

**510(k) SUBSTANTIAL EQUIVALENCE DETERMINATION  
DECISION SUMMARY  
DEVICE ONLY TEMPLATE**

**A. 510(k) Number:** k043543

**B. Purpose For Submission:**

Premarket Notification 510(k) of intention to manufacture and market the Freedom Blood Glucose Monitoring System.

**C. Analyte:** Whole Blood Glucose

**D. Type of Test:** Quantitative, utilizing Glucose Oxidase technology.

**E. Applicant:** American HealthCare, Inc.

**F. Proprietary and Established Names:** Freedom Blood Glucose Monitoring System.

**G. Regulatory Information:**

1. Regulation section: 21 CFR §862.1345, Glucose test system.
2. Classification: Class II
3. Product Code: NBW, CGA
4. Panel: 75 Chemistry

**H. Intended Use:**

1. Intended use(s):

See Indications for use below.

2. Indication(s) for use:

The Freedom Blood Glucose Monitoring System is used for the quantitative measurement of glucose level in whole blood as an aid in monitoring the effectiveness of diabetes management in the home and in clinical settings. The Freedom Blood Glucose Monitoring System is for testing outside the body (in vitro diagnostic use only). Testing sites include the traditional fingertip testing along with alternate site testing on the arm, palm, thigh, and calf.

3. Special condition for use statement(s):

Provides plasma equivalent results.

4. Special instrument requirements:

Freedom Blood Glucose Monitoring System

**I. Device Description:**

The Freedom Blood Glucose Monitoring System consists of the Freedom Meter, Freedom Test Strips, Auto-Lancet Device, Infopia Check Strip and Greenlan Lancets, Control Solution. Control Solution is sold separately from the kit. Control solution was cleared previously in k031501.

**J. Substantial Equivalence Information:**1. Predicate device name(s):

LifeScan, Inc. OneTouch Ultra®

2. Predicate K number(s):

k024194

3. Comparison with Predicate:

The US Diagnostics, Inc. Freedom Blood Glucose Monitoring System is substantially equivalent to the LifeScan, Inc. ONE TOUCH Ultra® Blood Glucose Monitoring System previously cleared under (k024194). The table below lists the similarities and differences between the predicate and proposed device.

**Similarities**

	Freedom	ONE TOUCH® Ultra®
Detection Method	Amperometry: current is generated by oxidation of reduced mediator.	Amperometry
Enzyme	Glucose Oxidase ( <i>Aspergillus niger</i> )	Glucose Oxidase ( <i>Aspergillus niger</i> )
Mediator	Hexaammineruthenium chloride	Potassium ferricyanide
Electrode	Carbon electrode	Carbon electrode

The other ingredients of test strip, such as enzyme stabilizer, buffer and binder are different.

The Freedom Blood Glucose Monitoring System provides the same glucose monitoring capability as the predicate device, the ONE TOUCH® Ultra®. The primary differences are in the advanced memory function and battery lifetime.

#### Differences

	Freedom	ONE TOUCH® Ultra®
Test range	10 ~ 600 mg/dL	20 ~ 600 mg/dL
Hematocrit Range	30 ~55%	30 ~ 55%
Test Time	5 seconds	5 seconds
Sample Volume	1uL	1uL
Temperature & Humidity range	50 ~ 104° F 10 ~ 40° C 10 ~ 90%	43 ~ 111° F 6 ~ 44° C 10 ~ 90%
Open use time	3 months	3 months
Coding	Button (C1 ~C45)	Button (C1 ~ C49)
Memory capability	From 7 to 99-day average and 250 tests in the memory	14-day average and last 150 tests in the memory
Power	3V Li battery (CR2032)	3V Li battery (CR2032)
Battery life	Running 5,000 test	Running 1,000 test
Size: LxWxH (mm)	91x54.5x22.8	79x57x21
Weight	55g(with battery)	42g (with battery)
Warranty	Lifetime	3 years
Software	Freedom diabetes management software	IN TOUCH® diabetes management software

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

- 1) National Committee for Clinical Laboratory Standards. *Point-Care Blood Glucose Testing in Acute and Chronic care Facilities; Approved Guideline, 2<sup>nd</sup> Edition*. NCCLS Document C30-A2 (ISBN1-56238-471-6).
- 2) National Committee for Clinical Laboratory Standards. *Statistical Quality Control for Quantitative Measurements; Principle and Definitions; Approved Guideline, 2<sup>nd</sup> Edition*. NCCLS Document C24-A2 (ISBN1-56238-371-X). 1999
- 3) National Committee for Clinical Laboratory Standards. *Preliminary Evaluation of Quantitative Clinical Laboratory Methods; Approved Guideline*. NCCLS Document EP10-A (ISBN1-56238-348-5). 1998
- 4) National Committee for Clinical Laboratory Standards. *Evaluation of Matrix Effects; Approved Guideline*, NCCLS Document EP14-A (ISBN1-56238-434-1).

- 5) National Committee for Clinical Laboratory Standards. *Estimation of Total analytical Error for Clinical Laboratory Methods; Proposed Guideline*. NCCLS Document EP21-P (ISBN1-56238-456-2).
- 6) National Committee for Clinical Laboratory Standards. *User Demonstration of performance for Precision and Accuracy; Approved Guideline*. NCCLS Document EP15-A (ISBN1-56238-451-1).
- 7) National Committee for Clinical Laboratory Standards. *Interference Testing in Clinical Chemistry; Proposed Guideline*. NCCLS Document EP7-P (ISSN 0273-3099).
- 8) National Committee for Clinical Laboratory Standards. *Evaluation of the Linearity of Quantitative Analytical Methods; Proposed Guideline, 2<sup>nd</sup> Edition*. NCCLS Document EP6-P2 (ISBN1-56238-446-5).
- 9) National Committee for Clinical Laboratory Standards. *Evaluation of Performance of Clinical Chemistry Devices; Approved Guideline*. NCCLS Document EP5-A (ISBN1-56238-368-X).
- 10) Clinical Chemistry, 2<sup>nd</sup> Edition
- 11) MERCK INDEX, 11<sup>th</sup> Edition.

**L. Test Principle:**

The Test Principle used by this device is electrochemical biosensor technology using Glucose Oxidase. The strip uses the enzyme Glucose Oxidase to produce an electrical current that will stimulate a chemical reaction. This reaction is measured by the Freedom meter and displayed as a blood glucose result.

**M. Performance Characteristics (if/when applicable):**

1. Analytical performance:
  - a. *Precision/Reproducibility:*

The sponsor indicated precision studies were assessed by taking 4mL of blood that was treated with EDTA drawn in a vacuum tube. Glucose was added to the 4 mL of blood to generate 5 different levels of glucose concentration for the test. Each of the samples was measured 5 times for precision.

***Day-to-Day precision also known as Between Day Precision***

The sponsor prepared three control solutions of Low, Normal and High. Each of the controls was measured twice a day, once in the morning and once in the afternoon for a month.

Table 1 (below) shows a summary of the Within-Run Precision and the Day-to-Day Precision Tests.

Table 1: Summary of Test Results

Control Samples	No. of Assay	Within-Run Precision		
		Mean (mg/dL)	SD (mg/dL)	CV (%)
Level 1	5	43	1.6	3.7
Level 2	5	81.6	2.1	2.5
Level 3	5	132.6	1.9	1.5
Level 4	5	211.6	5.9	2.8
Level 5	5	318.2	12	3.8

Control Samples	No. of Assay	Day-to-Day Precision		
		Mean (mg/dL)	SD (mg/dL)	CV (%)
Low	80	50.4	2.0	3.9
Normal	80	122.7	2.6	2.1
High	80	321.7	7.0	2.2

*b. Linearity/assay reportable range:*

***Test Procedure (Dilution Schemes)***

According to the NCCLS EP6-P2 protocol, a blood sample of 25 mL was taken, treated with the EDTA in a vacuum tube, and let set for a day. Two glucose concentrations of 10 mL (high and low concentrations) were prepared. As a measuring tool, nine glucose concentrations were prepared using the following dilution schemes (see Table 5).

Table 5: Levels of Dilution Schemes

S=9 Samples

Level 1(Low, L)	L
Level 2	0.875L + 0.125H
Level 3	0.750L + 0.250H
Level 4	0.625L + 0.375H
Level 5	0.500L + 0.500H
Level 6	0.375L + 0.625H
Level 7	0.250L + 0.750H
Level 8	0.125L + 0.875H
Level 9(High, H)	H

The meter used in this test can display below 10 mg/dL over 600 mg/dL for checking linear range.

Each of the glucose levels was measured 5 times to test for precision. In order to evaluate the straight line for the Sensory Strip that was used, the following formula was used:

$$1^{\text{st order}} \text{ polynomial, } y = ax + b, \quad 2^{\text{nd order}} \text{ polynomial, } y = aX^2 + bX + c$$

All dilution schemes start with a high and low concentration samples in which the concentrations meet or exceed the range of interest. For the test, the highest and lowest glucose concentration used was 620mg/dL and 8mg/dL. If a strip sensor has an ideal linearity ( $r^2=1$ ) from lowest to highest concentration, the ideal concentration of level 2 mixed with 0.875L and 0.125H volume ratio is a 99mg/dL  $[(0.875*37.4 + 0.125*530.2)/(0.875+0.125)]$ .

Table 6, below, shows a summary of the nine dilutions that were measured five times for precision.

Table 6: Test Result Summary

Dilution	Rep1	Rep2	Rep3	Rep4	Rep5	Mean
1	1	8	9	8	7	7
2	2	86	88	84	85	88
3	3	156	156	156	158	160
4	4	235	240	238	239	234
5	5	300	297	295	297	305
6	6	400	405	407	392	395
7	7	465	470	470	465	462
8	8	550	552	554	550	558
9	9	620	624	615	620	625

The dilution number at Table 6 and Figure 1 represents the Level number at Table 5.

Figure 1: Glucose Linearity Study (Dilution 1-9)

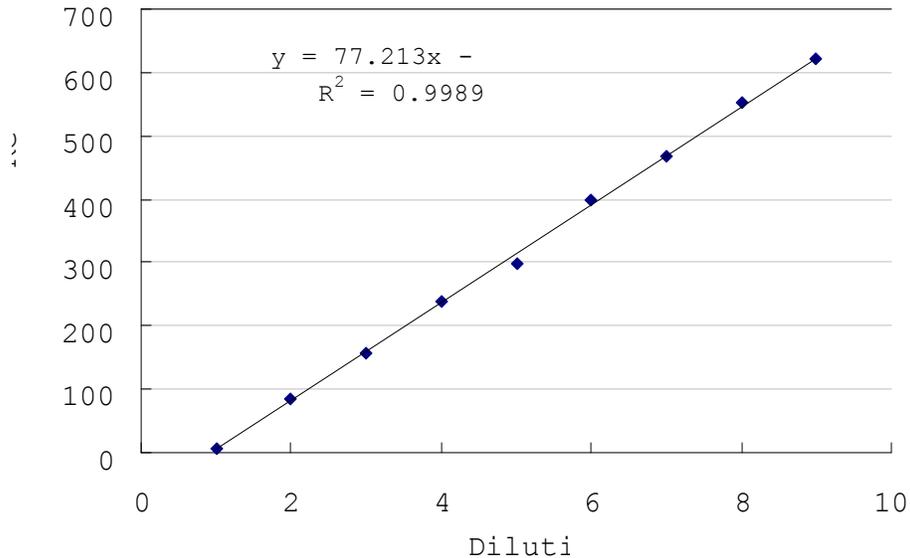


Table 7: The Polynomial Evaluation of Linearity

Dilution	Actual Mean	Predicted 1st order	Predicted 2nd order	Difference
1	<u>7.8</u>	5.3	8.1	-2.8
2	<u>86.2</u>	82.5	83.2	-0.7
3	<u>157.2</u>	159.7	158.9	0.8
4	<u>237.2</u>	236.9	235.2	1.7
5	<u>298.8</u>	314.1	312.1	2.0
6	<u>399.8</u>	391.3	389.6	1.7
7	<u>466.4</u>	468.5	467.7	0.8

8	<u>552.8</u>	545.7	546.5	-0.7
9	<u>620.8</u>	623.0	625.8	-2.8

It has been determined that the polynomial evaluation of linearity assumes that the data set is not linear. This approach assumes that the data points fall perfectly on a line or curve in the absence of random error. The method consists of two parts. The first part examines whether a nonlinear polynomial fits the data better than a linear one. The second part assesses whether the difference between the best-fitting nonlinear and linear polynomial is less than the amount of allowable bias for the method, which should be predefined.

The nonlinear 2<sup>nd</sup> fits the data better than a linear one, but the difference is lower than 2.0mg/dL from 7.8mg/dL to 620.8mg/dL. The R<sup>2</sup> of 1<sup>st</sup> order regression is a 0.9989.

*c. Traceability (controls, calibrators, or method):*

CAS# (Chemical Abstract Service)  
 MDL# (MDL, Inc. Formerly Molecular Design Laboratories)  
 Glucose # 492615 Sigma Ultra MFCD00063989  
 Traceability referenced to NBS, NIST Standards

*d. Detection limit:*

10 – 600 mg/dL  
 1.7 to 33.3 mmol/L  
 See linearity study above.

*e. Analytical specificity:*

Interference testing was conducted to determine the effect of select endogenous and exogenous substances.

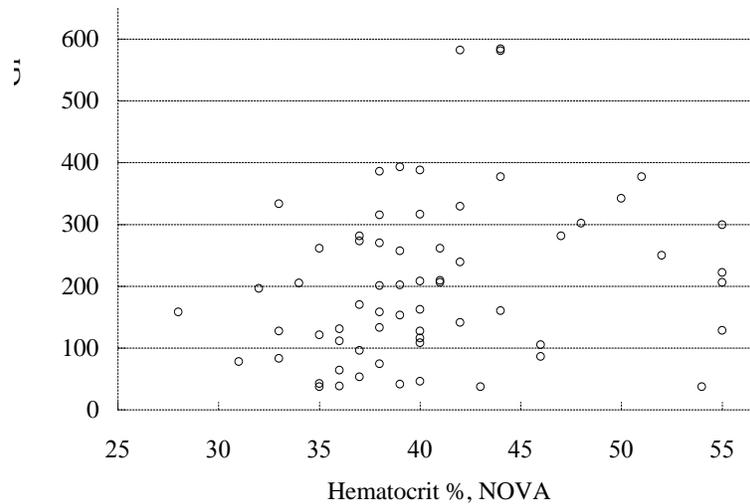
### **Hematocrit Study**

In this study, approximately 2 mL of blood was taken from 64 random diabetic individuals. The blood samples were treated with the EDTA vacuum tube and the glucose concentration was adjusted to < 50 ~ < 580 mg/dL by adding an adequate amount of the phosphate buffer (20mM with pH 7.4) that contains a different level of glucose. In order to adjust the Hematocrit value (30 ~ 55%), a proper volume of the centrifuged plasma (serum) was removed.

The Hematocrit level and glucose concentration in the blood was assessed by using the Nova Stat Profile M and the YSI2300 STAT (respectively).

Table 1. Test Result of Blood Glucose Range and Samples:

Result of Blood Glucose and Hematocrit Range

**Figure 1:** Blood glucose conc. Vs Hematocrit %

The % bias of the assay value of the FREEDOM™ system is relative to the YSI and does not have a negative or positive correlation to hematocrit level in this experiment. 98% of the data is within +/- 20% bias and 86% lies within +/- 10% in the overall range of glucose and hematocrit.

See Table 1 for summary of interferences tested.

Table 1: Summary of Tested Interferences:

Interferences	Mean of Test Results			Error %
	High Test Level(mg/dL)	Low (mg/dL)	High (mg/dL)	
Acetaminophen	<u>20</u>	98.7	100.7	<u>2.0</u>
Bilirubin	<u>40</u>	97.3	96.0	<u>-1.4</u>
Gentistic acid	<u>50</u>	114.3	140.3	<u>22.7</u>
Uric acid	<u>20</u>	92.3	86.0	<u>-6.9</u>
Levo-Dopa	<u>4</u>	98.0	109.3	<u>11.6</u>
Creatinine	<u>30</u>	119.3	126.0	<u>5.6</u>
Methyl-Dopa	<u>2.5</u>	105.3	113.3	<u>7.6</u>
Tolazamide	<u>5</u>	94.0	114.3	<u>21.6</u>
Dopamine	<u>13</u>	108.3	121.3	<u>12.0</u>
Ascorbate	<u>3</u>	112.3	115.3	<u>2.7</u>
EDTA	<u>640</u>	100.0	104.3	<u>4.3</u>

Glutathione	<u>1</u>	119.7	129.0	<u>7.8</u>
Heparin	<u>1,000</u>	126.3	127.7	<u>1.1</u>
Ibuprofen	<u>40</u>	121.3	130.7	<u>7.7</u>
Salicylic acid	<u>50</u>	135.7	137.3	<u>1.2</u>
Tetracycline	<u>0.4</u>	126.3	129.1	<u>2.2</u>
Tolbutamide	<u>100</u>	101.0	103.3	<u>2.3</u>
Urea	<u>500</u>	112.3	113.0	<u>0.6</u>
Cholesterol	<u>500</u>	123.0	138.7	<u>12.7</u>
Triglyceride	<u>2,890</u>	110.7	123.3	<u>11.4</u>

According to the sponsor, the list of interfering substances and their high test level were referenced to NCCLS Document EP7-P.

All low levels = 0 mg/dL except: Urea = 33 mg/dL  
 Cholesterol = 209 mg/dL  
 Triglyceride = 210 mg/dL

It has been determined that reducing substances such as uric acid affect the testing result by falsely increasing values and may activate or deactivate the activity of Glucose Oxidase (GOX), activating GOX makes the test results falsely high.

*f. Assay cut-off: Not Applicable*

## 2. Comparison studies:

### *a. Method comparison with predicate device:*

The method comparison to the predicate device was assessed with One hundred sixty subjects with Type 1 or Type 2 diabetes during a normally scheduled clinic visits. In the study protocol, both the lay user and a trained technician obtained fingerstick glucose readings on the FREEDOM™ and ONETOUCH ULTRA, as well as alternate site glucose testing on the forearm, part of the hand, upper arm, thigh and calf using both the FREEDOM™, and ONETOUCH ULTRA meters.

The readings were taken as close in time as possible. Within 5 minutes, a venous whole blood was drawn from alternate sites and centrifuged for making serum. The serum sample was tested by Hitachi 747. The sponsor indicated that during the comparison studies, alternate sites were vigorously rubbed by the lay user and trained technician before testing, and in some cases a warming pad was used. It has been suggested that the alternate site -to-finger difference may be minimized by rubbing the site before blood collection. <sup>1</sup>

Table 1. Summary of test results with finger capillary blood and palm blood obtained by lay users.

		Site 1	Site 2	Site 3
OneTouch (Palm) vs Hithchi747	Slope:	0.9788	0.9877	0.9520
	Y-intercept:	-4.2255	-0.1052	9.8344
	R:	0.9851	0.9702	0.9821
Freedom (Palm) vs Hithchi747	Slope:	1.053	1.0462	1.0464
	Y-intercept:	-4.6727	-4.5411	-5.0969
	R:	0.9772	0.9767	0.979
Freedom (Capillary) vs Hithchi747	Slope:	1.0418	1.0238	1.0336
	Y-intercept:	-3.2947	-3.7798	-2.2993
	R:	0.9846	0.9739	0.9844
Freedom (Palm) vs Freedom (Capillary)	Slope:	1.0059	0.9951	1.0024
	Y-intercept:	-0.4667	4.3643	-0.8446
	R:	0.9830	0.9509	0.9750

	Error Grid	Site 1	Site 2	Site 3
OneTouch (Palm) vs Hithchi747	A-region	100%	98%	98%
	B-region	0%	2%	2%
Freedom (Palm) vs Hithchi747	A-region	100%	100%	98 %
	B-region	0%	0%	2 %
Freedom (Capillary) vs Hithchi747	A-region	100%	100%	98 %
	B-region	0%	0%	2 %
Freedom (Palm) vs Freedom (Capillary)	A-region	100%	96%	96 %
	B-region	0%	4%	4 %

Table 2. Summary of test results with finger capillary blood and Arm blood obtained by lay users.

		Site 1	Site 2	Site 3
OneTouch (Arm)vs Hithchi747	Slope:			
	Y-intercept:	1.0291	0.9604	0.9925
	R:	-2.4835	5.2987	2.4925
Freedom (Arm) vs Hithchi747	Slope:	0.9774	0.9828	0.9639
	Y-intercept:	0.9947	1.0072	0.9619
	R:	0.7937	0.0238	7.1877
Freedom (Capillary) vs Hithchi747	Slope:	0.9909	0.9878	0.9915
	Y-intercept:	0.9753	0.9809	0.9690
	R:	-0.3977	0.3006	0.8785
Freedom (Palm) vs Freedom (Capillary)	Slope:	0.9847	0.9916	0.9940
	Y-intercept:	1.0052	1.0196	0.9881
	R:	3.9637	0.9198	7.169
		0.9776	0.9821	0.9882

	Error Grid	Site 1	Site 2	Site 3
OneTouch (Arm) vs Hithchi747	A-region	98 %	98 %	98 %
	B-region	2 %	2 %	2 %
Freedom (Arm) vs Hithchi747	A-region	100%	100%	100%
	B-region	0%	0%	0%
Freedom (Capillary) vs Hithchi747	A-region	100%	100%	100%
	B-region	0%	0%	0%
Freedom (Arm) vs Freedom (Capillary)	A-region	98 %	98 %	100%
	B-region	2 %	2 %	0%

Table 3. Summary of test results with finger capillary blood and calf, thigh blood obtained by lay users.

		Site 1	Site 2	Site 3
OneTouch (calf and thigh) vs Hithchi747	Slope:	0.9942	0.9913	0.9960
	Y- intercept:	0.5819	1.8588	-0.7162
	R:	0.9839	0.9893	0.9784
Freedom (calf and thigh) vs Hithchi747	Slope:	0.9988	0.9868	0.9792
	Y- intercept:	-3.8376	-2.6589	0.4095
	R:	0.9788	0.9748	0.9822
Freedom (Capillary) vs Hithchi747	Slope:	1.0224	0.9761	0.9800
	Y- intercept:	-4.7730	0.6462	3.2339
	R:	0.9752	0.9831	0.9825
Freedom (calf and thigh) vs Freedom (Capillary)	Slope:	0.9704	1.0072	0.9931
	Y- intercept:	1.9943	-2.6566	-1.6889
	R:	0.9904	0.9841	0.9876

	Error Grid	Site 1	Site 2	Site 3
OneTouch (calf and thigh) vs Hithchi747	A-region	100%	98 %	98 %
	B-region	0%	2 %	2 %
Freedom (calf and thigh) vs Hithchi747	A-region	100%	100%	100%
	B-region	0%	0%	0%
Freedom (Capillary) vs Hithchi747	A-region	100%	100%	100%
	B-region	0%	0%	0%
Freedom (calf and thigh) vs Freedom (Capillary)	A-region	98%	100%	100%
	B-region	2%	0%	0%

The comparison test results demonstrated similar results from both meters, with OneTouch at alternate site, Freedom at alternate site, and Freedom at fingerstick capillary according to the slope, Y-intercept, R and error % in Clark Error Grid region. Test results with Freedom at the alternative site of hand versus fingerstick capillary blood, correlation coefficient are 1.0059 ~ 1.053. Test results with Freedom at alternative site of arm versus fingerstick capillary blood, correlation coefficient are

1.0052 ~ 0.9947. Test results with Freedom at alternative site of leg versus fingerstick capillary blood, correlation coefficient are 0.9704~0.9988. The Freedom Blood Glucose Monitoring System demonstrated equivalence to the OneTouch Ultra predicate device.

### Reference

1. John M. E: Rapid Changes in Postprandial Blood Glucose Produce Concentration Differences at Finger, Forearm, and Thigh Sampling Sites. Diabetes Care 25: 961-964, 2002

b. Matrix comparison: Not Applicable

3. Clinical studies:

a. *Clinical sensitivity:* Not Applicable

b. *Clinical specificity:* Not Applicable

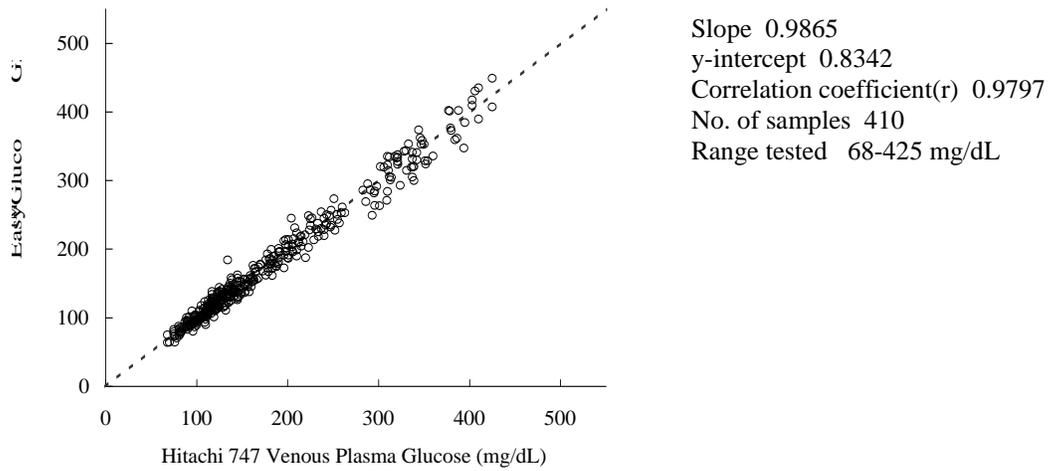
c. *Other clinical supportive data (when a and b are not applicable):*

The accuracy of the FREEDOM™ System was assessed by comparing blood glucose results obtained by patients with those obtained using the Hitachi 747, a laboratory instrument. Glucose levels were measured on 68 and 425 fresh capillary blood specimens by 104 diabetic patients and three healthcare professionals at three different clinical centers.

The correlation between Hitachi 747 and FREEDOM™ were confirmed in the 410 blood samples with the correlation coefficient  $R=0.9797$  and the 104 patients with the correlation coefficient  $R=0.9782$  (Fig. 1 and Fig. 2 respectively). Results indicate that the use of the FREEDOM™ generate results similar to the Hitachi 747.

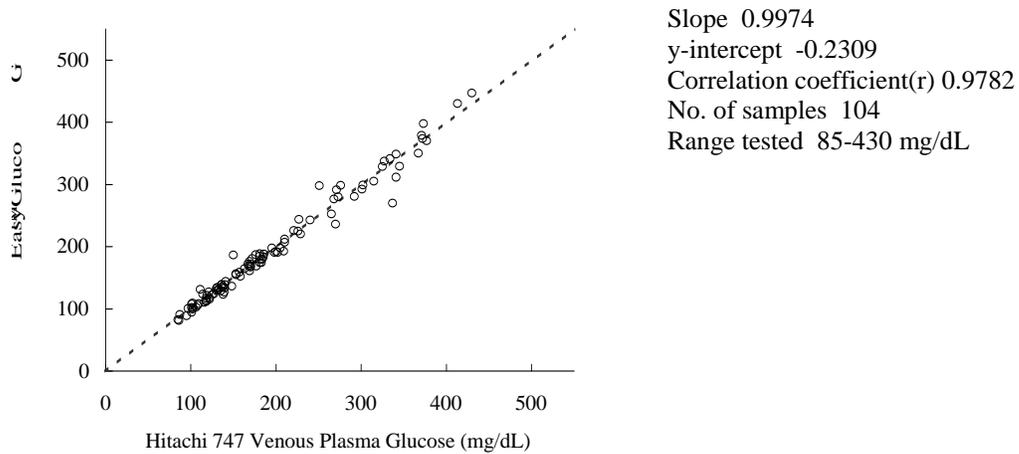
**Figure 1:** Linear regression of the 410 blood glucose samples with the Hitachi 747 Vs. FREEDOM™ System at the Clinical Centers.

## Obtained by Healthcare Professionals in Clinical Centers



**Figure 2:** Linear regression of the 104 diabetic patients – Hitachi 747 Vs. FREEDOM™ System

## Obtained by Lay diabetics



4. Clinical cut-off: Not Applicable

5. Expected values/Reference range:

The Range of Expected Values was referenced from the Joslin Diabetes Manual.

Expected blood glucose levels for people **without** diabetes:

<b><u>Time</u></b>	<b><u>Range (mg/dL)</u></b>	<b><u>Range (mmol/L)</u></b>
Before Breakfast:	70-105	3.9-5.8
Before lunch or dinner:	70-110	3.9-6.1
1 hour after meals:	Less than 160	Less than 8.9
2 hours after meals:	Less than 120	Less than 6.7
Between 2 and 4 AM:	Greater than 70	Greater than 3.9

**N. Proposed Labeling:**

The labeling is sufficient and it satisfies the requirements of 21 CFR Part 809.10

**O. Conclusion:**

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