0.999	-0.093	0.995
	223	Venous	1.000	-0.202	0.995

ii. Matrix Comparison:

Not Applicable.

C Clinical Studies:

i. Clinical Sensitivity:

Not applicable.

ii. Clinical Specificity:

Not applicable.

iii. Other Clinical Supportive Data (When 1. and 2. Are Not Applicable):

Not applicable.

D Clinical Cut-Off:

Not applicable.

E Expected Values/Reference Range:

The sponsor included reference range information in the labeling.

VIII Proposed Labeling:

The labeling support the finding of substantial equivalence for this device.

IX Conclusion:

The submitted information in this premarket notification is complete and supports a substantial equivalence decision.