Phosphate ($\text{PO}_4{^{3-}}$), Phosphorus (P), Phosphonates Troubleshooting Guide

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Scope and Principle:

Phosphate and Phosphorus:

Phosphorus occurs in natural water and wastewaters almost solely as phosphates. Phosphates may enter water from agricultural run-off and as biological and industrial wastes. They may be added to water in municipal and industrial water treatment processes to control corrosion. A certain amount of phosphate is essential for most plants and animals, but too much phosphate in water can contribute to eutrophication, especially when large amounts of nitrogen are also present.

Phosphorus can be classified as orthophosphate (also reactive), condensed phosphate or organically bound phosphate. Condensed phosphates are formed by dehydrating the orthophosphate radical; they include metaphosphate, pyrophosphate and polyphosphate. The only form of phosphate determined directly is orthophosphate; other forms require pretreatment for conversion to orthophosphate for analysis. When no pretreatment is used, phosphate analyses determine Reactive Phosphorus. Reactive phosphorus is a measure of orthophosphate, plus a small fraction of condensed phosphate that may have been hydrolyzed during the test.

Hach offers high and low range tests for reactive phosphorus. High range tests can be completed with the Amino Acid Method or the Molybdovanadate Method. The Molybdovanadate Method uses a single reagent and has a faster reaction than the Amino Acid Method. Both methods have a broad range and are free from most interferences. Low range tests use the Ascorbic Acid Method.

Condensed phosphates plus orthophosphate can be determined by acid hydrolysis using sulfuric acid, followed by the reactive phosphorus test for the appropriate range. A small amount of organically bound phosphorus will be included in this measurement. The results of the test are reported as acid-hydrolyzable phosphorus. Total phosphorus (orthophosphate, condensed and organically bound) can be determined by acid oxidation with persulfate, followed by the reactive phosphorus test. Organically bound phosphate can then be determined by subtracting the acid hydrolyzable phosphorus.

Phosphonates:

Phosphonates are employed as chemical additives to function as threshold antiscalants, corrosion inhibitors, chelants, sludge conditioners, deflocculants, dispersants and crystal growth modifiers in various industrial water treatment processes. They are used predominantly as scale and corrosion preventatives for boiler and cooling tower waters. Phosphonates exist in various formulations as acids or salts and are marketed in the form of concentrated solutions.

Until recently, analytical methods for phosphonates have been difficult, time consuming and subject to many interferences. The Ultraviolet (UV) Photochemical Oxidation Method involves a photochemical oxidation of phosphonate followed by conventional colorimetric determination of the liberated
orthophosphate by the Ascorbic Acid Method. The UV Photochemical Oxidation Method is rapid, easy to use, relatively free from interferences, and applicable to both field and laboratory situations.

Chemical Reactions:

- **Pretreatment Steps:** Reactions for pretreatment to determine acid-hydrolyzable and total phosphorus are illustrated below.

\[
R - O - P - O - R' + K_2S_2O_8 + H_2SO_4 \rightarrow \]

\[
H_3PO_4 + 2K^+ + 3SO_4^{2-} + \text{Various organic fragments}
\]

Figure 1. Example of potassium persulfate oxidation of organically bound phosphorus\(^1\)

\(^1\) R and R’ represent various organic groups

- **Amino Acid and Ascorbic Acid Methods:** Reactive phosphorus is determined in essentially two steps for either the Ascorbic Acid Method (low range) or the Amino Acid Method (high range). The first step involves reaction of orthophosphate with molybdate in acid solution, which forms a yellow-colored phosphomolybdate complex:

\[
12\text{MoO}_3 + H_2\text{PO}_4^- \xrightarrow{\text{Reduction}} (H_2\text{PMo}_{12}\text{O}_{40})^-
\]

The phosphomolybdate complex is then reduced by either an amino acid or ascorbic acid, causing a characteristic molybdenum blue species. Various structures for the molybdenum blue species have been suggested in the literature. For example, see Killeffer, D. H., *Molybdenum Compounds—Their Chemistry and Technology*, Interscience Publishers, 1952.

All reagents for the Ascorbic Acid Method are contained in PhosVer™3 Reagent Powder Pillows. Reagents for the Amino Acid Method are contained in Amino Acid Reagent Solution and Molybdate Reagent Solution.
• **Molybdovanadate Method:** Reactive phosphorus combines with molybdate in an acid medium to form a phosphomolybdate complex. Vanadium, contained in Molybdovanadate Reagent, reacts with the complex to form vanadomolybdophosphoric acid. Intensity of the resulting yellow color is proportional to the concentration of reactive phosphorus. One possible formula for the complex is suggested below. The exact structure is not known.

\[
[\text{PO}_4 \nn \text{VO}_3 \nn 16\text{MoO}_3]^{4-}
\]

**Phosphonates Chemical Reactions:**

Phosphonic acids are organic compounds of the form **R-PO3H2**. Structures of two commonly used treatment chemicals are shown below; the phosphonic acid group is shown in parentheses. Phosphonates are the corresponding anions formed by ionization of one or more of the acidic hydrogens.

*Figure 1 Chemical structures of two common phosphonic acids*

Decomposition of these compounds by oxidation will liberate the organically bound phosphate as orthophosphate. The combined action of the UV radiation and oxygen will liberate orthophosphate rapidly without the necessity of heat or corrosive agents. When the photo-oxidation is carried out in the absence of acid, no significant degree of depolymerization or hydrolysis of condensed (pyro, meta or other poly) phosphates occurs, making the method a true test for organic phosphate. Presence of excess oxygen is ensured by the addition of a small amount of potassium persulfate. In this oxygen-rich environment UV light will rapidly catalyze the oxidation of the phosphonate C-P bond.

\[
\text{UV} \rightarrow \text{C} \rightarrow \text{PO}_3\text{H}_2 \rightarrow \text{C} \rightarrow +\text{H}_3\text{PO}_4
\]

The orthophosphate formed can then be determined colorimetrically using the Ascorbic Acid method. Reagents for the Ascorbic Acid Method for orthophosphate have been combined into a single reagent.
powder, PhosVer™3. Determination of orthophosphate using PhosVer 3 is described in the Phosphorus methods.

### Phosphate Forms:

<table>
<thead>
<tr>
<th>Phosphate Form</th>
<th>Definition</th>
<th>Common Relationship</th>
<th>Hach Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphorus</td>
<td>Very important nutrient for the growth of organisms.</td>
<td>Condensed Phosphates = Polyphosphates</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Phosphorus is rarely found in its elemental form, P.</td>
<td>Metaphosphates and Pyrophosphates</td>
<td></td>
</tr>
<tr>
<td>Phosphate</td>
<td>Made up of phosphorus and oxygen (eg. PO₄³⁻). A salt of phosphoric acid.</td>
<td>Orthophosphate = Reactive Phosphate + small fraction of simple Condensed Phosphate</td>
<td>8178, 8048, 8114, 10055, 10214, 10209</td>
</tr>
<tr>
<td></td>
<td>Often classified as ortho-phosphates, condensed phosphate and organically bound phosphates</td>
<td>Hydrolyzed</td>
<td></td>
</tr>
<tr>
<td>Orthophosphate</td>
<td>Simple inorganic forms of phosphates, namely PO₄³⁻, HPO₄²⁻, H₂PO₄⁻, and H₃PO₄. This is the form most readily available for uptake by plants.</td>
<td>Total Inorganic Phosphate (TIP) = Ortho + Condensed Poly * A small amount of organic will be included.</td>
<td></td>
</tr>
<tr>
<td>Inorganic phosphate</td>
<td>A phosphate molecule not associated with organic material (eg. ortho-phosphates). Inorganic P can be adsorbed or absorbed in mineral fractions</td>
<td>Acid Hydrolyzable 8180</td>
<td></td>
</tr>
<tr>
<td>Total Reactive phosphorus</td>
<td>Any form of P that reacts with reagents in a colorimetric test without prior filtering, or digestion (acid and heating). Total reactive phosphorus includes ortho-phosphates, as well as other easily hydrolyzable organic and inorganic forms of P.</td>
<td>8178, 8048, 8114, 10055, 10214, 10209 **without filtration</td>
<td></td>
</tr>
<tr>
<td>Filterable reactive phosphorus</td>
<td>Any form of P that reacts with reagents in a colorimetric test following filtration of the sample through a 0.45 μm filter paper. This filtration separates most particulate P from dissolved P fractions, but not all.</td>
<td>8178, 8048, 8114, 10055, 10214, 10209 **with filtration</td>
<td></td>
</tr>
<tr>
<td>Organic phosphate</td>
<td>A phosphate molecule associated with a carbon-based molecule, as in plant or animal tissue.</td>
<td>Organic Phosphate = TP - TIP</td>
<td></td>
</tr>
<tr>
<td>Total Phosphorus</td>
<td>Sum of organic and inorganic forms of phosphorus in unfiltered water samples. Sample is hydrolysed with acid and digested (heated) which breaks down strong chemical bonds and allows all phosphorus in the sample to be measured colorimetrically.</td>
<td>Total Phosphorus (TP) = TIP + Organic</td>
<td>Accorbic Acid / Persulfate Digestion 8190 &amp; 10127, Accorbic Acid 10210</td>
</tr>
</tbody>
</table>
Selecting the Correct Phosphate Procedure:
Decision Tree to determine appropriate procedure for each application.

*TNT843, TNT844, TNT845 may be EPA approved, check with local regulation
Instrumentation Options:

**Colorimetric (Lab)**
- Phosphate DR300: Single Parameter, Portable, PhosVer 3 chemistry
  - Model LPV445.97.06110 Conc. Range 0.02-3.00 PO4 (powder pillow or AccuVac reagents)
- DR900: 9385100 Multiparameter Colorimeter: 90 parameters, Multiple concentration ranges, Portable, Multiple chemistry options
- Spectrophotometers: Multiparameter, Multiple concentration ranges, Portable/ Bench, DPD chemistry
  - Portable: DR1900: DR1900-01H
  - Bench: DR3900: LPV440.99.00012, DR6000: LPV441.99.00002 *older models are compatible
- Color Wheel: Multiple concentration ranges (see FAQ section), Portable
- Test Strips Phosphate: 2754150 (see FAQ section)

**Colorimetric Process (Continuous Monitoring)**
- Phosphax Analyzer: The instrument offers a wide measurement range for orthophosphate for a variety of wastewater and drinking water applications with detection limits as low as 0.05 mg/L and response time of less than five minutes including sample preparation. The Phosphate Analyzer also features minimum reagent consumption and easy handling with analysis accessible at all times.
- 5500 Phosphate Analyzer: The industry’s only pressurized reagent delivery system eliminates the frequent maintenance associated with pumps. Concentration range options include Low Range 0-3000 ug/L PO4 and High Range 200-50000 ug/L PO4.

Digestion Options:

**Total Phosphorus & Phosphate Hot Plate (Method 8190):**
Phosphates present in organic and condensed inorganic forms (meta-, pyro- or other polyphosphates) must be converted to reactive orthophosphate before analysis. Pretreatment of the sample with acid
and heat provides the conditions for hydrolysis of the condensed inorganic forms. Organic phosphates are converted to orthophosphate by heating (using a hot plate) with acid and persulfate. Organically bound phosphates are thus determined indirectly by subtracting the result of an acid hydrolyzable phosphorus test from the total phosphorus result.

This procedure must be followed by one of the reactive phosphorus (orthophosphate) analysis methods for determining the phosphorus content of the sample. If the ascorbic acid (PhosVer 3) method is used to measure the reactive phosphorus, this method is USEPA accepted for NPDES reporting.

The following reagents are required in addition to those required for the active phosphorus test. See method for full list of reagents and required apparatus.

Reagent Set: 2459000 (includes the following):
- Potassium Persulfate Powder Pillows: 245199
- 5.0N Sodium Hydroxide Solution: 245032
- 5.25N Sulfuric Acid Solution: 244932

**Total Phosphorus & Phosphate DRB200 Reactor Block (Methods 8190 & 10209):**

Phosphates present in organic and condensed inorganic forms (meta-, pyro- or other polyphosphates) must be converted to reactive orthophosphate before analysis. Pretreatment of the sample with acid and heat (using a DRB200 reactor block) provides the conditions for hydrolysis of the condensed inorganic forms. Organic phosphates are converted to orthophosphates by heating with acid and persulfate.

Orthophosphate reacts with molybdate in an acid medium to produce a mixed phosphate/ molybdate complex. Ascorbic acid then reduces the complex, giving an intense molybdenum blue color.

DRB200 configuration depends on the test tube reagent. Method 8190 utilizes a 16mm diameter test tube. Method 10209 utilizes a 13mm diameter test tube+.

Common Configuration Recommendations:
- Single Block: LTV082.53.30001
- Double Block: LTV082.53.42001
- Reducing Adaptor 20mm to 16mm: HHA155 (ea)
- Reducing Adaptor 16mm to 13mm: 2895805 (pkg 5)

**Ultra Low Range Total Phosphorus & Phosphate DRB200 Reactor Block (Literature 2097):**

The application note Lit 2097 describes how to achieve a low-end reporting limit of 10 μg/L PO₄-P, with a calculated statistical method detection limit (MDL) of 4.95 μg/L PO₄-P for reactive phosphorus and 5.35 μg/L PO₄-P for total phosphorus. The concentration range for this application is 10 to 500 μg/L PO₄-P.
Equipment needed for this application:

1) TNT 843, TNTplus phosphorus reagents
2) DRB200 Digital Reactor Block for TNTplus with 13 mm vial wells
3) 5-cm semi micro cuvette, PN LZP341

Phosphonates (Method 8007):

This method is directly applicable to boiler and cooling tower samples. The procedure is based on a UV-catalyzed oxidation of phosphonate to orthophosphate. The orthophosphate reacts with the molybdate in the PhosVer 3 reagent to form a mixed phosphate/molybdate complex. This complex is reduced by the ascorbic acid in the PhosVer 3, yielding a blue color that is proportional to the phosphonate present in the original sample. The orthophosphate present in the original sample is subtracted out by preparing the blank and using it to set zero concentration.

Common kits, reagents, apparatus:
- Pocket Colorimeter II Phosphonate Kit: 5870007
- Phosphonate Colorwheel kit (115V): 2113300
- Phosphonate Colorwheel kit (220V): 2113302
- Phosphonate Reagent Set: 2429700 *for digital instrument
- UV lamp Kit 115V: 2082800 –or – UV lamp Kit 230V: 2082802

Water Quality Factors:

Phosphorus levels in natural waters such as lakes and streams are typically very low, less than 0.05 mg/L as P. Higher phosphorus levels reflect contributions from raw or treated wastewater, agricultural drainage, or industrial waste. Some drinking water plants also add small amounts of orthophosphate or condensed phosphates during treatment.

Orthophosphate is the simplest phosphorus form to measure, but total phosphorus is considered the best indicator of phosphorus levels in water because it measures all three forms. If you are required to measure and report phosphorus levels to a regulatory agency, we advise that you check with your regulator to determine whether you are required to report ortho, condensed, or total phosphorus levels.

Condensed phosphates (also called meta, pyro, or polyphosphates) are two or more orthophosphate groups linked together. They are strong complexing agents and are widely used in treatment systems for boiler water, and are also used in detergents. To measure condensed phosphates follow a procedure for acid hydrolysable phosphorus.
Organic phosphates contain one or more orthophosphate groups that are attached to an organic molecule such as sugar. They are formed primarily by biological processes and can be found in organic matter such as plant or animal tissue, in sewage from animal or human waste and food residues, as well as in pesticides. To measure organic phosphates, follow a procedure for total phosphorus.

Both condensed phosphates and organic phosphates are not as stable as orthophosphate and naturally break down into orthophosphates over time. Therefore an orthophosphate test will likely measure a small amount of condensed phosphates, and an acid-hydrolyzable test will measure a small amount of organic phosphates.

FAQ

Q: What are the Hach test kit options for testing Phosphate and Phosphonate?

A:

<table>
<thead>
<tr>
<th>Test</th>
<th>EPA</th>
<th>Chemistry</th>
<th>Hach Method</th>
<th>Conc. Range</th>
<th>Product #</th>
<th>Compatible Instruments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphate, Ortho</td>
<td></td>
<td>PhosVer 3</td>
<td></td>
<td>0.0-0.8 mg/L, 0-4 mg/L, 0-40 mg/L PO₄</td>
<td>Model PO-19 224800</td>
<td>ColorWheel</td>
</tr>
<tr>
<td>Phosphate, Ortho</td>
<td></td>
<td>PhosVer 3</td>
<td></td>
<td>0.1-5.0 mg/L, 1-50 mg/L PO₄</td>
<td>Model PO-19A 224801</td>
<td>ColorWheel</td>
</tr>
<tr>
<td>Phosphate, Ortho</td>
<td></td>
<td>Phosphate 2</td>
<td></td>
<td>0.1-4.5 mg/L, 1-45 mg/L PO₄</td>
<td>Model PO-14 147500</td>
<td>ColorWheel</td>
</tr>
<tr>
<td>Phosphate, Total, Meta, Ortho</td>
<td></td>
<td>PhosVer 3</td>
<td></td>
<td>0-0.8 mg/L, 0-4 mg/L PO₄</td>
<td>Model PO-24 225001</td>
<td>ColorWheel</td>
</tr>
<tr>
<td>Phosphate, Meta, Ortho</td>
<td></td>
<td>PhosVer 3</td>
<td></td>
<td>0.1-0.4 mg/L, 1-40 mg/L PO₄</td>
<td>Model PO-23 224902</td>
<td>ColorWheel</td>
</tr>
<tr>
<td>Phosphate, Ortho</td>
<td></td>
<td>PhosVer 3</td>
<td></td>
<td>0.02-3.00 mg/L PO₄</td>
<td>5870006 5870006</td>
<td>Pocket Colorimeter II Digital Meter</td>
</tr>
<tr>
<td>Phosphonate</td>
<td></td>
<td>PhosVer 3</td>
<td></td>
<td>0-5, 0-25, 0-50, 0-125 mg/L PO₄</td>
<td>Model PN-10 NO UV lamp 2113301, 115V lamp 2113300, 230V lamp 2113302</td>
<td>ColorWheel</td>
</tr>
<tr>
<td>Phosphonate</td>
<td></td>
<td>PhosVer 3</td>
<td></td>
<td>0.1-2.5 / 1-125 mg/L PO₄</td>
<td>5870007 5870007</td>
<td>Pocket Colorimeter II Digital Meter</td>
</tr>
</tbody>
</table>
Q: What Hach methods are available for phosphates and phosphonates?

A:

<table>
<thead>
<tr>
<th>Test</th>
<th>EPA</th>
<th>Chemistry</th>
<th>Hach Method</th>
<th>Conc. Range</th>
<th>Product #</th>
<th>Compatible Instruments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphate, Ortho</td>
<td>Amino Acid</td>
<td>8178</td>
<td>Powder Pillow: 2105069, AccuVAC: 2508025</td>
<td>0.25-50.00 mg/L PO₄</td>
<td>2244100</td>
<td>DR900, DR1900, DR2700, DR2800, DR3800, DR3900, DR5000, DR6000</td>
</tr>
<tr>
<td>Phosphate, Ortho</td>
<td>*</td>
<td>Ascorbic Acid (PhosVer)</td>
<td>8048</td>
<td>0.02-2.50 mg/L PO₄</td>
<td></td>
<td>DR900, DR1900, DR2700, DR2800, DR3800, DR3900, DR5000, DR6000</td>
</tr>
<tr>
<td>Phosphate, Ortho</td>
<td>*</td>
<td>Ascorbic Acid (PhosVer)</td>
<td>8048</td>
<td>0.06-5.00 mg/L PO₄</td>
<td></td>
<td>DR900, DR1900, DR2700, DR2800, DR3800, DR3900, DR5000, DR6000</td>
</tr>
<tr>
<td>Phosphate, Ortho</td>
<td>Molybdovanadate</td>
<td>8114</td>
<td>Solution: 2075032, AccuVAC: 2525025</td>
<td>0.3-45.00 mg/L PO₄</td>
<td></td>
<td>DR900, DR1900, DR2700, DR2800, DR3800, DR3900, DR5000, DR6000</td>
</tr>
<tr>
<td>Phosphate, Ortho</td>
<td>Molybdovanadate</td>
<td>8114</td>
<td>TNT: 2767565</td>
<td>1.0-100.0 mg/L PO₄</td>
<td></td>
<td>DR900, DR1900, DR2700, DR2800, DR3800, DR3900, DR5000, DR6000</td>
</tr>
<tr>
<td>Phosphate, Ortho</td>
<td>Molybdovanadate Rapid Liquid</td>
<td>8114</td>
<td>Bulk Solution: 2076049</td>
<td>0.3-45.00 mg/L PO₄</td>
<td></td>
<td>DR1500, DR2700, DR2800, DR3800, DR3900, DR5000, DR6000</td>
</tr>
<tr>
<td>Phosphate, Ortho</td>
<td>*</td>
<td>Ascorbic Acid Rapid Liquid</td>
<td>10055</td>
<td>19-5000 ug/L PO₄</td>
<td>2678600</td>
<td>DR1900, DR2700, DR2800, DR3800, DR3900, DR5000, DR6000</td>
</tr>
<tr>
<td>Phosphate, Ortho &amp; Total</td>
<td>Molybdovanadate</td>
<td>10214</td>
<td>TNT: 8746</td>
<td>1.5-30.0 mg/L PO₄</td>
<td></td>
<td>DR900, DR2700, DR2800, DR3800, DR3900, DR5000, DR6000</td>
</tr>
<tr>
<td>Phosphate, Ortho &amp; Total</td>
<td>*</td>
<td>Ascorbic Acid</td>
<td>10209</td>
<td>0.15-4.50 mg/L PO₄</td>
<td>8743</td>
<td>DR900, DR2700, DR2800, DR3800, DR3900, DR5000, DR6000</td>
</tr>
<tr>
<td>Phosphate, Ortho &amp; Total</td>
<td>*</td>
<td>Ascorbic Acid</td>
<td>10209</td>
<td>1.5-15.0 mg/L PO₄</td>
<td>8744</td>
<td>DR900, DR2700, DR2800, DR3800, DR3900, DR5000, DR6000</td>
</tr>
<tr>
<td>Phosphate, Ortho &amp; Total</td>
<td>*</td>
<td>Ascorbic Acid</td>
<td>10209</td>
<td>5-50 mg/L PO₄</td>
<td>8745</td>
<td>DR900, DR2700, DR2800, DR3800, DR3900, DR5000, DR6000</td>
</tr>
<tr>
<td>Phosphate, Total</td>
<td>*</td>
<td>Ascorbic Acid-Acid Persulfate digestion</td>
<td>8190</td>
<td>0.06-3.50 mg/L PO₄</td>
<td>2742645</td>
<td>DR900, DR1900, DR2700, DR2800, DR3800, DR3900, DR5000, DR6000</td>
</tr>
<tr>
<td>Phosphate, Total</td>
<td>Molybdovanadate Acid Persulfate digestion</td>
<td>10127</td>
<td>TNT: 2767245</td>
<td>1.0-100.0 mg/L PO₄</td>
<td></td>
<td>DR900, DR1900, DR2700, DR2800, DR3800, DR3900, DR5000, DR6000</td>
</tr>
<tr>
<td>Phosphate, Acid Hydrolyzable</td>
<td></td>
<td>Acid Hydrolyzable with PhosVer</td>
<td>8180</td>
<td>0.06-3.50 mg/L PO₄</td>
<td>2742645</td>
<td>PC1, DR900, DR1900, DR2700, DR2800, DR3800, DR3900, DR5000, DR6000</td>
</tr>
<tr>
<td>Phosphonate</td>
<td>Persulfate UV Oxidation</td>
<td>8007</td>
<td>0.02-125 mg/L PO₄</td>
<td>2429700</td>
<td></td>
<td>PC1, DR900, DR1900, DR2700, DR2800, DR3800, DR3900, DR5000, DR6000</td>
</tr>
</tbody>
</table>

*Phosphate, Ortho tests can be used to measure Total Phosphate after a digestion is performed.*
Q: Does Hach have a total or orthophosphate test that can measure less than 50 ug/L?

A: Yes, an ULR phosphate method has been created utilizing TNT843 reagent vials and a DRB200 reactor. See application note Lit 2097. This application note details a procedure that has a method detection limit (MDL) of 4.95 ug/L PO4-P for Orthophosphate and 5.35 ug/L PO4-P.

Q: I have condensed phosphates in my water. Which test do I need?

A: Phosphates which are condensed (meta-, pyro-, and polyphosphates) are inorganic and must be hydrolyzed to orthophosphate using acid and heat. The Hach method 8180 utilizes an acid persulfate digestion followed by PhosVer3 chemistry and should be used for condensed phosphates.

Q: Our outside lab is getting total phosphate results that are about three times what we are getting in our lab. What is wrong with our test?

A: Phosphate readings are typically displayed in one of two ways chemical forms: as phosphate (PO₄³⁻) or as phosphorus (PO₄³⁻-P). A reading displayed as PO₄³⁻ can be converted to -P by multiplying the result by a factor of 0.3261. The factor was calculated by using the molecular weight of the phosphorus 30.97 and molecular weight of the phosphate molecule 94.97.

Therefore: 30.97 ÷ 94.97 = 0.3261

To convert phosphorus (PO₄³⁻-P) to Phosphate (PO₄³⁻) multiply the result by 3.066.

Q: If I convert my measurement from PO₄⁻P to PO₄, will that give me my total phosphorus reading?

A: No. Total phosphate is the sum of organic and inorganic forms of phosphate and requires a digestion using heat, acid and persulfate to convert organic and condensed phosphates to orthophosphate for measurement.

Q: I performed a digestion on my sample followed by the Phosver 3 method 8048, but I am getting very low results. What is going on?

A: When running digested samples using method 8048, the wait time must be increased from 2 minutes to 10 minutes. This gives all phosphates present time to react.
Q: We just added phosphate testing to our lab tests and our results seem to be very high. We have verified that we are reading in the correct form and a premade Hach standard runs correctly. What could be the cause of this?

A: The most common cause of unexpectedly high results is phosphate contamination. This is usually caused by the detergent that is being used to clean your lab glassware. Most detergents contain phosphate, which will adhere to the sides of glassware and can add a significant amount of phosphate to your test. Containers used for sample collection, storage and testing that have suspected contamination should be washed with a 1:1 HCl solution. Phosphate free detergents (such as Liquinox) should be used for cleaning glassware. Liquinox part numbers 3.78L = 2088117, 946mL = 2088153

Q: How does the EPA define dissolved phosphorus and insoluble phosphorus?

A: The dissolved phosphorus test measures that fraction of the total phosphorus which is in solution in the water (as opposed to being attached to suspended particles). It is determined by first filtering the sample, then analyzing the filtered sample for total phosphorus.

Insoluble phosphorus is calculated by subtracting the dissolved phosphorus result from the total phosphorus result.

Q: How are the Phosphonate PN-10 kits calibrated?

A: The test kit color wheel was calibrated using 100% active phosphonic acid. The dilution factor is worked into the color wheel measurements.

Q: When following the Accuracy Check procedure for phosphonates, why should my result be 10 times higher than the displayed value?

A: In the Accuracy Check section of the Phosphonate procedure (Hach Method 8007), a 1 mg/L phosphate standard solution is used to check the instrument calibration. Digestion is not necessary for this verification, and the standard does not need to be diluted.

Because you are not digesting or diluting the standard, you can equivalently begin with 10 mL of sample, add the PhosVer3, and read the result. The displayed result will be 10 times higher than the standard concentration because a factor of 10 is programmed into the instrument calibration. This factor allows the range of the test to go to 125 mg/L.

This factor assumes that a 10-fold dilution was made (5 mL in 50 mL). Note that if a 5 mL volume is used from Table 1, no multiplication factor is needed from Table 2 (factor=1). You could
alternatively follow the procedure using 50 mL of standard (using the volume suggested in Table 1 for a 1 mg/L concentration). From Table 2, for 50 mL you will multiply the displayed reading by 0.1. This adjusts for the factor of 10 programmed in the instrument calibration.

Q: How do I determine the conversion factor for a phosphonate compound not listed in the procedure?

A: The phosphonate test converts all phosphonate compounds into phosphate, and then measures the increase in phosphate due to the phosphonates. The conversion factor for a particular phosphonate is determined from the molecular weight of the phosphonate relative to phosphate, and the number of PO4 (or PO3) groups in the phosphonate molecule:

- Conversion factor = MW phosphonate/(MW PO4 x PO4 or PO3 groups)

Example:

- What is the conversion factor for MDTP (2-methylene diamine tetrakis-(Methylene Phosphonic Acid))?  
  - The molecular weight (MW) of MDTP is 490 g/mole  
  - The molecular weight of phosphate is 95 g/mole  
  - There are 4 PO3 groups per molecule of MDTP  
  - The conversion factor is: 490/(95 x 4) = 1.29

In this example, you would multiply the result displayed on your instrument by 1.29 to find the concentration of MDTP in your sample.

Q: Does Hach have a method for measuring forms of calcium phosphate (such as dibasic calcium monophosphate)?

A: Hach does not have a method that can measure calcium phosphates directly; an acid hydrolysis must be performed first.

Q: Does Hach have a method for measuring Trisodium Phosphate?

A: Trisodium Phosphate can be measured using any orthophosphate method.

Q: Can Amino Acid Powder Pillows 804XX be used in place of 1934XX Amino Acid Reagent Solution?
A: Yes, the powder pillows can be used in place of the solution for the HR phosphate tests. However, the calibration will be off slightly because there is no dilution of the sample by the powder reagent. The readings will be about 5% higher.

Q: What can cause my sample to not turn blue when following method 8178 Amino Acid method?

A: If the phosphate is out of the range of the test the color development might be other than blue. Nitrite in the sample may cause a bleaching of the blue color.

Q: Is there a difference between Phosphate 2 reagent and PhosVer3 reagent?

A: Phosphate 2 uses a different reducing agent. If you find the reagent has turned yellow then the reagent may not be stable and provide accurate measurement, analyze a primary standard.

Q: Are there a list of common interferences between the different phosphate chemistries?

A: Yes see attached excel sheet.
Q: How is the conversion factor from Orthophosphate (PO₄) to Phosphorus Pentoxide (P₂O₅) determined?

A: The WAH and most other procedural publications have a conversion at the end of the phosphate procedure showing a conversion factor from Ortho Phosphate(PO₄) to Phosphorus Pentoxide(P₂O₅) as 0.7473. This conversion is NOT based on the molecular weight of the two compounds. In solution phosphorus pentoxide converts to orthophosphate (and acid). The conversion of .75 is based on the rate of that reaction.

Q: Can a phosphonate be measured using a total phosphate test using a persulfate digestion instead of a UV oxidation?

A: Phosphonates are a form of organic phosphate. The compounds can sometimes be read with just an organic digestion (Total phosphate (TP) – Acid Hydrolyzable (TIP) instead of a UV oxidation (UV lamp).

Q: Many MSDS files, for a variety of phosphate chemistries, require an appropriate solvent to be used to rinse out test tube reagent vials prior to digestion (see section 13 in MSDS). What is an appropriate solvent?

A: Check with local regulations to determine if water is the appropriate solvent to be used for this purpose.

Q: Hach total phosphate chemistry 2742645 for method 8190 is on backorder, is an appropriate alternative: empty culture tubes 2275806 or 2899300, white caps 2241106, and hot plate digestion reagents?

A: No, the white caps 2241106 are not appropriate to the digestion and may cause leaking, sample volume loss, and inaccurate results. The correct caps for this digestion are semi-transparent with a blue liner. The acid and base reagents are not at the same concentrations between the two reagent sets.

Q: What is the expected life for the UV lamps 2670800 and 2671000?
A: Based on information supplied by the manufacture of the lamps, there is no lamp life estimate available. Lamp cycles or lamp life is based on the “on/off” cycle of the lamp and the power supply (115V, 220V, or Field Pack).

Q: Can the PhosVer 3 powder pillows be used with the Pour-thru cell or Sip10?

A: This chemistry is not listed in the Pour-thru manual or Sip10 manual as “Not Suitable”. However, the Phosver3 chemistry may not fully dissolve. Undissolved reagent may be a source of contamination. It would be recommended to utilize appropriate rinsing of the pour-thru cell or Sip10 between samples.