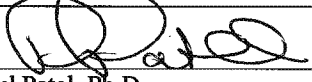


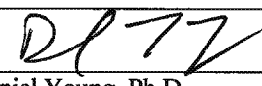
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Originator: Curtis Schneider		Date: 09/26/2013	

### Validation of Modified Siemens Chloride Assay


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## Chloride Plasma Assay

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## I. Overview

Chloride is the major anion in the extracellular water space. Its physiological significance is in maintaining proper body water distribution, osmotic pressure, and normal anion-cation balance in the extracellular fluid compartment.

Chloride is increased in dehydration, renal tubular acidosis (hyperchloremia-metabolic acidosis), acute renal failure, metabolic acidosis associated with prolonged diarrhea and loss of sodium bicarbonate, diabetes insipidus, adrenocortical hyperfunction, salicylate intoxication and with excessive infusion of isotonic saline or extremely high dietary intake of salt. Hyperchloremia acidosis may be a sign of severe renal tubular pathology.

Chloride is decreased in overhydration, chronic respiratory acidosis, salt-losing nephritis, metabolic alkalosis, congestive heart failure, Addisonian crisis, certain types of metabolic acidosis, persistent gastric secretion and prolonged vomiting, aldosteronism, bromide intoxication, syndrome of inappropriate antidiuretic hormone secretion, and conditions associated with expansion of extracellular fluid volume.

## II. Method Principle

The sample is mixed with ISE buffer, thereby providing a constant pH and a constant ionic strength solution. As the buffered sample is moved through the ISE, changes in the electrical potential take place. These electrical potential changes are measured against the potential of a reference electrode to derive the correct analog value for the sample. This assay has been modified from its original test method by pre-diluting the sample (6.25 fold) prior to testing.

## III. Definitions and Abbreviations

The following definitions and abbreviations are used in this document and related documents and attachments:

- a. **Accuracy:** Accuracy is defined by CLSI as the closeness of agreement between a test result and an accepted reference value. Method accuracy is used in a different sense by the American Association of Pharmaceutical Scientists where it is expressed as percent relative error (%RE). Trueness, a related CLSI term, is the closeness of agreement between the average of a number of replicate measured quantity values and a reference quantity value.

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- b. **Analyte:** Component represented in the name of a measurable quantity. The closely related term measurand is defined as the particular quantity subject to measurement.
- c. **Analytical sensitivity:** There are several alternative uses of this term. Most commonly, and for the purposes of this Validation Plan, it is used interchangeably with limit of detection. It is also used to describe the ability of an analytical method to assess small variations of the concentration of an analyte, such as the slope of the calibration curve (IUPAC).
- d. **Analytical specificity:** Ability of a test or procedure to correctly identify or quantify an entity, including in the presence of interfering substance(s) or phenomena.
- e. **Calibration:** Set of operations that establish, under specified conditions, the relationship between values of quantities indicated by a measuring instrument or measuring system, or values represented by a material measure or a reference material, and the corresponding values realized by standards. Under CLIA, calibration refers to the process of testing and adjusting an instrument, kit, or test system, to provide a known relationship between the measurement response and the value of the substance being measured by the test procedure (42 CFR 493.1217).
- f. **Calibrator:** A substance, material, or article intended to be used to establish the measurement relationships of a diagnostic medical device.
- g. **CLIA:** Clinical Laboratory Improvement Amendments of 1988. Congressional legislation that defined and requires specific quality assurance practices in clinical laboratories.
- h. **CLSI:** Clinical and Laboratory Standards Institute.
- i. **Coefficient of Variation:** The ratio of the standard deviation to the average, often multiplied by 100 and expressed as a percentage, abbreviated as %CV.
- j. **Colorimetry:** A technique used to determine the concentration of colored compound(s) in solution.
- k. **Interfering substance:** A substance or quantity thereof that is not the measurand but that affects the result of the measurement.
- l. **IUPAC:** International Union of Pure and Applied Chemistry

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- m. **LDT:** Laboratory –developed Test.
- n. **Linearity:** Linearity is the ability of a quantitative analytical method to provide results that are directly proportional to the concentrations of an analyte in test samples, within a given measuring interval. It is an important parameter to confirm when evaluating an analytical method because it verifies correct interpolation of results between points.
- o. **LMR:** Lower end of the measuring range is the lowest level at which defined conditions, including all stated characteristic of the method, are met.
- p. **LoB:** Limit of Blank is the highest value in a series of results on a sample that contains no analyte.
- q. **LoD:** Limit of Detection is the lowest amount of analyte in a sample that can be detected with stated probability, although perhaps not quantified as an exact value.
- r. **LoQ:** When used without a prefix, the Limit of Quantitation is the lowest actual concentration at which an analyte is reliably detected and at which uncertainty of the test result is less than or equal to the goal set by the manufacturer or laboratory. The term may also be used with prefixes L for lower (LLOQ) and U for upper (ULOQ), respectively. Note:  $LoB < LoD < LoQ$ .
- s. **Matrix:** All components of a material system, except the analyte. A specimen matrix is the biological milieu in which an analyte exists (e.g., plasma, serum, urine, or other body fluids).
- t. **Measuring Interval (reportable range; analytical measurement range or AMR):** A measuring interval consists of all numeric values between the lower and upper numeric values for which a method can produce quantitative results suitable for clinical use. Where applicable, a linearity study is frequently used to establish or verify the measuring interval that can be reported for a measurement method. Alternatively, the lower limit of the measuring interval may be assigned as the LoQ (LLOQ).
- u. **Precision:** Precision is the closeness of agreement between indications or measured quantity values obtained by replicate measurements on the same or similar objects under specified conditions. It is usually expressed numerically in terms of standard deviation (SD) or percent Coefficient of Variation (%CV).

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- v. **Reference interval:** The interval between and including two reference limits. It is common practice to define a reference limit so a stated fraction of the reference values is less than or equal, or greater than or equal, to the respective upper or lower limit.
- w. **SOP:** Standard Operating Procedure.
- x. **Spectrophotometry:** The quantitative measurement of the transmission (or reflection) properties of a material as a function of wavelength.
- y. **Testing System:** The entirety of the testing process, including instrument, sample, reagents, supplies, and procedures. Personnel are sometimes included in the definition.

#### IV. Pre-clinical Validation

##### a. Analytical Measurement Range

###### i. Limits of Blank, Detection and Quantitation

The analytical range 15 – 200 mmol/L for Chloride in plasma has been determined by Siemens. The precision and bias verified at 74.9 mmol/L was 3.5 % and -2.8% (n=80) respectively.

###### ii. Linearity

The Analytical Measurement Range (AMR) including linear measurement interval has been determined by Siemens. Refer to the Analytical Range section of the manufacturer product information insert for additional details.

##### b. Analytical Specificity

The analytical specificity for this assay has been determined by Siemens. Refer to the Interference section of the manufacturer product information insert for additional details.

##### c. Precision

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**Level = L1**

Number of observations 80  
 Number of runs 40  
 Number of days 20  
 Runs per day 2  
 Replicates per run 2

Mean 74.93774387

	SD	95% CI	CV
Repeatability	2.11117653	7.3330315 to 2.7012563	2.8%
Between-run	0.00000000		0.0%
Between-day	1.92804809		2.6%
Within-laboratory	2.85909702	2.37369442 to 3.5959049	3.8%

**Level = L2**

Number of observations 78  
 Number of runs 39  
 Number of runs excluded 1  
 Number of days 20  
 % of days with 1 run 5%  
 Runs per day 2  
 Replicates per run 2

CLSI guideline EP05-A2 section 10.4 recommends a minimum of 40 runs, with 2 replicates per run.

Mean 97.88380354

	SD	95% CI	CV
Repeatability	2.21725810	0.82039749 to 2.8369880	2.3%
Between-run	0.93796531		1.0%
Between-day	1.89178481		1.9%
Within-laboratory	3.06183967	2.56400250 to 3.8013949	3.1%

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Level = L3

Number of observations 80  
 Number of runs 40  
 Number of days 20  
 Runs per day 2  
 Replicates per run 2

Mean 116.5971406

	SD	95% CI	CV
Repeatability	2.784409132	2.28603579 to 3.5626593	2.4%
Between-run	0.00000000		0.0%
Between-day	2.34260172		2.0%
Within-laboratory	3.638779603	0.04336961 to 4.5260126	3.1%

Where CV's are reported as zeros in the precision summary output this is most likely a consequence of rounding values in StatSoft.

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## V. Clinical Validation

### a. Method Comparison with Predicate (Accuracy/Comparability):

To test the accuracy of the assay on the Theranos System, 68 unique patient samples were screened on the predicate method (Siemens, Advia) and on the Theranos method. Using the predicate method eighteen (18) values were within the reference range (99—109 mmol/L), twenty nine (29) were below the reference range, and twenty one (21) were above the reference range. Based on the results of the data examination, either a simple linear regression or alternative procedures were used to estimate expected (average) bias and the confidence interval of expected bias at the desired medical decision level(s) as per CLSI guidance EP09-A2. StataPro was used for bias calculations. These estimates were compared with internal criteria to judge the acceptability of the Theranos method. Each sample was run in duplicate on the predicate, and the average used for comparison to the Theranos method. Some samples were stored before analysis on both methods. If the confidence interval for the predicted bias includes the defined acceptable bias or if the acceptable bias is greater than the higher limit of the confidence interval of the predicted bias, then the data do not show that the bias of the Theranos method is different from the acceptable bias or there is a high probability (97%) that the predicted bias is acceptable, respectively. The acceptable bias at each medical decision level was determined based on the total allowable error (TEa) minus the measured precision at the level closest to that decision level. Total allowable error (TEa) was taken from American Proficiency Institute (API) peer proficiency testing criteria or CLIA proficiency testing criteria for acceptable analytical performance, as printed in the Federal Register February 28, 1992; 57(40):7002-186, when available. The TEa for Chloride is 5%. The table below shows the allowable bias and precision at 2 levels (values shown in parentheses) and the corresponding closest medical decision limits.

Table 1. Allowable Bias and Precision at the Medical Decision Levels

Medical Decision Levels (U/L)	90.0 (97.9)	112.0 (116.6)
Precision (%)	1.9	2.0
Allowable Bias (%)	3.1	3.0

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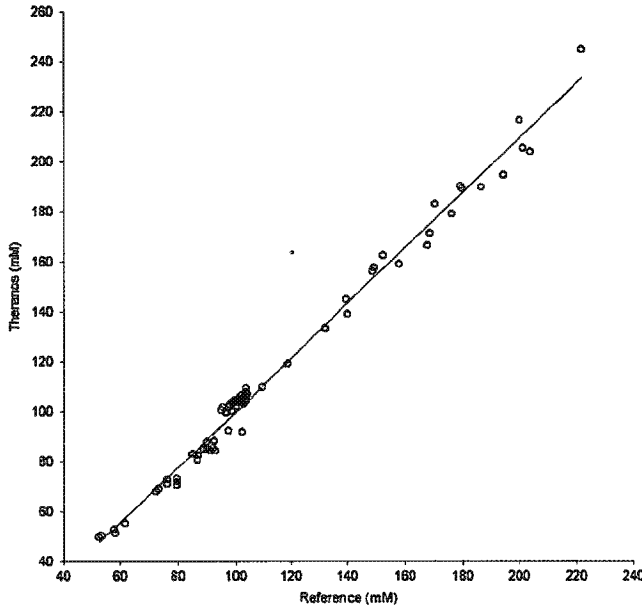
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Scatter plot  
 CLSI guideline EP09-A2-IR section 4.2



**Figure 1.** Graph showing Theranos method versus Predicate Method (Siemens Advia). Simple linear regression was used to establish a slope, intercept and an r<sup>2</sup>. The slope, intercept and clinical correlation were determined to be 1.1, -9.8 and 0.99 respectively.

**Comparability**

CLSI guideline EP09-A2-IR section 7

Level ID	Value	Difference	SE	95% CI	Allowable difference
	90.000000	-0.8820579	0.65429920	-2.1884084 to 0.4242926	4.5000000
	112.000000	1.3156078	0.56743262	0.1826920 to 2.4485235	5.6000000

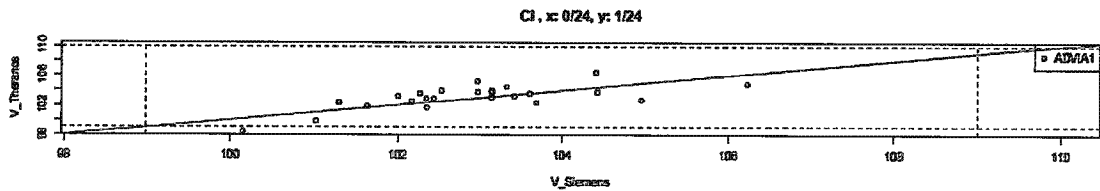
Difference is less than allowable bias: 5% upto 115mM then 10%.

The difference between the two methods is not greater than the allowable difference. The performance requirement is verified.

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**b. Transference and Verification of Reference Interval (Venous)**

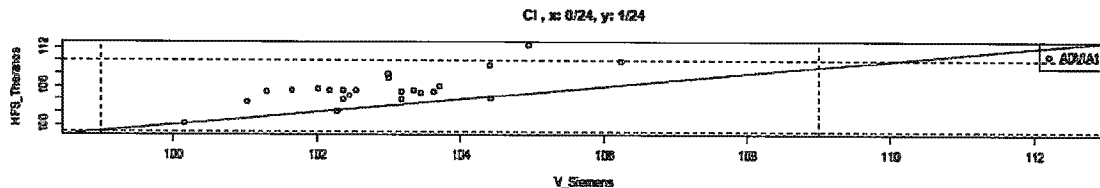
Reference ranges were modified by applying the regression equation to the lower and upper reference limits of existing reference interval to generate a new reference range. New reference ranges were verified with venous samples using twenty four (24) new normal subjects. For a reference range to pass verification, 95% of values should fall within the upper and lower reference limits and 5% or fewer values fall outside of the upper and lower reference limits. For lithium heparin venous verification 23 (95.5%) values fell within the new reference range and 1 (4.5%) values fell outside the new reference range. See graph below for venous samples verification.



**Figure 2.** Graph showing venous sample reference range verification.

**c. Verification of Reference Interval with Finger Stick Samples**

Finger stick reference range was also verified with venous matched finger sticks (lithium heparin) samples from twenty four (24) new normal subjects. The finger stick samples were also collected in a Theranos blood collection devices (BCD) configured with Lithium heparin vessel only. For finger stick verification 23 (95.8%) values fell within the new reference range and 1 (4.2%) values fell outside the new reference range. See graphs below for finger stick samples verification.



**Figure 3.** Finger stick sample reference range verification.

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The Lithium heparin finger stick reference interval for Chloride was determined to be 99.0 – 109.0 mM.

## VI. Stability

### a. Reagents

On-Board Stability

System	Stability
ADVIA 1200	30 days
ADVIA 1650/1800	30 days
ADVIA 2400	30 days

For all systems, unopened reagents are stable until the expiration date printed on the product label when stored at 5–25°C. Do not freeze reagents.

For more details, refer to the Methods Introduction section of the system-specific

### b. Sample

Plasma samples for Chloride analysis are stable for 2 weeks at 2-8 °C, or at least 90 days at -20 °C.

### c. Calibrators

Chloride calibrator is stored at 2-8 °C and stable for at least 6 months from date of manufacture.

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REVISION HISTORY			
Revision Level	Effective Date	Initiator	ECO Number
A	11/06/2013	A. Rosendorff	CL ECO-00117
Section Number	Description and Justification of Changes		
All	Initial Release		

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