*Name of Facility*

Standard Operating Procedure

for the Analysis of

pH

in Aqueous Waste

Method: SW-846 9040 C

 Effective Date:

Supervisor Signature Date

Supervisor Name (print)

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Appendix 1: Troubleshooting the pH Electrode Pg. x

 *Blue text is replaceable instructional language to be customized for your facility.*

1. **Summary of Method**
	1. This method is an electrometric procedure used to measure the pH of aqueous wastes and those multiphase wastes where the aqueous phase constitutes at least 20% of the total volume of the waste.
	2. The corrosivity of concentrated acids and bases, or of concentrated acids and bases mixed with inert substances, cannot be measured. The pH measurement requires some water content.
	3. pH is a method-defined parameter (MDP). MDPs are physical or chemical properties of materials determined with specific methods used to evaluate whether the materials comply with certain RCRA Subtitle C regulations. MDPs can only be determined by the methods prescribed in RCRA regulations because the methods are part of the regulations. These methods must be followed exactly as written, or the resulting data cannot be used to ensure regulatory compliance.
	4. The pH of the sample is determined electrometrically using either a glass electrode in combination with a reference potential or a combination electrode. The measuring device is calibrated using a series of standard solutions of known pH.
	5. *State what type of samples are analyzed (e.g., wastewater effluent, ground water monitoring well, etc.) and the permit limits, if applicable.*
	6. *State what your working range is, e.g., 2 to 12 S.U. This is based on the buffers you use.*
2. **Definitions**
	1. Calibration buffer: Standard of known pH used during the calibration of the pH meter.
	2. Calibration check buffer: Standard of known pH analyzed after calibration of the meter to check the calibration acceptability.
	3. *If needed: Post-analysis calibration verification: A calibration check buffer is analyzed at the end of the sampling day to verify the calibration is still valid.*

* 1. Reporting range: The pH range which can be reported determined by the highest and lowest buffer analyzed in the calibration and/or calibration check.
	2. S.U.: Standard Units, pH units
	3. NC WW/GW LC: North Carolina Wastewater/Groundwater Laboratory Certification
	4. *Add any other applicable acronyms used by your facility*
1. **Safety and Waste Handling**
	1. *Items that would be included in this section are things such as:*
* *Precautionary measures, including sampling site safety (list here and at the critical steps in the procedure)*
* *Personal protective equipment (e.g., gloves, eye protection, lab coat, work in a hood, etc.)*
* *Hazardous chemicals/reagents*
* *Storage and disposal of samples and reagents*
* *Reference to Chemical Hygiene Plan, if applicable*
* *Location of Safety Data Sheets (SDS)*
1. **Apparatus, Equipment and Reagents**

*Note: Include storage conditions. It is recommended catalog numbers also be included*

* 1. *List your pH instrument with make and model*
	2. *Include electrolyte solution if applicable*
	3. *Electrode type and model*
	4. Magnetic stirrer and stir bar
	5. Sample container *(such as beaker)*
	6. Calibration buffer- *state the value of the buffers (state if purchased or prepared- if prepared, how are they made)*

Note: High pH buffers stored with headspace or those not tightly capped could deteriorate prior to expiration date.

* 1. Calibration check buffer- *state the value of the buffer (state if purchased or prepared- if prepared, how is it made)*
1. **Interferences**
	1. The glass electrode, in general, is not subject to solution interferences from color, turbidity, colloidal matter, oxidants, reductants, or moderate (<0.1 molar solution) salinity.
	2. Sodium error at pH levels >10 S.U. can be reduced or eliminated by using a low-sodium-error electrode.
	3. Coatings of oily material or particulate matter can impair electrode response. These coatings can usually be removed by gentle wiping or detergent washing, followed by rinsing with distilled water. An additional treatment with hydrochloric acid (1:10) may be necessary to remove any remaining film.
	4. Temperature effects on the electrometric determination of pH arise from two sources. The first is caused by the change in electrode output at various temperatures. This interference should be controlled with instruments having temperature compensation or by calibrating the electrode-instrument system at the temperature of the samples. The second source of temperature effects is the change of pH due to changes in the sample as the temperature changes. This error is sample-dependent and cannot be controlled. It should, therefore, be noted by reporting both the pH and temperature at the time of analysis.
2. **Sample Collection, Preservation and Holding Time**
	1. *State what containers samples are collected in. Samples must be collected in glass, polyethylene or fluoropolymer containers.*
	2. There is no preservation requirement for pH.
	3. *Because of potential changes from microbial activity, or shifts in chemical equilibrium, sample pH should be measured as soon as possible upon receipt at the laboratory. Per guidance in the Frequent Questions section on the EPA SW-846 website, the holding time of "Analyze as soon as possible" is not clearly defined for SW-846 but is only recommended as a qualitative goal. In 2007, the definition for “immediately" was established as 15 minutes for the NPDES Program (40 CFR 136, Table II), however, that does not apply to the RCRA program and SW-846. Even though SW-846 Method 9040C is a Method Defined Parameter method and must be followed prescriptively, Section 6.0 of Method 9040C on holding time is not prescriptive. The method authors recognized changes in pH begin as soon as a sample is put into a container and specified that samples should be analyzed as soon as possible. If they meant to analyze by an exact time, the method authors would have put that time into the method. Instead, they left it up to the user to do what is feasible as soon as possible.*

***Therefore, the laboratory must set and adhere to a holding time based on agreement with the data receiving agency. This must be stated in the SOP.***

* 1. *State where the sample is analyzed e.g., in the stream, immediately at the sampling site, in the lab within holding time, etc.*
1. **Calibration**
	1. The pH meter must be calibrated daily before compliance sample analysis and the time documented.
	2. *If a separate pH calibration log is maintained state:* Document the instrument ID on the calibration log*.*
	3. The meter is calibrated using the following buffers: *(state here)*
	4. Place the buffer solution in a clean glass beaker using a sufficient volume to cover the sensing elements of the electrodes and to give adequate clearance for the magnetic stirring bar. Standards shall be gently stirred during measurement. The pH sensing portion and the reference junction must be completely immersed.
	5. Use a new portion of standard buffer for each calibration and discard any used buffer portions. Do not pour any unused portions back into the original bottle.
	6. *Include the manufacturer’s directions for calibration and operation. e.g., buttons to push, opening the electrolyte filling hole, maintaining electrolyte solution level, etc. Each instrument/electrode system must be calibrated at a minimum of two points that bracket the expected pH of the samples and are approximately three pH units or more apart. For corrosivity characterization, the calibration of the pH meter should include a buffer of pH 2 for acidic wastes and a pH 12 buffer for caustic wastes; also, for corrosivity characterization, the sample must be measured at 25 ± 1 °C if the pH of the waste is above 12.0. Various instrument designs may involve use of a dial, to "balance" or "standardize", or a slope adjustment, as outlined in the manufacturer's instructions. Repeat adjustments on successive portions of the two buffer solutions until readings are within 0.05 pH units of the buffer solution value.*
	7. After calibration, analyze a calibration check buffer *(state the value of the buffer here)* and document the value.
	8. The calibration check buffer must read within ± 0.1 S.U. to be acceptable. If the buffer does not read within ± 0.1 S.U., corrective actions must be taken before any samples are analyzed. See Section 14 of this SOP for corrective action options.
2. **Procedure**
	1. Place the sample in a clean glass beaker using a sufficient volume to cover the sensing elements of the electrodes and to give adequate clearance for the magnetic stirring bar. If field measurements are being made, the electrodes may be immersed directly into the sample stream to an adequate depth and moved in a manner to ensure sufficient sample movement across the electrode-sensing element as indicated by drift-free readings (< 0.1 pH).
	2. Thoroughly rinse and gently wipe the electrodes prior to measuring pH of samples. Immerse the electrodes into the sample beaker or sample stream and gently stir at a constant rate to provide homogeneity and suspension of solids. Document sample pH and temperature. Repeat measurement on successive aliquots of sample until values differ by < 0.1 pH units. Two or three volume changes are usually sufficient. *The laboratory is to establish which pH value will be reported out of those that differ by <0.1 S.U. (e.g., highest value, first value, last value, value closest to permit limit). This* must *be stated in the SOP.*
	3. Electrodes must be thoroughly rinsed between samples.
	4. *This section is for analysts who are taking measurements at multiple sites, for example, effluent and downstream. If samples from multiple sites are brought into the lab to analyze, a post-analysis verification is NOT required. Delete if not applicable.* If performing analyses at multiple site locations, a post-analysis calibration verification using the check standard buffer must be analyzed at the end of the run. The post-analysis check standard buffer must read within ± 0.1 S.U. of the true value or corrective action must be taken. See Section 14 of this SOP for corrective action options.
3. **Documentation**
	1. The following must be documented in indelible ink whenever sample analysis is performed.
		1. Date and time of sample collection
		2. Date and time of sample analysis to verify the *xx-minute (laboratory established)* holding time is met. Alternatively, one time may be documented for collection and analysis with the notation that samples are measured *in situ* or immediately at the sample site.
		3. Facility name, sample site (ID or location) and permit number
		4. Collector’s/analyst’s name or initials
		5. Instrument identification *(serial number preferred)*
		6. Parameter analyzed
		7. Method reference *(refer to Certified Parameters Listing (CPL) for correct method description)*
		8. Meter calibration and meter calibration time(s)
		9. True values of buffers used for calibration
		10. True value for the calibration check buffer
		11. Value obtained for the calibration check buffer (verification of ± 0.1 S.U.)
		12. *Delete if not applicable:* True value and value obtained for the post analysis calibration verification(s)
		13. *Delete if not applicable:* Indication of when the post analysis calibration verification was performed (e.g., time of analysis, end of day analysis, etc.)
		14. Units of measure
		15. Temperature of sample during pH measurement
		16. Final value to be reported
		17. Traceability for chemicals, reagents, standards and consumables
		18. Data qualifier(s), where applicable
		19. Equipment maintenance (recommended)
4. **Proficiency Testing (PT) Procedures**
	1. Analysis of a PT Sample is required at least once during every 9-month PT calendar year (January 1- September 30).

* + 1. A list of approved PT providers may be found on the NELAC website at:

 <http://nelac-institute.org/content/NEPTP/ptproviders.php>.

Check this list yearly to assure the chosen vendor is approved.

* + 1. A PT sample can be analyzed as early as January 1 and the graded result must be reported to NC WW/GW LC office from the PT vendor no later than September 30.
	1. PT Samples must be analyzed in accordance with routine testing, calibration and reporting procedures, unless otherwise specified in the instructions supplied by the PT Sample Provider. **NOTE:** Most PT Sample Providers instruct to report pH results to two decimal places.
		1. PT Samples are logged in and analyzed using the same staff, sample tracking systems, standard operating procedures including the same equipment, reagents, calibration techniques, analytical methods, and the same quality control acceptance criteria.

* + 1. PT Samples shall not be analyzed with additional quality control. They are not to be replicated beyond what is routine for Compliance Sample analysis.
		2. PT Sample analysis must be documented on the laboratory’s daily benchsheet.
	1. The PT Sample Provider’s instructions for analyzing the PT Sample must be followed and the practice documented by the analyst. The instruction sheet will be initialed and dated when the PT sample is prepared and retained for 5 years.
	2. The following information must be included on the results when reporting the PT Samples to the vendor.
		1. EPA Lab Code: *(enter here so it is easy to retrieve)*
		2. State Lab Certification number: *(enter here so it is easy to retrieve)*
		3. Method description: SW-846 Method 9040 C
		4. Mailing address for NC WW/GW LC:1623 Mail Service Center, Raleigh, NC 27699-1623
1. **Reporting**
	1. *State who is transcribing the data and whether anyone peer reviews (checks) it. Peer review is recommended, but if that is not possible, it is recommended that the employee rechecks their own transcription for errors after a certain amount of time has passed.*
	2. *State how the data is documented on the benchsheet. It is recommended to be documented to the one-hundredths (0.01 S.U.).*
2. **Quality Assurance and Quality Control**
	1. The calibration check buffer must read within ±0.1 S.U. of the true value to be acceptable. If the buffer does not read within ±0.1 S.U., corrective actions must be taken before any samples are analyzed. (See Section 14 for corrective actions)
	2. (if applicable) The post-analysis calibration check buffer(s) must read within ±0.1 S.U of the true value or corrective action must be taken per Section 14 of this SOP.
3. **Preventative Maintenance**
	1. *State if a maintenance log or record is maintained. Could include items like replacing the electrode solution.*
	2. *State if there is any scheduled timeframe for replacing probes.*
4. **Troubleshooting and Corrective Action**
	1. If the check buffer does not read within ± 0.1 S.U. of the true value, first try pouring a new aliquot of the check buffer and reading it again. If it still does not read within ± 0.1 S.U., the meter must be recalibrated.
	2. (*use if applicable*) If the post-analysis check standard buffer(s) do not read within ±0.1 S.U., corrective actions must be taken. If recalibration is necessary, all samples analyzed since the last acceptable calibration verification must be reanalyzed, if possible. If samples cannot be reanalyzed, the data must be qualified.
	3. Possible corrective actions include: check the meter calibration procedure, refer to the trouble shooting section in the instrument manual, and check the buffers. If, after recalibration, the check buffer does not read within ± 0.1 S.U., the meter and/or probe operation may be suspect and may require servicing. Also refer to ‘Troubleshooting the pH electrode’ published by Hach (Appendix 1). *If the laboratory does not have a back-up meter/electrode, or another meter/electrode cannot be procured, it is recommended that the lab report the measured pH results with a qualifier that indicates the value is estimated.*
5. **Employee Training**

Employee training must be documented and kept on file.

* 1. *Include required education, training, experience and/or demonstrated skills*
	2. Employee must have read this SOP *– may also include reading the Approved Procedure for the Analysis of pH*
	3. *Employee must obtain acceptable results on Proficiency Testing samples or other demonstrations of proficiency (e.g., Initial Demonstration of Capability (IDOC), side-by-side comparison with established analyst, etc.) before analyzing compliance samples for reporting.*
1. **References**
	1. EPA SW-846 Test Methods for Evaluating Solid Waste, Physical/Chemical Methods; 3rd Edition, Method 9040C, Revision 3, November 2004, pH Electrometric Measurement
	2. 15A NCAC 02H .0800.
	3. SW-846 pH Calibration Verification Policy
	4. *Troubleshooting the pH electrode*, Hach.
2. **Revision History**

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| --- | --- | --- |
| Type: Review or Revision | Date | Summary of Changes Made if Revision |
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Appendix 1: Troubleshooting the pH electrode (from Hach)

Problems with a pH electrode can be frustrating. The most common problems for electrodes are: **reference electrode fouling**, **a dirty or aging sensor**, and/or **bad buffers**.

Many analysts do not realize that the condition of the electrode can be readily determined. The best way to determine its condition is to place the electrode into [pH 7.0 buffer](http://www.hach.com/hc/search.product.details.invoker/PackagingCode%3D2283561/NewLinkLabel%3Dwww.hach.com/PREVIOUS_BREADCRUMB_ID%3DHcTrainingHcHTTCUpdatevnohtml/SESSIONID%7CBE5Ua3dNemN5TkNabmRXVnpkRmxUUlVWR01USXdOUT09Q1RNeA%3D%3D%7C). Select the mV mode on the pH meter and observe the millivolt value.

First, a mV value should reach reasonable stability within a minute at room temperature. Consider the electrode value stable if the mV reading is not changing by more than a couple of mV in a 15-30 second period. If the values are not stable, there is a strong possibility that the reference junction of the electrode is clogged or the reference electrolyte is contaminated. In most cases the electrolyte is not diffusing out of the reference electrode at an appropriate rate or concentration. This results in a weak salt bridge between the reference electrode and the H ion sensing electrode.

If the reference electrode can be emptied and refilled, try rinsing it inside and out with DI water and refilling it with fresh reference electrolyte. In some cases you might want to soak the electrode in hot tap water in case the saturated salts of the reference electrolyte have crystallized and clogged the reference junction. The hot water often dissolves the salts thereby freeing the junction for diffusion. If the electrode is a gel type, you might also try the hot water soak. These actions may or may not bring the electrode back to proper functioning. If it continues to cause failure you have little choice other than replacement.

Second, the value of the electrode in a 7.0 pH buffer should be 0 mV ± 30 mV. In a perfect world the value is 0.00. However, electrodes differ with manufacturing, use, and age. The mV difference between the meter reading and 0.0 is the best way to determine the electrode's condition. A good rule of thumb is if the reading is outside of plus or minus 15 mV then try cleaning the electrode according to the manufacturer's instructions. Retest and see if it has improved. Over time an electrode will age and fail regardless of how much you clean it, and will eventually need replacement. At the point where the value is in the 30 mV range and cannot be improved is an indication that you need to replace the electrode with a new one.

Third, record the value in the 7.0 buffer. Rinse and blot dry the electrode and place it in a fresh [4.0 pH buffer](http://www.hach.com/hc/search.product.details.invoker/PackagingCode%3D2283461/NewLinkLabel%3Dwww.hach.com/PREVIOUS_BREADCRUMB_ID%3DHcTrainingHcHTTCUpdatevnohtml/SESSIONID%7CBE5Ua3dNemN5TkNabmRXVnpkRmxUUlVWR01USXdOUT09Q1RNeA%3D%3D%7C). After it has stabilized record that value. Subtract the mV value of the 7.0 buffer reading from the 4.0 reading and divide the difference by 3. If the electrode is responding properly the calculated value should be 59 ± 3 mV.

**Example:**
mV reading in 7.01 Buffer = 5.2 mV
mV reading in 4.00 Buffer = 179.6 mV
Delta = 179.6 - 5.2 = 174.4
174.4 / 3 = 58.1

In this example, the result is well within the 59 ± 3 vM range. Therefore, the electrode is responding as it should.

Obviously all of these tests are assuming you are using [fresh buffers](http://www.hach.com/hc/browse.exploded.category.products/PRODCAT0641/NewLinkLabel%3DpH%2BBuffer%2BSolutions/PREVIOUS_BREADCRUMB_ID%3DHcTrainingHcHTTCUpdatevnohtml/SESSIONID%7CBE5Ua3dNemN5TkNabmRXVnpkRmxUUlVWR01USXdOUT09Q1RNeA%3D%3D%7C). Realize that pH 10.0 buffers are unstable. Because of their alkaline pH they quickly absorb CO2 in the air resulting in a pH drop to below 10.0. The pH 10.0 buffers that have been exposed to air for any length of time are questionable. The [pH 7.0 buffer](http://www.hach.com/hc/search.product.details.invoker/PackagingCode%3D2283561/NewLinkLabel%3Dwww.hach.com/PREVIOUS_BREADCRUMB_ID%3DHcTrainingHcHTTCUpdatevnohtml/SESSIONID%7CBE5Ua3dNemN5TkNabmRXVnpkRmxUUlVWR01USXdOUT09Q1RNeA%3D%3D%7C) is an ideal medium for microbial growth. If you notice cloudiness or slime in the buffer it should not be used. Never leave beakers of buffer open and exposed to air. Replace them from a fresh source on a daily basis to ensure accurate calibration.

Finally, repeat these series of tests on a frequent planned basis and log the changes in the electrode's behavior. This will gain you confidence in your pH values.