DOC326.97.00092

Soil and Irrigation Water Test Kit

SIW-1 (2496000)

12/2019, Edition 1

User Manual

Section 1 General information

In no event will the manufacturer be liable for direct, indirect, special, incidental or consequential damages resulting from any defect or omission in this manual. The manufacturer reserves the right to make changes in this manual and the products it describes at any time, without notice or obligation. Revised editions are found on the manufacturer's website.

1.1 Safety information

NOTICE

The manufacturer is not responsible for any damages due to misapplication or misuse of this product including, without limitation, direct, incidental and consequential damages, and disclaims such damages to the full extent permitted under applicable law. The user is solely responsible to identify critical application risks and install appropriate mechanisms to protect processes during a possible equipment malfunction.

Please read this entire manual before unpacking, setting up or operating this equipment. Pay attention to all danger and caution statements. Failure to do so could result in serious injury to the operator or damage to the equipment.

Make sure that the protection provided by this equipment is not impaired. Do not use or install this equipment in any manner other than that specified in this manual.

1.2 Use of hazard information

⚠ DANGER

Indicates a potentially or imminently hazardous situation which, if not avoided, will result in death or serious injury.

⚠ WARNING

Indicates a potentially or imminently hazardous situation which, if not avoided, could result in death or serious injury.

⚠ CAUTION

Indicates a potentially hazardous situation that may result in minor or moderate injury.

NOTICE

Indicates a situation which, if not avoided, may cause damage to the instrument. Information that requires special emphasis.

1.3 Product overview

The Soil and Irrigation Water Test Kit includes the necessary items to do basic analyses for soil fertility assessment and irrigation water quality. Refer to Table 1 and Table 2.

The procedures in this manual are adapted from the books and publications that follow:

- *Handbook on Reference Methods For Soil Testing*, Revised Edition—1980 The Council On Soil Testing and Plant Analysis
  1111, Plant Science Building, University of Georgia, Athens, Georgia
- *Recommended Chemical Soil Test Procedures for the North Central Region, Bulletin No. 499 (Revised) and North Central Regional Publication No. 221 (Revised)*
  North Dakota Agricultural Experiment Station, North Dakota State University, Fargo, North Dakota 58105
- *Diagnosis and Improvement of Saline and Alkali Soils, Agricultural Handbook No. 60*
  United States Department of Agriculture, issued February 1954 (out of print), compiled by the United States Salinity Laboratory Staff
- *Methods of Soil Analysis, Part 2*
  American Society of Agronomy, Madison, Wisconsin, 1965

Some measurement methods use reagents and color discs to make a visual determination of the parameter concentration. Refer to Figure 1. Other measurement methods use reagents and titration procedures or Pocket Pro Testers to measure the parameter concentration.

The lime requirement method uses the degree of effervescence to identify the calcareous of the soil. The potassium in soil method uses a potassium measuring dipstick to measure the parameter concentration.

Use the Digital Titrator for the titration procedures. Refer to the supplied documentation for the correct operation of the Digital Titrator. The Digital Titrator documentation also has more accuracy check procedures and descriptions of the chemical reactions.

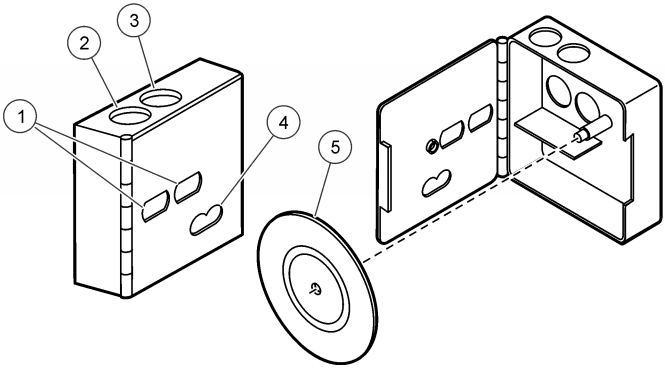
Table 1 Test kit parameters—Soil

Parameter	Units	Method
Gypsum requirement for soil	meq/100 g, tons/acre or metric tons/Ha	EDTA titration
Calcium and magnesium in soil	meq/100 g	EDTA titration
Lime, free (excess) in soil	Calcareous	Degree of effervescence
Lime requirement for soil	tons/acre	Pocket Pro pH Tester
Nitrate-Nitrogen in soil	0–60 ppm	Cadmium reduction with color disc
pH in soil	2–12 pH units	pH Pocket Pro Tester
Phosphorus in soil	0–130 mg/L (ppm)	PhosVer3 (ascorbic acid) with color disc
Potassium (exchangeable) in soil	0–250 mg/L (ppm), lbs/A, Kg/Ha or meq/100 g	Turbidimetric tetraphenylborate with potassium measuring dipstick
Salinity (conductivity/TDS) in soil	0 to 1999 ppm	Pocket Pro TDS Tester, low range
Texture estimation of soil	—	—
Total exchangeable acidity in soil	meq/100 g	NaOH titration

Table 2 Test kit parameters—Irrigation water

Parameter	Units	Method
Conductivity/TDS in irrigation water	0 to 1999 ppm	Pocket Pro TDS Tester, low range
Calcium + Magnesium in irrigation water	meq/L	EDTA titration
Nitrate Nitrogen in irrigation water	0–40 mg/L	Cadmium reduction with color disc
pH in irrigation water	2–12 pH units	Pocket Pro pH Tester
Phosphorus in irrigation water	0–5 mg/L	PhosVer3 (ascorbic acid) with color disc
Sodium estimation and Sodium Adsorption Ratio calculations in irrigation water	meq/L	Calculation

Figure 1 Color comparator box



1 Windows for color matching	**4** Scale window
2 Left opening for viewing tube	**5** Color disc
3 Right opening for viewing tube	

1.4 Product components

Make sure that all components have been received. Refer to the list that follows. If any items are missing or damaged, contact the manufacturer or a sales representative immediately.

- Hach Soil and Irrigation Water Interpretation Manual
- Beaker, polypropylene, 50 mL (2x)
- Bottle, narrow mouth, with flip-top caps 177 mL (3x)
- Bottle for sample, round with 20 and 25-mL marks and caps (10x)
- Clipper for powder pillows
- Color comparator box
- Color disc, Phosphate, 0–40 mg/L
- Color disc, Nitrate Nitrogen, 0–40 mg/L
- Demineralizer assembly, 473 mL
- Droppers, 0.5, 1.0 and 2.5 mL
- Erlenmeyer flask, 50 mL
- Erlenmeyer flask, 125 mL (2x)
- Filter paper, 8–12 µm, 15 cm (5.9 inch) diameter, 100 (4x)
- Funnel, polypropylene, 89 mm (3.5 inch) (4x)
- Graduated cylinder, polymethylpentene, 25 mL (4x)
- Pen, nalgene
- Pocket Pro pH Tester
- Pocket Pro TDS Tester, low range
- Potassium measuring dipstick
- Soil scoops, 1, 2 and 5 g
- Soil sieve
- Spatula, stainless steel, 7.6 cm (3-inch) blade
- Spoon, plastic, 0.1 g
- Stopper, size 2 (4x)
- Stopper, size 3 (4x)
- Tube, plastic (8x)
- Watch glass, Pyrex, 65 mm (2.56 inch)
- Alkaline EDTA Solution, 100 mL (9x)
- Buffer pH 7.00 Powder Pillow, 50
- Buffer Hardness 1 Solution, 100 mL (4x)
- Calcium Sulfate Powder, 5 g (3x)
- EDTA Standard Solution, 0.0075 N, 100 mL (6x)
- Hardness 2 Indicator Solution, 100 mL
- Hydrochloric Acid, 2.5 N, 100 mL
- Mehlich 2 Soil Extractant Solution, 500 mL (2x)
- Nitrate-Nitrogen Standard Solution, 15 mg/L, 100 mL
- Nitraver 5 Powder Pillow, 100 (3x)
- Phenolphthalein Indicator Solution, 5 g/L, 100 mL
- Phosver 3 Powder Pillow, 100 (3x)
- Potassium Chloride, 454 g (3x)
- Potassium 2 Reagent Solution Pillow, 25 (12x)
- Potassium 3 Reagent Powder Pillow, 100 (3x)
- Sodium Hydroxide Standard Solution, 0.075 N, 100 mL (3x)

Use the *Hach Soil and Irrigation Water Interpretation Manual* to identify the results. The *Hach Soil and Irrigation Water Interpretation Manual* gives basic data on soil fertility, soil characterization, plant nutrition, fertilizer recommendation and irrigation water quality.

In addition, the *Hach Soil and Irrigation Water Interpretation Manual* contains a section on standard conversion factors used in soil and water analysis, a glossary of terms, order information and technical support information. The last pages contain data recording sheets to record data and calculations from the analyses.

Section 2 Sample collection and preparation

2.1 Irrigation water sampling

For the best results, it is important that the water sample is representative of the water source. To get satisfactory samples of some waters, collect many samples at different times and mix them. The collection and mixing procedure are dependent on the local conditions.

- **Wells**—Collect samples from wells after the pump has operated for a minimum of 10 minutes.
- **Streams**—Collect stream samples from running water.

To collect a sample:

1. Rinse the sample container 3 times with the sample water.
2. Collect a minimum of 1 L of water.
3. Fully fill the container with the sample water, then tighten the cap.
4. For the best results, analyze the sample as soon as possible. Chemical and biological activity can change the sample.

2.2 Soil sampling

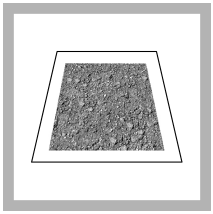
For the best results, it is important that the soil sample is representative of the area. The local extension office supplies the best information about sampling.

Use a coring tube, soil auger or shovel to collect 15 to 20 subsamples of approximately the same size from the area. Do not collect subsamples from unusual areas (e.g., old manure piles, lime piles or fence lines). Mix the subsamples together in a clean container. Use the mixed subsamples for the analysis of the area.

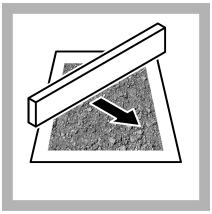
2.3 Soil preparation

For the best results, dry, crush and mix soil samples and then put the soil samples through the soil sieve in the kit before analysis. Refer to the procedure that follows.

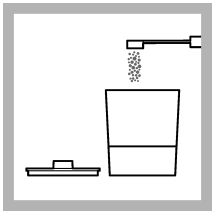
The procedure that follows is regularly used to prepare soil samples for analysis. The procedure is applicable for all types of soils. The procedure that follows is based on the *Recommended Chemical Soil Test Procedures for the North Central Region, Bulletin No. 499 (Revised)*, October, 1980 published by The North Dakota Agricultural Experiment Station, North Dakota State University.



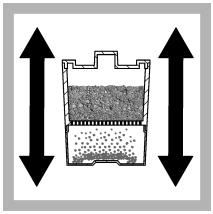
1. Break the large pieces of soil into small pieces. Fully dry the soil in the air. Prevent soil contamination from fertilizer dusts or other sources of contamination.
As an alternative, use a forced-draft oven or equivalent drying device. Set the heat to 60 °C (140 °F) maximum.



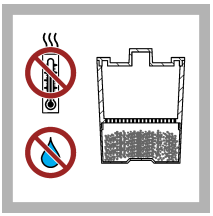
2. Use a clean, short 5 x 11 cm (2 x 4-inch) board or equivalent device to crush the dry soil.



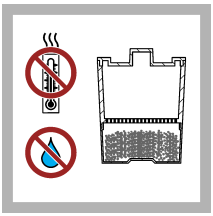
3. Put the soil in the 10-mesh (2 mm) soil sieve.



4. Shake the soil sieve to put the soil through the soil sieve.



5. Keep the soil in a cool, dry location until the analysis is complete.

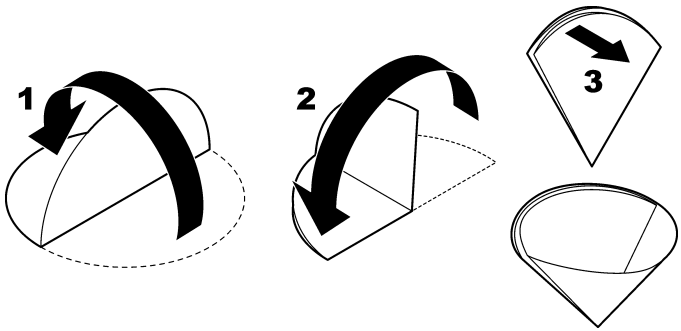


6. Keep the prepared soil samples after analysis. More analysis may be necessary.

2.4 Soil extract filtering

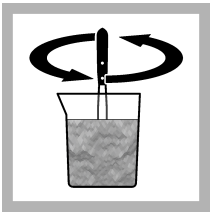
1. Fold a piece of filter paper in half and then in half again. Refer to Figure 2.
2. Pull one edge of the filter paper from the other three to form an inverted cone. Make sure that there are no holes or tears in the filter paper.
3. Make the funnel wet with deionized water. Shake the funnel to remove the water drops.
4. Put the filter paper in the funnel.
5. Put the funnel into a round sample bottle or plastic cup to collect the soil extract.

Figure 2 Fold the filter paper

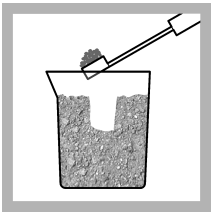


2.5 Soil scoop procedure

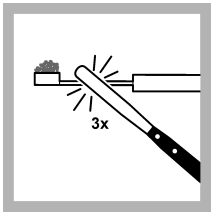
Use the procedure that follows to collect soil samples with a soil scoop.



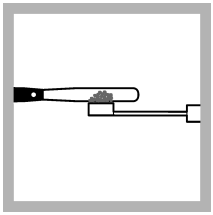
1. Use a spatula to stir the soil sample.



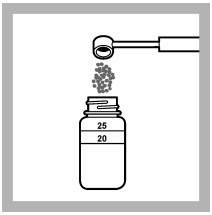
2. Collect more than a full scoop from the middle of the soil sample.



3. Tap the handle of the scoop 3 times with a spatula to settle the soil.



4. Hold the blade of the spatula perpendicular to the top of the scoop and remove the soil above the scoop.



5. Put the soil in the scoop into the applicable container for the procedure.

Section 3 Soil extraction procedures

⚠ CAUTION

Chemical exposure hazard. Obey laboratory safety procedures and wear all of the personal protective equipment appropriate to the chemicals that are handled. Refer to the current safety data sheets (MSDS/SDS) for safety protocols.

⚠ CAUTION

Chemical exposure hazard. Dispose of chemicals and wastes in accordance with local, regional and national regulations.

The usual procedure to analyze for a specific substance(s) in a soil is to add a solvent (extractant) that removes the substance from the soil. Then, the analysis is done on the solution that contains the removed substance.

This manual contains six extraction procedures. Table 3 shows which extractions to use to analyze specific substances or parameters. Make sure to use the correct extraction procedure. More than one type of extraction can be necessary for a sample.

Table 3 Extraction guide

Extraction procedure	Substance or parameter
Aqueous extraction on page 10	pH in soil on page 27
Calcium sulfate extraction on page 11	Nitrate-Nitrogen in soil (0–60 ppm) on page 25
Mehlich 2 extraction procedure on page 13	Phosphorous in soil (0–130 mg/L or 0–130 ppm) on page 28 Potassium, exchangeable, in soil (0–250 mL or 0–250 ppm) on page 30 Calcium + magnesium in soil on page 21
Potassium Chloride extraction procedure on page 15	Total exchangeable acidity in soil on page 35
Saturated Calcium Sulfate extraction procedure on page 16	Gypsum requirement or exchangeable sodium in soil on page 19 Salinity (conductivity/TDS) in soil on page 32
SMP buffer extraction on page 17	Lime requirement on page 24

The Mehlich 2 extraction procedure was selected for the reasons that follow:

- The Mehlich 2 procedure is applicable to phosphorus extraction from most types of soils.

- The reagent removes as much or more phosphorus from most soils than other standard extracts, which results in more color development. Thus, there is more accurate visual comparison of the color.
- The Mehlich 2 procedure extracts other macronutrients (e.g., potassium, calcium and magnesium), which can be measured and used to calculate cation exchange capacity and percent base saturation.

This manual includes two methods for the determination of lime requirement in soil.

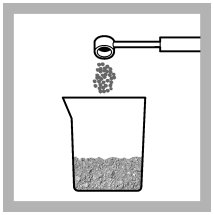
- For soils that have a lime requirement that is more than 2 tons/acre, use SMP buffer extraction and the lime requirement analysis procedure.
- For soils that have a lime requirement that is less than 2 tons/acre or in tropicals soils with high reserves of aluminum, use the potassium chloride extraction and the total exchangeable acidity analysis procedure.

The soil and irrigation water test kit uses a 1:1 soil suspension to determine soil salinity as an alternative to a saturated paste extract. But, where salinity management and leaching requirements are of high importance, determine salinity with the saturated paste method.

3.1 Aqueous extraction

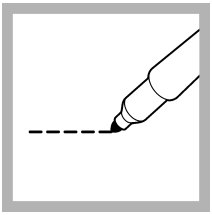
Use aqueous extraction to prepare a soil sample for salinity and pH measurements. It is not necessary to put the soil suspension through a filter to determine pH and salinity. Do measurements directly in the suspension.

Pre-requisite: Collect and prepare the soil sample. Refer to Soil sampling on page 7 and Soil preparation on page 7. Soil preparation is important for the volumetric measurement of the soil sample.

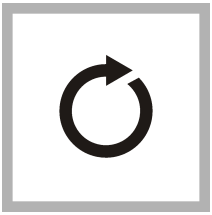


1. Use the 5-g scoop to add 4 scoops of the prepared soil sample to a 50-mL plastic beaker. Refer to Soil scoop procedure on page 8.

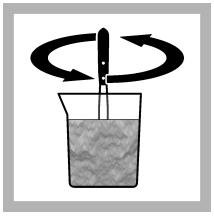
2. Use the 25-mL graduated cylinder to add 20 mL of deionized water to the 50-mL beaker.



3. Record the sample or test name on the plastic beaker.



4. Do steps 1 to 3 for each soil sample.



5. Use the spatula to mix the contents of the beaker for 1 minute at 10-minute intervals for a 30 minute period. Clean the spatula with deionized water between samples.

Note: *Small quantities of potassium chloride from pH determination have an effect on conductivity. Thus, make sure to measure the salinity of the soil sample before the pH is measured.*

3.1.1 Replacement items

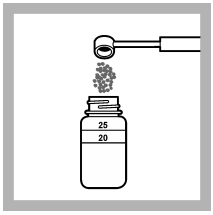
Note: *Product and Article numbers may vary for some selling regions. Contact the appropriate distributor or refer to the company website for contact information.*

Description	Unit	Item no.
Beaker, 50 mL, polypropylene	each	108041
Cylinder, graduated, polymethylpentene, 25 mL	each	217240
Soil scoop, 5 g	each	2657205
Soil sieve	each	4615900
Spatula, stainless steel, 3-in. blade	each	56162

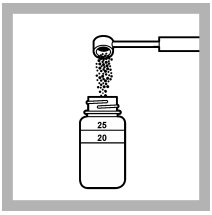
3.2 Calcium sulfate extraction

Use the calcium sulfate extraction to remove nitrate-nitrogen from all types of soils.

Pre-requisite: Collect and prepare the soil sample. Refer to Soil sampling on page 7 and Soil preparation on page 7. Soil preparation is important for the volumetric measurement of the soil sample.

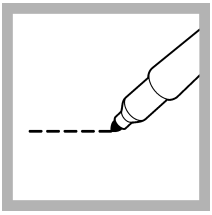


1. Use the 5-g scoop to add 2 scoops of the prepared soil sample to a round mixing bottle. Refer to Soil scoop procedure on page 8.

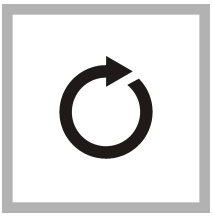


2. Use the 0.1-g plastic spoon to add 1 level spoonful of calcium sulfate to the round mixing bottle.

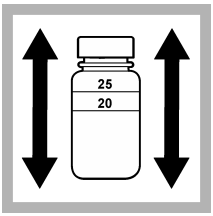
3. Use the 25-mL graduated cylinder to add 20 mL of deionized water to the round mixing bottle.



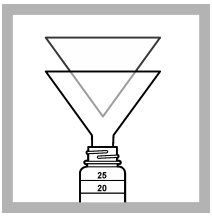
4. Record the sample or test name on the round mixing bottle.



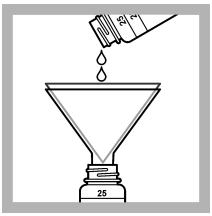
5. Do steps 1 to 3 for each soil sample.



6. Put the cap on the bottle. Shake the bottle quickly for 1 minute.



7. Put filter paper and a plastic funnel in a second round mixing bottle. Refer to Soil extract filtering on page 8.



8. Put the prepared sample through the filter.
Analyze the sample extract for nitrate-nitrogen within 2 hours or refrigerate for a maximum of 24 hours. Refer to Nitrate-Nitrogen in soil (0–60 ppm) on page 25. If refrigerated, let the extract increase to room temperature before analysis.

3.2.1 Replacement items

Note: *Product and Article numbers may vary for some selling regions. Contact the appropriate distributor or refer to the company website for contact information.*

Description	Unit	Item no.
Calcium Sulfate Powder	20 g	1232120
Bottle, mixing, round with cap	each	1862400
Cylinder, graduated, polymethylpentene, 25 mL	each	217240
Filter paper, 15 cm (5.9 in.)	100/pkg	50658
Funnel, poly, 82 mm	each	2415582
Spoon, measuring, 0.1 g	each	51100
Soil scoop, 5 g	each	2657205
Soil sieve	each	4615900

3.3 Mehlich 2 extraction

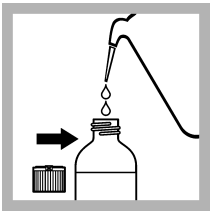
Use the Mehlich 2 extraction procedure to remove calcium + magnesium, phosphorus, and potassium from all types of soils. With highly calcareous soils, calcium and magnesium results will be artificially high.

Pre-requisite:

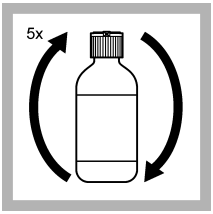
- Collect and prepare the soil sample. Refer to Soil sampling on page 7 and Soil preparation on page 7. Soil preparation is important for the volumetric measurement of the soil sample.
- Prepare the Mehlich 2 soil extractant. Refer to Prepare the Mehlich 2 soil extractant on page 13.

3.3.1 Prepare the Mehlich 2 soil extractant

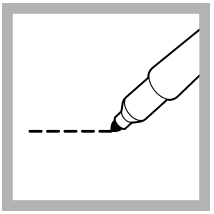
1. Use the 25-mL graduated cylinder to add 20 mL of the Mehlich 2 soil extractant to a dispensing bottle with a flip-top cap from the kit.



2. Add deionized water to the bottle until the solution level is at the bottom of the neck of the bottle.

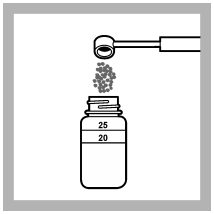


3. Invert the bottle 5 times to mix.



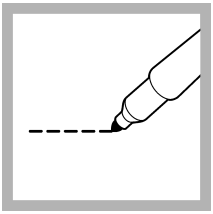
4. Use the laboratory pen to record the extract name on the bottle.

3.3.2 Mehlich 2 extraction procedure

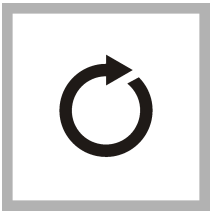


1. Use the 2-g scoop to add 1 scoop of the prepared soil sample to a round mixing bottle. Refer to Soil scoop procedure on page 8.

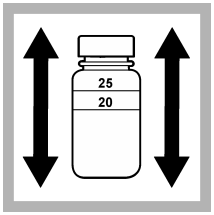
2. Use the 25-mL graduated cylinder to add 20 mL of the prepared Mehlich 2 soil extractant to the round mixing bottle.



3. Record the sample or test name on the round mixing bottle.

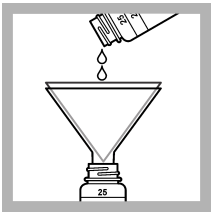


4. Do steps 1 to 3 for each soil sample.



5. Put the cap on the bottle. Shake the bottle for 5 minutes.

6. Put filter paper and a plastic funnel in a second round mixing bottle. Make the funnel wet with deionized water. Shake the funnel to remove the water drops. Refer to Soil extract filtering on page 8.



7. Put the prepared sample through the filter.
Analyze the sample extract within 24 hours or refrigerate to prevent microbial growth.
Note: *The volume of filtered sample is sufficient for the analysis of calcium + magnesium, phosphorus and potassium.*

3.3.3 Replacement items

Note: *Product and Article numbers may vary for some selling regions. Contact the appropriate distributor or refer to the company website for contact information.*

Description	Unit	Item no.
Mehlich 2 Soil Extractant Solution	500 mL	2266349
Bottle, mixing, round with cap	each	1862400
Bottle with narrow mouth, 177 mL	each	590900
Flip-top cap for 590900	each	591200
Cylinder, graduated, polymethylpentene, 25 mL	each	217240
Filter paper, 15 cm (5.9 in.)	100/pkg	50658
Funnel, poly, 82 mm	each	2415582
Soil scoop, 2 g	each	2657202
Soil sieve	each	4615900

3.4 Potassium chloride extraction

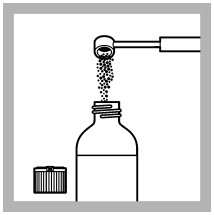
Use the potassium chloride extraction to prepare a soil sample for total exchangeable acidity determination.

Pre-requisite:

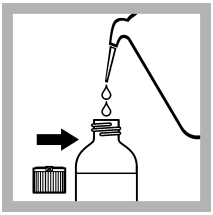
- Collect and prepare the soil sample. Refer to Soil sampling on page 7 and Soil preparation on page 7. Soil preparation is important for the volumetric measurement of the soil sample.
- Prepare the potassium chloride extractant. Refer to Prepare the potassium chloride extractant on page 14.

3.4.1 Prepare the potassium chloride extractant

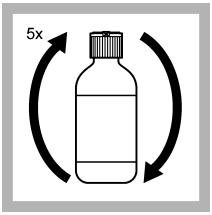
The procedure that follows makes sufficient extractant to do four test. The potassium chloride extractant is approximately a 1.0 N KCl solution.



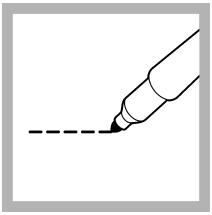
1. Use the 5-g soil scoop to add three scoops of potassium chloride to a dispensing bottle with a flip-top cap from the kit.



2. Add deionized water to the bottle until the solution level is at the bottom of the neck of the bottle.



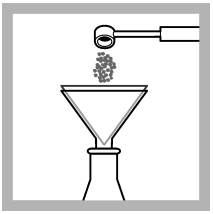
3. Invert the bottle 5 times to mix.



4. Use the laboratory pen to record the extract name on bottle.

3.4.2 Potassium Chloride extraction procedure

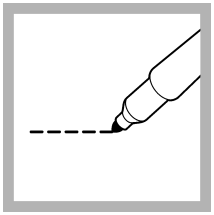
1. Put filter paper and a plastic funnel in a 125-mL Erlenmeyer flask. Make the funnel wet with deionized water. Shake the funnel to remove the water drops. Refer to Soil extract filtering on page 8.



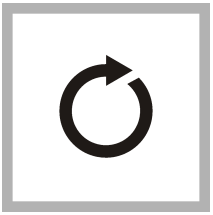
2. Use the 5-g scoop to add 1 scoop of the prepared soil sample to the funnel. Refer to Soil scoop procedure on page 8.

3. Use the 25-mL graduated cylinder to slowly add five 10 mL portions of potassium chloride extractant to the funnel over a 2-hour period.

4. Use the 25-mL graduated cylinder to slowly add two 10 mL portions of deionized water.



5. Record the sample or test name on the Erlenmeyer flask that contains the soil sample extract.



6. Do steps 1 to 5 for each soil sample.

7. Add deionized water to the 75-mL mark of the 125-mL Erlenmeyer flask that contains the sample extract. Analyze the diluted sample extract for the determination of total exchangeable acidity. Refer to Total exchangeable acidity in soil on page 35.

3.4.3 Replacement items

Note: *Product and Article numbers may vary for some selling regions. Contact the appropriate distributor or refer to the company website for contact information.*

Description	Unit	Item no.
Potassium Chloride	454 g	76401
Bottle with narrow mouth, 177 mL	each	590900
Flip-top cap for 590900	each	591200
Cylinder, graduated, polymethylpentene, 50 mL	each	217241
Flask, Erlenmeyer, polymethylpentene, 125 mL	each	2089843
Filter paper, 15 cm (5.9 in.)	100/pkg	50658
Funnel, poly, 82 mm	each	2415582

3.4.3 Replacement items (continued)

Description	Unit	Item no.
Soil scoop, 5 g	each	2657205
Soil sieve	each	4615900

3.5 Saturated calcium sulfate extraction

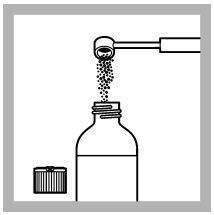
Use the saturated calcium sulfate extraction to prepare a sample for the determination of gypsum requirement. The estimated values of meq/100 grams of exchangeable sodium in the soil are calculated.

Saturated calcium sulfate extraction is based on the principle that the calcium ions in the saturated solution of $CaSO_4$ will replace the exchangeable sodium in the extract. The number of milliequivalents of sodium removed will equal the number of Ca^{2+} milliequivalents extracted from the saturated $CaSO_4$ solution.

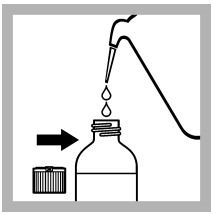
Pre-requisites:

- Collect and prepare the soil sample. Refer to Soil sampling on page 7 and Soil preparation on page 7. Soil preparation is important for the volumetric measurement of the soil sample.
- Prepare the saturated calcium sulfate extractant. Refer to Prepare the saturated calcium sulfate extractant on page 16.

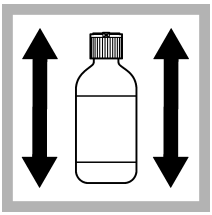
3.5.1 Prepare the saturated calcium sulfate extractant



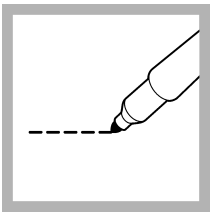
1. Use the 1-g soil scoop to add 1 scoop of calcium sulfate to a dispensing bottle with a flip-top cap from the kit.



2. Add deionized water to the bottle until the solution level is at the bottom of the neck of the bottle.

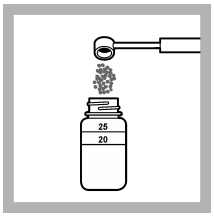


3. Shake the bottle quickly for 1 minute at 10-minute intervals for a 30-minute period. A small quantity of calcium sulfate may not dissolve.



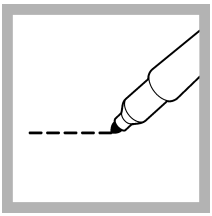
4. Use the laboratory pen to record the extract name on bottle.

3.5.2 Saturated Calcium Sulfate extraction procedure

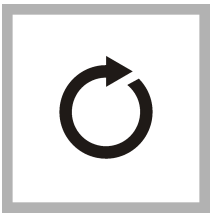


1. Use the 1-g scoop to add 1 scoops of the prepared soil sample to a round mixing bottle. Refer to Soil scoop procedure on page 8.

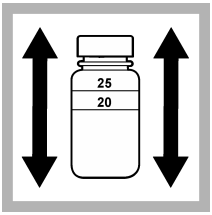
2. Use the 25-mL graduated cylinder to add 20 mL of the saturated calcium sulfate extractant to the round mixing bottle.



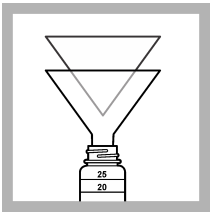
3. Record the sample or test name on the round mixing bottle.



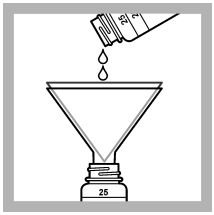
4. Do steps 1 to 3 for each soil sample.



5. Put the cap on the bottle. Shake the bottle quickly for 1 minute at 10-minute intervals for a 30-minute period.



6. Put filter paper and a plastic funnel in a second round mixing bottle. Make the funnel wet with deionized water. Shake the funnel to remove the water drops. Refer to Soil extract filtering on page 8.



7. Put the prepared sample through the filter.
Use the sample extract to determine the Gypsum requirement or exchangeable sodium in soil on page 19 and exchangeable sodium.

3.5.3 Replacement items

Note: *Product and Article numbers may vary for some selling regions. Contact the appropriate distributor or refer to the company website for contact information.*

Description	Unit	Item no.
Calcium Sulfate Powder	20 g	1232120
Bottle, mixing, round with cap	each	1862400
Bottle with narrow mouth, 177 mL	each	590900
Flip-top cap for 590900	each	591200
Cylinder, graduated, polymethylpentene, 25 mL	each	217240
Filter paper, 15 cm (5.9 in.)	100/pkg	50658
Funnel, poly, 82 mm	each	2415582
Soil scoop, 1 g	each	2657201
Soil sieve	each	4615900

3.6 SMP buffer extraction

Use the SMP buffer extraction to prepare a sample for lime requirement analysis. Use the SMP buffer extraction for soils that have a lime requirement that is more than 2 tons/acre (or 2,240 kg/Ha) and large quantities of exchangeable aluminum (Al).

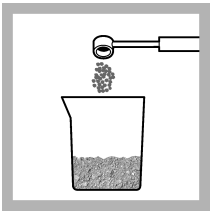
Note: *The Lime Requirement Buffer Pillow used for SMP buffer extraction is supplied by the user. The Lime Requirement Buffer Pillow is not available from Hach because the buffer contains chromium and p-nitrophenol, which classifies the solution as hazardous waste.*

Do not use the SMP buffer extraction procedure for the soil types that follow:

- Soils that contain organic matter of more than 10%
- Sandy soils
- Soils with high levels of kaolinite and hydroxy oxides of aluminum and iron in their clay fractions

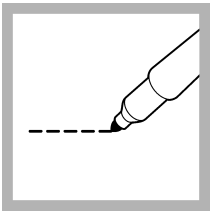
When the SMP buffer extraction is not applicable, use the Potassium Chloride extraction procedure on page 15 and the total exchangeable acidity analysis to determine the lime requirement.

Pre-requisites: Collect and prepare the soil sample. Refer to Soil sampling on page 7 and Soil preparation on page 7. Soil preparation is important for the volumetric measurement of the soil sample.

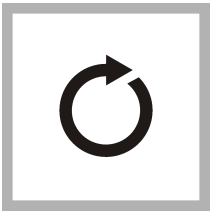


1. Use the 2-g scoop to add 4 scoops of the prepared soil sample to a 50-mL beaker. Refer to Soil scoop procedure on page 8.

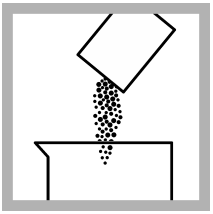
2. Use the 25-mL graduated cylinder to add 21 mL of deionized water to the 50-mL beaker.



3. Record the sample or test name on the 50-mL beaker.



4. Do steps 1 to 3 for each soil sample.



5. Add 1 Lime Requirement Buffer Pillow to the beaker. ***Note:*** *The Lime Requirement Buffer Pillow is supplied by the user. The Lime Requirement Buffer Pillow is not available from Hach.*

6. Use the spatula to mix the contents of the beaker for 1 minute. Clean the spatula with deionized water before each sample is mixed.

7. Wait 10 minutes. Use the prepared sample to determine the lime requirement. Refer to Lime requirement on page 24.

3.6.1 Replacement items

Note: *Product and Article numbers may vary for some selling regions. Contact the appropriate distributor or refer to the company website for contact information.*

Description	Unit	Item no.
Beaker, 50 mL, polypropylene	each	108041
Cylinder, graduated, polymethylpentene, 25 mL	each	217240
Soil scoop, 2 g	each	2657202
Soil sieve	each	4615900
Spatula, stainless steel, 3-in. blade	each	56162

Section 4 Soil analysis procedures

⚠ CAUTION

Chemical exposure hazard. Obey laboratory safety procedures and wear all of the personal protective equipment appropriate to the chemicals that are handled. Refer to the current safety data sheets (MSDS/SDS) for safety protocols.

⚠ CAUTION

Chemical exposure hazard. Dispose of chemicals and wastes in accordance with local, regional and national regulations.

4.1 Calculation of cation exchange capacity and percent base saturation

Calculate the cation exchange capacity (CEC) of soils to identify the quantity of potassium and herbicides to add to soils.

To calculate cation exchange capacity and percent base saturation, first determine the potassium, calcium + magnesium, sodium and lime requirement.

The accurate determination of CEC takes a lot of time. Soil testing labs in regions with acidic to neutral (pH 7) soils have determined that an estimate of the CEC can be calculated. Refer to the equation that follows:

CEC in meq/100 g = K + Ca + Mg + Na + (SMP lime requirement x 2)

The values for K (potassium), Ca (calcium), Mg (magnesium), and Na (sodium) are in meq/100 g, not in ppm. Refer to the individual procedures to get the correct units. Refer to Gypsum requirement or exchangeable sodium in soil on page 19 to calculate the Na value.

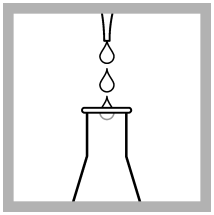
% Base Saturation = [(K + Ca +Mg + Na) x 100] ÷ CEC

A numeric value for both Na and exchangeable acidity are not usually included in the calculation. Acidic soils have a lime requirement and are usually sufficiently low in sodium that Na is not significant in the CEC calculation. Soils that are alkaline have no lime requirement value. Therefore, do not include the lime requirement in the calculation for soils that are alkaline.

Note: *Measurement of CEC for calcareous soils (pH less than 7) can be inflated by the $CaCO_3$ in the Mehlich 2 soil extractant.*

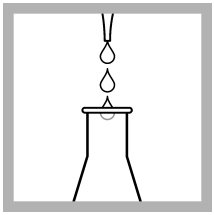
4.2 Gypsum requirement or exchangeable sodium in soil

Pre-requisite: Do the steps in Saturated Calcium Sulfate extraction procedure on page 16 to get a calcium sulfate extract for the soil.



1. Use a 1.0-mL dropper to add 1.0 mL of the calcium sulfate extract to a 50-mL Erlenmeyer flask.

2. Add deionized water to the 25-mL mark of the Erlenmeyer flask.

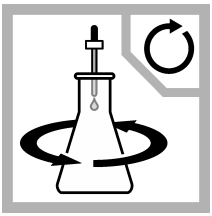


3. Add 1.0 mL of the Hardness 1 Buffer Solution to the Erlenmeyer flask.

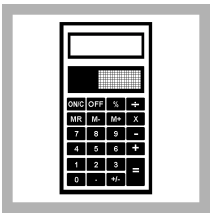
4. Swirl to mix.

5. Add 3 to 4 drops of Hardness 2 Indicator Solution to the Erlenmeyer flask.

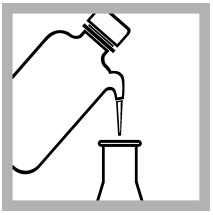
6. Swirl to mix.



7. Add the 0.0075 N EDTA Standard Solution by drops. Swirl after each drop. Count the drops until the color changes from wine red to pure blue.



8. Calculate the gypsum requirement and exchangeable sodium. Refer to Calculate the gypsum requirement and exchangeable sodium on page 20.
Note: *If the number of drops of titrant is 56 or more, there is no gypsum requirement.*



9. Immediately rinse the labware with tap water or deionized water.

4.2.1 Calculate the gypsum requirement and exchangeable sodium

To calculate ...	Formula
Gypsum requirement (meq/100 g)	[28 – (Number of drops ÷2)] × 2
Gypsum requirement (tons/acre)	Gypsum requirement (meq/100 g) × 1.7
Gypsum requirement (metric tons/Ha)	Gypsum requirement (meq/100 g) × 3.81
Estimated exchangeable sodium, Na (meq/100 g)	0.96 + [0.99 × Gypsum requirement (meq/100 g)]

Example:

The color of the solution in the Erlenmeyer flask changes to pure blue when 50 drops of 0.0075 N EDTA Standard Solution are added.

Gypsum requirement (meq/100 g) = [28 – (50 ÷2)] × 2 = 6

Gypsum requirement (tons/acre) = 6 meq/100 g x 1.7 = 10.2

Gypsum requirement (metric tons/Ha) = 6 meq/100 g × 3.81 = 22.86

Na (meq/100 g) = 0.96 + [0.99 × 6meq/100 g] = 6.9

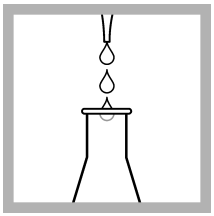
4.2.2 Replacement items

Note: *Product and Article numbers may vary for some selling regions. Contact the appropriate distributor or refer to the company website for contact information.*

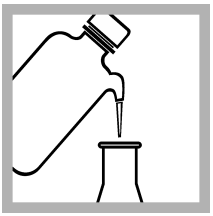
Description	Unit	Item no.
EDTA Standard Solution, 0.0075 N	100 mL MDB	2498132
Hardness 1 Buffer Solution	100 mL MDB	42432
Hardness 2 Indicator Solution	100 mL MDB	42532
Dropper, glass, 0.5- and 1.0-mL marks	5/pkg	1419705

4.3 Calcium + magnesium in soil

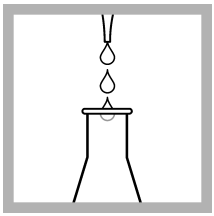
Pre-requisite: Do the steps in Mehlich 2 extraction procedure on page 13 to get a Mehlich 2 extract for the soil.



1. Use a 1.0-mL dropper to add 1.0 mL of the Mehlich 2 extract to a 50-mL Erlenmeyer flask.

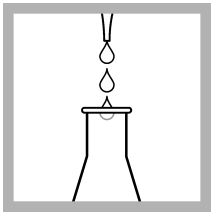


2. Add deionized water to the 25-mL mark of the Erlenmeyer flask.



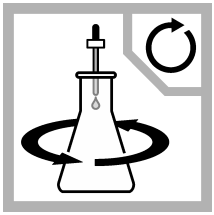
3. Add 1.0 mL of the Hardness 1 Buffer Solution to the Erlenmeyer flask.

4. Swirl to mix.

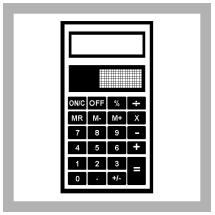


5. Add 3 to 4 drops of Hardness 2 Indicator Solution to the Erlenmeyer flask. If calcium and/or magnesium is in the extract, the solution changes to wine red.

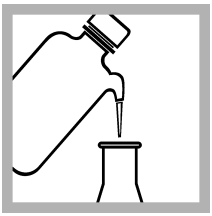
6. Swirl to mix.



7. Add the 0.0075 N EDTA Standard Solution by drops. Swirl after each drop. Count the drops until the color changes from wine red to blue (or a light violet). ***Note:*** *If the sample contains too much copper, the solution will not change to pure blue. If the solution does not change to pure blue, add drops of the 0.0075 N EDTA Standard Solution until no color change is seen.*



8. Divide the number of drops by 2 to calculate the calcium + magnesium (meq/100 g).



9. Immediately rinse the labware with tap water or deionized water.

4.3.1 Replacement items

Note: *Product and Article numbers may vary for some selling regions. Contact the appropriate distributor or refer to the company website for contact information.*

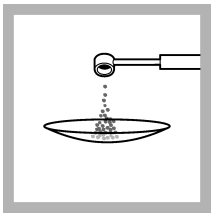
Description	Unit	Item no.
EDTA Standard Solution, 0.0075 N	100 mL MDB	2498132
Hardness 1 Buffer Solution	100 mL MDB	42432
Hardness 2 Indicator Solution	100 mL MDB	42532
Dropper, glass, 0.5- and 1.0-mL marks	5/pkg	1419705

4.4 Lime estimation free (excess) in soil

A calcareous soil is alkaline in pH because the soil contains calcium carbonate particles. Calcareous soils effervesce (fizz) when 2.5 N hydrochloric acid (HCl) is added. The degree of effervescence identifies if the soil is non-calcareous, slightly, moderately or highly calcareous.

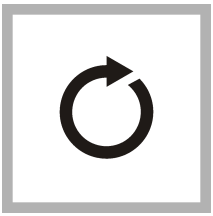
Calcareous soils cause several problems to crop management. While the soils are highly buffered against acidity (high percent base saturation), the alkaline pH decreases the phosphorus, iron, zinc, manganese, copper and boron available.

Pre-requisites: Collect and prepare the soil sample. Refer to Soil sampling on page 7 and Soil preparation on page 7. Soil preparation is important for the volumetric measurement of the soil sample.



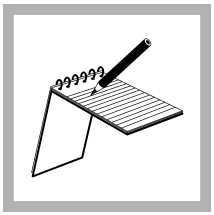
1. Use the 1-g scoop to add 1 scoop of the prepared soil sample to the watch glass. Refer to Soil scoop procedure on page 8.
Note: *To analyze two or more samples on the watch glass, use the laboratory pen to divide the watch glass into sections. Record the sample or test name on each section. Prevent cross-contamination between samples.*

2. Add deionized water one drop at a time to the soil until it is minimally saturated.
Note: *Water is added to remove air from the sample.*



3. Do steps 1 to 2 for each soil sample.

4. Add 3 drops of 2.5 N HCl to each soil sample and record the degree of effervescence. When this test procedure is first learned, do the test procedure on different soils of known pH and/or lime content to use as references.



5. Record the calcareous of the soil: non-calcareous, slightly, moderately or highly calcareous. The degree of effervescence identifies the calcareous of the soil.

4.4.1 Replacement items

Note: *Product and Article numbers may vary for some selling regions. Contact the appropriate distributor or refer to the company website for contact information.*

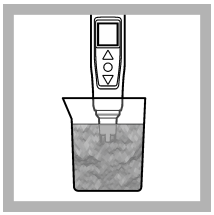
Description	Unit	Item no.
Hydrochloric acid standard solution, 2.5 N	100 mL MDB	141832
Laboratory pen	each	2092000
Soil scoop, 1 g	each	2657201
Watch glass, Pyrex, 65 mm (2.56 in.)	each	57867

4.5 Lime requirement

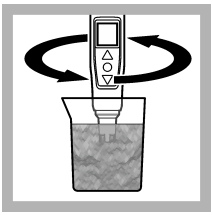
The usual method to determine lime requirement is to measure pH on an SMP extraction of the soil. In this method, a buffer is added to an acidic soil. The response of the soil, measured as an increase in pH, is used to calculate the tons of lime (as $CaCO_3$) per acre necessary to increase the soil pH to 6.5 or 7.0.

Pre-requisites:

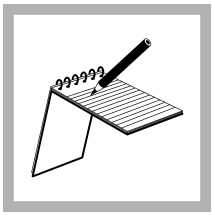
- Do the steps in SMP buffer extraction on page 17 to prepare the soil.
- Calibrate the Pocket Pro pH Tester with pH 7.00 buffer solution. Refer to the documentation supplied with the Pocket Pro TDS Tester. To prepare the pH 7.00 buffer solution, add one pH 7.00 Buffer Powder Pillow and 50 mL of deionized water to a beaker. Swirl until the powder is dissolved.
  Note: *If "C1" (custom standard) shows on the bottom line, change the bUFr setting to USA. Refer to Configure the settings in the expanded user manual on the manufacturer's website.*



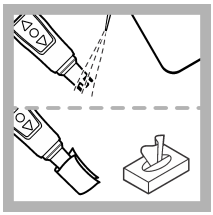
1. Put the calibrated Pocket Pro pH Tester 2.5 cm (1 inch) into the 50-mL beaker that contains the prepared sample.



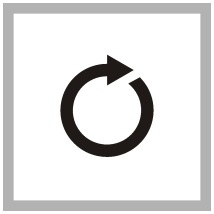
2. Slowly stir the prepared sample until the soil is fully suspended in the liquid and the pH reading is stable.



3. Record the pH reading to the nearest 0.1 pH unit.

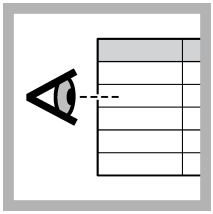


4. Rinse the pH electrode with deionized water. Clean the Pocket Pro pH Tester with a lint-free tissue.



5. Do steps 1 to 4 for each soil sample.

6. Prepare the Pocket Pro pH Tester for storage. Refer to the documentation supplied with the Pocket Pro pH Tester.



7. Refer to Lime requirement table on page 24 to determine the lime requirement of the soil.

4.5.1 Lime requirement table

Table 4 gives the tons of pure limestone (as $CaCO_3$) to add to each acre to increase the pH. Add the limestone to the top 20 cm (8 inches) of the soil. The values in Table 4 are based on tons of pure, fine $CaCO_3$ with a calcium carbonate equivalent (CCE) of 100.

To use limestone other than 100 CCE, calculate the quantity of agricultural limestone or other lime materials to add with the formula the follows:

pH reading from table ÷ CCE of the other lime material (as a percentage) = Tons/acre of the other lime material to add

For example, if the pH reading is 6.6, add 1.2 tons/acre of 100 CCE limestone to increase the soil pH to 7.0. If the CCE of the limestone is assayed at 87%, divide 1.2 by 0.87. The result is 1.37 tons/acre to increase the soil pH to 7.0.

Table 4 Lime requirement table

pH reading	Tons/acre for pH 7.0	Tons/acre for pH 6.5
6.8	0.1	0.1
6.7	0.7	0.6
6.6	1.2	1.0
6.5	1.9	1.6
6.4	2.7	2.3
6.3	3.4	2.9
6.2	4.2	3.6
6.1	5.1	4.3
6.0	5.7	4.8
5.9	6.7	5.7
5.8	7.5	6.4
5.7	8.4	7.1
5.6	9.1	7.7
5.5	9.8	8.3
5.4	10.7	9.1
5.3	11.5	9.8
5.2	12.4	10.5
5.1	13.1	11.1

4.5.2 Replacement items

Note: *Product and Article numbers may vary for some selling regions. Contact the appropriate distributor or refer to the company website for contact information.*

Description	Unit	Item no.
Buffer Powder Pillows, pH 7.00, yellow	50/pkg	2227066
Beaker, 50 mL, polypropylene	each	108041
Pocket Pro pH Tester	each	9531000

4.6 Nitrate-Nitrogen in soil (0–60 ppm)

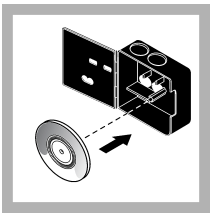
4.6.1 Test preparation

- Put the color disc on the center pin in the color comparator box (numbers to the front).
- Use sunlight or a lamp as a light source to find the color match with the color comparator box.
- If the color match is between two segments, use the value that is in the middle of the two segments.
- If the color disc becomes wet internally, pull apart the flat plastic sides to open the color disc. Remove the thin inner disc. Dry all parts with a soft cloth. Assemble when fully dry.
- Undissolved reagent does not have an effect on test accuracy.

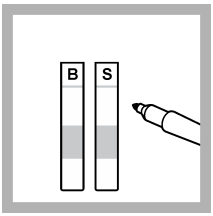
4.6.2 Test procedure

Pre-requisites: Do the steps in Calcium sulfate extraction on page 11 to get a calcium sulfate extract for the soil.

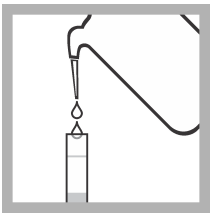
Practice (recommended): Use this test procedure to measure the 15-mg/L nitrate-nitrogen standard in the kit until repeated results are within 1 mg/L of each other. If the reading is less than 14 mg/L or more than 17 mg/L, do the procedure again until the reading is near 15 mg/L. Make sure to hold the color comparator box up to the same light for the standard and the sample.



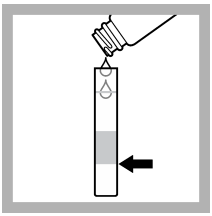
1. Put the nitrate nitrogen color disc in the color comparator box.



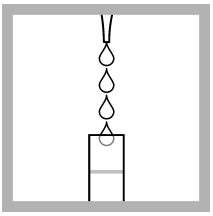
2. Write an "S" for sample on one tube. Write a "B" for blank on the second tube.



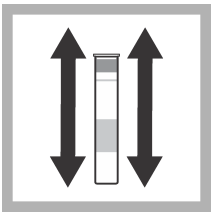
3. Rinse the tubes with deionized water. Shake the tubes to remove the remaining water.



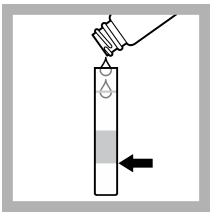
4. Prepare the blank: Add the calcium sulfate extract to the "B" tube to the first line (5-mL).



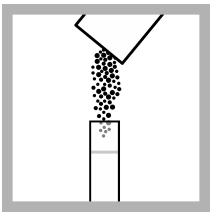
5. Prepare the sample: Add a small amount of the calcium sulfate extract to the "S" tube (approximately 6 mm (¼ inch)).



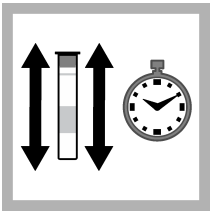
6. Put a cap on the tube. Shake for 3 seconds. Discard the extract.



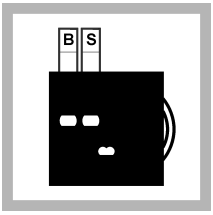
7. Add the calcium sulfate extract to the "S" tube to the first line (5-mL).



8. Add one NitraVer 5 Powder Pillow to the “S” tube.

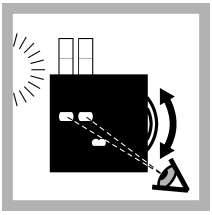


9. Put a cap on the tube. Quickly shake the tube for exactly 1 minute.

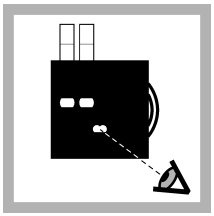


10. Immediately put the tubes into the color comparator box.

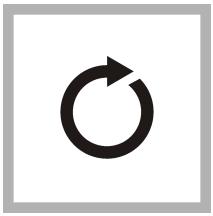
11. Wait 5 minutes. Read the result within 10 minutes.



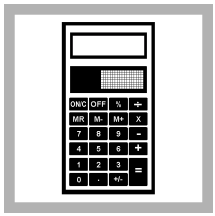
12. Hold the color comparator box in front of a light source. Turn the color disc to find the color match.



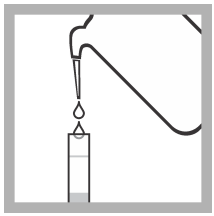
13. Read the value in the scale window.



14. Do steps 12 and 13 two more times within 5 minutes.



15. Calculate the average of the three readings. Multiply the average by 2 to get the available nitrate-nitrogen in the soil.



16. Immediately rinse the labware with deionized water. Shake dry.

4.6.3 Replacement items

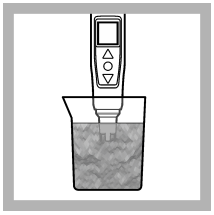
Note: *Product and Article numbers may vary for some selling regions. Contact the appropriate distributor or refer to the company website for contact information.*

Description	Unit	Item no.
NitraVer® 5 Nitrate Reagent Powder Pillows, 5 mL	100/pkg	1403599
Color disc, nitrate nitrogen, 0–40 mg/L	each	9261400
Color comparator box	each	173200
Plastic viewing tubes, 18 mm, with caps	4/pkg	4660004
Nitrate-Nitrogen Standard Solution, 15 mg/L	100 mL MDB	2415132

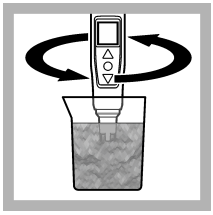
4.7 pH in soil

Pre-requisites:

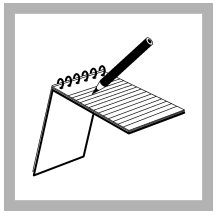
- Do the steps in Aqueous extraction on page 10 to get an aqueous extract for the soil.
- Calibrate the Pocket Pro pH Tester with pH 7.00 buffer solution. Add one pH 7.00 Buffer Powder Pillow and 50 mL of deionized water to a beaker. Swirl until the powder is dissolved.
  Note: *If "C1" (custom standard) shows on the bottom line, change the bUFr setting to USA. Refer to Configure the settings in the expanded user manual on the manufacturer's website.*



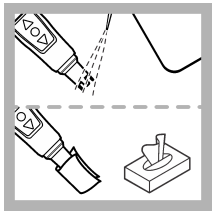
1. Put the calibrated Pocket Pro pH Tester 2.5 cm (1 inch) into the 50-mL plastic beaker that contains the aqueous extract.



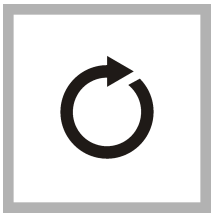
2. Slowly stir until the soil is fully suspended in the liquid and the pH reading is stable.



3. Record the pH reading to the nearest 0.1 pH unit.



4. Rinse the pH electrode with deionized water. Clean the Pocket Pro pH Tester with a lint-free tissue.



5. Do steps 1 to 4 for each soil sample.

6. Prepare the Pocket Pro pH Tester for storage. Refer to the documentation supplied with the Pocket Pro pH Tester.

4.7.1 Replacement items

Note: *Product and Article numbers may vary for some selling regions. Contact the appropriate distributor or refer to the company website for contact information.*

Description	Unit	Item no.
Buffer Powder Pillows, pH 7.00, yellow	50/pkg	2227066
Beaker, 50 mL, polypropylene	each	108041
Pocket Pro pH Tester	each	9531000

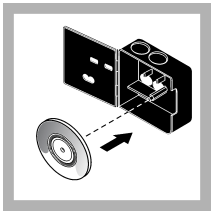
4.8 Phosphorous in soil (0–130 mg/L or 0–130 ppm)

4.8.1 Test preparation

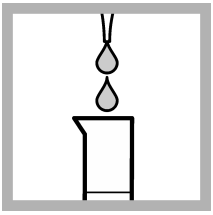
- Put the color disc on the center pin in the color comparator box (numbers to the front).
- Use sunlight or a lamp as a light source to find the color match with the color comparator box.
- If the color match is between two segments, use the value that is in the middle of the two segments.
- If the color disc becomes wet internally, pull apart the flat plastic sides to open the color disc. Remove the thin inner disc. Dry all parts with a soft cloth. Assemble when fully dry.
- Undissolved reagent does not have an effect on test accuracy.

4.8.2 Test procedure

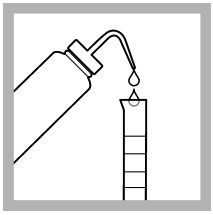
Pre-requisites: Do the steps in Mehlich 2 extraction procedure on page 13 to get a Mehlich 2 extract for the soil.



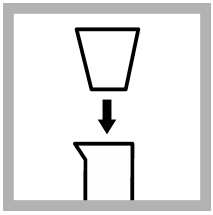
1. Put the phosphate color disc in the color comparator box.



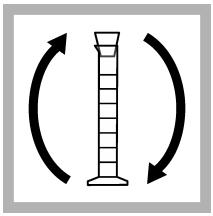
2. Use the 2.5-mL dropper to add 2.5 mL of the Mehlich 2 extract to a 25-mL graduated cylinder.



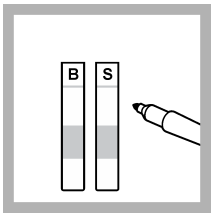
3. Add deionized water to the 25-mL mark.



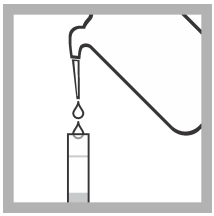
4. Put a stopper in the graduated cylinder.



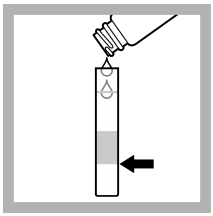
5. Invert to mix.



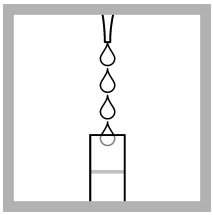
6. Write an "S" for sample on one tube. Write a "B" for blank on the second tube.



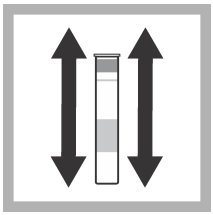
7. Rinse the tubes with deionized water. Shake the tubes to remove the remaining water.



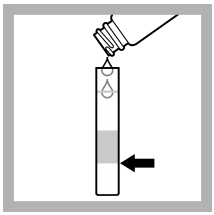
8. Prepare the blank: Add the Mehlich 2 extract to the "B" tube to the first line (5-mL).



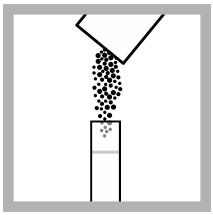
9. Prepare the sample: Add a small amount of the Mehlich 2 extract to the "S" tube (approximately 6 mm (¼ inch)).



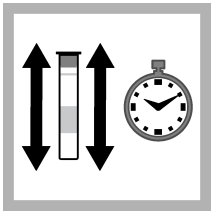
10. Put a cap on the tube. Shake for 3 seconds. Discard the solution.



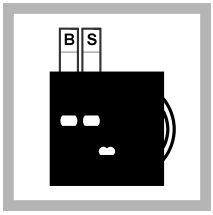
11. Add the Mehlich 2 extract to the "S" tube to the first line (5-mL).



12. Add one PhosVer 3 Powder Pillow to the “S” tube.

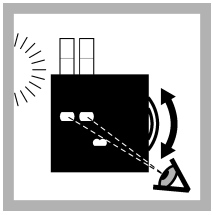


13. Put a cap on the tube. Quickly shake the tube for 1 minute.

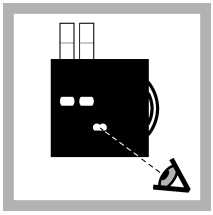


14. Immediately put the tubes into the color comparator box.

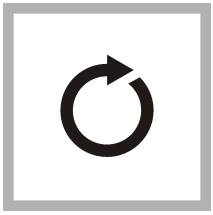
15. Wait 3 minutes. Read the result within 10 minutes.



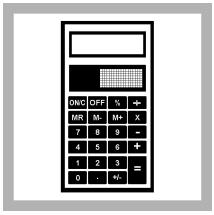
16. Hold the color comparator box in front of a light source. Turn the color disc to find the color match.



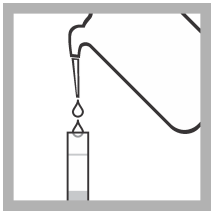
17. Read the value in the scale window.



18. Do steps 16 and 17 two more times.



19. Calculate the average of the three readings. Multiply the average by 3.3 to get the available phosphate-phosphorus in the soil.



20. Immediately rinse the labware with deionized water. Shake dry.

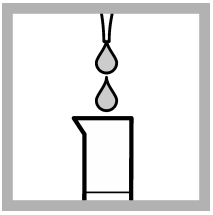
4.8.3 Replacement items

Note: *Product and Article numbers may vary for some selling regions. Contact the appropriate distributor or refer to the company website for contact information.*

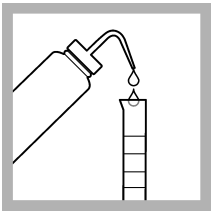
Description	Unit	Item no.
PhosVer® 3 Phosphate Reagent Powder Pillows, 5 mL	100/pkg	220999
Color disc, phosphate, 0–40 mg/L	each	9262100
Color comparator box	each	173200
Plastic viewing tubes, 18 mm, with caps	4/pkg	4660004
Cylinder, graduated, polymethylpentene, 25 mL	each	217240
Dropper 2.50 mL	each	1704500
Stopper for graduated cylinder, Neoprene, size 3	12/pkg	1480803

4.9 Potassium, exchangeable, in soil (0–250 mL or 0–250 ppm)

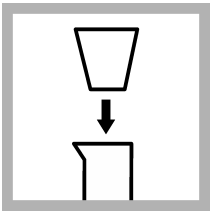
Pre-requisites: Do the steps in Mehlich 2 extraction procedure on page 13 to get a Mehlich 2 extract for the soil.



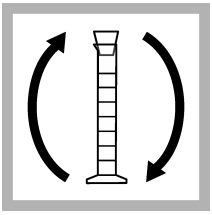
1. Use the 1-mL dropper to add 3.0 mL of the Mehlich 2 extract to a 25-mL graduated cylinder.



2. Add deionized water to the 21-mL mark.

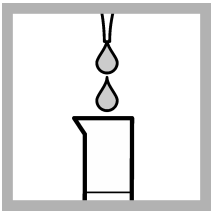


3. Put a stopper in the graduated cylinder.

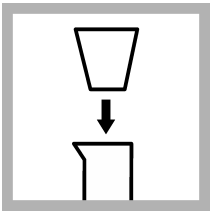


4. Invert to mix.

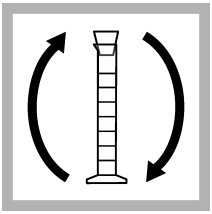
5. Add one Potassium 2 Reagent Solution Pillow to the graduated cylinder.



6. Add 3 mL of Alkaline EDTA Solution to the graduated cylinder.



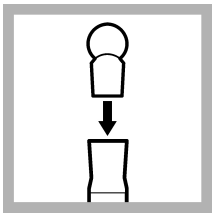
7. Put a stopper in the graduated cylinder.



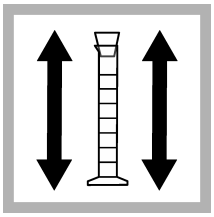
8. Invert to mix.

9. Wait 3 minutes.

10. Add one Potassium 3 Reagent Powder Pillow to the graduated cylinder.

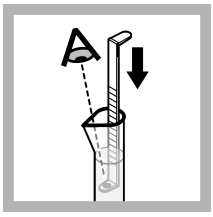


11. Put a stopper in the graduated cylinder.

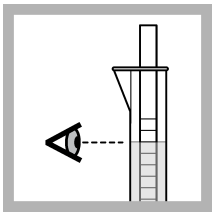


12. Quickly shake for 10 seconds.

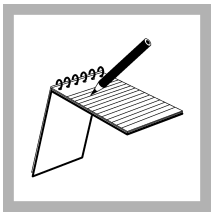
13. Wait 3 minutes. A white turbidity forms. Read the result within 10 minutes.



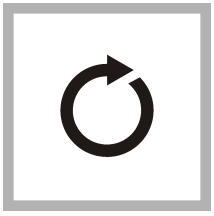
14. Look straight down into the graduated cylinder. Lower the potassium measuring dipstick into the graduated cylinder until the black dot cannot be seen from above.



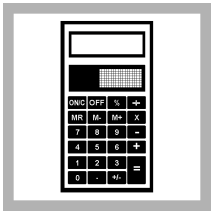
15. Do not let the dipstick move. Turn the graduated cylinder so the scale on the dipstick is seen.



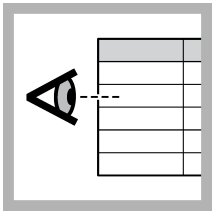
16. Record the number (mm) on the dipstick scale where the surface of the sample touches the dipstick scale.



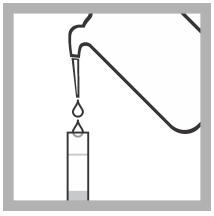
17. Do steps 14 and 16 two more times.



18. Calculate the average of the three readings.



19. Refer to Potassium conversion table on page 31 to determine the level of potassium in the soil.



20. Immediately rinse the labware with deionized water. Shake dry.

4.9.1 Potassium conversion table

Dipstick reading (mm)	mg/L (ppm) Potassium	lbs/A Potassium	Kg/Ha Potassium	meq/100 g Potassium
80	87	174	194	0.22
75	94	188	210	0.24
70	101	202	225	0.26
65	109	218	243	0.28
60	118	236	263	0.30
55	129	258	281	0.33

Dipstick reading (mm)	mg/L (ppm) Potassium	lbs/A Potassium	Kg/Ha Potassium	meq/100 g Potassium
50	143	286	319	0.37
45	159	318	355	0.41
40	180	360	401	0.46
35	207	414	462	0.53
30	243	486	542	0.62
25	294	588	656	0.75

4.9.2 Replacement items

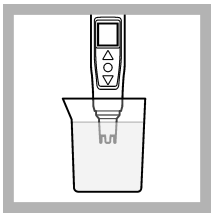
Note: *Product and Article numbers may vary for some selling regions. Contact the appropriate distributor or refer to the company website for contact information.*

Description	Unit	Item no.
Alkaline EDTA Solution	100 mL MDB	2268732
Potassium 2 Reagent Solution Pillows	25/pkg	1432298
Potassium 3 Reagent Powder Pillows	100/pkg	1432399
Cylinder, graduated, polymethylpentene, 25 mL	each	217240
Dropper, glass, 0.5- and 1.0-mL marks	5/pkg	1419705
Potassium measuring dipstock	each	4570000
Stopper for graduated cylinder, Neoprene, size 3	12/pkg	1480803

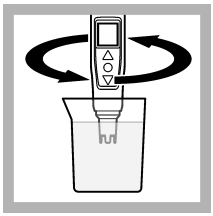
4.10 Salinity (conductivity/TDS) in soil

Pre-requisites:

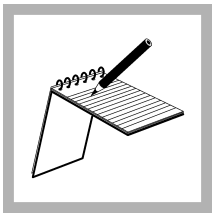
- Calibrate the Pocket Pro TDS Tester with a 1413 µS/cm conductivity standard. Refer to the documentation supplied with the Pocket Pro TDS Tester.
- Do the steps in Saturated Calcium Sulfate extraction procedure on page 16 to get a saturated calcium sulfate extract for the soil.



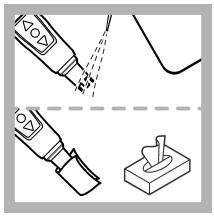
1. Put the calibrated Pocket Pro TDS Tester 2.5 cm (1 inch) into a 50-mL plastic beaker that contains 20 mL of the saturated calcium sulfate extract.



2. Slowly stir until the soil is fully suspended in the liquid and the TDS reading is stable.
Note: *The measurement range of the Pocket Pro TDS Tester is 0 to 1999 ppm.*



3. Record the TDS reading.
If the measurement is not within the measurement range of the Pocket Pro TDS Tester, add 20 mL of deonized water to the aqueous extract until the reading is within the measurement range. If 20 mL is added, multiply by 2. If 40 mL is added, multiply by 3. If 60 mL is added, multiply by 4.



4. Rinse the electrode with deionized water. Clean the Pocket Pro TDS Tester with a lint-free tissue.

5. Do steps 1 to 4 for each soil sample.

6. Prepare the Pocket Pro TDS Tester for storage. Refer to the documentation supplied with the Pocket Pro TDS Tester.

4.10.1 Replacement items

Note: *Product and Article numbers may vary for some selling regions. Contact the appropriate distributor or refer to the company website for contact information.*

Description	Unit	Item no.
Beaker, 50 mL, polypropylene	each	108041
Pocket Pro TDS Tester, low range	each	9531200
Conductivity standard, 1413 µS/cm, KCl, 20 mL SINGLET™	20/pkg	2771420

4.11 Texture estimation of soil

Soil analysis usually includes an estimation of the soil texture. The method that follows is used when exact proportions of sand, silt and clay are not necessary or when equipment for mechanical analysis of soil is not available.

Practice is necessary for an accurate soil texture estimation. To get satisfactory results, use the steps that follow and the modified textural triangle diagram in Figure 3. The procedure for the estimation of soil texture was made at Kansas State University by Dr. David Whitney.

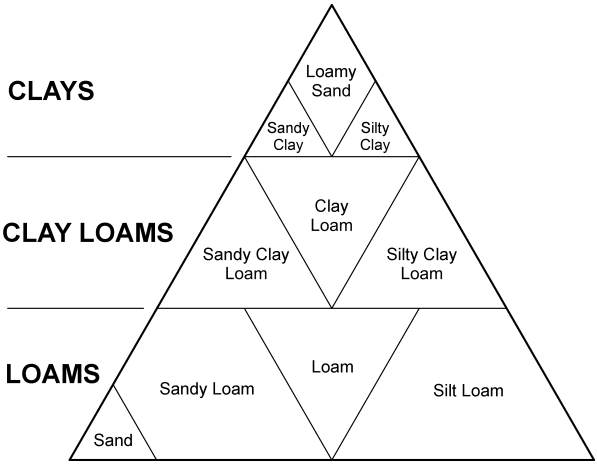
Figure 3 does not include the rare silt class and combines the loamy sand class with the sandy loam class. Figure 3 includes three tiers based on clay content:

- **Clays**—Soils high in clay content that form good ribbons and are sticky when moist. When dry, clay soils are hard clods.
- **Clay loams**—Soils that are intermediate in clay content that form medium ribbons when moist. When dry, clay loams are hard clods.
- **Loams**—Soils that are sufficiently low in clay that form poor or weak ribbons when moist. When dry, loams are soft clods. The sands do not form ribbons.

The three tiers are each divided into three classes:

- If silt content is high, the prefix “silt” or “silty” is used in the class name (right side of the triangle).
- If sand content high, the prefix “sandy” is used in the class name (left side of the triangle).
- When the content is not high in sand or silt, the class name is used without a prefix (center of the triangle).

Figure 3 Diagram for soil texture estimation



Do an estimate of the soil texture as follows:

1. Put approximately 25 g of soil in a hand.
2. Add water by drops until the soil is like play dough. Knead the soil to break down all aggregates. If the soil does not stay in a ball when squeezed, the soil is sand.
3. If the soil stays in a ball when squeezed, carefully push the soil with a thumb to squeeze it upward into a ribbon. Make a ribbon of uniform thickness and width. Let the ribbon go over the forefinger until it breaks from the weight of the soil.
   If the soil does not form a ribbon, the soil is loamy sand.
4. Add a lot of water to a small pinch of soil in a hand. Rub the soil with a forefinger.

   - If the ribbon is less than 1 inch and feels very gritty, the soil is sandy loam.
   - If the ribbon is less than 1 inch and feels very smooth, the soil is silty loam.
   - If the ribbon is less than 1 inch and does not feel gritty or smooth, the soil is loam.
   - If the ribbon is 1 to 2 inches and feels very gritty, the soil is sandy clay loam.
   - If the ribbon is 1 to 2 inches and feels very smooth, the soil is silty clay loam.

- If the ribbon is 1 to 2 inches and does not feel gritty or smooth, the soil is clay loam.
- If the ribbon more than 2 inches and feels very gritty, the soil is sandy clay.
- If the ribbon more than 2 inches and feels very smooth, the soil is silty clay.
- If the ribbon more than 2 inches and does not feel gritty or smooth, the soil is clay.

4.12 Total exchangeable acidity in soil

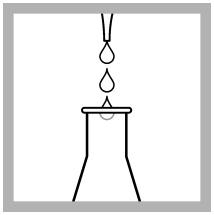
Total exchangeable acidity (TEA) is the quantity of exchangeable H^+ and Al^{3+} in the soil in milliequivalents per 100 grams (meq/100 g).

Lime requirement (LR) is the amount of 100% CCE (calcium carbonate equivalents) $CaCO_3$ necessary to increase the soil pH to 6.5 or to 7.0. Refer to Lime requirement on page 24.

For each 1 meq/100 g of TEA, 1.12 metric tons of 100% CCE $CaCO_3$ per hectare is necessary to neutralize the acid.

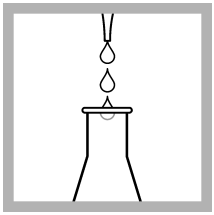
- LR (metric tons/Hectare) = TEA x 1.12
- LR (tons/acre) = TEA ÷ 2

Pre-requisites: Do the steps in Potassium Chloride extraction procedure on page 15 to get a potassium chloride extract for the soil.

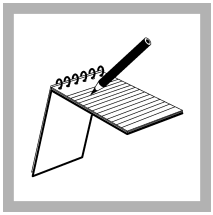


1. Add 5 to 6 drops of phenolphthalein to the 125-mL Erlenmeyer flask that contains the potassium chloride extract.

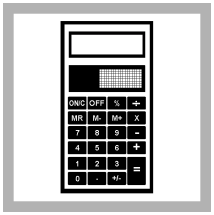
2. Swirl to mix.



3. Add 0.075 N Sodium Hydroxide (NaOH) Standard Solution one drop at a time and swirl the flask until the color changes from colorless to light pink and stays light pink when swirled. Count the drops.



4. Record the number of drops added.



5. Divide the number of drops 0.075 N NaOH Standard Solution by 10 to calculate the meq/100 g of total exchangeable acidity. For example, if 16 drops are added, the TEA is 1.6 meq/100 g.

Note: *Use the meq/100 g of total exchangeable acidity to calculate the cation exchange capacity of acidic soils and the lime requirement of highly acidic and weathered soils.*

4.12.1 Replacement items

Note: *Product and Article numbers may vary for some selling regions. Contact the appropriate distributor or refer to the company website for contact information.*

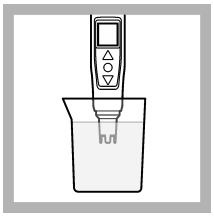
Description	Unit	Item no.
Phenolphthalein Indicator Solution, 5 g/L	100 mL MDB	16232
Sodium Hydroxide Standard Solution, 0.075 N	100 mL MDB	2498032
Flask, Erlenmeyer, polymethylpentene, 125 mL	each	2089843

Section 5 Irrigation water analysis procedures

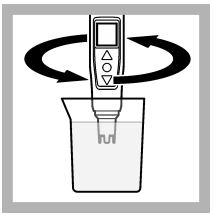
5.1 Conductivity/TDS in irrigation water

Pre-requisites:

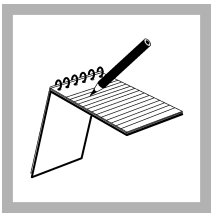
- Calibrate the Pocket Pro TDS Tester with a 1413 µS/cm conductivity standard. Refer to the documentation supplied with the Pocket Pro TDS Tester.
- Do the steps in Saturated Calcium Sulfate extraction procedure on page 16 to get a saturated calcium sulfate extract for the soil.



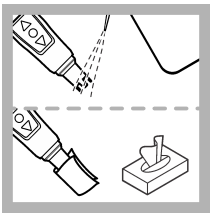
1. Put the calibrated Pocket Pro TDS Tester 2.5 cm (1 inch) into a 50-mL plastic beaker that contains 30 mL of the saturated calcium sulfate extract.



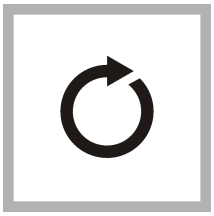
2. Slowly stir.
Note: *The measurement range of the Pocket Pro TDS Tester is 0 to 1999 ppm.*



3. When the measurement is stable, record the TDS reading.



4. Rinse the electrode with deionized water. Clean the Pocket Pro TDS Tester with a lint-free tissue.



5. Do steps 1 to 4 for each sample extract.

6. Prepare the Pocket Pro TDS Tester for storage. Refer to the documentation supplied with the Pocket Pro TDS Tester.

5.1.1 Replacement items

Note: *Product and Article numbers may vary for some selling regions. Contact the appropriate distributor or refer to the company website for contact information.*

Description	Unit	Item no.
Beaker, 50 mL, polypropylene	each	108041
Pocket Pro TDS Tester, low range	each	9531200
Conductivity standard, 1413 µS/cm, KCl, 20 mL SINGLET™	20/pkg	2771420

5.2 Calcium + magnesium in irrigation water

Pre-requisites: Measure the TDS of the irrigation water. Refer to Conductivity/TDS in irrigation water on page 37.

1. If the TDS of the sample is more than 1000 g/L, add 1.0 mL of sample to the 50-mL Erlenmeyer flask.

2. If the TDS of the sample is less than 1000 g/L, add 2.5 mL of sample to the 50-mL Erlenmeyer flask.

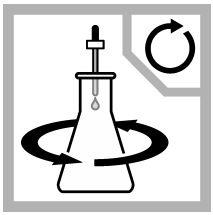
3. Add 25 mL of deionized water the 50-mL Erlenmeyer flask.

4. Add 1.0 mL of Hardness Buffer 1 Solution to the 50-mL Erlenmeyer flask.

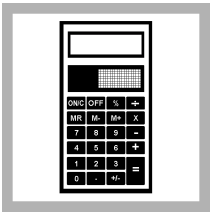
5. Swirl to mix.

6. Add 3 to 4 drops of Hardness 2 Indicator Solution to the 50-mL Erlenmeyer flask.

7. Swirl to mix. The color changes to a wine red color if calcium and/or magnesium is in the sample.



8. Add the 0.0075 N EDTA Standard Solution by drops. Swirl after each drop. Count the drops until the color changes from wine red to blue (or a little violet). ***Note:*** *If the sample contains a lot of copper, the solution will not change to pure blue. If the solution does not change to pure blue, add drops of the 0.0075 N EDTA Standard Solution until no color change is seen.*



9. Calculate the calcium + magnesium in the irrigation water: Ca + Mg meq/L = Drops of EDTA Standard Solution ÷ (2 × mL of sample)

10. Immediately rinse the labware with tap water or deionized water.

5.2.1 Replacement items

Note: *Product and Article numbers may vary for some selling regions. Contact the appropriate distributor or refer to the company website for contact information.*

Description	Unit	Item no.
EDTA Standard Solution, 0.0075 N	100 mL MDB	2498132
Hardness 1 Buffer Solution	100 mL MDB	42432
Hardness 2 Indicator Solution	100 mL MDB	42532
Cylinder, graduated, polymethylpentene, 25 mL	each	217240

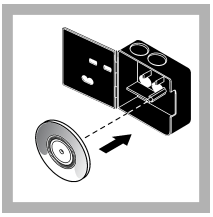
5.3 Nitrate-Nitrogen in irrigation water (0–40 mg/L)

5.3.1 Test preparation

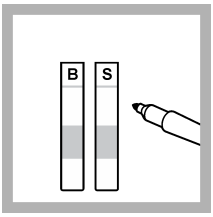
- Put the color disc on the center pin in the color comparator box (numbers to the front).
- Use sunlight or a lamp as a light source to find the color match with the color comparator box.
- If the color match is between two segments, use the value that is in the middle of the two segments.
- If the color disc becomes wet internally, pull apart the flat plastic sides to open the color disc. Remove the thin inner disc. Dry all parts with a soft cloth. Assemble when fully dry.
- Undissolved reagent does not have an effect on test accuracy.

5.3.2 Test procedure

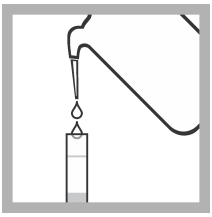
Practice (recommended): Use this test procedure to measure the 15-mg/L nitrate-nitrogen standard in the kit until repeated results are within 1 mg/L of each other. If the reading is less than 14 mg/L or more than 17 mg/L, do the procedure again until the reading is near 15 mg/L. Make sure to hold the color comparator box up to the same light for the standard and the sample.



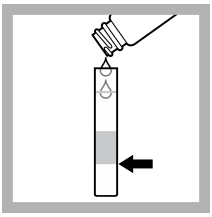
1. Put the nitrate nitrogen color disc in the color comparator box.



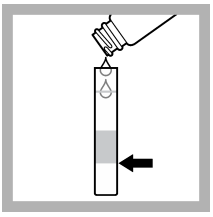
2. Write an "S" for sample on one tube. Write a "B" for blank on the second tube.



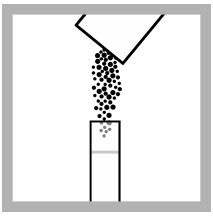
3. Rinse the tubes with deionized water. Shake the tubes to remove the remaining water.



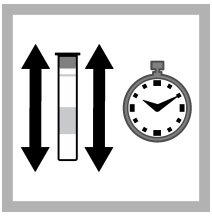
4. Prepare the blank: Add the sample to the "B" tube to the first line (5-mL).



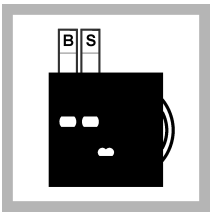
5. Prepare the sample: Add the sample to the "S" tube to the first line (5-mL).



6. Add one NitraVer 5 Powder Pillow to the “S” tube.

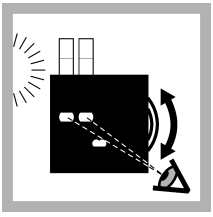


7. Put a cap on the tube. Quickly shake the tube for exactly 1 minute.

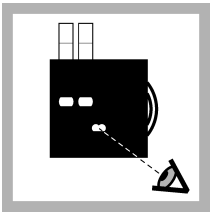


8. Immediately put the tubes into the color comparator box.

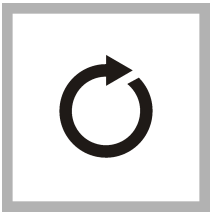
9. Wait 5 minutes. Read the result within 10 minutes.



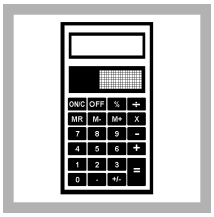
10. Hold the color comparator box in front of a light source. Turn the color disc to find the color match.



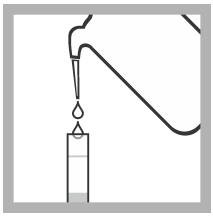
11. Read the value in the scale window.



12. Do steps 10 and 11 two more times within 5 minutes.



13. Calculate the average of the three readings to get the available mg/L NO_3-N in the sample.



14. Immediately rinse the labware with deionized water. Shake dry.

5.3.3 Replacement items

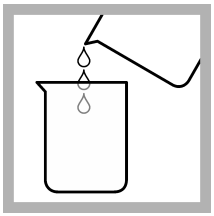
Note: *Product and Article numbers may vary for some selling regions. Contact the appropriate distributor or refer to the company website for contact information.*

Description	Unit	Item no.
NitraVer® 5 Nitrate Reagent Powder Pillows, 5 mL	100/pkg	1403599
Color disc, nitrate nitrogen, 0–40 mg/L	each	9261400
Color comparator box	each	173200
Plastic viewing tubes, 18 mm, with caps	4/pkg	4660004
Nitrate-Nitrogen Standard Solution, 15 mg/L	100 mL MDB	2415132

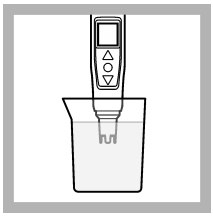
5.4 pH in irrigation water

Pre-requisites: Calibrate the Pocket Pro pH Tester with the pH 7.00 buffer solution. Add one pH 7.00 Buffer Powder Pillow and 50 mL of deionized water to a beaker. Swirl until the powder is dissolved.

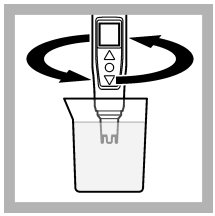
Note: *If "C1" (custom standard) shows on the bottom line, change the bUFr setting to USA. Refer to Configure the settings in the expanded user manual on the manufacturer's website.*



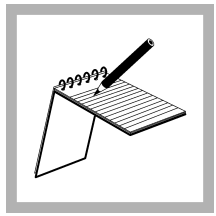
1. Add approximately 40 mL of sample to the 50-mL plastic beaker.



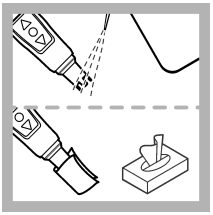
2. Put the calibrated Pocket Pro pH Tester 2.5 cm (1 inch) into the 50-mL plastic beaker.



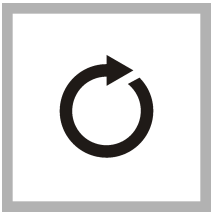
3. Slowly stir.



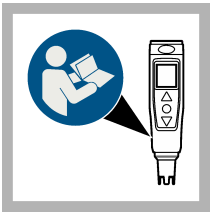
4. When the reading is stable, record the reading to the nearest 0.1 pH unit.



5. Rinse the pH electrode with deionized water. Clean the Pocket Pro pH Tester with a lint-free tissue.



6. Do steps 1 to 5 for each sample.



7. Prepare the Pocket Pro pH Tester for storage. Refer to the documentation supplied with the Pocket Pro pH Tester.

5.4.1 Replacement items

Note: *Product and Article numbers may vary for some selling regions. Contact the appropriate distributor or refer to the company website for contact information.*

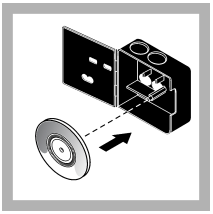
Description	Unit	Item no.
Buffer Powder Pillows, pH 7.00, yellow	50/pkg	2227066
Beaker, 50 mL, polypropylene	each	108041
Pocket Pro pH Tester	each	9531000

5.5 Phosphorous in irrigation water (0–5 mg/L)

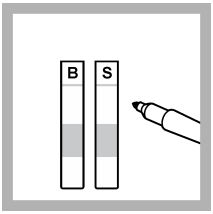
5.5.1 Test preparation

- Put the color disc on the center pin in the color comparator box (numbers to the front).
- Use sunlight or a lamp as a light source to find the color match with the color comparator box.
- If the color match is between two segments, use the value that is in the middle of the two segments.
- If the color disc becomes wet internally, pull apart the flat plastic sides to open the color disc. Remove the thin inner disc. Dry all parts with a soft cloth. Assemble when fully dry.
- Undissolved reagent does not have an effect on test accuracy.

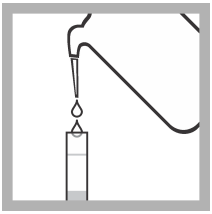
5.5.2 Test procedure



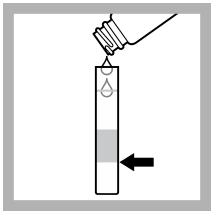
1. Put the phosphate color disc in the color comparator box.



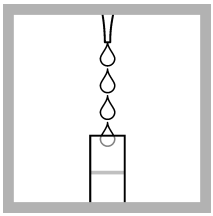
2. Write an "S" for sample on one tube. Write a "B" for blank on the second tube.



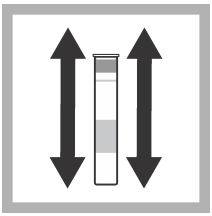
3. Rinse the tubes with deionized water. Shake the tubes to remove the remaining water.



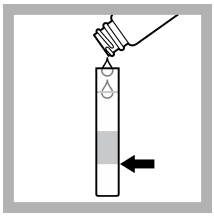
4. Prepare the blank: Add the sample to the "B" tube to the first line (5-mL).



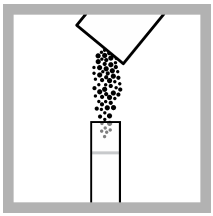
5. Prepare the sample: Add a small amount of the sample to the "S" tube (approximately 6 mm (¼ inch)).



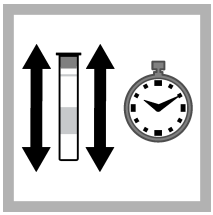
6. Put a cap on the tube. Shake for 3 seconds. Discard the solution.



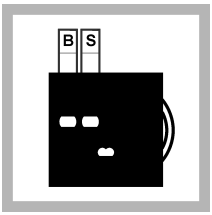
7. Add the sample to the "S" tube to the first line (5-mL).



8. Add one PhosVer 3 Powder Pillow to the “S” tube.

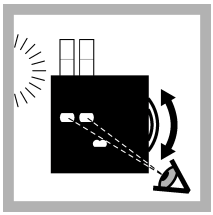


9. Put a cap on the tube. Quickly shake the tube for 15 seconds.

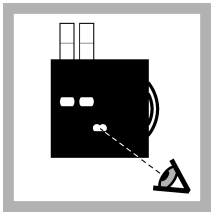


10. Immediately put the tubes into the color comparator box.

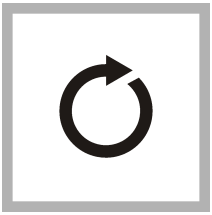
11. Wait 3 minutes. Read the result within 10 minutes.



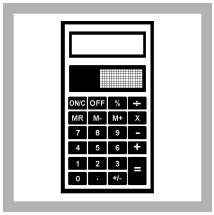
12. Hold the color comparator box in front of a light source. Turn the color disc to find the color match.



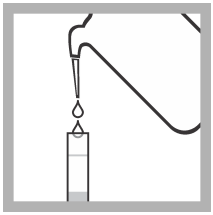
13. Read the value in the scale window.



14. Do steps 12 and 13 two more times.



15. Calculate the average of the three readings. Multiply the average by 10 to get the mg/L PO_4 in the sample.
Note: *To calculate mg/L P, divide the mg/L PO_4 value by 1.31.*



16. Immediately rinse the labware with deionized water. Shake dry.

5.5.3 Replacement items

Note: *Product and Article numbers may vary for some selling regions. Contact the appropriate distributor or refer to the company website for contact information.*

Description	Unit	Item no.
PhosVer® 3 Phosphate Reagent Powder Pillows, 5 mL	100/pkg	220999
Color disc, phosphate, 0–40 mg/L	each	9262100

5.5.3 Replacement items (continued)

Description	Unit	Item no.
Color comparator box	each	173200
Plastic viewing tubes, 18 mm, with caps	4/pkg	4660004

5.6 Sodium estimation + sodium adsorption ratio in irrigation water

1. Identify the TDS (ppm) of the sample. Refer to Conductivity/TDS in irrigation water on page 37.
2. Divide the TDS of the sample by 50 to determine the concentration of total soluable salts (meq/L).
3. Identify the calcium + magnesium in the irrigation water (meq/L). Refer to Calcium + magnesium in irrigation water on page 38.
4. Subtract the total soluable salts (meq/L) by the calcium + magnesium (meq/L) to get the sodium estimation.

   For example, if the TDS is 625 ppm and calcium + magnesium is 8.6 meq/L, then:

   Sodium estimation = 625 ÷ 50 – 8.6 = 3.9

   SAR (sodium adsorption ratio) = Sodium estimation ÷ square root of (calcium + magnesium ÷2) = 3.9 ÷ square root of (8.6 ÷2) = 3.9 ÷ square root of 4.3 = 1.88

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