SC 900
Soil Compaction Meter

PRODUCT MANUAL

CONTENTS

General overview

Thank you for purchasing the Field Scout™ SC 900 Soil Compaction Meter. This manual describes the features and operation of the meter.

Soil compaction prevents moisture penetration, reduces fertilizer and chemical uptake and hinders plant root growth. In some cases, yield losses can run as high as 30% due to compaction. This electronic soil compaction meter is the most versatile compaction meter on the market. Soil depth readings are determined by a sonic depth sensor. Cone index values are measured by a load cell sensor and can be displayed in PSI or kPa.

The Field Scout's shaft-mounted probe allows the user to easily and rapidly take many measurements. The probe has options for a 1/2" or 3/4" diameter cone tip. The shaft can be dissembled into 2 pieces for easy storage and transport. The meter's built-in datalogger can record data from several sites and eliminates the need to record data manually. Through the software, the user can download the data, change the logger settings and configure the meter.

Taking Compaction Measurements

The SC 900 is a state-of-the-art electronic cone penetrometer for use in soil density, trafficability and compaction studies. This soil compaction instrument measures cone index data, logs the data and allows the user to review the data to make soil management decisions.

When to sample

It is recommended that compaction measurements be taken after a rain, or in the spring when the soils have good moisture content. Measuring soil compaction in dry soil conditions will not yield meaningful results.

The SC 900 compaction meter should be used before tillage to determine where the compacted areas of a field/plot are. Once the compacted areas, along with compaction depths, have been determined, a much more effective tillage system can be employed.
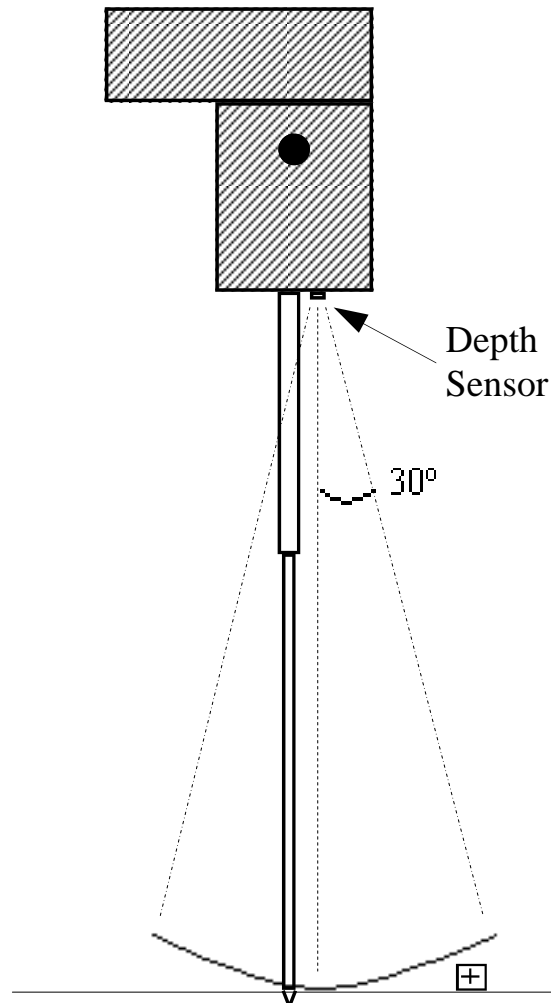
The unit works as an efficient diagnostic tool as well as a management unit after the tillage operation has been performed. One can determine how deep the soil has actually been worked and if the tillage operation has solved the compaction problems.

Selecting the cone tip

Meters with firmware v. 8.1 or greater can be equipped with either a 1/2" or 3/4" diameter cone tip. The 1/2" tip is appropriate for most soils. The 3/4" tip is recommended for coarse and sandy soils that provide less resistance to penetration. The cone selection screen appears at the end of the meter power up sequence (see **Meter Operation**, p. 6). Use the **REVIEW** button to select the desired cone tip option.

Depth Sensor

An ultrasonic sensor located at the base of the meter is used to measure the depth of penetration. The field of view extends about 30° from the shaft. The sensor measures distance by emitting a sound wave and measuring the travel time of the first reflected wave. Usually, this first reflection will come from the ground just adjacent to the shaft. However, if an object with a surface oriented toward the sensor is within the field of view, an erroneous depth measurement may be made. This can lead to depth error messages (see **Diagnostic Messages** p. 18). If possible, try to remove the object and/or smooth the surface. Repositioning your feet and knees may also eliminate these errors. If the problem persists, use the depth target included with the meter to test the depth sensor and, if necessary, to take measurements. If the depth target is not available, one can be made out of cardboard or something sturdier if more durability is required. To test the depth sensor, lay the target on the ground and place the shaft in the hole. Have another person slowly raise the depth target while you verify the meter is incrementing the depth.

Depth Sensor

30°

Meter operation

Powering up the meter

The **ON** switch turns the meter/ datalogger on and off. When the meter is powered up, it will display the battery status for 3 seconds.

```
BATTERY AT 70%
 Firmware v8.2
```

If the logger was enabled in the software, for the next 3 seconds, it will display how much logger memory has been used and whether the GPS signal was found (see sample screens below). If a GPS signal is found, latitude and longitude data will be included in the data file.

```
Logger 75% Full
GPS=Yes DGPS=No
```

```
Logger 75% Full
NO GPS FOUND
```

Sample meter power-up screens with datalogger enabled: left screen indicates GPS signal was found.

If the data logger is disabled, no data will be stored by the meter and the Logger/GPS screens above will be bypassed during startup. The data logger can be activated through the SC 900 software (see **Meter Settings**, p. 16).

If you <u>are</u> using GPS, but the meter doesn't find the GPS signal when powering up, the meter will **not** search for the GPS signal when taking readings. Turn the meter off and on so it can look for the GPS signal again. Once the signal is found, GPS information will be included in the data file until the signal is lost or the GPS unit is disconnected from the meter (see **Connecting to a GPS Unit** p. 12).

For meters with firmware version 8.1 or greater, the final startup screen displays the cone size currently selected. This cone size option can be changed by pressing the **RE-VIEW** button. Pressing the **START** button will transition the meter to the initial operation screen.

```
Use 1/2 in. Cone
Change w/   REVIEW
```

Cone Selection Screen

Note: Meters with firmware versions 8.0 or earlier will bypass the cone selection screen and move directly to the meter initial operation screen.

When the meter completes the startup procedure, it will proceed to the initial operation screen. From the initial operation screen, pressing the **START** button will put the meter into measurement mode and the LCD will display. The meter will then be ready to take readings (see **Measurement Procedure** p. 8).

```
Place Tip On Gnd
Then Press Start
```

Initial Operating Screen

Deleting data

Immediately after the meter has successfully taken a full profile measurement, but be-

```
Reading Deleted
```

fore measuring another profile, the **DELETE** button will delete the profile before that has just been sent to the data-logger. The screen will then indicate that the reading has been deleted. This feature is only active when the data logger is enabled.

Reviewing the most recent profile

After measuring a profile, pressing the **REVIEW** button allows the user to see the cone index value at each depth. As the button is pressed, the display screen will scroll sequentially through the entire profile.

Measurement Procedure

Recording the best quality data requires some practice. Your objective is to uniformly push the probe into the ground using an even motion. The programmed rate, specified in the ASABE standards, is approximately 1 second per 1 inch. If this rate is exceeded, the meter will display a warning message (see **Diagnostic Messages** p. 18).

Taking a profile measurement

1. With the Initial Operating Screen (see p. 7) visible, push and release **Start** button.
2. Wait for the LCD to display the Profile Information screen (see below). The top line shows the current cone index and the depth. At the surface, the depth will be zero. The second line indicates how many profiles have been taken (If the logger is disabled, the second line will indicate that the logger is off). This resets to 1 every time the meter is turned on.

```
0010 PSI 00 IN
       N=1
```

Profile Information Screen

3. Stand with your feet at least 4 to 6 inches from the probe tip. This ensures the sonic depth sensor will measure accurately. Tall, nearby objects or walls will also inhibit the ability of the depth sensor to "see" the ground surface. If you are working in turf or an especially uneven soil surface, you may need to use the depth target to ensure reliable performance (see **Depth Sensor** p. 5). It is advisable to smooth the soil surface as much as possible before inserting the probe. As the

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probe is inserted into the soil, the depth measurement on the display will increase in 1-inch increments. The cone index will change in response to soil compaction differences.

4. Push probe into ground slowly and evenly so that there is not any side stress on the shaft. The meter must be inserted at least 4" into the ground before a profile will be saved. If an error message is generated, it may be possible to save a profile (see **Diagnostic Messages** p. 18). Otherwise, start over by removing probe and pushing the **Start** button.

5. Remove probe gently. If the profile was successfully measured, the following message will be displayed.

```
Reading Complete
- -Review Mode- -
```

Reading Complete Screen

6. You can review compaction measurement increments by pushing the **Review** button . You can also delete the most recently measured profile by pushing the **De-lete** button. See **Meter Operation** (p. 7) for details.

7. Press **Start** to ready the probe for the next measurement.

Geo-Referencing Compaction Measurements

To geo-reference your data, you will need to connect a GPS/DGPS unit to the SC 900 and proceed as described above. The GPS format should be NMEA 0183. See **Connecting to a GPS Unit** (p. 12) for further details.

Connecting to a Computer
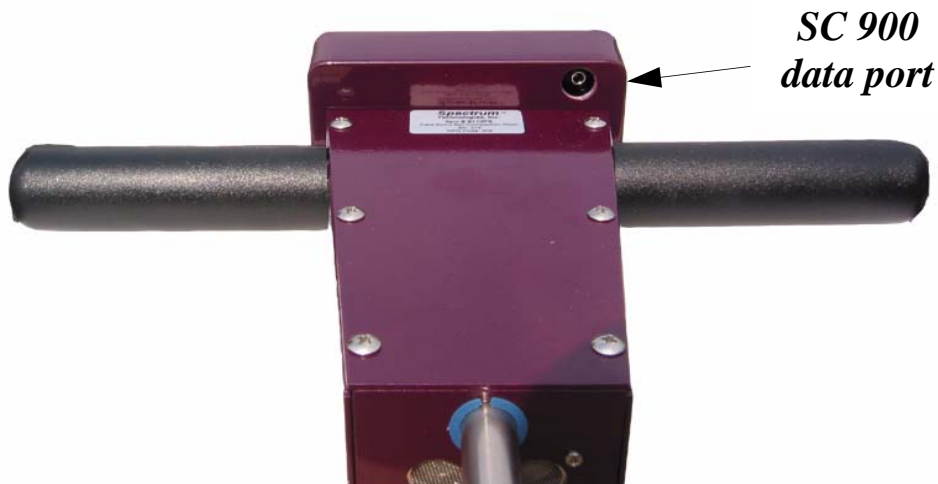
SC 900
data port

The data port on the underside of the SC 900 meter (shown above) can be accessed by removing the plastic screw. It is through this port that the meter is connected to either a PC or to a GPS unit.

Connecting to a PC

The SC900 software comes with a black PC interface cable. This cable connects to the USB port of your computer and to the meter's computer port. The meter's configuration can be modified by clicking on the **Meter Settings** button (see **Meter Settings**, p. 16). The **Com Port, Meter Type, Download, Clear Memory** and **Meter Settings** buttons are explained in the **Main Toolbar** section (p. 14).

Note: Prior to 2014, the meter was shipped with a gray cable that connected to a 9-pin serial port. This cable will still work but may require a USB-to-serial adapter.

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Identifying the Correct Com Port

Port Test

The Com Port to which the PC-3.5 cable is connected can be identified by using a paper clip.
1. Disconnect the logger from the serial cable.
2. Select the Com Port to be tested and click on the Test Port button. If the message "Connection OK" is displayed, either another device (such as a modem) is connected to that port or the serial cable is faulty. If the message "No Connection" is displayed, this port may be the one connected to your serial cable.
3. Place a paperclip on the end of the serial pin so that it touches both the tip of the pin and the metal area between the two black rings. Alternately, you can hold the two sections of the pin with wet fingers. Again click on the Test Port button. If the message "Connection OK" now appears, this is the Com Port connected to your serial cable.

Note: The dataloggers do not short-circuit the serial pin. Therefore, when the Test Port button is clicked while the logger is connected, the "No Connection" message will be displayed rather than "Connection OK".

Test Port Now   Cancel

The computer **Com**munications **Port** to which the cable is connected can be identified by using a paper clip.

1. Disconnect the serial cable from the meter.

2. To bring up the **Port Selection** screen, click on the **Com Port** Button, select the com port to be tested and click the **Port Test** button. Click the **Test Port Now** button. If the message "Connection OK" is displayed, another device (such as a modem) is probably connected to that port. If the message "No Connection" is displayed, this port may be the one connected to your serial cable and you can proceed to the next step.

3. Place a paperclip on the end of the serial pin so that it touches both the tip of the pin and the metal area between the two black rings. Again click on the **Test Port Now** button. If the message "Connection OK" now appears, this is the com port connected to your serial cable.

paper clip or wire ⇒
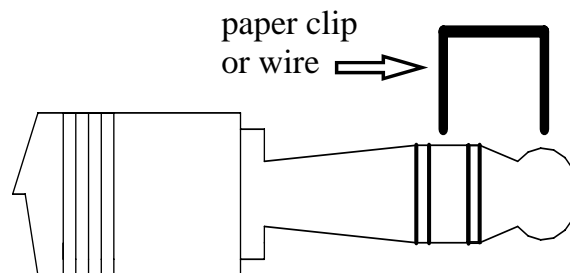
NOTE: The meter does not short-circuit the serial pin. Therefore, when the **Test Port Now** button is clicked while the meter is connected, the "No Connection" message will be displayed.
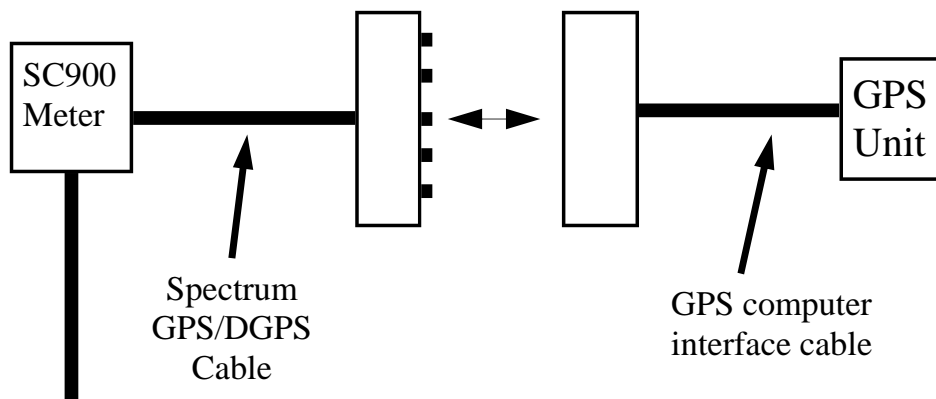
Connecting to a GPS Unit

Cable Connections

A GPS/DGPS cable (item # 2950CV5) is required to connect the SC900 meter to a GPS unit. This cable has a 9-pin male connection and a stereo pin that connects to the meter's data port. You will also need a cable that allows the GPS unit to connect to a 9-pin male serial port. If this cable doesn't come standard with your GPS unit, it should be available from the manufacturer. This cable is generally used to upload information from a computer to the GPS unit. These components should be connected as shown in the figure below.

GPS Setting

Your GPS unit must be set for NMEA 0183 input/output messages. If the meter has trouble receiving the GPS signal, check that it has the following settings:

Data bits: 8   Stop bits: 1
Baud rate: 4800 bps   Parity: None
Timing: 1 second   GGA data string

Connecting the SC900 meter to a GPS unit

Calibration/
Battery Change

Calibration

The reading of the meter's load cell can be recalibrated with the following procedure.

Note: During the calibration procedure, care must be taken to ensure that the only force on the load cell is the weight of the meter itself.

1. Balance the meter in an upright position on a hard surface.

2. Make sure the meter is turned **OFF**. Press and hold the **START** button.

3. With the **START** button depressed, press and release the ON button. The LCD will count down from 5 to 1.

4. The meter should now read between 5 and 10 P.S.I. (35 - 70 Kpa). This reflects the weight of the meter itself.

Changing the Batteries

To change the batteries, remove the 4 philips-head screws from the face plate of the meter. Remove the face plate to access the battery compartment. The meter requires 4 AAA batteries.
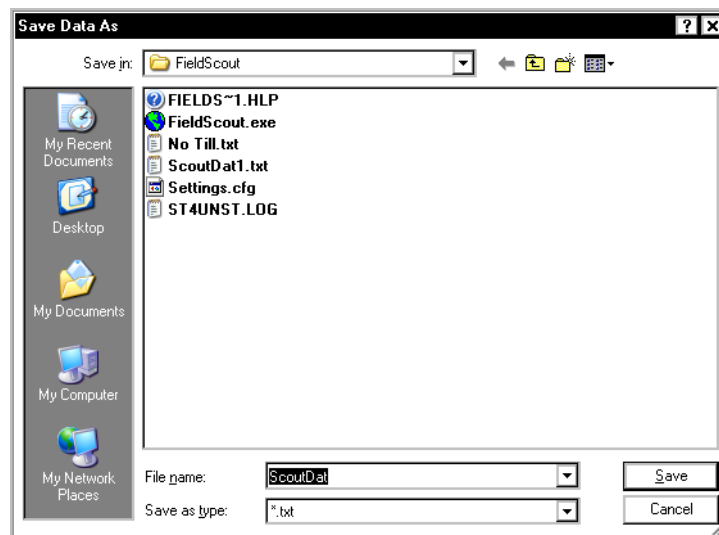
MAIN TOOLBAR
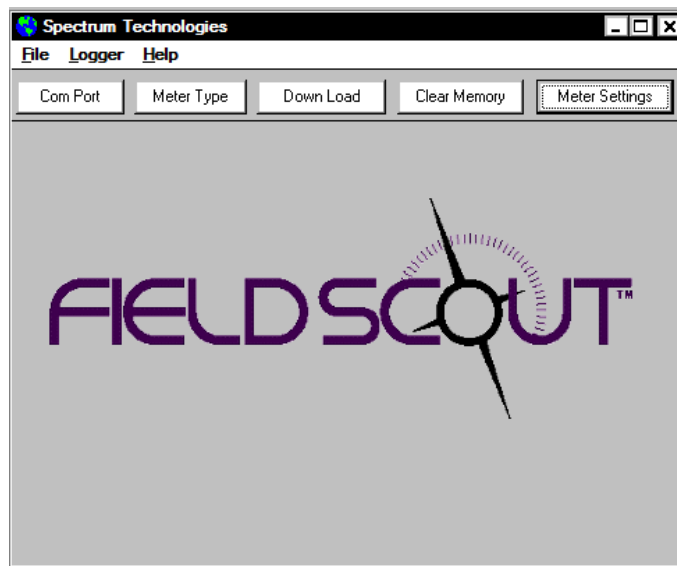
Com Port

The black software cable connects the meter to the computer data port. Select the Com Port that is assigned to the computer data port. See **Identifying the Correct Com Port** (p. 11) for instructions on how to determine which port to select.
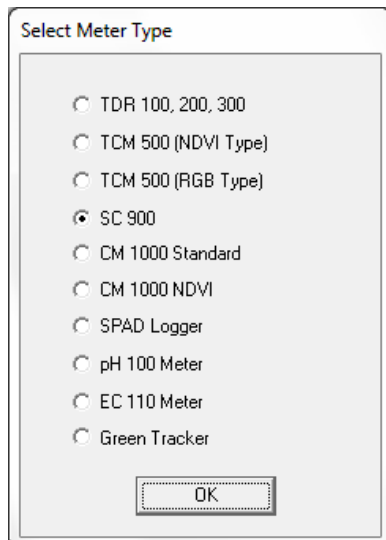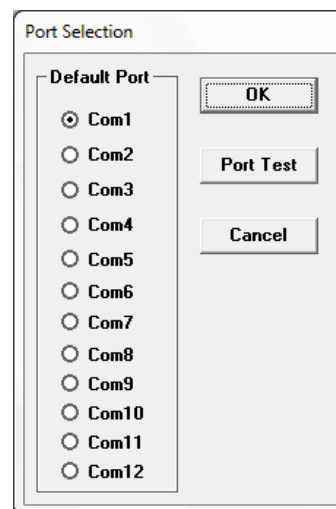
Meter Type

Select the SC900 option from the list of available Field Scout meters.

Download

To download data from the internal data logger, turn the meter off and connect the black serial cable to the RS-232 port on the underside of the meter. Click the **Download** button on the main software screen. In the **Save Data As** screen, give the file a descriptive name and select the location where it will be saved.

When the file has been saved, the software will give you the option of immediately viewing the file. The data file is stored as a comma-delimited text file and may be viewed in text editor or spreadsheet software.

Clear Memory

Data is not automatically removed from the logger memory after a download. The **Clear Memory** button clears all data from the logger memory.

Meter Settings

Click this button to configure the meter and data logger. Refer to **Meter Settings** (p. 16) for more details.

Meter Settings

Meter Settings

Meter Info.

Serial #: 637   Model #: SC 900   Firmware Version: 8.2

Meter Name: |Test|

(Max Length = 32 Characters)

Logger Settings

☑ Enable Meter's Logging Function (Must Be Checked to Log Data)

☐ Set Meter to Record Only GPS Readings with Differential Correction

|5| Enter Time Zone Correction Number (i.e. 5 for USA Central Time Zone)

Measurement Units

☑ PSI/Inches   ☐ KPa/cm

[Save]   [Cancel]

The Meter Settings screen in the Field Scout Soil Compaction Meter software is used to configure the meter and datalogger for your specific application. This screen can be accessed by clicking on the **Meter Settings** button on the main toolbar screen (see p. 14). The fields are described below.

Meter Name: The name given the meter will be the title on the first line of the downloaded text file.

Logger Settings: The datalogger is enabled and disabled by checking the first box. If the datalogger is enabled, it will search for a GPS signal when the meter is turned on. If a signal is found, position data will be stored along with the soil compaction data. If no GPS signal is available when the logger is turned on, the logger will no longer look for one when measuring and recording soil moisture data. If the second box is

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checked, the logger will store the GPS value **only** if it has been differentially corrected. If the differential correction is not found, only the soil compaction values will be stored in the data file. In general, it is recommended to leave this option unchecked. A time-zone correction should be entered in the third box. **Appendix 1** (p. 23) lists time zone corrections for several cities.

Measurement Units: The meter can be configured to display and record data in English units (Cone Index in PSI and depth in inches) or SI units (Cone Index in kPa and depth in centimeters).

DIAGNOSTIC MESSAGES

If the meter is unable to successfully measure a soil compaction profile, it will display one of the following warning messages and no data will be sent to the data-logger. In these instances, it may be necessary to withdraw the probe from the soil (if necessary) and hit the **START** button to continue using the meter (see **Measurement Procedure** p. 8).

Warning Messages

```
   Start Over
Start Depth > zero!
```

The meter cannot begin taking readings until the probe senses the tip is at the soil surface. The meter can sense a false non-zero depth if the user's feet are too close to the shaft, if an object such as a tree or large plant is near the measurement area or if debris such as roots, soil or leaf matter is clinging to the shaft.

```
 !Error-Too Fast!
 Hit RVW to Save
```

If the meter is inserted faster than 1 inch per 1 second, the ASABE standard states that the reading should be retaken. You may see this message more often when taking readings in areas with non-compacted zones beneath strongly compacted zones. You have the option of saving this profile anyway by pressing the **Review** button. This will bring up the Reading Complete screen (see p. 9). When reviewing the profile, you'll see a Profile Information Screen with an error message on the lower line.

```
 0010 PSI 00 IN
 !Error-Too Fast!
```

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```
!! Depth Error !!
 Hit RVW to Save
```

This error message indicates that the meter missed a depth reading. This can be caused by a momentary, but rapid, insertion of the probe into the soil or by an object such as a foot or a knee suddenly coming into the field of view of the sonic depth sensor. You have the option of saving this profile anyway by pressing the **Review** button. This will bring up the Reading Complete screen (see p. 9). When reviewing the profile, you'll see a Profile Information Screen with an error message on the lower line. Data records saved after a depth error was detected will have cone indexes of 0 PSI at all missed depths

```
 0010 PSI 00 IN
!! Depth Error !!
```

```
   Start Over
Excessive Force
```

The maximum load the load cell can withstand is 250 lbs (113 kg). Exceeding this limit can cause permanent damage to the meter. The "Excessive Force" warning message appears when 210 lbs (95 kg) or more is applied to the load cell.

```
  Low Battery
```

Indicates the batteries need to be changed. The battery compartment is located beneath the face of the meter.

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DATA MANAGEMENT

	A	B	C	D	E	F	V	W
1	Name: Spectrum							
2	Serial #: 282							
3	Datum: WGS 84							
4	Soil Compation In PSI							
5	Longitude	Latitude	Number	0 in.	1 in.	2 in.	18 in.	Cone Size
6			Logger Started					
7			N=1	148	224	188	0	1/2 Inch
8			N=2	10	10	153	0	1/2 Inch
9			N=3	107	168	193	0	1/2 Inch
10			Logger Started: 11:47:05					
11	-117.157	32.70801	N=1	168	87	132	0	1/2 Inch
12	-117.157	32.70803	N=2	132	148	183	0	1/2 Inch
13	-117.157	32.70803	N=3	173	168	153	0	1/2 Inch
14								

MTH0415

Sample data showing results of data collected with and without GPS activated. Note: GPS signal not found when recording first three sample numbers.

The data is stored in comma-delimited text files. These files can be opened with text-editing software (e.g. Microsoft Word) or spreadsheet software (e.g. Excel).

The first two lines of the data file give the logger's name and serial number. The third line indicates that latitude and longitude are referenced to the 1984 World Geodetic Survey datum. The fourth line shows the cone index unit system. The fifth line shows the column headings for the rest of the data file. Each row of data represents a measurement profile.

Logging sessions are started and completed by turning the meter on and off. The start of a logging session is indicated by the data line "Logger Started". If a GPS signal was found at the start of a logger session a time stamp is included on the "Logger Started" line.

Note: You must have meter firmware v. 8.2 or greater and Field Scout software v. 4.8 or greater to generate the cone size column.

Meter dimensions

The following are the dimensions of the SC 900 Soil Compaction Meter.

12"

Meter

7.25"

8.5"

19.75"

Shaft
Connection

Cone Tip
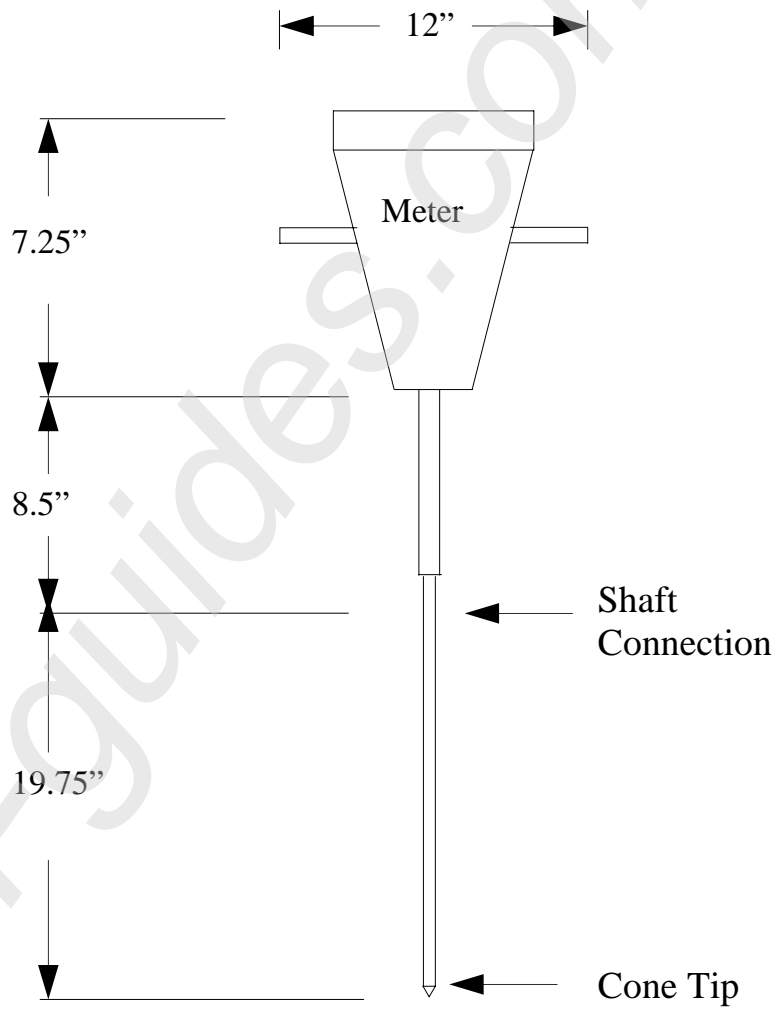
Specifications

Measurement Units	Cone Index (PSI or kPa)
Resolution	1" (2.5 cm), 5 PSI (35 kPa)
Accuracy	±0.5" (±1.25 cm), ±15 PSI (±103 kPa)
Range	0 - 18" (0 - 45 cm), 0 - 1000PSI (0 - 7000 kPa)
Maximum Insertion Speed *	72 in/min (182 cm/min)
Maximum Applied Load *	210 lbs
Power	4 AAA alkaline batteries Approximately 12 month life
Logger Capacity	772 profiles without GPS, 579 profiles with GPS/DGPS
Display	16 character, 2 line LCD
Weight	2.75 lbs. (1.25 kg)
Cone Size Diameters	1/2", 3/4" (must have firmware v. 8.1 or greater)

Appendix 1
Time zone corrections

Time Zone Correction	City
0	Dublin, Lisbon, London
3	Rio de Janeiro, Montevideo
4	Asuncion
5	Atlanta, Indianapolis, New York, Ottawa, Bogota, Montreal, Toronto
6	Guatemala City, Houston, New Orleans, Chicago, Mexico City, Winnipeg
7	Phoenix, Denver, Edmonton
8	San Francisco, Los Angeles, Vancouver
9	Anchorage
10	Honolulu
11	Wellington
13	Adelaide, Melbourne, Sydney
14	Vladivostok, Brisbane
15	Seoul, Tokyo
16	Beijing, Hong Kong, Manila, Singapore, Taipei
17	Hanoi, Jakarta, Vientiane
18	Calcutta, New Delhi
19	Kabul, Islamabad
20	Tehran, Abu Dhabi, Dubai
21	Moscow, Nairobi, Kampala, Riyadh
22	Ankara, Athens, Helsinki, Istanbul, Cairo, Johannesburg, Harare
23	Amsterdam, Barcelona, Berlin, Geneva, Paris, Prague, Rome, Brussels, Madrid, Stockholm, Warsaw, Lagos

Appendix 2
Determining when to replace the cone

Repeated soil sampling will wear down the metal cone, especially in coarse or sandy soils. It is recommended that the diameter of the cone be checked periodically to confirm that it is within the ASABE spec.

The determination as to when to replace the cone will depend on how the user is applying the meter.

When you are doing **comparative** analysis of the readings in a field or a plot, the measurements will be consecutive. The amount of wear of the cone will not be a factor. In this case, it is recommended that the cone be replaced when the shoulder is not easily recognizable as a shoulder anymore.

If you are using the meter to get **absolute** compaction readings, replace the cone when there is a "wear factor" of 3%. Three percent wear affects the cone index measurements by 5%. The minimum cone diameters (in inches) are shown in table 1.

Cone size	Cone Diameter (new)	Cone Diameter (3% wear)
1/2 inch	0.505	0.490
3/4 inch	0.798	0.774

Table 1: Minimum cone diameters

The cone diameter can be checked with the depth target or with a dial caliper or monitor.

Depth Target

The current versions of the depth targets (item# 6110FST) contain punched holes that are cut to the minimum cone diameter for each cone size. To check the cone diameter, place the meter on the ground, upside down, and try to slide the appropriate-sized wear guide hole over the cone. If the cone will fit through the hole, it should be replaced.

Dial Caliper/Micrometer

Measure the diameter of the cone using a dial caliper or micrometer that allows you 0.001-inch measurements.

Place the caliper/micrometer on the shoulder of the cone. Figure 1 the layout of the shoulder. Figure 2 illustrates the proper placement of the caliper. Cones should be re-placed when the diameters are less than those indicated in table 1.
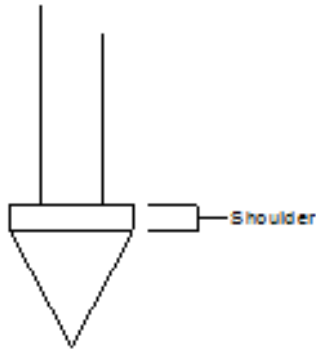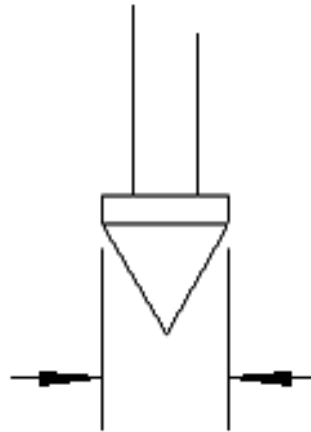
Figure 1   Figure 2

Cone Replacement

Replace the cone as follows:
1. Lay meter on its side
2. Unscrew worn cone by hand or with a pair of pliers
3. Attach new cone into meter shaft
4. Tighten to a snug fit with hands or pliers. Be careful not to imprint the cone with pliers.

Replacement cones can be ordered from Spectrum Technologies or an authorized Spectrum Dealer.

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