NOTES

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1.0 BACKGROUND

The **FS_3 Recycling Paper** is a battery operated, mobile, electronic hand held measuring instrument for non destructive determination of moisture content in bales and lose depots of waste paper up to a measuring depth of maximum 500 mm.

The instrument is work side calibrated for 4 different pressured densities and waste paper sorts. The basis of calibration is the gravimetric method of drying oven EN 20287 as reference method.

Waste paper bales can have very different moisture content. The reason therefore is the pressure density of different kinds of paper and the storage and transport at open depots with following surface drying. The moisture inside of the bales is higher than at the surface. The FS_3 Recycling Paper makes possible to determine the absolute moisture content in volume percent within seconds and with high precision.

The instrument works according the dielectric measuring principle. The dielectric measurement means: Penetration of an electric field into the material. Because of the polarity of water and the high dielectric constant of water in comparison to other materials (water has a dielectric constant of 83, paper and natural fibres have the dielectric constant of approx. 2), the capacity of the measuring field is determined of free water molecules. The measuring signal must be calibrated and depends on the kind of material, the density and the weight.

Measuring value is the dielectric constant (DC) which increases with increase of water content in paper, pulp etc. It depends also from the content of fillers, density of grinding of the fibres etc.

- the DC increases with increase of fillers in the paper,
- high density of paper results in a high DC,
- the DC increases with density of grinding of the fibres

These description shows, that:

- **The right calibration of the unit is absolutely necessary to obtain a high precision.**
- **It is absolute necessary to choose the right adjustment line in the unit.**

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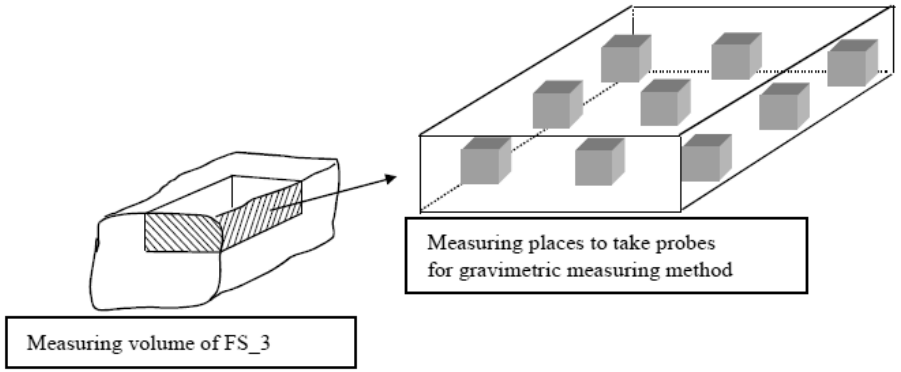


Illustration: How the test probes for gravimetric method must be taken.
The following procedure has proved:

1. One determines the measurement at a bale in the same place at every switch position with the FS_3 Recycling Paper as a mean average value of several individual measuring.
2. Because of the great inhomogeneity of the bales the complete material volume which is measured with the FS_3 Recycling Paper at one measuring must be examined with the drying oven method or one proceeds as above described.
3. The menue position is determined whose measurement least differs from the drying oven value/reference value.

In the practice is to find the following handling.

1. One accepts a given moisture value at a bale. It is to pay attention to the measurement unit (% total weight or % dry weight).
2. One determines with the FS_3 Recycling Paper beginning with the position 3 an average value, by carrying out single measurements at different places of the stack. Increases the deviation high from the required value for the following switch position one break off and use the last switch position.

The pressing density can be found out after the following scheme:

Volume of the sample in m³ = length * breadth * height in m (±3%), weight in kg (±3%)

Specific wet weight = weight in kg/volume in m³

Pressing density kg/m³ = specific wet weight / (1 + paper moisture / 100)

2.0 USE

The different parts of the FS_3 Recycling Paper are:

- Measuring instrument with electronic unit, display and batteries,
- Transportation case with calibration plate,
- Operating Instruction
- **Optional**: Interface connection cable, Data recording Software FS_3 View, mobile printer.

The basis and reference method of calibration of the adjustment line S3 to S6 is the dryingvoven method EN 20297. The adjusted lines can be chosen in the menu.

The unit adjustment is carried out with standard materials e.g. a special polypropylene plate. The manufacturer guarantees with the FS_3 Recycling Paper:

- High reproducibility of measuring,
- Long-term stable adjustment and the possibility to check up it every time,
- Long-term stable reproducibility in series manufacturing of ± 1 %,
- High correspondence with reference methods as drying oven method.

Important! The sensor plate of the instrument must be pressed by **one hand** to bale or stack. The optimum of measuring is reached if the button line is complete filled black (figure 02). With the second hand one should not press the measuring area against the material. It is absolute necessary to pay attention that no metals as watches, bracelets etc. are brought in the measuring field.

An electric field is generated elliptic around the measuring area. Despite of protection upwards the field is active short over the measuring area and the materials have influence on the measuring results. The grip of the unit is at safe distance to the electric field and only there one should press the unit to the bales/material.

After choose of the right adjustment line one can read the absolute moisture value in % at the display.

3.0 OPERATION

The menu operation is better to explain if one has the FS_3 in the hand

The instrument is battery operated. Press button **O/1** some seconds. In the display is shown the logo shortly, the state of battery and storage „MEM“ (memory) is shown. The unite is switched in the measuring menu and is ready for measuring now.

3.1 Keyboard

0/1	□	ON/OFF
0/1	□	Display – switch on background illumination
esc	□	Back to the main menu
◀	□	Contrast brighter, only in measuring menu
▶	□	Contrast darker, only in measuring menu
OK	□	Store measurement / enter
F1	□	Store measurement series
▲▼	□	Change adjustment lines/calibration lines

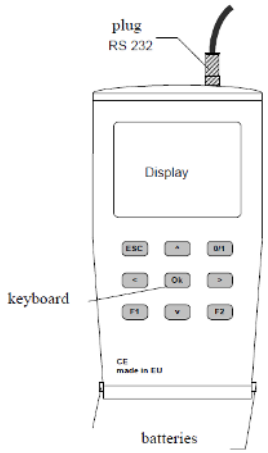
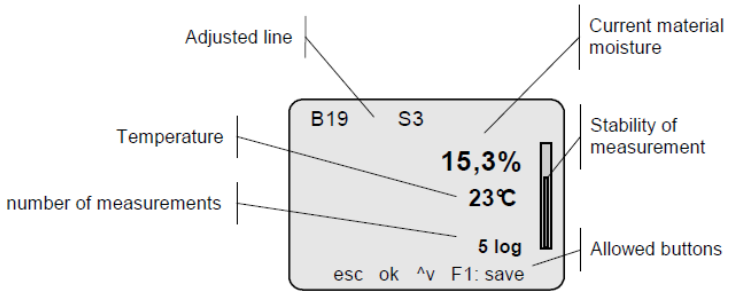


Figure 01

Keys can be occupied with short or long key pressure. For long key pressure the key must be held for at least 2 seconds.
For storage of measurements must be pressed the key F1 before change into other menu.

At the display are shown the allowed buttons (figure 02).



4. Choice of type

The device was calibrated by the gravimetric method of EN 20287 (drying oven method) for 6 different pressing densities or paper mixtures. The higher the pressing density, the higher the switch position.

Moisture fluctuations are detectable with each switch position. Because of these fluctuations the measurement can not be seen as absolute moisture. A range of values is agreed on for a certain switch position.

With previous experiences and measuring carried out a switch position of 3 to 5 can be recommended for the waste paper types 1.02 (B 12) and 1.04 (B 19).

Proven switch positions which, however, under no circumstances replace the necessity of the own selection in the concrete case were typed in in the table.

Switch position	*Pressing density*	*Paper type*
S 3	*	normally pressed newsprint
S 3		B12, B19
S 4	*	offset papers, solid carton
S 4		B12, B19
S 5	*	coated papers
S 5		B12, B19
S 6		
S 6		

At supplier relations it is necessary to exchange or to coordinate the switch positions so that you measure with the same standard.

By the addition of various substances at the paper production, mixture of different printed materials and paper bale pressed differently strongly the corresponding switch position must be found out once before use.

The switch position must be found out by comparable moisture measuring with calibrating capable methods according to norm of EN 20287 drying oven or dry kiln test.

Because of the high differences of the moisture content and the paper structure in a waste paper bales a minimum of 9 test probes must be taken out of the bale and, tested with the gravimetric method to reach an accurate comparability of the measuring value of the FS_3 Recycling Paper and the gravimetric method. The test probes must be taken from volume under the measuring area of the FS_3 Recycling Paper value (volume under the measuring area of w 110 x l 630 x h 500 mm) and the measuring results are to middle to a mean value (look at illustration 2).

3. Calculation of absolute Moisture

The calculation of the absolute moisture is carried out with the following formulae. The drying oven method is the reference method:

$$\%F = \frac{M_n - M_t}{M_n} \times 100$$

Control value calculation:

$$M_{ter} = \frac{M_{nk} \times (100 - \%F)}{100} \qquad \%F_{new} = \frac{M_{nnew} - M_{ter}}{M_{nnew}} \times 100$$

%F	% paper moisture (measured with drying oven)
Mn	Mass – weight of the wet sample before dehydration
Mt	Mass – weight of the dehydrated sample
Mnk	Mass – weight of the wet control sample before dehydration or hydration
Mnnew	Mass – weight after dehydration or hydration of the control sample
Mter	Calculated mass – weight of the dehydrated control sample
%Fnew	New moisture value of the paper for comparative measurement

Is shown the main menu after switching on one reaches the measuring menu via „Measure“ and pressing „OK“.

Air measurement shows a moisture value of around 0,5% at the display. The function of the instrument can be checked at each time with the calibration plate in the wooden case. For a correct documentation of the measuring values (figure 05) one should adjust the current date and time. These adjustment can be done in menu „Options“ as described in figure 02.

The display shows at the unit after new switching on, the last used menu.

3.2 **Display** (see figure 02)

Name of adjusted line
Each adjusted line can be renamed by the user e.g. B19. This name is shown above at the display.

Material moisture
Black numbers of material moisture mean the moisture is in the measuring range. Grey numbers mean the measuring range is exceeded, it is out of range. The valid range is adjusted during the calibration.

Temperature
The unit must be adapted to the surroundings temperature. The current temperature is shown and compensated.

Stability of measurements
The bar chart shows the stability of the measuring value. **Is the bar chart complete black marked the value is stable.**

Number of measurements (smp)
Shows the number of measurements of the series.

Function buttons
Shows the menu buttons.

Loading condition of the batteries and capacity of memory „MEM“:
The battery symbol is shown if the loading condition of batteries is decreased so, that exact measurements are not possible any more. The symbol is shown only shortly after switching on the instrument. But it can be interrogated with button „Status“.

3.3 Menu

From the main menu one can achieve the sub-menus (as you are knowing from your mobile phone). From the sub-menus one can achieve the main menu with **„ESC“**.
With help of the cursor one can scroll to the buttons.
By confirmation with **„OK“** the right functions of the sub-menu are achievable.

Measure Measurement

Options Date, Time
- Unlock only for superuser available
- Adjust only for superuser
- Calibr only for superuser
- Passwrd only for superuser
- Reload only for superuser

Datalog

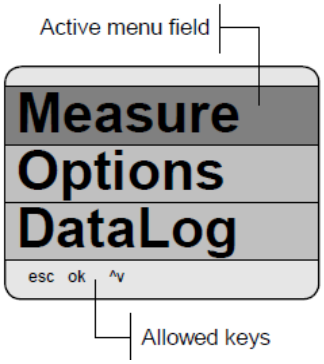
	Last	last measured series
	All	all series
	Clear	delete of measuring series

Print

	Last	last measured series
	All	all series
	Clear	delete of measuring series

Send

	Last	last measured series
	All	all series
	Clear	delete of measuring series



Menu display: figure 03

Status - Battery – Loading condition and memory capacity are shown

3.3.1 Functions of sub-menus

Date, Time

In this menu point is to enter the date and the time with „ ▶ “ (date see figure 02/03 -yy.mm.dd, time - hh.mm.ss), confirmation with **„OK“**. With **„ESC“** one can leave the menu without storage.

Unlock

These menu point is not available for the user, it is usable only for superuser with superuser key .

Sensor

These menu point is not activated until now by the manufacturer. It is reserved for connection of external sensors to use special applications.

2. Definition of absolute moisture

The absolute moisture is the percentage water content in a material applied on the dry mass or the total weight.

It has to be notice that the calibration is carried out at different moisture meters on a different basis. The gauges for wood moisture measuring are calibrated in % in correlation to the drying mass of material. The FS_3 Recycling Paper is calibrated in % in correlation to the total weight of the material - as in the paper industry is usual.

The German DIN norm doesn't fix any uniform directive to the calibration. The TAPPI norm requires calibration on % total weight of the material. One wants compare the measurements of a different equipments a uniform denominator must be created.

We describe the absolute moisture in % in correlation on the total weight with % W and the absolute moisture in % in correlation on the dry mass with % D. So we can see the correlation between both in the table below.

Display in % of the total weight		**Display in % of drying mass**
1 %W	=	1,01 %D
10 %W	=	11,1 %D
25 %W	=	33,3 %D
30 %W	=	42,9 %D
40 %W	=	66,7 %D
50 %W	2 kg material contain 1 kg water	100,0 %D
60 %W	=	150,0 %D

The numerical values differ very clear with increased moisture. In the paper industry the absolute moisture value in %W is preferred because one very simply can find out the water content or the hard substances by multiplication with the %-value.

The % D calculation is more difficult.

The following formula can mathematically be derived to compare both systems or convert values to each other.

With indication of absolute moisture X in % W and absolute moisture Y in % D one can convert
a) from % W in % D and with the formula b) from % D in % W.

a) $Y = \frac{X}{100 - X} * 100$ (in %D)

b) $X = \frac{Y}{100 + Y} * 100$ (in %W)

The drying oven method is the reference method for calibration of the gauges. The correlation between electrical signal and moisture value of a material is described as a material characteristic, it must be known as fact.

The adjustment of the gauges is carried out with standardized materials preferably with special long time stable synthetic materials.

The manufacturer ensures with the electronic measuring principle and the exact calibration method for all equipments:

- A high reproducibility of measuring
- A long time stable adjustment as well as her current effective check
- A long time stable reproducibility in the series production less than ±2%
- A good agreement with standard reference methods (drying oven).

Calibr
These menu point is not available for the user.

3.4 Change of battery

Open the battery depot by pressing the noses at left and right of the depot (figure 01) at the same time. Now one can change the batteries. When required please correct the contrast of the display.

4.0 Measurement

4.1 Selection of adjusted lines

Following lines are available:
EMPTY 1 -11 (Storage place for individual calibration)
Proofplate -12

The adjusted lines S3 - S6 are work side calibrated for different kinds of waste paper (comparable with the former AP 500).

S3 means pressed newsprint (B12 / B19) (1.02 = B 12), (1.04 = B 19)
S4 means offset paper or cardboard (B12 / B19)
S5 coated paper (B12 / B19)
S6 coated paper

4.2 Measuring of series

Measuring and transfer to PC or printer.
Date and time are adjusted.

0/1 (LT) □ Measuring menu
▲ ▼ □ Selection of calibration line (point 6.0)
► ◄ □ Contrast more dark ►; Lower contrast ◄
OK □ Measurement

The measurement is ready if the stability button shows a complete black line (figure 02). The number of measurements is as you like for a series.

ESC □ Finishing the series
edit? □ Storage question is shown at the display
OK □ Measurements are stored. The series can be inscribed as shown in figure 03.

Is the storage question answered with „ESC“ one achieve the measuring menu without storage of values.

The first three lines are available for description of the measurement (e.g. kind of paper, customer, wagon no., charge no. etc.). By pressing the ▲ key, capitals are selected. With (LT) is selected a fast run. The selected letter is to confirm wit **OK**, or is taken over after few seconds automatically. With ▼ key small letters are selected and written as capitals. Special letters are selected with **F1** and numbers with **F2**. With **esc** all letters right of the cursor are deleted. Stored is a series measurement if one confirm with **OK** after the third description line.

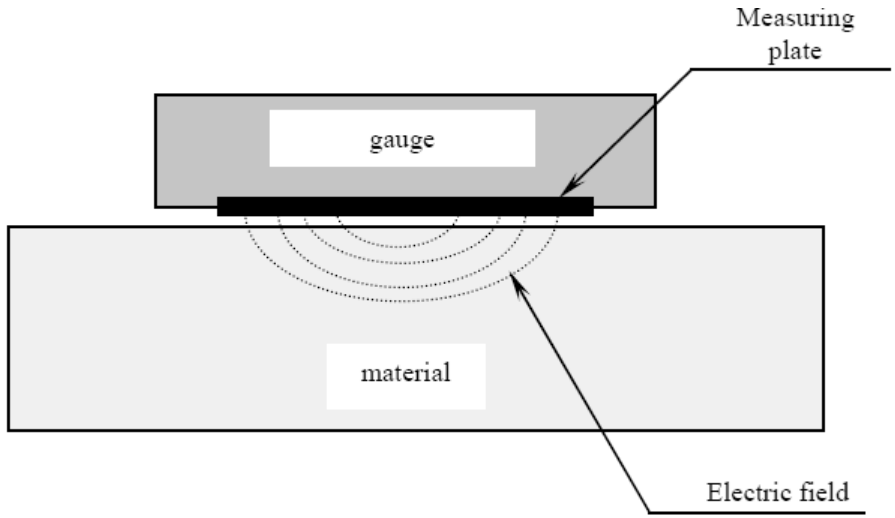
Appendix 1

1. The dielectric principle of the absolute moisture measurement

Different physical measuring principles are known to the moisture measuring such as the electrical conducting ability measuring, the electrical resistance measuring, the infrared measuring or the microwave measuring.

At the dielectric measuring the material situated in the measuring area is penetrated of an electric magnetic field whose properties are determined fundamentally by the available material moisture. Because of the distinctive polarity of the water molecule and the high dielectric constant of water of about 83 in comparison approximately to paper (natural fibres have a dielectric constant of 2) the capacity of a measuring area is dominantly determined by the quantity of free water molecules into paper.

The electrical measuring signal must be calibrated in every case. The calibration in % of the total weight has – provided the same material – the consequence that the calibration depends on the density or weight and the thickness of the material. Fluctuations in the material composition lead to measurement fluctuations. The proportionality applies: Fluctuation in % leads to the same fluctuation in per cent of the measurement i.e. the measurement is 100% and a measuring error arises of it in height of the percentage fluctuation. A weight, density or thickness fluctuation of 10% leads at a measuring value of 8% to a measuring error of ±0.8%.



The measuring technology is offered in the form of hand-held test equipments at which the measuring area must always completely be filled out with the material to be measured and as transmitter for the contact or contactless online measuring for different materials as wood, paper, board, leather, textiles, grain, liquids etc.

Accessories:

Wooden case with calibration plate:	Order # 10726 EN
Interface cable with FS_3 View-SW	Order # 10772 EN
Portable – Printer	Order # 10734 EN


```
Offset - B19
Samplemen Ltd.
Waggon 1.312
AP 500_S4
28.11.03              13:12:35
5 smp.                  15,9%
28.11.03              13:28:12
ok ESC <> ^ : A. .F1+- F2:0…
```

Figure 04

The display in the sub-menu - Measure (Figure 04)
Meaning of the lines:

1 - 3 description of the goods
4 Adjustment/Calibration line
5 Date at the beginning of measurement — time at the beginning of measurement
6 Number of measured values — Average of measured moisture for this number
7 Date at the end of measurement — time at the end of Measurement
8 allowed keys

Figure 05

4.3 Control of measurement series

After switching ON, the measuring- or main menu is shown at the display (figure 02/03). Change the menu to measuring menu and select the calibration line („▲“/„▼“) where you have measured the values. With the keys you can go step by step or 4-times steps. Next change with „ESC“ into the main menu. From menu point „DataLog“ one can change to menu point „ManLog.“ Please confirm with „OK“. The statistic evaluation of the series is shown (figure 04) at the display. With keys „◀“/„▶“ it is possible to control all measurements. With „ESC“ one can achieve the main menu. With menu point „clear“ one can delete the complete series.

5.0 TRANSFERRING THE MEASURING DATA TO THE PC

Open the Software **FS_3 View** on your PC and connect the interface cable to your PC and the FS_3. Select menu “send” and confirm with “OK“. Select the data (M – manual or A – automatic logged data) and press “OK”. The FS_3 is sending the data to the software. For further instructions consult the included help file in FS_3 View.

5.1 Output of measuring data to the mobile printer

Connect the interface cable to the mobile printer and the FS_3. From the main menu „print“ and confirm with „OK.“ The measurements are printed at the mobile printer.

6.0 REQUIREMENTS FOR ISO UNIT CHECK

The surface of polypropylene plate PP 2 in the wooden case must be not scratched, free of dust, fat or other dirt. The required temperature should be between 15 to 25°C, humidity 30 to 80%.

6.1 Check of calibration

Choose in the menu the calibration line „Proofplate“. Set the FS_3 Recycling Paper on the plastic plate in the wooden case an keep attention on the stability of measurement (point 7.0). The measuring value must be in the tolerance area as shown in the table below. The surroundings temperature for checking should be between 17 to 23°C. Write down the checking values in the table. Differ the checked values more then +/- 2 % from the calibration values the instrument must be calibrated new by the manufacturer.

Date:	Series# / FS_3: ……		Temperature °C: ..... Humidity %:	
	Air value: target	Air value: actual	Plastic plate: target	Plastic plate: actual
Proof plate	**0,5%**		**17,2**	
S 3	-		**17,2**	
S 4	-		**16,2**	
S 5	-		**14,6**	
S 6	-		**13,2**	

6.2 Technical Details

Measuring range standard:	1 – 50% moisture
Measuring depth effective:	300 mm
Operating temperature:	0°C to +40°C
Temperature of storage:	-20°C to +80°C
Temperature compensation:	0,05% per °C
Power supply:	3 pieces AA batteries 1,5V Mignon or NiMH- or NiCd- accumulator
Power consumption:	app. 40 mA
Loading condition of battery:	empty = shown BAT-Symbol
Resolution of display:	0,5% moisture 0,5°C temperature
Dimension (L x W x H):	620 x 100 x 150mm
Weight without wooden case:	940g

CHECK·LINE®
BY ELECTROMATIC

FS3 RP

RECYCLING PAPER MOISTURE METER

CHECK·LINE®
INSTRUMENTS

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OPERATING INSTRUCTIONS