Engineering Note

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Title:	Default Calibration for HP02
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Summary:	A Default Calibration for Sands and Aggregates (<10 mm) is Described Fine sand also added.

Contents

I - Summary

- A default calibration curve valid for sands & aggregates less than 10mm is described (See Figure 1).
- A second calibration curve, which has been found to be useful for some very fine sands, is also provided.
- Use of the default curve should give standard errors ~ 0.5% up to 15% moisture for most materials without any calibration.
- Over a more normal operating range (e.g. 4% - 10%) improved standard errors may be achieved (~ 0.16% for the KDS example shown here)
- Use of a single calibration point may further improve standard errors (~ 0.13% in the KDS example)
- For ultimate accuracy a complete calibration is required and much improved standard errors may be obtained (e.g. 0.08% for the same KDS calibration set).
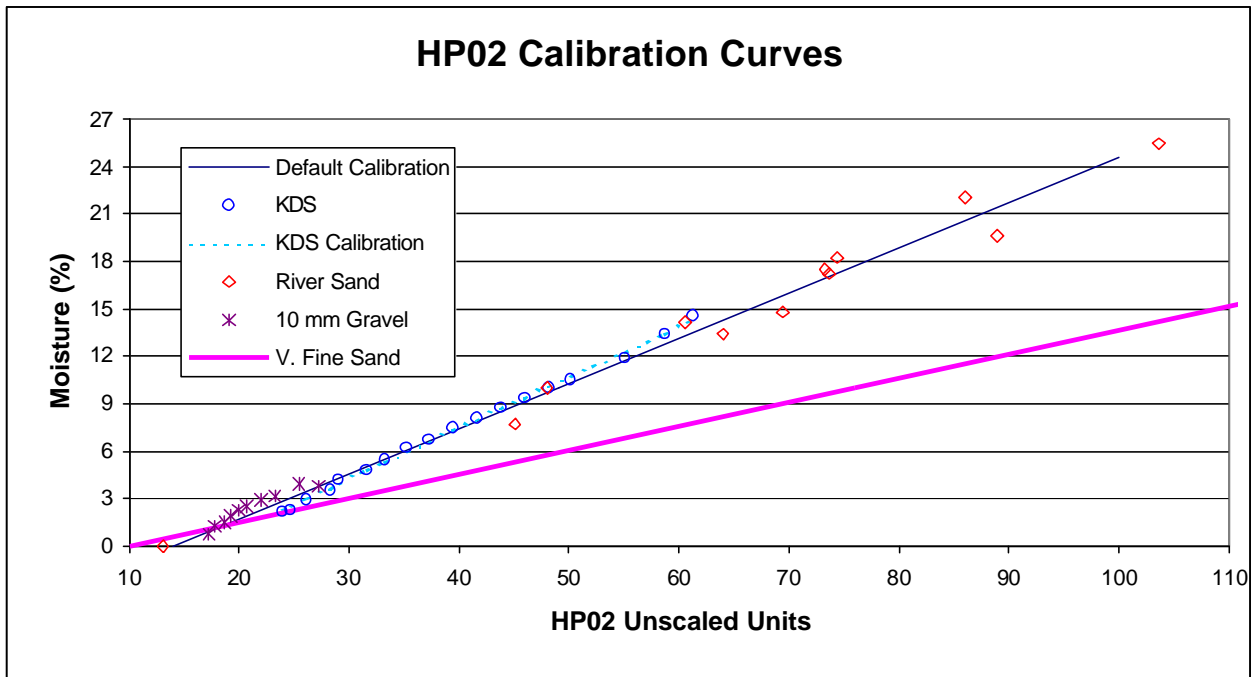
Figure 1 : Comparison of Default Curve with the Calibration Curves for Three Different Aggregates

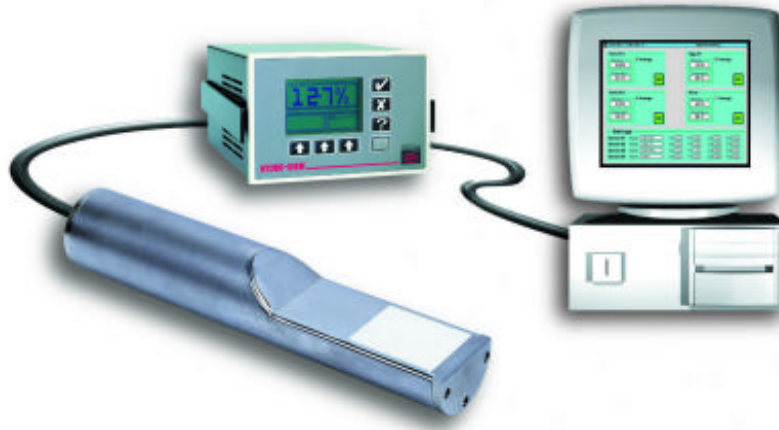## II - How To Use The Default Calibration

Hydronix sensors provide an analogue signal which is proportional to the sample moisture content. The signal may be converted from current (or voltage) units to moisture units either by the software within the sensor, or by the software in an external unit (e.g. Hydroview, PC or PLC).

Hydronix recommends that the conversion is done by the external unit because:

- This permits the use of a different calibration for each different material.
- It is usually quicker and easier to adjust calibrations in external units than to connect the sensor to a PC and use the Hydrolink configuration software to change the calibration
- If it is necessary to replace the sensor, a replacement Hydronix sensor can be connected and valid results obtained immediately without further calibration

To take advantage of this approach, the sensor needs to be set up in its factory default condition (analogue output set to 'unscaled'). If this is how the sensor is already set up, the calibration can be used as described below. If the HP02 is set up in some other configuration, see Section III for how to restore the default condition.

1. **I Want to connect my HP02 to a Hydroview (Sensor Configuration HP02C)**

The calibration needs to be entered into the Hydroview unit. To do this:

- Select the sensor calibration menu (You will need an access code for this).
- Select the material code that you want to use for the default calibration (e.g. 1)
- Select Unscaled i/p 1
- Change the value to 5.70
- Ensure that Moisture % 1 is set to 0.00 (the default Value for Material 1)
- Select Unscaled i/p 2
- Change the value to 26.22
- Ensure that Moisture % 2 is set to 11.00 (the default Value for Material 1)
- Accept these values – the values shown at the bottom of the screen should change to m=0.53 , c=-3.02.
- Press the tick (☑) to accept these values and write them into the sensor calibration table.

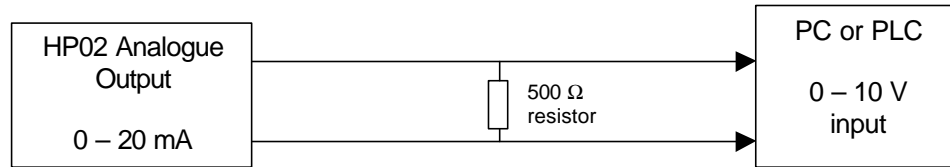2. **I Want to Use The 0-20mA Analogue Output on My HP02   (Sensor Configuration HP02T)**
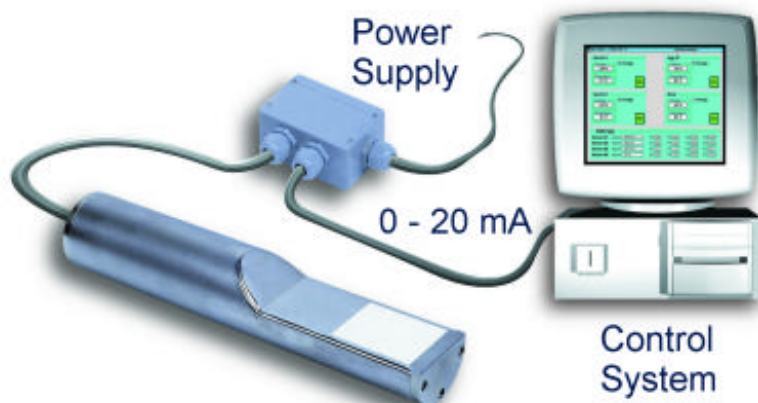
- 2.8 mA corresponds to 0% moisture
- 9.8 mA corresponds to 10 % moisture
- Other moistures can be determined by measuring the current and calculating the moisture according to the formula
- Moisture (%) = (current(in mA) – 2.8)/0.7

e.g. if current is 6.5 mA,   Moisture = (6.5-2.8)/0.7 = 3.7/0.7 = 5.29%

3. I Want To Use The 0-10 V Analogue Output on My HP02

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┌─────────────────┐                              ┌─────────────────┐
│ HP02 Analogue   │─────────────────────────────▶│   PC or PLC     │
│     Output      │         ▯ 500 Ω              │                 │
│                 │          resistor            │    0 – 10 V     │
│   0 – 20 mA     │─────────────────────────────▶│     input       │
└─────────────────┘                              └─────────────────┘
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- To do this make sure the analogue output of the HP02 is set to 0-20mA (see II.2 above) and then to put a 500Ω resistor in series with the signal. (See diagram)
- With this configuration:
- 1.4V corresponds to 0% moisture
- 4.9V corresponds to 10% moisture
- Other moistures can be determined by measuring the voltage and calculating the moisture according to the formula
- Moisture (%) = (Voltage – 1.4)/0.35

  e.g. if voltage is 4.5 V
  Moisture = (4.5-1.4)/0.35 = 3.1/0.35 = 8.86%

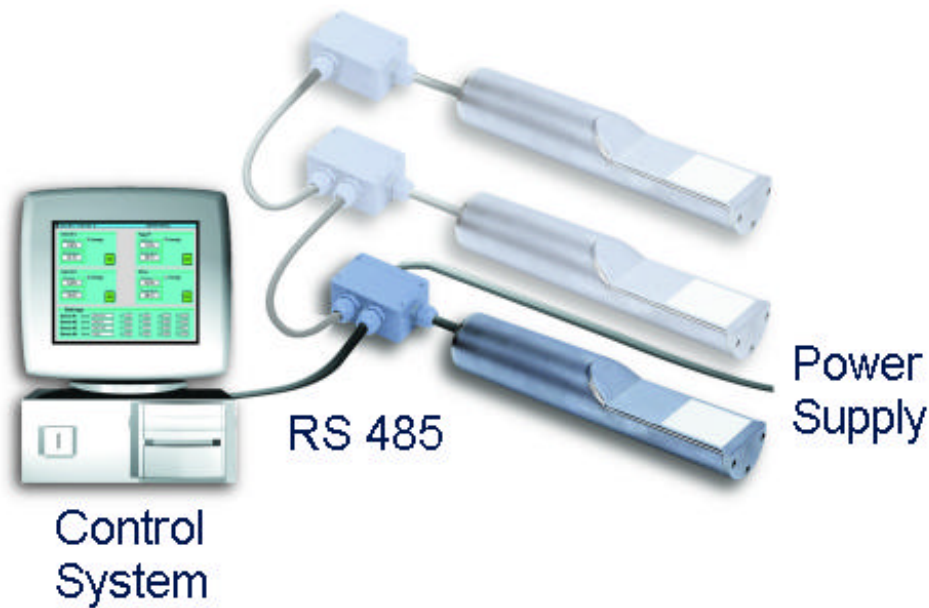### 4. I Want to Use The 4-20mA Analogue Output on My HP02
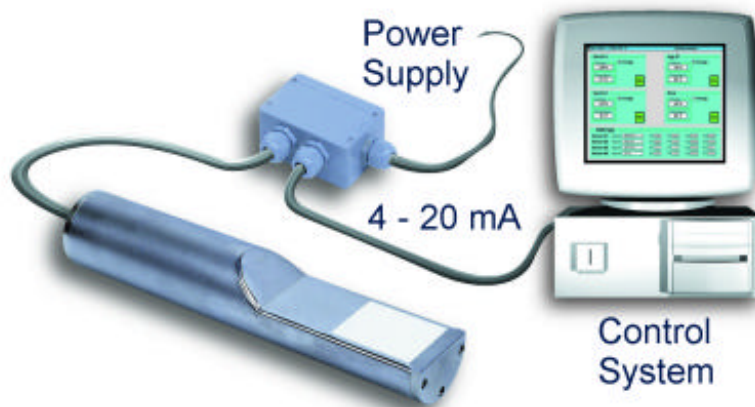
- 6.24 mA corresponds to 0% moisture
- 11.84 mA corresponds to 10 % moisture
- Other moistures can be determined by measuring the current and calculating the moisture according to the formula
- Moisture (%) = (current(in mA) – 6.24)/0.56

  e.g. if current is 10.0 mA
  Moisture = (10.0 - 6.24)/0.56 = 3.76/0.56 = 6.71%

5. I Want To Use The RS485 Direct Digital Communication on My HP02

- 14 unscaled units corresponds to 0% moisture
- 49 unscaled units corresponds to 10% moisture
- Other moistures can be determined by measuring the now unscaled value and calculating the moisture according to the formula
- Moisture (%) = (now unscaled − 14)/3.5

  e.g. if unscaled reading is 42.1
  Moisture = (42.1 − 14.0)/3.5 = 28.1/3.5 = 8.03%

6. I Want My HP02 To Give Me Readings Already Converted To Moisture

By default, the HP02 analogue output is set to give a 0-20mA output proportional to moisture. This permits precise scaling to true moisture values to be done in an external unit (See sections 1 – 5 above). However some users may not have external PC's or equipment capable of doing this scaling. In this case the signal can be scaled internally within the probe. This then permits a simple current loop meter to be connected to the analogue output and the loop meter display can be used to read the moisture units directly.

For example, suppose in normal use your moisture is never below 4% and never above 15%. You could configure the probe analogue output to produce 1 mA for each 1% moisture. If you then connected a mA meter onto the output, the number of mA displayed by the meter would be the same as the moisture measured by the probe.

However most loop panel meters give readings from "000.0" to "199.9", where 0 corresponds to 4 mA and 100 corresponds to 20 mA. In this case you would probably want to configure the probe output so that the meter reading would be the moisture value. To do this follow the procedure below:

- Connect the probe to a PC running the 'Hydrolink' configuration software and select the 'Configuration' tab. (See figure 2 below)

- Press the 'Read' button and ensure that in the User Calibration Box, the value shown for A is 0.2857 and B is – 4.000 as in Figure 2. If the reported values are different from these, you will need to install the Default calibration – See Section III – "How To Install or Restore The Default Calibration" below.

- Select the output type - say 4-20mA - as shown in Figure 2 below. *Note: You can't use the compatibility mode to get an output already converted to moisture*

- Select output variable to be 'Now Moisture %'

- In the box labelled 'Low %' enter the panel meter reading corresponding to 4 mA which in this example is 0.0

- In the 'High %' box enter the panel meter reading corresponding to 20 mA, which in this example is 100.0

- Press the 'Write' button at the bottom of the page to write these selections into the HP02's memory. After a couple of seconds a message informing you that the memory has been updated will appear. Click the OK button. The parameters shown in Figure 2 have now have now been permanently stored in the HP02 memory and you will not have to go through this procedure again unless you want to change the settings again later.

- From now on the meter output will display moisture in Percent.

- If your panel meter has a different range (e.g. –30.0 to 200.0) you will need to enter these values in the 'Low' and 'High' boxes.

III - How To Install or Restore The Default Calibration

All HP02 probes shipped by Hydronix after 1st August 2000 have the default calibration held in the probe's memory and if you communicate with the HP02 over an RS485 network, selection of any of the moisture variables will automatically use this calibration. If you want to get an analogue output from the HP02 which uses this calibration, you will need to set up the output, as described above in Section II – 'How to Implement the Default Calibration'.

If your probe was shipped before 1st August 2000 and you want to use this calibration:

- Connect the probe to a PC running the 'Hydrolink' configuration software
- Select the 'Configuration' tab.
- In the 'User Calibration' box at the top left of the screen, enter 0.2857 for B and - 4.000 for C.
- To set the system in factory default conditions enter 0-20mA for 'output type' and 'Now Unscaled' for output variable.
- Press the 'Write' button at the bottom of the page to write this calibration into the HP02's memory. After a couple of seconds a message informing you that the memory has been updated will appear.
- Click the OK button.

- The moisture values read out over an RS 485 network will now automatically use the default calibration.
- If you want to calibrate the analogue output with the default calibration you will need to set it up as described above in Section II – 'How to Implement the Default Calibration'
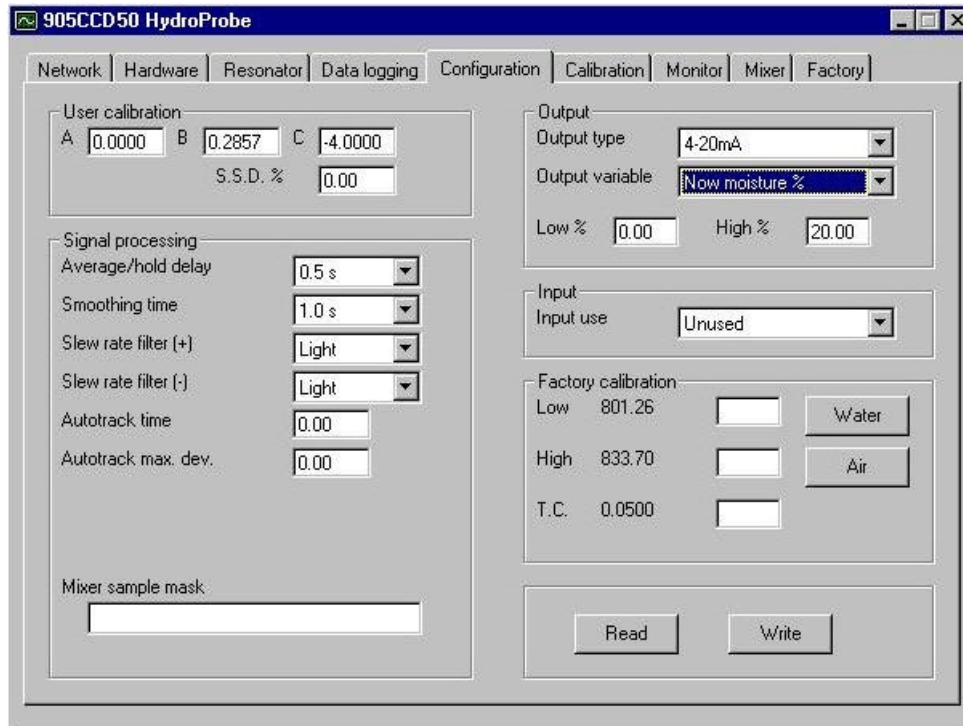

Figure 2: Installation of Default Calibration with Hydrolink Software

IV – How to Install & Use the Fine Calibration

Some customers have found that when measuring very fine materials (< 1mm) they achieve better results using the 'Fine' calibration line shown in Figure 1. This calibration is not stored as standard and must be written into the memory of the probe or Hydroview. The procedure is identical to that described above but the parameter values used are different. This section describes the values that should be used if the 'Fine' calibration is required.

1. **Use of Fine Calibration with Hydroview**

   - Use 3.57 for unscaled input 1.
   - Use Moisture % 1 as 0.00
   - Use 38.75 for unscaled input 2.
   - Use Moisture % 2 as 11.00
   - After accepting these values the screen should show m= 0.31 , c = -1.12
   - Press the tick (☑) to accept these values and write them into the sensor calibration table.

2. **Use of Fine Calibration with 0-20mA output (Sensor Configuration HP02T)**

   - 2.0 mA corresponds to 0% moisture
   - 15.2 mA corresponds to 10 % moisture
   - Other moistures can be determined by measuring the current and calculating the moisture according to the formula

- Moisture (%) = (current(in mA) – 2.0)/1.32

    e.g. if current is 6.5 mA,   Moisture = (6.5-2.0)/1.32 = 4.5/1.32 = 3.41%

3. Use of Fine Calibration with 0-10 V Analogue Output

- To do this make sure the analogue output of the HP02 is set to 0-20mA (see II.2 above) and then to put a 500Ω resistor in series with the signal. (See diagram)
- With this configuration:
- 1.0V corresponds to 0% moisture
- 7.6V corresponds to 10% moisture
- Other moistures can be determined by measuring the voltage and calculating the moisture according to the formula
- Moisture (%) = (Voltage – 1.0)/.66

    e.g. if voltage is 4.5 V
    Moisture = (4.5-1.0)/0.66 = 3.5/0.66 = 5.3%

4. Use of Fine Calibration with 4-20mA Analogue Output

- 5.6 mA corresponds to 0% moisture
- 16.16 mA corresponds to 10 % moisture
- Other moistures can be determined by measuring the current and calculating the moisture according to the formula
- Moisture (%) = (current(in mA) – 5.6)/1.056

    e.g. if current is 10.0 mA

    Moisture = (10.0 – 5.6)/1.056 = 4.4/1.056 = 4.17%

5. Use of Fine Calibration with RS485 Direct Digital Communication

- 10 unscaled units corresponds to 0% moisture
- 76 unscaled units corresponds to 10% moisture
- Other moistures can be determined by measuring the now unscaled value and calculating the moisture according to the formula
- Moisture (%) = (now unscaled – 10)/6.6

    e.g. if unscaled reading is 42.1
    Moisture = (42.1 – 10.0)/3.5 = 32.1/6.6 = 4.86%

6. Use of Fine Calibration with Output Already Converted to Moisture

- Connect the probe to a PC running the 'Hydrolink' configuration software
- Select the 'Configuration' tab.
- In the 'User Calibration' box at the top left of the screen, enter 0.1515 for B and – 1.5151 for C.
- To set the system in factory default conditions enter 0-20mA for 'output type' and 'Now Unscaled' for output variable.
- Press the 'Write' button at the bottom of the page to write this calibration into the HP02's memory. After a couple of seconds a message informing you that the memory has been updated will appear.
- Click the OK button.

- The moisture values read out over an RS 485 network will now automatically use the Fine calibration.

V - Technical Background

After suitable calibration, the Hydronix HP02 is able to measure the moisture content of sands and aggregates in silos to high accuracy (~ 0.2% moisture). However users may not have the facilities, the time or the operating conditions to perform a fully-fledged calibration during installation. For example under normal operating conditions, the moisture level in a sand silo may only vary a few tenths of a percent. This is too small a variation in moisture to permit a precise calibration and users may need to wait for a substantial change in the weather (or feedstock) to give the 2-3 % change in moisture required for a more precise calibration.

This note shows how users may obtain useful data immediately and without further calibration, by using the default calibration developed by Hydronix. This note also shows how the default calibration can be subsequently adapted to further improve the accuracy of results.

A default calibration for sands has been developed which gives a standard error of performance of ~ 0.5% or better with most sands and aggregates below 10mm. Figure 1 above shows that this default calibration closely approximates the fits for three different materials – a river sand, a fine builders sand (KDS) and a 10 mm gravel. The figure also shows that the calibration should be useful up to ~ 25 % Moisture (dry basis).

VI - Accuracy of the Default Calibration

When used with sands and gravels up to ~10 mm, the default calibration typically has a

HP02 Calibration Curves
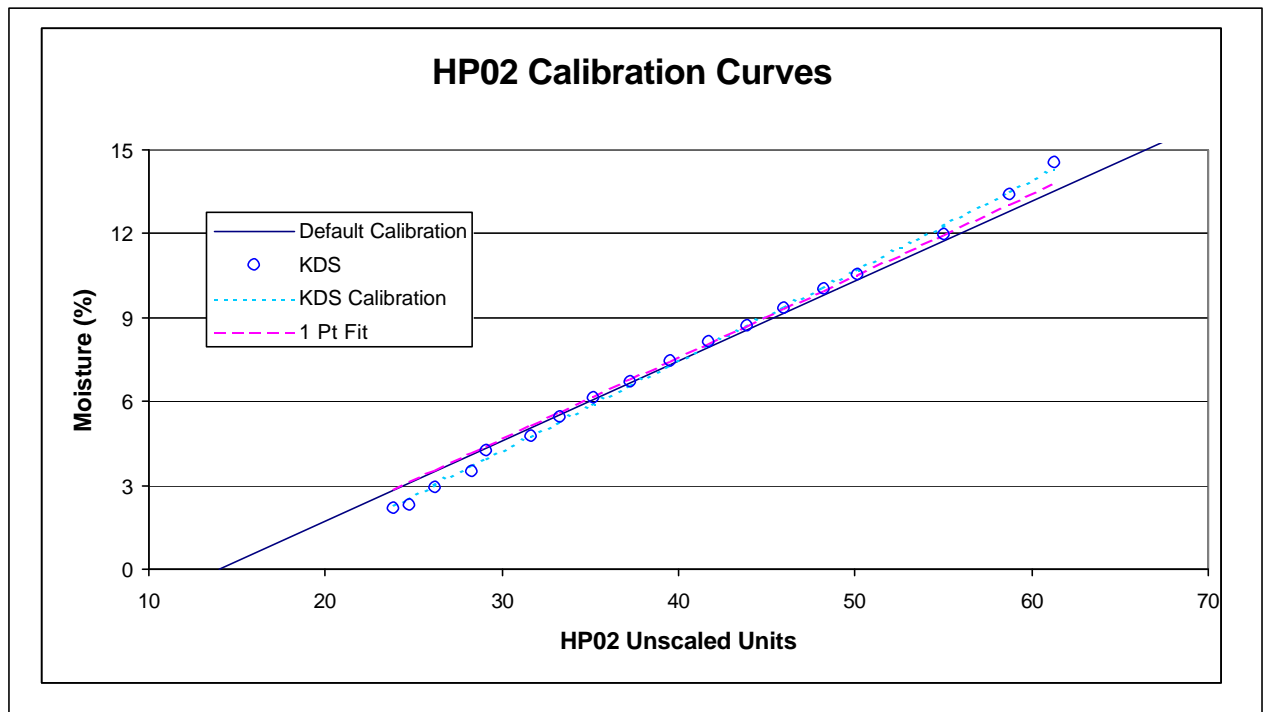
standard error of performance of < 0.5% moisture over the moisture range from 2 to 20%.

Standard Errors

Figure 3: KDS Data Only from Figure 1

As an example suppose the probe is installed in a silo using the KDS material shown in Figure 3. The standard error of performance for this data set over the moisture range 2% - 15% is 0.46%. However many users will not see material moisture swings over this large a range; a variation of say 4% to 10% is more typical. Over this more restricted range, the standard error of performance is improved to 0.16%. It should be noted that this accuracy is achieved on this data set without using any calibration points. It should also be noted that while other materials may have standard errors of performance which are better or worse than these figures, the numbers given here are believed to be illustrative for standard sands and aggregates up to 10 mm.

Improving the Accuracy by Using Calibration Points

The default calibration curve is a straight line based on Hydronix experience and development with a variety of fairly standard sands and aggregates. It is extremely unlikely that any real material will have a calibration curve which <u>exactly matches </u> the default calibration. While for some applications the default calibration may be good enough for use, accuracy can be improved by using calibration points.

To generate a full calibration curve requires at least two points which differ in moisture value by at least 2%. Under normal use an operator may have to wait days or weeks before the input material conditions change enough to give this large a change in moisture. In the interim, a useful improvement may be often be made by using a single calibration point collected by the user together with a single point from the default calibration curve.

Use of a Single Calibration Point

For example suppose that in normal operation the material moisture range swings from 5% to 9% moisture but that at installation time the moisture range is always close to 7.5% and that the user collects a calibration point with a moisture value of 7.44% and an unscaled reading of 39.52. (See the Hydroprobe manual, the Hydroview manual or the Hydronix Website for how to collect good calibration points). With the HP02 connected to a PC running Hydrolink, select the 'Calibration' tab. The default calibration is based on the following pair of default calibration points:

Unscaled input 1 = 14	Moisture 1 = 0.00%
Unscaled Input 2 = 49	Moisture 2 = 10.00%

(The values for the calibration in a Hydroview unit are different – see section II.1)

Examine the moisture value of your calibration point. If it is below 5% use your values for the first pair of readings in the calibration table and use 49 and 10.00 for the second pair of readings in the table. If the moisture is above 5% use 14 and 0.00 for the first pair of readings in the calibration table and use your values for the second pair of readings in the table.

In the example here, the moisture value is 7.44% so use 14 and 0.00 for the first calibration point and 39.52 (the measured unscaled reading) and 7.44 for the second point as shown in Fig. 4.
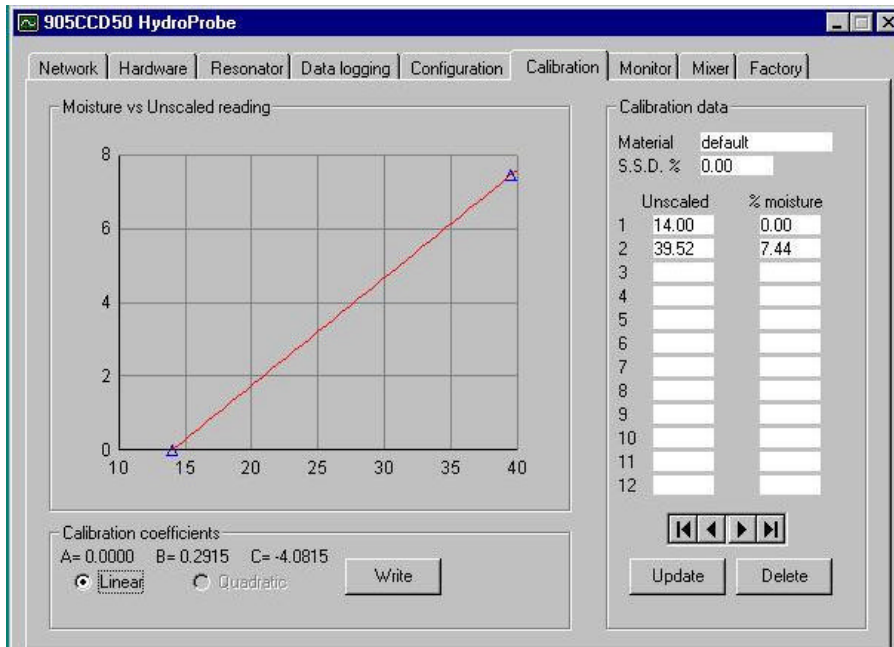
Figure 4: Hydrolink Calibration Tab.

If you press the 'Write' button in the lower centre of the screen, after a couple of seconds a box will appear telling you that the values have been written into the probe memory. Press 'OK' and the single point calibration is done.

Again as an example, if the upper default calibration point is replaced with the measured calibration point as described above, the 1 pt calibration line, shown dashed in Figure 3, will be obtained. With this revised calibration, the standard error for the KDS data set over the range of 4% to 10% improves slightly to 0.13% (compared to 0.16% using the default calibration with no calibration points).

Single Point Calibration with Hydroview

A similar procedure applies when using the Hydroview except that the default settings are different. The values for the Hydroview are:

Unscaled input 1 = 5.70   Moisture 1 = 0.0%
Unscaled Input 2 = 26.22   Moisture 2 = 11.0%

In the sensor calibration page, replace the first pair of readings if the calibration moisture value is below 5.5%, or replace the second pair of readings if the value is above 5.5%

Complete Material Calibration

To obtain the very best accuracy from the HP02 a calibration using two or more calibration points is required. To get a good calibration, the range of moistures covered should be at least 2% and generally speaking the wider the range of moistures covered in the calibration set, the better the calibration will be. For example in Figure 3, the data between 4% & 10% moisture was used to generate the dotted KDS calibration line. Use of this calibration line gave a standard error of 0.08%.