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

A. 510(k) Number:

K161738

B. Purpose for Submission:

New Submission

C. Measurand:

Glucose in capillary whole blood glucose from fingertip, venous and neonatal
β-Ketone in capillary whole blood from fingertip, and venous

D. Type of Test:

Quantitative Amperometric assay (Glucose dehydrogenase (FAD)) and
Quantitative Amperometric β-Ketone (beta-hydroxybutyrate)

E. Applicant:

TaiDoc Technology Corporation

F. Proprietary and Established Names:

FORA ADVANCED GD-40 Blood Glucose and β-Ketone Monitoring System
FORA ADVANCED GD-40 pro Blood Glucose and β-Ketone Monitoring System

G. Regulatory Information:

1. Regulation section:

   862.1345, Glucose Test System

   862.1435, Ketones (nonquantitative) test system

   862.1660, Quality control material (assayed and unassayed)

2. Classification:

   Class II
   Class I (reserved)

3. Product code:

   NBW - System, Test, Blood Glucose, Over-the-Counter

   LFR - Glucose Dehydrogenase, Glucose

   JIN – Nitroprusside, ketones (urinary, non-quant.)

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

4. Panel:

   (75) Chemistry

H. Intended Use:

1. Intended use(s):

   See indications for use below.

2. Indication(s) for use:

   FORA ADVANCED GD40 Blood Glucose and β-Ketone Monitoring System is intended for the quantitative measurement of glucose in fresh capillary whole blood from the finger, and for the quantitative measurement of β-ketone (beta-hydroxybutyrate) in fresh capillary whole blood from the finger. The FORA ADVANCED GD40 is intended for in vitro diagnostic use and is intended for single-patient use as an aid to monitor the effectiveness of a diabetes control program. The system should not be used for the diagnosis of or screening for diabetes.

   FORA ADVANCED GD40 Blood Glucose Test Strips are for use with the FORA ADVANCED GD40 Blood Glucose and β-Ketone Meter to quantitatively measure glucose in fresh capillary whole blood samples drawn from the finger. The FORA ADVANCED GD40 Blood β-Ketone Test Strips are for use with the FORA ADVANCED GD40 Blood Glucose and β-Ketone Meter to quantitatively measure β-ketone in fresh capillary whole blood samples drawn from the finger.

   β-Ketone Control Solutions are intended for use with FORA ADVANCED GD40 Blood Glucose and β-Ketone Monitoring System as a quality control check to verify the accuracy of blood ketone test results.

FORA ADVANCED GD40 pro Blood Glucose and β-Ketone Monitoring System is intended for the quantitative measurement of glucose in fresh capillary whole blood from the finger, and from venous, and neonatal whole blood, and for the quantitative measurement of β-ketone (beta-hydroxybutyrate) in fresh capillary whole blood from the finger, and from venous whole blood. The FORA ADVANCED GD40 pro is intended for in vitro diagnostic use and is intended for multiple-patient use in professional healthcare settings as an aid to monitor the effectiveness of a diabetes control program. This system should only be used with single-use, auto-disabling lancing devices. The system should not be used for the diagnosis of or screening for diabetes.

FORA ADVANCED GD40 pro Blood Glucose Test Strips are for use with the FORA ADVANCED GD40 pro Blood Glucose and β-Ketone Meter to quantitatively measure glucose in fresh capillary whole blood samples drawn from the fingertips, and from venous and neonatal whole blood. The FORA ADVANCED GD40 pro Blood β-Ketone Test Strips are for use with the FORA ADVANCED GD40 pro Blood Glucose and β-Ketone Meter to quantitatively measure β-ketone in fresh capillary whole blood samples drawn from the fingertips and from venous whole blood.

β-Ketone Control Solutions are intended for use with FORA ADVANCED GD40 pro Blood Glucose and β-Ketone Monitoring System as a quality control check to verify the accuracy of blood ketone test results.

3. Special conditions for use statement(s):

For the FORA ADVANCED GD40 Blood Glucose and β-Ketone Monitoring System:

- For in vitro diagnostic use (for use outside of the body only).
- For single use only.
- For single-patient use only.
- The system should not be used for the diagnosis of or screening for diabetes.
- This system is not for use in patients with abnormally low blood pressure or those who are in shock.
- This system is not for use in patients in hyperglycemic-hyperosmolar state, with or without ketosis.
- This system should not be used on critically ill patients.
- This system should not be used on patients with impaired peripheral circulation, severe dehydration as a result of diabetic ketoacidosis or severe hyperglycemia, hyperosmolar non-ketotic coma or shock.
- Neonatal Use: These test strips are not for use with neonates.
- Altitude Effects: This device has not been evaluated at altitudes above 10,742 feet above sea level

For the FORA ADVANCED GD40 pro Blood Glucose and β-Ketone Monitoring System:

- For in vitro diagnostic use (for use outside of the body only).
- For single use only.
- This system should only be used with single-use, auto-disabling lancing devices.
- The system should not be used for the diagnosis of or screening for diabetes.
- This system is not for use in patients with abnormally low blood pressure or those who are in shock.
- This system is not for use in patients in hyperglycemic-hyperosmolar state, with or without ketosis.
- This system has not been evaluated on critically ill patients.
- This system should not be used on patients with impaired peripheral circulation, severe dehydration as a result of diabetic ketoacidosis or severe hyperglycemia, hyperosmolar non-ketotic coma or shock.
- Altitude Effects: This device has not been evaluated at altitudes above 10742 feet above sea level

4. Special instrument requirements:

FORA ADVANCED GD-40 Blood Glucose and β-Ketone meter
FORA ADVANCED GD-40 pro Blood Glucose and β-Ketone meter

I. Device Description:

The FORA ADVANCED GD-40 and FORA ADVANCED GD-40 pro Blood Glucose and β-Ketone Monitoring Systems each consist of a meter, glucose and ketone test strips, and glucose and ketone control solutions (3 levels for glucose and 2 levels for ketone) sold separately.

The FORA Glucose Control Solutions for glucose monitoring were previously cleared in k093724. The β-Ketone Control Solutions are new.

J. Substantial Equivalence Information:

1. Predicate device name(s):

Nova Max Plus Blood Glucose and β-Ketone Monitor System

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

K091547

3. Comparison with predicate:

Similarities and Differences		
Item	Candidate Device FORA ADVANCED GD-40 and GD40 pro Blood Glucose and β-Ketone Monitoring Systems k161738	Predicate Device Nova Max Plus Blood Glucose and β-Ketone Monitor System K091547
Intended Use	For the quantitative measurement of glucose and β-ketone in whole blood	same
Sample type	Capillary whole blood from the finger, venous and neonatal whole blood	Capillary whole blood from the finger, palm and forearm
Glucose measuring range	20-600 mg/dL single patient 10-600 mg/dL multiple patient	20-600 mg/dL
β-Ketone measuring range	0.1 – 8.0 mmol/L	same
methodology	Glucose dehydrogenase β-hydroxybutyrate dehydrogenase	same
Sample size	0.9 uLglucose 1.0 uL ketone	0.3 uL glucose 0.8 uL ketone
Hematocrit range	20-70%	25-60%
Operating conditions	10-40^{0}C, 10-85% RH	14-40^{0}C, 10-90% RH
Reaction time	Glu = 5 seconds β-Ketone = 10 seconds	same same
Data storage	1000 events	400 events

Similarities and differences of the ketone control solution		
	Candidate Device β-Ketone Control Solutions k161738	Predicate Device Nova Max Plus Ketone Control Solutions k091547
Intended use/Indications for Use	Used to check that the meters and ketone test strips are working together properly and that the test is performing correctly.	Used as a quality control check to verify the accuracy of blood ketone test results

Matrix	Water, buffer, salts, viscosity modifier, β-hydroxybutyrate, preservatives, dyes	same
Levels	Levels 1 and 2	Levels 1, 2, and 3

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

CLSI EP05-A2, Evaluation of Precision Performance of Quantitative Measurement Methods; Approved Guideline–Second Edition
CLSI EP6-A, Evaluation of the Linearity of Quantitative Measurement Procedures: A Statistical Approach; Approved Guideline
CLSI EP07-A2, Interference Testing in Clinical Chemistry; Approved Guideline – Second Edition
IEC 60601-1-2, Medical electrical equipment- part 1-2: general requirements for basic safety and essential performance – collateral standard: electromagnetic compatibility – requirements and tests
IEC 62304, Medical device software – software life cycle processes
ISO 14971:2007, Medical Devices – Application of Risk Management to Medical Devices

L. Test Principle:

Glucose measurement is based on electrochemical biosensor technology using the enzyme glucose dehydrogenase to catalyze the formation of gluconolactone from the oxidation of glucose whereby two electrons are produced. The electrical current resulting from this enzymatic reaction is measured and correlated to glucose concentration by the meter. The magnitude of the current is proportional to the concentration of glucose in the sample. The test strip is calibrated to display the equivalent of plasma glucose values to allow comparison of results with laboratory methods. Using the same technology, β-hydroxybutyrate (β-ketone) is converted by β-hydroxybutyrate dehydrogenase and the magnitude of electrical current resulting from this enzymatic reaction is proportional to the amount of β-hydroxybutyrate present in the sample.

M. Performance Characteristics (if/when applicable):

1. <u>Analytical performance:</u>
   Performance testing was conducted on the FORA ADVANCED GD-40 Blood Glucose and β-Ketone Monitoring System only. This is acceptable because the only differences between the FORA ADVANCED GD-40 and FORA ADVANCED GD-40 pro systems are the name and intended use (single-patient vs. multiple-patient use).

a. *Precision/Reproducibility:*

Repeatability

Glucose

Venous blood was spiked with five different glucose concentrations (30-50, 51-110, 111-150, 151-250, and 251-400mg/dL) and tested on ten FORA ADVANCED GD-40 meters and three lots of test strips. Ten replicates were tested per meter per glucose concentration. The results from all strip lots are summarized below:

Glucose Level (mg/dL)	Lot	N	Mean (mg/dL)	SD (mg/dL)	CV (%)
30-50	1	100	47.6	2.10	4.41
	2	100	47.3	2.06	4.35
	3	100	47.1	2.00	4.25
51-110	1	100	92.1	2.62	2.85
	2	100	91.5	2.90	3.17
	3	100	92.8	2.80	3.02
111-150	1	100	132.3	4.18	3.16
	2	100	130.4	3.92	3.00
	3	100	133.7	4.28	3.20
151-250	1	100	225.9	7.10	3.15
	2	100	224.3	6.68	2.98
	3	100	223.5	6.39	2.86
251-400	1	100	386.1	12.08	3.13
	2	100	387.6	11.97	3.09
	3	100	388.3	11.49	2.96

Ketones

Venous blood was adjusted with three different β-ketone concentrations (0.5, 2.5, and 5.0 mmol/L) and tested on ten FORA ADVANCED GD-40 meters and three lots of test strips. Ten replicates were tested per meter per glucose concentration. The results from all strip lots are summarized below:

Ketone Level (mmol/L)	Lot	N	Mean (mmol/L)	SD (mmol/L)	CV (%)
0.5	1	100	0.49	0.057	11.63
	2	100	0.53	0.067	12.64
	3	100	0.52	0.063	12.12
2.5	1	100	2.89	0.099	3.44
	2	100	2.92	0.103	3.54
	3	100	2.95	0.108	3.66
5.0	1	100	5.01	0.191	3.82
	2	100	4.98	0.181	3.64
	3	100	5.00	0.176	3.53

Intermediate Precision:

Glucose

Intermediate Precision was evaluated using three lots of test strips and ten FORA ADVANCED GD-40 meters. Three levels of Glucose control solutions were used. For each level of control, ten replicates were taken each day for ten days, so that 100 individual measurements were generated per control level. The results from all strip lots are summarized below:

Control Level	Strip Lot	N	Mean (mg/dL)	SD (mg/dL)	CV (%)
Level 1 (30-50 mg/dL)	1	100	48.3	2.22	4.59
	2	100	48.7	2.14	4.39
	3	100	48.5	2.16	4.45
Level 2 (96-144 mg/dL)	1	100	131.5	4.48	3.40
	2	100	130.5	4.80	3.68
	3	100	132.8	4.58	3.45
Level 3 (280-420 mg/dL)	1	100	330.8	10.93	3.31
	2	100	331.3	11.47	3.46
	3	100	332.0	11.55	3.48

Ketones

Control Level	Strip Lot	N	Mean (mmol/L)	SD (mmol/L)	CV (%)
Level 1	1	100	0.586	0.057	9.71
	2	100	0.582	0.058	9.88
	3	100	0.583	0.059	10.07
Level 2	1	100	2.588	0.071	2.76
	2	100	2.598	0.074	2.84
	3	100	2.591	0.071	2.75

b. Linearity/assay reportable range:

Linearity for both analytes was evaluated using three lots of test strips and five FORA ADVANCED GD-40 meters. For glucose, 10 venous whole blood samples were spiked with glucose to the following glucose concentrations: 8, 45, 70, 115, 169, 298, 386, 494, 577 and 699 mg/dL. Each glucose level was analyzed 15 times, with 5 measurements per test strip lot. For ketones, 6 venous samples were supplemented with β-ketone concentrations to the following β-ketone concentrations: <0.2, 0.5, 1.0, 2.0, 4.0, and 8.0 mmol/L. Linear regression analysis for each lot compared to results obtained using YSI for glucose and β-Hydroxybutyrate LiquiColor analyzer for ketones resulted in the following:

Glucose
Lot 1: y = 1.006x + 2.406; R2 = 0.998
Lot 2: y = 1.0027x – 0.332; R2 = 0.998
Lot 3: y = 1.0034x + 0.104; R2 = 0.998

Ketone
Lot 1: y = 0.9865x + 0.0058; R2 = 0.9966
Lot 2: y = 0.9925x + 0.0292; R2 = 0.9973
Lot 3: y = 0.9998x – 0.0017; R2 = 0.9981

The results of the study support the sponsor's claimed glucose measurement range of 20-600 mg/dL for the GD40 system and 10-600 mg/dL for the GD40 pro system, and claimed ketone measurement range of 0.1- 8.0 mmol/L for both systems. The meters display 'Lo' when samples are below the measuring range and 'Hi' when samples are above the measuring range for both glucose and ketones. Validation testing was performed demonstrating that these feature function as intended.

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

The FORA ADVANCED GD-40 and FORA ADVANCED GD-40 pro systems are traceable to the NIST SRM 917c glucose reference material and to an in-house standard prepared gravimetrically from commercially available materials for the β-ketone. The method comparison study was performed using the YSI 2300 Glucose analyzer and the β-Hydroxybutyrate LiquiColor analyzer as the reference methods (see Section M.2.a.)

Test strip stability:

Glucose

Open and closed vial stability for the FORA ADVANCED GD-40 and FORA ADVANCED GD-40 pro Blood Glucose Test Strips were assessed in real-time studies. Study protocols and acceptance criteria were reviewed and found acceptable to support the sponsor's claimed closed vial (shelf life) stability of 21 months, and open vial stability of 6 months when stored under the recommended storage conditions of 36°F to 90°F (2-32°C) and relative humidity of 10-85%.

Ketone

Open and closed vial stability for the FORA ADVANCED GD-40 and FORA ADVANCED GD-40 pro Blood β-Ketone Test Strips were assessed in real-time studies. Study protocols and acceptance criteria were reviewed and found acceptable to support the sponsor's claimed closed vial (shelf life) stability of 18 months, and open vial stability of 6 months when stored under the recommended storage conditions of 36°F to 90°F (2-32°C) and relative humidity of 10-85%.

The FORA ADVANCED GD-40 and FORA ADVANCED GD-40 pro Blood β-Ketone Test Strips are also provided in individual foil packages. The shelf life stability of the foil packaged test strips was assessed in a real-time study. The study protocol and acceptance criteria were reviewed and found acceptable to support the sponsor's claimed stability of 18 months when stored under the recommended storage conditions of 36°F to 90°F (2-32°C) and relative humidity of 10-85%.

Control solution stability:

Glucose

The FORA Glucose Control Solutions were previously cleared (k093724). The stability protocols and acceptance criteria were reviewed under k093724 and found to be acceptable to support the claims that the closed control solution vials are stable for 24 months and the open control solution vials are stable for 90 days after opening when stored at the recommended storage conditions of 36°F-86°F (2°C-30°C).

Ketone

Open and closed vial stability protocols and acceptance criteria for the β-Ketone Control Solutions were reviewed and found to be acceptable to support closed vial stability of 24 months and open vial stability of 3 months when stored at the recommended storage conditions of 2-8^{0}C.

Value assignment of controls:

Glucose

The FORA Glucose Control Solutions were previously cleared (k093724) and are identical except in name. The value assignment protocol were reviewed under k093724 and found to be acceptable.

Ketone

Three targeted concentrations of the β-Ketone Control Solutions are prepared gravimetrically and analyzed using the YSI 2300 STAT Plus. Each level of the control solution is tested 25 times. The mean along with SD and CV are used to establish the ranges for each level which are then provided on the test strip vial label.

d. Detection limit:

The glucose measuring range is 20-600 mg/dL for the GD40 device and 10-600 mg/dL for the GD40 pro device, and the ketone measuring range is 0.1-8.0 mmol/L for both. These ranges are validated via the linearity study. See section M.1.b.

e. Analytical specificity:

Glucose

Interference testing was performed to evaluate exogenous and endogenous substances using venous blood spiked to two glucose levels of 75 and 170 mg/dL. The samples were divided into 2 aliquots: control (with no added interferent) and test (with added interferent at a toxic level or 10 times the known therapeutic level). Each sample was measured by the reference method (YSI) and four FORA ADVANCED GD-40 meters. The sponsor defines no significant interference as bias < ± 10% for the test compared to control samples. The following table lists the concentrations of each substance at which no significant interference was detected.

Substance	Highest concentration tested at which no significant interference is observed (mg/dL)
Acetylsalicylic acid	50
Acyclovir	3.1
Allopurinol	5
Amitriptylline	0.27
Amoxicillin	12.5
Ampicillin	5
Aspirin	60
Atenolol	10
Bicarbonate	336
Caffeine	10
Calcium	5mM
Ceftriaxone	250
Chloride	140mM
Cholesterol	500
Cholic acid	6
Clonidine	2
Creatinine	30
Digoxin	0.16
Diphenhydramine	1
Enalapril	0.15
Ephedrine HCl	50
Erythromycin	20
Estrone	0.1
Famotidine	0.13
Fluoxetine	0.8
Folic Acid	13.3
Fructose	1000
Furosemide	2

Substance	Highest concentration tested at which no significant interference is observed (mg/dL)
Galactose	1000
Gamma-Globulin	12000
Gentisic acid	2
Glyburide	1.07
Glycerol	1000
Hemoglobin	500
Ibuprofen	55
Icodextrin	2000
Isomalt	1000
Lactose	1000
Lactitol	1000
Lidocaine	6
Magnesium	5mM
Maltose	1000
Metaproterol	1.81
Metformin HCl	50
Metoprolol	0.3
Naproxen	100
Nifedipine	0.17
Nortriptyline	0.15
Penicillin	12
Phenytoin	10
Piroxicam	5
Potassium	10mM
Sodium	200mM
Sorbitol	1000
Sulfamethoxazole	120
Sulfate	5mM
Terfenadine	0.45
Tetracycline	10
Theophylline	25
Tolbutamide	64
Trimethoprim	12.5
Urea	600
Vancomycin	25
Verapamil	0.45
Vitamin E	20
Warfarin	2
Xylitol	1000

The following table lists the concentrations of substances at which interference was greater than 10%.

Substance	Lowest Concentration above which interference ≥10% is observed (mg/dL)
Acetaminophen	6.25
Ascorbic acid	5
Bilirubin	20
Dopamine	1.25
Levo-dopa	0.7
Mannitol	0.013
Mannose	1.15
Methyl-dopa	0.625
Reduced Glutathione	30
Pralidoxime Iodide	5
Tolazamide	6.25
Triglycerides	3000
Uric acid	10
Xylose	6.25

To address potential interference from acetaminophen ≥ 6 mg/dL and uric acid ≥ 10 mg/dL, the labeling contains the following statements:

Acetaminophen in your blood > 6.25 mg/dL might affect the reliability of your blood glucose results. If you are taking Tylenol your glucose results may not be reliable. If you are unsure, then ask your doctor.

If you have a disease or condition that elevates your blood uric acid level (>10mg/dL), such as gout, your blood glucose results may not be reliable. If you are unsure, then ask your doctor

Ketone

Interference testing was performed to evaluate exogenous and endogenous substances using venous blood spiked to two β-Ketone levels of 1.0 and 3.0 mmol/L. The samples were divided into 2 aliquots: control (with no added interferent) and test (with added interferent at a toxic level or 10 times the known therapeutic level). Each sample was measured by the β-Hydroxybuturate LiquiColor analyzer and four FORA ADVANCED GD-40 meters. The sponsor defines no significant interference as bias < ± 10% for the test compared to control samples. The following table lists the

concentrations of each substance at which no significant interference was detected:

Substance	Highest concentration tested at which no significant interference is observed (mg/dL)
Acetoacetate	20.4
Acetone	69.6
Acetylsalicylic acid	50
Acyclovir	3.1
Allopurinol	5
Amitriptylline	0.27
Amoxicillin	12.5
Ampicillin	5
Aspirin	60
Atenolol	10
Bicarbonate	336
Caffeine	10
Calcium	5mM
Chloride	140mM
Cholic acid	6
Clonidine	2
Creatinine	5
Digoxin	0.16
Diphenhydramine	1
Enalapril	0.15
Ephedrine HCl	60
Erythromycin	20
Estrone	0.1
Famotidine	0.13
Fluoxetine	0.8
Fructose	1000
Furosemide	2
Gamma-Globulin	12000
Glyberide	1.07
Ibuprofen	55
Isomalt	1000
Lactose	1000
Lactitol	1000
Lidocaine	6
Magnesium	5mM
Maltitol	1000
Maltose	1000
Mannitol	1000
Metaproterol	1.81

Metoprolol	0.3
Naproxen	100
Nifedipine	0.17
Nortriptyline	0.15
Penicillin	12
Phenytoin	10
Piroxicam	5
Potassium	10mM
Sodium	200mM
Sorbitol	1000
Sulfamethoxazole	120
Sulfate	5mM
Terfenadine	0.45
Tetracycline	4
Theophylline	25
Tolbutamide	64
Urea	600
Vancomycin	25
Verapamil	0.45
Vitamin E	20
Warfarin	2
Xylitol	1000
Xylose	1000

The following table lists the concentrations of substances at which interference was greater than 10%.

Substance	Lowest Concentration above which interference ≥10% is observed (mg/dL)
Ascorbic acid	4
Captopril	500
Cholestrol	500
Dopamine	0.09
Gentisic acid	1.8
Levo-dopa	0.6
N-acetlycysteine	2.59
Paracetamol	25
Triglycerides	1500
Uric acid	24
Unconjugated bilirubin	20

f. Assay cut-off:

Not applicable

2. Comparison studies:

a. Method comparison with predicate device:

Glucose

System accuracy for glucose was assessed in a study using six FORA ADVANCED GD-40 meters and three lots of FORA ADVANCED GD-40 Blood Glucose test strips. Results from the meter were compared to results from the YSI analyzer. Capillary samples from the finger and sodium heparinized venous samples from 172 participants were collected. The total glucose concentration range of capillary samples tested was 43 - 512 mg/dL and total glucose concentration range of venous samples was 44-514 mg/dL. To achieve glucose concentrations less than 50 mg/dL, 6 finger and venous samples were allowed to glycolyze. To achieve glucose concentrations greater than 400 mg/dL, 4 finger and venous samples were spiked. Results of the meter measurements relative to YSI are summarized below:

Capillary-

Glucose concentration <75 mg/dL

Within ±5 mg/dL	Within ±10 mg/dL	Within ±15 mg/dL
18/33 (54.5%)	28/33 (84.8%)	33/33 (100%)

Glucose concentration ≥75 mg/dL

Within ±5%	Within ±10%	Within ±15%	Within ±20%
85/139 (61.2%)	121/139 (87.1%)	136/139 (97.8%)	139/139 (100%)

Venous-

Glucose concentration <75 mg/dL

Within ±5 mg/dL	Within ±10 mg/dL	Within ±15 mg/dL
32/36 (88.9%)	36/36 (100.0%)	36/36 (100%)

Glucose concentration ≥75 mg/dL

Within ±5%	Within ±10%	Within ±15%	Within ±20%
105/136 (77.2%)	129/136 (94.9%)	136/136 (100%)	136/136 (100%)

Linear regression analyses results are summarized below:

capillary $y= 0.9800x – 0.859$, $R^2 = 0.9863$

venous $y = 0.993x – 1.443$, $R^2 = 0.9894$

Ketone

System Accuracy for β-Ketone was assessed in a study using six FORA ADVANCED GD-40 meters and three lots of FORA ADVANCED GD-40 β-Ketone test strips. Results from the meter were compared to results from the β-Hydroxybutyrate LiquiColor analyzer. Capillary samples from the finger and sodium heparinized venous samples from of 120 participants were collected. The total range of capillary samples tested was 0.11- 6.77 mmol/L and total range of venous samples was 0.04-5.59 mmol/L. Results of the meter measurements relative to the comparator method are summarized below:

Capillary-

Ketone concentration <2 mmol/L

Within ±3 mmol/L	Within ±5 mmol/L
84/89 (94.4%)	89/89 (100%)

Ketone concentration ≥2 mmol/L

Within ±5%	Within ±10%	Within ±15%	Within ±20%	Within ±25%
13/31(41.9%)	26/31(83.9%)	29/31 (93.5%)	31/31 (100%)	31/31 (100%)

Venous-

Ketone concentration <2 mmol/L

Within ±3 mmol/L	Within ±5 mmol/L
87/89 (97.8%)	89/89 (100%)

Ketone concentration ≥2 mmol/L

Within ±5%	Within ±10%	Within ±15%	Within ±20%	Within ±25%
15/31(48.4%)	27/31 (87.1%)	31/31 (100%)	31/31(100%)	31/31 (100%)

Results of the linear regression analyses are as follows:

capillary $y = 0.975x - 0.0283$, $R^2 = 0.9758$

venous $y = 0.988x - 0.0187$, $R^2 = 0.9833$

Neonatal Capillary heelstick

To assess the glucose performance of the FORA ADVANCED GD-40 system with neonatal capillary heelstick, the sponsor performed a study with a total of 364 neonates under 28 days old. 199 capillary heelstick samples were obtained. The samples ranged from 19.6-121 mg/dL as measured by YSI. The results are summarized in the tables below:

Capillary Heelstick

Glucose concentration <75 mg/dL

Within ±5 mg/dL	Within ±10 mg/dL	Within ±15 mg/dL
57/116 (49.1%)	102/116 (87.9%)	115/116 (99.1%)

Glucose concentration ≥75 mg/dL

Within ±5%	Within ±10%	Within ±15%	Within ±20%
42/83 (50.6%)	68/83 (81.9%)	81/83 (97.6%)	83/83 (100%)

Results of the linear regression analyses are as follows:

Capillary $y = 0.9154x + 7.413$, $R^2 = 0.9613$

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):

Glucose

To assess the glucose performance of the FORA ADVANCED GD-40 system in the hands of the intended users the sponsor performed a study with 160 diabetic lay user participants. Participants obtained and tested their own fingerstick samples with the FORA ADVANCED GD-40 system. Blood glucose results from the GD-40 meter obtained by the lay user were compared to the YSI reference value. The samples ranged from 49 to 520 mg/dL as measured by YSI. The results are summarized in the tables below:

Glucose concentration <75 mg/dL

Within ±5 mg/dL	Within ±10 mg/dL	Within ±15 mg/dL
22/33 (66.7%)	32/33 (97%)	33/33 (100%)

Glucose concentration ≥75 mg/dL

Within ±5%	Within ±10%	Within ±15%	Within ±20%
100/127 (78.7%)	122/127 (96.1%)	125/127 (98.4%)	127/127 (100%)

Results of the linear regression analysis:

$y = 0.9683x + 6.057$, $R^2 = 0.975$

Ketone

To assess the ketone performance of the FORA ADVANCED GD-40 system in the hands of the intended users the sponsor performed a study with 120 lay user participants. Participants obtained and tested their own fingerstick samples with the FORA ADVANCED GD-40 system. β-Ketone results from the GD-40 meter obtained by the lay user were compared to the β-Hydroxybutyrate LiquiColor analyzer. The samples ranged from 0.04 to 6.77 mmol/L. Results of the meter measurements relative to the comparator method are summarized below:

Ketone concentration <2 mmol/L

Within ±3 mmol/L	Within ±5 mmol/L
80/89 (89.9%)	89/89 (100%)

Ketone concentration ≥2 mmol/L

Within ±5%	Within ±10%	Within ±15%	Within ±20%	Within ±25%
15/31(48.4%)	25/31(80.6%)	30/31 (96.8%)	30/31 (96.8%)	31/31 (100%)

Results of the linear regression analysis:

$y=1.019x – 0.043$, $R^2= 0.979$

4. Clinical cut-off**:**

Not applicable

5. Expected values/Reference range:

The fasting adult blood glucose range for a person without diabetes[1]:

- Before meals <100 mg/dL (5.6 mmol/L)
- After meals: <140 mg/dL (7.8 mmol/L)

[1]American Diabetes Association: Standards of medical care in diabetes (2016). Diabetes Care, Vol 39, Supplement 1, S16.

N. Instrument Name:

FORA ADVANCED GD-40 Blood Glucose and β-Ketone Meter
FORA ADVANCED GD-40 pro Blood Glucose and β-Ketone Meter

O. System Descriptions:

1. Modes of Operation:

   Does the applicant's device contain the ability to transmit data to a computer, webserver, or mobile device?

   Yes _____x___ or No _____

   Does the applicant's device transmit data to a computer, webserver, or mobile device using wireless transmission?

   Yes _____x___ or No _____

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:

   The device is intended to be used with capillary whole blood from the finger, venous whole blood, and neonatal capillary heelstick and venous whole blood. The whole blood sample is applied directly to the test strip by capillary action therefore there are no special handling or storage issues.

5. Calibration:

   Coding is necessary for β-Ketone, but not for glucose. A code strip is provided and the user is instructed to calibrate every time a new vial of ketone test strips is begun.

6. Quality Control:

   The sponsor provides 3 levels of FORA Glucose Control Solutions and 2 levels of β-

Ketone Control Solutions, all sold separately. The outer kit box labels state that controls are necessary but not included and must be purchased separately.

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

1. **Altitude study:** An altitude study was performed in a glove box to simulate 3 different altitudes (0, 5000 and 15000 feet). Venous whole blood was spiked to achieve seven glucose concentrations (65, 110, 185, 275, 380, 465, and 580 mg/dL) and five ketone levels (0.2, 1.0, 3.0, 6.0, and 8.0 mmol/L). Each sample was tested with 4 meters and the glucose results were compared to YSI and the ketone results to β-Hydroxybutyrate LiquiColor. The results demonstrate acceptable bias to support the claims that altitudes up to 10,742 feet have no significant effect on blood glucose or ketone measurements with these systems.

2. **Hematocrit study:** The effect of different hematocrit levels were evaluated using venous whole blood samples with hematocrit levels of 20%, 30%, 40%, 50%, 60%, and 75%. Five samples were spiked to glucose concentrations of 57, 125, 236, 389, and 565 mg/dL, as measured by YSI, and four samples were spiked to β-ketone levels of 1.0, 2.8, 4.7 and 7.0 mmol/L, as measured by the β-Hydroxybutyrate LiquiColor method. The samples were tested with 6 meters and the results were compared to YSI and the normal 40% hematocrit. The % biases relative to YSI were acceptable within the claimed hematocrit range and support the claimed hematocrit range of 20 to 60%.

   The sponsor conducted an additional hematocrit evaluation with 22 neonate capillary blood samples with glucose concentrations ranging from 10-50 mg/dL and hematocrit levels from 50 – 65%. The data demonstrates no affect from high hematocrit levels at low glucose concentrations, as is expected to occur in the neonatal population. The data supports the claimed hematocrit range from 20-60%.

3. **Infection control studies:** The FORA ADVANCED GD-40 meter is intended for single-patient use, and the FORA ADVANCED GD-40 pro meter is intended for multiple-patient use. Disinfection efficacy studies were performed on the materials comprising the meters by an outside commercial laboratory service to demonstrate complete inactivation of hepatitis B virus (HBV) with Micro-Kill Wipes (EPA Reg. No. 59894-10-37549). Robustness studies were performed by the sponsor demonstrating that there was no change in performance or in external materials of the meters after 10,950 cleaning and disinfection cycles with Micro-Kill Wipes. The robustness studies were designed to simulate 3 years of multiple-patient use and 5 years of single-patient use. Labeling was reviewed for adequate instructions for the validated cleaning and disinfection procedures.

4. **Sample volume study:** A sample volume study was performed using venous whole blood samples. Three samples were spiked to glucose concentrations of 39 mg/dL, 133 mg/dL and 325 mg/dL, as measured by YSI, to evaluate the effect of different sample volumes (0.7 μL, 0.8 μL, 0.9 μL, 1.0 μL, 1.1 μL, and 1.2 μL) on the glucose

performance of the device. Three samples were spiked to β-Ketone levels of 0.5, 2.0, and 4.0 mmol/L, as measured by the β-Hydroxybutyrate LiquiColor method, to evaluate the effect of different sample volumes (0.8, 0.9, 1.0, 1.1, 1.2, and 1.3 mmol/L on the β-Ketone performance of the device. Three lots of test strips and 5 meters were used. Results from these studies support the claimed minimum sample volume of 0.9 µL for glucose and 1.0µL for β-Ketone. The meter displays an error message (E-F) for both analytes when an insufficient amount of blood sample is applied. The sponsor provided adequate validation for this error message.

5. **Operating Temperature and Humidity:** Operating temperature and humidity conditions were evaluated using four meters and three lots of glucose and ketone test strips with venous whole blood samples at three glucose concentrations (70 mg/dL, 125 mg/dL, and 320 mg/dL by YSI) and three β-Ketone levels (0.5, 2.0, and 4.0 mmol/L) The following temperature and humidity conditions were tested: 50°F (10°C)/10% RH, 50°F (10°C)/85% RH, 104°F (40°C)/10%RH, and 104°F (40°C)/85% RH. The results support the sponsor's claimed operating temperature from 50°F to 104°F (10°C - 40°C) and relative humidity range from 10-85%.

6. **EMC testing and Electrical Safety Studies:** The sponsor provided documentation certifying that acceptable electromagnetic testing (EMC) had been performed and the System was found compliant.

7. **Software documentation**: The software documentation was reviewed and found to be acceptable. The firm provided documentation to support the device was designed, developed and is under good software lifecycle processes .

8. **Readability Assessment:** A Flesch-Kinkaid reading level assessment was conducted demonstrating that the user manual, test strip inserts, and control inserts were written at or below an 8th grade reading level.

This device was cleared after the FDA issued final guidance documents for prescription use blood glucose monitoring systems (BGMS) and over-the-counter use blood glucose monitoring systems (SMBG). However, the recommendations in the guidance documents were not followed for this device since the submission was received prior to the finalization of the guidance documents.

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.