MODEL AM-III

Operation and Calibration Instructions

Part No. 9710793

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Model AM-III

Operating Instructions

REV	E.O.	DESCRIPTION	DATE	APPROVED
A	31791	Manual	4/8/98	GC.
B	32236	Curve Revision	6/30/04	JWL

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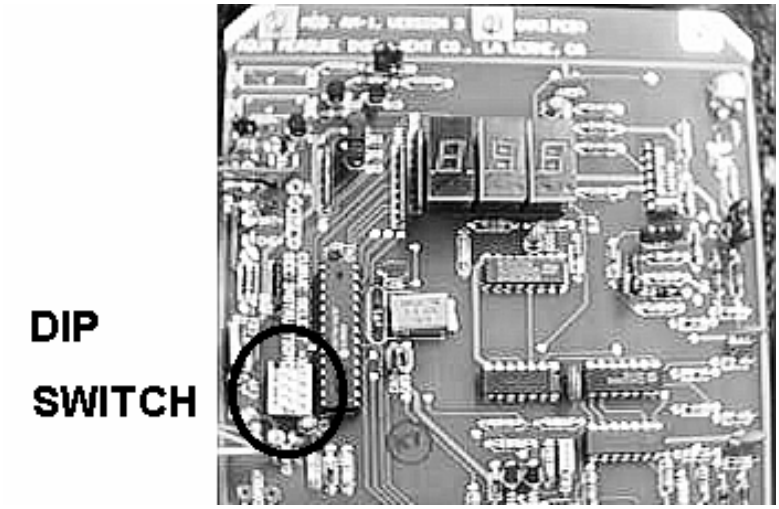
Quick Start Guide

(To be accomplished exactly in the order listed)

1. Hold the AM-III away from all objects (continue holding away from all objects through step 7).
2. Turn POWER switch (center front panel) to ON (up) position.
3. The AM-III instrument will now display the actual calibration Curve being used for the position of the program switch NORMAL or HIGH/LOW
4. Wait 3 seconds until the display reads " 0.0 ". Also make sure that at least 3 seconds have elapsed after the display reads “0.0” before placing the AM-III on the paper.
5. The AM-III instrument will read " HI. " indicating that the battery voltage is good.
6. Next the display will show the curve being used.
    a. **Example 1:** The display will read " C0.3 " indicating that curve 03 is being used.
    b. **Example 2:** The display will read " C1.3 " indicating that curve 13 is being used.
7. Then display will read " 0.0 " indicating the AM-III instrument has performed and passed the self checking and it's now ready to read moisture.
8. Turn STANDARD switch ON (up position) and check and/or set proper STANDARD NUMBER for paper grade to be measured. See Instrument Operation and calibration section regarding proper procedures for establishing the Standard Number.
9. Turn STANDARD switch OFF (down position).
10. Hold the AM-III against the moving or stationary paper roll and read percent moisture content on the display.
11. Zero occasionally during long test by holding the AM-III away from objects and turning the POWER switch OFF and ON again. Make sure that the STANDARD switch is in the down position before zeroing the AM-III.

Introduction to the AM-III

The Aqua Measure Model AM-III is the only preprogrammed portable paper moisture analyzer designed specifically to measure and display paper moisture on a direct reading digital basis. This is accomplished by the use of a MCU (Micro-Controller-Unit) that has in its permanent memory the moisture calibration curves for various papers.
The AM-III has been designed with provisions for field selection of any of eleven (11) Calibration Curve pairs. Calibration Curve pairs are selected using a four section “DIP” switch found on the circuit board adjacent to the MCU.



Opening the Instrument Case

To gain access to the DIP switch, it is necessary to remove the six (6) screws found on the ends of the enclosure. Place the instrument on a flat surface, and with a small Phillips Head screwdriver, remove the three screws from each end.

CAUTION: Sometimes the fit of the enclosure top is tight, so do not pull up such that when it comes off, the wires to the controls are stressed. Instead, lift and pry gently with the blade of a knife or flat screwdriver until the top can be lifted off instead of “popping’ off.

Setting the DIP Switches

Table I shows the switch positions for each pair of programmed Calibration Curves. When selecting a curve pair (e.g. Curves 3/2), Curve 03 will be found in the “Normal” Switch position, and curve 02 will be found on the HI/LOW Switch position

Match the position of the DIP Switch actuator buttons to the respective figure in Table I making sure that the actuator buttons are all the way to the ON or OFF position.

Table I - Dip Switch Settings

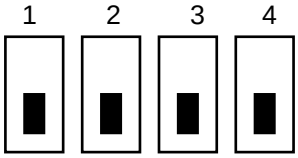
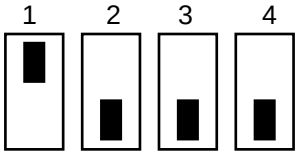
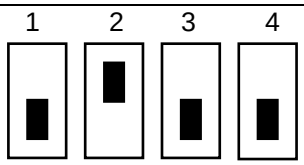
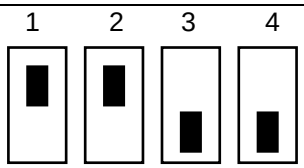
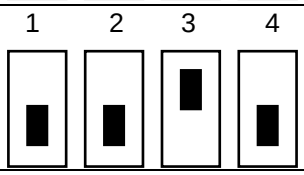
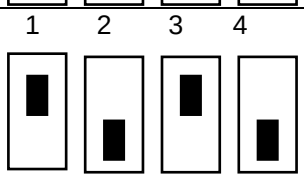
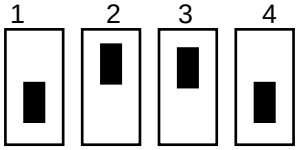
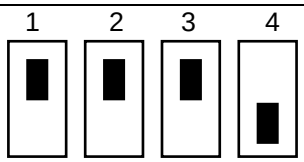
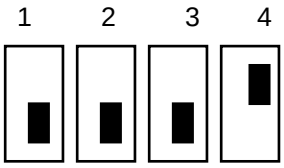
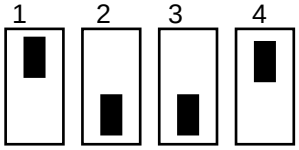
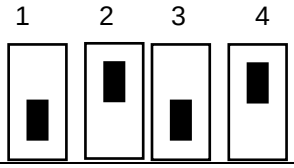
Curves 0, 3	
Curves 3, 2	
Curves 3, 4*	
Curves 3, 10	
Curves 3, 13	
Curves 2, 20	
Curves 6, 3	

Table I - Dip Switch Settings (cont.)

Curves 20, 3	
Curves 25, 3	
Curves 3, 15	
Curves 3, 8	

***NOTE:** The AM-III is completely compatible with the AM-1 instrument except when the No. 4 curve is selected. The AM-III will have a different STANDARD value than the AM-I when using the No. 4 curve as compared to the AM-1.

Checking the Curve Selection

The Dip Switch setting can be checked before the enclosure top is replaced. Set the Curve Selector Switch in the Normal position and turn the Power switch to the On position. Note that the display shows 'Cnn', where 'nn' is the curve number that has been selected. Now, turn the Power Switch Off, and set the Curve Selector switch to the HI/LO position. Again turn the Power Switch to On and note the displayed curved number. Check the DIP Switch positions again if the Curves displayed are not those expected. Turn the Power Switch Off.

Replacing the Instrument Case

1. After setting the DIP Switch, swing the enclosure top back on to the instrument, being careful that the wires do not get caught in the gap between the top and the bottom. Wire placement on the left side of the instrument is not critical, other than to be sure that no wires are pinched.
2. Replace all screws before tightening them. Moderately tighten all screws, but not so hard as to strip out the screw.
3. Re-check the curve indication in both Curve Selector Switch positions to be sure that the instrument is operating correctly.
4. Aqua Measure has shipped your unit with the calibration Curves already installed to measure your paper grades. Other calibration Curves are available to measure almost all other types and grades of paper and are stored in the MCU.

The raw data which made these curves possible was obtained by actually taking the AM-III into many different paper mills and accomplishing several hundred oven moisture analysis (gravimetric testing) which were then compared to the Model AM-III digital indication. All raw moisture data (oven vs. AM-III) was then programmed into our computer, which calculated a best-fit curve relationship. This best-fit curves were then transferred to the MCU memory circuit, which was then plugged into the circuit board of the AM-III. Thereafter when the AM-IIII is applied to a roll, stack, or ream of paper the AM-III will display in direct reading digital form, the percent moisture of the paper.

To utilize the AM-III on a particular grade of paper, certain calibration steps must be accomplished. These steps establish a STANDARD NUMBER for each grade, which will always be dialed-in on the AM-III display before the instrument is used on that particular grade. A following section on INSTRUMENT OPERATION AND CALIBRATION will describe how STANDARD NUMBERS are established.

The AM-III measures moisture by sensing the dielectric constant of any material placed in the radio frequency electric field emanating from its electrode rollers.

When water is present in paper, the paper's dielectric constant is increased in proportion to the moisture content (see section on PRINCIPLE OF OPERATION). The AM-III translates the increase in dielectric constant into a direct % moisture indication.

The range of the AM-III is generally 0-14.9% and its accuracy is usually within $\pm$0.25% moisture content on most grades. It is, however, no more accurate than the methods employed to establish the proper STANDARD NUMBER for your paper grades. Therefore, when calibrating, care must be taken to assure that the proper calibration procedures are followed.

It has been stated that the AM-III is a preprogrammed analyzer. This is true because the shape for slope of the calibration curve is fixed. The curve must, however, be shifted or "zero offset" so that the digital display matches a known moisture content sample of a given paper grade. This can be as simple as applying the AM-III to a roll of paper of known moisture content and turning the DENSITY CONTROL to make the AM-III display match the actual known moisture. In this manner, a STANDARD NUMBER is established for that particular grade and is recorded so that the AM-III is then fully calibrated for future use and will no longer have to be compared to any oven analysis.

Instrument Operation & Calibration

The steps necessary to properly operate the AM-III and to establish STANDARD NUMBERS for individual grades of paper are as follows:

1. Make sure the STANDARD switch is in the OFF (down) position before turning on the AM-III. If the STANDARD switch is in the ON (up) position before the AM-III is energized, the instrument will not zero.
2. Hold the AM-III away from the paper roll before turning the POWER switch to the ON position. If you energize the instrument while it is resting on the paper roll, (or any other object) the roll itself will be zeroed out (canceled) and the instrument will continue to read zero.
   The AM-III must be zeroed in the air ("AIR ZERO") in order to compensate for any room relative humidity which might be present. The effects of any room relative humidity are automatically canceled when the AM-III is "AIR ZEROED".
3. After energizing the unit, wait until the display reads 'Hi.' and then wait another 3 seconds before placing the AM-III against a paper roll or stack. The roll or stack should be at least 5cm (2") thick.
   If the AM-III continues to read zero when placed against the roll:
   a. You may not have waited the full 3 seconds before placing the AM-III on the roll. Take the instrument away from the roll (at least 6 inches away) and turn the POWER switch OFF and then back ON again. WAIT 3 SECONDS for the display to show **'0.0'** and place the AM-III back on the roll. When air zeroing, always remember to keep your fingers and hands away from the rollers or they may interfere with the radio frequency field which is emitted from the rollers and thereby prevent proper air zeroing.
   b. If the AM-III still reads only zero when placed against the roll, turn the DENSITY CONTROL clockwise until the digital readout displays readings above zero.
4. In order to permanently calibrate the AM-III upon initial use, the moisture content of the roll (preferably stationary) at the position where the AM-III is being utilized must be known. The best method to determine the actual moisture content is by oven gravimetric analysis. A detailed procedure used to establish a proper oven gravimetric analysis is described in the next section.

Calibration with Known Samples

If you do not have a sample of known moisture content, proceed to CALIBRATION BY OVEN TESTING.
If you do have a sample of known moisture content, simply turn the DENSITY CONTROL until the AM-III display matches the known moisture. By turning the DENSITY CONTROL you are merely positioning the calibration at the proper place on the slope of the preprogrammed curve.

After the instrument display matches the known moisture content, pick the AM-III up off the roll. Holding the AM-III at least 6" away from the roll and with fingers and hands clear of the rollers, turn ON the STANDARD switch. Write down the new reading, which will appear, on the display. This STANDARD NUMBER is now the permanent standard reading that will be used when measuring this paper grade in the future. Before the AM-III is used again, check or dial in the proper STANDARD NUMBER for that grade as determined above. This should always be done because the DENSITY CONTROL knob may have been turned accidentally or the AM-III may have been used on another grade of paper, which required a different DENSITY CONTROL setting and therefore would display a different STANDARD NUMBER reading.

When you wish to measure a different grade (density) paper, this paper may require a different STANDARD NUMBER. This is because the rollers of the AM-III emit a radio frequency field that penetrates 5cm (2") into the paper. If one paper is more dense than another, there will be physically more of the denser paper within this 2" field than there will be of the less dense paper. When the AM-III sees more paper within its 2" field it will naturally display a higher reading than on the light density paper.

This means, for example, that if the plant manufactures 8 different grades of paper, a worst-case situation may require 8 different STANDARD NUMBERS, one for each grade.

Remember, however, that in the plant the STANDARD NUMBERS and, consequently, the entire calibration for each grade have been determined by doing an oven moisture analysis on only one sample of each grade. This one known sample of each grade has allowed you to use the Model AM-III as a direct reading digital percent moisture indicator for every grade of paper that the plant manufactures. Since every moisture analyzer of any type must be calibrated via oven testing (for maximum accuracy), Aqua Measure has reduced the oven analysis required to just one analysis per grade of paper. THIS IS AS SIMPLE AS THE PROCEDURE CAN BE MADE.

In actuality, you will find that paper grades whose densities are near each other will require the same STANDARD NUMBER. Consequently, the above example probably would require only about 4 different STANDARD NUMBERS instead of 8.

After determining a STANDARD NUMBER for each paper grade, make a list of each grade and its proper STANDARD NUMBER. Be sure that the operator always dials in (via Density Control) the proper STANDARD NUMBER for the paper grade he is about to measure. It is advisable to post the proper STANDARD NUMBER on the side of the AM-III by the use of Dymo-tape or a stick-on label. It is then a simple matter to obtain the proper STANDARD NUMBER before utilizing the AM-III.

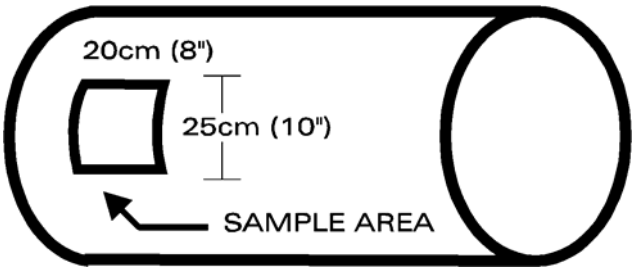
EXAMPLE: PAPER TYPE TO BE MEASURED: NEWSPRINT

1. Remove AM-III from case. Make sure STANDARD switch is off and fingers are not near rollers. Turn unit ON.
2. Wait 3 seconds and place the AM-III against the roll of newsprint. The Digital display may read 10.04%, however known moisture at this position on the roll equals 6.0%.
3. While holding AM-III against roll, turn DENSITY CONTROL counter-clockwise until display reads 6.0%.
4. Pick the AM-III up off the roll (fingers away from rollers) and turn ON the STANDARD switch. The display now reads 6.8. This reading is not moisture content. It is a permanent STANDARD NUMBER for this grade of paper. In the future, 6.8 would then be dialed in before using the AM-III to measure the same grade of paper

Calibration by Oven Testing

If you do not have a sample of known moisture content, but do possess a good weigh scale and industrial oven, a gravimetric analysis to determine the actual moisture content is accomplished as follows:

1. Obtain a sample roll of the grade for which the AM-III is to be calibrated. Preferably this roll will have a fairly even moisture profile and will have a moisture content approximately in the center of the moisture range of interest. The roll must have a diameter of at least 28cm (11") in order to support both AM-III sensor rollers. There must also be at least 5cm (2") of paper on the core of the roll.
2. With a pencil, mark off a rectangular area on the surface of the roll with these approximate dimensions:



   a. Using a very sharp knife, cut along the marked area down to a depth of at least 0.6cm (1/4"). The larger the sample the more accurate the result.
   b. Remove the cube of paper that has been cut from the roll and discard the top 3 or 4 sheets. These sheets may have been adversely affected by room relative humidity. Place the remaining sample in a plastic bag to prevent moisture changes. It is then advisable to cover the hole where the sample was removed with a sheet of plastic. This prevents room humidity from affecting the sample area. Save this roll of paper as it will be used for final instrument calibration.
   c. Remove the sample from the plastic bag and immediately weigh it on a scale that has a accuracy of at least 0.01 gram. Record the weight and then place the sample in a drying oven set at 230^0F (115^0C). The sample must be dried until no further weight loss occurs. This will take approximately 4-5 hours for a 0.6cm (1/4") thick sample or up to 10-12 hours for a 3.8cm (1 1/2") sample.
   d. Once the sample has dried to a constant weight, turn off the oven and let the sample cool to ambient temperature. The cooling is best accomplished by placing the dried sample in a desiccator so that no atmospheric humidity is regained. Weighing accuracy will probably not be greatly affected, however, if the sample is left to cool in the oven.
   e. When cool, very carefully re-weigh the dried sample and determine the weight loss and actual percent moisture content as follows:

$$Actual\%Moisture = \frac{\text{Original Weight (Wet Wt.)} - \text{Dry Weight}}{WetWeight}$$

3. Now take the AM-III to the paper roll where the sample was removed. Air-Zero the AM-III as specified earlier (i.e. hold it away from the roll before turning on the power switch). Wait 3 seconds after energizing the AM-III, then remove the plastic sheet covering the sample location and place the AM-III down into the sample hole. Press down until the AM-III display readings stabilize at a maximum reading. Then turn the DENSITY CONTROL KNOB until the display shows the actual % moisture content as determined by the oven gravimetric analysis. If you cannot turn the DENSITY CONTROL KNOB far enough to match the actual oven moisture, this may indicate that another calibration Curve is needed.
4. Once you have adjusted the display to match the actual oven gravimetric moisture analysis, remove the AM-III from the roll and hold it in the air. Turn the STANDARD switch to the ON position. The new number that will appear on the display represents the STANDARD NUMBER calibration, which must be recorded so that future moisture measurements can be made on this paper grade without having to oven dry another sample. This STANDARD NUMBER is then simply dialed in (using the DENSITY CONTROL KNOB with the STANDARD Switch in the ON position) when future measurements are required on this grade.

Curve Calibrations

The original gravimetric testing used to program the AM-III's MCU showed that there are actually 3 families of curve shapes or slopes. Ninety percent of all AM-III's in use utilize the #3 Curve that is used on all normal or average density papers. There are some very light density papers, however, which require a different curve shape. These papers (generally tissue, towels, creped wadding, roofing felt, etc.) utilize the #2 Curve. Yet another curve shape is the #4, which is used to measure heavy density papers, i.e. glassine, waxed, release, polyethylene films, heavily coated papers, some super-calendared papers, etc.

Since the MCU has enough storage space to hold more than these three curves, it is possible to supply an AM-III to a paper mill who manufactures or converts more than just average density papers. Since an AM-III of this nature

would contain two different calibration curves, a toggle switch is added to the AM-III's front panel and is labeled NORMAL/HI/LOW. This dual program feature is now a standard feature of the AM-III instrument.

NOTE: All corrugating medium of basis weight 33 lb./1000ft^2 (161gm/m^2) or less requires the use of #3/10 combination program. The HI/LOW on the toggle switch is used for the light grades of medium (33 lb. & below) while the NORMAL position is used for all linerboard and the other grades of corrugating medium.

Special Curves – Method of Calibration

Occasionally a customer will ask to use the AM-III on a type of paper that may require a different calibration curve than is presently available or will want to use the AM-III to measure moisture content up to 20%. This can be accomplished quite readily with the AM-III because of its microprocessor based memory circuit. A Special MCU can be programmed which contains the correct calibration Curve for the special paper. All that is needed by Aqua Measure is a table showing what the AM-III indications are versus the true oven analysis as determined by the customer.

Use the #2, #3, or the #4 Curves, the table data that is needed to program a special MCU is obtained in an identical manner no matter which of the 3 Curves is used.

Sample Data for Developing Custom Curve

AM-III MOISTURE INDICATION	TRUE OVEN MOISTURE RESULT
2.0%	1.8%
4.0%	2.7%
5.0%	3.3%
6.0%	4.0%
7.0%	4.8%
8.0%	5.9%
9.0%	7.0%
10.0%	8.3%
11.0%	10.0%
13.0%	13.7%
14.0%	16.6%
14.9% (Maximum Reading)	20.0%

An example of data needed and data taken is as above (Be sure all data is taken using the same STANDARD setting)

Aqua Measure will take this comparison data (10 or 12 points are enough) and program the relationship onto another MCU which will be either installed in a new AM-III to be sent to the customer or mailed with instructions to the customer to replace the existing MCU with which the original data was taken. Once the new MCU is installed and the proper calibration Curve selected, the AM-III will read in direct percent moisture to agree with true oven moisture results.

If the customer does not already possess an AM-III but wishes to have a special Curve for his special paper, they can use the #0 Curve. This Curve is preferred for generating the data to be used for the special MCU because it provides AM-III display readings in the range of 0-20.3. These readings are not percent moisture but only relative numbers such that the higher the reading the wetter the paper (or other measured material). The AM-III with #0 Curve can be used to generate data for programming a special MCU which would match oven moisture or it can be used to obtain data for a curve which measures to 20% maximum moisture (the maximum reading on a standard AM-III with #2 or #3 Curve is 14.9% and on a #4 Curve is 14.0%).

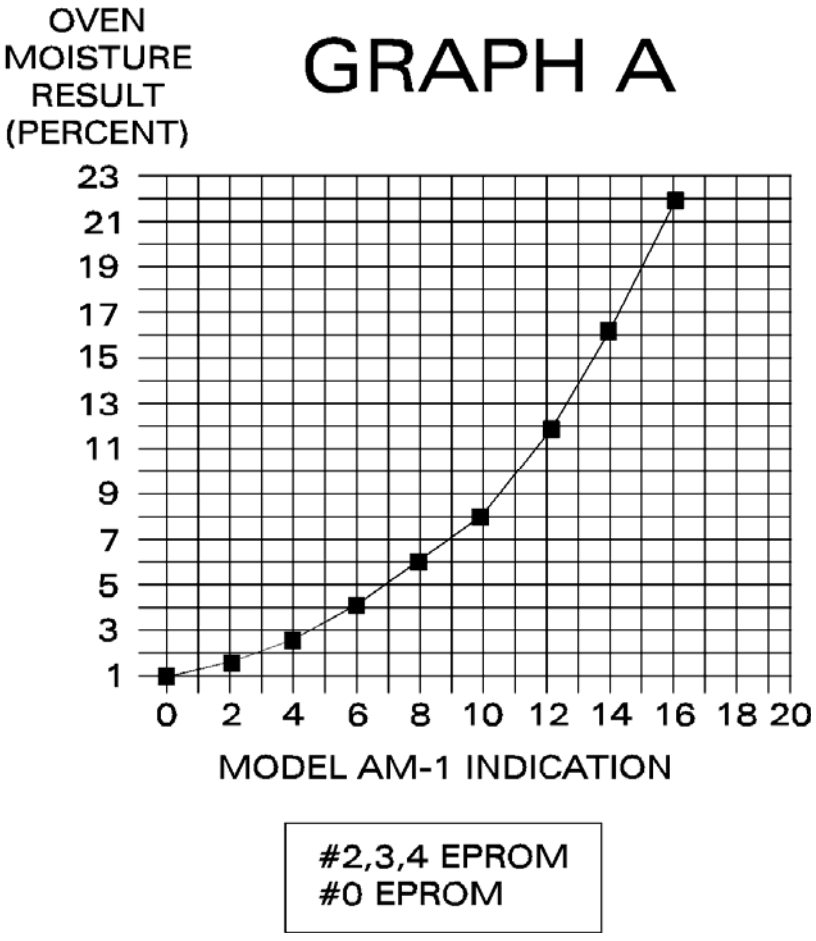
An example of data obtained with the #0 Curve to generate a special Curve to measure to 20% moisture is as follows:

AM-III RELATIVE INDICATION	ACTUAL OVEN MOISTURE RESULT
0.0%	1.5%
2.1%	1.8%
3.5%	2.4%
4.8%	3.2%
7.0%	4.8%
9.5%	10.5%
13.5%	15.1%
14.2%	20.0%
16.1%	23.5%

Again, this table data will be used by Aqua Measure to program a special MCU storing this special curve which in this case would measure up to 20% moisture instead of 14.9% maximum.

Data taken as above must be with the standard setting in the same position (constant). Also, Aqua Measure should be told what standard setting was used to obtain the data. The standard setting should be indicated on the same sheet as the table data

Graph A – Custom Curve



Use on Hot Rolls vs. Cold Rolls

You will find that on some types of paper the AM-III's response on hot paper (paper that is still on the paper machine) is somewhat different (usually higher) that the response which the instrument will exhibit on cold paper which has been off the machine for more that 20-30 minutes.

This reaction is especially noticeable on thicker board type materials and occurs because the sheet material just before it is wound onto the roll has a wetter center or core than does its outside surface, which has been exposed, to the air that surrounds and dries it. When the sheet is wound onto the roll the effect is wet and dry "layers". These "layers" absorb radio frequency energy somewhat differently than does a roll which has had sufficient time for the set center to reach an equilibrium condition with the drier surface. Any RF instrument would therefore exhibit a different reading on a "fresh" roll versus a "conditioned" roll.

This phenomenon is less likely to occur on light and average density papers and of course would not be a problem at all in any paper converting plant as that paper would already be in an equilibrium condition.

To use the AM-III on hot paper vs. cold paper, the plant would simply establish one STANDARD NUMBER for hot paper and another for cold paper. The appropriate STANDARD would then be dialed-in before using the AM-III on the paper to be measured. The different STANDARD NUMBERS compensate for the difference in AM-III readings caused by hot rolls versus cold rolls.

Density Changes Due to Wrap Tension Variations

Occasionally when a plant is running paper of a given grade, it is found that after being removed from the paper machine the individual rolls of paper are of a different weight even though their diameters are the same. This can often be attributed to variations in the tension with which the individual rolls were wound.

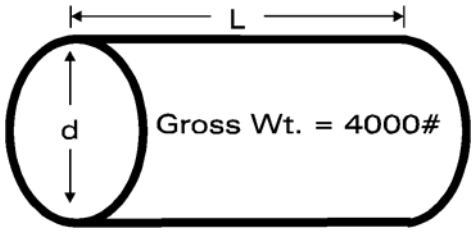
Since the Model AM-III's RF field of penetration is to a depth of 2", variations in the paper density can cause the AM-III reading to be in error by about the same amount as the percentage variation in the paper density. This is because the AM-III tends to "see" more paper within its 2" field of penetration on a roll which is heavier than normal and therefore reads slightly higher. A lighter than normal roll would present less paper within the 2" penetration and the AM-III would read slightly lower.

A method which can be used to correct the AM-III readings for this variation in paper density is as follows:

1. Measure the roll diameter. (d)
2. Measure the roll length. (L)
3. Obtain the gross weight of the roll.
4. Calculate the volume of the roll. (Volume = $\pi r^2 L$)
5. Calculate the density of the roll.
   (Density = Gross Weight / Volume)

Example -Variation in Paper Density Correction

1. d = 4', r = d/2 = 2
2. L = 6'
3. Gross Weight = 4000#. This is the target weight for this product)
4. Volume = PI * $r^2 L$ = (3.14) $(2')^2$ (6') = 75.36 ft^3
5. Density (Target) =Gross Weight - Volume = 4000# / 75.36 ft^3 = 53.08 #/ft^3



Now assume that the AM-III has been calibrated to this target roll and it is found that for an AM-III display reading of 6.0% moisture, the associated AM-III STANDARD NUMBER is 8.2.
After other rolls are examined the following table is established
(Assuming three rolls of the same size but with different moisture contents):

Gross Weight	AM-III Reading	Density	Percent Variation from target	Corrected AM-III Reading
3500#	8.0%	46.44#/Ft^3	-12.5%	9.0%
4000#	6.0%	53.08#/Ft^3	TARGET	6.0%
4500#	7.4%	59.71#/Ft^3	+2.5%	6.5%

Since one roll is lighter than target, this means the AM-III will read less on this roll than it would if the roll were up to target density. The density is down by 12.5% from the target, therefore the AM-III display reading on this light roll must be increased by 12.5% to arrive at a correct figure. Say the AM-III display read 8.0% on the light roll. A correct reading would really 8.0% + (12.5% X 8.0%) = 8.0% + 1.0% = 9.0%.

The other roll is heavier than target by 12.5% which means the AM-III will read too high on this roll. If the reading obtained was, say, 7.4%, the true reading would be 7.4% - (12.5% X 7.4%) = 7.4% - 0.9% = 6.5%.

In summary the AM-III display reading will be increased or decreased by the same percentage as the percentage variation in the roll density. It must always be remembered that if the roll density is less than target, add the percentage variation to the AM-III display. If the roll density is greater than target, subtract the percentage from the AM-III display reading.

Rechargeable Battery Maintenance

The continuous operating time of a fully charged battery is approximately four (4) hours. The charger is capable of restoring the battery to full charge in just four (4) hours. The instrument can be left on charge indefinitely, however this may lead to some decrease in battery life.

To prevent inaccurate readings resulting from low battery voltage, the AM-III has a low battery voltage disable feature. This feature results in the display being locked onto a fixed reading of LO.b (for low battery) irrespective of the material under the rollers, or the position of the STANDARD switch. The STANDARD switch will be inoperative. This action signals the requirement to recharge the battery. It is recommended that the battery be charged at least 4 hours to restore full charge before using the AM-III. In an emergency, sufficient charge can be replenished to finish a series of tests in one-half (0.5) hour.

To avoid shorting the battery, insert the charger plug into the receptacle on the bottom of the AM-III QUICKLY AND FIRMLY. Remove the same way.

Do

Charge a new or stored battery only for the minimum recommended time period (4 hours) the first few cycles.

Allow a battery that has been outside in the cold to warm to room temperature before charging.

Use only chargers designed for gel cell type batteries.

Use the proper size and type replacement battery.

Observe polarity when installing a new battery.

Don't

Charge a cold battery.

Use a charger designed for another battery system.

Charge at rates greater than battery label recommendations.

Allow battery to be placed across a direct short.

General Maintenance

In normal use, no maintenance to the AM-III is necessary. If paper fiber tends to build up in the electrode roller cavities, this can be blown out with an air hose. Should the AM-III become damaged due to physical abuse, the necessity for repair can be determined by assessing its operating characteristics on the paper roll. Rollers may become un-even if the case is deformed. This will cause lower moisture readings if not corrected. The entire width of the AM-III's rollers must contact the paper roll for proper readings.

If all other operating characteristics are normal, un-even rollers can be corrected by shimming under one roller mounting screws with a small washer. DO NOT ATTEMPT TO REMOVE THE ROLLERS, as the connecting wire may be broken.

All critical integrated circuit components are mounted on the circuit board in sockets to facilitate repairs. When removed from the circuitry the integrated circuit elements are susceptible to damage by static charges due to improper handling. Service of these components should be performed only at authorized service facilities. It is not recommended that any electrical repairs be attempted in the field, as the necessary physical standards for proper alignment are not available.

Do not change any of the screwdriver adjustments on the circuit board, as electrical alignment and measurement accuracy will be severely affected.

The factory maintains complete inventory, repair, and alignment facilities; therefore it is recommended that for any substantial repair, the AM-III should be returned for service.

Factory Warranty

The AM-III is warranted against defects in workmanship and component failures for a period of one (1) year from the date of shipment from the factory.

AQUA MEASURE INSTRUMENT COMPANY will repair or replace the defective AM-III unit at its discretion. Damage caused by abnormal abuse is not covered by this warranty. The customer is obligated for all shipping charges and for any other charges incurred in special handling of the shipment.

A second year's warranty coverage is available with the initial purchase of the AM-III at a nominal extra charge which is indicated on the AM-III price sheet. The terms of this additional warranty period are the same as those during the first year's coverage, except that the battery pack is excluded from the second year's warranty coverage.

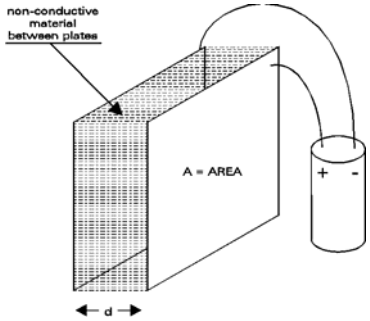
No other express or implied warranty is given by AQUA MEASURE INSTRUMENT COMPANY. AQUA MEASURE INSTRUMENT COMPANY shall not be liable for consequential damages.

Principle of Operation

The Model AM-III uses the capacitance principle to measure moisture. A capacitor is a device that can store energy when an electrical difference exists between its two plates. You could make a capacitor if you had two sheets (or plates) of metal held in close proximity to one another and applied a positive battery lead to one plate and the negative lead to the other plate.

Capacitance = $\frac{AK}{d}$

Where:
A = area of the plates
K = dielectric constant of the non
D = distance between the plates.



conductive material between the plates

The Capacitance (C) can then be thought of as a measure of the ability of the non-conductive material between the plates to add to the energy storage character of the capacitor. Dry air has a dielectric constant of very close to 1.0, and therefore provides a low capacitance when between the plates. Water, however, has a high dielectric constant, hence contributing to a high capacity when placed between the plates. The magnitude of the capacitance can then be used as a measure of the amount of moisture present in the gap between the capacitor plates.

The Model AM-III is designed to act as a capacitor wherein one of the capacitor plates is the AM-III roller and the other is the AM-III case. The radio frequency field begins at the roller, penetrates the paper roll to a depth of 2 inches (5cm.) and returns to the case to complete the circuit.

The formula for Capacitance has two constants, A and d. A is the area of the two capacitor plates, and since the AM-III case and roller are fixed in size and do not vary, the A is always the same. Likewise, d, or the distance between the roller and case is fixed since the rollers are attached to the case.

It is therefore apparent that the only thing that will change is the capacitance (hence the AM-III display reading) is the K, or the dielectric constant. Since water has a dielectric constant of about 80, whereas dry paper has a constant of only about 3, even a small amount of water present in the paper will cause the combination dielectric constant to increase substantially.

The AM-III can easily recognize this increase (or decrease) in water content and has been programmed to display the result in direct reading percent moisture content.

Calibration Curves

Factory Installed (0,2,3,4)

Factory Installed

CURVE	RANGE %	DESCRIPTION
#0	0 - 20.3	This curve causes the AM-IIIB to display readings on a 0 - 20.3 scale. The readings are not direct moisture but are simply a relative scale such that the higher the reading the wetter the material. The customer would use this curve on his "special" paper; which might be treated in some manner such that the moisture curve would not fit any of our standard programmed curve calibrations. They could give us a graph or table showing the AM-III reading versus oven analysis and we could program that relationship onto another MCU to replace the "0" curve in their unit. This gives them a direct reading instrument custom calibrated for their product
#2	0 - 14.9%	Light Density Papers. Example: Tissue, Wadding, Toweling, Roofing, Felt, etc.
#3	0 - 14.9%	Average Density Papers. Example: Kraft, Newsprint, Core, Jute, Fine Papers, Tube Stock, Bonds, Corrugated Medium and Linerboard (greater than 161 gm/m^2 or 33#/1000$ft.^2$), etc. This curve is the **most universal** and has been installed in approximately 80% of all AM-1 and AM-III sold.
#4	0 - 14.9%	Heavy Density Papers. Example: Glassine, Waxed Release, Heavy Coated Papers, Polyethylene Films, etc.

(6,8,10,13,15,20,25)

CURVE	RANGE %	DESCRIPTION
#6	0 - 14.9%	Special curve for Crepe Wadding.
#8	0 - 14.9%	Special curve for 61# Envelope Stock.
#10	0 - 14.4%	Special curve for Light Weight Corrugating Medium (less than or equal to 161 gm/m^2 or 33#/1000 $ft.^{2.}$ This curve is used in combination with a #3 curve since almost all corrugating medium and Linerboard plants manufacture both light grades and medium to heavy grades. The #3/10 combination curves will measure all grades. The #3 curve is

		located in the normal selector switch position and measures all grades of linerboard & medium except the lighter grades of medium as listed above. The light weight medium grades are measured by the #10 curve found in the HI/LOW position
#13	0 - 20.3%	Special curve for 1/2" thick Particleboard. Also for the AM-IIIB for light density single sheets of paper.
#15	0 - 20.3%	Special curve for Tissue and Towel. For the AM-IIIB for very light density single sheets.
#20	0 - 19.4%	Special curve for Pulp Sheets to 19.4% moisture.
#25	0 –14.6%	Curve for various liners.

Special Orders (5,7,9,11,12,14,16,17,18,19,21)

#5	0 - 12.4%	Special curve for coated solid Bleached Sulfate Board. Caliper 0.012 - 0.024. 120# to 275#/300 $ft.^2$.
#7	0 - 14.9%	Special curve for Fiber Mat & Hardboard.
#9	0 - 20.3%	Special curve for Tobacco paper to measure to maximum of 25.4% (with electronic modification to the AM-IIIB circuit board).
#11	0 - 20.3%	Special curve for Newsprint.
#12	0 - 13.6%	Special curve for lightweight paper grades (54 - 100 gm/m^2).
#14	0 - 20.3%	Special curve for a specific Tissue customer.
#16	0 - 20.3%	Special curve to measure packaged Disposable Diapers.
#17	0 - 20.3%	Special curve for some Boxboards.
#18	0 - 12.5%	Special curve to measure Sheet Plastics (PVC & Acrylic).
#19	0 - 16.8%	Linerboard curve.
#21	0 - 17.7%	Special curve for Pulp Sheets to 22% moisture (Higher readout obtained by internal electronic modification).

These special curves are available upon order. There is an additional charge to load any of these curves into an AM-IIIB. These curves can only be installed at the Factory. Please contact Aqua Measure Instrument Co. for more information or to order.

Notes:

AQUA Measure Instrument Co. and its Moisture Register Products division manufacture Continuous On-Line Systems and Hand-Held Portable Meters that are designed for optimum performance, essential convenience and complete reliability to accomplish a multitude of applications in a wide range of industries.

Our Continuous On-Line Systems offer Near Infrared and Radio Frequency Sensors to constantly measure your process moisture. These systems assist you in analyzing, recording and controlling moisture on your product line.

Our Hand-Held Portable Moisture Meters offer on the spot measurement as well as flexibility for use on a variety of materials such as:

LUMBER	**VENEER**
PLASTER WALL	**DRY WALL**
GYPSUM BOARD	**TEXTILES**
NONWOVENS	**PAPER PRODUCTS**
CORK	**AIRCRAFT RADOMES**

AQUA Measure Instrument Company and Moisture Register Products are fully committed in providing products and services at a quality level that continues to improve and that meets our customer's expectations.

www.MoistureRegisterProducts.com