

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

A. 510(k) Number:

k063771

B. Purpose for Submission:

New Device

C. Measurand:

Whole blood glucose

D. Type of Test:

Quantitative (Glucose Dehydrogenase- Flavine Adenine Dinucleotide [GDH-FAD])

E. Applicant:

Arkray, Inc.

F. Proprietary and Established Names:

Glucocard X-Meter Blood Glucose Monitoring System

G. Regulation section:

1. Regulation section:

21 CFR 862.1345 Glucose Test System

21 CFR 862.1660 Quality Control Material (assayed and unassayed)

2. Classification:

Class II, Class I (reserved)

3. Product code:

NBW – Blood glucose test system, over the counter

LFR – Glucose dehydrogenase, glucose

JJX – Single (specified) analyte controls (assayed and unassayed)

4. Panel:

75, Clinical Chemistry

H. Intended Use:

1. Intended use(s):

See indications for use below.

2. Indication(s) for use:

GLUCOCARD X-METER Blood Glucose Monitoring System:

The GLUCOCARD X-METER Blood Glucose Monitoring System is intended for the quantitative measurement of glucose in fresh capillary whole blood samples drawn from the fingertips, forearm, upper arm or palm. Testing is done outside the body (*In Vitro* diagnostic use). It is indicated for use at home (over the counter [OTC]) by persons with diabetes, or in clinical settings by healthcare professionals, as an aid to monitor the effectiveness of diabetes control.

GLUCOCARD X-METER:

The GLUCOCARD X-METER is intended for the quantitative measurement of glucose in fresh capillary whole blood samples drawn from the fingertips, forearm, upper arm or palm. GLUCOCARD X-SENSOR Blood Glucose Test Strips must be used with the GLUCOCARD X-METER. Testing is done outside the body (*In Vitro* diagnostic use). It is indicated for use at home (over the counter [OTC]) by persons with diabetes, or in clinical settings by healthcare professionals, as an aid to monitor the effectiveness of diabetes control.

GLUCOCARD X-SENSOR Blood Glucose Test Strips:

GLUCOCARD X-SENSOR Blood Glucose Test Strips are intended for the quantitative measurement of glucose in fresh capillary whole blood samples drawn from the fingertips, forearm, upper arm or palm. GLUCOCARD X-SENSOR Blood Glucose Test Strips must be used with the GLUCOCARD X-METER Blood Glucose Meter. Testing is done outside the body (*In Vitro* diagnostic use). They are indicated for use at home (over the counter [OTC]) by persons with diabetes, or in clinical settings by healthcare professionals, as an aid to monitor the effectiveness of diabetes control.

GLUCOCARD X-METER CONTROL:

For use with GLUCOCARD X-METER Blood Glucose Meter and GLUCOCARD X-SENSOR Blood Glucose Test Strips as a quality control check to verify the accuracy of blood glucose test results. Control solutions are available in three levels – Low (L),

Normal (N), and High (H).

3. Special conditions for use statement(s):

For over the counter use. Not for use with newborns. Galactose, Lactose, Maltose, Maltotriose, and Xylose each caused false elevation of glucose results and a warning was added to the limitations section of the labeling to alert users.

Alternate site testing (AST) can only be used during steady-state blood glucose conditions. AST should only be performed under the following conditions:

- Testing before a meal
- In a fasting state
- Two hours or more after a meal
- Two hours or more after insulin dosing
- Two hours after physical activity

4. Special instrument requirements:

Glucocard X-Meter Blood Glucose Meter

I. Device Description:

The Glucocard X-System consists of the Glucocard X-Meter Blood Glucose Meter, Glucocard X-Sensor Blood Glucose Test Strips (glucose dehydrogenase), and Glucocard X-Meter Control Solutions (low, normal, and high).

J. Substantial Equivalence Information:

1. Predicate device name(s):

Hypoguard Advance Micro-draw Blood Glucose Meter

2. Predicate 510(k) number(s):

k041881

3. Comparison with predicate:

Similarities		
Item	Device (Glucocard X-System)	Predicate (Advance Micro-draw)
Measuring Range	20 to 600 mg/dL	20 to 600 mg/dL

Reference	Plasma	Plasma
Sample Type	Capillary whole blood	Capillary whole blood
Operating Temperature Range	50°F to 104°F	50°F to 104°F
Operating Humidity Range	20% to 80%	20% to 80%

Differences		
Item	Device (Glucocard X-System)	Predicate (Advance Micro-draw)
Sample Source	Fingertip, palm, forearm, upper arm	Fingertip, palm
Enzyme	Glucose Dehydrogenase	Glucose Oxidase
Test Time	5 seconds	15 seconds
Control Solutions	3 levels	2 levels

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

CLSI EP7-A2 Interference Testing in Clinical Chemistry

CLSI EP5-A2 Evaluation of Precision Performance of Quantitative Methods

CLSI EP9-A2 Method Comparison and Bias Estimation Using Patient Samples

L. Test Principle:

The sample (whole blood) is drawn by capillary action at the tip of the test strip. Glucose in the sample reacts with glucose dehydrogenase and Hexaammineruthenium(III) chloride in the test strip, producing Hexaammineruthenium(II) chloride. Hexaammineruthenium(II) chloride is produced in proportion to the glucose concentration of the blood sample. Oxidation of the Hexaammineruthenium(II) chloride produces an electric current. The meter converts to the glucose concentration and displays it as the test result.

M. Performance Characteristics (if/when applicable):

1. Analytical performance:

a. Precision/Reproducibility:

Within run precision was performed using fully oxygenated whole blood samples obtained from non-diabetic donors. The whole blood was spiked to obtain high

glucose concentrations and allowed to undergo glycolysis to obtain the low concentration. The sample results ranged from approximately 35 to 495 mg/dL. Each sample was measured twenty times with three lots of test strips. The results are summarized below.

Within Run Precision Summary

Test Strip Lot 1					
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Mean (mg/dL)	40.5	71.7	135.4	242.9	498.8
%CV	3.2	3.5	2.6	2.7	2.3
Test Strip Lot 2					
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Mean (mg/dL)	39.6	73.1	133.5	237.6	498.1
%CV	3.7	3.7	3.4	2.5	2.0
Test Strip Lot 3					
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Mean (mg/dL)	38.1	72.7	125.2	226.6	472.6
%CV	2.8	1.9	2.3	3.6	4.0

Between run precision was performed using the same procedure as within run precision over six consecutive days. The results are summarized below.

Between Run Precision Summary

Test Strip Lot 1					
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Mean (mg/dL)	37.0	70.5	123.8	227.3	471.6
%CV	3.2	2.8	2.7	2.2	1.9
Test Strip Lot 2					
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Mean (mg/dL)	37.0	70.8	124.9	223.7	469.7
%CV	3.1	3.2	4.9	2.5	2.4
Test Strip Lot 3					
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Mean (mg/dL)	36.1	70.1	122.4	221.8	462.8
%CV	3.7	3.2	3.6	3.8	2.5

b. Linearity/assay reportable range:

The reportable range of the assay is from 20 mg/dL to 600 mg/dL. Linearity was combined with a temperature range study by testing venous blood adjusted to 11 glucose concentrations. The samples ranged from 17 mg/dL to 762 mg/dL and were tested five times each using the Glucocard X-System at 10°C, 25°C, and 40°C. The 17 mg/dL gave a “Lo” reading and the 762 mg/dL sample gave a “Hi” reading for all replicates tested. The remaining 9 samples ranged in concentration from 21 mg/dL to 584 mg/dL. The Glucocard X-System results showed agreement with the expected

values at all glucose concentrations tested. The regression equations from the Glucocard X-Meter measurements compared to the expected values performed at three temperatures were as follows

10°C: $y=1.0786x - 9.1001$ with an R^2 value of 0.996

25°C: $y=1.0283x - 7.0234$ with an R^2 value of 0.998

40°C: $y=0.9738x + 3.6443$ with an R^2 value of 0.998

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

The control solutions are prepared at three target concentrations by addition of glucose to an aqueous matrix. The glucose concentrations of the control solutions are traceable to NIST SRM 917b8.

Shelf life studies show that the unopened test strips have a 24 month life-span and 3 months shelf-life once a vial of strips is opened. Unopened controls have an 18-month shelf life and are stable for 3 months opening first use.

d. Detection limit:

The detection limit is 20 mg/dL. See linearity/assay reportable range section above.

e. Analytical specificity:

Hematocrit interference was evaluated by adjusting the glucose concentrations and hematocrit levels of venous blood samples from several donors. In the first study, the glucose concentrations were adjusted in increments from approximately 30 mg/dL to 515 mg/dL and the hematocrit levels were adjusted to 30%, 42%, and 55%. Each sample was run $n=10$ and the percent bias was calculated compared to the 42% hematocrit samples. Results are summarized in table 1 below. A second study evaluated more hematocrit concentrations between 42% and 55% and the results of this study are summarized in table 2. After analysis of both studies, the claim for the device was for use with samples having hematocrit concentrations ranging from 30% to 52%.

Table 1

Approx glucose (mg/dL)	34.2			57.4			119.8		
% hematocrit	30	42	55	30	42	55	30	42	55
Glucose (mg/dL) Average (n=10)	31.0	32.6	36.0	56.6	57.0	52.7	125.9	114.9	102.7
Bias (%) from Hct. 42% result	-4.9	0.0	10.4	-0.7	0.0	-7.5	9.6	0.0	-10.6

Table 1 (cont.)

Approx glucose (mg/dL)	332.2			517.9		
% hematocrit	30	42	55	30	42	55
Glucose (mg/dL) Average (n=10)	370.1	320.4	257.7	583.7	505.5	409
Bias (%) from Hct. 42% result	15.5	0.0	-19.6	15.5	0.0	-19.1

Table 2

Approx glucose (mg/dL)	31.6				54.5				76.5			
% hematocrit	42	49	52	55	42	49	52	55	42	49	52	55
Glucose (mg/dL) Average (n=10)	29.3	30.0	30.7	31.6	50.6	50.3	50.5	49.9	75.4	70.1	71.1	72.9
Bias (%) from Hct. 42% result	0.00	2.27	4.66	7.73	0.0	-0.6	-0.2	-1.4	0.0	-7.0	-5.7	-3.3

Table 2 (cont.)

Approx glucose (mg/dL)	123.6				176.2				246.8			
% hematocrit	42	49	52	55	42	49	52	55	42	49	52	55
Glucose (mg/dL) Average (n=10)	120.1	115.6	111.4	107.0	175.7	154.4	148.2	143.2	229.8	200.7	198.4	189.9
Bias (%) from Hct. 42% result	0.0	-3.8	-7.2	-10.9	0.0	-12.1	-15.7	-18.5	0.0	-12.6	-13.6	-17.4

Table 2 (cont.)

Approx glucose (mg/dL)	324.6				497.5			
% hematocrit	42	49	52	55	42	49	52	55
Glucose (mg/dL) Average (n=10)	314.2	283.0	271.8	243.8	480.1	418.7	410.3	379.7
Bias (%) from Hct. 42% result	0.0	-9.9	-13.5	-22.4	0.0	-12.9	-14.5	-20.9

Interfering substances were dissolved in venous blood samples at several concentrations each, then these were divided into three aliquots and spiked to nominal glucose concentrations of 60, 120, and 320 mg/dL. These samples were tested against control samples which had a blank solvent added at the same volume as the interferent. Samples were tested n=10 and the percent difference of the interfering samples was calculated compared to the control samples. The following substances were tested.

Compound	Concentrations tested
Acetaminophen	5 mg/dL
Acetyl-salicylic acid	13, 40, 65 mg/dL
Ascorbic acid	3 mg/dL

Bilirubin-unconjugated	10, 20 mg/dL
Bilirubin-conjugated	20, 40 mg/dL
Cholesterol	150, 250, 300 mg/dL
Creatinine	6, 20 mg/dL
L-Dopa	1.0, 3.4, 6.8, 13.0 mg/dL
L-Dopamine	0.05, 0.10 mg/dL
Ephedrine	0.014, 0.056 mg/dL
Fructose	5, 10, 15 mg/dL
Galactose	5, 10, 30 mg/dL
Gentisic acid	1.0, 1.8 mg/dL
L-Glutathione	0.79, 1.05, 3.00 mg/dL
Hemoglobin	735 mg/dL
Ibuprofen	1, 7, 10, 50 mg/dL
Lactose	5, 10, 25 mg/dL
Maltose	5, 12.5, 50 mg/dL
Maltotetraose	60, 120 mg/dL
Maltotriose	120, 240 mg/dL
Mannitol	100, 200, 400, 800 mg/dL
Mannose	2.5, 5.0, 10.0 mg/dL
Methyl-L-Dopa	0.10, 0.75, 1.50 mg/dL
Sorbitol	2.5, 5.0, 10.0 mg/dL
Tolazamide	1.5, 3.0, 8.4 mg/dL
Tolbutamide	5.4, 10.8, 64.0 mg/dL
Triglyceride	500, 3000 mg/dL
Urea	20, 40, 80, 260 mg/dL
Uric Acid	10, 20, 50 mg/dL
Warfarin	0.1, 0.3 mg/dL
Xylitol	5.0, 10.0, 25.0 mg/dL
Xylose	5.0, 10.0, 25.0 mg/dL

Galactose, Lactose, Maltose, Maltotriose, and Xylose each caused false elevation of sample results and a warning was added to the limitations section of the labeling alerting users.

When ibuprofen was tested at 50 mg/dL in a sample with a glucose concentration of 54 mg/dL it showed a bias of 18%, however all other ibuprofen and glucose concentrations tested showed bias of $\leq \pm 9\%$. When mannose was tested at 10 mg/dL in a sample with a glucose concentration of 60 mg/dL it showed a bias of +18%, however all other mannose and glucose concentrations tested showed a bias of $\leq \pm 8\%$.

All other compounds tested above showed biases of $\leq \pm 15\%$.

An altitude study was performed with venous whole blood adjusted to four different glucose concentrations ranging from approximately 56 to 540 mg/dL. One aliquot of each sample was tested on the ground at 900 feet above sea level and the other was

tested at 10,000 \pm 20 feet in a small non pressurized airplane. The result of each sample tested at 10,000 feet was within \pm 10% of the sample tested on the ground. This demonstrates that the meter may be used up to an altitude of 10,000 feet above sea level.

Temperature and humidity studies were performed and showed that the meter can be used at temperatures from 50°F to 104°F and at relative humidity ranging from 20% to 80%.

f. Assay cut-off:

Not applicable

2. Comparison studies:

a. Method comparison with predicate device:

The method comparison study was performed with 142 capillary fingerstick patient samples. In order to fully cover the measuring range, 27 of the samples were spiked with glucose or allowed to glycolyze. The samples ranged in concentration from 24 to 466 mg/dL on the Glucocard X-Meter device and met the ISO 15197 sample distribution requirements. Samples were measured in singlicate on the Glucocard X-Meter and in duplicate on the YSI analyzer. An analysis of the results calculated a slope of 0.982, an intercept of -3.9, and correlation value of 0.98. In addition, 98% of the results were within the ISO 15197:2003 accuracy criteria of 95% of samples with \pm 15 mg/dL bias for glucose samples \leq 75 mg/dL and \pm 20% bias for glucose samples $>$ 75 mg/dL. System accuracy results are presented in the tables below.

System accuracy results for glucose concentrations $<$ 75 mg/dL

Within \pm 5 mg/dL	Within \pm 10 mg/dL	Within \pm 15 mg/dL
9/30 (30%)	24/30 (80%)	30/30 (100%)

System accuracy results for glucose concentrations \geq 75 mg/dL

Within \pm 5%	Within \pm 10%	Within \pm 15%	Within \pm 20%
39/112 (35%)	71/112 (63%)	95/112 (85%)	109/112 (97%)

Method comparison studies were performed using alternate site testing (AST) samples compared to professional fingerstick samples. The studies were performed using professional and participant AST samples taken from the palm, forearm and upper arm. The results are shown below.

Palm (Thenar and hypothenar)	Regression equation	r	N	Conc. range (mg/dL)
Participant	$y = 1.010x + 2.21$	0.98	106	51 - 406
Professional	$y = 0.994x - 0.456$	0.98	106	52 - 454
Forearm				
Participant	$y = 0.965x + 14.902$	0.94	101	63 - 373
Professional	$y = 0.976x + 2.092$	0.97	106	67 - 425
Upper Arm				
Participant	$y = 1.022x + 3.345$	0.96	98	72 - 462
Professional	$y = 0.935x + 4.722$	0.98	105	72 - 410

In addition a small study was performed to show that the two palm sites (thenar and hypothenar) demonstrated equivalent performance. In this study 27 patients were first tested by professional fingerstick. Then both professional and participant samples were taken from the hypothenar and thenar palm site for each patient. Sample results ranged from approximately 75 mg/dL to approximately 375 mg/dL. The results are shown below.

	Slope	Intercept	Correlation (r)
Thenar Participant (n =26*)	1.10	-7.1	0.99
Thenar Professional (n = 27)	1.00	+3.1	0.99
Hypothenar Participant (n=27)	0.98	+7.9	0.98
Hypothenar Professional (n=27)	1.11	-11.7	0.99

b. Matrix comparison:

Not applicable

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:

Expected blood glucose levels for non-diabetics ^{1,2}

Fasting	70-110 mg/dL
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1 to 2 hours after meals	<120 mg/dL
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1. Burtis, C.A. Ashwood, E.R., eds.: Tietz Textbook of Clinical Chemistry. 2nd Edition. Philadelphia: W.B. Saunders. (1994), 2190.
2. Krall, L.P. and Beaser, R.S.: Joslin Diabetes Manual. Philadelphia: Lea and Fibiger (1989), 138.

N. Instrument Name:

Glucocard X-Meter

O. System Descriptions:

1. Modes of Operation:

Each test strip is single use and must be replaced with a new strip for each additional reading.

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:

There is no sample identification function with this device. Samples are applied directly to the test strip as they are collected.

4. Specimen Sampling and Handling:

This device is intended to be used with capillary whole blood. Since the whole blood sample is applied directly to the test strip, there are no special handling or storage issues.

5. Calibration:

The meter automatically detects the code number when a test strip is inserted. The user must check to see if the code number the meter displays matches the number on the test strip vial. If the number matches, the user is instructed to begin testing. If the number

does not match, or if no number appears, the user is instructed to try another test strip. If this fails the user is instructed to try a new vial of strips and to call customer service if this also fails. No other calibration is required from the user.

6. Quality Control:

One control level is provided with the device and two additional control levels are available. The user is instructed to call their supplier or pharmacy to obtain controls and to call Arkray customer service if the supplier or pharmacy does not stock the controls. The user is instructed to run controls when the meter is first used in order to verify that they can use the meter correctly. In addition they are instructed to run a control when a new vial of test strips is opened, when they suspect the meter or strips are not working correctly, when test results are not consistent with the patient's symptoms or the patient does not think the results are accurate, if the meter is dropped, to check their technique, if the test strip bottle had been left open or stored outside its recommended temperature range, or when the Glucocard X-Meter has been stored outside its recommended temperature range. The acceptable results ranges are shown on the test strip vial label. If the results are outside the expected range, the user is instructed to repeat the test. If the repeated test falls outside the range the user is instructed to repeat the test using a new control solution or test strip. If the control continues to read outside the expected range the user is told not to use the test system until the control result reads within the acceptable range.

P. Other Supportive Instrument Performance Characteristics Data Not Covered In The "Performance Characteristics" Section above:

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.