

# Laboratory Procedure Manual

*Analyte:*        **Bicarbonate**

*Matrix:*        **Serum**

*Method:*        **Roche Cobas 6000 (c501 module)**

*Method No.:*

*Revised:*

*As performed by:*    **University of Minnesota  
Advanced Research and Diagnostic Laboratory (ARDL)  
1200 Washington Ave S, Suite 175  
Minneapolis, MN 55415**

*Contact:*        **Anthony Killeen, MD, PhD, Laboratory Director  
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## **Important Information for Users**

The Advanced Research and Diagnostic Laboratory (ARDL) periodically refine these laboratory methods. It is the responsibility of the user to contact the person listed on the title page of each write-up before using the analytical method to find out whether any changes have been made and what revisions, if any, have been incorporated.

### Public Release Data Set Information

This document details the Lab Protocol for testing the items listed in the following table:

<b>Data File Name</b>	<b>Variable Name</b>	<b>SAS Label</b>
BIOPRO_J	LBXSC3SI	Bicarbonate (mmol/L)

## **1. SUMMARY OF TEST PRINCIPLE AND CLINICAL RELEVANCE**

After chloride, bicarbonate is the second largest fraction of anions in plasma. In addition to bicarbonate ( $\text{HCO}_3^-$ ), this fraction also includes carbonate ( $\text{CO}_3^{2-}$ ) and the carbamino compounds. Since bicarbonate is present in a concentration that is approximately 1000 times that of the other compounds, the other two are generally disregarded.

The bicarbonate content of plasma is a significant indicator of electrolyte dispersion and anion deficit. Together with pH determination, bicarbonate measurements are used in the diagnosis and treatment of numerous acid-base imbalances involving the respiratory and metabolic systems.

This Roche method utilizes an enzyme-based reaction. Phosphoenolpyruvate (PEP) is added to the specimen containing bicarbonate. Under the action of phosphoenolpyruvate carboxylase (PEPC) the PEP accepts the bicarbonate and is converted to oxaloacetate. Then under the action of malate dehydrogenase, and in the presence of an NADH analog, the oxaloacetate is converted to malate, with the NADH analog converting to an NAD analog. The rate of disappearance of NADH analog is measured at 415 nm, and it is directly proportional to the amount of bicarbonate in the specimen.

Cobas 6000 Application Code: 763

## **2. SAFETY PRECAUTIONS**

Caution: This product is of human and animal origin. Handle as though capable of transmitting infectious disease. Wear appropriate PPE when handling equipment, reagents, and samples.

## **3. COMPUTERIZATION; DATA SYSTEM MANAGEMENT**

ARDL utilizes a highly specialized Laboratory Information System (LIS) (STARLIMS, Abbott Informatics Corporation; Hollywood, FL, 33021-6755) for all lab functions. Major instrument platforms are interfaced directly to the LIS, allowing data to be electronically transferred directly to the main database. The system provides an extensive quality assurance package and data management tools. Numerous networked computer workstations are used in the laboratory for data management and transmission, and

also include software for word and spreadsheet creation and manipulation, statistical analysis, report presentation, and electronic communication. All workstations are user password protected with job specific security access levels and have idle time out functionality. All systems are redundantly backed up on a real time basis.

#### **4. SPECIMEN COLLECTION, STORAGE, AND HANDLING PROCEDURES; CRITERIA FOR SPECIMEN REJECTION**

a. **Specimen Type and Requirements:** Anaerobically collected venous blood is the preferred specimen type. Serum or lithium heparin-anticoagulated plasma are acceptable for this procedure. The NHANES Biochem study uses refrigerated serum. This test is analyzed from NHANES Vial 018.

b. **Specimen Volume:** Optimum/Minimum volume: 100  $\mu$ L in a sample cup or 2 mL microtube (2  $\mu$ L for test; remainder for dead volume).

c. **Acceptable Specimens/Unacceptable Specimens:** Serum, and lithium heparin-anticoagulated plasma. Other anticoagulants are not acceptable.

d. **Specimen Stability and Storage:** Separated serum or plasma should be removed from the cells within 1 hour of collection. Bicarbonate content in uncapped tubes decreases approximately 4 mmol/L after one hour. When stored in a tightly-stoppered vial serum or plasma is stable for 40 hours at 15-25°C; seven days at 4-8°C and up to six months at -20°C or -80°C. Spurious high values can occur when frozen specimens are shipped on dry ice, presumably from carbon dioxide permeating the sealed plastic vials. Shipping specimens refrigerated in serum separator tubes can result in decreased bicarbonate levels (Kirschbaum B. Am J Kidney Dis 2000;35:1068).

e. **Interferences or limitations:** Icteric index <60: no interference. Hemolytic index < 600: no interference. Lipemic index <1800: no interference. Drugs: No interference was found at therapeutic concentrations using common drug panels. In very rare cases, gammopathy, in particular type IgM (Waldenström's macroglobulinemia), may cause unreliable results. An abnormally elevated concentration of ambient carbon dioxide (CO<sub>2</sub>) may occur under certain environmental conditions in the laboratory. The fluctuating ambient CO<sub>2</sub> concentration may interfere with the CO<sub>2</sub>-L assay leading to higher CO<sub>2</sub> results. Under these circumstances, a reduction of the re-calibration interval

may become necessary if the laboratory is unable to keep the ambient CO<sub>2</sub> concentration at a normal level by appropriate countermeasures.

**f. Specimen Handling and Transport:** Mix specimens well, allow clot to fully form (if serum), and centrifuge 10 minutes at 2000 x g before use. Aliquot a minimum of 0.1 mL. Store sample in refrigerator until shipment. Ship at refrigerated temperature. Specimens must be at room temperature prior to assay.

## **5. PROCEDURES FOR MICROSCOPIC EXAMINATIONS; CRITERIA FOR REJECTION OF INADEQUATELY PREPARED SLIDES**

“Not applicable for this procedure.”

## **6. EQUIPMENT AND INSTRUMENTATION, MATERIALS, REAGENT PREPARATION, CALIBRATORS (STANDARDS), AND CONTROLS**

### **a. Reagents and Supplies**

Roche Cat. No. 03289923190, CO<sub>2</sub>-L reagent kit (250 tests):

### **b. Reagent Preparation (\*Reagents are ready to use; no preparation required)**

- R1 reagent: Phosphoenolpyruvate:  $\geq 40$  mmol/L; NADH analog:  $\geq 2$  mmol/L; MDH (porcine):  $\geq 314.3$   $\mu$ kat/L; PEPC (microbial):  $\geq 30.8$   $\mu$ kat/L.

- Storage and stability. The reagent is stable until the expiration date on the cassette when it is stored at 2-8°C. The reagent is stable for 6 weeks refrigerated on the analyzer.

### **c. Equipment/Instrumentation-**

- Roche Cobas 6000 Chemistry Analyzer (Roche Diagnostics Corporation, Indianapolis, IN 46250)

- The Millipore Elix Gulfstream Clinical 35 System is designed to meet CLSI Clinical Laboratory Reagent Water (CLRW) standards. Water purification is achieved by reverse osmosis, electrodeionization, bactericidal 254 nm UV lamp and 0.22  $\mu$ m filtration.

### **d. Specimens are run in singleton**

#### e. Quality Control

- Normal pooled serum control (CQ). Stable at -80°C for up to 4 years, at refrigerated temperature for up to 1 day and at room temperature for up to 4 hours.
- Roche Precipath U Plus Control (catalog #12149443160). Roche Diagnostics 9115 Hague Road Indianapolis, IN 46250-0457). Stable until expiration date on package when unopened and stored at 2-8°C. To prepare, open bottle 1 and pipette in exactly 3.0 mL of diluent (bottle 2). Dissolve by gentle swirling for 30 minutes. Prepared control is stable for 24 hours at room temperature (closed bottle), 1 hour at room temperature (open bottle), 5 days at 2-8°C, and one month at -20°C (when frozen once).

### 7. CALIBRATION AND CALIBRATION VERIFICATION PROCEDURES

Roche Ammonia/Ethanol/CO<sub>2</sub> Calibrator, catalog #20751995190, 2 x 4 mL. The calibrator is stable until the expiration date on the dropper bottle when stored at 2-8°C. It requires no preparation prior to use. After transferring calibrator solution to a sample cup, immediately re-cap the bottle and return to refrigerator. After opening, the calibrator is stable for eight weeks at 2-8°C, if tightly stoppered.

Traceability: This method has been standardized against a primary standard.

Calibration frequency: A two-point calibration (H<sub>2</sub>O + calibrator) must be performed when there is a reagent lot change. The Cobas 6000 will not allow testing to proceed until a successful calibration has been completed. Monitor control values to determine stability of the current calibration.

Manual calibration should be performed if:

- A reagent lot change has not occurred in the past 6 months
- After major service or repairs
- As needed for troubleshooting

If calibration fails perform the following corrective action steps in sequence:

- Check reagent and calibrator for appropriate lot numbers, expiration dates, preparation and storage conditions.
- Repeat calibration with new calibrator.
- Repeat calibration with new reagent and new calibrator
- If successful calibration is not achieved, discontinue testing and notify the supervisor.

## 8. OPERATING PROCEDURE INSTRUCTIONS; CALCULATIONS; INTERPRETATION OF RESULTS

- Instrument Operation:** The Roche/Hitachi Cobas 6000 analyzer series is a fully automated, random-access, software controlled system for immunoassay and photometric analyses intended for qualitative and quantitative in vitro determinations using a wide variety of tests. The Cobas 6000 analyzer series is optimized for workloads using a combination of photometric and ion-selective electrode (ISE) determinations (c501 module), and electrochemiluminescence (ECL) signal in the immunoassay analysis module (e601 module). The ISE system is used in the quantitation of sodium, potassium and chloride. The photometric system can measure colorimetric or immunoturbidimetric reactions utilizing end point or kinetic (rate) absorbance measurements. Test ordering and execution on the Cobas 6000 and data entry in the STARLIMS host computer system may be done manually or these tasks may be executed via a barcode-based bi-directional interface. The Cobas 6000 can utilize both of these two systems simultaneously.
- Professional Judgement:** Check results for error flags and take appropriate corrective action. Investigate alert values and delta checks.
- Result Entry**

STARLIMS test code: CO2

### Manual Results

- Bicarbonate results are reported as a whole number, as in x, mmol/L.
- Report low results as <2 mmol/L.

- Report high results as >50 mmol/L
- Check results for error flags and take appropriate corrective action.
- Investigate critical values and delta checks.

## 9. REPORTABLE RANGE OF RESULTS

Out of Range results: Certain tests have pre-programmed limits that trigger an automatic re-analysis by the COBAS. These limits may be low-end values or high-end values (but within technical range). If the duplicate value is in agreement with the initial value, then the initial value is reported.

Results are reported to the whole number, as in x, mmol/L. Report low results as <2 mmol/L. Report high results >50 mmol/L. Check results for error flags and take appropriate corrective action. Investigate critical values and delta checks.

a. Reportable Range of Test Results: Reportable Range 2-50 mmol/L

Intra-assay %CV (10 within-day replicates at a concentration of 17.7 mmol/L) 0.8%

Intra-assay %CV (10 within-day replicates at a concentration of 33.6 mmol/L) 0.8%

Inter-assay %CV (between day replicates at a concentration of 23.3 mmol/L) 4.4%

Inter-assay %CV (between day replicates at a concentration of 29.5 mmol/L) 7.4%

Dilutions: The confirmed analytical measurement range of the assay is 2 - 50.0 mmol/L (serum). Specimens with bicarbonate values exceeding the high limit are exceptionally unlikely. The analyzer does not dilute these specimens, but will automatically repeat them.

b. Reference Range: Plasma, adult 22-29 mmol/L

c. Critical Results: None

d. Analytical Measurement Range: 2-50 mmol/L

Reportable Range: 2-50 mmol/L

Limit of Detection (standard 1 + 3 SD): 2 mmol/L

## 10. QUALITY CONTROL (QC) PROCEDURE

## Quality Control

- Normal pooled serum control (CQ). Stable at -80°C for up to 4 years, at refrigerated temperature for up to 1 day and at room temperature for up to 4 hours.
- Roche Precipath U Plus Control (Roche Cat. No. #12149443160). Roche Diagnostics 9115 Hague Road Indianapolis, IN 46250-0457). Stable until expiration date on package when unopened and stored at 2-8°C. To prepare, open bottle 1 and pipette in exactly 3.0 mL of diluent (bottle 2). Dissolve by gentle swirling for 30 minutes. Prepared control is stable for 24 hours at room temperature (closed bottle), 1 hour at room temperature (open bottle), 5 days at 2-8°C, and one month at -20°C (when frozen once).
- Both levels of quality control are analyzed at the start of the day and results are verified for acceptability prior to testing specimens. Quality control is also analyzed at the end of the shift, with change in reagent, after major maintenance, or as needed for troubleshooting.
- The analytical measurement range (AMR) must be validated every 6 months or after major maintenance or service procedures. The laboratory enrolls in the College of American Pathologist (CAP) linearity program. Bicarbonate is included in the LN2 kit that is shipped twice per year. Follow kit instructions for preparation. Analyze samples in duplicate. Results are due within two to four weeks of receipt of kit. Results are submitted online to the CAP website by the lead or supervisor. The linearity report is available online at the CAP website shortly after the due date. Confirm reported values are within acceptability limits. Place instrument printouts, worksheets and CAP results in the CAP three ring binder.
- New Lot Verification: Each new reagent lot must be verified for acceptability before being placed into use. Calibration, quality control, and comparison of at least 5 patient samples on the old and new lots must be performed and found to be within acceptable limits before a new lot can be placed into use.
- Quarterly Technical Progress Report:

Progress reports for each quarter of the calendar year are submitted to NHANES. The report includes 1) a summary of the status of all specimens including date of arrival, deviations from protocol, handling, storage, and manipulation of vials and all laboratory procedures used, 2) a description of any major problems such as missing data, out of range values or inconsistent data and what was done to overcome them, internal and external quality control for runs containing NHANES specimens, instrument calibration and repairs, reagent lots and dates of use.

## **11. REMEDIAL ACTION IF CALIBRATION OR QC SYSTEMS FAIL TO MEET ACCEPTABLE CRITERIA**

- If QC values are outside of specified ranges, do the following, in order, until QC is acceptable:
  1. Repeat the analysis using fresh QC material.
  2. Perform a calibration.
  3. Check for system problems.
  4. Contact Roche Technical Support for assistance and possible service dispatch.  
Phone: 1-800-428-2336; account number: 55042919

## **12. LIMITATIONS OF METHOD; INTERFERING SUBSTANCES AND CONDITIONS**

- a. Analytical Measurement Range: 2-50 mmol/L
- b. Icteric index <60: no interference. Hemolytic index < 600: no interference. Lipemic index <1800: no interference. Drugs: No interference was found at therapeutic concentrations using common drug panels. In very rare cases, gammopathy, in particular type IgM (Waldenström's macroglobulinemia), may cause unreliable results. An abnormally elevated concentration of ambient carbon dioxide (CO<sub>2</sub>) may occur under certain environmental conditions in the laboratory. The fluctuating ambient CO<sub>2</sub> concentration may interfere with the CO<sub>2</sub>-L assay leading to higher CO<sub>2</sub> results. Under these circumstances, the reduction of the re-calibration interval may become necessary if the laboratory is

unable to keep the ambient CO<sub>2</sub> concentration at a normal level by appropriate countermeasures.

### **13. REFERENCE RANGES (NORMAL VALUES)**

Plasma, adult: 22-29 mmol/L

### **14. CRITICAL CALL RESULTS ("PANIC VALUES")**

Not applicable.

### **15. SPECIMEN STORAGE AND HANDLING DURING TESTING**

Specimens are stored at refrigerated temperature between sample receipt and analysis on the instrument. Specimens must be at room temperature prior to assay. Specimens are returned to refrigerated or frozen temperature post analysis depending on the study specific requirements.

### **16. ALTERNATE METHODS FOR PERFORMING TEST OR STORING SPECIMENS IF TEST SYSTEM FAILS**

Should the testing system become inoperable, discontinue testing and notify the supervisor. While instrument trouble-shooting or repair occurs; keep specimens at refrigerated or frozen temperature depending on study specific requirements.

### **17. TEST RESULT REPORTING SYSTEM; PROTOCOL FOR REPORTING CRITICAL CALLS (IF APPLICABLE)**

All data is reported electronically via an eFile that is uploaded to the WESTAT secure website within 21 days of receipt of specimens.

### **18. TRANSFER OR REFERRAL OF SPECIMENS; PROCEDURES FOR SPECIMEN ACCOUNTABILITY AND TRACKING**

#### **Specimen Receipt:**

Shipments for NHANES generally arrive on Tuesdays and/or Wednesdays. These shipments are recorded on the Log of Quality Assurance located in a binder labeled NHANES Shipping Log in the receiving area. The specimen barcode numbers in the boxes are checked against the manifests. The receipt date is written on top of the boxes. The frozen samples (vial 11-Iron/UIBC & vial 13-CRP) are placed in the

designated -70°C freezer and the refrigerated samples (vial 18-Biochem panel) are placed in the designated 2-8°C refrigerator until analysis. The manifests are filed in a binder labeled NHANES Shipping Manifests located in the receiving area. All labels are removed from the shipping box and the provided airbill is attached for return shipment.

**Quality Assurance Log:**

A Quality Assurance Specimen Receipt and Specimen Return Log is maintained by laboratory staff. The following parameters are tracked: NHANES shipper I.D., NHANES Container I.D., Vial #, Date Received, Specimen Receipt Conditions, Number of Specimens Received, 2.5% QC Repeats, Total Number of Specimens, 21 Day Due Date, Analysis Date, Date Results Sent, Number of Days For Result Return, Thaw Date (if applicable), Return To Freezer Date, Number of Days at Refrigerated Temperature, 1 Year Discard or Return Date, NHANES Quarterly Report Date

QUALITY ASSUR SPECIMEN RECEIPT					# received, analyzed		
NHANES shipper I.D.	NHANES container I.D. #	vial #	date rec'd	receive spec. cond.	and transmitted		
					spec.	2.5% qc rpts	total
778177102370	368009	018	1/17/2017	ok	47	1	48
778204066788	368058	018	1/24/2017	ok	44	1	45
778299222501	368100	018	1/31/2017	ok	41	1	42
778354403016	368143	018	2/7/2017	ok	25	1	26
778355410426	369009	018	2/7/2017	ok	42	1	43
778408602420	369092	018	2/14/2017	ok	54	1	55
778407805716	368181	018	2/14/2017	ok	22	1	23
778454414575	368221	018	2/21/2017	ok	21	1	22
778463664926	369135	018	2/21/2017	ok	44	1	45
778511320887	369176	018	2/28/2017	ok	29	1	30
778517067017	370009	018	2/28/2017	ok	44	1	45
778564705940	370058	018	3/7/2017	ok	64	1	65

QUALITY ASSURANCE OF SPECIMEN RETURN								1 year	
21-day	analyzed	date	# days	thaw	return to	# days	discard	NHANES	
due date	date	result	results	date	freezer	at frig	or return	Quarterly	
date	sent	return	date	date	temp	date	Report		
2/7/2017	1/18/2017	1/30/2017	13	NA	1/20/2017	2			
2/14/2017	1/25/2017	2/6/2017	13	NA	1/27/2017	2			
2/21/2017	2/1/2017	2/6/2017	6	NA	2/2/2017	1			
2/28/2017	2/8/2017	2/10/2017	3	NA	2/10/2017	2			
2/28/2017	2/8/2017	2/10/2017	3	NA	2/10/2017	2			
3/7/2017	2/15/2017	2/17/2017	3	NA	2/16/2017	1			
3/7/2017	2/15/2017	2/17/2017	3	NA	2/16/2017	1			
3/14/2017	2/22/2017	2/27/2017	6	NA	2/24/2017	2			
3/14/2017	2/22/2017	2/27/2017	6	NA	2/24/2017	2			
3/21/2017	3/1/2017	3/3/2017	3	NA	3/3/2017	2			
3/21/2017	3/1/2017	3/3/2017	3	NA	3/3/2017	2			
3/28/2017	3/8/2017	3/10/2017	3	NA	3/10/2017	2			

**Specimen Ordering/Labeling:**

Electronic files for all NHANES specimens are sent via email from Westat, Inc to the NHANES contact person shortly before they are to be received. These files include the Sample ID, Analyte Type, Slot No, Sample Collection Date, Sample Comment, Age Grouping, Astro ID, Receipt Date, Analysis Date, Run Number, Tech ID, Analyte Result, Result Comment, Adjusted Result, QC Repeat, LOD, Change Reason, and Change Reason Other. The first seven columns are protected and cannot be altered. The files are saved on the laboratory’s common S drive in the NHANES Biochem folder. After analysis, the contact person returns the completed files via their website to Westat, Inc.

The NHANES spreadsheets are used to set up pending batches for batch accession upload in the Laboratory Information system (STARLIMs). New labels are generated out of the Laboratory Information System (STARLIMs). The new bar-coded labels are attached to a carrier tube. The Cobas analyzer reads the bar-coded label for the sample ID and test information.

**Specimen Storage:**

The temperatures for all freezers and refrigerators are monitored 24 hours a day/ 7 days a week. If the temperature for any unit falls outside the allowable range, action is taken to resolve the problem. If the temperature cannot be corrected, the contents are moved to a different unit.

**Specimen Handling/Specimen Return:**

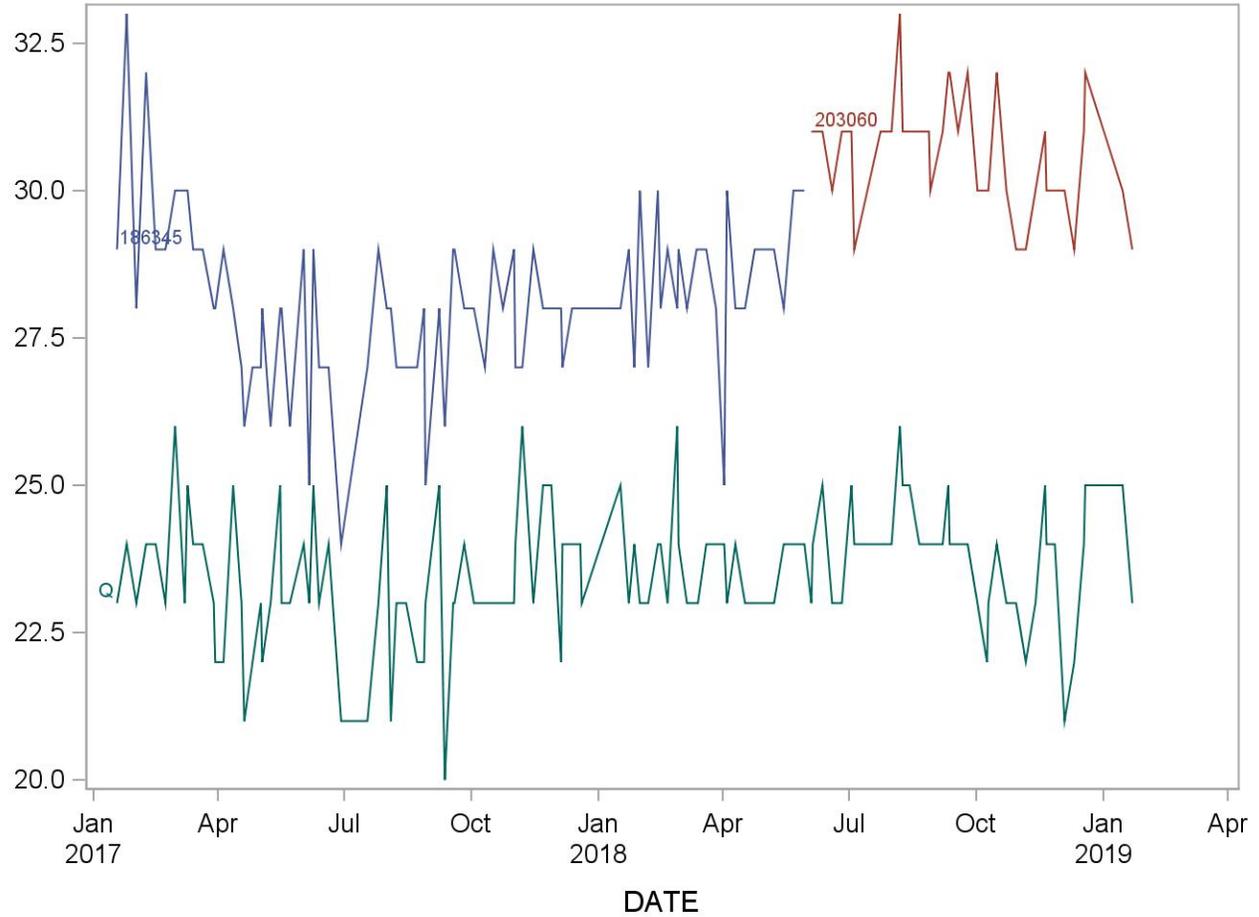
Prior to analysis, the specimens are stored in the designated 2-8°C refrigerator. On the day of analysis, the specimens are selected by the technician operating the COBAS. After analysis and the QC repeats have been run, the specimens are refrozen. After 1 year, the specimen vials that have at least 0.2ml of sample remaining will be shipped to SriSai Biopharmaceuticals in Frederick, MD. These specimens will be shipped on dry ice via Federal Express.

**19. SUMMARY STATISTICS AND QC GRAPHS**

See following page.

### Summary Statistics and QC Chart for Bicarbonate (mmol/L)

Lot	N	Start Date	End Date	Mean	Standard Deviation	Coefficient of Variation
186345	84	18JAN17	30MAY18	28.1	1.4	5.1
Q	122	18JAN17	22JAN19	23.5	1.1	4.7
203060	38	04JUN18	22JAN19	30.6	1.0	3.2



## REFERENCES

1. Cobas 6000 Analyzer Operator's Manual. Roche Diagnostics Inc., 9115 Hague Road Indianapolis, IN 46250-0457. Version 5.0.
2. Roche Ammonia/Ethanol/CO2 Calibrator package insert. Version 2017-10, V12.0. Roche Diagnostics Inc., 9115 Hague Road Indianapolis, IN 46250-0457.
3. Roche CO2-L reagent package insert. Version 2017-01, V11.0. Roche Diagnostics Inc., 9115 Hague Road Indianapolis, IN 46250-0457.
4. Roche Precipath U Plus package insert, Version 2015-11, V5.0. Roche Diagnostics Inc., 9115 Hague Road Indianapolis, IN 46250-0457.