The Design Bureau Fizelektronpribor, Ltd.

Russian Classification of Production 42 1550

Moisture Analyzers (Moisture Meters)
FIZEPR-SW100

Technical description and operation manual
VIGT.415210.100-01RE
Part 1
(Rev 3.10)

Samara, 2022

CONTENTS

1. Introduction

1.1 This technical description and operation manual are designed for familiarization with the device, principle of operation, installation, preparation, inspection and maintenance rules of moisture analyzers (moisture meters) FIZEPR-SW100 VIGT.415210.100.

1.2 Moisture analyzers FIZEPR-SW100 are entered into the State Register of Measuring Equipment of the Russian Federation:

1) Registration No. 58390-14, Pattern Approval Certificate of Measuring Instruments RU.C.31.001.A No. 56698, 08.09.2014, Verification Method MP 242-1715-2014.

2) Registration No. 75771-19, Pattern Approval Certificate of Measuring Instruments OC.C.31.006.A No. 74665, 26.08.2019, Verification Method MP 0919-6-2018.

1.3 Moisture analyzers FIZEPR-SW100 are entered into the Register of the State System for Ensuring the Uniformity of Measurements of the Republic of Kazakhstan:

1) Certificate No. 12284, registered on 27.10.2015, No. KZ.02.03.06827-2015/58390-14.
2) Certificate No. 587, registered on 03.03.2021, No. KZ.02.03.00587-2021/75771-19.

1.4 Moisture analyzers FIZEPR-SW100 are manufactured in the following basic versions:

- General purpose industrial version
- Explosion-proof version.

Moisture analyzers FIZEPR-SW100 are certified for use in hazardous areas, Certificate of Conformity No. TR CU 012/2011 No. TR CU C-RU.АД07.В.03758/21, Series RU No. 0264976, issued by CERTIFICATION CENTER "VELES" LLC on 09.09.2021. Explosion-proof marking is provided in Table 12.

For explosion-proof moisture meters, the scope of electronic unit application is explosive zones of Class 1 and Class 2 according to GOST IEC 60079-10-1-2011, IIA, IIB explosive mixture categories according to GOST R IEC 60079-20-1-2011, explosive zones of Class 21 and Class 22 according to GOST IEC 60079-10-2-2011 containing explosive dust of Subgroups IIIA, IIIB and IIIC, as well as underground workings of coal mines and pits including those hazardous in terms of gas (methane) and/or coal dust, and their surface structures according to electrical equipment explosion-proof markings, GOST IEC 60079-14-2011 and other regulatory documents governing the use of electrical equipment in potentially explosive environments.

Applications of sensors for explosion-proof moisture meters are explosive zones of Class 0, Class 1 and Class 2 according to GOST IEC 60079-10-1-2011, IIA, IIB explosive mixture categories according to GOST R IEC 60079-20-1-2011, explosive zones of Class 20, Class 21 and Class 22 according to GOST IEC 60079-10-2-2011 containing explosive dust of Subgroups IIIA, IIIB and IIIC, as well as underground workings of coal mines and pits including those hazardous in terms of gas (methane) and/or coal dust, and their surface structures according to electrical equipment explosion-proof markings, GOST IEC 60079-14-2011 and other regulatory documents governing the use of electrical equipment in potentially explosive environments.

1.5 Moisture analyzers FIZEPR-SW100 correspond to Class III of electrical shock protection in accordance with GOST 12.2.007.0-75. Moisture analyzers are designed to operate at a safe ultra-low voltage (24V) and have neither external nor internal electrical circuits operating at a higher voltage.

1.6 Moisture analyzers FIZEPR-SW100 are equipped with two channels to transmit measurement results:

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- RS-485 digital interface, MODBUS RTU protocol
- 4-20 mA current loop analog interface.

1.7 The manufacturer retains the right to make modifications in the design and circuit of moisture analyzers that do not affect their specifications, without adjusting the operating and maintenance documentation.

2. Purpose and general description of moisture meters

2.1 Moisture analyzers (moisture meters) FIZEPR-SW100 (hereinafter – moisture meters) are designed to measure moisture content – water fraction (in percentage terms) in bulk, granular and paste-like materials, as well as in liquid liquids including aqueous suspensions.

Note. Moisture analyzers FIZEPR-SW100 designed to measure water content in petroleum and petroleum products, as well as in other liquid materials are covered by the operation manual: "Moisture analyzers (moisture meters) FIZEPR-SW100 for measuring petroleum and petroleum products. Technical description and operation manual VIGT.415210.100RE. Part 1" These moisture meters meet requirements of GOST 8.614-2013 GSI. "State system for ensuring the uniformity of measurements. State verification schedule for instruments measuring the volumetric water cut of oil and oil products" and their verification is carried out according to the document "GSI Instructions. Moisture analyzers (moisture meters) FIZEPR-SW100. Verification Method MP 0919-6-2018" approved by FSUE "All-Russian Research Institute for Flow Metering" on 15.11.2018.

2.2 Due to the principle of operation the moisture meter FIZEPR-SW100 is a radiowave device – dielectric moisture meter. The method of permittivity ($\boldsymbol{\varepsilon_r}$) measurement is direct, based on measuring deceleration factor (k_{dec}) of an electromagnetic wave in the controlled material. Deceleration factor k_{dec}, also called refractive index, is the ratio of electromagnetic wave propagation speed in air (i.e. light speed) to its propagation speed in the controlled material. Measurements are made by probing the medium with radio waves at frequencies of the 40 ... 750 MHz range and 0.2-1500 MHz range for moisture meters versions "with an extended range of frequencies". To find k_{dec}, the moisture meter calculates the ratio of sensor resonant frequency in air to its resonant frequency in the controlled material. Based on the found deceleration factor value, the moisture meter processor calculates water content taking into account the material temperature. The calculation is made based on calibration tables prepared for each type of the controlled material and stored in the moisture meter memory.

The moisture measuring method used provides high accuracy and repeatability of measurement results. The moisture meter metrological characteristics do not depend on external conditions, and measurements are not affected by the temperature of semiconductor converters and the electronic unit itself.

It is important to note that to ensure high accuracy of moisture measurement, calibration of the moisture meter (preparation of calibration tables) must be performed on the material to be measured.

2.3 Moisture content – a parameter measured by the moisture meter – is a ratio between the weight of water contained in the material to the wet material weight and is defined by the following formula:

$$W = \frac{m_w - m_d}{m_w} \times 100\%,$$

where W - material moisture content;

m_w - weight of the wet material sample;

m_d - weight of the same material sample after drying.

Liquid material measurements are more frequently made using a calibration corresponding to the volumetric water content of the material defined by the following formula:

$$W = \frac{V_{water}}{V_{sample}} \times 100\%,$$

V_{water} - volume of water in the sample;

V_{sample} - volume of the sample.

The type of the calibration used is specified in the moisture meter data sheet.

2.4 The moisture meter consists of an electronic unit and a sensor connected by a cable. Cable connection with the sensor is non-separable and filled with compound. Cable connection with the electronic unit is detachable.

Depending on application conditions and controlled material, the following versions of moisture meters are available:

- Probe version permanently installed in hoppers, tanks, augers, trays, on conveyor belts and in mixers (VIGT.415210.100-**10, -11, -12** and higher);
- In-line version with flange mounting installed in pipelines (VIGT.415210.100-**20, -21** and higher);
- Laboratory version (VIGT.415210.100-**30, -31** and higher).

All these moisture meter versions are distinguished by sensor design. All sensor designs include a probe introduced in the controlled material. The probe is made of the following stainless steel grades: AISI 321, AISI 420, ASTM 440B, AISI 316Ti, AISI 431. Electronic units of the moisture meter are interchangeable. Electronic units of moisture meters used under the conditions of explosion-hazardous production facilities are made in an explosion-proof enclosure with intrinsic safety barriers additionally introduced to ensure explosion safety of the line for signal transmission to the sensor and electrical circuits of the sensor.

Sensors in all moisture meter versions include a thermal detector (thermocouple or thermal resistor) to ensure measurement of controlled material temperature.

2.5. The list of moisture meter designs (versions) is provided in Tables 1 - 9.

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Table 1

Moisture analyzers (moisture meters) FIZEPR-SW100.10.x containing a panel with a probe mounted on it

Moisture meter reference code*	Application, materials controlled	Moisture meter version
FIZEPR-SW100 VIGT.415210.100 **-10.6**	Bulk materials in hoppers, augers, trays, pipes, on conveyor belts and in drying units (grain, sand, etc.). For materials with grain size up to 30 mm.	 The sensor is made as a panel with a flat-topped probe mounted on it. 120 x 356 mm panel. Probe-to-panel clearance is 40…45 mm. The sensor is made of stainless steel AISI 321.
FIZEPR-SW100 VIGT.415210.100 **-10.21**	Bulk materials in hoppers, augers, trays, pipes, on conveyor belts and in drying units (grain, sand, etc.). For materials with grain size up to 30 mm.	 The sensor is made as a panel with a flat-topped probe mounted on it. The additional shield conductor is installed on the panel parallel to the probe to prevent the effect of metal objects located near the sensor. Probe-to-panel clearance is 40 mm. The sensor is made of stainless steel AISI 321.
FIZEPR-SW100 VIGT.415210.100 **-10.61**	Bulk materials in drying units (grain, sand, etc.). For materials with grain size up to 30 mm. Working temperature is up to +300°C.	The sensor is made as a flat-topped probe mounted on the panel. Probe-to-panel clearance is 40…45 mm. The sensor is made of stainless steel AISI 321. The sensor measuring cell (sensor version **B** or **B1**) is separated in space from the probe to ensure sensor operation at extreme temperatures.
FIZEPR-SW100 VIGT.415210.100 **-10.63**	Powdered, granular, bulk materials in a mixer (silicate mass, sand, etc.). For materials with grain size up to 30 mm.	 The sensor is made as a panel with a flat-topped probe mounted on it. The 120 x 356 mm panel is radiussed (radius to be specified when ordering. Probe-to-panel clearance is 40 mm. The sensor is made of stainless steel AISI 321.
FIZEPR-SW100 VIGT.415210.100 **-10.22**	Powdered, granular, bulk materials in a mixer (silicate mass, sand, etc.). For materials with grain size up to 30 mm.	 The sensor is made as a panel with a flat-topped probe mounted on it. The additional shield conductor is installed on the panel parallel to the probe to prevent the effect of metal objects located near the sensor. The panel is radiussed (radius to be specified when ordering. Probe-to-panel clearance is 40 mm. The sensor is made of stainless steel AISI 321.

FIZEPR-SW100 VIGT.415210.100 **-10.5**	Bulk materials (grain, sand, etc.) on conveyor belts. For materials with grain size up to 30…40 mm.	 The sensor is made of stainless steel AISI 321 (or AISI 316Ti). It is mounted above the conveyor belt in the material flow. The sensor shape is selected so that it creates minimum flow resistance. A steel "bucket" is mounted in front of the sensor with increased shock and abrasion resistance to ensure material loosening and complete probe-to-panel clearance filling with the material.
FIZEPR-SW100 VIGT.415210.100 **-10.51**	Bulk materials (sand, silicate mass in silica brick production) on conveyor belts. For materials with grain size 30…40 mm.	 The flat sensor is made of wear-resistant stainless steel AISI 321. It is mounted above the conveyor belt in the material flow. The sensor shape is selected so that it creates minimum flow resistance.
FIZEPR-SW100 VIGT.415210.100 **-10.16**	Bulk materials featuring by high electrical conductivity (coal, iron ore, salts, etc.) in hoppers or trays. For materials with grain size up to 40…50 mm.	 The sensor is made as a panel with a flat-topped probe mounted on it. Probe diameter is 14 mm. Probe-to-panel clearance is 60 mm (sensors with a clearance of 45 mm are available on request). The sensor is made of stainless steel AISI 321.
FIZEPR-SW100 VIGT.415210.100 **-10.162**	Bulk materials featuring by high electrical conductivity (anthracite, iron ore, etc.) in hoppers, trays or in a flow on the conveyor belt. For materials with grain size up to 40...50 mm	 Made as a panel with a flat-topped probe. Probe diameter is 20 mm. Probe-to-panel clearance is 60 mm (sensors with a clearance of 45 mm are available on request). The sensor is made of stainless steel AISI 321.
FIZEPR-SW100 VIGT.415210.100 **-10.166**	Bulk materials featuring by high electrical conductivity (coal, iron ore, salts, etc.) in hoppers or trays. For materials with grain size up to 30…40 mm. The sensor can be used on materials with temperatures up to 120°C.	 The sensor is made as a panel with a probe mounted on it. The probe is interchangeable and it can be replaced when it wears out. Probe diameter is 18 mm. Probe is made of heat treated (hardened) stainless steel ASTM 440B. Probe-to-panel clearance is 45 mm. The sensor enclosure is made of stainless steel AISI 321.

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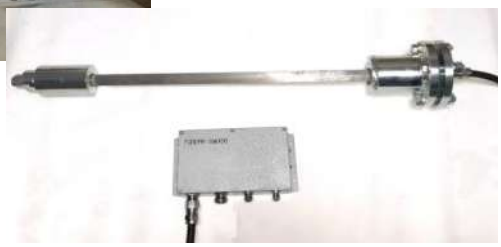
FIZEPR-SW100 VIGT.415210.100 **-10.56**	Bulk materials featuring by high electrical conductivity (coal, iron ore, salts, etc.) in a flow on the conveyor belt. For materials with grain size up to 30…40 mm.	 The flat sensor is made of stainless steel AISI 321 (or AISI 316Ti). It is mounted above the conveyor belt in the material flow. The sensor shape is selected so that it creates minimum flow resistance. The sensor probe is made of shock-resistant Hadfield steel (ASTM A128).
FIZEPR-SW100 VIGT.415210.100 **-10.561**	Bulk materials featuring by high electrical conductivity (coal, iron ore, salts, etc.) in a flow on the conveyor belt. For materials with grain size up to 30…40 mm.	 The flat sensor is made of wear-resistant stainless steel AISI 321 (or AISI 316Ti). It is mounted above the conveyor belt in the material flow. The sensor shape is selected so that it creates minimum flow resistance. The probe is interchangeable and made of hardened stainless steel ASTM 440B. In case of significant wear the sensor probe can easily be replaced with a backup one.

Table 2

Moisture analyzers (moisture meters) FIZEPR-SW100.10.4x containing a probe made as a rod

FIZEPR-SW100 VIGT.415210.100 **-10.4**	Bulk materials (sand, crushed stone, gravel, ore, grain, wood chips, etc.) in a hopper, dispenser, including materials that adhere on hopper walls and a probe. For materials with grain size up to 100…150 mm.	 The sensor contains a probe made of the S27 mm hexagonal bar up to 1.2 m in length. The probe is made of stainless steel AISI 321. A set of coupling holders is made of galvanized AISI 1020 steel. 
FIZEPR-SW100 VIGT.415210.100 **-10.44**	Bulk materials (sand, crushed stone, gravel, ore, grain, etc.) in a hopper, dispenser, including materials that adhere on a probe and hopper walls. For materials with grain size up to 100…150 mm.	 The probe is made of stainless steel AISI 321 as a S27 mm hexagonal bar up to 1.5 m in length. A set of coupling holders is made of AISI 1020 steel.

FIZEPR-SW100 VIGT.415210.100 **-10.441**	Bulk materials (sand, crushed stone, gravel, ore, grain, etc.) in a hopper, dispenser, including materials that adhere on a probe and hopper walls. For materials with grain size up to 100…150 mm.	 The probe is made of stainless steel AISI 321 as a S27 mm hexagonal bar up to 2 m in length. A set of coupling holders is made of AISI 1020 steel.
FIZEPR-SW100 VIGT.415210.100 **-10.41**	Powdered, granular, bulk materials in hoppers, pipes or trays including sawdust and wood chips, wafers, grain, etc.	 The probe is made of stainless steel AISI 321 as a straight rod 14 mm in diameter and up to 0.6 m in length. The sensor also contains a set of coupling holders also made of stainless steel AISI 321.
FIZEPR-SW100 VIGT.415210.100 **-10.411**	Powdered, granular, bulk materials in hoppers, pipes or trays including sawdust and wood chips, wafers, grain, etc. The moisture meter can be used on materials with temperatures up to 180°C.	 The sensor (Version B) contains a straight rod (probe) 20 mm in diameter and up to 1 m in length. The sensor probe and a set of coupling holders are made of steel AISI 321. The sensor measuring cell is located outside coupling holders to ensure material measurements at extreme temperatures.
FIZEPR-SW100 VIGT.415210.100 **-10.42**	Ore and other bulk materials in hoppers, dispensers or collecting ducts above the conveyor belt including materials that adhere on a probe and hopper walls. For materials with grain size up to 100 mm.	 The sensor contains a probe made of the S27 mm hexagonal bar up to 1 m in length, the probe is made of heat-treated (hardened) stainless steel ASTM 440B (AISI 420) featuring improved hardness. The sensor features a removable probe to enable its replacement during the operation.
FIZEPR-SW100 VIGT.415210.100 **-10.43**	Bulk materials (grain, sawdust, etc.) in screws.	 The probe is made as a radially bent rod 14 mm in diameter. It is bent to the screw diameter. Screw dimensions are specified when ordering. The sensor is made of stainless steel AISI 321.

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FIZEPR-SW100 VIGT.415210.100 **-10.45**	Rough materials (ore) in hoppers. For materials with grain size up to 200 mm or more.	Sensor VIGT.415210.100-10.45 contains a probe made of stainless steel AISI 431 as a straight rod 40 mm in diameter and up to 1.5 m in length . A set of coupling holders is made of AISI 1020 and AISI 321 steel. Design feature: the sensor measuring cell is removable to enable the customer to manufacture and replace damaged parts in case of sensor probe wear or damage.
FIZEPR-SW100 VIGT.415210.100 **-10.46**	Bulk materials featuring by high electrical conductivity (coal including anthracite, iron ore and other materials) including materials that adhere on a probe and hopper walls. For lump materials with grain size up to 100 mm.	 The probe is made as a straight rod 32 mm in diameter and up to 1 m in length. All sensor parts are made of stainless steel AISI 321.
FIZEPR-SW100 VIGT.415210.100 **-10.461**	Bulk materials featuring by high electrical conductivity (coal including anthracite, iron ore and other materials) including materials that adhere on a probe and hopper walls. For lump materials with grain size up to 100…150 mm.	 The probe is made as a straight rod 32 mm in diameter and up to 1.5 m in length. All sensor parts are made of stainless steel AISI 321.

Table 3

Moisture analyzers (moisture meters) FIZEPR-SW100.11.x with a probe made as two parallel pins

FIZEPR-SW100 VIGT.415210.100 **-11.32**	Powdered, granular and bulk materials in hoppers, mixers, as well as liquid materials (e.g. sludge) in tanks, trays. It can be used for bulk material measurements in clamps.	 Sensor with a two-pinned probe. Sensor enclosure is equipped with a G1 thread fitting. The sensor is mounted on the 1" pipe, but it can also be attached directly to the hopper wall. The probe is made of stainless steel AISI 321. Sensor enclosure is made of 2024 aluminum alloy, but it can be made of stainless steel AISI 321 as agreed with the customer.
FIZEPR-SW100 VIGT.415210.100 **-11.33**	Powdered and granular bulk and paste-like materials (e.g. silicate mass) on the conveyor belt, as well as liquid materials (e.g. sludge) in trays.	 Sensor with a two-pinned bent probe. Sensor enclosure is equipped with a G1¼ thread fitting for mounting to a 1¼ " pipe. All sensor parts are made of stainless steel AISI 321.

FIZEPR-SW100 VIGT.415210.100 -**11.4**	To control soil moisture and measure the moisture content of bulk materials.	 Submersible sensor with a two-pinned probe. The probe is equipped with a tip to immerse the sensor in a dense controlled material including in soil. Enclosure is equipped with a G1 thread fitting. It is mounted permanently to a 1" pipe. Sensor parts are made of stainless steel AISI 321.
FIZEPR-SW100 VIGT.415210.100 -**11.41**	Grain and other bulk materials as well as paste-like and liquid products.	 Submersible sensor with a two-pinned probe. Ø10 mm probe pins are made as a fork and have a length of 160 mm. Enclosure is equipped with a G1 thread fitting for sensor mounting to a 1" pipe. Sensor parts are made of stainless steel AISI 321.
FIZEPR-SW100 VIGT.415210.100 -**11.411**	For boiler applications with temperatures up to 200°C and pressures up to 6 at.	 Submersible sensor with a two-pinned probe. Ø10 mm probe pins are made as a fork and have a length of 160 mm. Enclosure is equipped with a G1 thread fitting for sensor mounting to a 1" pipe. Enclosure diameter is 48 mm. Sensor parts are made of stainless steel AISI 321. Working temperature is up to +180°C.
FIZEPR-SW100 VIGT.415210.100 -**11.412**	Grain and other bulk materials as well as paste-like materials in hoppers.	 Submersible sensor equipped with fittings for mounting on tank, hopper walls. Sensor parts are made of stainless steel AISI 321.
FIZEPR-SW100 VIGT.415210.100 -**11.6**	Paste-like and liquid materials featuring high conductivity located in trays and tanks including wastewater sludge, ion-exchange resin, etc.	 Submersible sensor with a two-pinned probe. Enclosure is equipped with a G1 thread fitting and can be mounted on a 1" pipe.

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Table 4

Moisture analyzers (moisture meters) FIZEPR-SW100.12.x for paste-like and liquid materials

FIZEPR-SW100 VIGT.415210.100 **-12**	Paste-like and liquid materials in trays and tanks including sludge in cement production, diesel oil emulsion, etc.	 The probe sensor contains a center pin and 4 perimeter-wise pins. The sensor is made of stainless steel AISI 321. Sensor enclosure has a G2 thread, but it can also be mounted to a G1 fitting. The sensor is mounted in a tank and mounted to a 1" or 2" pipe.
FIZEPR-SW100 VIGT.415210.100 **-12.16 (-21.16)**	Paste-like and liquid materials featuring high conductivity located in trays and tanks including wastewater sludge, ion-exchange resin, etc.	 The probe sensor contains a center pin and 4 perimeter-wise pins. The sensor is made of stainless steel AISI 321. The sensor contains a flange for mounting to the tank wall.

Table 5

Moisture analyzers (moisture meters) FIZEPR-SW100.14.x for measurements in boilers, clamps, as well as for soil moisture measurement

FIZEPR-SW100 VIGT.415210.100 **-14.1** **-14.11**	Bulk as well as paste-like and liquid materials. It can be used for soil moisture measurement. Version **14.11** is designed for syrup, meat and bone meal measurements in boilers at temperatures up to 180°C and pressures up to 6 at.	 The sensor contains a Ø24 mm probe 400…1000 mm in length (to be specified when ordering). It is made of stainless steel AISI 321. Sensor version 14.11 (Version **B**) is equipped with a G1 pipe thread coupling for sensor mounting in boilers (tanks).

Table 6

Moisture analyzers (moisture meters) FIZEPR-SW100.16.x for measurements of bulk, paste-like and liquid materials in tanks, boilers and pipelines

FIZEPR-SW100 VIGT.415210.100 **-16.1**	Water and sand pulp, coal sludge and other liquid and paste-like as well as bulk materials in tanks and pipelines with a diameter of at least 200 mm and working pressure up to 10 at. The sensor can be designed for boiler applications at temperatures up to 200°C.	 In-line probe sensor with one Ø16 mm, 150 mm long pin installed along the pipeline diameter. Attachment - to a nozzle with a flange welded to a pipeline, tank wall. Sensor enclosure and probe are made of stainless steel AISI 321. For use on water and sand pulp and in the sand flow, the probe is made of hardened stainless steel, the probe is made of hardened stainless steel ASTM 440B.

Table 7

Moisture analyzers (moisture meters) FIZEPR-SW100.17.x for concrete mixture, coal and other bulk and paste-like materials

FIZEPR-SW100 VIGT.415210.100 **-17.1**	Measurement of water content in concrete mixture inside concrete mixing machines, material moisture content measurements on conveyor belts.	 Sensor 80 mm in diameter (supplied with a fixing set). Sensor head is made of hardened stainless steel.
FIZEPR-SW100 VIGT.415210.100 **-17.2**	Measurement of water content in concrete mixture inside twin-shaft concrete mixers, measurement of bulk and paste-like material moisture in cylindrical sampling systems. Sensor head surface is concave to for sensor mounting on walls shaped as a round cylinder. .	  The sensor is made in the cylindrical enclosure 80 mm in diameter (the sensor is supplied complete with a fixing set). Sensor head surface is made concave as a round cylinder surface, and the cylinder radius is selected to meet customer requirements for sensor installation on the cylindrical wall of the twin-shaft concrete mixer or inside the sampling system pipe. Sensor head is made of hardened stainless steel.

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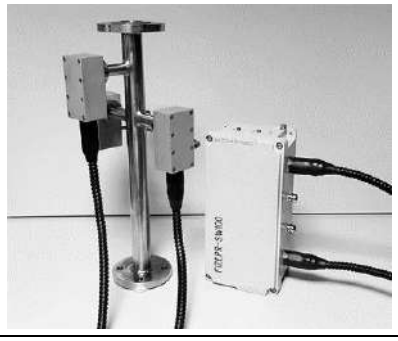
FIZEPR-SW100 VIGT.415210.100 **-17.21**	Measurement of bulk, paste-like materials in sampling systems 50 mm in diameter (diameter is specified when ordering).	 Sensor is made as a piston with a diameter of 50 mm. Allowable force on the piston is 5000 N.
FIZEPR-SW100 VIGT.415210.100 **-17.8**	Measurement of water content in concrete mixture inside concrete mixing machines, material moisture content measurements on conveyor belts. Sensor head surface is made concave to fit the cylindrical surface of the twin-shaft concrete mixer.	 Sensor 108 mm in diameter (supplied with a fixing set). Sensor head is replaceable, it is made of hardened stainless steel. The sensor enclosure is made of stainless steel AISI 321.
FIZEPR-SW100 VIGT.415210.100 **-17.81**	Replaceable sensor head for the moisture meter sensor FIZEPR-SW100.**17.8** moisture meter sensor	 Replaceable sensor head is made of hardened stainless steel.
FIZEPR-SW100 VIGT.415210.100 **-17.12**	Control of water content in concrete mixture inside concrete mixers, moisture control of bulk materials (powders and other bulk materials) on conveyor belts (sand, coal, carnallite).	 Sensor of 108 mm diameter (supplied with a fixing set). Sensor head is covered with a disk (plate) made of abrasion resistance alumina ceramics. Sensor design feature: customers can replace the ceramics disk on their own.
FIZEPR-SW100 VIGT.415210.100 **-17.121**	Replaceable alumina ceramics disk for FIZEPR-SW100.**17.12** sensor	 Replaceable alumina ceramics disk. To replace the disk, unscrew the sensor cover using the FIZEPR-SW100.**17.122** accessory wrench.

FIZEPR-SW100 VIGT.415210.100 **-17.122**	Cover removal/installation device, it is used for ceramics disk replacement.	 Sensor cover unscrew device for FIZEPR-SW100.**17.121** ceramics disk replacement.

Table 8

Moisture analyzers (moisture meters) FIZEPR-SW100.2x.x
for in-flow liquid material measurement
(complete information on in-flow analyzers for liquid materials is provided in the Technical Description and Operation Manual VIGT.415210.100-2 RE, Part 1)

FIZEPR-SW100 VIGT.415210.100 **-20.53**	Liquid materials as well as steam water mixture in DN50 pipelines, pressure is up to 25 at. Range of operating temperatures: -20 … +200°C. The analyzer is designed to control heterogeneous media, e.g. the flow of steam water mixtures formed when mixing water and superheated steam.	 Straight-flow sensor made as a DN50, PN25 pipe section, made of steel AISI 321; 50-25-01-1-B flanges according to GOST 33259-2015.
FIZEPR-SW100 VIGT.415210.100 **-23.01**	Liquid materials as well as steam water mixture in DN50 pipelines, pressure is up to 160 at. Range of operating temperatures: -20 … +320°C. The analyzer is designed to control homogeneous media in the longitudinal direction of media.	 Straight-flow sensor made as a DN50, PN160 pipe section, made of steel AISI 321; 50-160-11-1-E (or 50-160-11-1-J) flanges according to GOST 33259-2015.
FIZEPR-SW100 VIGT.415210.100 **-23.32**	Liquid materials as well as steam water mixture in DN32 pipelines, pressure is up to 6 at. Range of operating temperatures: -20 … +320°C. The analyzer is designed to control homogeneous media in the longitudinal direction of media.	 Straight-flow sensor made as a DN32, PN6 pipe section, made of steel AISI 321; 50-25-01-1-B flanges according to GOST 33259-2015.

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Laboratory moisture analyzers (moisture meters) FIZEPR-SW100.30.x

FIZEPR-SW100 VIGT.415210.100 **-30.1**	Laboratory measurements of predominantly liquid materials.	 Sensor contains a 46 mm diameter probe to make measurements in a standard 500 ml measuring cylinder (included in the scope of supply). Volume of controlled sample – 450 ml. Sensor enclosure and probe are made of stainless steel AISI 321.
FIZEPR-SW100 VIGT.415210.100 **-30.11**	Laboratory measurements mostly of liquid materials and measurements in tanks at different depths. Sensor is equipped with a coupling for mounting on the rod (pipe) with G1 thread.	 Sensor contains a 46 mm diameter probe to make measurements in a standard 500 ml measuring cylinder (included in the scope of supply). Volume of controlled sample – 450 ml. Sensor enclosure and probe are made of stainless steel AISI 321.
FIZEPR-SW100 VIGT.415210.100 **-30.2**	Laboratory measurements of bulk and paste-like materials (the sensor can also be used for liquid material control).	 The sensor contains: a 220 x 100 x 100 mm rectangular measuring cell with a probe. Volume of controlled sample is 2 l. The sensor is made of stainless steel AISI 321.
FIZEPR-SW100 VIGT.415210.100 **-30.26**	Laboratory measurements of bulk, paste-like and liquid materials featuring by high electrical conductivity (including salt solutions, etc.)	 Sensor contains a 220 x 100 x 100 mm rectangular measuring cell with a probe. Volume of controlled sample is 2 l. The sensor is made of stainless steel AISI 321.

FIZEPR-SW100 VIGT.415210.100 **-30.261**	Laboratory measurements of bulk, paste-like and liquid materials featuring by high electrical conductivity (including salt solutions, etc.)	 Sensor contains a 210 x 60 x 60 mm rectangular measuring cell with a probe and a cover. Volume of controlled sample is 0.7 l. The sensor is made of stainless steel AISI 321.
FIZEPR-SW100 VIGT.415210.100 **-30.3**	Laboratory measurements of liquid materials	Ø17.5 mm, 190 mm sensor for P1-21-200 and P2-21-200 vials according to GOST 25336-82. Volume of controlled sample – 15 ml. The sensor is made of stainless steel AISI 321.

**Note:* decimal number of the moisture meter version corresponds to the decimal number of the sensor used.

2.6 The list of electronic unit designs is provided in Table 10.

Table 10

Electronic unit reference code (decimal number)	Version
VIGT.415210.101	General purpose industrial electronic unit with cable lead-in couplings. Additional unit marking symbols: **N** - with extended frequency range **P** - with phase measurement **I** - with built-in digital indicator.
VIGT.415210.101-**01**	General purpose industrial electronic unit with RF connectors.
VIGT.415210.101-**02**	General purpose industrial electronic unit in a certified explosion-proof enclosure. Explosion proof mark on the unit enclosure is in accordance with Table 12. Additional unit marking symbols: **N** - with extended frequency range **P** - with phase measurement.

3. Technical requirements

3.1. Main parameters and specifications

Moisture meters are manufactured in accordance with technical specifications 4215-010-21161167-2014TU (VIGT.415210.100TU) based on the set of design documentation VIGT.415210.100.

Table 11 lists main moisture meter specifications.

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Table 11

TS No.	Parameter description	Value for analyzer versions	
		-10…-19	**-20…-29 -30…-39**
3.1.1	Measurement range of moisture W - mass (volume) water fraction, % ***(see Note 1)***	0 to 100	
3.1.2	Limits of permissible absolute error Δ of mass (volume) water fraction measurement according to MP242-1715-2014, % ***(see Note 2)***	Δ=0.035+0.05*W	Δ=0.02+0.025*W
3.1.3	Limits of permissible absolute error Δ of volume water fraction measurement according to MP 0919-6-2018 (analyzer versions: **-20.x**, **-21.x**, **-24.x**), % - When measuring in the 0 to 2% range - When measuring in the 2 to 10% range - When measuring in the 10 to 20% range - When measuring in the 20 to 50% range - When measuring in the 50 to 100% range		 ±0.06 ±0.15 ±0.4 ±1.0 ±2.5
3.1.4	Permittivity measurement range: - Real component (ε_r) - Dielectric loss tangent value (tg δ) ***(see Note 3)***	1 … 100 0 … 100	
3.1.5	Controlled material temperature range where moisture meter calibration is made, °C ***(see Notes 4 and 5)***	+ 5 … + 80	
3.1.6	Working temperature range of sensor operation, °C: - Version **A** - Version **B** - Version **B1** (for extreme temperatures) ***(see Notes 5 and 6)***	 -20 … +120 -20 … +180 -20 … +300	
3.1.7.1	Working temperature range of Version **A** electronic unit operation, °C	-20 … +80	
3.1.7.2	Working temperature range of Version **B** electronic unit operation (with extended temperature range), °C	-40 … +80	
3.1.7.3	Working temperature range of Version **A** explosion-proof electronic unit operation, °C	-20 … +60	
3.1.7.4	Working temperature range of Version **B** explosion-proof electronic unit operation (version with extended temperature range), °C	-40 … +60	

3.1.8	Temperature measurement range, °C for sensor versions: - **A** - **B** - **B1** (for extreme temperatures)	 -50 … +150 -50 … +200 -50 … +340
3.1.8.1	Limits of permissible absolute error of temperature measurement (in +5 … +80°C temperature range), °C	±1
3.1.9	Measurement period, maximum, sec ***(see Note 7)***	1
3.1.10	Output interface - digital - current, mA	 RS-485 Modbus RTU 4-20
3.1.11	Supply voltage, V nominal allowable ***(see Note 8)***	 24 18...32
3.1.12	Current consumption, mA, maximum	200
3.1.13	Dimensions of electronic unit in general purpose industrial version, mm	255 x 170 x 60
3.1.14	Dimensions of electronic unit in certified explosion-proof enclosure, mm	285 x 230 x 120
3.1.15	Weight of electronic unit in general purpose industrial version, kg	2
3.1.16	Weight of electronic unit in certified explosion-proof enclosure, kg	7
3.1.17	Dust and moisture ingress protection rating of electronic unit in general purpose industrial version according to GOST14254-2015	IP54
3.1.18	Dust and moisture ingress protection rating of electronic unit in certified explosion-proof enclosure according to GOST14254-2015	IP66
3.1.19	Dust and moisture ingress protection rating of sensor according to GOST14254-2015	IP67
3.1.20	Length of communication cable between sensor and electronic unit, m ***(see Note 9)***	1 … 4
3.1.21	Maximum length of communication cable (RS485 digital signal, 4-20 mA analog signal) from electronic unit to indication or control device (controller, computer), minimum, m	1000
3.1.22	Average time between failures, h	25 000
3.1.23	Average life, years	10

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Notes

1. Moisture meters for bulk materials are calibrated in mass units of moisture content. For liquid materials, calibration may be both in mass and in volume units of moisture content. The type of calibration used is specified in the moisture meter data sheet.
2. Absolute error values and factors affecting the error value are specified in Section 3.2 of this manual.
3. The dielectric loss tangent value (tg δ) of the controlled material for **-10.x**, **-11.x**, **-12.x**, **-30.1** и **-30.2** moisture analyzer versions may be in the tg δ = 0…0.5 range. For **-10.16**, **-10.46**, **-10.56**, **-30.26** moisture analyzer versions and their modifications the possible dielectric loss tangent range is 0 … 100, and may exceed 1000 in some cases.
   At the customer's request, the dielectric loss tangent value of the controlled material can be displayed on an external indicating device.
4. The user can freely update analyzer calibration with data for extension of moisture measuring temperature range for materials measured using supplied software by the method described in the operation manual.
5. When measuring materials containing ice, the moisture meter detects only unfrozen water. Measurement accuracy for materials containing ice is not regulated.
6. For materials with a temperature of over +120 but not more than + 180°C, sensors are available in Version **B** with a measuring cell mounted on a branch at a distance from the sensor enclosure. In order to measure materials with a temperature over + 180°C, sensors are available in Version **B1** with a measuring cell placed in an enclosure thermally insulated from the sensor enclosure.
7. The measurement time for fast processes can be reduced, e.g. for **-17.x** moisture meters (supplied for concrete mixer applications), the maximum measurement period is 100 ms.
8. Supply voltage can be set to 12 V at the customer's request.
9. Required communication cable length between the sensor and the electronic unit is agreed when ordering. Maximum cable length for the moisture meter in explosion-proof version is 4 m.

3.2 Measurement error.

Refer to Table 12 for absolute error Δ values calculated by mathematic expressions (formulas) provided in Section 3.1.2.

Table 12

Moisture content value **W**	Limits of permissible absolute error **Δ**	
	for analyzer versions **- 10** … **- 19**	for analyzer versions **- 20 … - 29, - 30 … - 39**
5%	0.3%	0.15%
10%	0.5%	0.3%
20%	1%	0.5%
40%	2%	1%
50%	2.5%	1.3%
70%	3.5	1.8%
100%	5%	2.5%

This absolute error value is determined based on Verification Method 242-1715-2014 in accordance with Section 6.4 of this Verification Method. It is important to note that moisture meter verification according to this Verification Method is performed using the following liquids: reference sample of mass (volume) water fraction GSO 9829 - 2011, GSO 8999-9007 - 2008, GSO 9261-9262 – 2008 or check mixtures for transformer oil and water. However, when measuring liquid materials, a very important factor is excluded that affects the results of bulk material measurements, in particular, the effect on the bulk density measurements of bulk materials. The bulk density of bulk materials depends on the measurement place and conditions selected (refer to Section 9.7 and Section 12.4 of this manual). The bulk density of bulk materials on a conveyor belt, is unstable, and the higher the conveyor belt speed, the more the bulk material density can change and, accordingly, the higher the measurement error. The most stable, as practice shows, is the bulk density of bulk materials measured in hoppers. But even in hoppers, the real absolute measurement error is usually not less than 0.4%.

3.3 Main specifications and explosion-proof marking of moisture analyzers in explosion-proof version are shown in Table 13.

Table 13

Parameter	Value
Explosion-proof marking: - Electronic unit - Sensor	 Ex 1Ex d [iaGa] IIB T5 Gb Ex Ex tb [ia Da] IIIC T100ºC Db Ex PB Ex d [ia Ma] I Mb Ex 0Ex ia IIB T5 Ga Ex Ex ia IIIC T100ºC Da Ex PO Ex ia I Ma
Ambient temperature range, °C: - For Version **A** electronic unit - For Version **B** electronic unit	 –20 to +60 –40 to +60
Sensor operating temperature range (measured material temperature range), °C - For Version **A** sensor - For Version **B** sensor	 -20 to +120 -20 to +180
Ingress protection rating according to GOST 14254-2015: - Electronic unit - Sensor	 IP66 IP67
Electronic unit supply voltage (DC), V	 18 – 36
Maximum voltage U_m, V	36
Parameters of intrinsically safe circuits of the electronic unit	
Maximum output voltage U_o, V	10.5
Maximum output current I_o, A	1.11
Maximum external capacity C_o, µF	14
Maximum external inductance L_o, mH	0.02

Explosion protection of moisture meters is ensured by their design that meets the general requirements according to GOST 31610.0-2014 (IEC 60079-0:2011), explosion protection type "explosion-proof enclosures "d" according to GOST IEC 60079-1-2011, explosion protection

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type "intrinsically safe circuit "i" according to GOST 31610.11-2014 (IEC 60079-11:2011), dust ignition explosion protection type "t" according to GOST R IEC 60079-31-2010.

3.4 The moisture meter is designed for continuous operation.

4. Scope of supply

4.1 Analyzer scope of supply:

1. Sensor
2. Electronic unit
3. Technical description and operation manual VIGT.415210.100 RE
4. Data sheet VIGT.415210.100 PS
5. CD with SW100 and SWPro software

4.2 The items listed in Table 14 may be additionally included in the scope of supply at the customer's request.

Table 14

Item description	Type, brand
USB – RS-485 interface converter (PC USB port supply)	AS4 converter by Owen
USB – RS-485 interface converter (PC USB port supply)	ATsDR.426469.032 by RPE "Bolid"
Measuring and regulating device with digital indication (input signal – 4-20 mA current)	TRM1 by Owen
Measuring and regulating device with digital indication (input signal – 4-20 mA current)	TRM-201 by Owen
Operator panel with digital indication (MODBUS RTU RS-485 input signal)	SMI1 by Owen
Measuring and regulating device (input signal – 4-20 mA current)	METAKON-1105 by KontrAvt
24V supply unit	BP30B-D3-24 by Owen
Explosion-proof thermal cover for electronic unit. It is used when operating at low temperatures below -40°C. Supplied with: - Thermal cover (wear-resistant, chemically stable, water-oil repellent fabric) - 25 NTR2-VT, 50Hz, 220V, 2ExellT6 self-regulating heating tape with power cable in the 3 m metal hose - Terminal box.	EkoTerm Ex-02 by EkoTerm

4.3 Example of the moisture meter designation in the order and technical documentation of other products:

"Moisture analyzer FIZEPR-SW100 VIGT.415210.100-10.6".

The following abbreviated designation is allowed:

"Moisture analyzer FIZEPR-SW100.10.6".

5. Design features of moisture meter versions and moisture meter operation

5.1 Probe moisture meters VIGT.415210.100-**10.x** are designed to control moisture content in powdery, granular, paste-like and bulk materials including crushed stone, gravel, sand, ore, grain, peat, sawdust, etc.

The sensor probe is made of the AISI 321 stainless steel bar (optionally sensors can be made of steel grades AISI 420, AISI 316Ti, etc.). The probe is placed in a controlled material. VIGT.415210.100-**10.x** sensor versions can be mounted in hoppers, silos, on trays or above conveyor belts. Moisture meter design allows for a fairly simple sensor installation and dismantling while in service.

5.1.1 The VIGT.415210.100-**10.21** and VIGT.415210.100-**10.6** moisture meter sensor versions are shown in Appendices 1 - 2. The sensor is made of stainless steel AISI 321 and contains a flat-topped probe fixed on the mounting panel. The sensor can be mounted on walls in hoppers, dryers or above conveyor belts. The VIGT.415210.100-**10.21** moisture meter version is distinguished from VIGT.415210.100-**10.6** by an additional shield electrode – a flat-topped rod installed parallel to the probe. This additional shield electrode eliminates the influence of metal structures located near the sensor.

These moisture meter versions can be used to control bulk materials in tanks, dryers, as well as for measurements on conveyor belts. Controlled material must completely fill the space between the probe and the panel, as well as the space around the probe at a distance of 10...15 cm and more. When choosing the place for sensor installation, it is necessary to exclude any protruding metal elements near the sensor probe (at distances less than 20 cm).

5.1.2 The VIGT.415210.100-**10.16** moisture meter version (shown in Appendix 3) is identical to the **-10.6** moisture meter in terms of design and application specifics, but it is designed to control materials with high electrical conductivity such as anthracite or concentrates of various ores.

5.1.3 The VIGT.415210.100-**10.5** moisture meter version (see Appendix 4) is designed to control bulk materials on conveyor belts only. The sensor is installed along the material flow. A special shape of the sensor ensures complete sensor filling with controlled material and minimum flow resistance.

5.1.4 The VIGT.415210.100-**10.4** moisture meter version (shown in Appendices 5-8) is equipped with a sensor probe made as a S27 mm straight rod – a hexagonal AISI 321 stainless steel bar (27 mm is the inscribed circle diameter). The probe is fixed on the opposite hopper walls with coupling holders (see Appendix 9). Probe length in the **-10.4** moisture meter is selectable in the range from 50 cm to 120 cm. **-10.44** probe length is up to 1.5 m, **-10.441** probe length is up to 2 m. This moisture meter provides averaged measurement results throughout the volume of hundreds of liters to 1 cubic meter, and thus differences in moisture content of particular local areas do not lead to errors when determining average moisture content across such a big volume. In concrete production such averaging may reduce errors in the proportioning of components caused by uneven moisture distribution in sand and crushed stone.

This moisture meter is indispensable for controlling materials adhering to the probe and hopper walls. It is clear that the volume of adhering material in relation to the measured volume is a very small value, so the effect of adhering on the measurement results is negligible.

The VIGT.415210.100-**10.46** moisture meter sensor is similar in design to the **-10.4** version, but this moisture meter is intended to measure materials with high electrical conductivity (anthracite, concentrates of various ores, salts, etc.)

5.1.5 The VIGT.415210.100-**10.41** moisture meter version (shown in Appendices 5, 10, 11) is equipped with a sensor probe made as a straight rod – an AISI 321 stainless steel bar 14 mm in di-

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ameter. The probe is fixed on the opposite hopper walls with coupling holders. Probe length in this moisture meter design is selectable in the range from 25 cm to 60 cm. This design provides averaged measurement results throughout the hopper volume and thus differences in moisture content of particular local areas do not lead to errors when determining average moisture content. It is mainly designed to control wood waste including sawdust, wood chips, and grain.

5.1.6 The VIGT.415210.100-**11.x** probe moisture meters include a sensor formed by two pins (sensor versions are shown in Appendices 12 and 13). This moisture meter is designed to control both bulk (e.g., grain in hoppers) and liquid (paste-like) materials. The sensor is hermetically sealed and can be immersed into a tank with liquid material (e.g. fuel oil). The sensor is mounted on the 1" or 1¼ " pipe. The sensor cable runs through the specified pipe. Appendix 14 shows the **-11.41** sensor mount.

Due to pin design of the sensor, **-11.x** moisture meters can also be used for moisture control of soil, peat and plant products in clamps. Unlike other **-11.x** series versions, the **-11.33** sensor pins are turned relative to the sensor axis. This sensor is designed to measure bulk materials on a conveyor belt, as well as liquid materials in trays.

5.1.7 The VIGT.415210.100-**12** probe moisture meter includes a sensor that consists of a center probe pin and four guard pins located around the center pin (see Appendix 15). The sensor probe and enclosure are made of AISI 321 stainless steel. This sensor is designed for installation in tanks with liquid materials: fuel oil, cement production sludge, etc. The sensor can be fixed to a pipe with 1" (G1) cylindrical pipe thread in accordance with GOST 6357-81, and to a pipe with 2" (G2) internal thread. The sensor cable runs through the specified pipe. Such mounting allows the user to adjust depth of sensor immersion into a tank, and thereby control moisture at different levels. It is recommended to use silicone sealants in order to hermetically seal the junction of a sensor and a pipe.

5.1.8 The VIGT.415210.100-**17**, **-17.1**, **-17.2**, **-17.8**, **-17.12** moisture meters (see Appendix 16) are designed to measure bulk and paste-like materials in hoppers, on conveyor belts, in mixers. The sensing element (probe) of the **-17, -17.1 and -17.8** sensors is a flat surface made of hardened stainless steel (AISI 420, ASTM 440B). The probe surface of the **-17.2** sensor version is curved along the radius, which allows this sensor version to be installed on the side wall of the twin-shaft concrete mixer.

5.2 The VIGT.415210.100-**30.x** laboratory moisture meters are used to control liquid, bulk and paste-like materials.

5.2.1 The VIGT.415210.100-**30.1** moisture meter version (see Appendix 17) contains a sensor with a diameter of 46 mm to control liquid materials in standard 500 ml measuring cylinders according to GOST 1770-74. Volume of controlled sample – 450 ml.

5.2.2 The VIGT.415210.100-**30.11** moisture meter version contains a sensor that does not externally differ from the VIGT.415210.100-**30.1** sensor, but can be used to monitor liquids in tanks. The sensor is equipped with a G 3/4 (or G1) pipe fitting for fastening to the stem (pipe) when immersed in the tank.

5.2.3 The VIGT.415210.100-**30.2** moisture meter version (see Appendix 18) is made as a rectangular measuring cell that can be filled with either controlled bulk material or liquid. The measuring cell is made of AISI 321 stainless steel. Internal dimensions of the measuring cell: 220 x 100 x 100 mm, controlled sample volume is 1.8 l.

5.2.4 The VIGT.415210.100-**30.26** moisture meter version (see Appendix 18) is made as a rectangular measuring cell that can be filled with either controlled bulk material or liquid. The measuring cell is made of AISI 321 stainless steel. Internal dimensions of the measuring cell: 220 x 100 x

100 mm, controlled sample volume is 1.8 l. Unlike the VIGT.415210.100-**30.2** version, this moisture meter is designed to control materials with high electrical conductivity.

5.2.5 The VIGT.415210.100-**30.3** moisture meter version is made as a small diameter probe to measure liquid materials inside test tubes of P1-21-200 and P2-21-200 types according to GOST 25336-82 widely used in chemical laboratories. Volume of controlled sample – 15 ml.

Appendices 19 and 20 show three versions of electronic units. The moisture meter can be equipped with electronic units in general purpose industrial version and version with a certified explosion-proof enclosure that has an explosion-proof marking provided in Table 12.

The electronic unit in general purpose industrial version is equipped with two LEDs mounted on its enclosure to monitor moisture meter operation. One LED is connected to the +24 V input power supply circuit and illuminates when power is supplied. The second LED is bi-color. Green light indicates RS-485 network communication. Red light illuminates when the instrument transmits the data to the network.

The electronic unit of a permanently installed moisture meter is fixed near the sensor at a distance determined by the connection cable length specified in the order. If cable is 1.5 m long, the electronic unit is installed at a distance of no more than 1.2 m from the sensor.

6. Physical principles of moisture meter operation

Moisture meter operation is based on measuring electromagnetic wave deceleration factor (k_{dec}) in the controlled material. Deceleration factor k_{dec} is equal to the square root of the permittivity ($\boldsymbol{\varepsilon_r}$), and it is the ratio of electromagnetic wave propagation speed in air (i.e. light speed) to its propagation speed in the controlled material. As the water content in the material increases, the permittivity of the material rises and so the wave propagation velocity decreases. The proportion of water - material moisture content W - is calculated according to the deceleration factor value.

Measurements are made by probing the medium with radio waves with the simultaneous frequency tuning of the probing signal in the working frequency range. The choice of the working frequency range is determined by the sensor design and possible dielectric parameters of the controlled material. Minimum possible frequency in the working range is 0.2 MHz, and maximum possible frequency is 750 MHz, but maximum frequency can be increased to 1500 MHz, if necessary).

k_{dec} is determined by the characteristic (resonant) frequencies in the sensor signal spectrum, i.e. the frequencies at which a whole number of half-waves of the electromagnetic signal fits within the sensor primary transducer length. At these frequencies, the sensor signal spectrum has minimum values (spectrum example is shown in Fig. 1 in Part 2 of this manual).

Electromagnetic wave deceleration factor in the material k_{dec} is calculated according to the formula:

$$k_{dec} = f_0 / f_M \ ,$$

where f_0 – – empty sensor (sensor filled with air) resonant frequency

f_M – sensor resonant frequency when it is filled with controlled material.

The measurement consists in periodical measurements of resonant frequency f_M and k_{dec} deceleration factor value calculation. k_{dec} value conversion to W moisture content is performed using calibration tables providing correspondence between k_{dec} deceleration factor, moisture and temperature.

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Thus, the moisture meter principle of operation is to periodically search for sensor resonant (characteristic) frequency f_M, measure temperature and calculate moisture content based on these parameters.

A tunable generator forming a harmonic probing signal and a sensor signal processing device are located in the moisture meter electronic unit. The sensor includes a primary transducer (i.e. a probe) and an electronic detector that converts a high-frequency signal at the sensor output into low-frequency voltage.

In **-30.x, -11.x, -12.x** sensor versions, the primary transducer (probe) is formed by two (or more) rods that form a segment of a so-called long transmission line.

In **-10.x** sensor versions, the probe also is a segment of a two-conductor line, but it is formed by a metal rod and a shield conductor (steel panel or metal hopper walls). In **-17.x** sensor version, the primary transducer is a capacitive structure forming a capacitor, to which an inductive element is connected.

The moisture meter generator is periodically automatically tuned in the frequency range. The moisture meter finds resonant (characteristic) frequencies f_M in the spectrum obtained as a result of scanning. The moisture meter calculates electromagnetic wave deceleration factor in the material from the lowest found frequency f_M , as well as frequency f_0. Then, according to the calibration tables compiled for a set of temperatures and stored in the electronic unit memory for the selected material, the moisture meter microcontroller calculates the material moisture content W. Calibration tables for different materials (sand, gravel, sunflower oil, cement production sludge, etc.) are entered into the electronic unit memory from the computer. The total number of such tables stored in the moisture meter memory is almost unlimited.

It should be noted that water permittivity $\boldsymbol{\varepsilon_r} \approx 80$, and permittivity of most materials does not exceed $\boldsymbol{\varepsilon_r} = 3$. Significant difference between permittivity of water and other materials is exactly what allows to measure water content in the mixture due to a noticeable increase of total mixture permittivity if moisture is present in the material.

Please note: ice permittivity is $\boldsymbol{\varepsilon_r} \approx 3$, so these moisture meters (as well as all known industrial moisture meters of other types) do not allow ice amount measurements.

The resulting measured moisture value is transmitted from the electronic unit output via RS-485 digital interface and, simultaneously, via 4-20 mA current signal to the external indicator or industrial controller that controls process.

7. Labeling

7.1 The electronic unit enclosure is labeled with the following markings:

Instrument type - on the front panel (on the cover)

Moisture meter serial number - on the enclosure side wall or also on the cover.

When using a moisture meter for commercial accounting, a seal is installed on one of the screws that fix the protective cover inside the electronic unit.

8. Transport and consumer packaging

8.1. Transport and consumer packaging is designed to store and transport the moisture meter, and to ensure its safety during transportation for the entire storage period.

8.2. The moisture meter, parts and components included in the scope of supply complete with operational documentation must be packed in a transport packaging.

8.3. Operational documentation must be wrapped in a polyethylene film.

8.4. Together with the delivery set, transport packaging must contain a packing list indicating description and quantity of supplied products.

9. General operation instructions

9.1 The moisture meter consists of an electronic unit and a sensor connected by a cable. Cable connection with the sensor is non-separable and filled with compound. **Opening the sensor is not allowed and leads to loss of warranty.** Cable connection with the electronic unit is detachable. If it is necessary to disconnect the sensor and the electronic unit, open the electronic unit cover, disconnect the cable wires from the terminal block, disconnect the RF connector, then loosen the cable entry clamp. After that the cable must be carefully removed from the electronic unit cable entry.

9.2. The moisture meter must be powered from a general-purpose stabilized DC voltage source with the output voltage of 24 V (maximum permissible supply voltage values are 18 ... 32 V). Own power consumption of the moisture meter electronic unit does not exceed 3.6 W.

9.3. Information is transmitted simultaneously and independently via two lines:

- Digital communication line, RS-485 Modbus RTU interface
- 4-20 mA current loop.

9.4. The moisture meter is ready for operation in 1-2 minutes after the supply voltage is applied.

9.5. Unpacking rules

9.5.1. Upon receipt of the container with a moisture meter, visually inspect it together with the person responsible for transportation. It is necessary to ensure the complete container integrity. In case of damage to the packaging prepare a report signed by the persons responsible for acceptance and transportation, seal and send to the transport company.

9.5.2. During the cold season, containers must be unpacked only after holding them in a warm room for 2 hours at a temperature not lower than 18-20°C.

9.5.3. After unpacking, check the contents of packages against the inventory in the packing lists and check the completeness in the “Scope of supply” section of the equipment certificate. Description, designation, serial number and quantity of products listed in the equipment certificate shall correspond to the records in packing lists.

9.6. Inspection rules.

9.6.1. Perform visual inspection in order to check safety and integrity of the moisture meter enclosure. The product shall be free from scratches, cracks, dents, corrosion and other defects that can be detected by visual examination.

9.6.2. All defects and irregularities detected during unpacking, visual inspection and completeness check shall be reported in a damage complaint report that shall be signed by persons responsible for acceptance of the moisture meter, approved by the Director of the customer company, and sent to the manufacturer.

9.7 Selection of sensor version and installation place, requirements for operating conditions.

For the correct operation of the FIZEPR-SW100 moisture meters, the following conditions must be met:

9.7.1 The area controlled by the moisture meter sensor (a space between sensor electrodes, as well as around electrodes) must be completely filled with the measured material. If this area is filled, at least partially, with air or foreign objects (debris) instead of the controlled material, correct measurements are not possible.

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This requirement is applicable to sensors used on conveyors (**-10.5x**, **-11.33**, **-17.x** versions) is as follows: the thickness (height) of the material layer on the conveyor belt must be such as to eliminate the appearance of an air gap under the sensor "shoe" (base). This condition can only be met if the conveyor speed is not too high and the thickness of the material layer on the belt is not less than 10 cm (for **-17.x** sensors - not less than 5 cm), and the layer width with the indicated thickness must not be less than 15 cm. At a high conveyor speed, the sensor can scatter the material, which will lead to the downward bias of the measured moisture, but if there is a material layer with a "margin" on the sensor sides and above the sensor, then the effect of material "scattering" can be compensated in some cases.

9.7.2 The amount of material in the volume (area) controlled by the sensor must be approximately the same for all measurements, i.e. the material bulk density must be stable. When the material bulk density changes, the weight of the material fallen into the volume of space controlled by the sensor changes. Accordingly, the amount of water detected by the sensor also changes along with the change in the material weight in the specified volume. This statement is true for all moisture meters existing in the world of any measurement principle, except for optical (infrared) moisture meters. It should be noted that in the hopper, as practice shows, the bulk density of the bulk material is the most stable, so the maximum measurement accuracy is achieved exactly on **-10.4x** version moisture meters installed in hoppers.

9.7.3 When measuring materials on a conveyor and in a concrete mixer, it is necessary to exclude material sticking, because it is the adhering layer that will influence the measurement results. If sticking cannot be excluded, then it is recommended to switch to periodic measurement, e.g. once every 30...60 seconds or even less often in conveyor applications. In this case, the sensor must be inserted into the material flow for 5...10 seconds, then the sensor should be raised. This problem is easily solved using a standard drive. Such operation will decrease material sticking on the sensor. In addition, you can make sure that when lifting the sensor, it passes between the brushes that clean off the adhering layer.

It should be noted that material sticking on **-10.4x** sensors installed in hoppers and directly on hopper walls is quite acceptable, since the material volume of hundreds of liters is measured at once, while the volume of stuck material usually do not exceed ten liters, and the stuck material, due to its relatively small volume, does not affect the measurements.

9.7.4 When ordering moisture meters for materials that lack sufficient application practice, we usually recommend that customers send material samples in the amount of 2...4 liters to the Design Bureau Fizelektronpribor, Ltd. address. Using the sent samples it is possible to select the best sensor design, perform pre-calibration on the provided material.

10. Safety precautions

10.1 A 24 VDC voltage source used to power the moisture meter must be a power source that converts a higher voltage to a safe extra-low voltage by an isolation transformer or a converter with separate windings. For example, OWEN BP30B-D3-24 24V power supplies that meet the above requirements can be used as a source for powering the moisture meter.

The moisture meter corresponds to Electric Shock Protection Class III in accordance with GOST 12.2.007.0-75 when using a source for powering the moisture meter that meets the above requirement.

10.2. Do not operate the moisture meter if the electronic unit cover is removed.

10.3. Do not operate the moisture meter with poorly attached connectors or poor contact in terminal connectors.

10.4. Do not operate the moisture meter in explosive production conditions without grounding the moisture meter electronic unit.

10.5. The moisture meter electronic unit and sensor must be installed on grounded metal structures.

10.6. Only persons who have studied this technical description, and have been instructed in safety precautions when working with electrical installations and electronic equipment, shall be allowed to install (dismantle), operate, maintain and repair the moisture meter.

10.7 All types of maintenance, repair and installation associated with the replacement of fuses, disconnection and switching of wires, etc., as well as moisture meter dismantling must be performed only when it is disconnected from the power source.

11. Installation procedure

11.1. Safety regulations set out in Section 10 of this manual and in regulatory technical documents applicable at the customer plant shall be strictly observed during the moisture meter installation.

11.2. The moisture meter supplied for on-site installation has passed in-plant testing.

11.3. First choose mounting locations for a sensor and an electronic unit. Take into account permissible operating conditions when choosing mounting locations. Prepare mounting locations for moisture meter components in accordance with overall and mounting dimensions.

11.4. The moisture meter on-site installation is carried out in the following order:

- - Mount the sensor in a prepared location
- Fix the electronic unit in a prepared location
- Remove the electronic unit cover and make electrical installation.

11.5. Possible moisture meter wiring diagrams are presented in Appendix 21. Measurement results can be displayed on a controller or a computer via RS-485 Modbus RTU interface. Besides, measurement results can be displayed on any display device with 4-20 mA current input. For example, the measuring and regulating device OWEN TRM-201 (see Appendix 21), as well as other similar measuring devices manufactured by a number of companies, can be connected to the moisture meter current output. Calibration instructions for the TRM-201 measuring and regulating device are given in Appendix 22.

The moisture meter must be powered from a 24 VDC voltage source, e.g. OWEN BP 30B-D3-24.

If it is necessary to set the current output parameters, obtain diagnostic information about the moisture meter operation, record its characteristics, adjust the moisture meter or change the communication parameters, connect a computer (laptop) to the electronic unit using the RS-485-USB interface adapter converter. Parameter adjustment instructions are provided in Part 2 of this manual.

11.6. Electrical connection of the moisture meter shall be carried out in the following order:

11.6.1. Connect the grounding contact on the enclosure of the explosion-proof electronic unit with the ground bus.

11.6.2. Connect the digital interface cable to the RS-485 terminals (if a digital data transmission channel from the moisture meter is used).

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11.6.3. Connect the communication cable to the 4-20 mA "GND Current", "+ I GND Current" terminals of the current output (if a data transmission channel from the moisture meter is used via the current loop).

Note. Current output and RS-485 signal circuits are not galvanically isolated from 24V power circuits.

11.6.4 Cable connection with the sensor is non-separable and filled with compound. Cable connection with the electronic unit is detachable. Cable connection with the sensor is non-separable and filled with compound. Cable connection with the electronic unit is detachable. If the sensor cable is disconnected from the electronic unit, cable wires must be connected in accordance with the marking on the terminals as provided by the diagram given in Appendix 21.

Note. Upon delivery of moisture meters, their packaging shall be carried out with the sensor cable connected to the electronic unit.

11.6.5. Connect the power cable to the "24V" terminals.

11.7. Assembly and disassembly features of **-10.21, -10.6** sensor versions

11.7.1. Make a (310…315) x (80…85) mm rectangular hole in the hopper wall to install the sensor on the hopper with controlled material, The sensor panel is attached to the outside of the hopper so that the probe is inside the hopper and is completely immersed in the controlled material. When choosing the place for sensor installation, it is necessary to exclude any protruding metal elements near the sensor probe (at distances less than 20 cm) inside the hopper.

11.7.2. The sensor panel is attached to the hopper wall with screws.

11.8 Assembly and disassembly features of **-10.4x** sensor versions on metal hopper walls

NOTE: THE MOISTURE METER PROBE MUST BE REMOVED FROM THE COUPLINGS AND UNPLUGGED FROM THE ELECTRONIC UNIT DURING WELDING

11.8.1. Sensors **-10.4x** with a probe made as a straight rod (Appendices 5-11) are installed in the following order: insert end 4 of rod 5 into the hole in coupling 9 and pass it through the hole in coupling 8. Press enclosure 6 to the base by screwing fixing cover 1 (or by a flange fixed with four bolts). Then, screw bushing 7 with internal thread onto another end 4 of rod 5, and twist it until tight against the bottom of coupling 8. Fix bushing 7 in this position with fixing cover 2. This ensures reliable contact of the primary transducer high-frequency circuits without the need to precisely select the probe length (rod 5) for hopper dimensions.

11.8.2. Once installation is complete, calibrate the **-10.4x** sensor versions with an empty hopper in accordance with Section 5, Part 2 of this operation manual. Calibration is necessary since the probe length is matched to couplings mounted on the hopper. For example, with the specified length of 900 mm, the probe length can be in the range of 800-1000 mm (allowable values) when couplings are welded to hopper walls.

Note. The specified probe length is a distance between hopper walls along the probe axis.

Disassemble the probe in reverse order.

11.9 Features of assembly and disassembly of **-11.x, -12** sensor versions

When attaching these sensors to a pipe, apply silicone sealant to threaded connection to prevent liquid ingress to the pipe used for routing the cable connecting the sensor to the electronic unit.

12. Pre-starting and operation procedure, measurement procedure

12.1. The moisture meter must be serviced by an operator who is familiar with the operation of electronic equipment, has studied this technical specification and operation manual and have been instructed in safety precautions when working with electrical equipment.

12.2 Preparation for work is performed in the following order:

12.2.1. Make sure that electrical connections correspond to the wiring diagram. Check reliability of wire connection to terminal clamps.

12.2.2. Energize the moisture meter.

12.2.3. Make sure that the "POWER" LED on the electronic unit side panel is illuminated.

12.2.4. Make sure that the "CONTROL" LED on the electronic unit side panel is flashing (when RS-485 line is connected).

Note. LEDs of electronic units made in explosion-proof enclosure are located on a top panel – connection board.

12.2.5. Once all the above actions are performed the moisture meter is ready for operation.

12.2.6. If any moisture meter failure is detected, turn off power, identify and correct the occurred failure as described in Sections 13 and 14 of this manual (Part 1).

12.3 Measurement procedure

Before taking measurements, make sure that the moisture meter sensor is completely filled with the controlled material. Read measurement results from the indicator device (OWEN TRM-201 measuring and regulating device or a computer screen).

12.4. Evaluation of measurement reliability

Evaluation of measurement reliability (accuracy) is performed by comparing moisture meter readings with laboratory test results.

These data are entered into the "Measurement Reliability Evaluation Report" (see Appendix 38) with the date of sampling and the temperature of the material.

When taking samples for laboratory measurements from the controlled material volume with the moisture meter, the moisture meter readings are recorded in the report, and once the laboratory analysis is completed, the results are recorded in a corresponding line. Then the difference between obtained values is calculated taking into account the sign.

The frequency of sampling is determined by the company.

In case of systematic unacceptable differences between moisture meter and laboratory data perform the analysis of possible causes listed below.

List of possible reasons for such differences:

1) The instrument was not calibrated on an empty hopper after installation.
2) The plant laboratory a moisture calculation method different from that given in Section 2.3 of this manual.
3) An unrepresentative sample is taken for laboratory analysis.
4) The controlled material structure is unstable in terms of moisture content.
5) Incomplete filling of the sensor (the volume of space covered by the sensor during measurements) with the controlled material.
6) Unstable bulk density (looseness) of the controlled bulk material (the moisture meter was calibrated at a certain bulk density of the material, and during measurements the bulk density changed).
7) Sensor clogging due to the controlled material stuck in it or due to foreign objects that have fallen into the sensor. The material stuck in the sensor will determine the moisture meter readings.

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The following solutions are recommended for the above causes for discrepancies:

Cause 1. The instrument was not calibrated on an empty hopper after installation

After installation of pin-type sensors (**-10.4x**) it is necessary to calibrate the moisture meter to determine resonant frequency on an empty hopper in accordance with Section 11.8.2 of this Operation Manual. Failure to perform such calibration may shift readings towards overestimation or underestimation of results. Calibration shall be carried out when the hopper is completely emptied. In order to assess operating quality and calibration accuracy of the moisture meter, you may use the manufacturer's warranty services by sending a configuration file to info@fizepr.ru. This file must be saved immediately after calibration using the software included in the scope of supply (see Section 2.2, Part 2 of the Operation Manual).

Cause 2.

The plant laboratory uses a different method of moisture calculation

There are two main moisture measurement methods as specified in the industry standards:

1) Moisture content is calculated as a ratio between water mass and wet material weight
2) Moisture content is calculated as a ratio between water mass and dry material weight

FIZEPR-SW100 moisture meters usually use the first method (see Section 2.3 of this Operation Manual). If measurement by the second method or using moisture volume units is required, calibration tables must be modified for the selected method and moisture volume units by recalculating table values. Such recalculation can be done unassisted or using the manufacturer's services (warranty service) after moisture meter delivery or at the ordering stage.

Cause 3.

An unrepresentative sample is taken for laboratory analysis

When sampling the material for laboratory analysis, the following mandatory condition shall be fulfilled: moisture content in a sample must be equal to the average moisture content in the material volume measured with the moisture meter. The measured volume for **-10.4x** versions of probe moisture meters ranges from hundreds of liters to one cubic meter. For **-10.21** and **-10.6** versions of moisture meters, the measured volume is tens of liters.

For example, in a standard dispenser, the moisture content of sand prepared for a concrete mixer may differ by 1% or more at different points in volume (about 0.5 cubic meters). Therefore, there are certain features of sampling for laboratory analysis. A representative sample must contain material from different parts of the entire volume, which can be achieved, for example, by repeated gradual discharging material in small doses from a hopper (dispenser). Otherwise, the calculated accuracy of the laboratory analysis will not be achieved and its result cannot be considered reliable.

We can recommend another method for obtaining samples: at least 8...10 samples must be taken from different parts of the volume controlled by the moisture meter (it is performed when pouring sand out of the hopper). Use the laboratory method for each sample to determine the moisture. Determine the resulting moisture by mathematical averaging. The advantage of this method is that it also allows estimating the accuracy of laboratory analysis by the magnitude of the variation in the sample measurement results.

Cause 4. Controlled material has an unstable composition changing over time

The results of measuring the moisture content of bulk materials are affected by the material grain particle-size distribution, fine dust volume, salt content. All these physical factors may affect material dielectric parameters and standard calibration used by the manufacturer may not be suitable. In this case, it is necessary to create a new calibration based on a comparison of measurement results obtained by the moisture meter with laboratory analysis results. Based on the comparative

statistics of moisture meter readings and their corresponding laboratory results, the user can create a new calibration on his own or contact the moisture meter manufacturer.

Cause 5. Incomplete filling of the sensor (the volume of space covered by the sensor during measurements) with the controlled material

Cause 6. Unstable bulk density (looseness) of the controlled bulk material (the moisture meter was calibrated at a certain bulk density of the material, and during measurements the bulk density changed)

Cause 7. Sensor clogging by the controlled material stuck in it or foreign objects that have fallen into the sensor (e.g. wire, cloth, grass when measuring sand moisture content)

To accurately measure the moisture content of bulk materials, you must:

a) Ensure the stability of the material bulk density at the sensor location.

b) Completely fill the sensor with controlled material.

c) Exclude sensor clogging because if the sensor is “clogged” with material, then this stuck material will determine the moisture meter readings.

Causes of the material bulk density impact on measurements:

Measurement with any moisture meter (except for optical moisture meters) can be represented as a measurement of the total amount of water in the volume covered by the sensor during measurements. If a larger amount of bulk material is placed (tamped) in this volume, then the amount of water in this volume will be greater as well. Accordingly, the moisture meter will show a higher moisture content reading.

Note that it is relatively difficult to ensure the bulk density stability on a conveyor belt, especially at a high belt speed. In the hopper, if the material is pressed down by the top layer, the bulk density stabilizes and more accurate readings are obtained.

To prevent debris from getting on the sensor installed on the conveyor, it is recommended to install a rake in front of the sensor at a distance of about 1 m from it. The ingress of large debris into the hopper van be prevented by the correctly selected mesh size of the grate installed above the hopper.

13. Description of communication protocol

13.1. Digital communication with the moisture meter is carried out via MODBUS RTU protocol with the following parameters:

- Connection speed - 9600, 14400, 19200, 38400; 57600 or 115200 baud
- Parity - none
- Number of stop bits - 2 or 1.

Default communication parameters (factory settings):

- Connection speed – 19200 baud
- Number of stop bits - 2
- Address – 127
- Timeout between requests 100 ms.

13.2. Features of MODBUS RTU protocol implementation:

- Register reading by 03 (03h) command
- Support of echoing back testing 08 (08h) command
- When attempting to read address range that exceeds limits specified in the table, the moisture meter gives no response

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- Register record by 16 (10h) command

- Register record is possible only in those registers for which record is allowed. In addition, recording must additionally be allowed by writing the password to 0020 (0014h) register. When trying to record in registers that are read-only or if there is no password, the moisture meter gives no response.

13.3 MODBUS RTU registers are shown in Table 15.

Table 15

Register address (DEC)	Register address (HEX)	Description	R/W
0000	0000	Measured moisture content expressed in hundredths of a percent. True moisture content must be calculated according to the formula: W = reg[0000] / 100 with an accuracy of 2 decimal places.	R
0001	0001	Temperature in degrees Kelvin. Temperature in degrees Celsius must be calculated according to the formula: t = reg[0001] – 273.	R
0002	0002	Not used	R
0003	0003	Moisture meter firmware version number	R
0007	0007	***For firmware version 33 and earlier.*** Deceleration factor k measured by the moisture meter and multiplied by 5000. Deceleration factor is calculated according to the formula: k = reg[0007] / 5000 with an accuracy of 4 decimal places.	R
0020	0014	Record protection register	R/W
0163	00A3	Total number of moisture meter calibrations	R
0164	00A4	Number of current calibration	R/W
0224	00E0	Temperature in degrees Celsius. ***(Register value is relevant only for positive temperatures)***	R
0229-0230	00E5-00E6	***For firmware version 34 and later.*** Refined refractive index (x100000). Deceleration factor is calculated according to the formula: k = (reg[0230]+reg[0229]*65536) / 100000 with an accuracy of 5 decimal places.	R
0231	00E7	***For firmware version 34 and later.*** Temperature in tenths Kelvin. Temperature in degrees Celsius must be calculated according to the formula: t = reg[0231] / 10 – 273 accurate to a tenth.	R

14. Maintenance check

Table 16 contains the list of main maintenance checks.

Table 16

Checking procedure	Technical specifications
1. Grounding check with an ohmmeter	Transitional resistance value standard for wires and grounding contacts determined by the in-plant regulatory documents and Electrical Installation Code.

2. Insulation resistance check with a megger	Not less than 20 MΩ at relative humidity from 30 to 80% and temperature of 20°C.
3. Visual inspection	See Section 15 "Maintenance".

15. Troubleshooting

15.1. It is allowed to eliminate detected failures directly on site only when the moisture meter is disconnected from the power supply.

15.2. When replacing failed components, strictly follow instructions specified in Section 15 "Maintenance" of this manual.

15.3. Replacing the failed components and checking the moisture meter after the elimination of detected failures must be carried out by a service technician.

15.4. A list of the most possible failures is provided in Table 17.

Table 17

Failure description, outer indicators and additional symptoms	Possible cause	Troubleshooting method
1. Power LED is off when the moisture meter is energized. Additional symptoms: - supply voltage at the input of communication line power cable is 24VDC - power supply circuit current is absent or less than 20 mA.	Broken power wire. Reversing the power wires. Burnt-out FU1 fuse.	Persons responsible for electrical installation and operation of communication lines shall correct the failure in accordance with regulations in force. Disconnect moisture from the grid. Open the cover of the electronic unit and replace the FU1 fuse.
2. Power LED is off when the moisture meter is energized.	Short circuit in the moisture meter power supply circuit	Persons responsible for electrical installation and operation of communication lines, as well as for moisture meter operation, shall correct the failure in accordance with regulations in force.
3. No connection with the moisture meter.	Breakdown or reversal of the communication cable, incorrect network settings of the moisture meter	Persons responsible for electrical installation and operation of communication lines, as well as for moisture meter operation, shall correct the failure in accordance with regulations in force. If cable is OK, but there is still no connection, check network settings of the moisture meter. Press and hold "Reset" button for at least 5 seconds to reset moisture meter network settings (restore default network settings). The button is located on the bottom board of the electronic unit under the cut in the top board.

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16. Maintenance

16.1. General instructions.

16.1.1. Maintenance is carried out to ensure normal operation and preserve the operational and technical characteristics of the moisture meter throughout its service life.

16.1.2. Maintenance is the systematic monitoring of the moisture meter technical condition, regular technical inspection and elimination of any failures.

16.1.3. After troubleshooting, check the moisture meter technical state for normal operation.

16.2. Types and frequency of maintenance.

16.2.1. Depending on frequency and scope of work the following maintenance types are specified as listed in Table 18.

Table 18

Maintenance types	Frequency	Person responsible for maintenance
1. Scheduled maintenance: - weekly maintenance - preventative maintenance	 Once a week Every six months	 Operator handling the moisture meter Specialist handling the moisture meter
2. Unscheduled maintenance	When a moisture meter failure is detected	Specialist handling the moisture meter

16.2.2 Dates of preventive maintenance can be changed and brought in line with the production plans and terms adopted at the plant operating moisture meters. At the same time, preventative maintenance frequency shall be at least once a year.

16.2.3 Weekly maintenance includes a visual inspection to ensure:

- Reliability of connection, as well as the absence of breaks or damage of the connecting cable insulation.
- Absence of dents and visible mechanical damage to the moisture meter enclosure.

16.2.4. During preventive maintenance, the following works shall be carried out:

- Removal of dust and dirt from external surfaces of the electronic unit and the moisture meter sensor.
- Visual inspection
- Checking the status of communication cables and connecting wires.
- Measurement of current consumption and supply voltage.

16.2.5. Unscheduled maintenance is carried out in case of failure and includes moisture meter repair.

17. Storage and transportation

Moisture meter storage and transportation conditions are in accordance with GOST 15150-69 for Groups 3 and 5, respectively.

17.1. The moisture meter components in the manufacturer's package can be stored under conditions of heated hard-wall rooms with the air free from acid vapors, alkalis and other hazardous substances that cause corrosion.

17.2. Moisture meter shelf life in the manufacturer's package is 1 year.

17.3. The moisture meter packed in a shipping container can be transported by any means of transport in closed vehicles at any distance.

17.4 Transportation must be carried out with all precautionary measures. Boxes with packaging must not be thrown or turned over.

18. Recycling

18.1. The moisture meter contains no precious metals or other substances subject to mandatory recycling.

18.2. The moisture meter is not dangerous to human life and health, as well as the environment. After the end of the service (operation) life, it can be disposed according to the technology adopted by the company operating the moisture meter.

19. Moisture meter verification, moisture meter calibration

19.1 The need for the initial verification of the moisture meter depends on the planned application. According to GOST R 8.674-2009, measuring instruments intended for use in the areas of state regulation in the field of ensuring the uniformity of measurements are subject to a testing procedure as required by law for the purpose of type approval, as well as a verification procedure.

Measuring instruments and technical systems and devices with measuring functions not intended for use in the areas of state regulation in the field of ensuring the uniformity of measurements are subject to calibration in the manner established by the manufacturer of measuring instruments and technical systems and devices with measuring functions and regulated in the operational documentation for measuring instruments and technical systems and devices with measuring functions.

19.2 Moisture meters intended for measurements of in oil and oil products, and in some cases in liquid materials in the material flow are subject to verification according to the document "GSI Instructions. Moisture analyzers (moisture meters) FIZEPR-SW100. Verification Method MP 0919-6-2018" approved by FSUE "All-Russian Research Institute for Flow Metering" on 15.11.2018.

19.3 Verification of the metrological parameters of moisture meters designed to measure bulk materials can be carried out according to the document "Moisture analyzers FIZEPR-SW100. Verification Method MP242-1715-2014 approved by the State Center for Testing Measuring Instruments FSUE "D.I. Mendeleev All-Russian Institute for Metrology" (VNIIM) 16.05.2014.

The use of dielectric moisture meters for bulk materials is allowed only for process measurements, for process control. Dielectric moisture meters are not applicable in the areas of state regulation (for commercial operations, e.g. with grain).

19.4. Periodic verification of the moisture meter that has passed initial verification shall be performed at least once a year.

Unscheduled verification of the moisture meter is carried out:

- After repair
- When moisture meter operability must be proved
- When the seal is damaged and documents confirming periodic verification of the moisture meter are missing.

Verification of the moisture meter after elimination of failures that do not affect its metrological characteristics (replacement of fuses, wires or connectors) is not performed.

19.5 When the customer specifies the material to be measured by the moisture meter, the manufacturer stores the corresponding calibration tables in the memory of the moisture meter supplied. But materials of even the same type may have differences in composition, therefore, it may be required to refine the moisture meter calibration during its operation. The moisture meter is calibrated according to the document: "Setup Manual and Software Description" (Technical Description and

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Operation Manual. Part 2). The user can either independently change and correct the calibration tables, or use the warranty services of the manufacturer – Design Bureau Fizelektronpribor, Ltd.

20. Warranty

Warranty period is at least 24 months from the date of delivery to the customer.

Warranty obligations are subject to the conditions and rules of operation, transportation and storage specified in this operation manual.

21. Appendices

List of appendices

1. Sensors of moisture meters VIGT.415210.100-10.6 and VIGT.415210.100-10.21 for bulk materials
2. Design of the sensor VIGT.415210.100-10.6 (- 10.21) equipped with a flat-topped probe for bulk materials
3. Explosion-proof moisture meter VIGT.415210.100-10.16 for bulk materials featuring high electrical conductivity
4. Sensor of the moisture meters VIGT.415210.100-10.5 and VIGT.415210.100-10.56 for bulk materials on a conveyor belt
5. Sensor VIGT.415210.100-10.4 (-10.41) equipped with a probe made as a straight rod
6. Sensor of the moisture meter VIGT.415210.100-10.4 for bulk materials in hoppers
7. Sensor of the moisture meter VIGT.415210.100-10.4 (front coupling)
8. Sensor of the moisture meter VIGT.415210.100-10.4 (latch-in rear coupling)
9. Installation option of the moisture meter sensor VIGT.415210.100-10.4
10. Sensor of the moisture meter VIGT.415210.100-10.41 for bulk materials
11. Sensor of the moisture meter VIGT.415210.100-10.41 (coupling design)
12. Sensors VIGT.415210.100-11.32 and -11.33
13. Sensor of the moisture meter VIGT.415210.100-11.41 for hoppers with grain
14. Sensor of the moisture meter VIGT.415210.100-11.41, drawing of installation options in a hopper
15. Sensor of the moisture meter VIGT.415210.100-12
16. Sensor of the moisture meters VIGT.415210.100-17.8 and -17.12
17. Sensor of the laboratory moisture meter VIGT.415210.100-30.1
18. Sensors of the laboratory moisture meter VIGT.415210.100-30.2 and -30.26
19. Three versions of electronic units
20. Appearance of the electronic unit VIGT.415210.101-02 in 1ExdIIBT5 explosion-proof enclosure with the top cover removed
21. Wiring diagram for moisture meter FIZEPR-SW100 connection to external circuits (OWEN TRM201 measuring and regulating device as an indicator)
22. Setting relay actuation parameters of the OWEN TRM201 measuring and regulating device
23. Measurement reliability evaluation report

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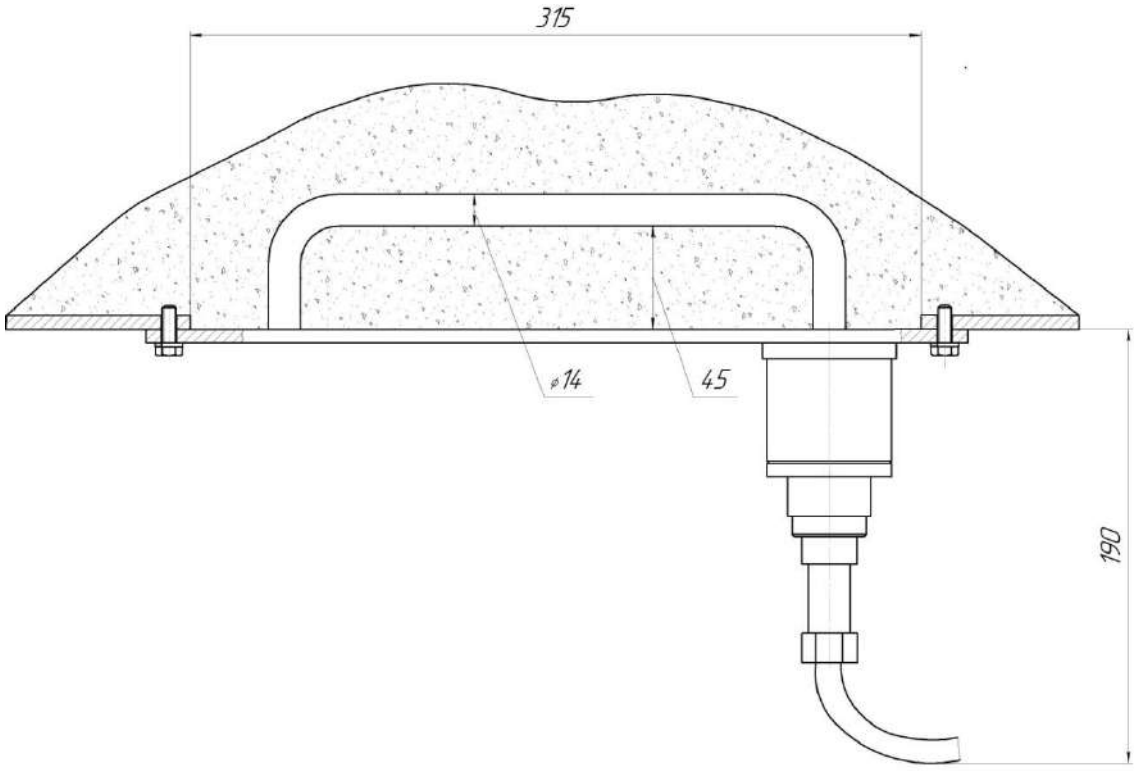
Sensors of moisture meters VIGT.415210.100-10.6 and VIGT.415210.100-10.21 for bulk materials

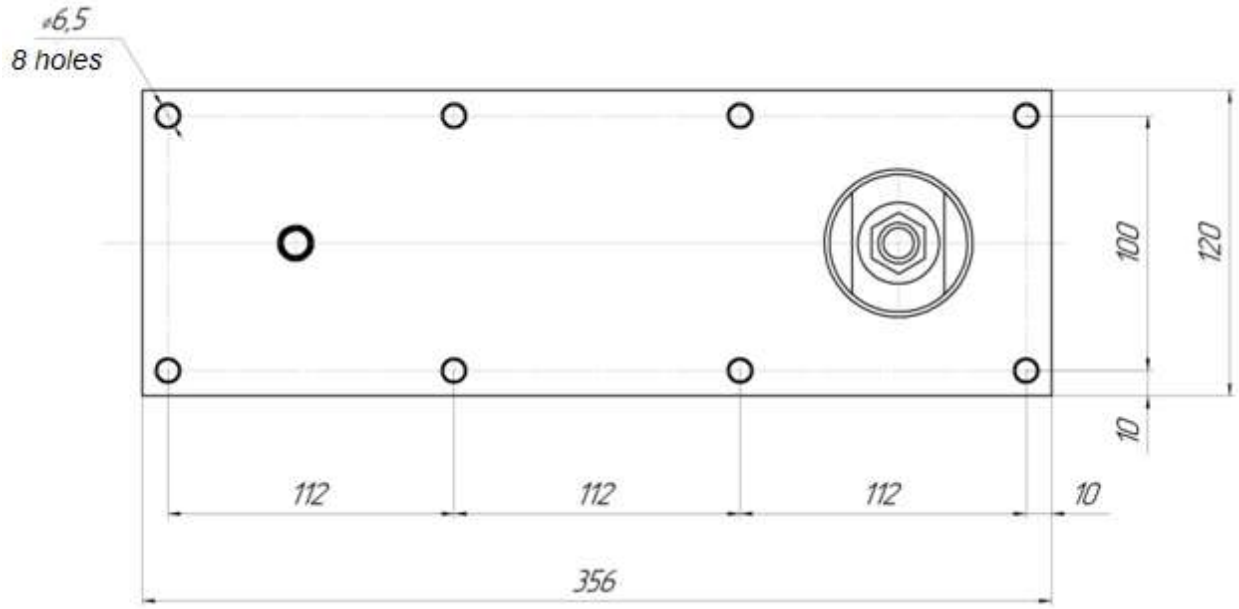
Sensor VIGT.415210.100-10.6

Sensor VIGT.415210.100-10.21

Design of the sensor VIGT.415210.100-10.6 (- 10.21) equipped with a flat-topped probe for bulk materials



Example of sensor securing to the hopper wall



Overall and coupling dimensions of the sensor panel

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Explosion-proof moisture meter VIGT.415210.100-10.16 for bulk materials featuring high electrical conductivity

Sensor of the moisture meter VIGT.415210.100-10.5 for bulk materials on a conveyor belt

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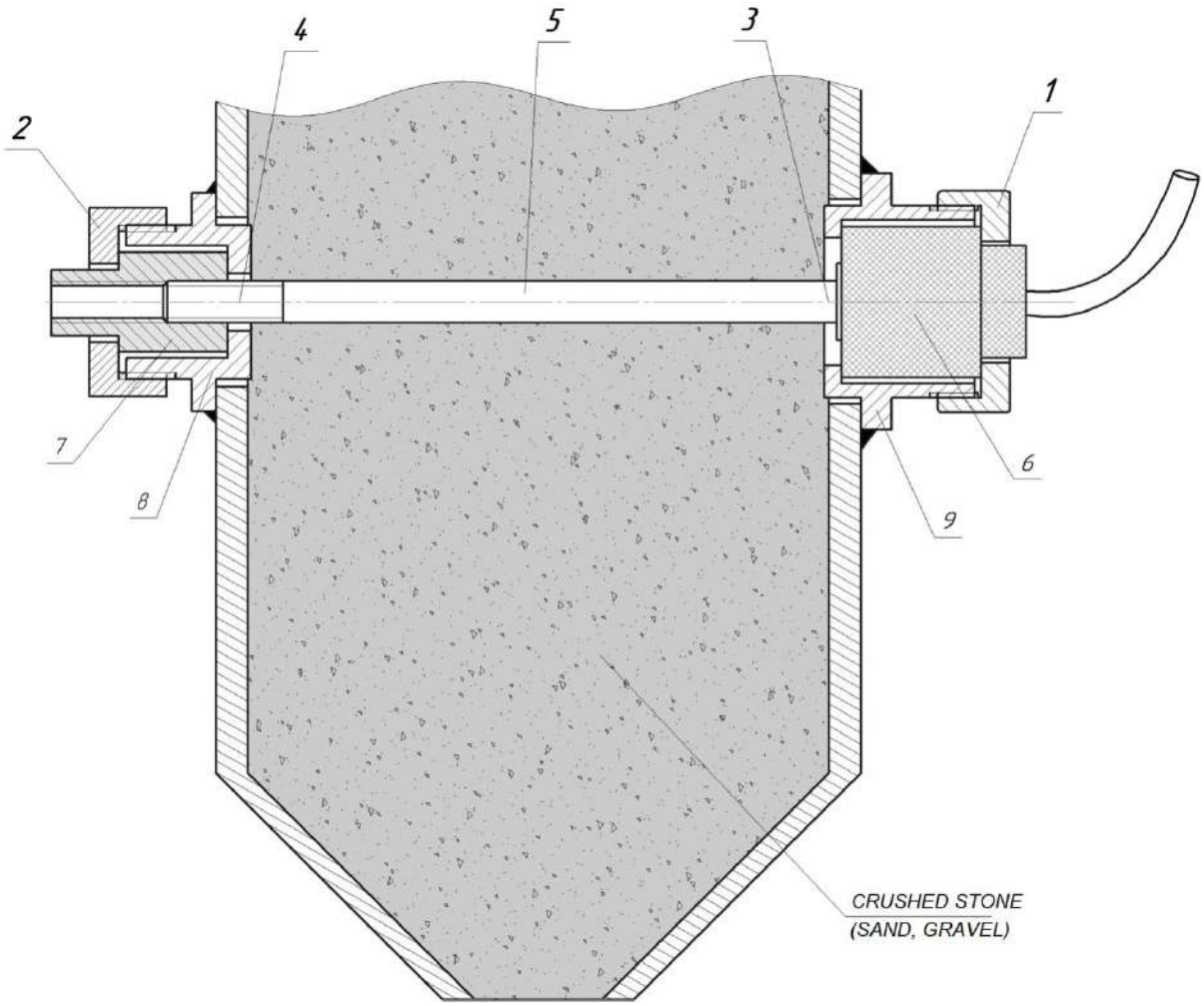
Sensor VIGT.415210.100-10.4 (-10.41) equipped with a probe made as a straight rod



Sensor of the moisture meter VIGT.415210.100-10.4 for bulk materials in hoppers

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Sensor of the moisture meter VIGT.415210.100-10.4
(front coupling)

Probe with the front coupling assembled with a flange

Probe with the front coupling,
appearance of the unit before probe securing with a flange

Sensor of the moisture meter VIGT.415210.100-10.4 (latch-in rear coupling)

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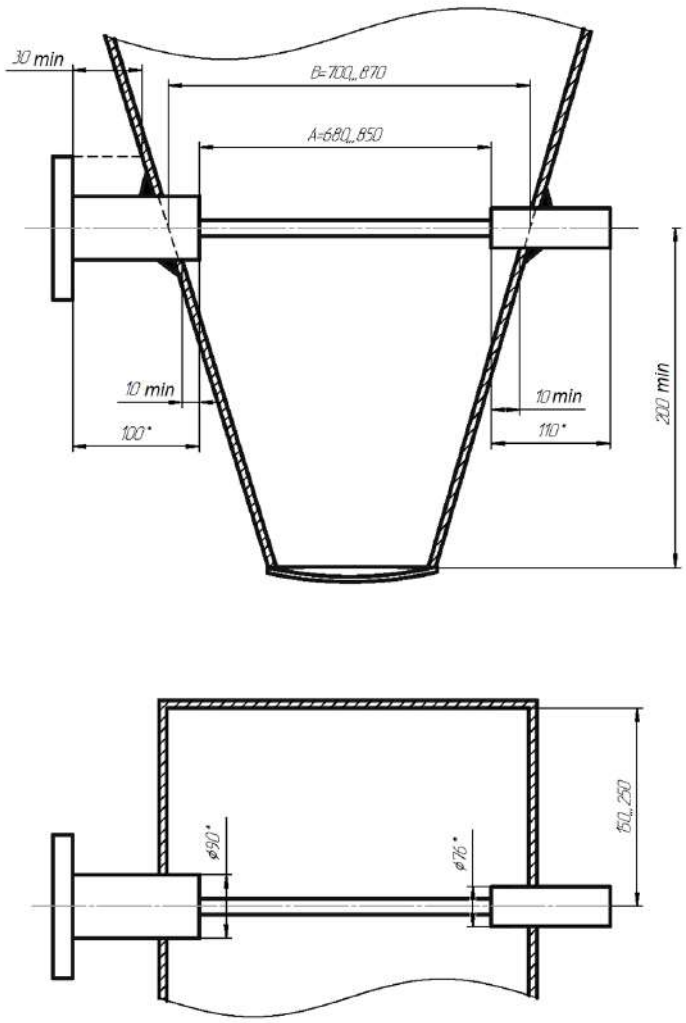
Installation option of the moisture meter sensor VIGT.415210.100-10.4



1.* Reference dimension
2. It is acceptable to reduce size A to 400 mm. In this case, thread M27x2 on the rod shall be extended.
PLEASE NOTE! When thread cutting, the sensor shall be attached only to the rod.

Sensor of the moisture meter VIGT.415210.100-10.41
for bulk materials

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Sensor of the moisture meter VIGT.415210.100-10.41 (coupling design)

Front coupling assembly

Front coupling disassembled before probe securing

Disassembled front coupling

Sensors VIGT.415210.100-11.32 and -11.33

Sensor VIGT.415210.100-11.32

Sensor VIGT.415210.100-11.33 for conveyor belts

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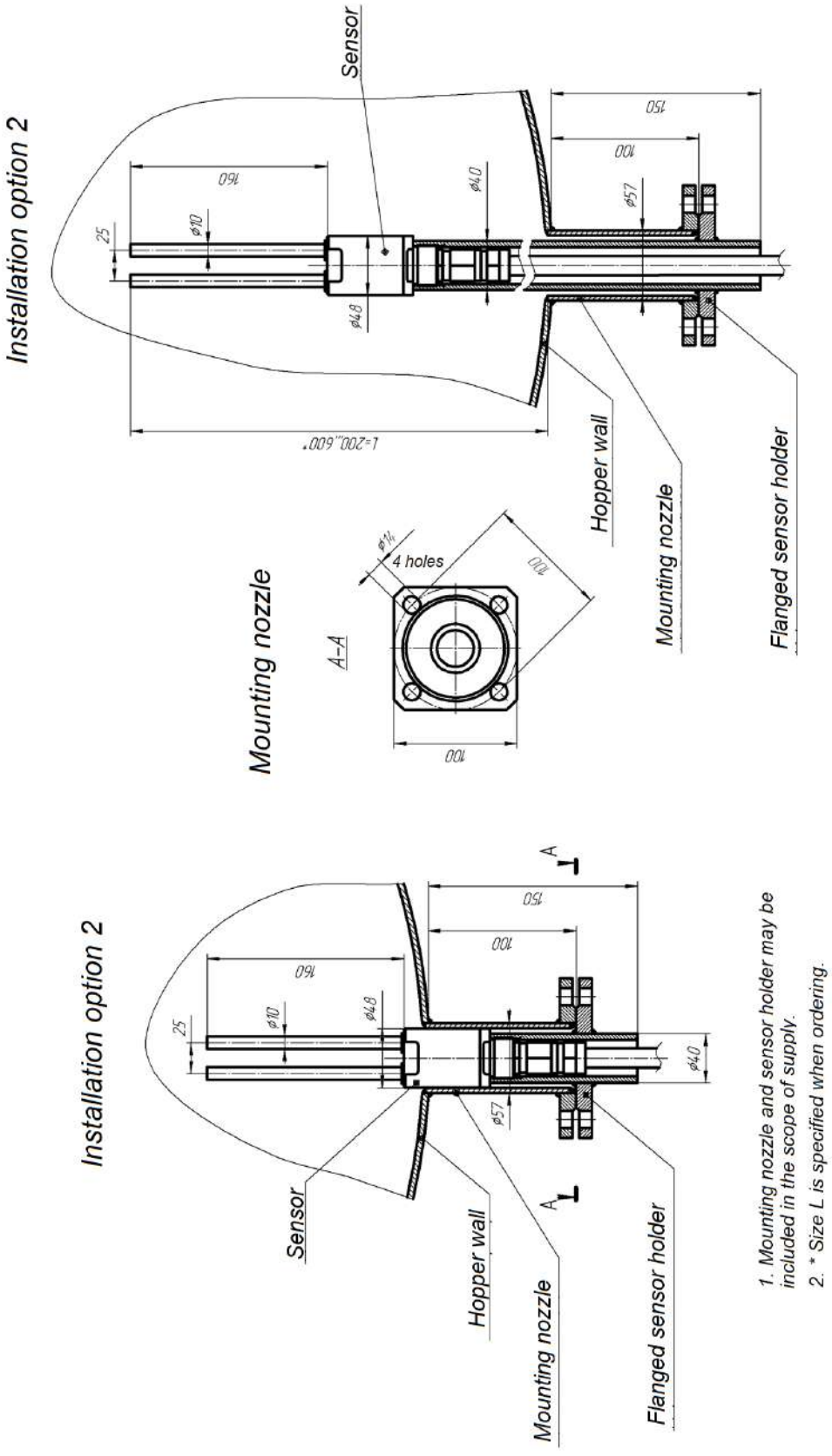
Sensor of the moisture meter VIGT.415210.100-11.41
for hoppers with grain

Sensor of the moisture meter VIGT.415210.100-11.41, drawing of options for mounting in a hopper



c

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Sensor of the moisture meter VIGT.415210.100-12

Sensor of the moisture meters VIGT.415210.100-17.8 and -17.12

Sensor VIGT.415210.100-17.8 with fittings and
a backup sensing head

Sensor VIGT.415210.100-17.12 with fittings

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Sensor of the laboratory moisture meter VIGT.415210.100-30.1

Sensors of the laboratory moisture meter VIGT.415210.100-30.2 and -30.26

Sensor VIGT.415210.100-30.2

Sensor VIGT.415210.100-30.26

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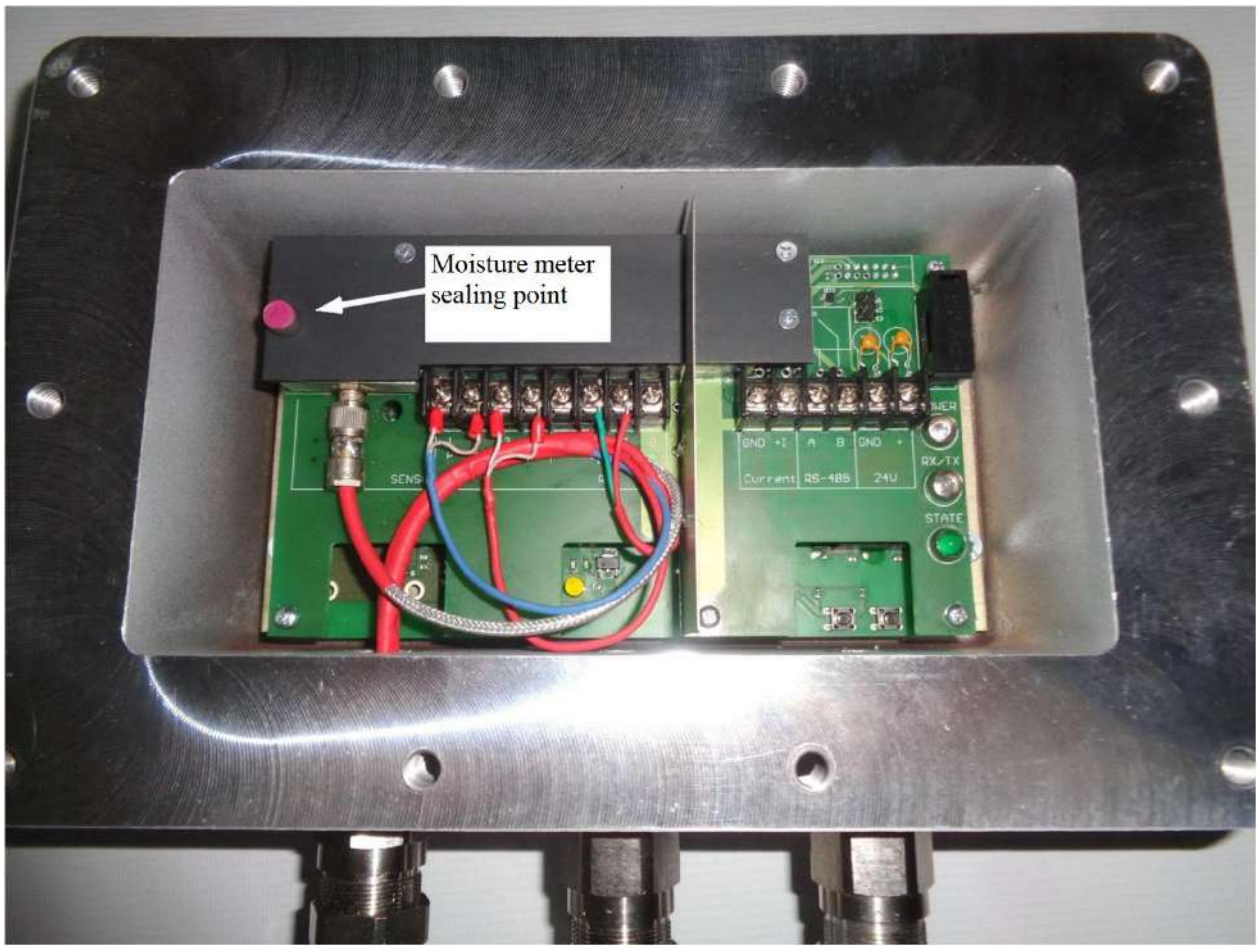
Three versions of electronic units

General purpose industrial unit VIGT.415210.101

General purpose industrial unit VIGT.415210.101-01 with connectors

Unit VIGT.415210.101-02 in 1ExdIIBT5 explosion-proof enclosure

Appearance of the electronic unit.415210.101-02 in 1ExdIIBT5 explosion-proof enclosure with the top cover removed



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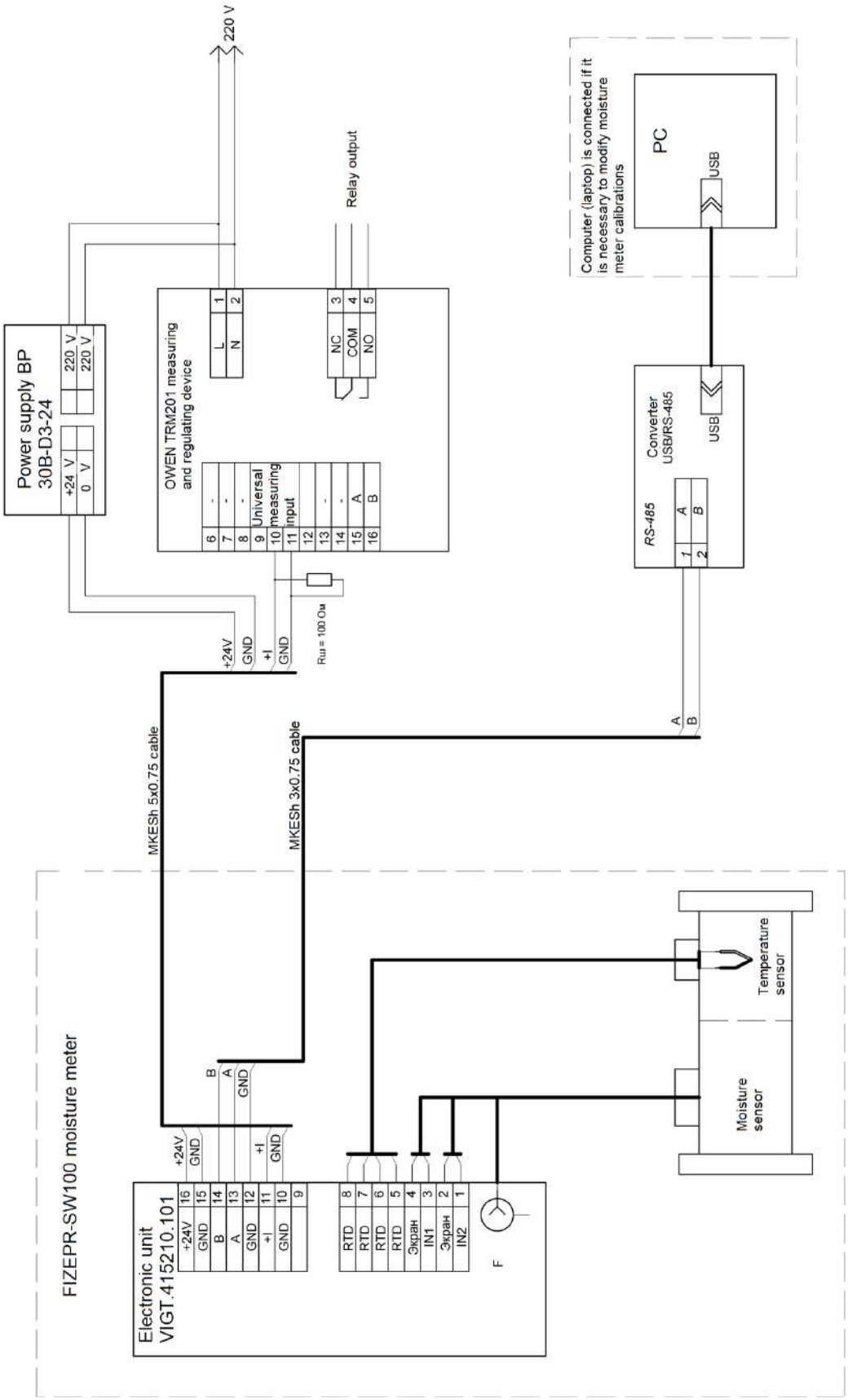
Wiring diagram for moisture meter FIZEPR-SW100 connection to external circuits (OWEN TRM201 measuring and regulating device as an indicator)



Setting relay actuation parameters of the OWEN TRM201 measuring and regulating device

The following example shows how to program the measuring and regulating device in order to control the water valve depending on the moisture content in diesel oil emulsion.

Let us consider the following case:

The water valve must be closed if moisture content in diesel oil emulsion rises to **15**% or higher.

If moisture content in emulsion drops to **10**% or lower, the water valve must be opened.

For this case the TRM201 measuring and regulating device is set as follows:

threshold - 12.5%; hysteresis - 2.5%.

1. ***Selection of the actuation threshold*** (actuation threshold value is displayed on the lower green display).
   1.1. The required actuation threshold can be set with "up" and "down" arrow buttons. We set the threshold value of **12.5** (press and hold to speed up searching process).
   1.2. Briefly press "PROG." button.

2. Hysteresis setting

2.1. Enter the menu by pressing and holding "PROG." button for 3 - 6 sec.

The upper display will indicate the 'nEnU' caption (the first letter is 'n' with an overscore); the lower display will indicate the 'LuōP' caption (menu items are indicated on the green display).

2.2. Press "Up" button repeatedly to find 'LuōU' menu item.

2.3. Briefly press "PROG." button ('SL.L' caption appears on the upper red display).

2.4. Press (repeatedly) "PROG." button to find a submenu item labeled 'HYS' on the upper red display.

2.5. Use "up" and "down" arrow buttons to set the required hysteresis value. Set **2.5**.

2.6. Briefly press "PROG." button.

2.7. To exit to the initial menu:

2.7.1. Press and hold "PROG." button until the following captions appear: 'nEnU' – on the upper red display (the first letter is 'n' with an overscore), 'LuōU' – on the lower display).

2.7.2. Use "down" arrow button to find 'LuōP' menu item.

2.7.3. Press "PROG." button (switch to indication mode: the red display shows the measured parameter value, the green display shows the actuation threshold).

3. Setting relay actuation method

Go through Sections 2.1 - 2.3.

3.1. Briefly press "PROG." button until the 'CnP' caption appears ('n' letter with an overscore) on the upper display.

3.2. Use arrow buttons to select the parameter value: 1. If 1 is selected, the relay is activated (relay contacts 3,4 are open, the valve is open) if the moisture value is below 10%, and disabled (valve closed) if the moisture value is above 15%.

Note. When the specified parameter value is set to 2, the relay is disabled if moisture drops below the threshold, and activated if moisture exceeds the threshold.

3.3. Briefly press "PROG." button.

3.4. Go through Section 2.7.

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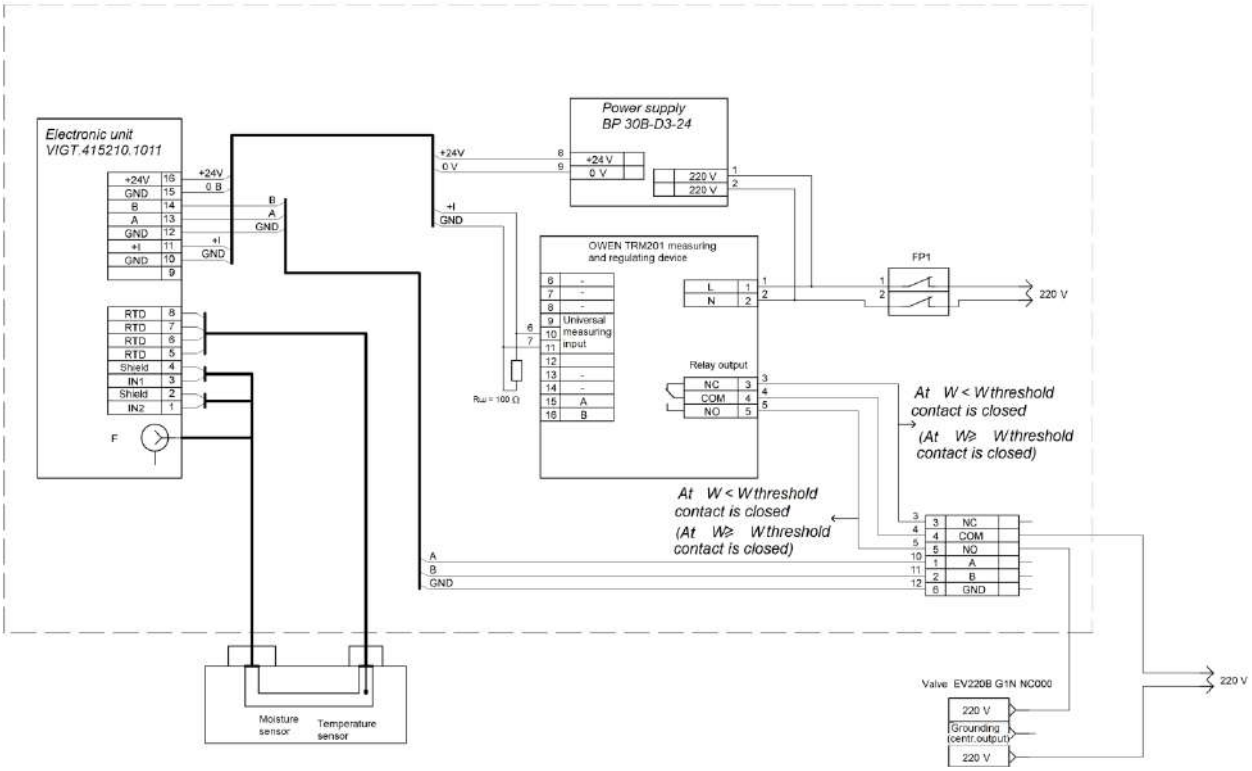
Please note that if zero voltage is applied to the valve, water supply is cut off. The valve is connected to normally open relay contacts (5, 6) in accordance with the diagram below.



Wiring diagram for moisture meter FIZEPR-SW100 connection
for water valve control (normally closed valve)

Measurement Reliability Evaluation Report

Sampling date and time	Material temperature, ˚C	Moisture measured with the moisture meter, %	Moisture measured in laboratory, %	Difference in readings, %	Remarks

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