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# Grain Moisture Analyzer PCE-A-315 INSTRUCTION MANUAL



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## General safety recommendations



The product is designed for industrial use. Installation and service must be carried out only by trained and authorized personnel and according to valid standards.



Before making any electrical connections, ensure that power supply voltage and frequency meet the specifications provided on the labels of devices and in this manual.

Incorrect connection may cause damage to the device. When installing, always refer to relevant safety regulations.



Before carrying out any welding work near the device, make sure that the device is disconnected from the power supply.



Do not use the device with damaged insulation of cables. In the case of damage to the cable, disconnect the device from the power supply and contact manufacturer or local dealer for cable replacement.



In case of device malfunction do not attempt to disassemble and repair the device. Please, contact manufacturer or local dealer for repair.



Take precautions when mounting the equipment by using appropriate lift gear, platforms and tools.

## 1. General information

The system of online moisture content measurement is designed for continuous measurement of current moisture content of grain products, oil or leguminous crops and other products at inlet and outlet of continuous flow grain dryers.



fig 1. System of online moisture content measurement

The system can be used for measuring moisture content of the following products:

<b>Grain:</b>	- wheat - barley - oats - triticale - rye - corn - buckwheat - millet - sorghum - rice	<b>Oil crops:</b>	- rape - sunflower - jojoba
<b>Leguminous crops:</b>	- peas - lupine - soybean	<b>Other:</b>	- seaweed - coffee

The system of online moisture content measurement consists of two A315 microwave moisture sensors and control panel (fig. 1). One moisture sensor is installed at the inlet of dryer and another is at the outlet of dryer. If grain drying complex has two drying shafts, one moisture sensors can be installed at the outlet of each shaft.

Control panel is installed at the operator station and intended for monitoring of input and output flow moisture. Information about grain moisture and temperature is displayed in digital form and in the form of charts (trends).

Control panel allows adjusting scaling settings of two moisture content current loop outputs for use in automation systems, storing correction coefficients for measured moisture content of every product, time-averaging of measurement results and other functions described in this manual.

## 2. Specifications

- Sensor type ..... microwave;
- Measuring mode ..... continuous;
- Measuring range ..... 5 – 40%;
- Moisture content measurement error (up to 18%) .....  $\pm 0.5\%$  max;
- Moisture content measurement error (18-40%) .....  $\pm 1\%$  max;
- Product temperature .....  $+5^{\circ}\text{C} - +55^{\circ}\text{C}$ ;
- Ambient temperature .....  $0^{\circ}\text{C} - +55^{\circ}\text{C}$ ;
- IP rating ..... IP65;
- Communication protocol ..... RS-485;
- Cable length between sensor and control panel ..... up to 100 m;
- Analog output ..... 4-20 or 0-24 mA;
- Analog output loading capability ..... 400  $\Omega$  max;
- Sensor weight ..... 6.5 kg;
- Control panel weight ..... 4.5 kg;
- Control panel power supply ..... 100-240VAC / 50-60Hz;
- Sensor power supply ..... 24VDC.

### 3. Principle of operation

The principle of sensor A315 operation is based on the considerable difference of the permittivity of dry substances and water at ultra-high frequencies (UHF).

The feature and important advantage of A315 moisture content sensor is that due to simultaneous measurement of resonant frequency and amplitude of the resonance and special processing algorithm, moisture content measurements become practically independent of product bulk density.

The sensing element is based on a ring resonator. The resonator has a cavity formed by a PTFE tube for grain flow. Interaction of grain flow with resonator field inside the tube influences parameters of the resonator. Temperature sensors in measuring channel allow automatic correction of measured value of moisture content from the grain temperature.

Electronics of the sensor consists of two units – UHF module and data processing module that control frequency response of measurement resonator, provide necessary calculations and transfer of data to control panel via RS-485 interface.

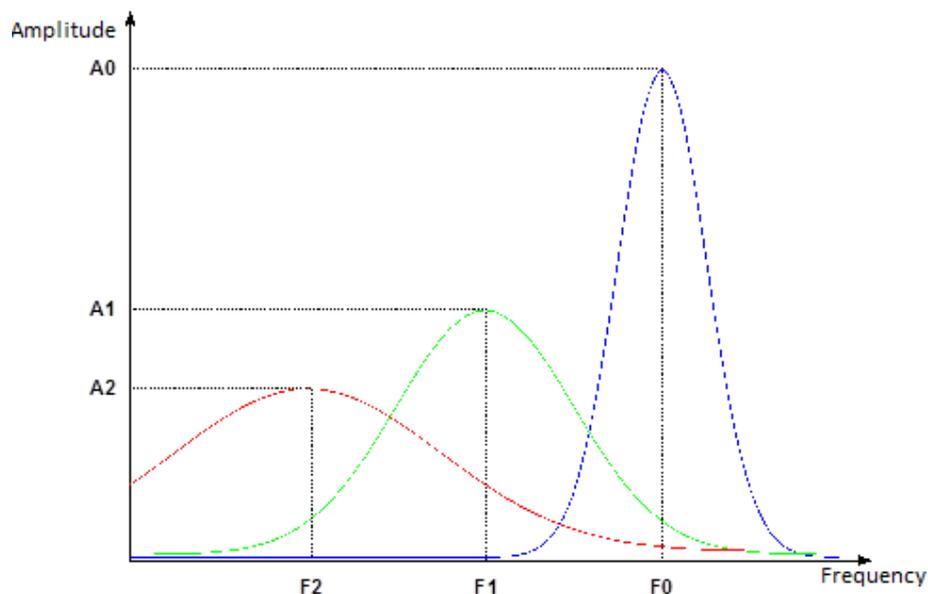


fig 2. Principle of operation

When the measuring channel is empty, the resonator has resonant frequency  $F_0$  and amplitude  $A_0$  (fig. 2). When the channel is filled with grain with certain moisture content, the resonant frequency and amplitude decrease to  $F_1$  and  $A_1$  respectively. With the increase of moisture content in measured product, resonant frequency and amplitude decrease even more ( $F_2$  and  $A_2$ ). Simultaneous measurement of resonant frequency and amplitude allows determining moisture content independently of grain density.

## 4. Working with control panel

### 4.1. Connections

Control unit is designed to work with two A315 grain moisture content sensors. One of the sensors has address **A**, and the second one – address **B**.

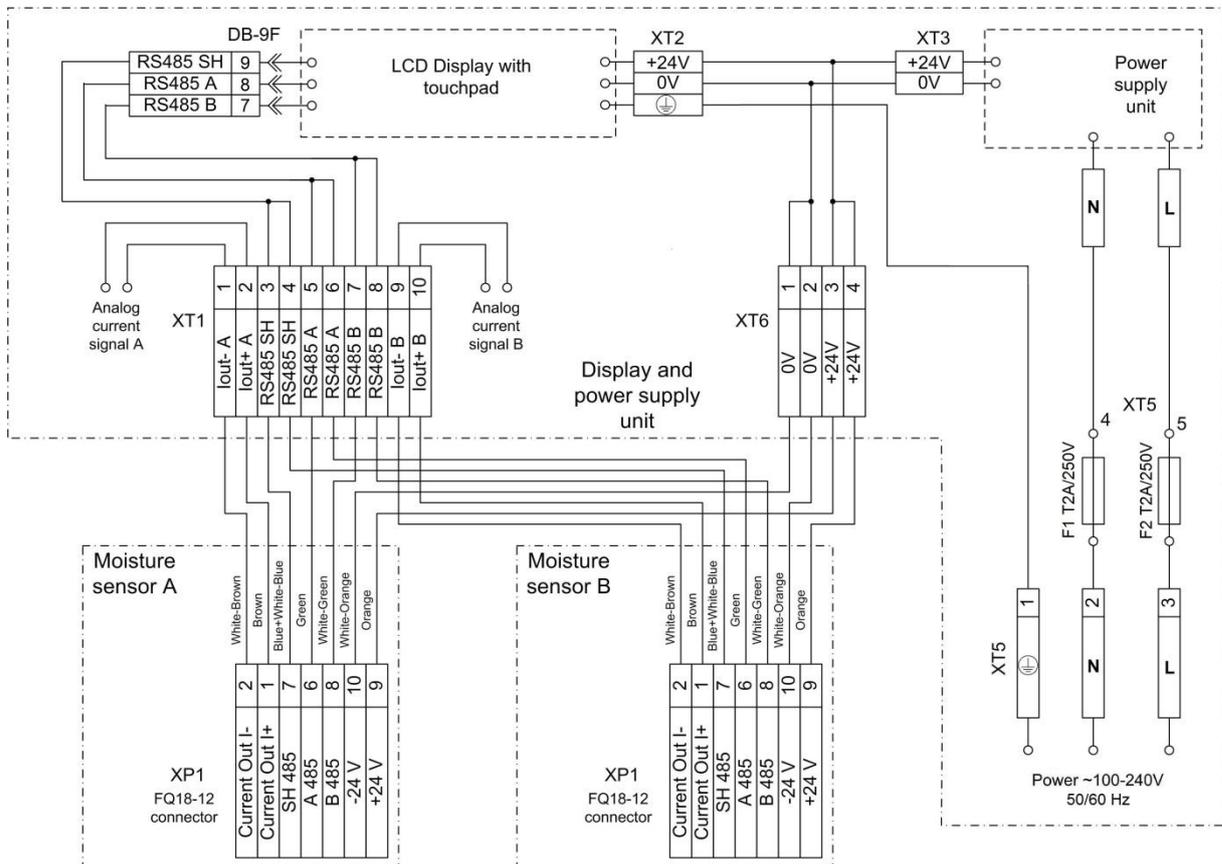


fig 3. Wiring diagram

Control panel is supplied with two pre-wired cables (3 m each) for connecting the sensors. This allows to quickly plug the sensors and check their operation before installation on the grain dryer and to learn how to work with the control panel.

For installation on the grain dryer 7-terminal junction box should be mounted at the distance of up to 3 m from a sensor and sensor cable should be connected to it. Communication lines (4 twisted pairs) of the required length (up to 100 m) from each junction box are wired to the operator station where control panel is installed. Connections should be performed according to wiring diagram shown in fig. 3.

In order to check operation of measurement system place both sensors on a table, connect the cables from control panel to sensors **A** and **B** and power up the control panel. After startup the display should look as shown in fig. 4. Two green indicators  show that sensors are ready for measurements.

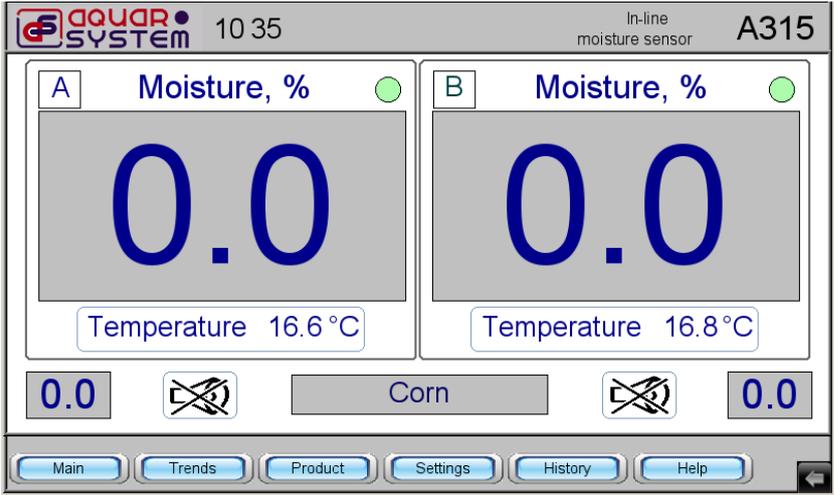


fig 4. Control panel screen after system startup

## 4.2. Selecting product and performing moisture measurements

The work with moisture content sensors starts with product selection. Press

 to open product selection menu (fig. 5).



fig 5. Product selection menu

Select the product and confirm selection by pressing . Now moisture sensors are ready to work with the selected product. Select  mode and fill the measurement channels of the sensors with grain. Green indicators will turn white  and measured value of moisture content for each sensor will be shown on the display (fig. 6).

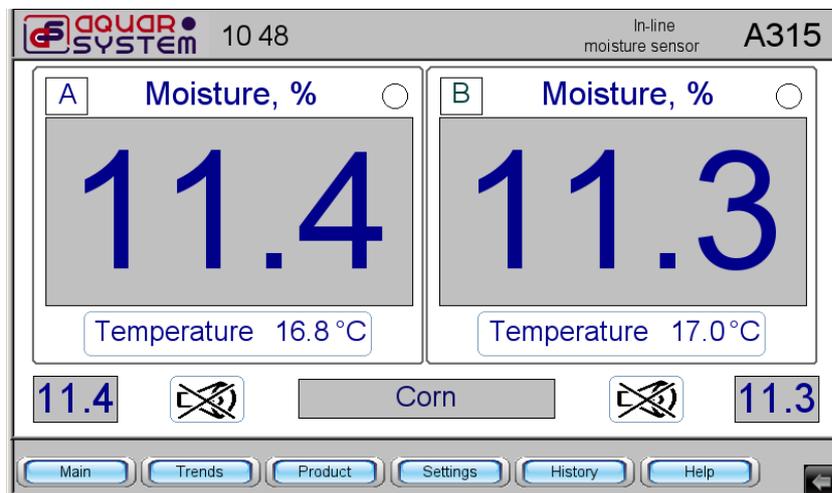


fig 6. Instantaneous and averaged moisture values

Small numbers in the bottom-left and bottom-right corners of the display represent instantaneous measured values for each sensor. Large numbers in the center of the display show moisture contents values averaged over time (see section 4.4 for averaging settings).

When grain is removed from moisture meters, the current values of the moisture will show zero, but the average values will retain their previous readings (fig. 7). Averaged values can be reset by pressing on them when the measurement channel of the sensor is empty.

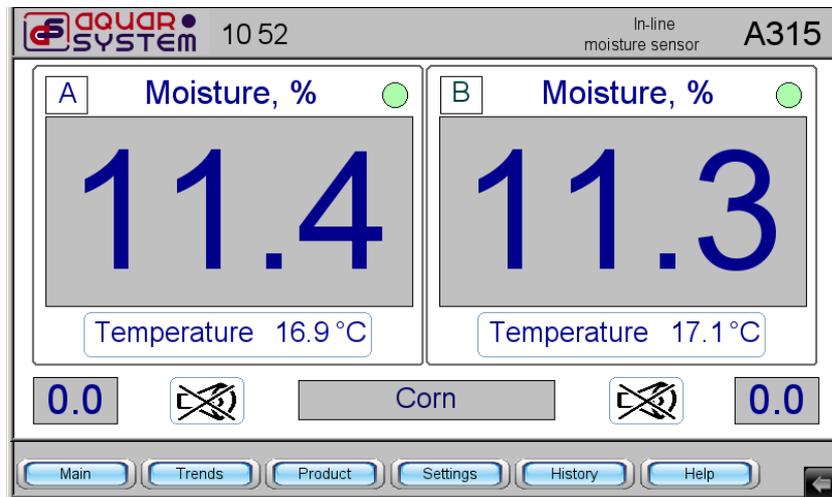


fig 7. Showing average moisture values

Special **Laboratory** mode can be used in order to simulate flow measurement process in the moisture control system (fig. 8). It allows obtaining an average moisture value for the same product based on the results of several single measurements. After selection of the product press **Laboratory** button to switch to “Laboratory” mode (fig. 8).

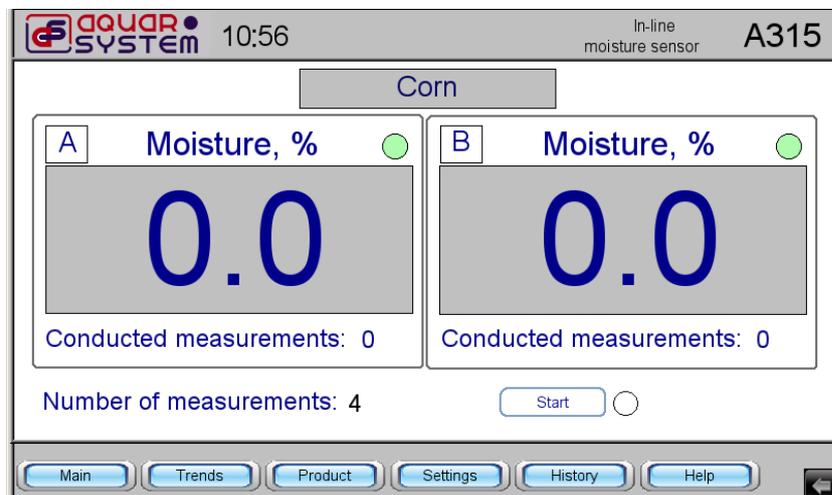


fig 8. “Laboratory” mode

By default “**Number of measurements**” line should read 4. Press **Start** button and fill moisture sensor **A** with a portion of grain. Wait for sound signal and the appearance of figure “1” in “**Conducted measurements**” line. Remove grain from the sensor and then fill in the sensor with again to see figure “2” after the signal. Repeat the procedure four times. After the four measurements “**Moisture %**” window would

display average of moisture content of the product based on four sample measurements. After this the similar procedure can be performed for sensor **B** (fig. 9).

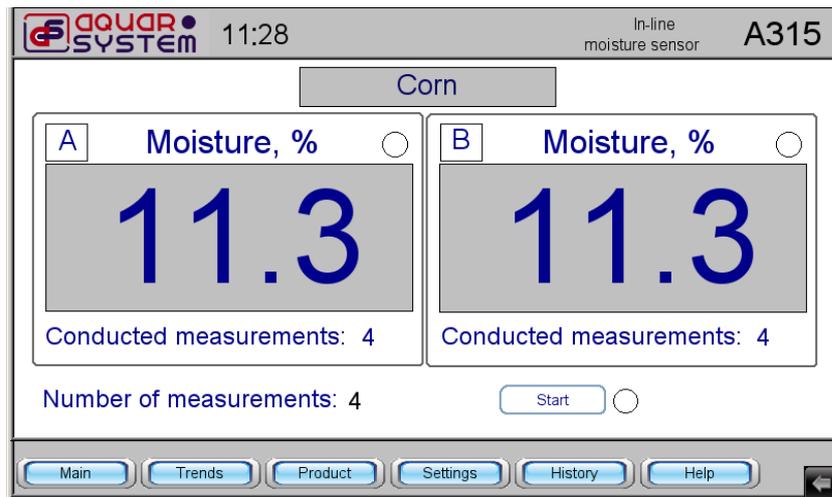


fig 9. Product moisture measured in “Laboratory” mode

In certain cases the number of measurements in **Laboratory** mode should be increased for correct measurements. This is especially important for wet grain (more than 18% for grain and leguminous products and more than 13% for oilseeds) because wide dispersion of moisture and density of samples is usually observed. For example in order to obtain correct measurement results for wet corn the number of measurements should be increased to 10.

In order to change the number of measurements press on the digit following “Number of measurements” line and enter a new number using the appeared numeric pad (fig. 10), confirm input by pressing **ENT**.

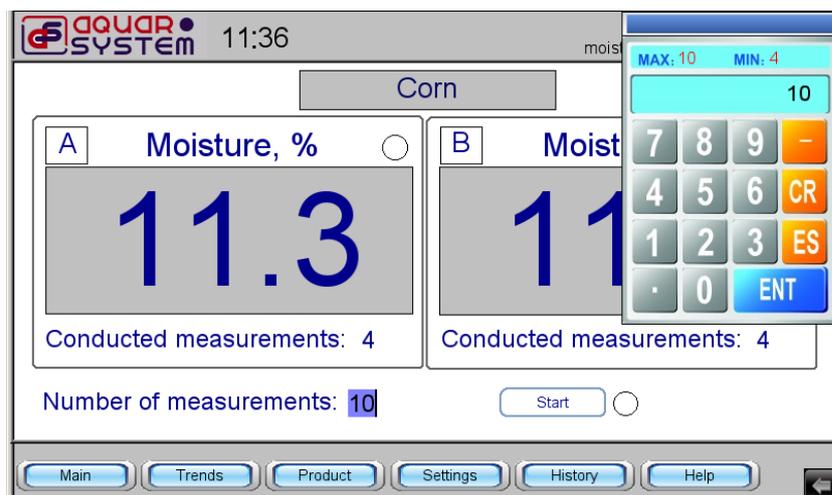


fig 10. Selecting number of measurements for “Laboratory” mode

After setting the number of measurements, press **Start** button and perform 10 fillings to get the correct moisture content value.

### 4.3. Trend view

Control panel provide an option to display trends of measured grain temperature and moisture content for the time period since the sensor start up. Press  button to view trends. The screen will display the last 10 minutes trend of moisture content for sensor **A** (fig. 11).

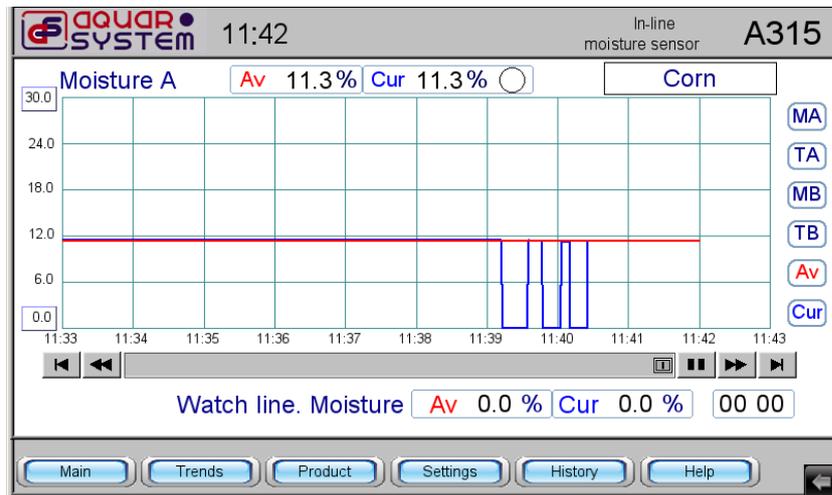


fig 11. Moisture content trend

The blue line shows the instantaneous (current) value of moisture, the red line shows the time-averaged value. By pressing the buttons  and  you can turn on and off the current and average value trends. To see trends for different time periods press arrow buttons  and  below the chart.

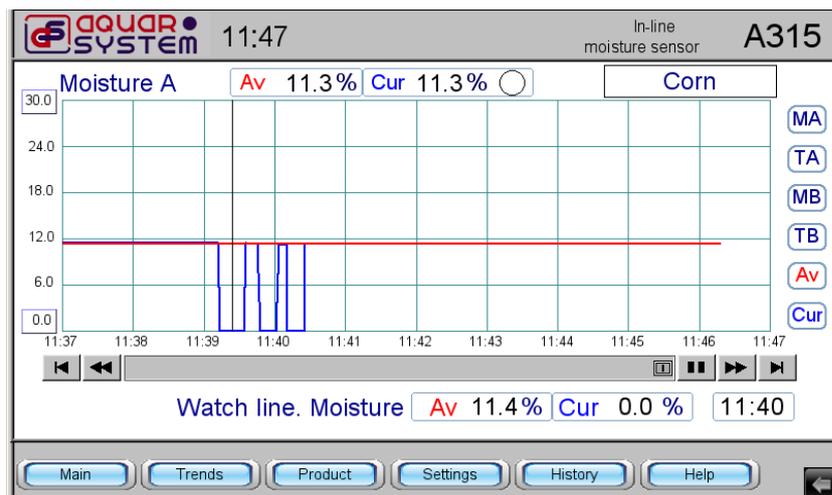


fig 12. Watch line

To view the trend of grain temperature in sensor **A** click , to view the trend of moisture content in sensor **B** press , to view the trend of grain temperature in sensor **B** press . To see the value of either moisture or temperature for each of

the sensors at a particular moment of time click on a trend section corresponding to this moment and read the value in the "Watch line" line at the bottom of the screen (fig. 12).

The scale of vertical axis can be changed. To change the upper limit press on the limit value and enter a new value using numeric keypad. The limit can be changed in increments of 5% (fig. 13). Press **ENT** button on the numeric keypad to complete the operation. Similarly you can change the lower limit value of the trend in increments of 5% by pressing the lower limit of vertical axis.

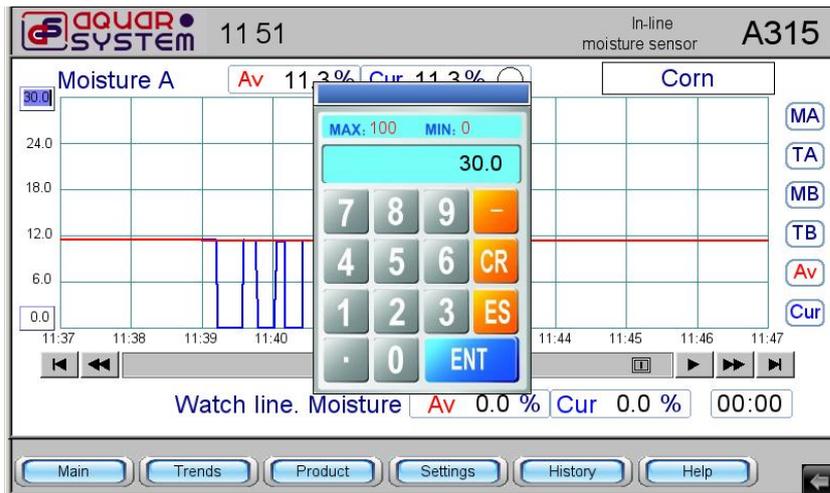


fig 13. Changing vertical axis limits

"Trends" mode can be accessed from **Main** mode (fig. 4). Press the figure of instantaneous value of moisture content or temperature for chosen sensor to switch to "trends" mode.

#### 4.4. Entering corrections and parameters

The system of online moisture control allows adjusting scaling parameters of current loop outputs and applying individual correction and averaging coefficients for each sensor.

Press  button to enter “Settings” menu. The display will show password enter screen. Press symbol \* on the display to see keypad for entering password (fig. 14). Enter “315” as the password using the keyboard and press  button. “Settings” menu is shown in fig. 15.



fig 14. Password screen

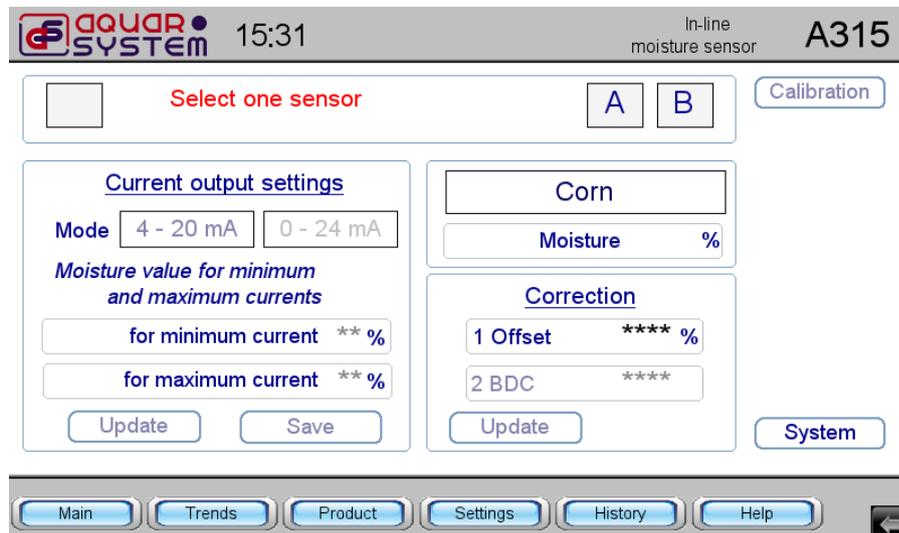


fig 15. “Settings” screen

Correction parameters can be selected for each sensor individually. If the system operates two sensors together or both of them are switched off than at the top of the display the following warning text will appear: “**Select one sensor**”. In order to select the required sensor press buttons  and  located in the upper right corner

of the screen. The selected sensor is indicated by the corresponding letter in the left top corner of the panel (fig. 16).

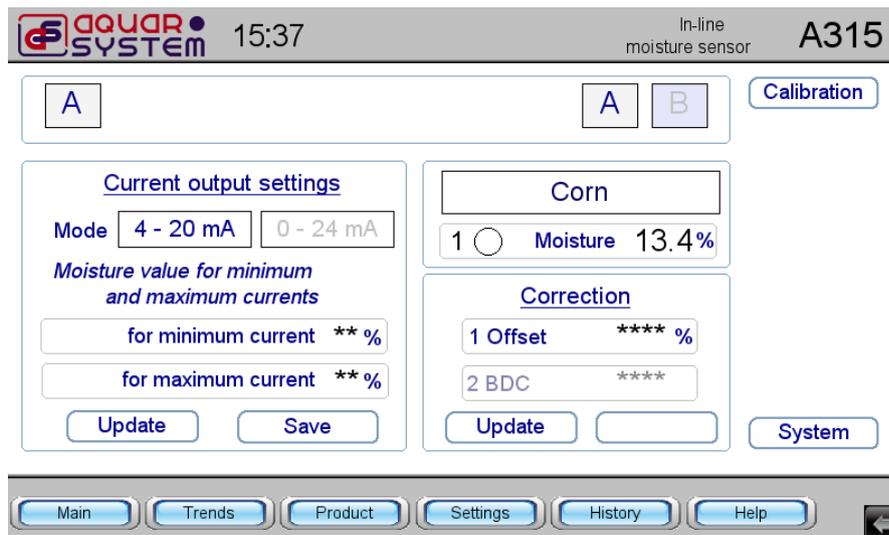


fig 16. Selecting sensor **A**

Press  button to read parameters from sensor **A** (fig. 17).

To select mode for current loop output press button  or  and confirm selection by pressing . Check the settings by pressing .

Current loop output is adjusted by setting moisture values for minimum and maximum currents. Fig. 17 shows that 4-20 mA mode is selected - the minimum current value 4 mA corresponds to 4% moisture content and the maximum current value 20 mA corresponds to moisture of 20%. That means that if moisture of 12.9% is indicated on your sensor **A** than the current output signal shall be 12.9 mA

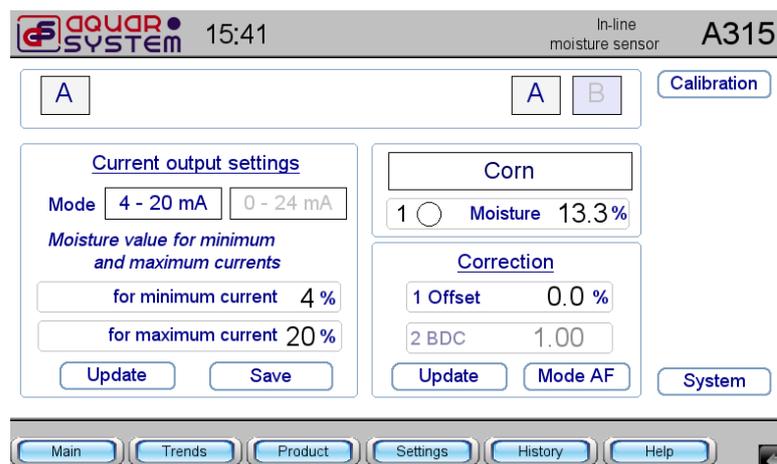


fig 17. Current output settings

Moisture content values for minimum and maximum currents are set in the following manner. To change the value for the maximum current press on the figure in

“for minimum current” line. Enter new value and press **ENT** (fig. 18). Press **Save** and **Update** in the “Current output settings” to apply and check new settings. The moisture content value corresponding to the minimum current can be changed in similar way.

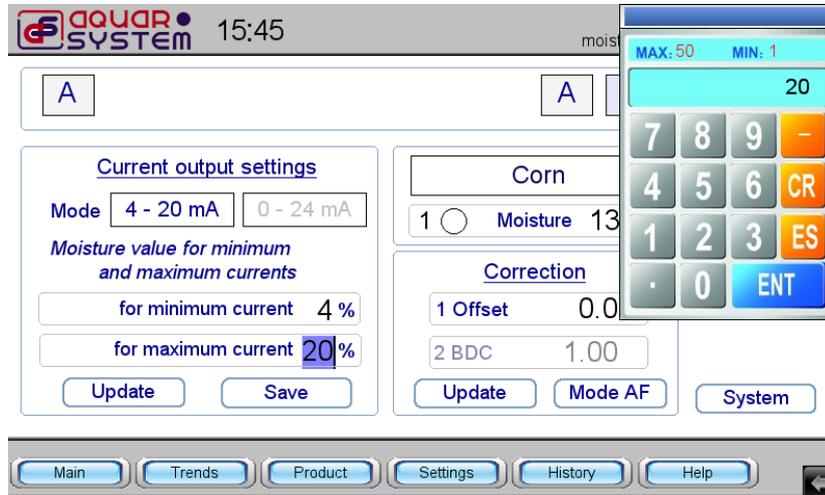


fig 18. Adjusting current output settings

A315 sensor can perform measurements in mode **Mode AF** or **Mode F**. Moisture calculation in “Mode AF” is performed using two algorithms. Calculation algorithm is selected automatically by the sensor depending on grain moisture content and temperature. Selected method is indicated with number “1” or “2” in “Moisture” line. Both algorithms allow to apply correction coefficients.

Fig. 17 shows figure “1” in “Moisture” line with measured moisture content value reading 13.3 %. It means that moisture calculation is performed using algorithm “1” and only correction coefficient “1 Offset” is valid for this algorithm.

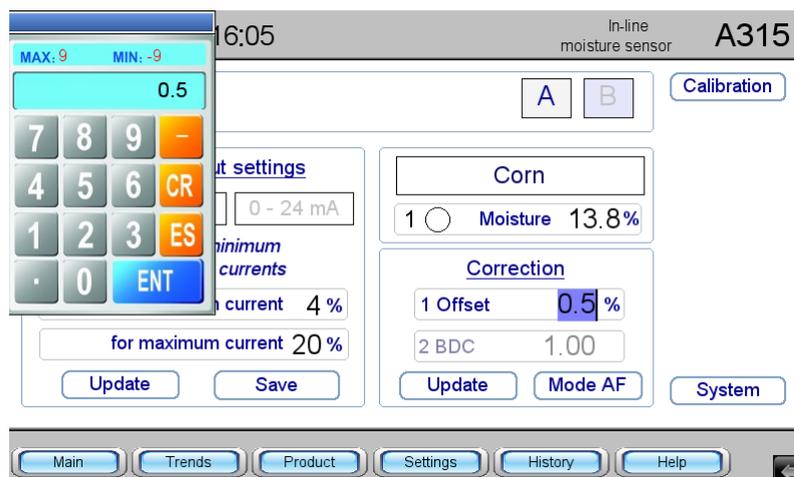


fig 19. Entering correction for algorithm 1

If for grain sample with known moisture content, for example, 13.8% the sensor reads 13.3 %, then the correction of 0.5% must be applied. To input correction press

“1 Offset - 0.0%” and enter “0.5%” confirming input by pressing **ENT**. After this the “Moisture” line should read 13.8% (fig. 19).

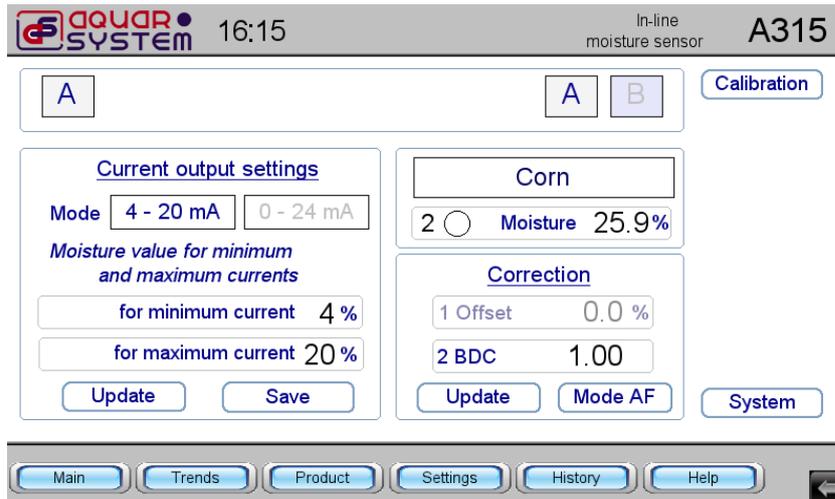


fig 20. Algorithm 2

Algorithm 2 uses Bulk Density Coefficient (BDC) (fig. 20). Sensor A315 is calibrated for different products with bulk densities (test weight) as per Table 1.

Table 1.

PRODUCT	Bulk density (test weight)	
	kg/l	Lb/bu
Rape	0.646	50.19
Barley	0.702	52.54
Wheat	0.789	61.32
Oats	0.560	43.51
Corn	0.726	56.40
Rye	0.713	55.39
Lupine	0.810	62.90
Triticale	0.711	55.24
Buckwheat	0.608	47.23
Millet	0.726	56.40
Sunflower	0.415	32.24
Peas	0.810	62.90
Soybean	0.717	55.70
Sorghum	0.454	35.27
Rice	0.514	39.93
Jojoba	0.574	44.59
Seaweed	0.480	37.29
Coffee	0.685	53.22

When it is possible to determine bulk density of the custom product then correction coefficient “2 BDC” may be tuned for better measurement accuracy. For example, the measured bulk density of corn passing through sensor is 0.810 kg/l. According to Table 1, bulk density of corn for which the moisture sensor was calibrated is 0.726 kg/l. Then the value of BDC correction can be calculated:

$$\text{«BDC»} = 0.726/0.810 = 0.896$$

Changing the value of "BDC" is carried out by analogy with the changing of the "Offset" correction. "BDC" can be further adjusted manually to achieve better agreement of sensor's readings with laboratory result within  $\pm 1.0\%$  error. Increase of "BDC" value leads to increase in moisture readings and vice versa. Recommended step when changing "BDC" value is 0.01-0.02.

*Moisture correction shall be performed only when measurement channel of the sensor is filled with grain to know which correction shall be entered - "1 Offset" or "2 BDC".*

**Mode AF** is more preferable because it provides the most accurate measurement of moisture at the grain dryer outlet for products with temperature up to 40°C.

When grain temperature at dryer outlet is higher and moisture contents if higher at the inlet it's preferable to use **Mode F**, however this increases measurement error. The choice of specific measurement mode must be made according to on-site conditions and the results of laboratory measurements.

To change the mode press button **Mode AF**. Then **Mode F** will appear that confirms mode changing (fig. 21).

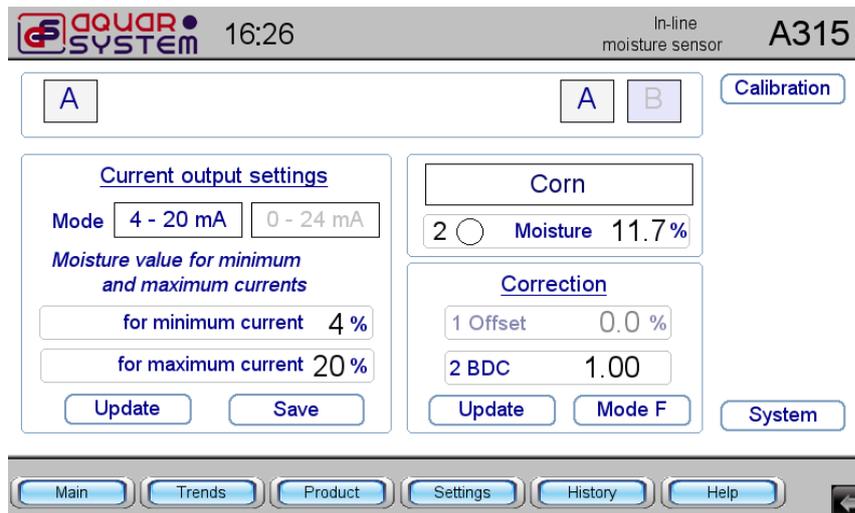


fig 21. Changing moisture measurement mode

When A315 sensor shows non-zero moisture content value with empty measurement channel or green light indicating the readiness for measurement is off, that means the sensor requires zero calibration. To perform calibration empty the meas-

urement and press **Calibration** button on the **Settings** screen. Calibration screen will appear (fig. 22).

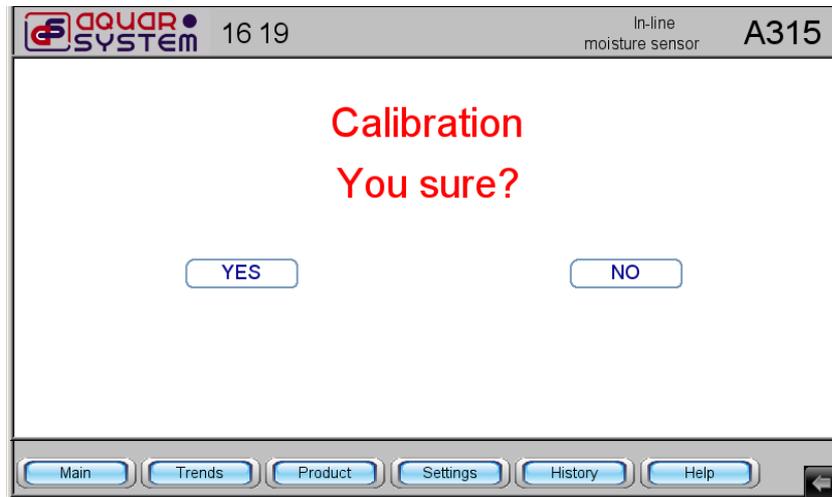


fig 22. Calibration

Press **YES** and after the calibration the screen should show “-  **Moisture 0.0%**” (fig. 23). Calibration is finished and the sensor is ready for measurements.

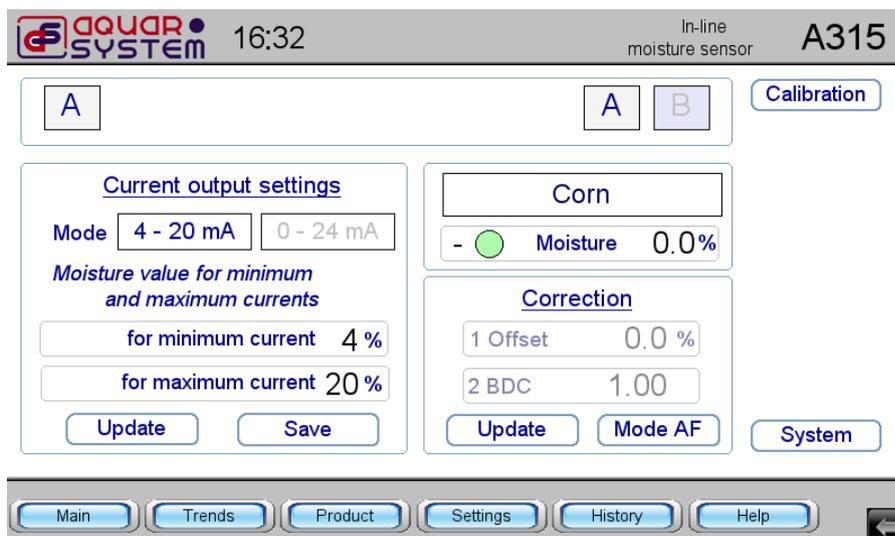


fig 23. “Settings” screen after the calibration

To access service functions menu (fig. 24) press **System** button.

The left area of the screen displays the table of target moisture levels for drying process for each product. The signal is sent to operator when the target value of moisture content for selected product is achieved. Moisture content control mode can be enabled for each sensor individually by pressing **Moisture control disabled** button.

For example, the target moisture content for corn is set at 15% (fig. 24). Sound alarm will be triggered when measured moisture content will become lower than the

target and **Moisture %** line will turn red and start flashing (fig. 25). Sound alarm can be disabled by pressing  button.



fig 24. «System» screen

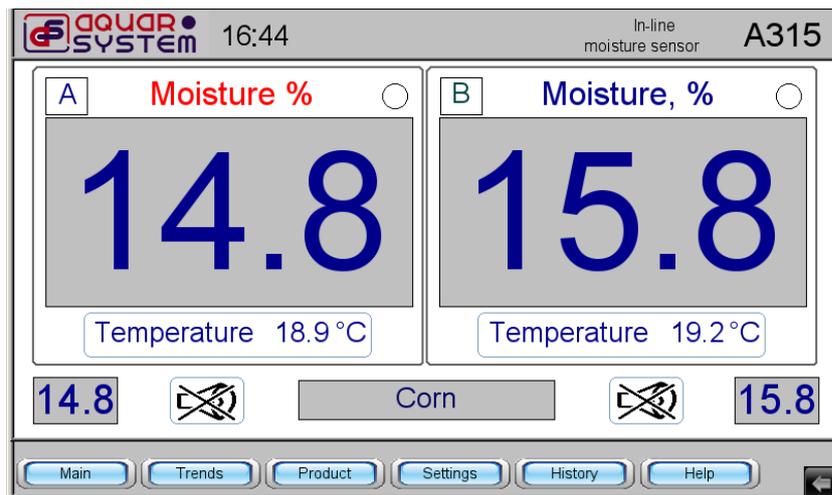


fig 25. Moisture level alarm

Sliding window averaging may be used for averaging of moisture content measurement results. Window size can be changed from 1 to 200 samples. With a sampling speed of 1 sample per second this equals to 1...200 seconds.

Specific value of averaging parameter is chosen experimentally with regard to drying dynamics. To set window size refer to "Averaging" line in the upper-right area of the screen.

Setting of target moisture and averaging parameter is carried by analogy with setting of other parameters as described above.

Four interface languages are available: Russian, English, French and German. To select your language press the corresponding button in the lower-right area of the screen: , ,  or .

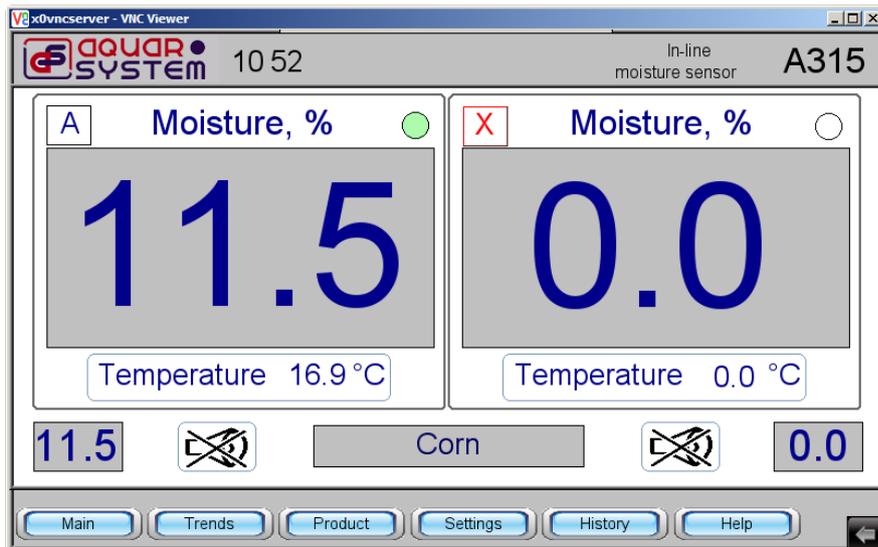


fig 26. Turning off sensors

Selection of sensor **A** or **B** can be performed not only in  mode but in  mode (fig. 4) as well. Pressing the letter corresponding to the sensor address in  mode will turn the sensor off (fig. 26). Moisture and temperature values will read zero. To switch the sensor back on press  button.

## 4.5. Viewing archive data

Control panel stores data archive for the whole period of grain dryer operation. To view the archive, press **History** button, and the panel will display image of moisture content trend over the past day (fig. 27).

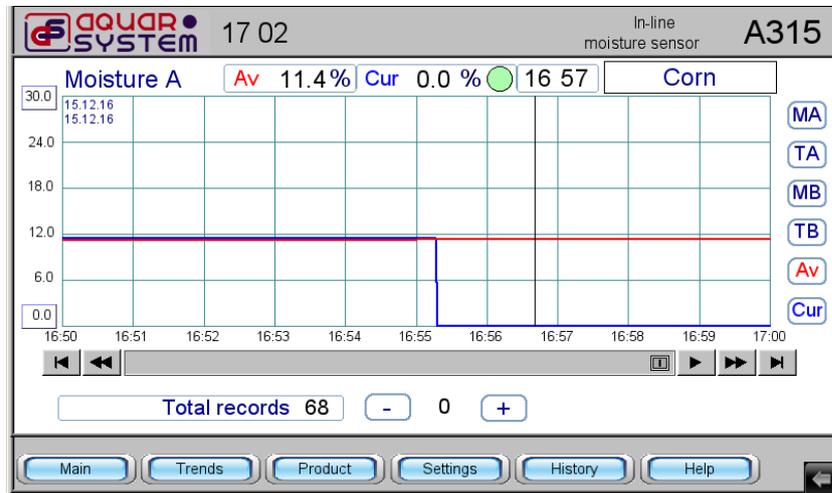


fig 27. "History" mode

Navigation and operation in "History" mode is the same as in "Trends" mode (see section 4.3). To view history data for the different day press **+** and **-**. The date corresponding to displayed information is shown the upper left corner of the chart.

To get the value of moisture or temperature for each of the sensors at a particular moment of time click on a trend section corresponding to this moment and read the values in the line above the chart.

Specific number of history record can be entered by pressing of a number between buttons **+** and **-**.

## 4.6. Setting time and date

To set time and date press  button in the bottom right corner of the display. In the appeared menu press  button. Password window and keyboard will appear (fig. 28). Input “111111” (six times “one”) as the password. Press “Time/Date” button to enter time and date settings mode and set correct time and date with buttons  and . Confirm time and date settings by pressing “OK”.

Control panel must be switched off and of after this operation.

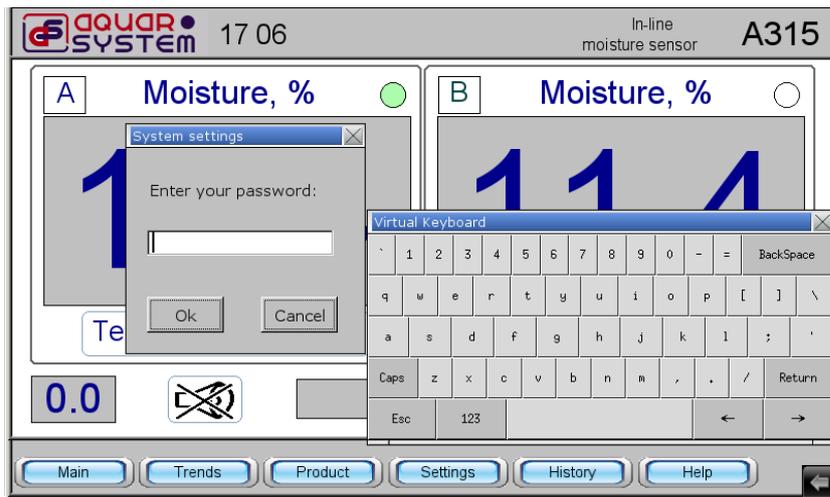


fig 28. Enter password to access control panel system settings

## 5. Installation

*For correct operation and measurement complete filling of sensor's measuring channel with grain must be ensured.*

Depending on the design of grain dryer sensors can be installed different ways. Several methods are described in this manual.

To control flow moisture content of at the inlet the sensor should be installed on the side wall of bunker in its upper part where the bunker is filled. A315 sensor should be placed between high and low level sensors of the drying column closer to the low level sensor (fig. 29).

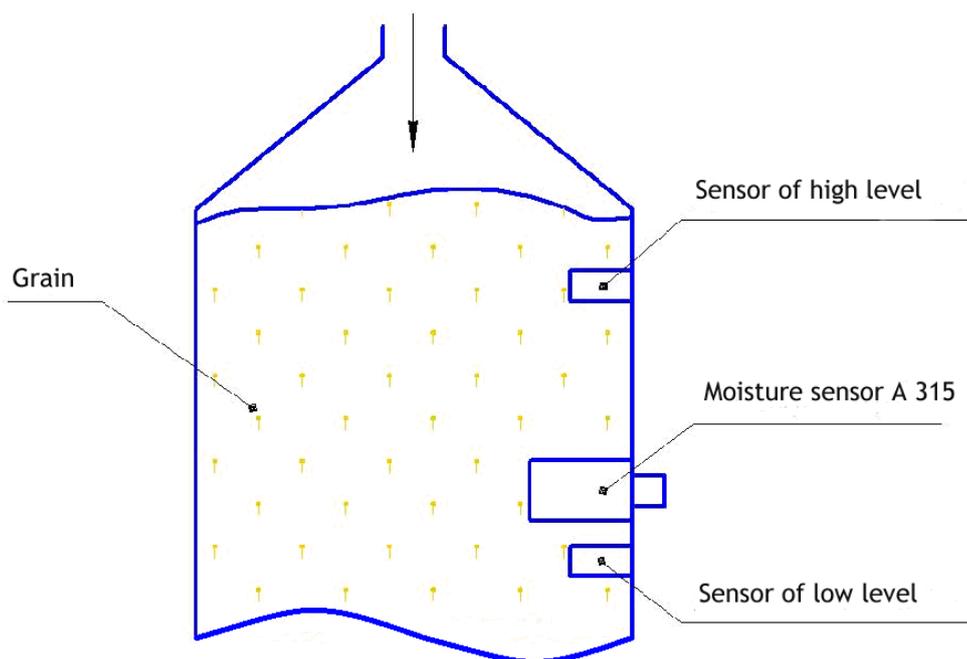


fig 29. Installation on the side wall of the bunker

As the grain is filling the drying column and sensor measurement channel is filling as well and the sensor begins to measure moisture content of the product. When the grain level falls below the sensor level, the measurement channel becomes empty of grain and moisture sensor reads zero values and automatic calibration is performed (green light ● on the panel). The process repeats for the new loading of grain.

To control flow moisture content at the outlet of dryer the sensor is placed in output bunker above output conveyor (fig. 30).

When a certain portion of dried grain is discharged from the bunker, moisture contents sensor gets fully covered and grain slowly passes through the measurement channel and is then carried away by output conveyor. Measurement continues until the measurement channel is empty. After this the sensor is automatically calibrated

(green light ● glows on the panel) and is ready for measuring moisture content of a new portion of grain.

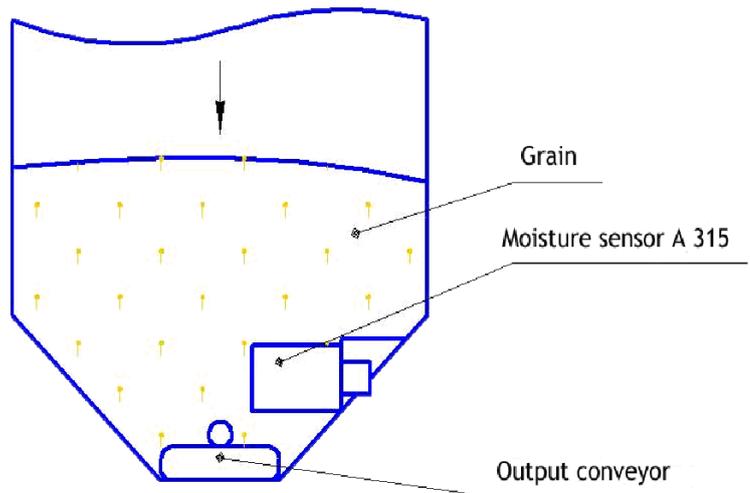


fig 30. Installation in the output bunker

Not all grain dryer allow installing A315 sensors in the described manner. In case grain is unloaded from the bunker in small portions, the most accurate measurements can be demonstrated when using small flexible spiral screw conveyor mounted below moisture sensor (fig. 31).

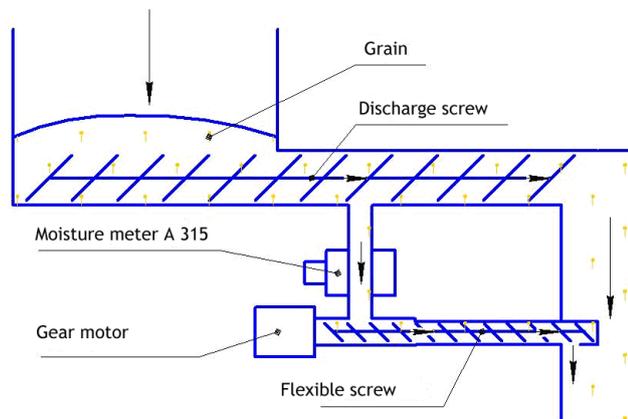


fig 31. Installation with a sampling conveyor

Part of grain flow from the unloading conveyor passes through DN60 (60 mm) pipe to the measurement channel. Spiral screw with the same diameter (DN60) is mounted below the sensor. The screw is driven by electric motor reducer rotating at the speed of 1-2 RPS (60-120 RPM) and slowly conveying grain passing through the moisture content and returning it to the main flow. When this method of installation is used, the grain flow through the sensors should be interrupted for 20-30 seconds every 30 minutes in order to initiate automatic calibration of sensor. After interruption of grain flow the sensor shall read zero moisture value and green light ● shall glow on the panel indicating its readiness for the new portion of grain.

## 6. Troubleshooting

**Problem:** «Communication error» message on the screen (fig. 32).

**Solution:** check the integrity of communication cables from moisture sensors to the control panel and reliability of connecting leads.

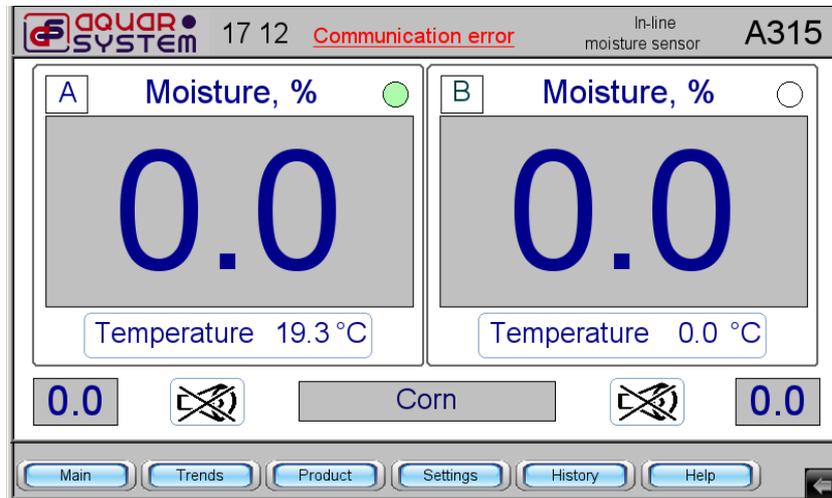


fig 32. "Communication error" message

**Problem:** «Error 7» message on the screen (fig. 33).

**Solution:** repeat selection of product in  mode.

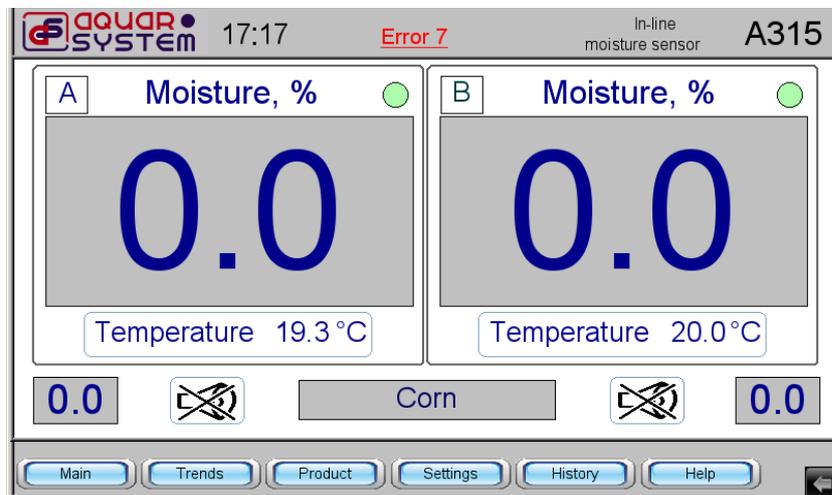


fig 33. "Error 7" message

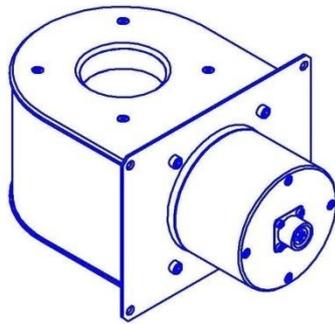
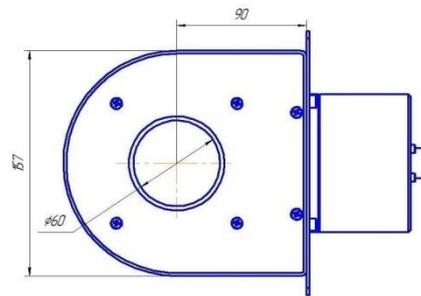
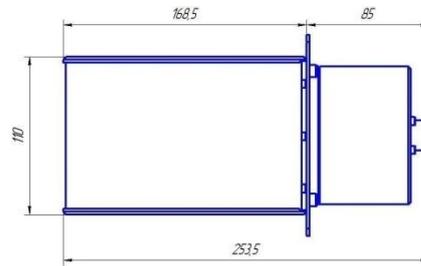
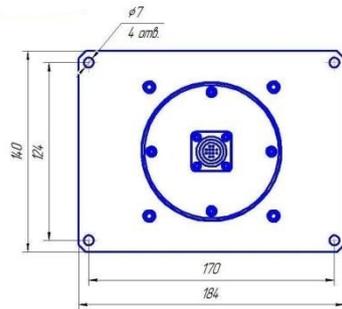
**Problem:** one or both sensors show moisture values other than 0.0% and readiness indicators are white  when there is no grain in measuring channel.

**Solution:** perform calibration according to section 4.4 of this manual.

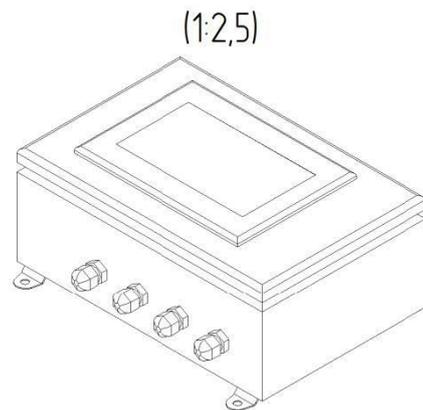
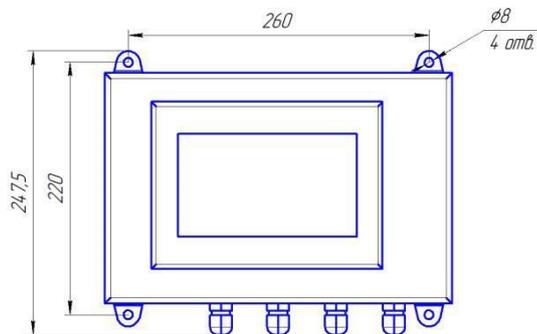
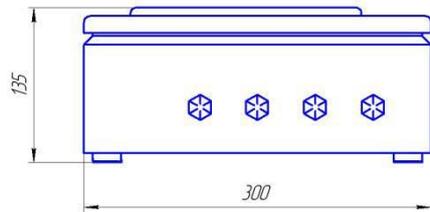
In case of other failures please contact the manufacturer representatives or local dealer.

*After the end of drying season it is recommended to dismount moisture sensors from the grain dryer and store them in dry heated space. Moisture sensor connectors shall be protected from direct water effect.*

## 7. Dimensional drawing



\*Units Measured in Millimeters



\*Units Measured in Millimeters