510(k) SUBSTANTIAL EQUIVALENCE DETERMINATION
DECISION SUMMARY

A. 510(k) Number:
k112755

B. Purpose for Submission:
New device

C. Manufacturer and Instrument Name:
Diatron US Inc., Abacus 5

D. Type of Test or Tests Performed:
Quantitative test for WBC, NEU%, NEU#, LYM%, LYM#, MON%, MON#, EOS%, EOS#, BAS%, BAS#, RBC, HGB, HCT, MCV, MCH, MCHC, RDWcv, RDWsd, PLT, and MPV parameters.

E. System Descriptions:

1. Device Description:
   The Abacus 5 is a fully automated bench-top hematology analyzer featuring a color touch screen display with a user interface capable of reporting 21 hematology parameters including CBC with a five-part WBC differential. The analyzer is supplied with specialized reagents including Diluent, Lyse, Diff and Cleaner. An optional Autosampler is available for automated processing of up to 100 sample tubes for increased laboratory efficiency. The main analyzer, data module, and display station are housed as a single unit. The Abacus 5 analyzer's software system supports the use of commonly used external printers via USB connections.
2. Principles of Operation:
   The Abacus 5 analyzer uses volumetric impedance to determine the cellular concentrations and volume distributions of WBC, RBC, and PLT. The HGB concentration is determined by photometric measurement of light absorbance. Optical measurement of light scattering and diffraction is used to determine the five-part leukocyte differential parameters. The MCV and RDW values are derived from statistical analysis of the RBC histogram. The HCT, MCH, and MCHC are calculated values. The MPV value is derived from statistical analysis of the PLT histogram.
3. Modes of Operation:
   The Abacus 5 operates in both open and closed sample tube mode.
4. Specimen Identification:
   The sample ID can be entered by the operator from a keyboard or hand held barcode reader for a manually processed specimen. For automatically processed specimens, the sample ID can be read from a sample tube barcode or entered into a list for one of the automatic processing list modes.
5. Specimen Sampling and Handling:
   Manually presented whole blood K_3EDTA sample tubes must be mixed properly prior to specimen analysis. Sample tubes are placed into a tube adapter inserted

on the sample rotor for closed vial or open vial single tube manual sample processing. A minimum of 30 minutes should elapse between collection of the blood sample and analysis on the Abacus 5 to ensure that the interaction of blood and anticoagulant has fully stabilized.

6. Calibration:
   The Abacus 5 analyzer calibration process consists of running a commercial calibrator material multiple times. The calibration procedure ends when three or seven accepted calibration replicates are completed. The known calibrator parameter values and the average values of multiple runs are used to calculate calibration factors. Diatron recommends performing calibration at installation, when indicated by quality control, after major maintenance or service, and at periodic time intervals as directed by laboratory regulatory agencies.
7. Quality Control:
   Diatron recommends the use of CBC-3K controls from R&D Systems to verify performance of the Abacus 5. Perform quality control at intervals established by the laboratory or as required by laboratory accreditation, licensing, or regulatory agencies.
8. Software:
   FDA has reviewed applicant's Hazard Analysis and Software Development processes for this line of product types:
   Yes___X____ or No_____

F. Regulatory Information:

1. Regulation section:
   21 CFR § 864.5220, Automated differential cell counter
2. Classification:
   Class II
3 Product code:
   GKZ, Counter, differential cell
4. Panel:
   Hematology (81)

G. Intended Use:

1. Indication(s) for Use:
   The Diatron Abacus 5 System is a quantitative multi-parameter automated hematology analyzer designed for in-vitro-diagnostic use in clinical laboratories for enumeration of the following parameters in K_3EDTA anti-coagulated venous whole blood samples: WBC, LYM%, LYM#, MON%, MON#, NEU%, NEU#, EOS%, EOS#, BAS%, BAS#, RBC, HGB, HCT, MCV, MCH, MCHC, RDWcv, RDWsd, PLT, and MPV. The Diatron Abacus 5 is indicated for use to identify patients with hematologic parameters within and outside of established reference ranges.
2. Special Conditions for Use Statement(s):
   For Prescription Use Only

H. Substantial Equivalence Information:

1. Predicate Device Name(s) and 510(k) numbers:
   Abbott Cell-Dyn 3700 (k991605)
2. Comparison with Predicate Device:

Similarities		
Item	Device	Predicate
	Abacus 5	Cell-Dyn 3700
Intended Use	The Diatron Abacus 5 System is a quantitative multi-parameter automated hematology analyzer designed for in-vitro-diagnostic use in clinical laboratories for enumeration of the following parameters in K_3EDTA anti-coagulated venous whole blood samples: WBC, LYM%/#, MON%/#, NEU%/#, EOS%/#, BAS%/#, RBC, HGB, HCT, MCV, MCH, MCHC, RDW, PLT, MPV	The CELL-DYN 3700 System is a automated, multi-parameter hematology analyzer intended to classify the following formed elements of EDTA anticoagulated blood: WBC, NEU%/#, LYM%/#, MONO%/#, EOS%/#, BASO%/#, RBC, HGB, HCT, MCV, MCH, MCHC, RDW, PLT, MPV
Sampling Mechanisms	Manual sampling (open tube mode) Closed vial mode Autosampler cap piercing	Same
Sample ID	Manual and barcode	Same
Methodology	WBC Differential-Optical RBC, PLT- Impedance HGB – Photometric MCV- Derived	Same
Parameters	WBC, LYM%/#, MON%/#, NEU%/#, EOS%/#, BAS%/#, RBC, HGB, HCT, MCV, MCH, MCHC, RDWcv, RDWsd, PLT, MPV.	Same except RDWsd
QC data	Maintains QC files; generated Levey-Jennings charts	Same
Flags/Alerts	Provides dispersional data alerts, suspect parameter messages and suspect population flags to assist in data review.	Same

Differences		
Item	Device	Predicate
	Abacus 5	Cell-Dyn 3700
Methodology	WBC- impedance	WBC- simultaneous optical and impedance
Parameter (reticulocytes)	Not performed	RETIC#/%, IRF
Throughput	60 samples/hr.	90 samples/hr.
Sample Aspiration Volume	Open Mode: 110µL Closed Vial Mode: 110µL Autosampling: 110µL	Open Mode: 130µL Closed Vial Mode: 240µL Autosampling: 355µL
Sample Type	K_3EDTA anticoagulated venous whole blood	K_3 and K_2EDTA anticoagulated venous whole blood
Reagents	Diatro Dil-5P Diluent, Diatro Lyse-5P, Diatro Diff-5P, Diatro Hypocleaner CC	Diluent, CN-Free Lyse Reagent, Enzymatic Cleaner, Detergent Sheath Reagent, Reticulocyte Reagent
Calibrator, and Controls	R&D Systems CBC-3K®, R&D Systems CBC CAL Plus	CELL-DYN 26 Plus Control, CELL-DYN HemCal Plus Calibrator
Data Storage	100,000 record storage capacity	10,000 record storage capacity

I. Special Control/Guidance Document Referenced (if applicable):

CLSI EP05-A2 Evaluation of Precision Performance of Quantitative Measurement Methods; Approved Guideline-Second Edition

CLSI EP06-A, Evaluation of the Linearity of Quantitative Measurement Procedures: A Statistical Approach; Approved Guideline

CLSI EP07-A2 Interference Testing in Clinical Chemistry; Second Edition

CLSI EP09-A2, Method Comparison and Bias Estimation Using Patient Samples; Approved Guideline-Second Edition

CLSI EP17-A Protocols for the Determination of Limits of Detection and Limits of Quantitation; 1st Edition

CLSI H26-A2 Validation, Verification, and Quality Assurance of Automated Hematology Analyzers; 2nd Edition

CLSI C28-A3 Defining, Establishing, and Verifying Reference Intervals in the Clinical Laboratory; 3rd Edition

CLSI H20-A2 Reference Leukocyte (WBC) Differential Count (Proportional) and Evaluation of Instrumental Methods; 2nd Edition

J. Performance Characteristics*:*

1. Analytical Performance:
   a. Accuracy:
   Each parameter of the Abacus 5 was compared to the predicate analyzer Cell-Dyn 3700. A total of 828 samples were analyzed at three (3) sites, two in Hungary and one in the US. Patient demographics include age range from >1

month to >80 years of age. Approximately, one-third (n = 281) samples were normal and two-thirds (n = 563) had one or more abnormal conditions. In addition, 47.5% were male and 52.5% were female. The correlation analysis was performed using the first valid replicate of the Abacus 5 against the first valid replicate of the Cell-Dyn 3700. Accuracy summary data analysis is provided in the tables below:

Site 1- Regression Results

(n = 295)				Intercept 95% CI			Slope 95% CI	
Parameter	Range	(r)	Intercept	Lower	Upper	Slope	Lower	Upper
WBC	0.30-52.4	0.9994	0.0221	-0.0555	0.0996	0.9956	0.9835	1.0077
NEU%	8.4-91.6	0.9915	0.9888	-0.1620	2.1396	1.0123	0.9943	1.0303
LYM%	3.9-88.0	0.9934	-0.1398	-0.5329	0.2532	0.9867	0.9718	1.0016
MON%	0.0-13.8	0.9218	-0.5901	-0.9555	-0.2247	0.9708	0.9165	1.0251
EOS%	0.0-12.2	0.9662	0.0594	-0.0617	0.1805	0.9852	0.9267	1.0437
BAS%	0.0-2.7	0.4960	-0.0431	-0.1245	0.0383	0.9385	0.8603	1.0168
RBC	1.59-7.38	0.9088	0.0331	-0.0048	0.0710	0.9958	0.9866	1.0050
HGB	4.8-21.3	0.9983	0.0716	-0.0313	0.1744	1.0023	0.9943	1.0104
MCV	61-113	0.9947	0.1371	-0.9124	1.1867	0.9990	0.9877	1.0102
RDWcv	12.6-29.6	0.9828	-0.1139	-0.5485	0.3206	1.0055	0.9787	1.0323
PLT	19-1095	0.9971	-0.8223	-3.0071	1.3625	1.0143	1.0064	1.0223
MPV	3.0-12.7	0.9548	-0.9445	-1.3741	-0.5149	1.1102	1.0566	1.1638

Site 2- Regression Results

(n =295)				Intercept 95% CI			Slope 95% CI	
Parameter	Range	(r)	Intercept	Lower	Upper	Slope	Lower	Upper
WBC	0.11-87.0	0.9987	0.1430	0.0218	0.2642	0.9674	0.9519	0.9828
NEU%	0.40-93.7	0.9924	1.8630	0.5963	3.1296	0.9957	0.9755	1.0160
LYM%	2.3-86.1	0.9932	0.2191	-0.2648	0.7030	0.9626	0.9438	0.9814
MON%	0.9-25.6	0.8531	-0.6116	-1.3303	0.1072	1.0110	0.9173	1.1047
EOS%	0.0-13.0	0.9349	-0.0791	-0.1898	0.0317	1.0152	0.9536	1.0767
BAS%	0.0-4.9	0.6136	-0.5237	-0.9532	-0.0942	1.3386	0.8424	1.8349
RBC	1.49-7.99	0.9358	0.0366	-0.0106	0.0837	0.9852	0.9740	0.9965
HGB	3.8-23.9	0.9966	-0.2970	-0.4611	-0.1328	1.0374	1.0236	1.0511
MCV	61-106	0.9771	-8.2639	-10.7298	-5.7980	1.0960	1.0676	1.1243
RDWcv	11.8-35.9	0.8645	-2.7534	-5.2632	-0.2436	1.2337	1.0584	1.4090
PLT	7-1154	0.9741	-6.9212	-14.6317	0.7894	1.0674	1.0317	1.1032
MPV	3.0-14.3	0.7219	-2.5373	-5.0791	0.0046	1.2490	0.9550	1.5429

Site 3- Regression Results

(n =238)				Intercept 95% CI			Slope 95% CI	
Parameter	Range	(r)	Intercept	Lower	Upper	Slope	Lower	Upper
WBC	0.85-88.6	0.9974	-0.0731	-0.6645	0.5182	0.9928	0.9224	1.0633
NEU%	2.0-96.4	0.9912	0.3192	-1.4153	2.0538	1.0102	0.9844	1.0360
LYM%	1.7-96.7	0.9876	0.9019	0.1517	1.6522	0.9510	0.9197	0.9823
MON%	0.5-22.2	0.7952	-0.4382	-1.6670	0.7905	0.9997	0.8169	1.1825

(n =238)				Intercept 95% CI			Slope 95% CI	
Parameter	Range	(r)	Intercept	Lower	Upper	Slope	Lower	Upper
EOS%	0.0-10.7	0.9200	-0.0729	-0.2168	0.0711	0.9730	0.8682	1.0778
BAS%	0.0-7.6	0.5366	-0.4982	-1.1825	0.1860	1.5717	0.5926	2.5508
RBC	1.84-7.39	0.9355	0.0017	-0.0549	0.0584	0.9928	0.9793	1.0063
HGB	3.0-22.5	0.9972	-0.2427	-0.3888	-0.0966	1.0273	1.0148	1.0397
MCV	66-109	0.9846	0.8628	-1.2881	3.0136	0.9895	0.9649	1.0141
RDWcv	12.5-23.9	0.9189	0.4077	-1.3426	2.1581	0.9914	0.8753	1.1075
PLT	9-916	0.9814	3.0983	-4.1731	10.3696	1.0285	0.9941	1.0629
MPV	3.1-16.6	0.6783	-0.8755	-2.9770	1.2261	1.0587	0.8673	1.2501

The ability of the Abacus 5 to flag abnormal samples was evaluated per CLSI H20-A2 in comparison with the reference method (Manual Microscopy). A total of 210 samples were analyzed on the Abacus 5 in combination with manual differential reviews. The WBC distributional flagging statistical analysis data are summarized in the tables below:

Distributional Results: 2 x 2 Table and Figures of Merit

		Abacus 5	
		Positive (Abnormal)	Negative (Normal)
Manual Microscopy	Positive (Abnormal)	63	7
	Negative (Normal)	23	117

Agreement	85.7%
Sensitivity	90.0%
Specificity	83.6%

b. Precision/Reproducibility:

The Abacus 5 repeatability evaluation was conducted using 22 human blood samples and three levels of control. The samples were selectively chosen to span the analytical measuring range and to be close to clinical decision points on two Abacus 5 instruments. A minimum of 15 and a maximum of 21 replicates were run for each sample.

The following tables represent reproducibility and intermediate precision using commercial controls. Two replicates of low, normal, and high control samples were run twice per day at three different sites for 20 working days. The data from three instruments was analyzed to determine the overall mean and precision for between-site, between-day, within-day, and within-device.

Low Control	WBC	RBC	HGB	MCV	RDWcv	PLT	MPV
Mean (n = 240)	3.1	2.19	5.5	83.0	17.4	95.2	8.4
Between-Site SD	0.043	0.028	0.005	0.911	0.690	1.573	0.762
Between-Day SD	0.020	0.000	0.052	0.295	0.126	3.714	0.229
Within-Day SD	0.020	0.024	0.000	0.383	0.000	3.011	0.250
Within-Device SD	0.064	0.033	0.101	0.641	0.305	6.698	0.569
Within-Device CV	2.06%	1.49%	1.83%	0.77%	1.75%	7.0%	6.79%

Low Control	NEU%	LYM%	MON%	EOS%	BAS%
Mean (n = 240)	48.4	44.8	5.2	1.6	0.121
Between-Site SD	1.319	0.375	1.497	0.202	0.020
Between-Day SD	0.521	0.107	0.417	0.085	0.009
Within-Day SD	0.731	0.000	0.635	0.130	0.019
Within-Device SD	1.466	1.073	1.003	0.295	0.038

Normal Control	WBC	RBC	HGB	MCV	RDWcv	PLT	MPV
Mean (n = 240)	7.9	4.63	13.0	96.4	15.3	269	8.9
Between-Site SD	0.071	0.051	0.102	1.331	0.611	4.654	0.429
Between-Day SD	0.059	0.031	0.067	0.351	0.076	7.454	0.385
Within-Day SD	0.045	0.022	0.000	0.638	0.082	6.541	0.172
Within-Device SD	0.128	0.061	0.169	0.837	0.243	12.450	0.540
Within-Device CV	1.62%	1.32%	1.30%	0.87%	1.59%	4.6%	6.05%

Normal Control	NEU%	LYM%	MON%	EOS%	BAS%
Mean (n = 240)	65.2	27.3	2.9	4.4	0.123
Between-Site SD	0.768	0.385	0.773	0.368	0.027
Between-Day SD	0.353	0.172	0.347	0.050	0.019
Within-Day SD	0.501	0.000	0.327	0.191	0.014
Within-Device SD	0.897	0.647	0.565	0.362	0.036

High Control	WBC	RBC	HGB	MCV	RDWcv	PLT	MPV
Mean (n = 240)	24.1	5.16	16.4	101.7	15.1	501.5	8.9
Between-Site SD	0.325	0.058	0.120	1.183	0.389	1.257	0.345
Between-Day SD	0.166	0.029	0.090	0.365	0.030	5.458	0.104
Within-Day SD	0.177	0.025	0.068	0.475	0.122	5.042	0.117
Within-Device SD	0.354	0.060	0.168	0.806	0.262	11.783	0.258
Within-Device CV	1.47%	1.16%	1.02%	0.79%	1.74%	2.4%	2.91%

High Control	NEU%	LYM%	MON%	EOS%	BAS%
Mean (n = 240)	69.9	23.4	3.7	2.7	0.177
Between-Site SD	1.394	0.557	1.453	0.450	0.041
Between-Day SD	0.276	0.134	0.213	0.086	0.000
Within-Day SD	0.459	0.167	0.408	0.102	0.016
Within-Device SD	0.816	0.403	0.739	0.209	0.029

c. *Linearity*:
The analytical measuring range (AMR) was established by analyzing dilutions made from manipulated whole human blood or from commercial linearity kit material. In order to demonstrate that each parameter is within the claimed performance, a minimum of 9 proportional dilutions spanning the reportable range were run in triplicate on two Abacus 5 analyzers. The high concentration sample is diluted with low concentration sample to create seven intermediate proportional dilutions. All of the eight linearity runs produced coefficients of determination (r^2) >0.95 for each measurand. The following parameters are linear within the stated AMR:

Measurand	Units	AMR
WBC	$10^3/\mu L$	0.21 – 100.0
HGB	g/dL	1.1 – 22.2
RBC	$10^6/\mu L$	0.36 – 7.19
PLT	$10^3/\mu L$	16 – 1000

d. *Carryover*:
Carryover was determined using three Abacus 5 analyzers by running whole blood specimens with high target values (HTV) of WBC, RBC, HGB, and PLT. Each specimen was run in triplicate followed by three aspirations of whole blood specimens with low target values (LTV). Carryover % was

calculated by using the following equation: % Carryover = (LTV1 − LTV3)/ (HTV1 − LTV3) x 100. The maximum carryover for WBC, RBC, HGB, and PLT are 1.00%, 0.50%, 0.80%, and 1.00% respectively. The upper 95% confidence intervals (CI) of the carryover point estimates for each parameter tested are shown in the following table:

Abacus 5	Upper 95% CI			
	WBC	RBC	HGB	PLT
Analyzer #1	0.043%	0.10%	0.46%	0.30%
Analyzer #2	0.017%	0.04%	0.23%	0.63%
Analyzer #3	0.017%	0.07%	0.68%	0.51%

e. Interfering Substances:

Test samples are created by adding interfering substances to normal samples such as bilirubin and lipids based on CLSI EP07-A2. Other evaluations were made by finding naturally occurring human blood samples with potential interferences such as high WBC, platelet abnormalities and NRBCs. A bias of 5% or more was considered clinically significant in the directly measured parameters. Two Abacus 5 instruments were used in the evaluation of interfering substances. Measurands were not impacted by bilirubin up to 30 mg/dL. The following parameters were affected by interference from NRBC, PLT clumps/large PLT, increased WBC, and lipids (see table below):

Parameter	Interference
WBC	> 5 NRBCs/100 WBCs , PLT clumps/large PLTs
RBC	WBC Count > 75.0 x103/µL
MCV	WBC Count > 75.0 x103/µL
PLT	PLT clumps/large PLTs
Hemoglobin	WBC count > 75.0 x103/µL , Lipids > 280 mg/dL
Differential	> 5 NRBCs/100 WBCs , PLT clumps/large PLTs

f. Background Counts:

Daily Start-up background counts were performed on the Abacus 5 and were verified by each site against the specifications. Start-up background specifications were achieved before data collection. The Abacus 5 background specifications are as follows:

Measurand	Background Concentration Limits
WBC	≤ 0.20
RBC	≤ 0.05
HGB	≤ 1.0
PLT	≤15

2. Other Supportive Instrument Performance Data Not Covered Above:

Studies were conducted to support claims and attributes for whole blood sampling. They were designed to evaluate the following:

a. Sample stability:

The parameters selected for this evaluation are the directly measured parameters (WBC, RBC, HGB, PLT), the optically measured parameters (NEU%, LYM%, MON%, EOS%, BAS%) and the derived parameters (MCV, RDWcv, MPV). A total of 10 normal and six abnormal K_3 EDTA anticoagulated human whole blood samples were analyzed on two Abacus 5 instruments at 0.5 hours after venipuncture and at various time intervals thereafter. The averages of the parameters at each time point were compared to the baseline averages. The results support sample stability at room temperature (20 - 23°C) of 7 hours.

b. Comparison of open and closed vial sampling:

A minimum of 31 K_3 EDTA anticoagulated human blood samples spanning the reportable range were used in the study. The specimens were run in closed vial cap pierce mode (selected as the reference as per CLSI H26-A2) and compared to the open vial mode and to the Autosampler automatic processing mode. The testing demonstrated that the Abacus 5 will process specimens using open and closed mode sampling in the same manner.

c. Reference ranges:

Evaluation of reference ranges for the Abacus 5 instrument was conducted using a data set of 240 normal human whole blood samples collected at the US site. Of these 240 samples, 120 were from female patients and 120 were from male patients. The manufacturer recommends each laboratory establish its own reference range.

Parameter	Units	Lower limit	Upper limit
WBC	$10^3/\mu L$	4.50	10.37
LYM	%	14.76	45.40
MON	%	2.91	12.1
NEU	%	42.90	78.10
EOS	%	0.10	7.00
BAS	%	0.15	1.60
LYM	$10^3/\mu L$	1.08	3.17
MON	$10^3/\mu L$	0.20	0.91
NEU	$10^3/\mu L$	2.43	7.42
EOS	$10^3/\mu L$	0.01	0.53
BAS	$10^3/\mu L$	0.01	0.13
RBC	$10^6/\mu L$	F-3.86 M-3.91	F-5.18 M-5.62
HGB	g/dL	F-11.8 M-12.0	F-15.1 M-16.9
HCT	%	F-35.5 M-36.2	F-46.5 M-48.0
MCV	fl	81.6	97.7
MCH	pg	26.8	33.8
MCHC	g/dL	31.1	35.5
RDWcv	%	12.8	16.8

Parameter	Units	Lower limit	Upper limit
PLT	$10^3/\mu L$	151	361
MPV	fL	6.1	14.1

d. Determination of lower limits of detection and quantitation:

The lower limit of detection (LLoD) and the lower limit of quantitation (LLoQ) of WBC and PLT were quantified as per CLSI H26-A2 section 5.8. To determine LLoD, 12 blank runs were collected daily over five days (total 60 blank runs) on two instruments using alternating operators. The values of WBC and PLT for these blank runs are analyzed to determine the LLoD. Once the LLoD is calculated, five low level specimens are run over a period of five days. One specimen was run each day using alternating operators. Twelve replicates per specimen were collected for a total of 60 replicates. The CVs of each dilution of WBC and PLT were analyzed to determine the LLoQ of each.

Item	WBC	PLT
LLoD	0.0748	5.6138
LLoQ	0.18	15.07

K. Proposed Labeling:

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

L. Conclusion:

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