

User Manual

FMI

Contact-free industrial wood moisture meter

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Preface

Congratulations on your purchase of the FMI contact-free industrial wood moisture meter. The FMI is a Dutch quality product considered to be the best and most advanced contact-free wood moisture meter for production and sorting lines in the wood industries.

The FMI system consists of a microprocessor-controlled operating unit and one or more microprocessor-controlled contact-free wood sensors.

The FMI system is a capacitive measuring system that determines the dielectric constant of the material over (sensor designed for transversal measurement) or between (sensor designed for longitudinal measurement) the sensor plates. Consequently, the wood does not have to touch the sensor plates, and the system measures without any contact.

By applying two fast microprocessors, and because of the high-frequency capacitive measuring method used, the FMI system has a capacity of 400 measurements per second.

Enschede, 1 August 1999

Revision

Date 1 August 1999

- Operating unit software version 3.30
- Sensor software version 3.13
- CPU FMI3-7182/0

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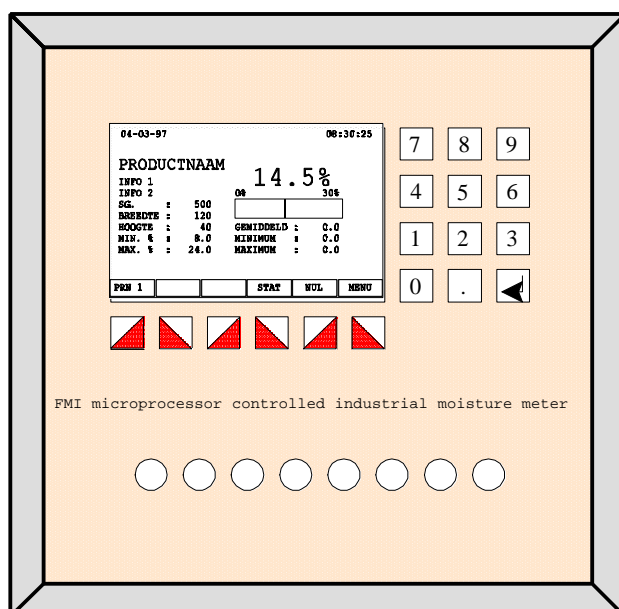
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1 Description of the FMI system

The FMI system consists of an operating unit with one or more contact-free sensors for measuring wood moisture. The FMI system can:

- *Determine the moisture content of wood in automated production lines and sorting installations.*
- *Measure while the wood is being transported and without the sensor having to make contact with the wood.*
- *Communicate with a PLC or PC for the processing of the measured data and the settings.*
- *Mark the wood measured based on the required moisture content for automatic grading or ejection.*

1.1 FMI operating unit



Picture 1 FMI Operating unit

The control electronics is installed in a sheet steel cabinet with an aluminium control panel and an optional perspex safety door with safety locks. The 6 mm thick safety door offers optimal protection against exposure and unauthorized operation. The cabinet as a unit is splash-proof.

The microprocessor controller consists of:

- *Graphic screen*
- *Keyboard with 18 keys*
- *On-Off Switch*
- *1 Digital input "Automatic zero-setting"*
- *1 Digital input "Start/Stop measuring"*
- *1 Relay output "Watchdog"*
- *1 Relay output "Wood moisture content higher than maximum level set"*
- *1 Relay output "Wood moisture content lower than minimum level set"*
- *1 Relay output "Real-Time" (FMI system with a longitudinal sensor only)*
- *1 Relay output "Alarm"*
- *1 Analogue output "Wood moisture 0(4)-20 mA / 0-10 Volts"*
- *1 Digital communication port "RS 232"*
- *1 Digital communication port "RS 485"*

An extensive software program operates the control electronics for the preparation of product programs. A product program consists of all the important characteristics of the product to be measured. The software is menu driven and has a capacity of 250 product programs. The settings for each product program are:

- *Type of wood (numeric and alphanumeric)*
- *Wood dimensions (metric or imperial)*
- *Specific weight of the wood at 0% wood moisture*
- *Calibration procedure I; calibrate on single or multiple planks*
- *Calibration procedure II; calibrate automatically or manually*
- *Batch information 1, for example lot number (numeric or alphanumeric)*
- *Batch information 2, for example user information (numeric or alphanumeric)*
- *Setting the maximum and minimum moisture content for marking wood which is either too wet or too dry*
- *Setting the moisture content levels of the statistics screen*
- *Setting the marking method according to peak, average or real-time moisture measurement*
- *Setting of analogue and digital output as well measuring screen according to peak or average moisture measurement*

The FMI system gives the following information when measuring:

- *Measuring screen: the average-, maximum-, minimum-, and real-time moisture content of each measured plank, and also the most important settings of the selected product program*
- *Statistics screen: a statistical overview of the measured moisture content of the batch with information of the number of planks measured per moisture content level*

The FMI can generate reports for each measured batch. For this the FMI has a communication port. Depending on the FMI software, the following reports are possible:

- *Reporting on a printer or PC*
- *Analyse of a batch on a PC*

1.2 FMI wood moisture sensor

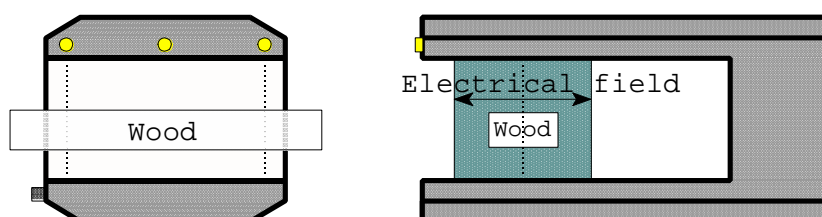
The microprocessor-controlled sensor measures the moisture content of the wood without any contact. To do this, the wood is fed through or over the sensor. The maximum speed of the wood may be as high as 600 metres/minute. The sensor measures the moisture content of the wood 400 times per second. The calibration of the sensor is fully automatic; there are no potentiometers in the sensor.

The FMI wood moisture sensor is available in four models:

- *“standard” longitudinal measurement*
- *“core” longitudinal measurement*
- *transversal measurement 400 mm*
- *transversal measurement 600 mm*

1.2.1 FMI sensor for longitudinal measurement “standard”

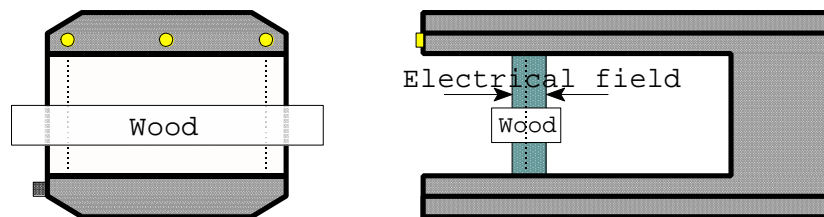
This FMI wood moisture sensor measures the moisture content over the entire length of the wood over a width of approx. 15 cm. The wood must be fed through the sensor in a longitudinal direction and move freely through the sensor. Movements in the height and width of the wood have virtually no influence on the wood moisture measurement. The sensor is fitted with two photocells, which determine accurately that wood enters the sensor, is in the sensor, or is leaving the sensor.



Picture 2 FMI wood moisture sensor for longitudinal measurement “standard”

1.2.2 FMI sensor for longitudinal measurement “core”

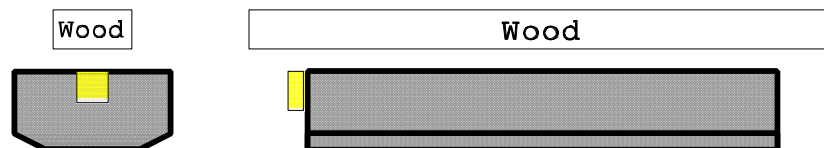
This FMI wood moisture sensor measures the moisture content over the entire length of the wood over a width of approx. 4 cm. The wood must be fed through the sensor in a longitudinal direction and move freely through the sensor. Movements in the height of the wood have virtually no influence on the wood moisture measurement. With core-type longitudinal measurement, the wood must travel through the centre of the sensor. The sensor is fitted with 2 photocells which determine accurately that wood enters the sensor, is in the sensor, or is leaving the sensor.



Picture 3 FMI wood moisture sensor for longitudinal measurement “core”

1.2.3 FMI sensor for transversal measurement

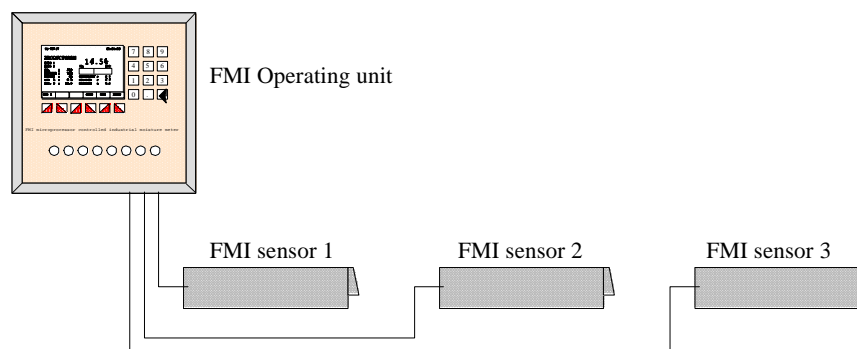
This FMI wood moisture sensor measures the moisture content over a width of approx. 6 cm over the entire length of the sensor. The wood must be fed crossways over the sensor. The wood must move freely over the sensor. Movements in height influence the wood moisture measurement. This is why fitting a top-guide is important. The sensor has one photocell which determines accurately when wood is fed over the sensor.



Picture 4 FMI wood moisture sensor for transversal measurement

The moisture content is measured over a length of 400 mm or 600 mm. If the moisture content needs to be determined over a greater length, more sensors must be interconnected. A maximum of 3 sensors (400 mm or 600 mm) may be linked together. Each sensor measures the moisture of the section of the wood which is positioned over the sensor. The average, maximum and minimum moisture contents are now calculated in the operating unit. The photocell on each sensor determines whether that sensor is active. The

sensor must be positioned in such a way that the photocell is free from the stop; this is to ensure that the photocell only sees wood when the entire sensor is covered. In the example below, the stop is located on the left-hand side.



Picture 5 FMI wood moisture measurement for transversal measurement using 3 sensors

2 Operation

This user manual contains an explanation of how to operate the industrial FMI wood moisture meter.

2.1 Keys

A foil keyboard with 18 keys and a backlit graphics LCD screen is fitted on the front plate of the operating unit. The LCD screen displays all the information about the status and settings of the FMI system. Depending on the screen displayed, the specific functions of the keys can be divided into groups. The groups are Function, Cursor, Numeric, Alphanumeric keys and the ENTER key.

2.1.1 Function and cursor keys

Keys F1 to F6 on the operating unit are the Function and Cursor keys. Depending on the screen displayed, each has a specific function. The section "Overview of key functions" contains a table of the functions of the function keys.

2.1.2 Numeric and alphanumeric keys

Keys 0 to 9 on the operating unit are the Numeric keys. These keys are used to enter a number.

Keys 0 to 9 also function as alphanumeric keys. The alphanumeric keys are used to enter numbers and letters. By pressing the key quickly in succession, the various letters and numbers can be entered. The section "Overview of key functions" includes a table of numeric and alphanumeric keys.

2.1.3 Enter key

The Enter key has the same functions as the OK key of the function keys. The section "Overview of key functions" includes a table with the enter key.

2.1.4 General

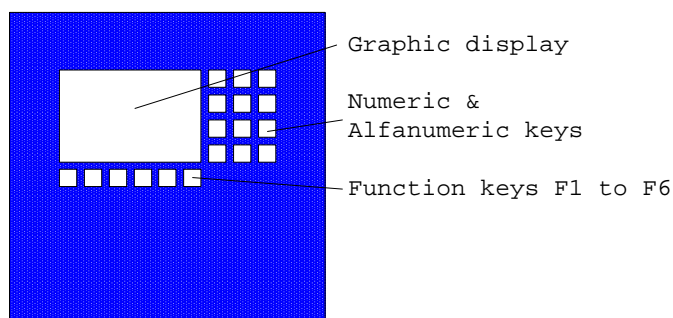
After a keystroke, the FMI operating unit communicates with the FMI sensor and all the settings are checked. During this process, the FMI operating unit does not accept keystrokes. The measurement screen and the reference screen will now display --.-%, instead of the moisture content as a percentage.

2.2 Illustrations

This user manual contains numerous illustrations of the LCD screen. Obviously, these only serve as examples. The practical values will differ for each application.

3 Operating unit

The operating unit is the nerve centre of the FMI system and is fitted with a graphics screen and a keyboard.



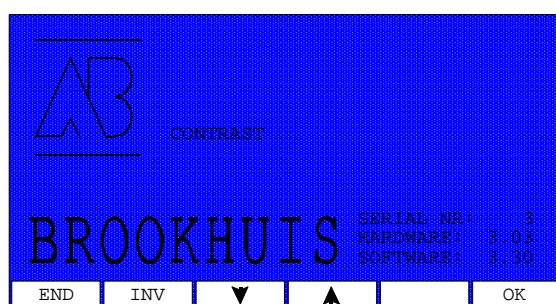
Picture 6 Operating unit

Function keys “F1” to “F6” are the software-controlled function keys, the functions of which are displayed on the screen. A description along with an explanation of the function keys is included in a table in the section “Overview of key functions.”

3.1 Switching on

When the FMI system is switched on, the Start screen is displayed for about 0,5 seconds.

The Start screen is for checking and setting the contrast of the graphics screen. The Start screen also displays the serial number, the hardware version and the software version of the operating unit.



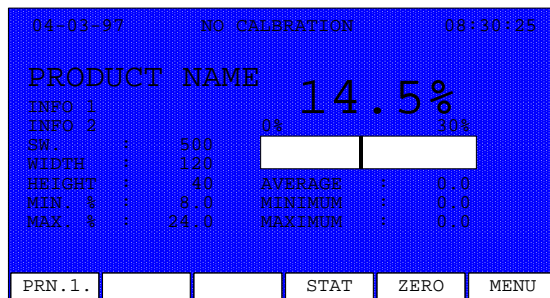
Picture 7 Start screen

3.2 Measuring

The FMI system measures the moisture content of the wood between (longitudinal measurement) or over (transversal measurement) the sensor plates continuously.

The FMI system automatically calculates the average moisture content when the wood leaves the sensor. If a “longitudinal measurement” type sensor is used, or when more than one “transversal measurement” type sensor is connected, the FMI system also computes the maximum and minimum moisture content of the wood.

3.2.1 Measurements screen



Picture 8 Measurements screen

The measurements screen is the main screen. It is the first screen that appears after the start screen. The measurements screen displays all the important information about the contact-free wood moisture measurement.

- *The digitally displayed moisture content and analogue bar graph display the actual moisture value of the measured material. If the wood is fed over or through the sensor too quickly, the value of the digitally displayed moisture content will not always be the true moisture content as this display is slow. The digital display is mainly used to measure wood that does not move. With the function “display mode” the digital value can also display the average or maximum moisture content.*
- *The average moisture content is only displayed when the measurement has been carried out correctly. When the wood is in the sensor for longer than one minute, the FMI system assumes that the wood is at a standstill and an average moisture content is not calculated.*
- *The minimum and maximum moisture content are only displayed when using “longitudinal measurement” type sensors and when more than one “transversal measurement” type sensor is connected.*
- *The text fields containing “PRODUCT NAME”, “INFO 1”, and “INFO 2”, and also the values for SW, WIDTH, HEIGHT, MIN. % and MAX. % are examples, and inform about the selected product program.*

- When a product program is not calibrated, the message “NO CALIBRATION” is shown.

3.2.2 Statistics screen

The statistics screen gives an overview of the moisture content of the measured wood. This data can be printed. The statistical overview gives a quick impression of the moisture content of a large amount of wood.

04-03-97		PRODUCT NAME		08:30:25	
< 08			3		1
08-10			55		18
10-12			36		12
12-16			6		2
16-20			0		0
> 20			0		0
AVG	9.78	STD	0.64	Σ	33
PRN.1.	RESET	PRINT	MEAS	ZERO	MENU

Picture 9 Statistics screen

The statistics screen displays the following information:

- The average moisture content (AVG) is the average of the number of moisture measurements up to that time (Σ).
- The standard deviation (STD) is the standard deviation calculated from the number of moisture measurements up to that time (Σ).
- The total batch is 100%. Per moisture content range, the percentage of the number of moisture measurements up to that time is calculated (Σ).
- The total batch is Σ . Per moisture content range, the number of wood sections is calculated from the number of moisture measurements up to that time.

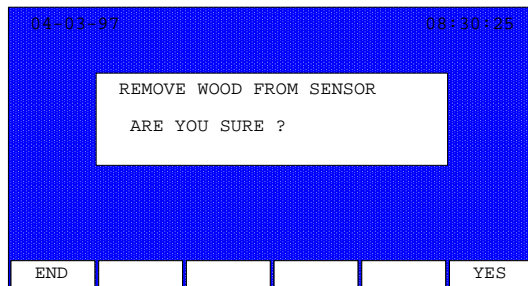
3.2.3 Zero screen

The zero screen compensates for sawdust and relative air humidity on the sensor. When “zero” is selected, it first asks the question of whether it is correct that there is no wood in the sensor.

04-03-97		08:30:25	
NO WOOD IN SENSOR ? ARE YOU SURE ?			
END			YES

Picture 10 Zero screen

When “yes” is now pressed and the photocells of the FMI sensor are still covered with wood or sawdust, the following screen will appear:



Picture 11 Remove wood from sensor

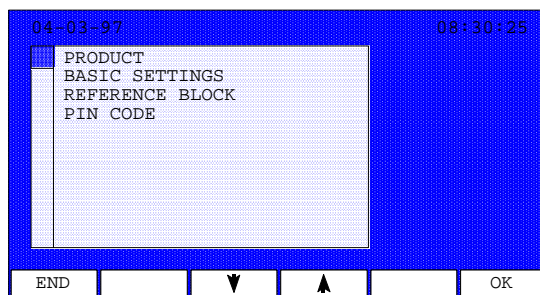
When the photo-cells no longer detect any wood or sawdust, zero setting will take place automatically.

Zero setting:

- *An external input allows automatic “zero setting”. When there is wood at the moment of an external zero setting, the zero setting will not take place and the display will jump back to the measuring screen.*

3.3 Menu

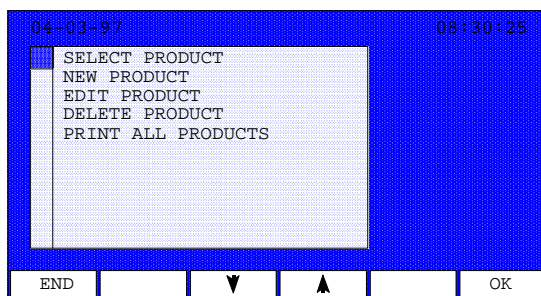
The menu screen gives access to the product programs, the settings of the FMI system, the calibration procedure with the reference block and the setting of the pin code.



Picture 12 Menu screen

3.3.1 Product screen

In the product screen, new products may be programmed. Then the products can be selected, changed or removed. If a printer is connected to the FMI system, all the programmed products can be printed.

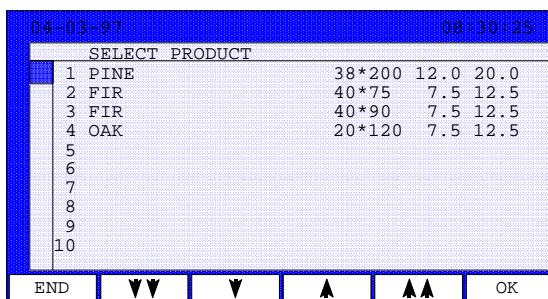


Picture 13 Product screen

3.3.1.a Select product

The product for which the wood moisture content must be determined is selected using the cursor keys. Only programmed product programs can be selected. In the Select product screen, the following can be displayed per product line:

- Number and name of the product program
- Height and width of the wood to be measured
- Minimum and maximum moisture content



Picture 14 Select product

The product program selected is activated by pressing the “OK” key. As a check, the complete information for the chosen product is displayed on the screen.

04-03-97		08:30:25	
NAME	:	FIR	
HEIGHT	:	38	
WIDTH	:	200	
SPECIFIC WEIGHT	:	460	
USER INFO 1	:	WOOD FROM SWEDEN	
USER INFO 2	:	DRIED TO 16%	
MINIMUM VALUE	:	12	
MAXIMUM VALUE	:	20	
CORRECTION Ax+B	:	1.00 0.00	
MARKING	:	PEAK VALUE	

END			SW	OK
-----	--	--	----	----

Picture 15 Overview of Select Product

- If it appears that the product program chosen is not the correct one, the “end” key can be pressed, which will return to the previous screen.
- If a large amount of wood has a different specific weight from that of the calibrated product program, the specific weight can be edited using the “SW” key. The correction for the newly set specific weight now occurs fully automatically. The new value set for the specific weight remains in force as long as the product program chosen is active. However, the calibrated product program remains unedited.

3.3.1.b New product

When a “new product” is chosen, the cursor automatically moves to the next product number which has not yet been programmed. The procedure for programming a new product program is explained in the appendix “Product programs”.

04-03-97		08:30:25	
SELECT PRODUCT			
1	PINE	38*200	12.0 20.0
2	FIR	40*75	7.5 12.5
3	FIR	40*90	7.5 12.5
4	OAK	20*120	7.5 12.5
5			
6			
7			
8			
9			
10			

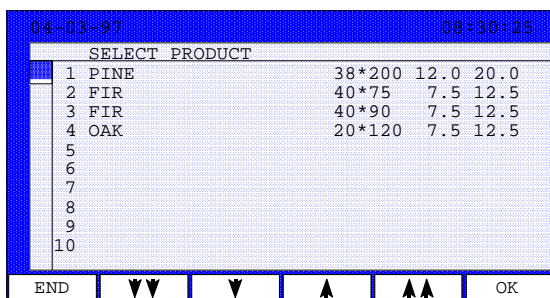
END	▼▼	▼	▲	▲▲	OK
-----	----	---	---	----	----

Picture 16 New product

3.3.1.c Edit product

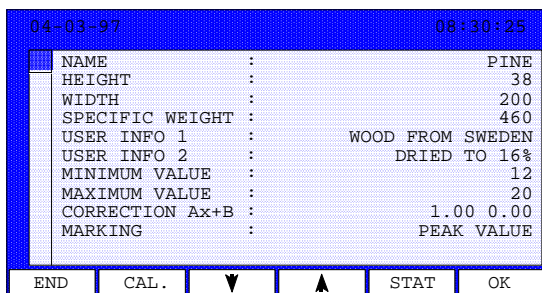
When it appears that a product program needs to be edited, because, for instance, the measurements are incorrect, the name is incorrect, a new calibration procedure has to be carried out, or for whatever reason, the

option “edit product” must be chosen. The product program to be edited must be chosen using the cursor keys.



Picture 17 Edit product

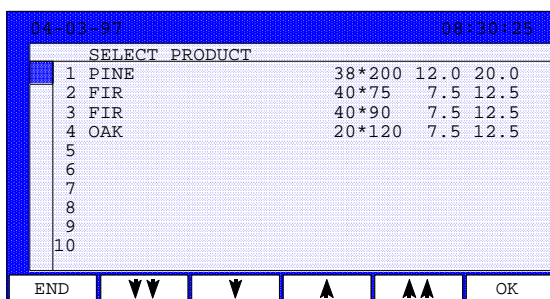
The product program chosen is activated by pressing the “OK” key. Now the full information of the product program chosen appears on the screen, which may be changed per item. The procedure for editing a product is explained in the appendix “Product programs”.



Picture 18 Overview edit Product

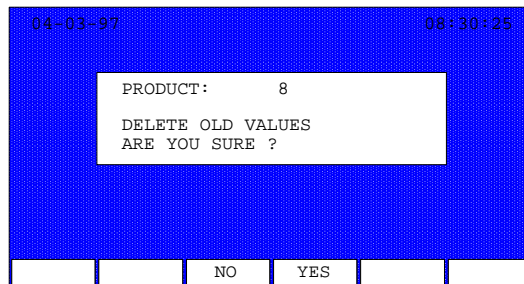
3.3.1.d Delete product

When a product is no longer used, it can be deleted from the list of programmed product programs. The program to be deleted is chosen using the cursor keys.



Picture 19 Delete product

The chosen product is activated using the “OK” key. Before the FMI system actually deletes the product program, confirmation is required.



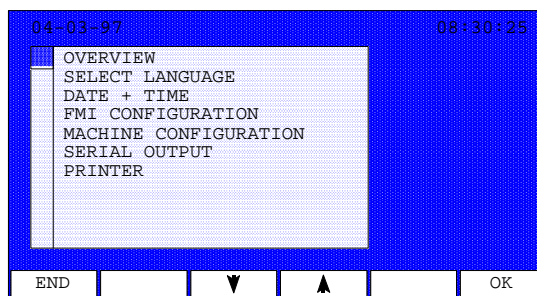
Picture 20 Delete OK?

3.3.1.e Print all products

With the “print all products” function, all product programs with their individual settings are printed if a printer is connected.

3.3.2 Basic screen

The basic screen displays an overview of the basic setting options within the FMI system.

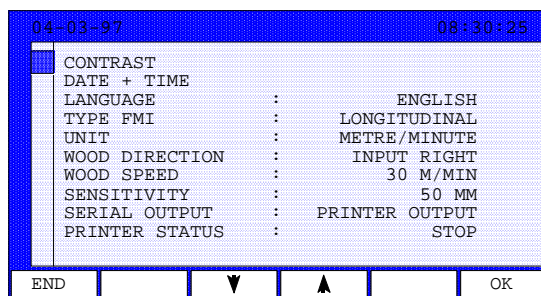


Picture 21 Basic settings

- *De choice “printer” is only visible when this option is selected in “serial output”.*

3.3.2.a Overview

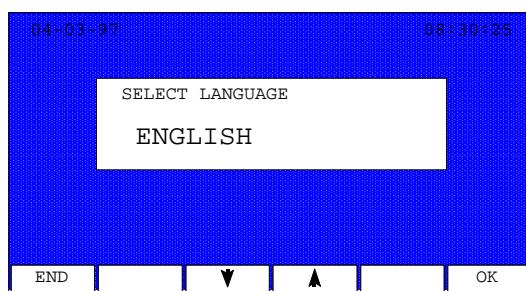
The “overview” option displays the basic settings. These settings can be changed by selecting an option using the cursor keys followed by pressing OK.



Picture 22 Overview of settings

3.3.2.b Language

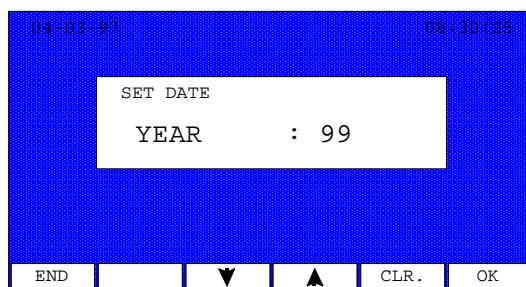
The “Language” option refers to the language of the screen texts. Depending on the type of FMI system, a number of languages can be selected.



Picture 23 Select a language

3.3.2.c Date + Time

The internal clock of the FMI system is set with “Date + Time”.



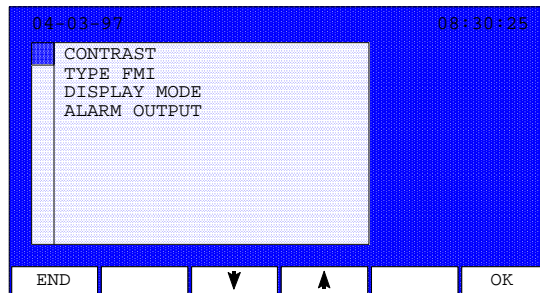
Picture 24 Setting date and time

- When the year has been set, the month, day, hours, minutes, seconds and date format can be set.

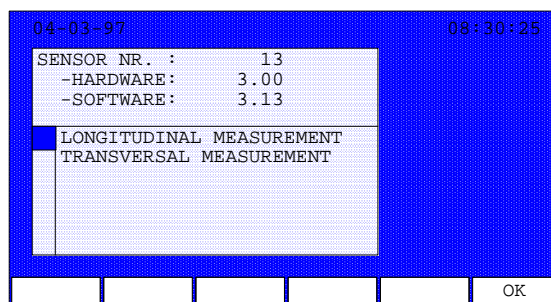
3.3.2.d FMI configuration

The “FMI configuration” option activates the following functions:

- *The contrast of the screen can be set.*
- *The information about the sensor(s) connected to the FMI system can be displayed.*
- *The display mode can be set.*
- *The alarm output can be activated.*



Picture 25 FMI configuration screen



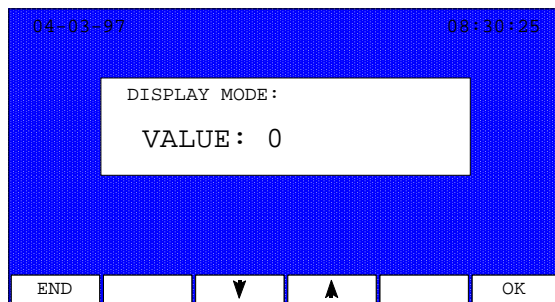
Picture 26 FMI configuration

The “FMI type” option displays the following information:

- *Serial number of the sensor*
- *Hardware version number of the sensor*
- *Software version number of the sensor*
- *Design of the sensor, longitudinal or transversal measurement*

The “Display mode” option provides the input screen for setting the display mode:

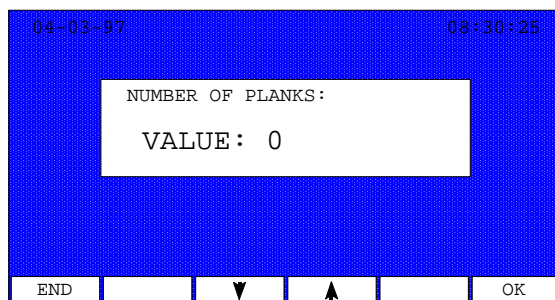
- *The “0” option provides the continuously measured moisture content in the measurement screen and the “1” option gives the result of the moisture measurement. Depending on the choice in the product program selected, this can be the average of highest measured moisture content.*



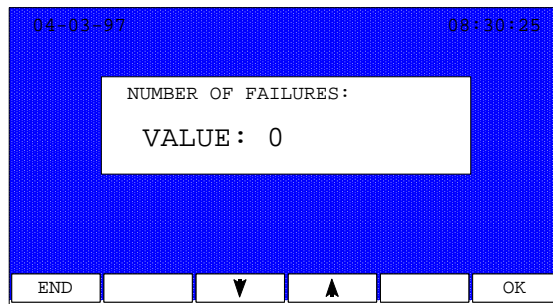
Picture 27 Display mode

The alarm output is activated when the total number of defective planks is larger than the value entered for “total defects” in relation to the value of entered for “total planks”.

Firstly, the total number of planks to be measured is entered, and then the total number of defective planks. The alarm output is automatically switched off as soon as the following good plank enters.



Picture 28 Alarm output - number of planks

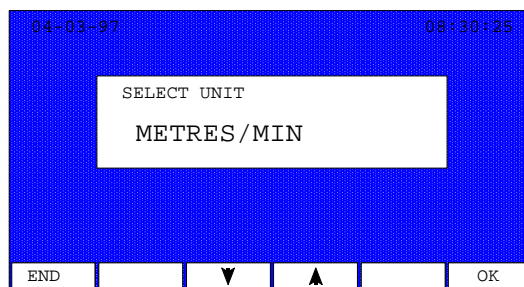


Picture 29 Alarm output - number of failures

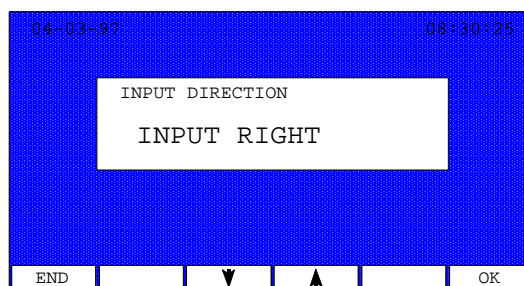
3.3.2.e Machine configuration

The “Machine configuration” option activates the following functions:

- *The unit for the speed of the wood*
- *The feeding direction in the sensor*
- *The speed of the wood*
- *The sensitivity*

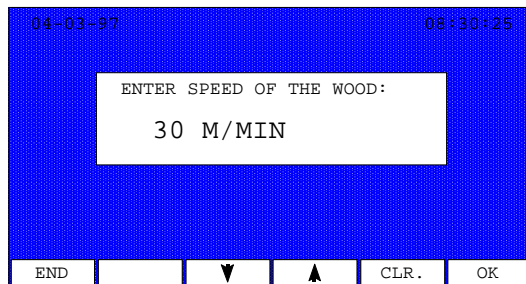


Picture 30 Unit for speed of the wood



Picture 31 Feeding direction

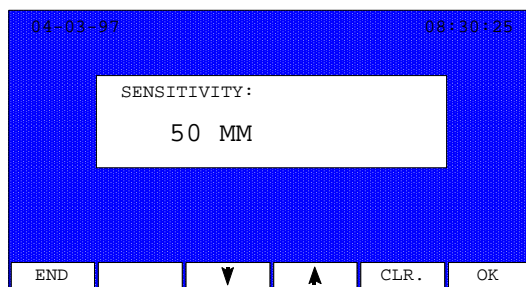
- This setting is for the longitudinal sensor only.



Picture 32 Setting the speed of the wood

Mark:

- The length marked for wood which is either too wet or too dry is related to the speed of the wood set.
- The sensitivity of the length of wood to be measured is related to the speed of the wood set.
- When the wood speed is variable, the highest possible wood speed is entered for wood speed.



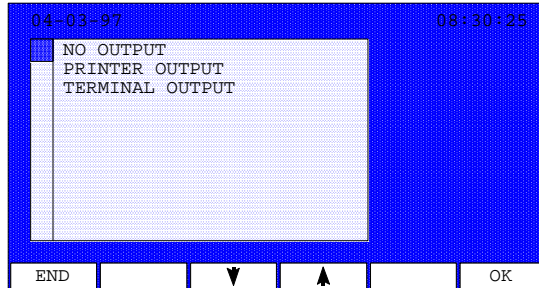
Picture 33 Setting the sensitivity

Sensitivity:

- The sensitivity suppresses for the influence of knots and finger joints in the wood.
- The sensitivity is the length or width of the wood, of which the FMI calculates the average wood moisture content. When the speed of the wood varies, the sensitivity is entered in this screen for the length of which the FMI calculates the average moisture content at the highest wood speed. The maximum value for the sensitivity may not be more than half the board length (longitudinal) or half the board width (transversal).

3.3.2.f Serial port

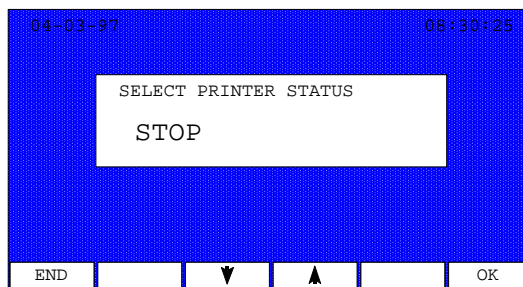
The FMI system offers the option to send data to a Printer or a PC. This option can be selected in the serial port screen.



Picture 34 Selection of serial output

3.3.2.g Printer

When the port has been set for serial, the “printer” screen will display the status of the printer control. If required, the status can be changed using the cursor keys.

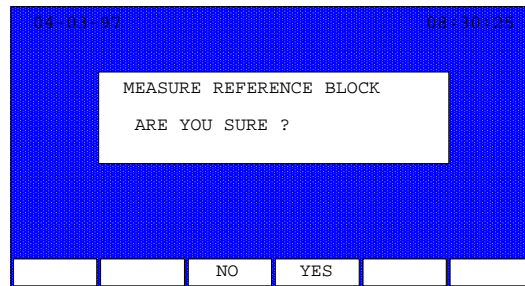


Picture 35 Set printer and display status

- *The PRN.1 option shows that the FMI has been entered as a logger. All settings and measurements are then automatically printed. If the “PRINT” key is pressed in the statistics screen, a statistical overview is printed.*
- *If PRN.0 is chosen, no data is printed and the FMI does not operate as a logger. If the “PRINT” key is pressed in the statistics screen, the selected product program is printed with a statistical overview.*

3.3.3 Reference screen

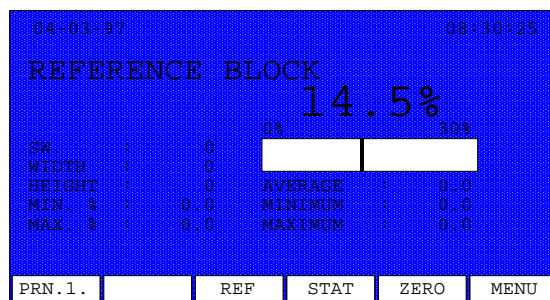
In order to check whether the FMI system is calibrated correctly, a reference block is required. After proper installation and calibration, the FMI system must indicate the correct moisture content on the screen as it is marked on the reference block.



Picture 36 Measure reference block

3.3.3.a Measure reference block

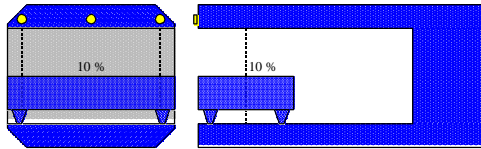
The reference screen is almost identical to the measurement screen, the main difference being the function key “REF”. This key is used to calibrate the FMI system to the value of the reference block.



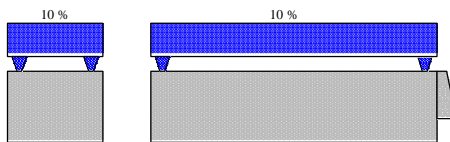
Picture 37 Reference screen

With no wood or reference block in or on the sensor, the reference screen should indicate 0.0%, with the reference block the screen must display the value which is indicated on the reference block.

- *The display mode must be set to “display mode 0”.*



Picture 38 Reference block in longitudinal sensor

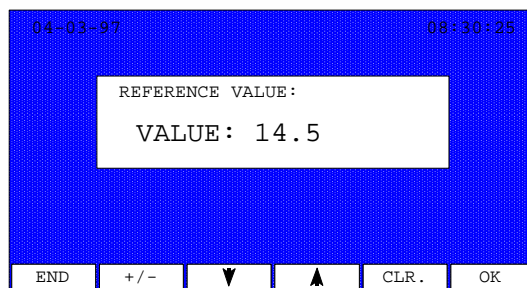


Picture 39 Reference block in transversal sensor

Accuracy:

- *The maximum deviation may not exceed approx. 0.3%.*

3.3.3.b Calibration using reference block

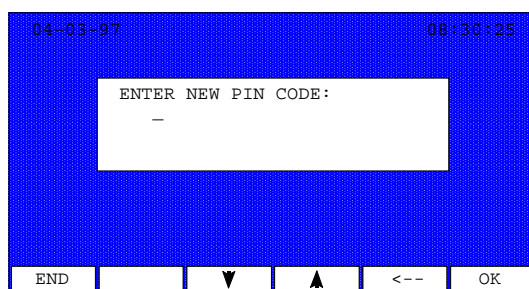


Picture 40 Set the reference block

Enter the value of the reference block and press OK. Before the reference block can be measured, the system must first be zeroed. In order to do this, the sensor may not contain any wood or the reference block.

3.3.4 Pin code screen

If the FMI system is not set correctly, the measurements may be corrupt. To prevent anyone from being able to change product programs or settings, the FMI system offers the option of screening the most important functions through a pin code. This pin code is entered in the pin code screen.



Picture 41 Entering the pin code

Entering the pin code:

- The pin code may comprise a maximum of 10 figures.
- The pin code screen appears with the options “new product”, “edit product”, “delete product”, “basic settings” and “edit the reference settings”. When an incorrect pin code or when no pin code is entered, the measurements screen is displayed without any settings having been changed.
- When a new pin code is entered, it has to be entered twice, as confirmation.
- When a pin code is to be changed, the old pin code must first be entered.
- In order not to activate the pin code system, nothing must be entered when prompted to enter a “new pin code”. This selection is confirmed with the “OK” key. From now on, none of the menus are protected by a pin code.
- When a pin code has been lost, the pin code protection can be switched off by entering the factory code. This factory code is listed on the packing slip of the FMI system.

4 Overview of key functions

In this section, the functions of the various keys on the operating unit of the FMI system are explained.

4.1 Function keys

The function keys are displayed on screen. Their functions are listed in the table below.

Key	Function
+/-	Enter minus number
CAL	Calibration procedure
CLR.	Delete the number or text entered
END	Go back to the previous screen, or return to the measurement screen
INV	Screen is inverted
MEAS	Go to the measurement screen
MENU	Go to the menu screen
NO	Not OK with selection made, operation not carried out, negative confirmation of a question
OK	Confirm selection and go to the next screen
PRINT	Print statistical overview
PRN 0	Printer is switched off, press this key to change status
PRN 1	Printer is switched on, press this key to change status
PRN P	Printer is paused, press this key to change status
REF	Set and calibrate with reference block
RESET	Reset counter for statistical overview
STAT	Go to statistics screen, key in moisture content values of statistic screen
SW	Input for specific weight
YES	OK with selection made, operation carried out, positive confirmation of a question
ZERO	Zero manually

4.2 Cursor keys

The cursor keys are displayed on this screen. The functions are explained in the following table

Key	Function
↓	Reduce contrast (contrast screen) Go down one position (selection screen) Lower a number by one unit (entry screen)
←	When entering figure or number, go back one digit
↑	Increase contrast (contrast screen) Step up one position (selection screen) Increase a number by one unit (entry screen)
⇓	Go to the next page (selection screen)
⇑	Go to the previous page (selection screen)

4.3 Numeric and alphanumeric keys

The numeric and the alphanumeric keys can be found next to the screen. The table below lists their functions.

Key	Function	
	Alphanumeric	Numeric
0	0	0
1	S, T, U, 1	1
2	V, W, X, 2	2
3	Y, Z, space, 3	3
4	J, K, L, 4	4
5	M, N, O, 5	5
6	P, Q, R, 6	6
7	A, B, C, 7	7
8	D, E, F, 8	8
9	G, H, I, 9	9
.		.

4.4 Enter key

The enter key is located next to the screen. Its function is explained in the following table.

Key	Function
↵	OK, acknowledge the selection and go to the next screen

5 Product Programs

The FMI system is a programmable wood moisture measurement system. This means that the system is already prepared for measuring wood moisture, but specific product data still have to be entered. This product data is stored in what is known as product programs. The memory of the FMI system can accommodate a total of 250 of these programs.

5.1 Creating a new product program

In the "measurement screen", the "menu screen" option is selected; in the "menu screen", the "product screen" option is selected, and in the "product screen", the "new product" option is selected. The cursor will now move to the next empty position in the "select product" screen. The number that appears next to the cursor is the number of the new product program. If now "OK" is pressed, the procedure for creating a new product program will start.

5.1.1 Enter product name

You can now enter a product name, which may have a maximum of 16 characters. It is usual to key in the type of wood here.

- *The product name is entered using the alphanumeric keys. By repeatedly pressing one of these keys, the characters as stated in the table of numeric and alphanumeric keys are displayed consecutively. These characters are also marked on the keys. The letters are represented first (alphanumeric characters), and then the figures (numeric characters). The "←" key can be used to delete each last character.*

5.1.2 Product height key

Product height is the thickness of the wood to be measured.

5.1.3 Product width key

Product width is the width of the wood to be measured.

5.1.4 Specific weight key

The specific weight is the average specific weight of the wood at 0% wood moisture. The FMI system takes account of the specific weight for an optimum wood moisture measurement. The specific weight of the wood to be measured can be calculated by dividing the weight (in kg) by the volume (in m³). There are also tables available in which the specific weight of wood is listed per type of wood and per felling area. When two specific weights are indicated, the average specific weight of the relevant wood type is taken.

5.1.5 User information keys 1 and 2

User information keys 1 and 2 give further information about the product to be measured. This could be a supplier or customer, for example, or a comment about the product, such as whether it is finger-jointed, or whether the batch is of a certain quality.

5.1.6 Minimum wood moisture content key

The FMI system can grade wood for minimum moisture content. The wood to be measured may not be drier than the minimum moisture content entered. If the wood is drier, a relay is automatically activated. This relay operates a marker unit or an ejection mechanism.

5.1.7 Maximum moisture content key

The FMI system can grade wood for maximum moisture content. The wood to be measured may not be wetter than the maximum moisture content entered. If the wood is wetter, a relay is automatically activated. This relay operates a marker unit or an ejection mechanism.

5.1.8 Enter Statistical screen

The FMI system shows the measured moisture content in a so called statistical screen with 6 levels. For each product program, these levels can be programmed. With DEFAULT, the standard settings are chosen. By keying the arrow key, the selection MANUAL can be selected. With OK the selection will be made. The levels can be modified according to the following schema:

- From 0% until moisture level 1
- From moisture level 1 until moisture level 2
- From moisture level 2 until moisture level 3
- From moisture level 3 until moisture level 4
- From moisture level 4 until moisture level 5
- From moisture level 5 until 100%

Option “MANUAL”: The value in the display is the value for a range in the statistics screen. With the first value the lowest range is mentioned, with the following value the next etc. The values to key in must be whole numbers. The FMI system will increase the value automatically with 1 for the next range.

Option “STANDARD”: In the FMI system the levels 8, 10, 12, 16 and 20% are preprogrammed.

5.1.9 Select marker method

If the measured wood moisture content is lower than the set minimum or higher than the set maximum, the “minimum” and “maximum” wood moisture content relays, respectively, will be activated. There are three marker possibilities: average, peak value or real time. In case of an FMI System with one transversal sensor, the marker setting will be peak value only.

5.1.9.a Average marker method

With the “average” marker method, there is one mark for each plank measured. The wood moisture content is measured and then the average moisture content calculated. If the average moisture content is lower than the set minimum or higher than the set maximum, a mark will be applied at the end of the measured plank.

5.1.9.b Peak value marker method

With the “peak value” marker method, there are two markers for each plank measured. The wood moisture content is measured and then the highest and lowest values are calculated. If the moisture content is higher than the set maximum or lower than the set minimum, one or two marks, respectively, are applied to the end of the measured plank.

5.1.9.c Real time marker method

With the “real time” marker method, the relays for minimum and maximum wood moisture content continuously follow the moisture content being measured. If the wood moisture content is lower or higher than the set minimum or maximum values, the appropriate relay is shortly activated. The relay will be activated again when the moisture content is 0.2% higher than the minimum moisture content set or 0.2% lower than the maximum moisture content set.

5.1.10 Calibration number key

At least 10 planks are needed for satisfactory calibration of a product program. Here, the number of planks used for the calibration of the product program are keyed in.

5.1.11 Select calibration method

To calibrate a product program, automatic or manual wood feed is selected. The choice of calibration method will depend largely on the set-up of the machine.

5.1.11.a Automatic calibration method

Each plank used for calibration is passed through or over the sensor, one after the other. The sensor automatically recognizes and counts the wood. Calibration is finished when the last calibration plank has passed the sensor.

5.1.11.b Manual calibration method

Each plank is placed in or on the sensor by hand and confirmed on the screen of the operating unit. Calibration is finished when the last calibration plank has passed the sensor.

5.1.12 Zero

Before calibration is started, the FMI system must be set to zero. When this is done, no wood may be in or on the sensor.

5.1.13 Key in wood moisture content, then place wood in sensor

Before the calibration wood goes through or over the sensor, the moisture content of these planks must be entered.

5.1.13.a Automatic wood feed

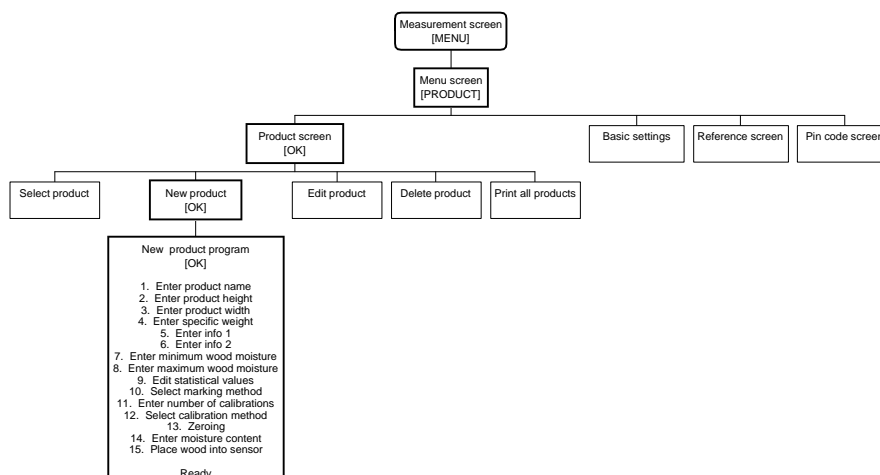
In the case of automatic wood feed, the previously measured moisture content of all planks used for calibration are entered and consecutively measured by the sensor. A counter on the screen shows the number of planks measured.

5.1.13.b Manual wood feed

In the case of manual wood feed, the moisture content of each plank used for calibration is entered and measured. A counter on the screen shows the number of planks measured. The screen on the operating unit shows exactly which action has to be performed.

5.1.14 Overview of “new product program”

The overview below shows the actions required for creating a new product



Picture 42 Prepare new product program

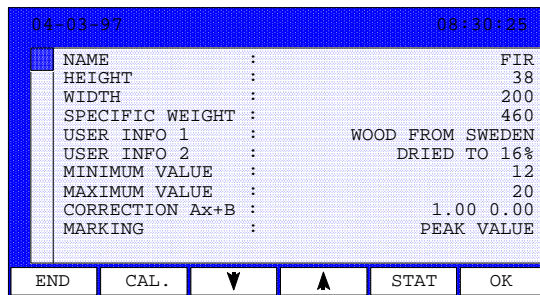
5.2 Editing a product program

When a product program has been prepared and it appears that certain data need to be changed, the product program may be edited.

The “menu” option is chosen from the “measurement screen”, the “product” option from the “menu screen”, and the “edit product” option from the “product screen”. Now the cursor jumps to the first item in the “select product screen”. The product that is to be edited is selected using the cursor. Now the relevant program number is displayed. If the “OK” key is now entered, the procedure to edit the product program will be started.

5.2.1 Overview of product program

The “product program overview” screen shows all the settings of the selected product program. The cursor key is used to go to the position that requires editing. With the “OK” key this choice is confirmed, and retrieve the screen to carry out the editing. The method for this is the same as that for creating a new product program.

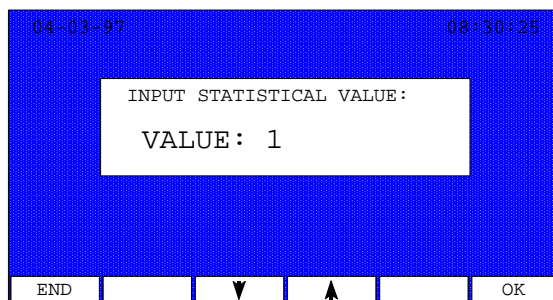


Picture 43 Edit product program

If data is edited, the FMI system will ask for it to be saved as soon as the editing has been completed. If the name, height, width or specific weight are changed, the FMI system will also ask whether the product is to be recalibrated. There is no obligation to do so, as a certain setting may simply have been wrongly typed, for instance.

5.2.2 Statistic values

By pressing the STAT key, the values of the statistical screen can be edited for the corresponding product program.



Picture 44 Setting of statistical values

With DEFAULT, the standard settings are chosen. By keying the arrow key, the selection MANUAL can be selected. With OK the selection will be made.

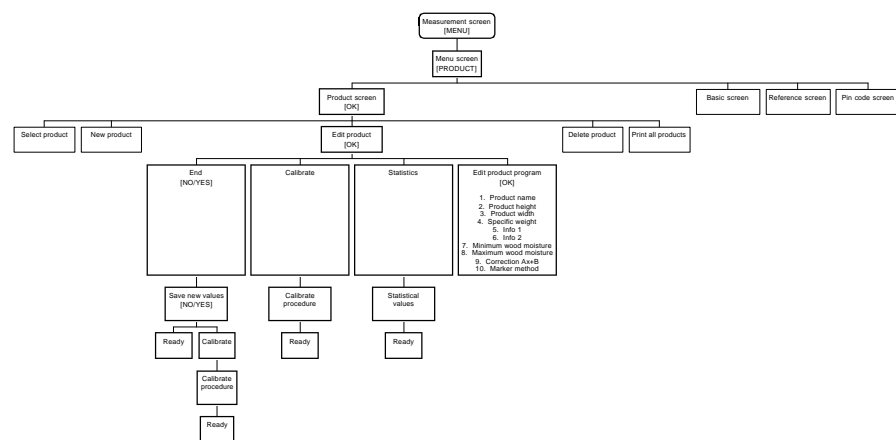
5.2.3 Ax+B Correction

If it appears that the measurements of the FMI system can be further optimized, the FMI system offers the option of correcting calibrations already saved by means of an amplification factor (A) and an offset factor (B). The mathematical procedure for this is known as linear regression. The FMI system allows this procedure to be carried out automatically. The “measurement optimization” appendix explains this on the basis of

measurement results and the linear regression function. As long as the values for A and B are 1.00 and 0.00, respectively, no correction has taken place. When a product program is calibrated, the values for A and B will be set to 1.00 and 0.00 automatically.

5.2.4 Overview “edit product program”

In the following diagram, all the actions required to edit a product program are indicated.



Picture 45 Edit product program

Appendix - FMI calibration

Each product program in the FMI system must be calibrated to the correct wood moisture content.

Since wood is a natural product of inhomogeneous composition, variations in the electrical conductivity and capacity may occur even in wood samples of the same wood type with identical moisture content and temperature.

Electrical moisture meters measure the wood moisture content locally. You must ensure that the moisture content of the wood to be measured is distributed homogeneously. This means that large differences in moisture may not exist when measuring in length, width or depth.

By calibrating the FMI system through measurements on a minimum of 10 planks from different trees, the program will be calibrated optimally for the average result of those measurements. In the drying oven test, the moisture measurement can be checked and if required, optimized.

FMI calibration using FME or FMD-Plus moisture meter

The FME and FMD-Plus moisture meters are instruments which operate according to the resistance method. Two measuring probes are used at a specific location and a specific depth to measure the wood moisture content.

The FME and FMD-Plus moisture meters are set to the correct wood type. The wood temperature is entered or measured using the optional temperature probe. The FMD-Plus moisture meter has a memory for 1000 measurement values, the FME moisture meter for 50. In addition, the FMD-Plus moisture meter is equipped with a serial port for the moisture content measured to be printed with the statistical overview.

Calibrating FMI using an FMW moisture detector

The FMW moisture detector is an instrument operating by the capacitive method. The average moisture content is measured over an area of approx. 2 x 2 cm and to a depth of approx. 2.5 cm. The FMW moisture detector does not damage the wood. The surface of the wood must be smooth.

The FMW moisture detector is set to the correct specific weight. Temperature correction is not required as long as the wood is not frozen. The FMW moisture detector has a memory of 50 measurement values and a "highest value" (peak hold) value.

FMI calibration using the drying oven

Determining the moisture content by drying and weighing is the drying oven method. Here, a wood sample weighing between 100 and 200 grams is first weighed and then dried in a drying oven at 102 to 105°C, then the dry samples are weighed again.

The drying oven method determines the average moisture content of a wood sample. If the sample contains a large proportion of resins - for instance in the case of fir - the resins will also evaporate in the drying oven causing the result to be inaccurate.

Appendix - Setting specific weight and dimensions

The moisture measurement of the FMI system is largely dependent on the specific weight and the dimensions of the wood. In order to perform a moisture measurement using the FMI system, the specific weight and the dimensions of the wood must first be keyed in.

Specific weight

The greater the specific weight of the wood entered in the FMI system, the lower the moisture content the FMI system will indicate and the smaller the variances will be. If a specific weight is entered incorrectly, the accuracy of the moisture measurement with the FMI system will be affected. This is why entering the correct average specific weight of the wood from a certain felling area in each production program is very important.

Dimensions

The larger the width and thickness of the wood set in the FMI system, the higher the moisture content that will be displayed. Consequently, wood of varying dimensions cannot be measured with the same product program.

Appendix - Optimizing measurements

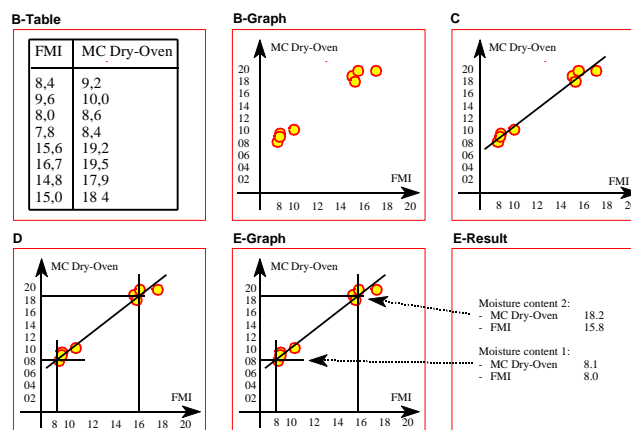
A simple linear regression function has been built into the FMI system. Using this function, the system can independently apply a correction factor to the moisture content measured. This method is called “practical optimization method” of the measurements with the FMI system.

Using this mathematical “linear regression” function, the measurements with the FMI system can also be optimized. A spreadsheet program such as MS Excel, Lotus 123 or Corel Quattro Pro has this “linear regression” functionality. We call this method “theoretical optimisation method” of the measurements with the FMI system.

Linear regression: “Practical method”

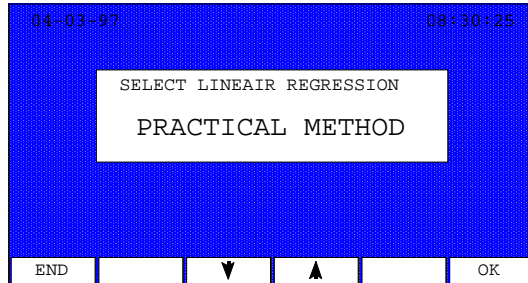
When, on the basis of the comparison measurements between, for instance, the drying oven method and FMI, it appears that there is room for improvement in the results for a certain product program, the practical approach of the linear regression method is a convenient solution. The procedure is very simple and can be described as follows:

- A number of comparison measurements between the drying oven or a manual system and FMI are performed. The values for “Correction $Y=aX+b$ ” must be $a=1.00$ and $b=0.00$.
- These measurements are recorded in table format and plotted.
- A straight line is drawn between the measurements that best match the measuring results.
- Then two points are selected in the graph that represent the FMI measurements which are at least 5% apart.
- The lowest moisture content of the FMI is then called “moisture 1”, and the highest moisture content of the FMI is then “moisture 2”.



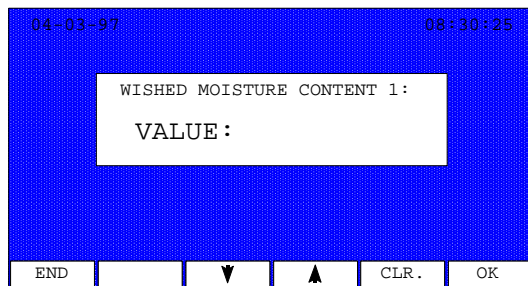
Picture 46 Overview of practical linear regression

The practical linear regression result can now be entered into the product program. In order to do so, select “edit product”, and select the product program for which the calculation was done and then select “practical method”.



Picture 47 Select linear regression method

Now enter the outcome for moisture-1 and moisture-2 respectively.



Picture 48 Practical linear regression settings

The edited product program now contains the optimized calibration data, provided the option “save” was chosen under option “end”.

Linear regression: “Theoretical method”

Linear regression draws a straight line between the “Y” value determined through the drying oven process and the “X” value as measured with the FMI system. The formula for linear regression is:

$$Y_i = a * X_i + b$$

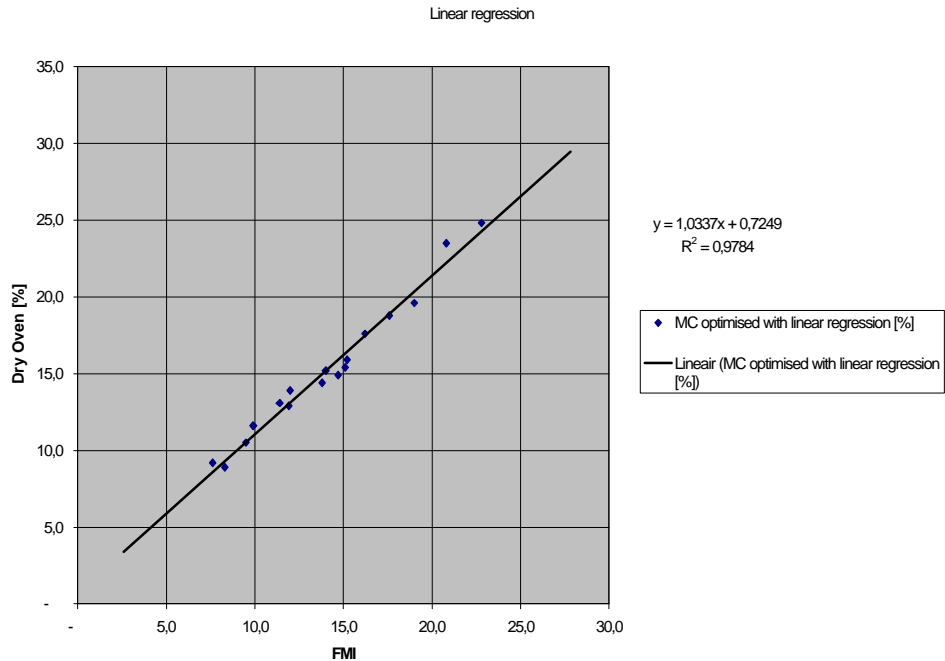
- Y_i is the i -value for Y and X_i the i -value for X .
- The expected Y for a given X , is $b+a*X$.
- The offset (intercept) is b , this is the expected value of Y when $X=0$
- The gain (slope) is a , this is the increment of Y for a given X .

Example of linear regression

Assume that a number of moisture measurements were carried out with the FMI system which are compared with the measurements from the drying oven test. It now appears that the results of the measurements with the FMI system could be improved. A table is then made in a spreadsheet program as indicated below.

MC measured by FMI [%]	MC according to dry oven [%]	MC optimised with linear regression [%]
7,6	9,2	8,6
8,3	8,9	9,3
9,5	10,5	10,5
9,9	11,6	11,0
11,4	13,1	12,5
11,9	12,9	13,0
12,0	13,9	13,1
13,8	14,4	15,0
14,0	15,2	15,2
14,7	14,9	15,9
15,1	15,4	16,3
15,2	15,9	16,4
16,2	17,6	17,5
17,6	18,8	18,9
19,0	19,6	20,4
20,8	23,5	22,2
22,8	24,8	24,3

- In the column "Moisture content determined with FMI system", the moisture values measured with the FMI system are entered
- In the column "Moisture content determined with drying oven" the moisture values determined by the drying oven tests are entered.
- In the column "Moisture content optimized through linear regression", the corrected FMI moisture measurements are generated according to the formula "Moisture content FMI * a + b".



Picture 49 Linear regression

According to the “linear regression” formula, the “X-coefficient” is value “a” (gain factor in the FMI system) and the “Constant” value “b” (offset in the FMI system). These values can be entered into the FMI system with two-digit accuracy. To do this, select “edit product”, and select the product program for which the computation was carried out and now select “theoretical method”. Then select the option “Correction Ax+B” and enter the values for a and b respectively.

04-03-97
08:30:25

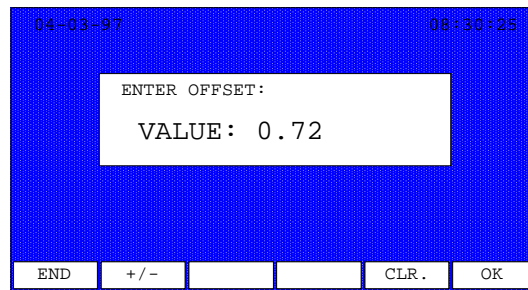
ENTER GAIN:

VALUE: 1.03

END
+/-

CLR.
OK

Picture 50 Gain factor a

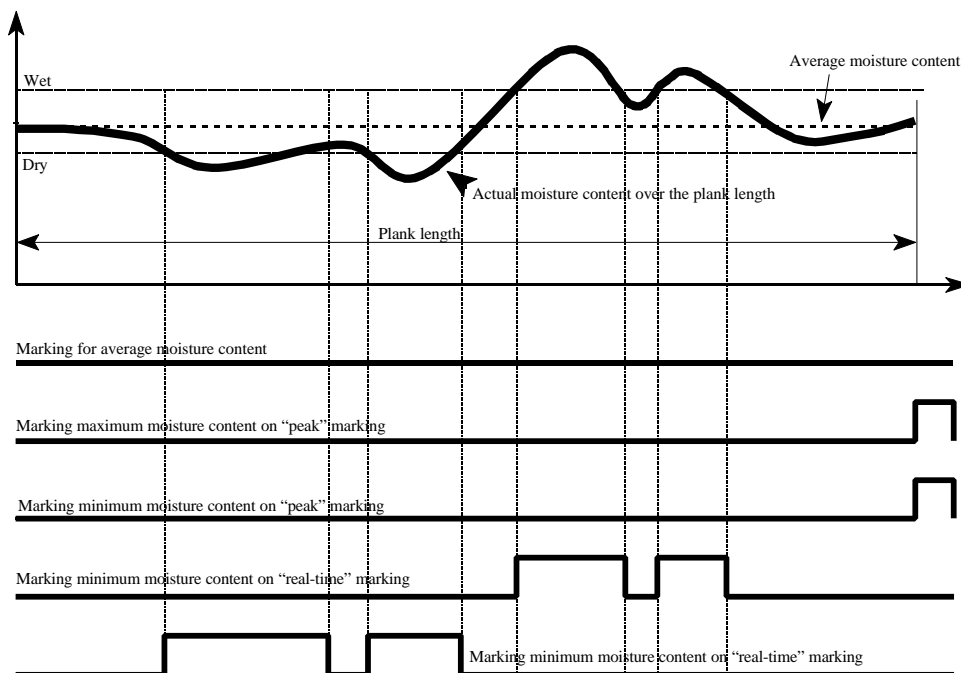


Picture 51 Offset factor b

The edited product program now contains the optimised calibration data provided the option “save” is selected under “end”.

Appendix - Marking in the FMI system

To explain the marking function in the FMI system type “longitudinal measurement”, the following figure illustrates how the moisture content may vary over the length of a plank.



Picture 52 Explanation of marking method longitudinal measurement

In this illustration, the thick line is the current moisture content and the horizontal dotted line is the average moisture content over the entire plank length. The thin lines “Wet” and “Dry”, indicate the marking settings for the minimum and maximum moisture content.

Average marking

- In this example the “wet” and “dry” relay will not be switched in the case of average moisture content marking.

Peak marking

- In this example when the system is set to peak marking, both the “wet” relay and the “dry” relay will be switched at the end of the plank.

Real-time marking

- In this example when the system is set for real time marking, both the “wet” relay and the “dry” relay will be switched instantaneously when the relevant locations pass the sensor.

Sorting on 4 levels

In case the FMI system has the option “sorting”, each product program (with the FMI longitudinal system only for average MC) can sort the wood into 4 levels.

Level 1: $\text{FMI \%} < \text{minimum MC setting 1}$

Level 2: $\text{minimum MC setting 1} \leq \text{FMI \%} < \text{minimum MC setting 2}$

Level 3: $\text{minimum MC setting 2} \leq \text{FMI \%} \leq \text{maximum MC setting}$

Level 4: $\text{FMI \%} > \text{maximum MC setting}$

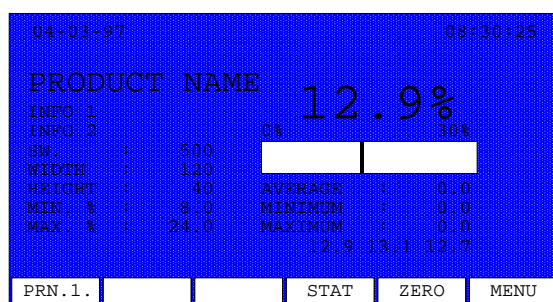
Appendix - Multiple Sensor Mode

When the FMI system is set in “multiple sensor mode”, the system operates with several sensors switched as one long sensor.

Each sensor measures the current moisture content, which is displayed by the system. The average current moisture content from all the sensors is calculated.

When the wood travels over the sensors, the measurement is carried out and the FMI system will calculate the average moisture content from the active sensors as well as the highest and lowest moisture content measured. A sensor is active if the photocell detects wood over the sensor.

Measuring screen



Picture 53 Measuring screen - Multiple Sensor Mode

Display Mode 0

Explanation measuring screen “Multiple Sensor Mode” in “Display Mode 0”

- 12.9 (large) The current average moisture content of the connected sensors
- Average The average moisture content of the wood measured by the active sensors
- Minimum The minimum moisture content of the wood measured by the active sensors
- Maximum The maximum moisture content of the wood measured by the active sensors
- 12.9 (left) Current moisture content of the first sensor
- 13.1 (centre) Current moisture content of the second sensor
- 12.7 (right) Current moisture content of the third sensor

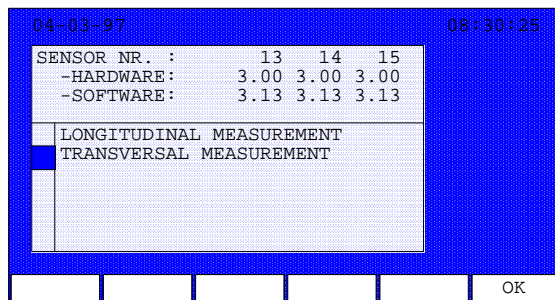
Display Mode 1

Explanation measuring screen “Multiple Sensor Mode” in “Display Mode 1”

- 12.9 (large) MC measurement according to setting of product program (average or peak MC)
- Average The average moisture content of the wood measured by the active sensors
- Minimum The minimum moisture content of the wood measured by the active sensors
- Maximum The maximum moisture content of the wood measured by the active sensors
- 12.9 (left) Not displayed
- 13.1 (centre) Not displayed
- 12.7 (right) Not displayed

When the moisture content of one of the sensors is less than 2%, the system will not accept the moisture content of that sensor although the photocell detected the wood.

Configuration screen

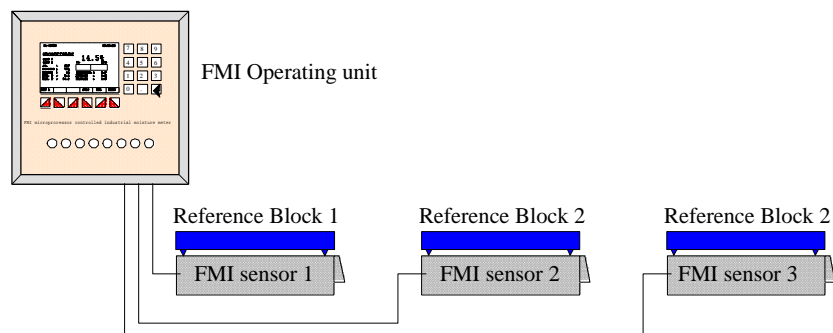


Picture 54 Configuration screen - Multiple Sensor Mode

The configuration screen of the FMI system in Multiple Sensor Mode displays the serial number as well as the hardware and software revision numbers of the connected sensors.

Calibration

In order to check the FMI system in Multiple Sensor Mode for correct calibration, each connected sensor will require a reference block. The calibration procedure is identical to the calibration procedure with one reference block.



Picture 55 Location of reference blocks for the FMI “transversal measurement” sensors

Settings of the FMI system

FMI control box

- Serial number:
- Hardware version
- Software version

FMI Sensor(s)

- Number of sensors
- Reference block(s) %
- Serial number(s)
- Hardware version(s)
- Software version(s)

FMI Settings

- Language
- Date and Time (European date) yes / no
- FMI configuration - Display mode 0 / 1
- FMI configuration - Alarm output ____ / ____
- Machine configuration - Unit m/min or feet/min
- Machine configuration - Feeding direction left / right
- Machine configuration - Speed
- Machine configuration - Sensitivity
- Serial output Printer / Terminal
- Terminal output mode

FMI Serial communication

- 9600 Baud, 8 Data bits, No parity, 1 Stop bit

Notes