# Cardy Nitrate
# $NO_3^-$ Meter

## PRODUCT MANUAL

Item 2305G


Spectrum®
Technologies, Inc.

# Contents



This manual will familiarize you with the features and operation of your Cardy Nitrate meter. Please read this manual thoroughly before using your meter. For customer support or to place an order, contact Spectrum Technologies, Inc between 7:30 a.m. and 5:30 p.m. CST.


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**Website:** www.specmeters.com

# INTRODUCTION

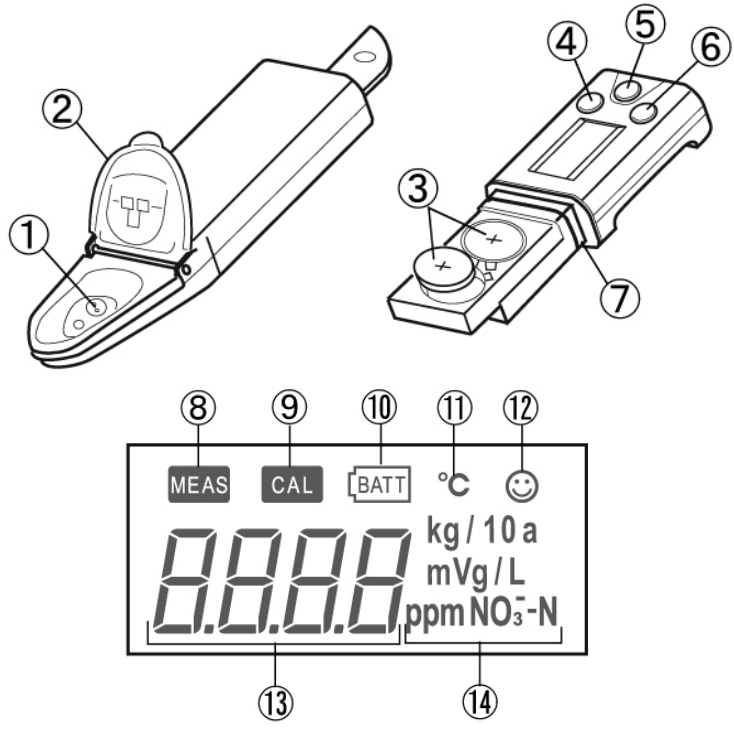
Congratulations on the purchase of your Cardy Nitrate ($NO_3^-$) meter. This manual describes how to use your Cardy meter and how to keep it working accurately for many years. Read it thoroughly in order to make effective use of your meter.

Nitrogen is one of the most important elements required for plant growth. It is a key component in chlorophyll, the pigment in plants that harnesses the sun's energy to convert $CO_2$ into carbohydrates and makes plants green. Tools that provide increased management of N offer significant economic benefits to plant growers of all types. In addition, applying just the right amount of nitrogen at the right time can help safeguard the environment by reducing the amount of residual soil nitrate
($NO_3^-$) available to leach into ground water

This self-contained, waterproof, digital meter delivers high quality answers to nitrate level questions in soils, plants, and water- based solutions. The replaceable pen-type sensor makes the measurement of small samples much more convenient. When replacement of the sensor is required, the sensor cartridge snaps in and out of the meter at a touch.

The readout of the measurement value is an LCD display. It a has a total display range of 14 - 1400 ppm $NO_3^-$ -N. The display can be set to readout in units of nitrate ($NO_3^-$) or nitrate-nitrogen ($NO_3^-$ -N).

# Meter Components And Functions

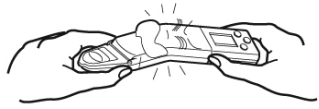



| No. | Name | Description |
|---|---|---|
| **1** | Flat sensor | Consists of a liquid junction (electrode A) and response membrane (electrode B). Both electrodes must be covered by sample to enable accurate measurement. |
| **2** | Light shield cover | Cover used to shield sensor from light. Because the sensor is affected by light, attach the light shield cover before starting measurement. |
| **3** | Lithium batteries | CR2032 |

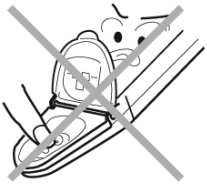
| No. | Name | Description |
|---|---|---|
| **4** | MEAS button | Used during measurement. Press the button for ½ second to evaluate the stability of the measured value. The screen will lock onto a stable value. If this button is pressed for 5 seconds, the meter will go into the special setting mode (p. 14) |
| **5** | ON/OFF button | Press and hold for at least 2 seconds to turn meter ON or OFF. |
| **6** | CAL button | Press and hold for at least 2 seconds to calibrate the meter. |
| **7** | Waterproofing gasket | Provides waterproof seal for meter. |
| **8** | MEAS icon | Flashes during calibration and lights steadily when meter locks onto a measurement. |
| **9** | CAL icon | Flashes during measurement and lights steadily when calibration is finished. |
| **10** | Battery alarm icon | Lights when batteries are low in power and need to be replaced. |
| **11** | Temperature alarm icon | Flashes when the measuring environment temperature is out of range (not between 5º and 40ºC). |
| **12** | Stability icon | Lights only when the measured value has stabilized. |
| **13** | Display | Flashes when the measurement is out of range. When **Hi** is displayed, the result is too high. Dilute the sample and take measurement again. |
| **14** | Measurement unit display | The default setting is "$NO_3^-$". See "Special Setting Modes" (p. 16) for instructions to change modes. |

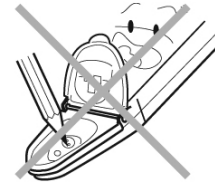
# Handling Precautions

- Neither the meter nor sensor is waterproof by itself. The sensor must be securely mounted on the meter before use.
- Never drop the meter or apply excessive force to it.



- The sensor is made of PVC and may get scratched if not handled with care.



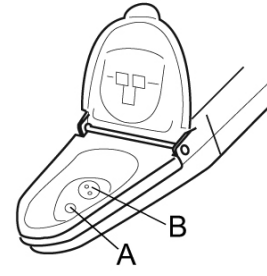


- Do not leave the meter in areas of direct sunlight or high temperature/humidity
- Do not clean the meter with organic solvents.


- When using the meter for the first time, or after several weeks of inactivity, the sensor may be slow to respond. Put some reference solution on the sensor and wait 10 to 60 minutes before switching the meter on.

- Measurement of organic solvents, oils, adhesives, cement, alcohols or concentrated acids (pH less than 2) will shorten the sensor's life.
- Some sample types (such as oily plant sap) may not yield stable values.
- To ensure a waterproof seal, check that the waterproofing gasket is not scratched or dirty and is properly seated in the groove.
- Wash off any calibration solution that comes into contact with hands or exposed skin. If fluid gets in the eyes, rinse them immediately and see a doctor.
- White powder may appear on sensor electrode A (the liquid junction) when using the meter in low-humidity environments. Liquid may appear on the electrode in high humidity environments. The appearance of powder or liquid is normal. Simply wash it off with water before using the meter.

- Sensor B is made of PVC. Because the PVC's plasticizer may seep into the fluid being measured, never drink any fluid that has come in contact with the sensor.
- The batteries provided with the meter are for monitoring and may have a short life.




- When replacing batteries, replace both at once.
- Never dispose of batteries in an open flame or attempt to recharge them. Keep used batteries out of reach of children.
- Replace the batteries when the low voltage alarm icon illuminates. When the voltage is low, you may not be able to turn the meter on.
- The sensors cannot be repaired. They must be replaced when they get damaged or when performance deteriorates due to age.

# CALIBRATING SOLUTIONS

**$NO_3^-$ (nitrate) versus $NO_3^-$-N (nitrate-nitrogen)**

The sensor of the Cardy meter measures $NO_3^-$ nitrate ion activity similar to the way a pH sensor measures $H^+$ ion activity. Decide whether you desire the meter LCD display to express the sample concentration as $NO_3^-$ nitrate or $NO_3^-$-N nitrate-nitrogen. (Note: this is similar to referencing length as 6 in. or ½ ft.). Laboratory analysis and university guidelines are generally expressed as $NO_3^-$-N nitrate-nitrogen.

To convert $NO_3^-$-N nitrate-nitrogen to $NO_3^-$ nitrate:

| multiply | or | divide |
|---|---|---|
| $NO_3^-$-N x 4.42 = $NO_3^-$ | | $NO_3^-$-N / .226 = $NO_3^-$ |

Therefore:

2000 ppm $NO_3^-$ nitrate = 450 ppm $NO_3^-$-N nitrate-nitrogen
150 ppm $NO_3^-$ nitrate = 34 ppm $NO_3^-$-N nitrate-nitrogen

The following table shows the concentrations of the various calibration standards in each unit of measurement.

| Description | ppm $NO_3^-$ | ppm $NO_3^-$-N |
|---|---|---|
| #2311 450 ppm $NO_3^-$-N * | 2000 | 450 |
| #2312 34 ppm $NO_3^-$-N * | 150 | 34 |
| #2336 450 ppm $NO_3^-$-N ** | 2000 | 450 |
| #2334L 34 ppm $NO_3^-$-N ** | 150 | 34 |

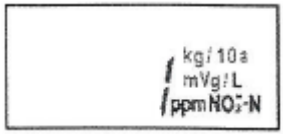
*** For use with plant sap, water and nutrient solutions.**
**** For use with soil samples (contains aluminum sulfate).**

# CALIBRATION

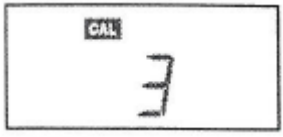
Selecting the Calibration Mode.

The meter is shipped with the meter in 2-point calibration mode. The calibration mode can be changed as follows (see also “Special Settings Modes” , p. 14)

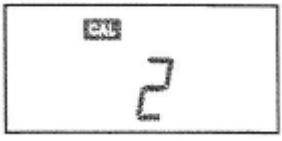
1. With the meter on, press and hold the **MEAS** button for at least 5 seconds to enter the special setting mode. When all the LCD elements illuminate, release the **MEAS** button so the number 1 appears. If the button is held too long, the LCD will display the word “Unit”. In this case, press and hold the **MEAS** button to get back into measurement mode and repeat this step.




2. Press and hold the **CAL** button until the **CAL** icon and the number 3 appear. If you pass number 3, press and hold the **CAL** button until it cycles around to number 3



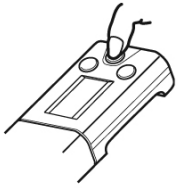

3. Press the **MEAS** button to displays the current calibration mode (1- or 2-point). Press the **CAL** button until the desired number of calibration points appears (It will toggle between 1 and 2).



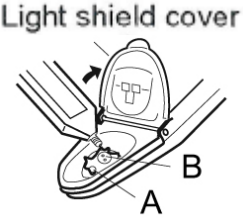

4. Press the **MEAS** button to save the calibration mode. The meter will return to standard measurement mode.

One-Point Calibration (ppm $NO_3^-$ - N mode)

1. Press and hold the ON/OFF button for, at least, two seconds to power the unit on.



2. Open the light shield cover and add enough of the 450 ppm $NO_3^-$ - N reference solution to cover the space between electrodes A and B. Rinsing the sensor pad with reference solution beforehand will increase the accuracy of the calibration.




3. Close the light shield cover and press the **CAL** button until the **CAL** icon flashes (a minimum of 2 seconds).


4. When the calibration has been finalized, the **CAL** icon will stop flashing. The reference solution concentration will be displayed along with the ☺ icon. The meter has not properly calibrated if the **CAL** icon remains flashing or if the **ERR** symbol is displayed on the LCD. In this case, confirm you have used the correct calibration solution, wash the sensor thoroughly and try to re-calibrate the sensor.

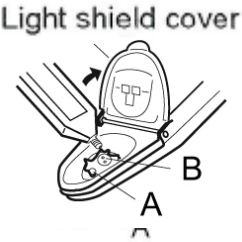
5. Wash the sensor with tap water and remove any adhering droplets before taking measurements.

6. Press the **MEAS** button to return to measurement mode.

Two-Point Calibration (ppm $NO_3^-$ - N mode)

1. Press and hold the ON/OFF button for, at least, two seconds to power the unit on.

2. Add enough of the 34 ppm $NO_3^-$-N reference solution to cover the space between electrodes A and B. Close the light shield cover and press the **CAL** button until the **CAL** icon flashes (a minimum of 2 seconds).




3. When the first calibration has been finalized, the **CAL** icon will stop flashing. The first calibration must be finalized before proceeding to the second calibration.

4. Repeat step 2 with the 450 ppm $NO_3^-$-N reference solution.

5. When the second calibration has been finalized, the **CAL** icon will stop flashing and the reference solution concentration will be displayed. The meter has not properly calibrated if the **CAL** icon remains flashing or if "ERR" is displayed on the LCD. In this case, confirm you have used the correct calibration solution, wash the sensor thoroughly and try to re-calibrate the sensor.

*If the two calibrations fail but the displayed reference solution concentration is correct, the sensor should be replaced.*

6. Wash the sensor with tap water and remove any adhering droplets before taking measurements.

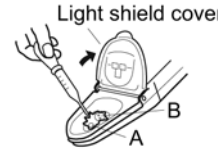
7. Press the **MEAS** button to return to measurement mode.

# MEASUREMENT PROCEDURE

Measurement on a flat surface

**Important: Do not make measurements with the meter (sensor) in direct sunlight.**

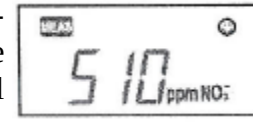
1. Open the light shield cover and add enough of the sample to cover the space between electrodes A and B.




2. Close the light shield cover


3. When the stability icon ☺ appears, the LCD will display the current nitrate concentration. To lock in a reading, press the **MEAS** button. The **MEAS** icon will flash to indicate that measurement has begun.


4. When the measurement is complete, the **MEAS** icon will cease flashing and the displayed value will be locked.



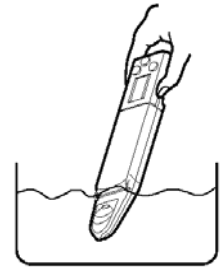

5. Press the **MEAS** button again to unlock the LCD and return to dynamic reading mode. After rinsing the sensor, steps 1 - 4 can then be repeated.

*Measurements can be made without pressing the **MEAS** button. In this case, the meter will remain in dynamic measurement mode.*

Submerged Measurement

1. Open the light shield cover's sliding cap. Submerge the senor in the sample and shake it gently 2 or 3 times

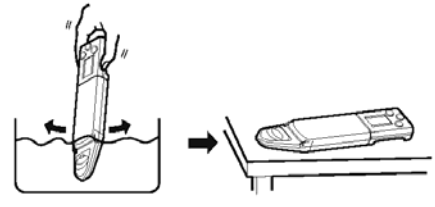
2. When the stability icon ☺ appears, proceed as with flat surface measurements (p. 12).

Scoop Measurement

1. Open the light shield cover's sliding cap. Submerge the sensor in the sample and shake it gently 2 or 3 times. Scoop up some of the sample onto the meter. Place the meter on a flat surface.

2. When the stability icon ☺ appears, proceed as with flat surface measurements (p. 12).

Temperature Measurement

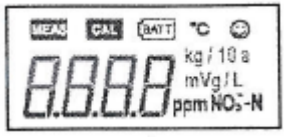
The meter has an internal temperature sensor. A reading can be taken in special settings mode 2 (see p. 15).

# Setting Special Modes

The Cardy nitrate meter has 6 special modes that can be modified at the user's discretion. The modes are:

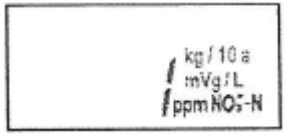
1. Set measurement units
2. Temperature measurement
3. Set number of calibrations
4. Set slope coefficient
5. Set offset coefficient
6. Voltage measurement

**Entering Special Setting Mode**
Press and hold the **MEAS** button for, at least, 5 seconds while the meter is in measurement mode. Release the **MEAS** button as soon as you see all the LCD elements illuminated.



Full display screen

The LCD will then transition to special setting mode starting with the screen for mode 1. If the **MEAS** button is not released immediately after seeing the full display, the meter will enter the "Set measurement units" mode and display the word "Unit". In this case, press and hold the **MEAS** button to return to measurement mode and start over.

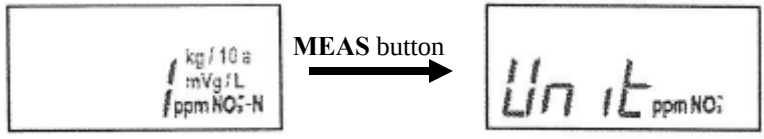


Sample mode selection screen

To scroll to the next mode, press the **CAL** button for half a second. If the **CAL** button is held down, the meter will cycle through the modes sequentially.

Once in the desired mode selection screen, press and hold the **MEAS** button for half a second to modify that configuration. Pressing and holding the **MEAS** button will take you out of special setting mode. See the following pages for details on each mode.

**Mode 1 (Set measurement units)**

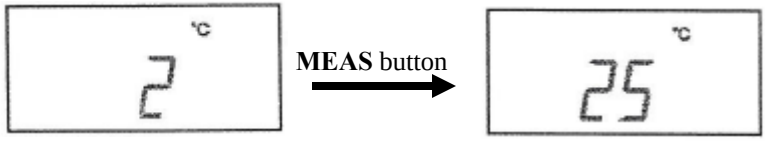



From mode selection screen 1, press the **MEAS** button for half a second. From here, you can configure which units will be displayed. Press the **CAL** button for half a second to cycle to the desired option. The choices are:

ppm $NO_3^-$ - N, ppm $NO_3^-$, mg/L $NO_3^-$ - N, and mg/L $NO_3^-$

Press and hold the **MEAS** button to return to measurement mode.

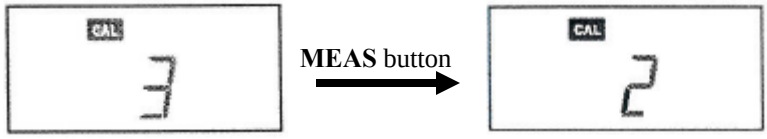
**Mode 2 (Temperature measurement)**




From mode selection screen 2, press the **MEAS** button for half a second. This is not a mode configuration screen. Instead, in this mode, the meter displays the reading of the internal temperature sensor (in Celsius). The measurement precision is not guaranteed and should only used as an estimate.

Press and hold the **MEAS** button to return to measurement mode.

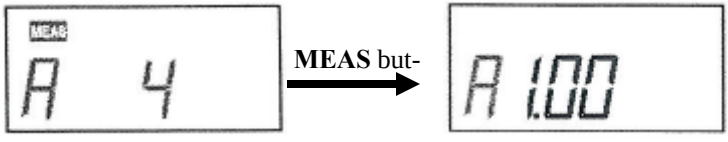
**Mode 3 (Set number of calibrations)**




From mode selection screen 3, press the **MEAS** button for half a second. From here, you can configure the number of solutions that will be used to calibrate the meter. The options are 1- and 2-point calibration. Press the **CAL** button for half a second to cycle to the desired option.

Press and hold the **MEAS** button to return to measurement mode.

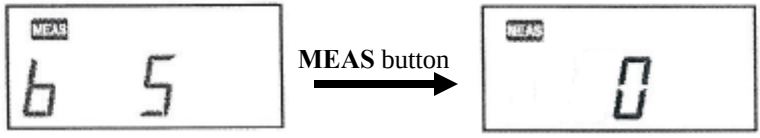
**Mode 4 (Set slope coefficient)**




From mode selection screen 4, press the **MEAS** button for half a second. From here, you can set a multiplicative constant (0.1 to 9.9) that will be multiplied by the reading. This, along with the offset setting (mode 5), can be used to modify the output value to suit a specific application such as dilute or concentrated solutions. The default setting is 1.00.

Press and hold the **MEAS** button to return to measurement mode.

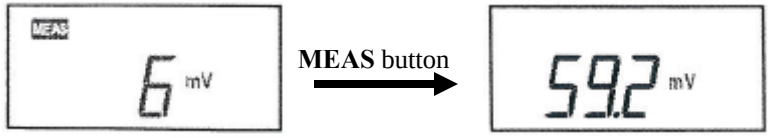
**Mode 5 (Set offset coefficient)**




From mode selection screen 5, press the **MEAS** button for half a second. From here, you can set an additive constant (-1000 to 1000) that will be added to the reading. This, along with the slope setting (mode 4), can be used to modify the output value to suit a specific application such as dilute or concentrated solutions. The default setting is 0.

Press and hold the **MEAS** button to return to measurement mode.

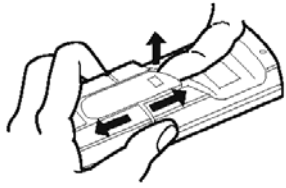
**Mode 6 (Sensor voltage measurement)**

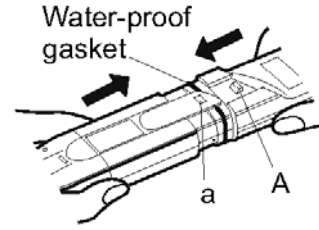



From mode selection screen 6, press the **MEAS** button for half a second. This is not a mode configuration screen. Instead, in this mode, the meter displays the reading of the sensor voltage (in mV). Use this mode to evaluate sensor performance or to create your own calibration curve.

Press and hold the **MEAS** button to return to measurement mode.

# Replacing the Sensor



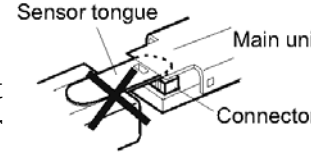



**Removal**
Lift hole **a** off tab **A** and slide the sensor away from the chassis.

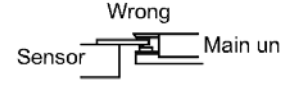
**Replacement**
Slide the sensor onto the body so that tab **A** fits into hole **a**. Take care not to twist the waterproof gasket

**Precautions**

- As shown here, make sure that the sensor tab is inserted over the copper strip on the main unit. Be careful not to damage the connector





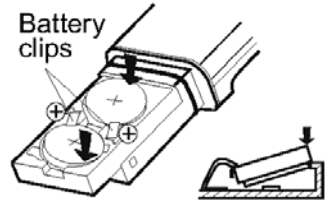



- When removing the sensor, carefully wipe off any drops of sample remaining on the water proof gasket. Do not let water permeate the main body.
- When replacing the sensor or batteries, be sure the unit is powered off.

# Installing and Replacing Batteries

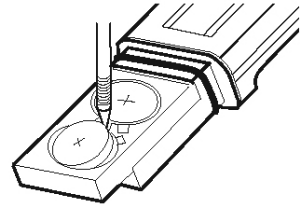
**Installation**

Slide both batteries into the battery clips as shown such that the positive sides are facing upward.




**Replacement**

Use a small flat-head screwdriver or other instrument to pry the batteries from the clips as shown. Always replace both batteries at once.



# Preparing Soil Samples

## Sample Collection

Collect at least 15 to 20 core samples from an area not exceeding ten acres by using a Z pattern. Areas having different soil types or management histories should be sampled separately. Sample the top 12 inches of soil. Some universities recommend sampling the top 24 inches in 12 inch increments. Contact your county extension agent for recommendations. Care should be taken to ensure that soil samples are not biased by the presence of rows or bands of fertilizer.

## Soil Preparation

Samples should be dried within 24 hours of collection to minimize changes in $NO_3^-$-N concentrations. Before drying, crumble the soil to avoid large clods that will be difficult to crush when dry. The samples should then be dried by spreading on a thin layer of newspaper at least 3 pages thick and placing overnight in a warm spot with good air movement. Soil will dry in a few hours if placed in a sunny location exposed to the wind. If dried indoors, 24 to 48 hours may be required. Indoor drying time can be reduced with the use of a fan. For oven drying, spread a thin layer of soil on a cookie sheet or pie plate. Place it in an oven set to no more than 250$^{o}$F with the door slightly ajar. Consider the soil dry when it crumbles rather than compacts under pressure. After drying, crush the soil by using a block of wood or other suitable device. Crush until the soil particles are the size of BB's or smaller. Sift with a flour sifter or other 10 mesh screen. Mix soil thoroughly.

Soil testing of mineral soil requires the Soil Test Kit (item #2330). Be sure you are using the soil standard solutions (item nos. 2334L and 2336) when calibrating the meter for soil tests. Do not use the calibration standards for water/plant sap (See **Calibrating Solutions**, p. 8).

**Sample Preparation**

1. Measure 2 level measuring spoons (30 ml) full of dry soil into the soil sample cup.

2. Add 2 (30 ml) measuring spoons of the soil extractant to the soil.

3. Mix the soil and the solution by stirring with the spoon for at least 2 minutes, making sure the soil sample is thoroughly mixed. Let stand for 5 minutes

4. Fold a circular filter in half 'twice' and open it up to form a cone. Place it in the soil suspension as far as possible. The filtration will take place from the outside of the filter to the inside.

5. As soon as sufficient filtrate accumulates in the filter, use the small pipette to transfer the soil extract onto the sensor of the Cardy meter.

6. Read the value from the digital display after it has stabilized (30 - 45 sec.). Subtract 34 from the display value. This accounts for the 34 ppm $NO_3^-$ in the extractant solution. For lbs/acre, multiply by 4 for a sampling depth of 12 inches. Note: For soils very low in nitrate, it is possible to get sensor readings less than 34.

7. Rinse sensor and blot dry. Display should read close to "0" with distilled water on it, if not rinse again.

## Correction for moist soil

In order to make accurate soil nitrate measurements, the soil must be dry. Nitrate is extracted by mixing a precise amount of dry soil with a measured amount of extracting solution. If the soil is moist, the dilution varies and the result is an understated nitrate test concentration.

When soil nitrate testing is used for **diagnostic** purposes, it may be useful to perform in-field tests using **moist** soil. When performing the rapid test, the content of water in the soil should be taken into account.

The wetter the soil, the greater the tendency for a low result. Precise work requires that the measured nitrate content be multiplied by a correction factor. Table 1 gives the correction factor to be added (in percent) for each type of soil as a function of soil wetness.

| Moisture content | Sand | Clay sand | Sandy clay | Clay, Loess |
|---|---|---|---|---|
| Very dry | +8% | +15% | +17% | +23% |
| dry | +12% | +20% | +24% | +33% |
| Med-moist | +12% | +25% | +31% | +43% |
| moist | +14% | +30% | +38% | +53% |
| Very moist | +16% | +35% | +45% | +63% |

**Table 1**: Estimated soil nitrate percentage correction for soils at various field moisture levels. Increase the value given by Cardy meter by the percentage shown in the table.

# Collecting Tissue Sap

When conducting a test on plant materials, the biggest source of error is due to sampling. This error results when a sample is not representative of the source. Follow these steps to gather and care for your sample:

1.) Do not sample plants which show obvious signs of nutrient deficiency or damage from disease, insects, or chemicals unless these plants are the subject of a study. Plants which have been under stress for a period of time may not give a true picture of the nutrient status of the field.

2.) The leaves or parts of leaves selected should be of the same age and relative position on the plant. The most recently matured leaves should be used. These are the leaves that have stopped expanding in size. The petiole or leaf stem of the leaf or appropriated plant material should be used for the test.

3.) A minimum of 25 petioles or leaves should be collected. This is enough to represent a five to ten acre field if the field is judged to be uniform. Chop up the petioles and mix and sub-sample these pieces for testing. Crops with small, dry petioles, such as strawberries require much larger samples to get enough sap compared to fleshy crops such as tomatoes. Store whole petioles, not leaves, at room temperature for up to 1½ hours or on ice for up to eight hours. Cold petioles should be warmed to room temperature before taking a measurement.

4.) Depending on how succulent the petiole is, use a handheld or hydraulic plant sap press (p. 27) to squeeze sap from the petioles.

# Preparing Soil-less media

**Sample collection**

1. Collect sample just before plants are irrigated.
2. Avoid the top layer of media with no roots.
3. Collect root media from the bottom ⅔ of the pot.
4. Take samples from 10 or more plants distributed in the sample population.
5. When a sufficient amount of root media is collected, mix the sample.

**Sample Preparation and Analysis**
**1:2 Extraction method**

Measure a known volume of root media in a beaker or cup (usually 50 to 100 ml or ¼ to ½ cup). Fill firmly so it is compressed as it was in the pot. Be consistent when measuring. DO NOT lightly fill or heavily pack the beaker. Place the sample into a cup or beaker.

Add 2 equal volumes of distilled water into the cup, mix the sample and wait 10 minutes. Measure the nitrate after sieving out the large particles. The nitrate level can be read directly from the slurry.

**Saturated media extract method**

Place 300 to 500 ml (1 to 2 cups) of root media sample in a cup or beaker.

Slowly add distilled water, constantly stirring the sample with a spatula or knife. Add enough distilled water so that the sample behaves like a paste with the surface glistening with water, but with no free water on the surface of the sample.

After 15 minutes, add more water if needed.

Extract the solution from the media using a pipette, Buchner funnel, side arm, flask and vacuum pump, filter bag or sieve. Make any additional measurements (such as EC) using the extracted solution. Table 2 gives a general idea of the nitrate levels to look for in the extracted solution.

| **Media Type** | **ppm $NO_3^-$-N in extract** |
|---|---|
| Seedlings | 40 - 70 |
| Young pot and foliage plants | 50 - 90 |
| Pot and bedding plants-growing on | 80 - 160 |
| Roses, mums or snapdragons in ground or raised beds | 120 - 200 |
| Lettuce and tomatoes in ground beds | 125 - 225 |
| Celery transplants | 75 - 125 |

**Table 2: Interpretation of Greenhouse Soils:** Desirable $NO_3^-$-N concentrations in saturated media extract.

# SPECIFICATIONS

| | |
|---|---|
| **Principle** | Ion electrode method |
| **Readout** | 4-digit LCD digital display |
| **Reproducibility** | ±10% of indication value |
| **Measurement Range** | 14 to 1400 ppm $NO_3^-$ - N |
| **Operating Temperature** | 5 to 40 °C |
| **Operating Humidity** | maximum 85% RH |
| **Calibration** | 1-pt (450 ppm $NO_3^-$-N) or<br>2-pt (34 and 450 ppm $NO_3^-$-N) |
| **Weight** | 52g (approx. 1.8 oz) |
| **Power** | 2 - CR 2032 batteries |
| **Auto Power OFF** | 30 seconds |
| **Dimensions** | 165mm x 29mm x 19mm<br>(6.5” x 1.1” x 0.8”) |
| **Sample volume** | 0.3 to 2.0ml |

# Soil Test Kit Accessories

| Description | #2330 Replenishment Kit |
|---|---|
| Std. Solution 450ppm $NO_3^-$-N (30ml)* | 1 |
| Extractant 34ppm $NO3^-$-N (1 Liter)* | 2 |
| Cups - 8oz. | 3 |
| Measuring Spoon (29.5 cc) | 1 |
| Pipet | 1 |
| Filter Papers | 30 |

* Calibration solutions in soil test kits include $AlSO_4$

Hydraulic Plant Sap Press
(item #2720)

Handheld Plant Sap Press
(item #2725)

# Petiole $NO_3^-$-N Sufficiency Levels For Drip-Irrigated vegetables

(Source: UC-Davis)

| Crop | Growth Stage | Petiole $NO_3^-$-N concentration Dry Tissue | Fresh Sap |
|---|---|---|---|
| Broccoli | Mid growth | 10,000 - 20,000 | 1000 - 1600 |
| | Button formation | 8000 - 15,000 | 800 - 1200 |
| | Preharvest | 5000 - 8000 | 600 - 1000 |
| Cabbage | Cupping | * | 1200 - 1500 |
| | Early heading | * | 1000 - 1200 |
| | Mid heading | * | 700 - 900 |
| Canteloupe | Early flower | 12,000 - 15,000 | 1000 - 1600 |
| | Fruit bulking | 8000 - 10,000 | 800 - 1000 |
| | First harvest | 4000 - 6000 | 700 - 800 |
| Cauliflower | Mid growth | * | 1000 - 1600 |
| | Curd development | * | 700 - 1000 |
| | Preharvest | * | 500 - 800 |
| Celery | Mid growth | 7000 - 10,000 | 600 - 800 |
| | Preharvest | 6000 - 10,000 | 400 - 600 |
| Lettuce | Early head formation | 7000 - 10,000 | 400 - 600 |
| | Preharvest | 6000 - 8000 | 300 - 500 |
| Onion | Bulbs 0.5-1.5 in. | * | 350 - 500 |
| Pepper | Vegetative growth | 7000 - 10,000 | 900 - 1200 |
| | Early flower/fruit | 5000 - 8000 | 700 - 1000 |
| | Fruit bulking | 5000 - 8000 | 700 - 1000 |
| | Preharvest | 5000 - 7000 | 700 - 900 |
| Potato | Early vegetative | 17,000 - 22,000 | 1300 - 1600 |
| (Russet Burbank) | Mid tuber/bulking | 11,000 - 15,000 | 900 - 1200 |
| | Late tuber/maturation | 6000 - 8000 | 550 - 700 |
| Sweet Corn | Entire season | * | 600 - 700 |
| Tomato | Vegetative growth | 10,000 - 14,000 | 700 - 900 |
| | Early flower/fruit | 9000 - 12,000 | 600 - 800 |
| | Fruit bulking | 6000 - 8000 | 500 - 700 |
| | Preharvest | 4000 - 7000 | 400 - 600 |
| Watermelon | Early flower | 12,000 - 15,000 | 1000 - 1600 |
| | Fruit bulking | 8000 - 15,000 | 700 - 900 |
| | Fruit harvest | 5000 - 8000 | 500 - 700 |

# Petiole $NO_3^-$-N Sufficiency Levels

## (Source: University of Florida)

| Crop | Growth Stage | $NO_3^-$-N (ppm) Fresh Sap |
|---|---|---|
| Cucumber | First blossom | 800 - 1000 |
| | Fruits 3-inches long | 600 - 800 |
| | First harvest | 400 - 600 |
| Broccoli & Collards | Six-leaf stage | 800 - 1000 |
| | Just prior to harvest | 500 - 800 |
| | At first harvest | 300 - 500 |
| Summer Squash | First blossom | 900 - 1000 |
| | First harvest | 800 - 900 |
| Muskmelon | First blossom | 1000 - 1200 |
| | Fruits 2-inches long | 800 - 1000 |
| | First harvest | 700 - 800 |
| Tomato (field) | First buds | 1000 - 1200 |
| | First open flowers | 600 - 800 |
| | Fruit 1-inch diameter | 400 - 600 |
| | Fruit 2-inch diameter | 400 - 600 |
| | First harvest | 300 - 400 |
| | Second harvest | 200 - 400 |
| Bell Pepper | First flower buds | 1400 - 1600 |
| | First open flowers | 1400 - 1600 |
| | Fruits half-growth | 1200 - 1400 |
| | First harvest | 800 - 1000 |
| | Second harvest | 500 - 800 |
| Eggplant | First fruit (2-inches long) | 1200 - 1600 |
| | First harvest | 1000 - 1200 |
| | Mid harvest | 800 - 1000 |
| Potatoes | Plants 8-inch tall | 1200 - 1400 |
| | First open flowers | 1000 - 1400 |
| | 50% of flowers open | 1000 - 1200 |
| | 100% of flowers open | 900 - 1200 |
| | Tops falling over | 600 - 900 |

# Petiole $NO_3^-$-N Sufficiency Levels (Cont.)

(Source: University of Florida)

| Crop | Growth Stage | $NO_3^-$-N (ppm) Fresh Sap |
|---|---|---|
| Annual Hill Strawberries (October planting) | November | 800 - 900 |
| | December | 600 - 800 |
| | January | 600 - 800 |
| | February | 300 - 500 |
| | March | 200 - 500 |
| | April | 200 - 500 |
| Watermelon | Vines 6-inches long | 1200 - 1500 |
| | Fruit 2-inches long | 1000 - 1200 |
| | Fruits half mature | 800 - 1000 |
| | First harvest | 600 - 800 |

## Petiole $NO_3^-$-N Sufficiency Levels For Potatoes (Source: Univ. Wiisconsin-Madison)

Optimum range of nitrate-nitrogen concentrations (dry weight and sap basis) in potato petiole at various stages of growth

| Growth Stage (days after emergence) | Norkotah, Norland, Atlantic, Kennebec | Shepody, R. Burbank, Snowden | Onaway Superior |
|---|---|---|---|
| **dae** | **Dry Weight Basis (% $NO_3^-$-N)** | | |
| 30 | 2.5 - 2.8 | 2.0 - 2.3 | 2.3 - 2.5 |
| 40 | 2.3 - 2.5 | 1.7 - 2.2 | 2.0 - 2.3 |
| 50 | 1.8 - 2.3 | 1.2 - 1.6 | 1.5 - 1.9 |
| 60 | 1.3 - 1.9 | 0.8 - 1.1 | 0.9 - 1.2 |
| 70 | 0.8 - 1.1 | 0.5 - 0.8 | 0.4 - 0.6 |
| | **Sap Basis (ppm $NO_3^-$-N)** | | |
| 30 | 1900 - 2100 | 1600 - 1800 | 1800 - 1900 |
| 40 | 1800 - 2000 | 1600 - 1700 | 1600 - 1800 |
| 50 | 1400 - 1800 | 1000 - 1300 | 1200 - 1500 |
| 60 | 1110 - 1500 | 700 - 900 | 500 - 1000 |
| 70 | 700 - 900 | 500 - 700 | 400 - 600 |

Values from the Cardy can be converted to dry tissue calibration by using the equation:

%Dry Weight $NO_3^-$-N = 0.00142 (ppm sap $NO_3^-$-N) - 0.21

## Petiole $NO_3^-$-N Sufficiency Levels Russet Burbank Potatoes (Source: Univ. of Minnesota)

| Growth Stage | Petiole $NO_3^-$-N (ppm) Dry Tissue | Fresh Sap |
|---|---|---|
| Early Vegetative/tuberization | 17,000 - 22,000 | 1300 - 1600 |
| Mid tuber growth/bulking | 11,000 - 15,000 | 900 - 1600 |
| Late tuber growth/maturation | 6,000 - 8,000 | 550 - 700 |

# Petiole $NO_3^-$-N Sufficiency Levels
## (Source: Michigan State University)

The following guidelines are based on one year's research results and will be revised as necessary based on future research findings. Readings taken on youngest fully extended petiole.

**Carrots**

| | Adequate petiole sap nitrate concentration | |
|---|---|---|
| Carrot shoulder diameter (in.) | Nitrate-N (ppm) | Nitrate (ppm) |
| Prior to sizing | 750+ | 3,300+ |
| 0.00 - 0.25 | 550+ | 2,420+ |
| 0.25 - 0.50 | 450+ | 1,980+ |
| 0.50 - 0.75 | 300+ | 1,320+ |
| 0.75 - 1.50 | 250+ | 1,100+ |
| > 1.50 | 200+ | 880+ |

**Celery**

| | Adequate petiole sap nitrate concentration | |
|---|---|---|
| Weeks after transplant | Nitrate-N (ppm) | Nitrate (ppm) |
| 0 - 5 | 800+ | 3,520+ |
| 5 - 6 | 725+ | 3,190+ |
| 6 - 7 | 650+ | 2,860+ |
| 7 - 8 | 575+ | 2,530+ |
| 8 - 9 | 500+ | 2,200+ |
| 9 - 10 | 425+ | 1,870+ |
| 10 - 11 | 350+ | 1,540+ |
| 11+ | 275+ | 1,210+ |

**Onions**

| | Adequate petiole sap nitrate concentration | |
|---|---|---|
| Growth Stage | Nitrate-N (ppm) | Nitrate (ppm) |
| Up to 5 leaves | 800+ | 2,520+ |
| 5 to leaves | 600+ | 2,640+ |
| Bulb initiation | 300+ | 1,320+ |
| Bulb bulking | 250+ | 1,110+ |

# Pre-Sidedress Nitrate (PSNT) Soil Test Interpretation

**University of Tennessee**

| | |
|---|---|
| <17 | ppm $NO_3^-$-N Low |
| 17 - 25 | ppm $NO_3^-$-N Low |
| >25 | ppm $NO_3^-$-N Low |

**Rutgers Cooperative Extension**

| **PSNT Soil Test Level (ppm $NO_3^-$-N)** | **Sidedress N Recommendation** |
|---|---|
| 1 - 15 | 160 |
| 16 - 20 | 120 |
| 21 - 25 | 80 |
| 26 - 30 | 40 |
| 31+ | 0 |

**University of Wisconsin**

| | Soil Potential* | |
|---|---|---|
| | Very High/High | Medium/Low |
| **PSNT result (ppm N)** | **N/application Rate (lbs/Acre)** | |
| <10 | 160 | 120 |
| 11 - 12 | 150 | 80 |
| 13 - 14 | 125 | 80 |
| 15 - 17 | 100 | 40 |
| 18 - 20 | 60 | 40 |
| >21 | 0 | 0 |

** consult WMEX pub. A2809*

**Pennsylvania Nitrogen Soil Test Recommendation (Lbs N/Acre)**
(Source: Penn State University)

| | **Corn Yield Goal** | | | | |
|---|---|---|---|---|---|
| Soil Test Level (ppm $NO_3^-$-N) | 100 | 125 | 150 | 175 | 200 |
| 0 - 10 | 100 | 130 | 160 | 190 | 220 |
| 11 - 15 | 75 | 100 | 125 | 150 | 150 |
| 16 - 20 | 50 | 75 | 100 | 125 | 125 |
| 21 - 25 | 25 | 50 | 75 | 100 | 100 |
| 25+ | 0 | 0 | 0 | 0 | 0 |

**Note: Check you county extension office for updates**

# Warranty

This product is warranted to be free from defects in material or workmanship for one year from the date of purchase. During the warranty period Spectrum will, at its option, either repair or replace products that prove to be defective. This warranty does not cover damage due to improper installation or use, lightning, negligence, accident, or unauthorized modifications, or to incidental or consequential damages beyond the Spectrum product. Before returning a failed unit, you must obtain a Returned Materials Authorization (RMA) from Spectrum. Spectrum is not responsible for any package that is returned without a valid RMA number or for the loss of the package by any shipping company.

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Spectrum Technologies, Inc.
12360 S. Industrial Dr. East
Plainfield, IL 60585 USA

The Manufacturer's **DECLARATION OF CONFORMITY** is on file at the above address, and certifies conformity to the following:

| | |
|---|---|
| Model Number: | 2305G |
| Description: | Nitrate Meter |
| Type: | Electrical Equipment for Measurement, Control, and Laboratory Use |
| Directive: | 2004/108/EC |
| Standards: | EN 61326-1 (2006), Class B |

Douglas L. Kieffer,
Soil/Water Products Manager March 4, 2009


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