AK30 / AK40GW / MK30R

PORTABLE MOISTURE METERS

APPLIES ALSO FOR

AK50

ON-LINE MOISTURE METERS

USER'S GUIDE FOR CALIBRATIONS

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1. Introduction

As a user of **AK30/40/50/MK30R** moisture meter you already have found out that the calibration library contains ready-to run calibrations for the grades or materials ordered. Sometimes it may happen that new grades appear and their calibration is required.

New calibrations can be added in several ways:

- samples sent to manufacturer to be calibrated at a fee (meter needs to be sent too)
- Flash calibration in AK30/40/MK30R products (see the User's Guide for details) allowing a rapid calibration in a few seconds with the knowledge of the basis weight (BW g/m2)
- in AK50 there is a Composer expert system both inside the meter and in the Advanced PC program for generating a new calibration. The internal Composer can be used with a standard terminal program.
- field calibration with the meter having at least two samples with different known moistures
- accurate calibration in a climate chamber

In the following we concentrate on the most accurate calibrations made with the climate chamber which is used always while performing the basic calibrations before delivery. For all the other options, one may refer to each User's Guide for more information on how to use those features. The discussion applies to AK30/40/MK30R products but can be applied as such to the AK50 series as well.

Before attempting to make a high-accuracy calibration with the meter, please learn thoroughly how to use the meter and read the manuals attached. This is a short course on how, what, when and with which accessories the calibration is completed successfully.

2. Basic Information

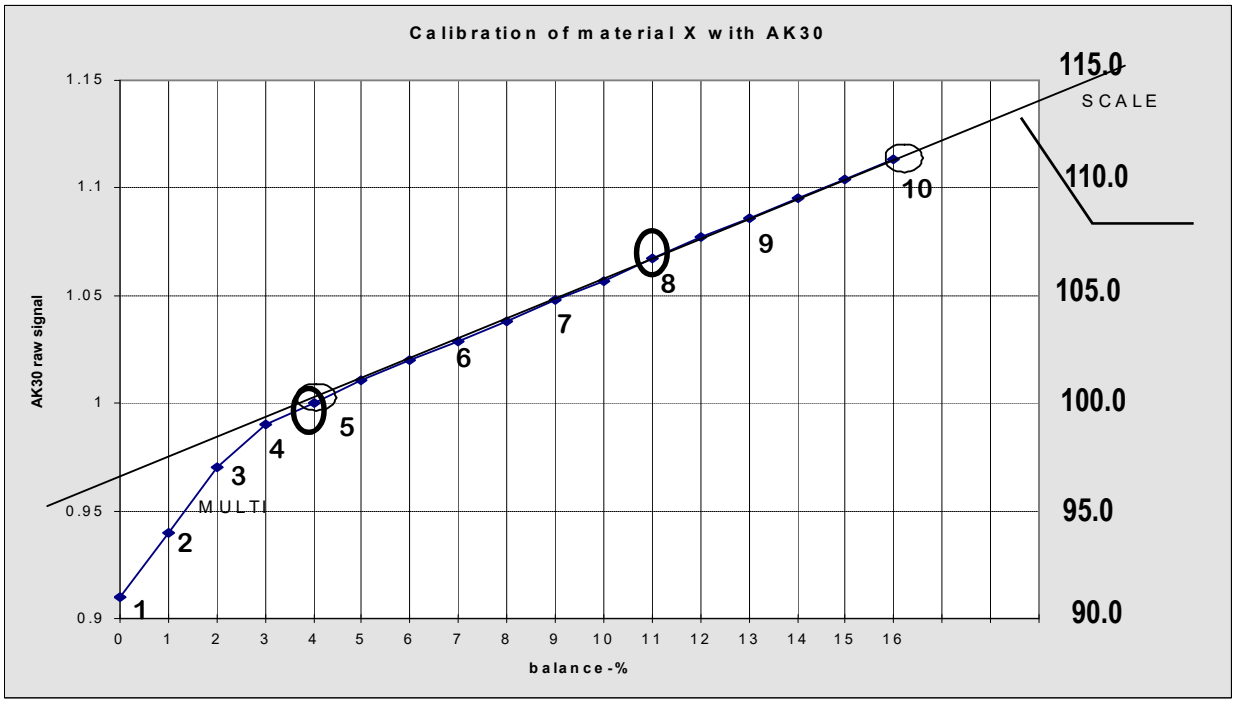
Result of Measurement

The moisture value the meter indicates has a unit which is either a percent relative to the total weight or dry weight of the material or it is the water density in the material. The practical moisture range (total percentage) is 0..70% but numerically can go higher. The instrument has been designed to give reliable values through all this range. The internal noise is very low at moistures below 10% and increases somewhat at higher levels. The repeatability (see specifications) of the instrument is within +/-0.2% below 10% moisture. Typically it is better. The absolute accuracy depends on the calibration for the material. The calibration generates a group of points on a balance-% vs. meter signal plot. **AK30** places segments of line onto this plot from one point to another thus linearizing the original meter response curve.

The internal sampling rate for moisture values is about 72 Hz and the meter display is updated about once per two seconds. The light source applied in the instrument has a lamp with a radiating power of the order 200 mW. Of this the material under test receives typically 2 to 5 mW approximately. That does not cause any notable warming up or drying effects in any known material.

The original signal is a raw nonlinear reading which has a value typically between 0.90 and 1.50. The raw signal is linear when the target is a thin paper (< 60 g/m2) with no backing. When we have a thick paper, the behavior becomes two lines at different slopes connected with a curved part. The bending moisture is usually around 4 - 6 %. This three-region curve requires identification and transformation to a calibration table to give a corrected output in moisture percent or dryness value or any other process value requested. See Fig. 1 below. The raw nonlinear signal can be expressed in **MULTI**-point calibration or a **SCALE** calibration which is only a multiplication of the signal by 100.0. In the Fig. 1 the line belongs to the SCALE calibration and the curve made with line segments to MULTI-point calibration. As can be observed, the multiplier in the SCALE calibration is here 100 X. That has a useful purpose as then one will get two more significant digits to the readings improving accuracy. While calibrating for the MULTI-point calibration, one will need working in the SCALE mode (with a scaling 100X for instance) or by using the regular table **#68 SCALING** reserved for this purpose, doing effectively the same thing. SCALE is not meant for practical measurements, calibration operations only.

Figure 1. Calibration of a material in SCALE and MULTI modes.



Some mills use a different view on moisture than the others by applying the dry weight moisture, the rest using the total weight moisture. They are based on the formulas below.

pd = (m - m0) * 100 / m0

pt = (m - m0) * 100 / m

Here **m0** is the dry weight after oven drying and **m** is the sample weight. **pd** and **pt** represent the dry and total weight moistures. They are related to each other as

pd = pt * 100 / (100 - pt)

or

pt = pd * 100 / (100 + pd)

Calibration Libraries

The calibration library in the instrument offers information for some materials in paper and board industry. Each material holds a unique position among the 100 different materials. One can further develop and complete the library with **AK30** and save them to a PC. Correspondingly, one can transfer from PC any library to **AK30**. It is also possible to move particular material calibration tables into any direction to tailor a special library or copy the libraries or entries to other AK30/40/50 products. The library files can be opened with a spreadsheet program like Open office or Excel but they should not be edited nor saved after that if the purpose is to **Upload** the library to a meter. The office tools may modify the file contents in a bad way becoming unreadable for the meters. In the following we talk about **AK30** but refer to any meter model. Small variations in features are obvious.

AK30 moisture meters are manufactured according to close tolerances. The units are similar to each other and they are finally adjusted to be as close to each other as possible. The libraries are compatible with all models and can be transferred to other units of same model in your company. The library error tolerance is typically better than +/-2.0% in the 0...10% range. Some fine tuning may be required for best results. This is now very easy to do with the Automatic Fine tuning feature of the Advanced software (optional, licensed). AK30/40 series include the Fine adjust feature to be used via keyboard.

AK30 can be calibrated in the same conditions and with the same equipment as you have used earlier for the same purpose. The minimal requirements for calibration are **a balance** and some method for drying the material (**an oven**) and determining the dry weight. **A climatic chamber** with controllable relative humidity and perhaps controllable temperature is recommended for more exacting work. That will also increase accuracy significantly and diminish deviations. The surface moisture varies in many substances due to factors like air flow, temperature differences and external relative humidity. In extremely accurate calibrations, also effects of static electricity (at dry end) and water condensation (at wet end) must be taken into account to avoid trouble. Static electricity may cause mechanical forces to highly sensitive balances interfering severely. An **air ionizer** is recommended as an accessory for such cases.

Using up to 10 calibration points will ensure good accuracy on a larger moisture range if the points are selected carefully and the curvature of the curve insists on it for the MULTI calibration. The number of calibration points is a flexible quantity. The SCALE-mode is applied for transferring nonlinear moisture signal to PC. Note that **AK30** is not able to reverse the linearization process to gain the original nonlinear raw signal. If the nonlinear raw signal is required, it must be collected separately (by scaling it only). The user is not able to change the SCALE scaling but it is fixed to 100X the raw signal for simplicity. The Advanced PC program offers a Math facility for restoring a measurement data file to any mode in case measurements have been performed with an incorrect calibration table.

AK30 can be connected to a PC by using the Bluetooth or via a standard serial port RS232. One is then able to modify some of the meter's settings and download to PC the data series which is collected earlier at the field. The data can be further handled with the AK30 program following the instrument or can be saved into files. Then the data can be more extensively manipulated with e.g. spreadsheet programs. Also the libraries can be manipulated through the serial port. Currently we can offer AK30, AK30Mini, IRMA7Basic, ATOM, Profiler and Advanced programs for handling data and meter configurations. The AK30 and AK30Mini have French language versions too.

General Information about Calibration

The inaccuracies in calibration come mainly from two sources, the moisture nonlinearity with the signal and the difference between the assumed total moisture and measured surface moisture. You can gain information from both effects with this instrument and eliminate them. The nonlinearity can be observed after taking several measurements in a climatic chamber and by reading the balance at the same time. AK30's nonlinearity is very small above 8% with most materials. The evenness of moisture in the sample is left for the user's responsibility.

The dry weight should be determined with an oven. The drying should be executed at a proper temperature determined by standards or experience avoiding browning or melting of the material and evaporation of solvents or other components. Use an aluminum bag for keeping and handling of the sample in the oven and balance. Taring the balance afterwards is easy. Else you have a risk of exposing the bare sample to humid external air while attempting to determine its dry weight, getting excessive weight readings. An error of 0.5 to 2% at this point is not uncommon. Keep the bag open to let air flow through it when in oven. For thick materials, it is best to keep it outside the bag for a good while and then quickly move it inside. After some time, you can close the bag and weigh it. This will ensure that the sample is thoroughly dried.

Climatization

To minimize differences between total and surface moistures, the samples should be saturated at constant conditions for an extended time to make sure that these two moistures are equivalent. Some thick materials require longer times than average to settle in this respect and the suitable times are learned by experience. The simplest way to know when a sample has reached the equilibrium moisture is to measure the moisture with AK30 at regular intervals when the chamber temperature and moisture are held constant. When the sample's moisture signal and weight have not changed for a few intervals it is possibly close to equilibrium. However, note that there are materials which saturate very slowly. It may take hours, days or weeks for them to settle into a new level. Patience is the best friend in calibration. A paper of 80 grams / m2 or thinner, will settle in less than 30 minutes. A board of 600 g / m2 will require several hours to arrive at the same state. Do not forget the hysteresis effect in many fiber products. This is important to be kept in mind when moistening and drying the samples. You will not arrive at the same moisture content at the same %RH when you have wetted or dried the sample and then you vary the %RH value of the chamber up and down. Hysteresis is an atomic effect where the water molecules are locked to the cellulose structures but can be released again when heat is available. The dry end of the calibration is affected by water molecule monolayer which will always cover all materials when not in a vacuum. The humid air will give a tightly-packed one molecule layer of water to all surfaces. The AK series meters are able to measure it.

Sample Sizes

Large samples may bring another factor affecting calibration accuracy. Some parts of the sample may be at different moisture levels, i.e. the sample moisture is not even. That happens easily with sheetlike products. The moisture differences can be eliminated by careful climatization in a chamber. There should be fans mixing the air around the sample to make the surroundings isotropic moisture-wise. Thin samples are difficult to calibrate as such since the weight of the sheet is very small and balance-based errors become significant. This is solved by having several sheets in the same conditions, weighed as a bunch and measured with the meter by taking samples from several sheets.

The meter's response curve can be determined by taking several points both from the balance and AK30. The values can be copied to some spreadsheet program to visualize the curve. This will help a lot in getting successful calibrations. Visualization will indicate if some value is outside the curve pointing to a mistake in many cases. That point needs to be remeasured or ignored.

Performing MULTI Calibration when Working with a Climatic Chamber and a Balance

Just to remind the user, here is the same page as in the actual User's Guide.

1. Place the sample into an oven for two hours at about +102 C or whatever your standards require. Do not overheat the sample!

2. While drying, place the balance and the moisture meter into the climatic chamber. If your balance can not withstand the humid conditions, do the weighing outside the chamber with e.g. a plastic bag or with a balance bottom hook through the roof. Start the chamber control system and adjust the relative humidity to the lowest possible value. Arrange the moisture meter, if possible, so that you can simultaneously read both the balance and the meter. The sample should also be later placed so that the surrounding air can circulate around it and the wetting will be even at every point on the sample. AK30 *should be in SCALE calibration mode*. You can use scaling up of the raw moisture signal with a factor of 100 (default) or 1000 to make its reading easier and more accurate as instructed in the previous section.

3. Quickly move the sample to your balance for weighing, preferably using an aluminum or plastic bag. Note that static electricity may interfere distorting weighing results at the dry end. The result is the dry weight of the sample. Try to read also the moisture meter signal. That is usually a difficult task as both the weight and the signal increase so rapidly within the first 0..2 % range. The dry weight is used later in calculating the actual moisture percentages.

4. Continue reading the moisture signal-weight pairs as the moisture level slowly increases. Make notes of these readings. At first, you can take readings every minute but as the wetting of the sample will become slower it may be enough to take samples at longer intervals. If long intervals are used, it is advisable to place the meter into low power mode and to tare the balance before each use.

5. Control the chamber's %RH to a higher value as a series of steps with time intervals long enough to allow for proper settling of the sample (saturation to an even moisture over the sample area / depth). Suitable levels could be 20, 30, 40 etc. %RH up to 80 %RH. Higher levels may cause water condensation on the walls and the sample may be in danger.

6. Feed the collected data into your spreadsheet program and draw a picture of it thus forming the actual calibration curve. The %RH values themselves have no meaning at this point but only the weight / signal values.

7. Decide whether the results are reasonable. If not, you have to start from step 1. again

8. Having obtained a reliable calibration curve, decide which points on it actually are adequate for representing it with the accuracy you have specified. You can use only 2 to 10 of them for the linearization table. Straight parts of the curve can be handled with single line segments.

9. Take a printout of the calibration points and mark the selected points with step numbers

10. In the measuring state, select another empty material whose table has not been used (or in the Material menu)

11. Go to the MULTI calibration menu and then the EDIT menu

12. Set the step number in "2".

13. Press "4" and type in the corresponding signal (now scaled down if you earlier scaled it up) as a decimal number. The value is normally between 0.90 and 1.400. Use always as many decimals as there are available and try to round them correctly.

14. Press "5" and set the corresponding moisture value.

15. Repeat the steps 12., 13. and 14. until all calibration points are fed in.

16. In the upper menu, set the calibration mode to MULTI instead of SCALE.

The most accurate calibration is now done. After calibration, the set of points (table) is immediately in use in MULTI mode and will stay in the nonvolatile memory for at least 40 years after you press the Save key.

3.Tasks in Calibration

Preparation Stage

One should carefully prepare the calibration since there are some parts of it which cannot be reverted without losing a lot of work.

Let us assume that we are dealing with samples of single sheets of sufficient BW so that one sheet will weigh at least 5 g. We assume having a laboratory balance capable of accuracy to 1 mg or better. If the sample weighs less than that, it is advised to use more than one sheet for the calibration, all prepared in the same way. Similar thinking is valid for calibration of other kinds of materials.

The paper samples are **marked clearly** and cut to such a size which can be easily handled in the climate chamber. It is useful to have hooks in the chamber and therefore also to **punch holes** to the sides for hanging. Cutting of the corners is useful to avoid breaking them. It is critical that no part of the sample is broken during the process, else all the work is lost. Having **isolating gloves** for manipulating samples in the chamber is a huge advantage. Else the door must be opened destroying the conditions. Plan the **arrangement** of the samples properly (numbering) to be processed always in the same way to avoid mistakes.

The balance is recommended to be located **outside of the chamber**, presumably over the chamber roof and having a **bottom hook** going inside the chamber through a narrow hole. Most good quality balances have the bottom hook option. The balances do not tolerate high humidities for long times and start getting corroded failing eventually. Also taring the balance is easier outside. One should also have **a clear visibility** to the chamber to manipulate the samples. The chamber is required to have **fans** to force the air circulating and flushing the samples, forcing them to stabilize as fast as possible. The fans need to be **able to be turned off** when the weighing is done and back on again. The balance will also need an **upper holder** for holding the Aluminum bags taken from the oven.

For thin sheets it is greatly recommended to have a **black Aluminum plate (oxidated)** over which one will work with the samples. Then the background is always the same unless the samples are stacked to imitate a reel measurement. In this way, one is able to do both at the same time.

The %RH conditions to be used should be examined a little before starting to do anything. Some papers do not tolerate high humidities and start behaving in a bad way, like wrinkling or disintegrating. Therefore, the %RH range to be run needs to be thought over and also the number of steps to avoid unnecessary work.

The purpose of calibration is to collect data and make notes to an Excel sheet to visualize the resulting curve and then feed in the representative points to the meter. In order to reach the goal, working must be careful and systematic. Doing too many tasks at the same time may confuse at some point making the results useless. Manual notes can be made for instance to a sheet at the end of this document before entering a spreadsheet. Or the data can be typed into the spreadsheet. A sample Excel sheet is on the manufacturer's web site and should be attached to this document too.

Prepare the working area in the chamber so that everything is at hand and easily reached with the gloves. Place the moisture meter over the Aluminum plate and lead the charger cable out from the chamber through a proper duct which can be tightened with a piece of foam to prevent losing the %RH levels by leaking. Start the PC program you plan to use and make sure you have a working connection to the meter. Turn the meter to LowPower mode. Switch to using the table #68 and keep using that particular table consistently (save configuration).

You should now be able to place the sample to the bottom hook extension hook or a holder, read the balance and then place the sample under the meter and get the reading to the PC program (like AK30 or Advanced). Then you have gotten one data point (weight / raw signal 100X). The raw signal obtained is multiplied with 100.0 and should be **divided** at this point. However, the sample was likely not stabilized at all and the purpose is to run the set of samples in the chamber in a certain %RH for a longer period of time.

Thin papers climatize or stabilize rather quickly, usually less than one hour is required. The thicker the paper, the longer time it will take. It is recommended to go upwards from very dry samples to wet samples. If the samples can tolerate drying in the oven without damage, then it might be good to perform the dry weight determination before entering the climate chamber task. If dry weight is not available, then one can estimate what it might be and use that information in the Excel sheet temporarily to see some reasonable graph of the results. The final curve will be gotten when the dry weight is known at the end.

While starting to calibrate **on-line meters, like AK40 or AK50**, they do have their proper working distance to the target paper. That must be recognized and applied accurately to get best results. Arrange some sort of **sample holders** for keeping the samples steady and the distance correct at all stages.

Calibration Tasks

Collection of Climate Chamber Data

The operation while calibrating cycles through the following steps until a sufficient amount of data is at hand.

1. Run the climate chamber to a preset level of %RH and keep it there for a sufficient time with the samples hanging in the hooks in the flowing air.

2. Turn on the moisture meter and prepare everything for getting in numeric data. Turn off the fans and tare the balance. If the %RH generator causes vibrations affecting the balance, then also the %RH generator must be paused at that time.

3. Place the sample to the balance's hook, weigh it and turn on the fans (and the %RH generator running). Place the sample under the meter to get a proper raw signal reading to the PC program.

Hint: You can set the PC program Acquiring continuously to get in all data you provide for it and then you pick up that part of it with cursors (Archives page) which is pertinent to the actual measurement. The signal level and nature will change usually a lot when a paper is under the meter and can clearly be seen on the graph. Make notes either on paper or to the Excel sheet of the weight and raw signal of this point and this sample.

4. Repeat step 3. until all samples have been processed.

5. Hang up all samples to the hooks **in order and so that you can see the numbering** .

6. Turn the meter to LowPower state and stop the PC program. Program the climate chamber for reaching the next %RH level and start it.

7. Repeat steps 1. to 6. until all predefined %RH steps have been completed. You should now have a good set of data to see a clear curve of data in the Excel sheets graph, for each sample of different grade. If any points are mistaken, you will need to repeat them unless the curve itself is very clear in behavior. Making mistakes is humane so do not get depressed if something goes wrong. There are also some materials and special paper types needing much more attention and rehearsal until the goal is reached.

Hint: At very high %RH be careful not to allow water droplets falling on the samples. In such a case, the sample should be removed from the chamber and let it dry before putting back to the chamber. Water condensation may happen already at lower %RH if some part of the chamber is colder than the rest . Therefore, fans are most useful in equalizing temperatures preventing condensation.

Determination of the Dry Weight

The sample dry weight is the single critical data item which requires special attention. The samples are put to Aluminum bags or foil or anything equivalent capable of working passively in the high temperatures. The bags

should be marked clearly for identification. Plastic bags are not recommended unless they can stay in > +150C for long periods of time. The plastics can vaporize some solvents which may harm the samples by sticking.

1. The samples are bagged but left open and put to the oven at 105 C or whatever is considered suitable. Thin samples dry in two hours but thick samples may require 8 - 48 hours of drying to make sure they are bone dry.

2. Before taking them from the oven, the bags are closed and one more hour if left for drying. In the mean time, the moisture meter is prepared and the PC program too. Then one bag at a time is taken very quickly from the oven and carried to the balance's upper holder. The weight is read and the bag is thrown inside the climate chamber where it is opened and the sample is put under the meter to get the very dry data point, if needed. The bag is taken outside for determination of its weight. Now one is able to calculate the dry weight.

Finalizing Tasks

We are almost there but not yet. The data is acquired but we must have it on the spreadsheet and to see it on a graph. At this point we have all the data points and the dry weight determined. For instance, we may have something like in Fig. 2, a calibration of an AK30 for a 110 g/m2 packaging paper, the upper curve is for reel and the lower curve is for a single sheet. The bending range is from 5 to 7 % total for both curves. The highest %RH data points are not successful but the behavior can be estimated suitably from this. Straight lines can be

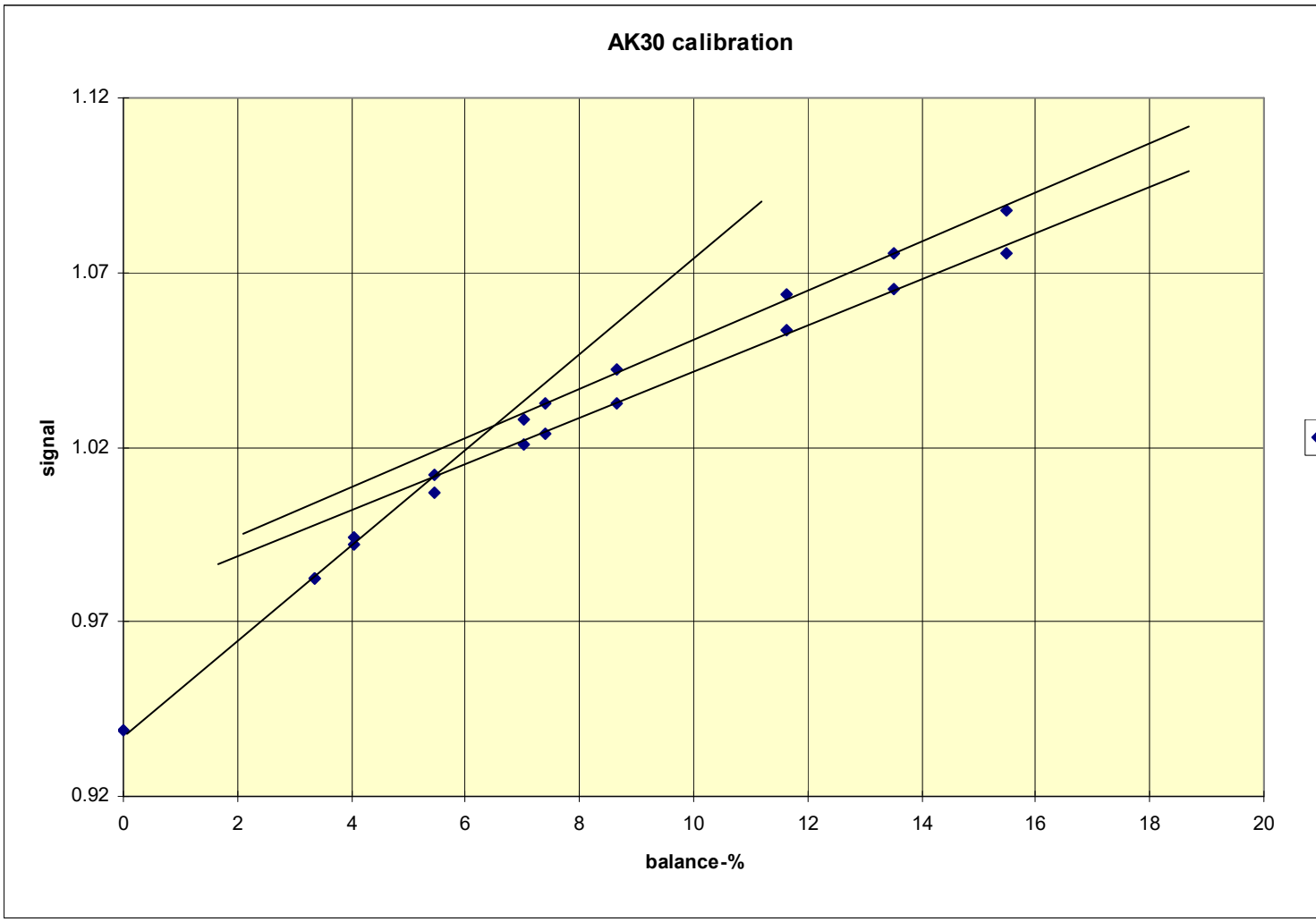


Figure 2. Calibration of a packaging paper

drawn and some representative data point pairs selected. At least two points are needed, up to 10 points optionally.

If you are accustomed in having a lot of points and they do not seem to be along the same line on the graph, you may use statistical methods to generate regression lines and get the slope and offset in that way. However, you will need in that case to type in artificial data among the data points behaving according to this slope and offset and to see it on the graph too.

1. Mark those points to a printout which are suitable for your measurement range, with a number starting from one in order from the low moisture up. The number of points is N.

2. Find from the table the corresponding pair of % moisture and raw signal and put the corresponding number on it.

3. With AK30 you can feed in the calibration data by hand via keyboard and display but it can be done with the PC program in a more fluent way. First, select some unused or unimportant calibration table in the library and switch to it. Enter the Calibration task in the PC program, GET the current calibration table. Check that its number is correct.

4. Start Editing it. Fill in the data point pairs in order, one pair at a time until all N points (2..10) have been completed. The fields raw signal (nonlinear signal) and moisture % must all be filled with proper values.

5. Then you can edit the number of the points to become N, make the table active by setting it MULTI instead of SCALE. Remember to edit the same of the new calibration to reflect the target material. AK30 will show only 8 characters on its display.

6. Stop Editing and observe the new calibration curve on the display. It should not have any extra kinks on it but be a nicely running curve as you would see in the Excel graph.

7. **Upload** the new calibration to the meter and reply to the security request (important).

8. When all different calibrations have been handled in this way remember to modify the name of the library (Library page) and Save the meter's configuration. Download the whole library to the PC and save library file for archiving.

You are done.

Sometimes the calibrations may show being very similar or identical to eachother indeed. Then, it might be best to generate one calibration only for the user of the meter to avoid unnecessary work at field.

CODE:____________________

Moisture calibration sheet
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grade:

Mtot:

MAI:

M0:

Distance:

Latit. Angle:

Longit. Angle:

Model:

Special:

signal	weight	signal	weight

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