510(k) SUBSTANTIAL EQUIVALENCE DETERMINATION
DECISION SUMMARY
ASSAY ONLY

I Background Information:

A 510(k) Number
K230285

B Applicant
Abbott Point of Care Inc.

C Proprietary and Established Names
i-STAT CG8+ cartridge with the i-STAT 1 System

D Regulatory Information

Product Code(s)	Classification	Regulation Section	Panel
CHL	Class II	21 CFR 862.1120 - Blood Gases (PCO2, PO2) And Blood pH Test System	CH - Clinical Chemistry

II Submission/Device Overview:

A Purpose for Submission:
Modification to a previously cleared device.

B Measurand:
pO2, pCO2, and pH

C Type of Test:
Quantitative, amperometric for pH and pCO2
Quantitative, potentiometric for pO2

III Intended Use/Indications for Use:

A Intended Use(s):
See Indications for Use below.

B Indication(s) for Use:
The i-STAT CG8+ cartridge with the i-STAT 1 System is intended for use in the in vitro quantification of pH, partial pressure of oxygen (PO2), and partial pressure of carbon dioxide (PCO2), in arterial, venous, or capillary whole blood in point of care or clinical laboratory settings.

pH, PO2, and PCO2 measurements are used in the diagnosis, monitoring, and treatment of respiratory, metabolic and acid-base disturbances.

C Special Conditions for Use Statement(s):
Rx - For Prescription Use Only
For Point-of-Care or clinical laboratory setting

D Special Instrument Requirements:
i-STAT 1 Analyzer

IV Device/System Characteristics:

A Device Description:
The i-STAT CG8+ cartridge is used with the i-STAT 1 analyzer as part of the i-STAT 1 System.

The single-use, disposable i-STAT CG8+ cartridge contain the required sensors, a fluid pack (calibrant pouch), a sample entry well and closure, fluid channels, waste chamber, and the necessary mechanical features for controlled fluid movement within cartridge. The i-STAT cartridge format allows all the tests in the cartridge to be performed simultaneously. All the test steps and fluid movement occur within the i-STAT CG8+ cartridge. Cartridges require two to three drops of whole blood (95µL) to be run on the analyzer.

The candidate device is for the use of pH, pO2, and pCO2 detection on the i-STAT CG8+ cartridge with the i-STAT 1 System. Additional analytes on the i-STAT CG8+ cartridge with the i-STAT 1 System were cleared in K223710 (glucose), K230300 (ionized calcium and hematocrit), and K230275 (sodium and potassium).

B Principle of Operation:
pH is measured by direct potentiometry. In the calculation of results for pH, concentration is related to potential through the Nernst equation.

pO2 is measured amperometrically. The oxygen sensor is similar to a conventional Clark electrode. Oxygen permeates through a gas permeable membrane from the blood sample into an internal electrolyte solution where it is reduced at the cathode. The oxygen reduction current is proportional to the dissolved oxygen concentration.

pCO2 is measured by direct potentiometry. In the calculation of results for pCO2, concentration is related to potential through the Nernst equation.

V Substantial Equivalence Information:

A Predicate Device Name(s):
RAPIDPoint 500e Blood Gas System

B Predicate 510(k) Number(s):
K192240

C Comparison with Predicate(s):

Device & Predicate Device(s):	K230285	K192240
Device Trade Name	i-STAT CG8+ Cartridge with the i-STAT 1 System	RAPIDPoint 500e Blood Gas System
General Device Characteristic Similarities		
Intended Use/Indications For Use	Intended to measure pH, partial pressure of oxygen (pO2), and partial pressure of carbon dioxide (pCO2).	Same
Reportable Range	6.500 – 7.800 pH units	Same
Sample Type	Arterial, venous or capillary whole blood	Same
General Device Characteristic Differences		
Reportable Range	pO2: 5 – 700 mmHg pCO2: 5 – 130 mmHg	pO2: 10 – 700 mmHg pCO2: 5 – 200 mmHg
Sample Volume	95 µL	100 µL

VI Standards/Guidance Documents Referenced:

CLSI EP05-A3: Evaluation of Precision of Quantitative Measurement Procedures; Approved Guideline-Third Edition

CLSI EP06: Evaluation of Linearity of Quantitative Measurement Procedures; 2nd Edition.

CLSI EP07: Interference Testing in Clinical Chemistry; 3rd ed.

CLSI EP09c: Measurement Procedure Comparison and Bias Estimation using Patient Samples, 3rd ed.

CLSI EP 17-A2: Evaluation of Detection Capability for Clinical Laboratory Measurement Procedures; Approved Guideline

CLSI EP37: Supplement Tables for Interference Testing in Clinical Chemistry; 1st ed.

CLSI EP35: Assessment of Equivalence or Suitability of Specimen Types for Medical Laboratory Measurement Procedures; 1st ed.

VII Performance Characteristics (if/when applicable):

A Analytical Performance:

1. Precision/Reproducibility:

Internal within-site precision (aqueous control material):
A single site precision study for the candidate test was conducted following the recommendations in CLSI EP05-A3. Up to five concentration levels of commercially available calibration verification samples were tested using one lot of i-STAT CG8+ (white) cartridges and ten i-STAT 1 Analyzers. Each sample was measured in duplicates per run, with two runs per day for 20-days by two operators resulting in a total of 80 test results per level. The results are summarized below.

Test (units)	Fluid Level	Mean	Repeatability		Between-run		Between-day		Within-Laboratory	
			SD	%CV	SD	%CV	SD	%CV	SD	%CV
pH (pH units)	L1	6.5831	0.00284	0.04	0.00354	0.05	0.00162	0.02	0.00482	0.07
	L2	7.0326	0.00165	0.02	0.00121	0.02	0.00102	0.01	0.00229	0.03
	L3	7.4574	0.00118	0.02	0.00170	0.02	0.00065	0.01	0.00217	0.03
	L4	7.6365	0.00133	0.02	0.00201	0.03	0.00072	0.01	0.00251	0.03
pO2 (mmHg)	L1	75.7	1.93	2.54	1.45	1.92	0.77	1.02	2.53	3.35
	L2	87.3	1.81	2.07	0.46	0.53	0.55	0.63	1.94	2.23
	L3	115.0	2.40	2.08	1.76	1.53	0.47	0.41	3.01	2.62
	L4	144.1	2.74	1.90	2.62	1.82	1.02	0.70	3.92	2.72
	L5	371.6	6.25	1.68	8.29	2.23	2.97	0.80	10.80	2.91
pCO2 (mmHg)	L1	88.55	0.781	0.88	0.973	1.10	0.392	0.44	1.307	1.48
	L2	54.96	0.598	1.09	0.139	0.25	0.055	0.10	0.616	1.12
	L3	28.90	0.300	1.04	0.082	0.28	0.082	0.28	0.321	1.11
	L4	22.59	0.268	1.19	0.112	0.50	0.066	0.29	0.298	1.32
	L5	13.81	0.335	2.42	0.157	1.13	0.181	1.31	0.412	2.98

Point of Care precision (aqueous control material):
A multi-day precision study was performed at three sites using aqueous solutions of pH, pO2, and pCO2. At each site, each level was tested once a day by two operators for five days on six i-STAT 1 analyzers using i-STAT CG8+ cartridges, resulting in a total of at least 90 test results per level. When a cartridge generated a star-out (non-reported result) for one assay, an additional cartridge was run to replace the star-out result, which produced additional test results. Within-day, between-day and total variance components were calculated by site. These components were also calculated for all sites combined and provided in the tables below:

Test (units)	Fluid Level	N	Mean	Between-Day		Between-Operator		Between-Site		Overall	
				SD	%CV	SD	%CV	SD	%CV	SD	%CV
pH (pH units)	L1	90	6.5829	0.00267	0.04	0.00329	0.05	0.00000	0.00	0.00579	0.09
	L2	90	7.0332	0.00135	0.02	0.00054	0.01	0.00000	0.00	0.00349	0.05
	L3	96	7.4571	0.00080	0.01	0.00085	0.01	0.00000	0.00	0.00258	0.03
	L4	90	7.6372	0.00038	0.01	0.00116	0.02	0.00000	0.00	0.00221	0.03
pO2 (mmHg)	L1	91	81.1	1.00	1.23	1.56	1.92	0.00	0.00	3.30	4.07
	L2	90	91.2	1.31	1.43	0.84	0.92	0.00	0.00	3.69	4.04
	L3	97	118.3	1.06	0.89	0.93	0.78	0.99	0.84	2.94	2.48
	L4	90	147.3	2.17	1.48	2.29	1.56	0.00	0.00	3.96	2.69
	L5	90	367.7	4.25	1.16	9.62	2.62	0.00	0.00	12.24	3.33
pCO2 (mmHg)	L1	90	88.67	0.349	0.39	0.620	0.70	0.000	0.00	1.489	1.68
	L2	90	56.08	0.379	0.68	0.000	0.00	0.000	0.00	0.754	1.35
	L3	96	29.42	0.173	0.59	0.033	0.11	0.000	0.00	0.376	1.28
	L4	90	22.73	0.166	0.73	0.105	0.46	0.000	0.00	0.427	1.88
	L5	90	13.17	0.188	1.43	0.123	0.93	0.181	1.37	0.477	3.63

Test (units)	Fluid Level	N	Mean	Within-Run		Within-Site (Total)	
				SD	%CV	SD	%CV
pH (pH units)	L1	90	6.5829	0.00395	0.06	0.00579	0.09
	L2	90	7.0332	0.00317	0.05	0.00349	0.05
	L3	96	7.4571	0.00231	0.03	0.00258	0.03
	L4	90	7.6372	0.00184	0.02	0.00221	0.03
pO2 (mmHg)	L1	91	81.1	2.73	3.37	3.30	4.07
	L2	90	91.2	3.34	3.67	3.69	4.04
	L3	97	118.3	2.38	2.01	2.76	2.34
	L4	90	147.3	2.39	1.62	3.96	2.69
	L5	90	367.7	6.27	1.71	12.24	3.33
pCO2 (mmHg)	L1	90	88.67	1.308	1.48	1.489	1.68
	L2	90	56.08	0.652	1.16	0.754	1.35
	L3	96	29.42	0.332	1.13	0.376	1.28
	L4	90	22.73	0.379	1.67	0.427	1.88
	L5	90	13.17	0.381	2.89	0.442	3.36

Point of Care Precision (Whole Blood)

A multi-site precision study was conducted using arterial, venous, and capillary whole blood specimens collected with lithium heparin collection devices targeted to levels within the reportable range of the pH, pO2, and pCO2 tests. The whole blood precision was assessed using the duplicate test results collected across multiple point of care sites. For each sample type, samples were grouped into subintervals based on their mean values. The precision results between sites were similar. The combined results of the whole blood precision are shown below:

Test (units)	Sample Type	Sample Range	N	Mean	SD	%CV
pH (pH units)	Venous Whole Blood	6.500-7.300	14	7.0076	0.00378	0.05
		>7.300-7.450	95	7.3790	0.00605	0.08
		>7.450-7.800	9	7.5257	0.00350	0.05
	Arterial Whole Blood	6.500-7.300	7	7.2059	0.00292	0.04
		>7.300-7.450	100	7.3772	0.00574	0.08
		>7.450-7.800	41	7.4704	0.00585	0.08
	Capillary Whole Blood	6.500-7.300	0	N/A	N/A	N/A
		>7.300-7.450	108	7.4075	0.01847	0.25
		>7.450-7.800	45	7.4729	0.02508	0.34
pO2 (mmHg)	Venous Whole Blood	10-40	72	30.5	0.98	3.21
		>40-50	15	44.7	0.68	1.53
		>50-100	20	58.9	1.17	1.99
		>100-250	5	141.1	4.72	3.35
		>250-700	6	550.1	5.35	0.97
	Arterial Whole Blood	10-40	2	37.3	1.12	3.00
		>40-50	3	48.2	1.22	2.54
		>50-100	61	76.7	1.26	1.64
		>100-250	66	161.2	3.87	2.40
		>250-700	15	323.3	7.45	2.30
	Capillary Whole Blood	10-40	5	36.3	1.52	4.18
		>40-50	13	45.5	2.49	5.47
		>50-100	136	70.4	7.50	10.65*
		>100-250	0	N/A	N/A	N/A
		>250-700	0	N/A	N/A	N/A
pCO2 (mmHg)	Venous Whole Blood	5.0-35.0	27	33.30	0.555	1.67
		>35.0-50.0	70	45.32	0.777	1.71
		>50.0-62.5	14	55.79	1.592	2.85
		>62.5-130.0	9	97.07	1.312	1.35
	Arterial Whole Blood	5.0-35.0	51	33.76	0.714	2.12
		>35.0-50.0	85	43.56	0.958	2.20
		>50.0-62.5	10	60.78	0.489	0.81
		>62.5-130.0	2	87.85	0.570	0.65
	Capillary Whole Blood	5.0-35.0	51	31.23	2.048	6.56
		>35.0-50.00	97	40.16	1.749	4.36
		>50.0-62.5	5	54.82	2.835	5.17
		>62.5-130	0	N/A	N/A	N/A

*Precision for capillary whole blood for pO2 sample range 50-70 mmHg is as follows: Mean=61.3 mmHg, SD (95% CI)=4.72 mmHg (4.05, 5.64), %CV (95% CI)=7.69 (6.61, 9.21).

2. Linearity:

The linearity study was designed based on CLSI EP06-Edition 2. The linearity of the i-STAT pH, pO2, and pCO2 tests in the i-STAT CG8+ (white) cartridge with the i-STAT 1 System was evaluated by preparing venous whole blood samples collected in lithium heparin tubes from healthy subjects of varying analyte levels for each i-STAT test. Each sample for pO2, pCO2, and pH testing was prepared via tonometry to eleven target analyte concentrations. Each test sample was tested in replicates of 3 per cartridge lot for a total of 15 results per level. Each level was tested using 5 lots of i-STAT CG8+ cartridges. The linearity study results support that the assays are linear across the following claimed reportable ranges:

i-STAT Test	Reportable Range
pH	6.500 – 7.800 pH Units
pO2	10 – 700 mmHg
pCO2	5.0 – 130.0 mmHg

3. Analytical Specificity/Interference:
The analytical specificity of the pO2, pCO2, and pH tests of the i-STAT CG8+ (white) cartridges using the i-STAT 1 system was established by conducting interference testing following the recommendations in CLSI EP07-Edition 3. Interference from certain exogenous and endogenous substances was assessed using lithium heparin venous whole blood samples tonometered to two concentrations of low and high samples: pO2 (20-40 mmHg and 55-95 mmHg), pCO2 (20-40 mmHg and 60-80 mmHg), and pH (7.2-7.4 and 7.3-7.5). Each low and high sample was further divided into two aliquots: control (with no added interferent) and test (with added interferent). Each sample was measured in replicates of 10 using two lots of the i-STAT CG8+ (white) cartridges. A substance was identified as an interferent if the difference in the mean between the control and test sample was outside of the predefined allowable error:

For pO2: ± greater of 5 mmHg or 10% of the control (mmHg)
For pCO2: ± greater of 5 mmHg or 8% of the control (mmHg)
For pH: ± 0.04 pH units

The following table lists the concentrations of each substance at which no significant interference was found.

i-STAT CG8+ pO2, pCO2 and pH:

Substance	Highest concentration at which no significant interference was observed
Acetaminophen	1.03 mmol/L
Atracurium	0.0287 mmol/L
Calcium	20 mg/dL
Ethanol	130 mmol/L
Ibuprofen	1.06 mmol/L
Morphine	0.0273 mmol/L
Potassium	8 mmol/L
Sodium	170 mmol/L
Bilirubin	40 mg/dL
Hemoglobin	10 g/L
Triglyceride**	1500 mg/dL
Intralipid**	2684 mg/dL
Thiopental	1.66 mmol/L

**Intralipid 20% and Triglyceride were assessed using the same data set.

4. Assay Reportable Range:
See section VII.A.2 Linearity.

5. Traceability, Stability, Expected Values (Controls, Calibrators, or Methods):
Traceability
pH: Traceable to NIST SRM 185, 185, and 187 reference materials via the IFCC blood reference method.

pO2: Traceable to U.S. National Institute of Standards and Technology (NIST) standard reference materials via commercially available certified specialty medical gas standards.

pCO2: Traceable to U.S. National Institute of Standards and Technology (NIST) standard reference materials via commercially available certified specialty medical gas standards.

Sample stability
A study was conducted to verify the whole blood sample stability after sample collection with anticoagulant for i-STAT pO2, pCO2, and pH tests using the i-STAT CG8+ (white) cartridges on the i-STAT 1 Analyzer. The results support the sponsor's sample stability claims. The sample stability claims for pO2, pCO2, and pH are 10 minutes for arterial and venous samples and three minutes for capillary samples with lithium heparin anticoagulant. Venous and arterial samples are stable for up to three minutes without anticoagulant.

The device performed adequately at an altitude of approximately 10,000 feet.

6. Detection Limit:
Linearity studies were used to support the lower end of the measuring range for pH, pO2, and pCO2 (see section VII.A.2. above). In addition, to support the limit of quantitation (LoQ) a study was performed according to CLSI EP17-A2. The LoQ of the i-STAT pH, pO2, and pCO2 tests in the i-STAT CG8+ cartridge was evaluated on the i-STAT 1 analyzer using two i-STAT CG8+ cartridge lots, and whole blood that was altered using tonometry to low pH (≤ 6.5 pH units), pO2 (≤ 10.00 mmHg), pCO2 (≤5.000 mmHg). The LoQ for each test is shown below.

Analyte	Reportable range	LoQ
pH (pH units)	6.5 – 7.8	6.464
pO2 (mmHg)	5 – 700	5
pCO2 (mmHg)	5.0 – 130.0	3.2

7. Assay Cut-Off:
Not applicable.

B Comparison Studies:

Method Comparison with Predicate Device:
Method comparison for arterial, venous, and capillary whole blood specimens on the i-STAT CG8+ cartridge with the i-STAT 1 System was performed based on CLSI EP09c-ED3. Lithium heparin arterial and venous whole blood specimens collected across point of care sites were evaluated using i-STAT CG8+ cartridges on the i-STAT 1 analyzer and compared to whole blood specimens tested on a comparative method. Capillary whole blood specimens collected with balanced heparin capillary tubes from multiple point of care sites were evaluated and analyzed in singlicate on the i-STAT 1 analyzer against the comparative method. For pH, pO2,

and pCO2, a Passing Bablok linear regression analysis was performed using the first replicate result from the i-STAT 1 analyzer versus the singlicate result from the comparative method. Venous, arterial, and capillary whole blood samples were combined. The regression analysis for all sites combined for these samples are summarized below:

Test (units)	N	Slope	Intercept	r	Medical Decision Level	Bias at Medical Decision Level
pH (pH units)	468	1.00	0.00	0.99	7.300	-0.0040
					7.350	-0.0040
					7.400	-0.0040
pO2 (mmHg)	461	1.03	-0.72	0.99	30	0.1
					45	0.5
					60	0.9
pCO2 (mmHg)	465	1.08	-1.13	0.97	35.0	1.79
					45.0	2.63
					50.0	3.04
					70.0	4.71

Summary data for the capillary samples is described in the tables below:
Native and Contrived Capillary Results:

Test (units)	N	Slope	Intercept	r	Sample range
pH (pH units)	195	1.02	-0.11	0.98	6.619-7.772
pO2 (mmHg)	190	1.02	-1.75	0.99	12.8-652.6
pCO2 (mmHg)	189	1.09	-1.90	0.97	9.1-124.9

Bias at the Medical Decision Levels - Native and Contrived Capillary Samples:

Test (units)	N	Range Min	Range Max	Medical Decision Level	Bias	
					Estimate	95% CI
pH (pH units)	195	6.691	7.768	7.300	-0.0033	(-0.0151, 0.0020)
				7.350	-0.0026	(-0.0100, 0.0012)
				7.400	-0.0018	(-0.0061, 0.0012)
pO2 (mmHg)	190	14	662	30	-1.1	(-2.9, 0.1)
				45	-0.8	(-2.1, 0.2)
				60	-0.4	(-1.5, 0.5)
pCO2 (mmHg)	189	5.2	116.1	35.0	1.09	(0.65, 1.66)
				45.0	1.94	(0.98, 2.93)
				50.0	2.37	(1.03, 3.68)

Bias at the Medical Decision Levels - Native Capillary Samples:

Test (units)	N	Range Min	Range Max	Medical Decision Level	Bias	
					Estimate	95% CI
pH (pH units)	179	7.289	7.531	7.300	-0.0160	(-0.0352, 0.0020)
				7.350	-0.0101	(-0.0211, 0.0010)
				7.400	-0.0041	(-0.0083, 0.0008)
pO2 (mmHg)	175	32	108	30	-1.8	(-4.7, 0.9)
				45	-1.3	(-3.0, 0.2)
				60	-0.7	(-1.9, 0.1)
pCO2 (mmHg)	179	26.9	59.3	35.0	1.17	(0.66, 1.75)
				45.0	1.79	(0.68, 3.05)
				50.0	2.11	(0.48, 3.86)

Matrix Comparison:

A matrix comparison study was conducted following the recommendations in CLSI EP35 to evaluate the performance of the i-STAT pH, pCO2, and pO2 tests on the i-STAT 1 System using non-anticoagulated venous and arterial whole blood specimens (i.e. candidate specimen type), and comparing them to samples collected with heparin anticoagulant (primary specimen type). A total of 241 whole blood samples tested include, native venous (n=106) and native arterial (n=135) specimens. Each specimen was tested in duplicate using two i-STAT CG8+ cartridges with two i-STAT 1 analyzers. A Passing-Bablok linear regression analysis was performed using the first replicate result from the candidate (y-axis) versus the mean result from the primary specimen (x-axis). The assay can also be used for testing heparinized capillary whole blood samples. The regression analysis results are summarized below:

Test (units)	N	Candidate Specimen Range	Primary Specimen Range	r	Slope	Intercept
pH (pH units)	241	7.126-7.585	7.130-7.607	0.98	0.97	0.19
pO2 (mmHg)	241	13-606	14-555	0.98	0.94	1.28
pCO2 (mmHg)	241	22.0-87.7	22.4-85.2	0.96	1.02	-0.23

C Clinical Studies:

1. Clinical Sensitivity:
   Not applicable.

2. Clinical Specificity:
   Not applicable.

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

D Clinical Cut-Off:

Not applicable.

E Expected Values/Reference Range:

Expected values on the i-STAT CG8+ cartridge are cited from literature*:

Analyte	Units	Reference Range	
		arterial	venous
pH	pH units	7.35 - 7.45 [1]	7.31 – 7.41*
pO2	mmHg kPa	80 – 105 [2]** 10.7 - 14.0 [2]**	N/A
pCO2	mmHg kPa	35 - 45 [1] 4.67 - 6.00	41 – 51[1] 5.47 - 6.80

***** Calculated from Siggard-Andersen nomogram

****** The reference ranges shown are for a healthy population. Interpretation of blood gas measurements depend on the underlying condition (e.g., patient temperature, ventilation, posture, and circulatory status).

[1] P.C. Painter, J.Y. Cope, J.L. Smith, "Reference Ranges, Table 41–20" in Tietz Textbook of Clinical Chemistry - Second Edition, C.A. Burtis and E.R. Ashwood, eds. (Philadelphia: W.B. Saunders Company, 1994).

[2] B.E. Statland, Clinical Decision Levels for Lab Tests (Oradell, NJ: Medical Economics Books, 1987).

VIII Proposed Labeling:

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

IX Conclusion:

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