Using your CPN503 neutron probe
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This document briefly discusses the following topics:

1. Calibrating the CPN503DR
2. Setting up a reference calibration drum
3. Re-calibrating on the reference drum
4. Setting up cable stops
5. Clearing the memory and setting the number of depths
6. Logging data
7. Downloading data
8. Trouble shooting

Pictured below is the face plate of the CPN 503DR

1. CALIBRATING YOUR CPN 503DR NEUTRON PROBE

In simple terms, a neutron moisture probe measures water by bouncing neutrons off Hydrogen molecules and counting the number of hits (say 5,000). The number of hits is directly related to the water content of the soil in which the probe is. Thus 5000 indicates wetter than 4000. These are just numbers and need to be equated or calibrated to the actual moisture content of the soil, in a unit that we can use in irrigation planning, such as Mm/m, Inch/foot or %Volume.

A count of 5,000 from an instrument does not mean the same thing as a 5,000 count from another instrument. This is because each neutron probe has its own reference of how many neutrons it emits per unit time, called the internal Standard Count (say 10,000). To put these counts on the same scale we therefore work with the Count Ratio. In this example the Count Ratio=0.5 (5,000/10,000). It is this variable count ratio that we will equate with actual moisture content of the soil. To do this we need to determine the actual water content of the soil at the time and depth where the reading is taken.

The water holding capacity of soils varies a lot. Generally speaking, the finer the grains, the higher the water holding capacity will be. Your 503DR will in fact not respond the same across all soil types. For practical reasons we suggest you do not create more calibrations than is required for practical purposes. On most ranches a single calibration will do.
The diagram below displays a typical relationship between the (Silt+clay) content of soils and the Moisture holding capacity. We suggest the following calibrations:

Calibration 1: for 125 mm/m (1.5 Inch/ft) and under.
Calibration 2: for 125 – 300 mm/m (1.5 – 3.5 Inch/ft).
Calibration 3: for 300+ mm/m (above 3.5 Inch/ft)

Before we do any calibration, we want to be sure that the internal standard count is ok.

1.1 Getting a new Standard Count

Set the instrument on it's case with the probe in the safe position.
Press the STD button. It will display “S 9999” or some other value, being the currently stored standard count (9 could be any figure)
Press ENTER. On the new Tank head it will enter an edit mode. Do not make any changes.
Press ENTER again. It will display “P 9999” being the previous standard count.
Press ENTER again. It will display “CHI 0.99” indicating the accuracy of the std count. An acceptable value is between .95 – 1.05.
Press ENTER again. It will prompt “NEW STD?”
Press ENTER again. At his point the instrument will start a series of counts taking several minutes. At the end you will be prompted to save the new count, press ENTER again.

1.2 Determining actual moisture content.

First we will determine the actual water content by **gravimetric means**.

You will need the following to do this:
- Your 503DR neutron probe
- An access tube of the type you will be using
- A short piece of thin walled tubing (50mm length of 50mm diameter tube will do. Or 2 inch length of a 2 inch diameter aluminum tube) – our soil sample tube.
- An scale accurate to 1 gram or better.
- A pan or similar container that can be heated to dry the soil
- A spade
- A soil auger or tube to hammer in

Go to a site on your ranch where you have typical soil that you will be working with. You need an area with wet soil and another with dry soil. Follow the procedure below for both the wet and the dry spot.

Dig down to 30cm (12 inches).

Take the short soil sample tube and drive it into the undisturbed soil at 30cm until it is completely filled. Now dig it out and level off both ends. Fill any cavities that develop.

Weigh the pan and make a note of the weight (P)

Empty the wet soil sample into the pan. Weigh the pan+wet soil and make a note (PW)

Dry the soil in a micro wave oven or over a propane burner until dry.

Weigh the pan+dry soil and make a note (PD)

\[
\text{%Water (by weight)} = \frac{\text{soil weight loss}}{\text{dry soil weight}} = \frac{\text{PW} - \text{PD}}{\text{PD} - \text{P}}
\]

We will however not be using %weight and must convert to mm/m (mm of water per meter of soil) or inch/foot (inches of water per foot of soil). To do this we need the relative density of the soil (mass/volume). Calculate the inner volume of your soil sample tube in cubic centimeter. The RD = (dry soil weight)/cc

All of the above is very simple if you are using the **Probe Schedule** software because there is a built in calculator that does all the above for you. You just punch in the weights!

Repeat the above for a site with dry soil. If you do not have any dry soil available we will suggest a shortcut later.

**Install an access tube** in the wet soil 60cm (2ft) away from your excavation by auguring a tight fit hole down to 40cm (18”) and inserting the tube all the way down.

**Set your probe units to ratio** as follows:
- Press the UNITS button.
- Now press STEP repeatedly until “rat” appears and then press ENTER.

**Set your count time to 60 seconds** as follows:
- Press TIME
- Now press STEP repeatedly until 64 is displayed (old head) and press ENTER.
- On the new TDR head you can simply punch in 60 en press ENTER

Lower your probe down the access tube to just off the bottom and take a reading.

Make a note of the count ratio that is displayed.

Repeat this in the dry soil.

Set the probe unit back to what you will be using, either “ipf” for Inch per foot or “gcc” for Mm/meter.

We now have 2 count ratios and the corresponding moisture contents and can construct the **calibration line**.
On the 503DR, in this range, the calibration is a straight line of the form:

\[
WATER = A \times RATIO + B
\]

Where \( A \) is the slope of the line and \( B \) is the intercept. In the Excel regression below \( A=3 \) and \( B=-0.5 \) (in real terms -0.5 is too small a number)

Let’s assume we got the following figures:
Wet soil moisture content = 200 mm/m (2.5 Inch/ft) and Ratio=1.00
Dry soil moisture content = 125 mm/m (1.5 Inch/ft) and Ratio=0.50

You can put these values into your spreadsheet and do a regression. The output will be similar to the diagram below.

If you do not have a computer at hand you could get it right by trial-and-error working between the two tubes.

**TIP:** A quick way of getting an acceptable result is to analyze only a wet soil as described above. Now set the \( B \) value to -0.1 (for Inch and -10 for mm) and then alter the \( A \) value until the wet soil reading on your neutron probe is right.

**2. SETTING UP A REFERENCE CALIBRATION DRUM**
The reference drum is simply a large container of wet soil that does not change, where the instrument can be checked to see if it is still on the same scale or to bring it back to where it should be.

Take a 44 gallon (200 liter) drum and fill with sand or sandy soil. Any drum will do (steel, plastic or a trash can from Wal-Mart). A trash can with lid is a good idea because it slows the evaporation. Lightly compact the soil as it is filled. Take an access tube and seal the bottom (preferably with an internal plug). Auger a tight fit hole down to 1/3 from the bottom and insert your tube. Fill the container with water until it ponds on top. Seeing the pond on top at all times indicates that the soil is saturated and will give the same probe reading.

(By the way, we use saturated sand because this gives a reading in the range where we will be using the probe (2.8" or 230 mm) and the calibration of the probe is linear in this zone. It is wrong to use a drum of pure water because the relationship is no longer linear approaching pure water and different neutron probes often respond differently in this zone. This means that two neutron probes calibrated in water will give different readings when used in the same access tube).

Lower your calibrated probe down to the bottom and take a 60 second reading. Write the reading you get on the container. This is your reference value. It does not matter what the reading is, it is simply a fixed value against which the instrument can be checked on a regular basis.

Check your instrument on this drum on at least a weekly basis. If the value is not within 95% of the indicated value, you need to re-calibrate.

If the water does not show on top, add water before taking a reading.

3. RE-CALIBRATING ON THE REFERENCE DRUM
You only have to re-calibrate if the reading in the drum changes by more than 5% of the reference value.

Lower the probe to the bottom
Press CALIB on the probe keypad
Press ENTER twice. The UNIT will be displayed. Verify that this is correct.
Press ENTER until A 9.999 is displayed. This is the value you want to alter.
If your probe was reading too high, make this value smaller and test again.
If your probe was reading too low, make this value bigger.
Press ENTER again. B -0.010 should be displayed (-10.000 for mm/m).
Press ENTER again. It will prompt “DATA OK?”
Press ENTER again to save.

Take another reading to verify that the probe now gives the right value. If not, repeat the process above.

4. SETTING UP CABLE STOPS

The cable stops tied to the probe cable determine at what depth the probe is hanging when a reading is taken. If you are using the Probe Schedule program, simply go to the wizard that tells you where to put the stops.

The position of the first stop is influenced by the height of the tube above the ground and the additional height due to the recess in the bottom insert.

In the USA probe readings are usually taken every six inches from 6” to 36”. It is obvious that the cable stops will be 6” apart. The placement of the first stop is important.

Refer to the diagram below the meaning of tube height and recess. Measurements below are from the top of the lock plate to the bottom of the first stop.

<table>
<thead>
<tr>
<th>Height of tube above ground</th>
<th>2”</th>
<th>3”</th>
<th>4”</th>
<th>5”</th>
<th>6”</th>
<th>3”</th>
<th>4”</th>
<th>5”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recess</td>
<td>1”</td>
<td>1”</td>
<td>1”</td>
<td>1”</td>
<td>1”</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Distance to first stop</td>
<td>12”</td>
<td>13”</td>
<td>14”</td>
<td>15”</td>
<td>16”</td>
<td>12”</td>
<td>13”</td>
<td>14”</td>
</tr>
</tbody>
</table>

In inches, the formula is:

\[\text{Distance to first stop} = 9" + \text{Tube height} + \text{Recess height}\]

In metric (all in cm) the formula is:

\[\text{Distance to first stop} = 28\text{cm} + \text{Tube height} + \text{Recess height}\]
5. CLEARING THE MEMORY AND SETTING NUMBER OF DEPTHS

Before logging new data you probably want to erase any old data in memory.

Press FMT, the display changes to REC xxx. (on older DR head)
Press ENTER, the display changes KDATA (DR head) or KEYS (TDR head).
Type 0 and press ENTER if any other number is displayed.
Some models will display Dxxxxxxxxx. If so, press Enter again.
Press ENTER, the display changes to DPTHS 9.
If you are reading 6 depths, type 6 or 8 for 8 depths etc.
Press ENTER, the display changes to SET FMT?
Press ENTER. The old data in memory is now cleared.
The display changes to REC 999 indicating the number or records it can store.
Press CLEAR.

6. LOGGING PROBE READINGS

For routine probe readings the count time is usually set at 4 seconds. You should however test your instrument and decide at what count the variance is acceptable.

To take readings and log the data, put the instrument on an access tube and lower down to the last cable stop. Take care not to drop the probe in this process. Ensure that you always have one hand on the cable. Taking readings from the bottom up makes it easy to work through the latch with one hand.

Press LOG, the display changes to ID 592 (remaining memory).
Type the tube ID (eg. 12001) and press ENTER.
The display changes to **TAKE 7** (if you set it up to log 7 depths). Press **START** to take the reading. On older heads, the display changes to **COUNT 7**. On the TDR head it will display **BAT 99%** and then a countdown. When done it will display the moisture content at that depth **7M 999.999**. This is the moisture at depth 7. Press **ENTER** to store the reading. The display changes to **TAKE 6**.

**Raise the probe to the next cable stop.**

Press **START** to count depth 6. Repeat the **START-ENTER-RAISE** cycle until all are done. After the last reading, some instruments display **TM xxx** (total moisture). Press **ENTER**, display changes to **DATA OK?** Press **ENTER** to store all the probe readings for that site.

Move to the next tube and repeat the process.

### 7. Download Probe Readings

#### 7.1 Set up probe to download probe readings

Press **MENU**, display changes to **BAUDRATE**. Press **ENTER**, display changes to **BDR 1200**. Press **STEP** repeatedly until **9600** is displayed. Press **ENTER**, display changes to **BAUDRATE**. Press **CLEAR**, display changes to **READY**.

#### 7.2. Download probe readings

Connect a comm. port of your PC to the neutron probe RS232 port with download cable. Note that the small red dot must be facing up. Ensure that the cable is in all the way. (When removing the cable later, take it by the serrated section and pull. This will release the catch. Never pull the cable).

In the **Probe Schedule** program, activate the download module as indicated below.

<table>
<thead>
<tr>
<th>Daily</th>
<th>Data</th>
<th>Reports</th>
<th>Graphs</th>
<th>Setup</th>
<th>Utilities</th>
<th>Probe</th>
<th>Preferences</th>
<th>Projects</th>
<th>Maps</th>
<th>Help</th>
<th>Exit</th>
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- Down load probe readings and adjust moisture balance
- Delete all probe readings on a specific day
- View POST .DAT ascii file
- View original probe readings
- Convert neutron probe counts to moisture (mm)
- Convert probe readings to another calibration
- Set cable stops for CPN-50/3DR

If you are doing this for the first time, you need to set the **baud rate** and **comm. port**. Select the **Config** button and set **Comm. Port** to 2 and **Baud Rate** to 9600. (See figure below).

On the new **TDR** head, wake the instrument up by pressing **CLEAR**. On older heads, the program should wake the probe up and start the download. If the probe does not respond, press **PRINT**. The display changes to **PRINT CD**.

On the PC you should still be in the download module.
Click on **Data** and then **Start the Download**.
With a bit of luck the data will start flowing.
If nothing happens, press **ENTER** on the probe.

If nothing happens, repeat the process using another comm port.

8. **TROUBLE SHOOTING**

8.1 **How do I know if I have a TDR head (the plate says 503DR Hydorprobe)**
They all say that.
One way to find out is to go to VERSION under MENU.
A quick way is to look at the bottom of the head. The TDR has a white RESET button while the DR has a charger jack in the same place.
Yet another way is to look and listen while it counts. The TDR displays BAT 99% indicating the status of the non-rechargeable Alkaline battery and after the count it has an annoyingly load piep-piep-piep.

8.2 **When I press CALIB I get “SET UNIT” or “BAD MUNT”**
You are stuck on Counts (CNT) or Ratio (RAT). You must set the unit to something like “ipf” or “gcc” before you can set a calibration.

8.3 **When I take a reading it takes forever to get it done.**
Your time is still set on 60 seconds. Press TIME. On the TDR type the seconds you want (eg 4). On older heads, press STEP until the desired count time is displayed.

8.4 **A tube does not go as deep as the others (so I have stops to spare)**
Lets assume you normally take 6 readings down to 36” but this site only goes down to 24” (4 readings). It is stop 6 and 5 that you do not have. Your FORMAT is set up do read 6 depths and it will prompt for 6 on this site as well. At that time you press ENTER without START (counting). Repeat for depth 5 and when it prompts for Depth 4, you press START and take you first reading at 24”. When down loading there will be zeros at 30” and 26”.
8.5 When taking a reading, I briefly get “BAT LOW” on the display.
You have an older type head with re-chargeable batteries and the battery is low.
A good battery will allow you to work the rest of the day but an old battery will die on
you any time soon. Put it on charge over night. A good battery should give you a week
of daily use on a full charge.

8.6 When I take a probe reading I get “CNT ZERO” or *.*
This means there is no communication between the surface electronics (head) and the
probe down the hole. Your probe cable is loose or broken. Tighten the cable and test.
If the problem still persists, unscrew both ends and test each line with a multi tester.
There should be good contact between A=A at each end of the cable, same with B=B,
C=C, D=D. There should not be any other links such as A=B.
The cable is a simple 4 core A to A assembly and can be fixed by yourself if the
instrument is not under warranty. First open the probe end. The problem is most often
at this end.

8.7 While taking readings in one place like the drum or in the wax, my readings
are all over the place, I get BIG variation.
Check that the cable is on tight (hand tight).
If the cable is on tight, there is a problem with the probe. It could be the head, the
probe cable or the subsurface electronics. You should let a technician look at it.

8.8 When I select a comm. Port and activate it, the program responds with
Unable to open Comm.
This means that the selected comm. port is not available on your computer. Select
another comm. port. On most PC’s it will be either Comm 1 or Comm 2.

8.9 I have tried all comm. ports and nothing happens.
There are several possibilities.
1. Is the cable plugged in ?
2. The comm. port on your computer could be faulty and needs replacing. If you can
activate the port and communicate with anything else, the port is OK.
3. Some other process might not have released the port. Try to re-boot your PC and try
the download again.
4. The down load cable could be faulty or the wrong kind. If you have a TDR head, you
need a new style cable. Ask your supplier to help with this issue.
5. Do you have a Motorola Irrigation Controller on this PC? If yes, the Motorola
takes over all the comm. ports. You will need to boot your PC without activating the
Motorola and then do the download. This is a nuisance. I suggest you do the download
on another PC and bring the download file here.

8.10 When I Start the download, there is a flickering but nothing happens.
The flickering means that there is communication. So the comm. port is correct but
there is another problem. Check these possibilities:
1. The baud rate is probably wrong. Check both the probe and the PC for identical
baud rate.
2. If you are using a RS323 to USB converter, that converter cable has it’s own
driver which must be correctly installed. It is not a plug-and-play device.
3. On some 503’s you need to go thru a specific sequence of event, namely: a)
activate the comm. Port, b) wake up the probe and press “PRINT” on the probe
keypad. c) now click “Start the download” in the PS program.