510(k) SUBSTANTIAL EQUIVALENCE DETERMINATION
DECISION SUMMARY
ASSAY AND INSTRUMENT COMBINATION TEMPLATE

A. 510(k) Number:
k092686

B. Purpose for Submission:
New Device

C. Measurand:
pH, pCO2, pO2, Potassium, Sodium, Calcium, Chloride, Glucose, Lactate, Hemoglobin, sO2, FO2Hb, FCOHb, FMetHb, FHHb and FHbF

D. Type of Test:
Quantitative - Sensors using Potentiometry, Amperometry, Optical pO2 and Spectrophotometry

E. Applicant:
Radiometer Medical Aps

F. Proprietary and Established Names:
ABL90 FLEX

G. Regulatory Information:

1. Regulation section:
   21CFR 862.1600: Potassium test system.
   21CFR 862.1345: Glucose test system.
   21CFR 862.1170: Chloride test system.
   21CFR 864.7425: Carboxyhemoglobin assay.
   21CFR 864.5620: Automated hemoglobin system.
   21CFR 862.1145: Calcium test system.
   21CFR 862.1665: Sodium test system.
   21CFR 862.1150: Calibrator.
   21CFR 864.7455: Fetal hemoglobin assay.
   21CFR 862.1660: Quality control material (assayed and unassayed).
   21CFR 862.1450: Lactic acid test system.

2. Classification:
   II, II, II, II, II, II, II, II, II, I (reserved), I (limitation to exemption per 21 CFR 862.9 (c)(9)), respectively

3. Product code:

   CEM - ELECTRODE, ION SPECIFIC, POTASSIUM
   CGA - GLUCOSE OXIDASE, GLUCOSE

CGZ - ELECTRODE, ION-SPECIFIC, CHLORIDE
GHS - ASSAY, CARBOXYHEMOGLOBIN
GKR - SYSTEM, HEMOGLOBIN, AUTOMATED
JFP - ELECTRODE, ION SPECIFIC, CALCIUM
JGS - ELECTRODE, ION SPECIFIC, SODIUM
JIX - CALIBRATOR, MULTI-ANALYTE MIXTURE
KQI - ASSAY, FETAL HEMOGLOBIN
JJY - MULTI-ANALYTE CONTROLS, ALL KINDS (ASSAYED AND UNASSAYED)
KHP - ACID, LACTIC, ENZYMATIC METHOD

4. Panel:
Clinical Chemistry (75) and Hematology (81)

H. Intended Use:

1. Intended use(s):
See Indication(s) for use below

2. Indication(s) for use:

The ABL90 FLEX is a portable, automated analyzer that measures pH, blood gases, electrolytes, glucose, lactate and oximetry in heparinized whole blood. The ABL90 FLEX 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:

pH, pO2 and pCO2 : pH, pCO2 and pO2 measurements are used in the diagnosis and treatment of life-threatening acid-base disturbances.

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.

Chloride (cCl-): chloride measurements are used in the diagnosis and treatment of electrolyte and metabolic disorders such a cystic fibrosis and diabetic acidosis.

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 in plasma. 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.)

Total Hemoglobin (ctHb): total hemoglobin measurements are used to measure the hemoglobin content of whole blood for the detection of anemia.

sO2: oxygen saturation, more specifically the ratio between the concentration of oxyhemoglobin and oxyhemoglobin plus reduced hemoglobin.

FO2Hb: oxyhemoglobin as a fraction of total hemoglobin.

FCOHb: carboxyhemoglobin measurements are used to determine the carboxyhemoglobin content of human blood as an aid in the diagnosis of carbon monoxide poisoning.

FMetHb: methemoglobin as a fraction of total hemoglobin.

FHHb: reduced hemoglobin as a fraction of total hemoglobin.

Fraction of Fetal Hemoglobin (FHbF): FHbF indicates the amount of fetal hemoglobin. FHbF is seldom used clinically.

3. Special conditions for use statement(s):
   Prescription use

4. Special instrument requirements:
   ABL90 FLEX analyzer

I. Device Description:

The ABL90 FLEX system consists of a modular analyzer incorporating a user interface module with a large color touch screen interfacing the analyzer electronic and fluidic modules. The user interface module contains the analyzer CPU and all of the required electronic interfaces for external communication and data storage.

Sensors that measure pH, pO2, pCO2, potassium, sodium, calcium, chloride, glucose and lactate are contained in a sensor cassette that connects to the sample inlet. This cassette attaches to the front of the instrument. An oximetry module measures ctHb, sO2, FO2Hb, FCOHb, FMetHb and FHHb. This module consists of a spectrometer, an ultrasonic hemolyzer and thermostatic components integrated into the instrument.

The system also includes a solution pack for the calibration and automatic quality control of the sensor and oximetry system. The solution pack includes calibration and quality control reagents individually packaged in sealed foil pouches.

J. Substantial Equivalence Information:

1. Predicate device name(s):

   Radiometer's ABL80 FLEX CO-OX (k080370), ABL800/700 (k002290, k041874, k050869), NPT7 (k982928)

2. Predicate 510(k) number(s):
   See predicate device names above

3. Comparison with predicate:

Similarities		
Item	**Device** **ABL90 FLEX**	**Predicate Device** **ABL80 FLEX CO-OX (k080370)**
Intended use/Indications for use	A portable, automated analyzer that measures multiple analytes in heparinized whole blood. It 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.	Same
Blood Gas Measurement	pH and pCO2 by potentiometry	Same
Electrolyte Measurement	cK+, cNa+, cCa2+, cCl- by potentiometry	Same
Metabolite Measurement	cGlu by amperometry	Same
Oximetry Measurement	Contains spectrophotometer for oximetry	Same
Sensor Technology	Potentiometric and amperometric sensors on a single substrate micro-electrode array	Same
Sample introduction	Aspiration	Same
In-use-life of consumables	Up to a maximum of 30 days	Same
Calibration Method	Two-Point liquid calibration	Same
Calibration and QC reagents	Calibration and QC reagents plus a waste reservoir are contained in one solution pack	Same

Calibration and QC reagents	"Smartchip "technology for unique identification and lot specific calibration and quality control data	Same
User interface	Menu driven touch screen	Same
Other analyzer hardware	Hard drive and printer	Same
Software operating system	Microsoft XPe	Same
Item	**ABL90 FLEX**	ABL800/700 (k002290, k041874, k050869)
Blood Gas Measurement	pH and pCO2 by potentiometry	Same
Electrolyte Measurement	cK+ ,cNa+ ,cCa2+ ,cCl- by potentiometry	Same
Metabolite Measurement	cGlu, cLac by amperometry	Same
Oximetry Measurement	ctHb ,sO2, FO2Hb, FHHb, FCOHb, FMetHb, FHbF,	Same
Hemoglobin measurement	Spectrophotometry	Same
Calibration Method	Two-Point liquid calibration	Same
User interface	Menu driven touch screen	Same
Other analyzer hardware	Hard drive and printer	Same
Software operating system, data management	Microsoft XPe	Same
Item	**ABL90 FLEX**	**ABL800 (k050869)**
Sample preparation	Built-in sample mixer	Same
Item	**ABL90 FLEX**	**NPT7 (K982928)**
Blood Gas Measurement	pO2 optical	Same
ctHb, sO2, FO2Hb	Spectrophotometry	Same
Calibration	Atmospheric air	Same

Differences

Item	**ABL90 FLEX**	**ABL80 FLEX CO-OX (k080370)**
Sample volume	65 micro liters	100 micro liters
Solution Pack	Contains a pouch with low pressure gas for quality control of oxygen sensor	No gas pouch
Storage conditions of Sensor Cassette	2°C-8°C w/ up to two weeks at 32°C	5°C-25°C w/ up to two weeks at 32°C
Storage conditions for the Solution Pack	2°C-25°C w/ up to two weeks at 32°C	12-25°C with up to two weeks, at 32°C

Analyzer operating temperature	15-32°C	12-28°C
Software, wet section control	Independently designed	Independently designed
Item	**ABL90 FLEX**	**ABL800/700 (k002290, k041874, k050869)**
Oximetry system	Contains oximetry system based on a 256-wavelength spectrophotometer with a measuring range of 467-672 nm	Oximetry module is based on a 128-wavelength spectrophotometer with a measuring range of 478-672nm
Sensors	The amperometric sensors for glucose and lactate and the potentiometric sensors for pH, cNa+, cK+, cCa2+, cCl-, pCO2 in a disposable sensor cassette	Traditional, discrete amperometric and potentiometric sensors installed in the analyzer
Calibration and QC solutions	Calibration and QC solutions, plus a waste reservoir are contained in one solution pack	Discrete bottles and ampoules
Sample volume	65 micro liters	195 microliters
Software, wet section control	Independently designed	Independently designed
Item	**ABL90 FLEX**	**NPT7 (k982928)**
Sensor technology	pH, pCO2 by potentiometry	pH, pCO2 by optical sensors
Sensor cassette	Multiple measurements up to 900 specimens	30 test cartridges, each for one specimen only
Calibrants	Liquid calibrants and atmospheric air	Atmospheric air as sole calibrant/calibration verification compound
Analyzer hardware and software	Independently designed	Independently designed

K. Standard/Guidance Document Referenced (if applicable):

CLSI - Evaluation of Precision Performance of Clinical Chemistry Devices - EP05-A2

CLSI - Evaluation of the Linearity of Quantitative Analytical Methods - EP06-A

CLSI - Interference Testing in Clinical Chemistry - EP07-A2

CLSI - Method Comparison and Bias Estimation Using Patient Samples - EP09-A2

CLSI - Protocols for Determination of Limits of Detection and Limits of Quantitation - EP17-A

L. Test Principle:

There are four different measuring principles employed in the sensors in the ABL90 FLEX analyzer.

- Potentiometry: The potential of a sensor chain is recorded using a voltmeter, and related to the concentration of the sample (the Nernst equation). The potentiometric measuring principle is applied in the pH, pCO2, K+, Na+, Ca2+ and Cl- sensors.

- Amperometry: The magnitude of an electrical current flowing through a sensor chain is proportional to the concentration of the substance being oxidized or reduced at an electrode in the chain. The Amperometric measuring principle is applied in the cGlu and cLac sensors.

- Optical pO2: The optical system for pO2 is based on the ability of O2 to reduce the intensity and time constant of the phosphorescence from a phosphorescent dye that is in contact with the sample. This measuring principle is applied in the pO2 sensor.

- Spectrophotometry: Light passes through a cuvette containing a hemolyzed blood sample. The specific wavelengths absorbed and their intensity generates an absorption spectrum used to calculate oximetry parameters. This measuring principle is used for measuring ctHb, sO2, FO2Hb, FCOHb, FHHb, FMetHb, and FHbF

M. Performance Characteristics (if/when applicable):

1. Analytical performance:
   a. Precision/Reproducibility:

Study design
A Point-of-care (POC) precision study was performed using NCCLS "Evaluation of Precision Performance of Quantitative Measurement Methods; Approved Guideline - Second Edition", NCCLS EP5-A2, 2004 as guidance.

The study was performed at 3 POC sites. Each site used one ABL90FLEX for precision evaluation of syringe mode, one ABL90FLEX for precision evaluation of capillary mode and one ABL735 for reference purposes.

The test material was prepared samples of heparinized whole blood. Samples for all parameters were prepared to simulate high, medium and low physiological levels. In each study multiple POC staff members performed sample handling and sample transfer.

Each study ran over 20 test days. On each test day, each parameter and level were tested in duplicate per run, two runs per day. The testing was performed in both syringe and capillary mode.

Results

In the tables below Sr is estimate of repeatability and ST is estimate of precision as defined in NCCLS EP5-A2. Low fractions of low hemoglobin are not calculated for % CV.

ABL90 FLEX Precision - Syringe Study - Pooled Data from 3 Sites

Low level	pH	pCO2	pO2	Ca	Cl	K*
Unit		mmHg	mmHg	mEq/L	mEq/L	mEq/L
Mean	7.272	28	44.5	1.15	94	-
Sr	0.0019	0.55	0.21	0.006	0.21	-
ST	0.0037	0.67	0.68	0.035	1.08	-
%CV	-	2.4	1.5	3.1	1.2	-
N	240	240	240	240	240	-
Low level	Na	Glu	Lac*	tHb	sO2	COHb
Unit	mEq/L	mg/dL	mg/dL	g/dL	%	%
Mean	119	13.2	-	3.8	75.1	-
Sr	0.3	0.52	-	0.06	0.24	-
ST	0.6	1.16	-	0.09	0.38	-
%CV	0.5	8.8	-	2.2	0.5	-
N	240	240	-	240	240	-
Low level	MetHb	HHb	O2Hb	HbF		
Unit	%	%	%	%		
Mean	-	-	72.4	-		
Sr	-	-	0.23	-		
ST	-	-	0.46	-		
%CV	-	-	0.6	-		
N	-	-	240	-		
Medium level	pH	pCO2	pO2	Ca	Cl	K
Unit		mmHg	mmHg	mEq/L	mEq/L	mEq/L
Mean	7.37	41.6	76.1	2.42	108	4.75
Sr	0.0012	0.64	0.7	0.013	0.35	0.034
ST	0.0034	0.86	1.12	0.042	1.42	0.065
%CV	-	2.1	1.5	1.7	1.3	1.4
N	240	240	240	240	240	240
Medium level	Na	Glu	Lac	tHb	sO2	COHb
Unit	mEq/L	mg/dL	mg/dL	g/dL	%	%
Mean	141	98.3	19.1	15	93.1	3.2
Sr	0.4	0.72	0.51	0.09	0.14	0.05
ST	0.7	3.18	1.2	0.13	0.034	0.21
%CV	0.5	3.2	6.3	0.9	0.4	6.6
N	240	240	240	240	240	240
Medium level	MetHb	HHb	O2Hb	HbF		
Unit	%	%	%	%		
Mean	3.4	6.7	90.5	40.7		
Sr	0.07	0.14	0.27	1.93		
ST	0.17	0.31	0.35	4.98		

%CV	5	4.6	0.4	12.2		
N	240	240	236	236		
High level	pH	pCO2	pO2	Ca	Cl	K
Unit		mmHg	mmHg	mEq/L	mEq/L	mEq/L
Mean	7.472	60.3	204.3	3.78	122	6.63
Sr	0.0011	0.96	1.43	0.017	0.2	0.022
ST	0.0047	1.43	2.66	0.066	1.03	0.059
%CV	-	2.4	1.3	1.8	0.8	0.9
N	240	240	240	240	240	240
High level	Na	Glu	Lac	tHb	sO2	COHb
Unit	mEq/L	mg/dL	mg/dL	g/dL	%	%
Mean	151	264.3	144.3	21.7	99.7	38
Sr	0.3	2.56	3.6	0.11	0.09	0.06
ST	0.7	8.77	13.13	0.15	0.17	0.24
%CV	0.5	3.3	9.1	0.7	0.2	0.6
N	240	240	240	240	240	240
High level	MetHb	HHb	O2Hb	HbF		
Unit	%	%	%	%		
Mean	10.1	24.3	97.2	63.8		
Sr	0.06	0.21	0.15	3.8		
ST	0.23	0.32	0.23	68.4		
%CV	2.3	1.3	0.2	10.7		
N	240	240	240	240		*

ABL90 FLEX Precision - Capillary Study - Pooled Data from 3 Sites

Low level	pH	pCO2	pO2	Ca	Cl	K*
Unit		mmHg	mmHg	mEq/L	mEq/L	mEq/L
Mean	7.271	27.9	44.8	1.15	94	-
Sr	0.0025	0.59	0.44	0.036	0.32	-
ST	0.0044	0.67	0.91	0.052	1.1	-
%CV	-	2.4	2	4.6	1.2	-
N	240	240	240	240	240	-
Low level	Na	Glu	Lac*	tHb	sO2	COHb
Unit	mEq/L	mg/dL	mg/dL	g/dL	%	%
Mean	120	14	-	3.7	75.9	-
Sr	0.3	0.56	-	0.06	0.25	-
ST	0.7	1.53	-	0.07	0.48	-
%CV	0.6	10.9	-	1.9	0.6	-
N	240	240	-	240	240	-
Low level	MetHb	HHb	O2Hb	HbF		
Unit	%	%	%	%		
Mean	-	-	74.1	-		
Sr	-	-	0.25	-		
ST	-	-	0.52	-		
%CV	-	-	0.7	-		
N	-	-	240	-		
Medium level	pH	pCO2	pO2	Ca	Cl	K
Unit		mmHg	mmHg	mEq/L	mEq/L	mEq/L

Mean	7.375	41.5	76.6	2.42	108	4.75
Sr	0.0022	0.63	0.78	0.017	0.36	0.039
ST	0.0049	0.88	1.45	0.045	1.43	0.091
%CV	-	2.1	1.9	1.9	1.3	1.9
N	240	240	240	240	240	240
Medium level	Na	Glu	Lac	tHb	sO2	COHb
Unit	mEq/L	mg/dL	mg/dL	g/dL	%	%
Mean	141	99	19	15	93.4	3.2
Sr	0.4	1.24	0.6	0.12	0.17	0.03
ST	0.9	3.06	1.16	0.25	0.35	0.22
%CV	0.7	3.1	6.1	1.6	0.4	6.7
N	240	240	240	240	240	240
Medium level	MetHb	HHb	O2Hb	HbF		
Unit	%	%	%	%		
Mean	3.4	6.6	89.1	41.7		
Sr	0.09	0.22	0.23	2.38		
ST	0.25	0.39	0.34	5.52		
%CV	7.4	6	0.4	13.2		
N	240	240	240	240		
High level	pH	pCO2	pO2	Ca	Cl	K
Unit		mmHg	mmHg	mEq/L	mEq/L	mEq/L
Mean	7.473	60.5	205.2	3.79	122	6.64
Sr	0.0027	0.87	1.92	0.058	0.31	0.035
ST	0.0052	1.18	3.65	0.111	1.32	0.07
%CV	-	1.9	1.8	2.9	1.1	1.1
N	240	240	240	240	240	240
High level	Na	Glu	Lac	tHb	sO2	COHb
Unit	mEq/L	mg/dL	mg/dL	g/dL	%	%
Mean	151	272	143	21.6	99.8	37.3
Sr	0.4	3.27	3.1	0.16	0.09	0.03
ST	0.9	10.4	10.6	0.21	0.16	0.24
%CV	0.6	3.8	7.4	1	0.2	0.7
N	240	240	240	240	240	240
High level	MetHb	HHb	O2Hb	HbF		
Unit	%	%	%	%		
Mean	10	23.8	97.1	64		
Sr	0.1	0.22	0.17	2.41		
ST	0.22	0.47	0.23	5.53		
%CV	2.2	2	0.2	8.6		
n	240	240	240	240		

*Values were below the measuring in this study. See the in house study below that was performed for additional precision for potassium and lactate.

An in house study using blood samples covering the measuring range for potassium (13 days 10 instruments) and lactate (22 days 8 instruments) was performed. The results are presented in the table below.

cK+(meql/L)	S0	SX	CV%
2	0.02	0.08	4
4	0.01	0.08	2
6	0.01	0.11	1.8
8	0.01	0.12	1.5
10	0.02	0.12	1.2

cLac(mg/dL)	S0	SX	CVX%
4.54	0.06	0.20	4.00
9.08	0.09	0.70	6.99
13.62	0.10	0.84	5.54
22.70	0.22	2.11	8.44

b. Linearity/assay reportable range:

Linearity Study - Study design

The linearity study was performed according to CSLI "Evaluation of the Linearity of Quantitative Measurement Procedures: A Statistical Approach; Approved Guideline. CSLI document EP6, 2003.

Each parameter was tested with one analyzer, one day, at least 7 levels (except for the parameter calcium where only 6 levels were available) and 2 replicates per level.

The study was an in-house study.
Test material was:

- whole blood for pH, blood gases, pCO2, pO2, Na, K, Cl and co-oximetry parameters
- standards for calcium
- serum pools for glucose and lactate.

Where whole blood was used as test material, the true values of the test material were established from measurements with a secondary instrument (predicate ABL735). Reference verified by making verification against primary reference.

Linearity Study - Results
For each parameter the ABL90FLEX results were analyzed for linearity.

Parameter	Unit	Slope	Intercept	R^2	Reportable range claimed
pH	pH scale	0.988	0.084	0.9999	6.818 - 7.797
*p*CO2	mmHg; Torr	0.997	0.056	0.9993	15.4 - 98.3
	kPa	0.997	0.0075	0.9993	2.05 - 13.1
*p*O2	mmHg; Torr	1.028	-1.837	1.0000	30.1 - 488
	kPa	1.028	-0.24	1.000	4.0 - 65.0
*c*tHb	g/dL	0.999	0.0978	0.9999	0.1 - 24.0
	g/L	0.999	0.978	0.9999	0.8 - 240
	mmol/L	0.999	0.061	0.9999	0.05 - 14.9
sO_2	%	0.998	-0.153	1.0000	3.3 - 100.0
	fraction	0.998	0.0006	1.0000	0.033 - 1.000
FO_2Hb	%	0.996	-0.054	0.9999	3.3 – 98.5
	fraction	0.996	-0.001	0.9999	0.033 – 0.985
*F*COHb	%	1.004	0.1083	1.0000	1.0 - 92.2
	fraction	1.004	0.0011	1.0000	0.010 - 0.922
*F*MetHb	%	1.002	0.0168	1.0000	1.0 - 91.0
	fraction	1.002	0.0002	1.0000	0.010 - 0.910
*F*HHb	%	1.000	0.290	1.0000	2.4 - 98.5
	fraction	1.000	0.0029	1.0000	0.024 - 0.985
*F*HbF	%	0.925	3.96	0.9977	21 - 83
	fraction	0.925	0.040	0.997	0.21 - 0.83
cK^+	mmol/L; meq/L	0.984	0.164	0.9998	2.1 - 10.5
cNa^+	mmol/L; meq/L	1.017	-1.730	0.9998	116 - 180
cCa^{2+}	mmol/L	0.992	0.026	0.9999	0.50 - 2.48
	meq/L	0.992	0.052	0.9999	1.00 - 4.96
	mg/dL	0.992	0.104	0.9999	2.00 - 9.92
cCl^-	mmol/L; meq/L	0.993	1.825	0.9997	86 - 151
*c*Glu	mmol/L	0.977	0.185	0.9998	0.5 - 41

	mg/dL	0.977	3.33	0.9998	9 - 738
*c*Lac	mmol/L; meq/L	1.050	-0.060	0.9997	0.4 - 24
	mg/dL	1.050	-0.541	0.9997	4 - 216

c. Traceability, Stability, Expected values (controls, calibrators, or methods):

Calibrators and controls are for all parameters except pH and ctHb traceable to NIST certified reference materials. pH is traceable to standards certified by the Danish Primary Laboratory for Electrochemistry and ctHb is traceable to a Haemoglobin Cyanide standard from J.T. Baker.

The final stability claim will be based on real-time data for both the Solution Pack and the Sensor Cassette. Real-time testing will be ongoing, until the full test plans covered in the stability protocols are completed. The following stability that will be claimed at the time of release of the ABL 90 for the US market:

- 6-month lifetime for the Solution Pack based on 12 months real-time test on three lots.

- 4-month lifetime for the Sensor Cassette based on 6 months real-time test on three lots.

d. Detection limit:

LoB, LoD and LoQ were established following the guideline CSLI. *Protocols for Determination of Limits of Detection and Limits of Quantitation; Approved Guideline,CSLI* document EP17-A

Parameter	**LoB**	**LoD**	**LoQ**
Ca	0.143 mM 0.572 mg/dL	0.151 mM 0.606 mg/dL	0.417 mM 1.666 mg/dL
Glu	0.33 mM 5.98 mg/dL	0.47 mM 8.52 mg/dL	0.47 mM 8.52 mg/dL
Lac	-0.008 mM -0.07 mg/dL	0.05 mM 0.45 mg/dL	0.27 mM 2.41 mg/dL
tHb	0.042 g/dL	0.062 g/dL	0.084 g/dL
sO2	0.316%	1.038%	3.306%
O2Hb	0.316%	1.038%	3.306%
HHb	0.124%	0.615%	2.42%
COHb	*Not determined*	*Not determined*	1%
MetHb	*Not determined*	*Not determined*	1%
HbF	5.8%	11.4%	21%

e. Analytical specificity:

a. Study design

Radiometer has defined interference limits parameters that are analyte specific to determine whether a suspected interferent is considered an interferent or not. The difference between test results for a sample with and without suspected interferent was compared to the target and the parameters were tested at their normal physiological levels. Radiometer tested levels of interferents that are close to the required levels provided by the standard EP7-A2.

Results

pH/BG

pH has been tested for interference from Intralipid, Fluorescein, K^+, Na^+, Ca^{++}, hemolysis, unconj. Bilirubin and conj. Bilirubin. No interference was seen at the levels tested.

***p*O$_2$** has been tested for interference from Intralipid, Fluorescein, hemolysis, unconj. Bilirubin and conj. Bilirubin. Hemolysis will interfere with the *p*O$_2$ test when present in an amount greater than 13.3% (20% hemolysis corresponds to 2.8 mg/dL hemoglobin). No interference was seen from the other tested compounds at the levels tested.

***p*CO$_2$** has been tested for interference from hemolysis, unconj. Bilirubin and conj. Bilirubin. No interference was seen at the levels tested.

Electrolytes

K+ was tested for interference from Li+, Ca++, NH4 +, Zn+ ,benzalkonium chloride, hemolysis, Intralipid, unconj. Bilirubin and conj. Bilirubin. Benzalkonium chloride will interfere with the K+ test if present in an amount greater than 2.4 mg/mL. Hemolysis will interfere with the K+ test if present in an amount greater than 0.15%. No interference was seen from the other tested compounds at the levels tested.

Na+ was tested for interference from Li+, K+, Ca++, NH4 +, Mg++, Zn+, benzalkonium chloride, hemolysis, Intralipid, unconj. Bilirubin and conj. Bilirubin. Ca++ will interfere with the Na+ test if present in an amount greater than 2.7 mM/5.4 mEq/L. Benzalkonium chloride will interfere with the Na+ test if present in an amount greater than 0.75 mg/mL. Hemolysis will interfere with the Na+ test if present in an amount greater than 0.85%. Intralipid will interfere with the Na+ test if present in an amount greater than 2%. Conj. Bilirubin will interfere with the Na+ test if

present in an amount greater than 17.9 mg/dL No interference was seen from the other tested compounds at the levels tested.

Ca++ was tested for interference from Li+, K+, Na+, Mg++, Zn+, Sr+, pH, perchlorate, benzalkonium chloride, hemolysis, Intralipid, unconj. Bilirubin and conj. Bilirubin. Na+ will interfere with the Ca++ test if present in an amount greater than 168 mM/ mEq/L. Mg++ will interfere with the Ca++ test if present in an amount greater than 14.1mM/ 28.2mEq/L. Zn+ will interfere with the Ca++ test if present in an amount greater than 140 mM. pH will interfere with the Ca++ test if sample pH is changed more than 0.54 pH units. Benzalkonium chloride will interfere with the Ca++ test if present in an amount greater than 1 mg/mL. Hemolysis will interfere with the Ca++ test if present in an amount greater than 0.47%. No interference was seen from the other tested compounds at the levels tested.

Cl- was tested for interference from NH4 +, pH, Br-, I-, F-, ClO4 -, benzalkonium chloride, acetylsalicylic acid, salicylic acid, thiocyanic acid, ascorbic acid, citrate, oxalate, lactate, caprylic acid, acetyltryptophane, hemolysis, Intralipid, unconj. Bilirubin and conj. Bilirubin. NH4 + will interfere with the Cl- test if present in an amount greater than 0.9 mM/ 1.5mg/dL. Br- will interfere with the Cl- test if present in an amount greater than 0.5 mM/ mEq/L. I- will interfere with the Cl- test if present in an amount greater than 0.3 mM/ mEq/L. Perchlorate will interfere with the Cl- test if present in an amount greater than 0.2 mM/ mEq/L. Acetylsalicylic acid will interfere with the Cl- test if present in an amount greater than 1.7 mM/ 0.31g/L. Salicylic acid will interfere with the Cl- test if present in an amount greater than 1.5 mM/ 0.2g/L. Thiocyanic acid will interfere with the Cl- test if present in an amount greater than 0.1 mM/ 6µg/L. Citrate will interfere with the Cl- test if present in an amount greater than 8 mM/ 1.5g/L. Hemolysis will interfere with the Cl- test if present in an amount greater than 1.27%. Intralipid will interfere with the Cl- test if present in an amount greater than 3%. Unconj. Bilirubin will interfere with the Cl- test if present in an amount greater than 29.2 mg/dL. No interference was seen from the other tested compounds at the levels tested.

Metabolites

Glu was tested for interference from Acetominophen (Paracetamol), acetylsalicylic acid, Ibuprofen (sodium), dopamine HCl, chlorpromazine HCl, ethanol, glucosamine HCl, glycolic acid, lactic acid, maltose (monohydrate), mannose, salicylic acid, sodium thiocyanate, xylose, acetoacetate (lithium acetacetoacetate), creatinine, galactose, pyruvate (pyruvic acid sodium salt), urea, uric acid, heparin, EDTA (edetate disodium $2H_2O$), citrate (sodium citrate $2H_2O$), oxalate (sodium oxalate),

fluoride (sodium fluoride), pralidoxime chloride, 2-deoxy glucose, unconjugated bilirubin, conjugated bilirubin, ascorbic acid, Intralipid and hemolysis. Glucosamine HCl will interfere with the Glu test if present in an amount greater than 1.67 mM. Mannose will interfere with the Glu test if present in an amount greater than 0.9 mM. Sodium thiocyanate will interfere with the Glu test if present in an amount greater than 0.065 mM. Galactose will interfere with the Glu test if present in an amount greater than 2.3 mM. Hemolysis will interfere with the Glu test if present in an amount greater than 8.3%. No interference was seen from the other tested compounds at the levels tested

Lac was tested for interference from Acetominophen (Paracetamol), acetylsalicylic acid, Ibuprofen (sodium), dopamine HCl, chlorpromazine HCl, ethanol, glucosamine HCl, glycolic acid, maltose (monohydrate), mannose, salicylic acid, sodium thiocyanate, xylose, acetoacetate (lithium acetacetoacetate), creatinine, galactose, D-glucose, pyruvate (pyruvic acid sodium salt), urea, uric acid, heparin, EDTA (edetate disodium $2H_2O$), citrate (sodium citrate $2H_2O$), oxalate (sodium oxalate), fluoride (sodium fluoride), pralidoxime chloride, unconjugated bilirubin, conjugated bilirubin, ascorbic acid, Intralipid and hemolysis. Glycolic acid will interfere with the Lac test if present in an amount greater than 0.08 mM. Sodium thiocyanate will interfere with the Lac test if present in an amount greater than 0.07 mM. Acetoacetate (Lithium acetacetoacetate) will interfere with the Lac test if present in an amount greater than 1.8 mM. D-Glucose will interfere with the Lac test if present in an amount greater than 32 mM. Fluoride (sodium fluoride) will interfere with the Lac test if present in an amount greater than 38 mM. No interference was seen from the other tested compounds at the levels tested.

Co-oximetry

The co-oximetry parameters were all tested for interference from pH, Fluorescein, beta-carotene, Patent Blue V, Methylene Blue, Cardio Green, Evans Blue, Intralipid, HiCN, SHb, hydroxycobalamin, cyanocobalamin and hemolysis. In addition all parameters except bilirubin were tested for interference from bilirubin (unconj.)and bilirubin (conj.). ctHb Fluorescein will interfere with the ctHb test if present in an amount greater than 95 mg/L. Methylene Blue will interfere with the ctHb test if present in an amount greater than 10 mg/L. HiCN will interfere with the ctHb test if present in an amount greater than 13%. SHb will interfere with ctHb test if present in an amount greater than 5%. Hydroxy-cobalamin will interfere with the ctHb test if present in an amount greater than 0.4 g/L. Cyanocobalamin will interfere with ctHb test if present in an amount greater than 0.4 g/L. No interference was seen from the other tested compounds at the levels tested.

sO2 - pH will interfere with the sO2 test if sample pH is changed more than 0.5 pH units. Fluorescein will interfere with the sO2 test if present in an amount greater than 78 mg/L. Methylene Blue will interfere with the sO2 test if present in an amount greater than 14 mg/L. SHb will interfere with the sO2 test if present in an amount greater than 29%. Cyanocobalamin will interfere with the sO2 test if present in an amount greater than 0.5 g/L. No interference was seen from the other tested compounds at the levels tested.

FO2Hb - pH will interfere with the FO2Hb test if sample pH is changed more than 0.2 pH units. Fluorescein will interfere with the FO2Hb test if present in an amount greater than 26 mg/L. Patent Blue V will interfere with the FO2Hb test if present in an amount greater than 7 mg/L. Methylene Blue will interfere with the FO2Hb test if present in an amount greater than 2 mg/L. Cardio Green will interfere with the FO2Hb test if present in an amount greater than 18mg/L. Intralipid will interfere with the FO2Hb test if present in an amount greater than 3.5%. SHb will interfere with the FO2Hb test if present in an amount greater than 8%. Hydroxycobalamin will interfere with the FO2Hb test if present in an amount greater than 0.1g/L. Cyanocobalamin will interfere with FO2Hb test if present in an amount greater than 0.1g/L. No interference was seen from the other tested compounds at the levels tested.

FCOHb - Fluorescein will interfere with the FCOHb test if present in an amount greater than 61 mg/L. Methylene Blue will interfere with the FCOHb test if present in an amount greater than 50 mg/L. Hydroxycobalamin will interfere with the FCOHb test if present in an amount greater than 0.8 g/L. Cyanocobalamin will interfere with FCOHb test if present in an amount greater than 0.7g/L. No interference was seen from the other tested compounds at the levels tested.

FMetHb - pH will interfere with the FMetHb test if sample pH is changed more than 0.4 pH units. Fluorescein will interfere with the FMetHb test if present in an amount greater than 23 mg/L. Methylene Blue will interfere with the FMetHb test if present in an amount greater than 2.5 mg/L. Cardio Green will interfere with the FMetHb test if present in an amount greater than 25 mg/L. SHb will interfere with the FMetHb test if present in an amount greater than 7%. Hydroxycobalamin will interfere with the FMetHb test if present in an amount greater than 0.1g/L. Cyanocobalamin will interfere with FMetHb test if present in an amount greater than 0.2g/L. No interference was seen from the other tested compounds at the levels tested.

FHHb - pH will interfere with the FHHb test if sample pH is changed more than 0.5 pH units. Fluorescein will interfere with the FHHb test if present in an amount greater than 86 mg/L. Methylene Blue will interfere

with the FHHb test if present in an amount greater than 11 mg/L. SHb will interfere with the FHHb test if present in an amount greater than 31%. Cyanocobalamin will interfere with the FHHb test if present in an amount greater than 0.6 g/L. No interference was seen from the other tested compounds at the levels tested.

FHbF - pH will interfere with the FHbF test if sample pH is changed more than 0.6 pH units. Fluorescein, Patent Blue V, Methylene Blue, Cardio Green, HiCN, SHb, hydroxycobalamin and cyanocobalamin will all interfere to such an extent that the ABL90FLEX software will determine that the spectra are abnormal. Hence no values are displayed by the ABL90FLEX. No interference was seen from the other tested compounds at the levels tested.

f. Assay cut-off:
Not Applicable

2. Comparison studies:
   a. Method comparison with predicate device:

Method comparison studies were performed at four user sites. The purpose was to evaluate whether the ABL90 FLEX is equivalent to a current test method for each of the parameters measured by the ABL90FLEX analyzer (pH, pCO2, pO2, Ca, Cl, K, Na, Glu, Lac, tHb, sO2, FO2Hb, FHHb, FCOHb, FMetHb, FHbF). The studies were conducted in a point-of-care setting and were using methods described in CLSI. "Method Comparison and Bias Estimation Using Patient Samples; Approved Guideline – Second Edition", CLSI EP9-A2.

The material used was random patient samples and spiked blood samples. Spiked samples were needed in order to support the full reportable range.

In each study sample handling and sample transfer were performed by multiple POC staff members.

The studies were performed in both syringe mode and capillary mode of the ABL90FLEX.

Pooled data for Site 1, 2 and 3: ABL90FLEX in Syringe mode vs. Predicate device

Parameter	Units	Range Low	Range High	Total n	Slope	Intercept	R^2	$S_{y.x}$
pH	N/A	6.840	7.774	652	1.02	-0.18	0.9915	0.011
pCO_2	kPa mmHg	2.1 15.5	13.1 98.3	636 636	0.99 0.99	0.04 0.27	0.9927 0.9927	0.15 1.09

Parameter	Units	Range Low	Range High	Total n	Slope	Intercept	R^2	$S_{y.x}$
pO_2	kPa mmHg	4.0 30.1	65.0 487.5	588 588	1.04 1.04	-0.39 -2.94	0.9979 0.9979	0.43 3.25
cCa^{2+}	mEq/L mM	1.00 0.50	4.96 2.48	649 649	1.10 1.10	-0.15 -0.07	0.9937 0.9937	0.04 0.02
cCl^-	mEq/L mM	86 86	149 149	618 618	0.99 0.99	0.71 0.71	0.9816 0.9816	1.11 1.11
cK^+	mEq/L mM	2.2 2.2	10.5 10.5	654 654	1.00 1.00	0.17 0.17	0.9949 0.9949	0.08 0.08
cNa^+	mEq/L mM	116 116	180 180	657 657	1.05 1.05	-5.91 -5.91	0.9906 0.9906	0.85 0.85
*c*Glu	mg/dL mM	11 0.6	702 39.0	655 655	0.96 0.96	-1.16 -0.06	0.9943 0.9943	6.48 0.36
*c*Lac	mg/dL mM	4 0.4	216 24.0	670 670	0.87 0.87	1.56 0.17	0.9748 0.9748	4.66 0.52
*ct*Hb	g/dL	1.0	23.8	654	0.95	0.34	0.9914	0.31
sO_2	%	6.1	100.0	626	1.00	-0.45	0.9981	0.75
*F*HHb	%	2.4	98.5	468	1.00	0.23	0.9980	0.84
FO_2Hb	%	5.5	98.5	629	1.00	-0.23	0.9983	0.75
*F*COHb	%	1.0	89.3	596	1.00	0.20	0.9989	0.31
*F*MetHb	%	1.0	83.3	202	1.00	-0.01	0.9993	0.35
*F*HbF	%	21	78	30	1.10	-5.28	0.8747	6.70

Pooled data for Site 1, 4 and 3: ABL90FLEX in Capillary mode vs. Predicate device

Parameter	Units	Range Low	Range High	Total n	Slope	Intercept	R^2	$S_{y.x}$
pH	N/A	6.824	7.797	465	0.99	0.09	0.9898	0.012
pCO_2	kPa mmHg	2.1 15.5	12.9 96.8	465 465	0.95 0.95	0.14 1.04	0.9895 0.9895	0.20 1.51
pO_2	kPa mmHg	4.1 30.5	62.2 466.5	441 441	0.99 0.99	0.17 1.26	0.9969 0.9969	0.50 3.75
cCa^{2+}	mEq/L mM	1.02 0.51	4.74 2.37	438 438	0.96 0.96	0.09 0.04	0.9795 0.9795	0.05 0.03
cCl^-	mEq/L mM	86 86	150 150	446 446	1.00 1.00	-0.12 -0.12	0.9663 0.9663	1.71 1.71
cK^+	mEq/L mM	2.1 2.1	10.5 10.5	458 458	1.01 1.01	-0.06 -0.06	0.9952 0.9952	0.09 0.09
cNa^+	mEq/L mM	117 117	176 176	462 462	1.07 1.07	-8.49 -8.49	0.9870 0.9870	0.93 0.93
*c*Glu	mg/dL mM	9 0.5	738 41.0	466 466	1.00 1.00	-1.43 -0.08	0.9962 0.9962	6.02 0.33

Parameter	Units	Range Low	Range High	Total n	Slope	Intercept	R^2	$S_{y.x}$
*c*Lac	mg/dL mM	4 0.4	198 22.0	447 447	1.05 1.05	-1.71 -0.19	0.9805 0.9805	4.28 0.48
*ct*Hb	g/dL	0.6	24.0	468	0.99	0.20	0.9947	0.27
sO_2	%	11.8	100.0	450	1.00	-0.55	0.9973	0.78
*F*HHb	%	2.4	98.5	331	1.00	0.43	0.9978	0.87
FO_2Hb	%	3.7	98.5	446	1.00	0.30	0.9984	0.81
*F*COHb	%	1.0	92.2	198	1.01	-0.48	0.9994	0.43
*F*MetHb	%	1.0	91.0	246	1.00	0.29	0.9984	0.63
*F*HbF	%	21	83	25	0.95	5.62	0.8298	8.17

b. Matrix comparison:
Only matrix recommended for ABL90FLEX is heparinized whole blood.

3. Clinical studies:
   a. Clinical Sensitivity:
   Not Applicable

   b. Clinical specificity:
   Not Applicable

   c. Other clinical supportive data (when a. and b. are not applicable):
   Not Applicable
4. Clinical cut-off:
   Not Applicable

5. Expected values/Reference range:

Parameter	Population	Reference range	Cited from
pH,	Children, adults	7.35-7.45	Tietz 2008[1]
pCO_2	Female	4.3-6.0 kPa	Tietz 2008
	Male	4.7-6.4 kPa	Tietz 2008
pO_2	2days- 60years	11.0-14.4 kPa	Tietz 2008
cK^+	Male, female	3.4-4.5 meq/L	Tietz 1987[2]
cNa^+	Male, female	136-146 meq/L	Tietz 1987
cCa^{2+}	Adult	2.30-2.66 meq/L	Tietz 2008
cCl^-	Adult	98-107 meq/L	Tietz 2008
*c*Glucose	Adult	65-95 mg/dL	Tietz 2008
*c*Lactate	Female, male	4.5-14.4 mg/L	Tietz 1987
	At bed rest	3.0-7.0 mg/L	Tietz 2008
*ct*Hb	Female	12.0-16.0 g/dL	Tietz 1987
	Male	13.5-17.5 g/dL	Tietz 1987

[1] Tietz: Fundamentals of Clinical Chemistry, 3th edition 1987
[2] Tietz: Fundamentals of Clinical Chemistry, 6th edition 2008

Parameter	Population	Reference range	Cited from
sO_2	Male, female	95-99 %	Siggaard-Andersen et al[3].
	Infants, children, adults	94-98 %	Tietz 2008
	Newborn	40-90 %	Tietz 2008
*F*O2Hb	Male, female	94-98 %	Tietz 1987
*F*COHb	Male, female	0.5-1.5 %	Tietz 1987
*F*HHb	N/A	N/A	N/A
*F*MetHb	Male, female	0.0-1.5 %	Tietz 2008
*F*HbF	Neonates	≈ 80 %	Tietz 2008

N. Instrument Name:

Radiometer ABL90 FLEX

O. System Descriptions:

1. Modes of Operation:

   Single sample mode

2. Software:

   FDA has reviewed applicant's Hazard Analysis and software development processes for this line of product types:

   Yes ___X____ or No _____

3. Specimen Identification:

   Single Sample

4. Specimen Sampling and Handling:

   This device is intended to be used with whole blood samples.

5. Calibration:

   Two-Point liquid calibration. Calibration and QC reagents plus a waste reservoir are contained in one solution pack. "Smartchip "technology for unique

[3] Siggaard-Andersen O, Wimberley PD, Fogh-Andersen N, Gøthgen IH. Arterial oxygen status determined with routine pH/blood gas equipment and multi-wavelength hemoximetry: reference values, precision and accuracy. Scand J Clin Lab Invest 1990; 50, Suppl 203: 57-66.

identification and lot specific calibration and quality control data

6. Quality Control:

   QC reagents plus a waste reservoir are contained in one solution pack. "Smartchip "technology for unique identification and lot specific calibration and quality control data

P. Other Supportive Instrument Performance Characteristics Data Not Covered In The "Performance Characteristics" Section above:
None

Q. Proposed Labeling:
The labeling is sufficient and it satisfies the requirements of 21 CFR Part 809.10.

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