Electro Pneumatic System for Measuring Level in Ballast, Service Cargo Tanks and Vessel Draught

BMS4

Operating manual

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CONTENTS

1 Introduction

1.1 Purpose and structure of the operating manual

This operating manual (hereinafter the manual, OM) is designed to study the principle of operation, construction, work and the correct and safe operation of the BMS4 pneumatic system (hereinafter the System) for measuring the level in ballast and service tanks, cargo density and vessel draught, as well as the installation instructions and the System equipment replacement.

1.2 The required level of special training for the maintenance personnel

The System equipment must be installed and serviced by qualified personnel coming into contact with voltages reaching 1000 V. Personnel must be familiar with this manual and have the necessary knowledge to manage the installation, assembly and maintenance of the System.

1.3 Product modifications covered by operating manual

This operating manual covers the BMS4 pneumatic system.

The manufacturer can make changes to the System equipment, not reflected in this document, without prior notice.

2 Description and operation

2.1 Description and operation of the system

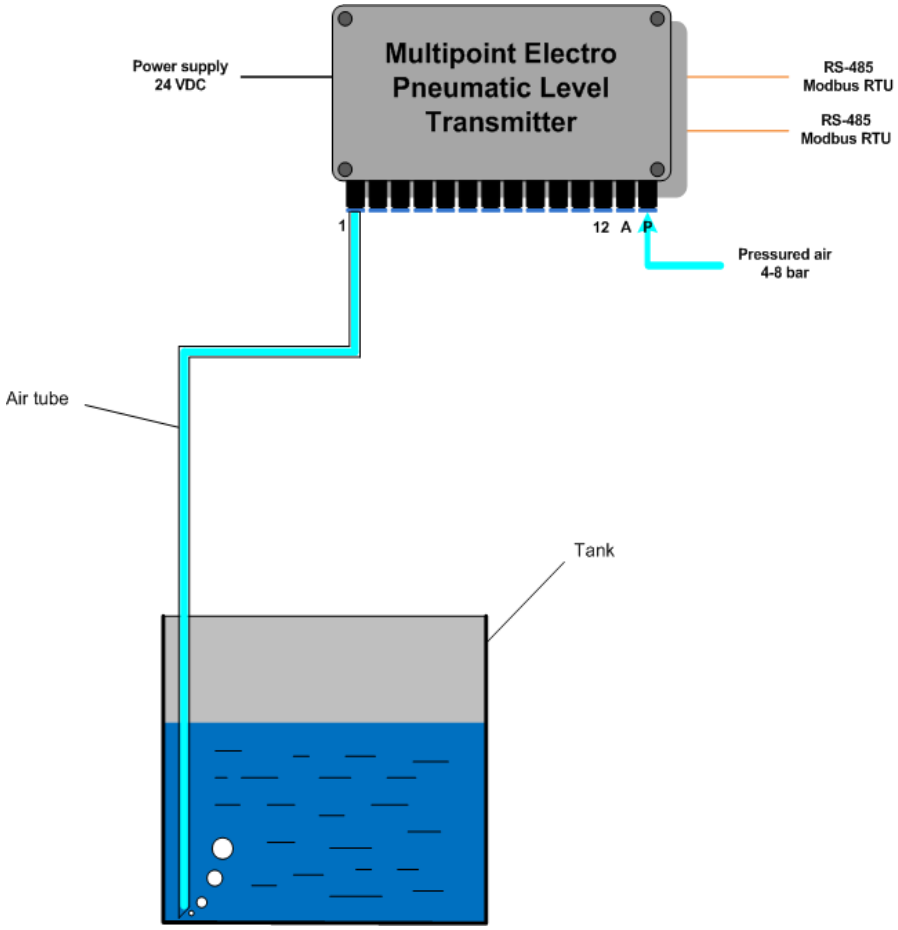
2.1.1 Purpose of the BMS4 system

The BMS4 pneumatic level measuring system is designed to measure the level in ballast and service tanks, the cargo density in the tanks and the vessel draught.

The System can also be used to measure the level and density of liquids in shore storages.

The principle of level measurement with the System consists of a periodic supply of compressed air into the tank through an air tube that runs from the system to the tank bottom (Pic. 1). After air is supplied into the tube, excess air pressure is charged through the open end of the tube, located at the bottom of the tank, and the pressure in the tube is equal to the hydrostatic pressure of the liquid column in the tank. This way, by measuring the steady pressure of the air in the tube, we can calculate the current level of the liquid in the tank by knowing its density.

Measuring the vessel draught is similar to measuring the liquid level in tanks. In this case the air tube is lead out from the System to the bottom of the vessel.



Pic. 1. Pnuematic method for level measuring

2.1.2 Characteristics

2.1.2.1 Overview

The main elements of the System that determine its characteristics are:

– ***Multipoint Electro Pneumatic Level Transmitter*** (hereinafter Level Transmitter), supplying air into the tube and providing the pressure measurement and calculation of the level/draught /density;

– ***Air Handling Unit***, for the preparation of the compressed air according to the parameters required for the operation of the Level Transmitter. The air handling unit may not be installed if the compressed air supplied to the System meets the parameters required for the Level Transmitter operation.

2.1.2.2 Main parameters and characteristics

Number of the measuring channels	max. 12 for one Level Transmitter, the number of level transmitters in the System is not limited.
Measuring range:	
– pressure	0-1.8 bar-g
– level (for fresh water, =1 т/м^3)	0-18 m
Measurement error*:	<0.25% of the max. value of the measuring range, usually 1.5-2 cm
Resolution:	0.001 bar / 0.01 m
Measurement rate:	5-30 s. (depends on the number of channels in the level transmitter, changes in the level of the tanks, air leaks in the pipes)
Parameters of the compressed air supplied to the System:	
– when using the air handling unit	Air MCI (MEASURING AND CONTROL INSTRUMENTS), pressure 4.8 bar, dried (air dryer can be installed in the air handling unit)
– without using the air handling unit	pressure of 2 bar, cleaned and dried, not oily or without addition of lubricating oil, filtering is not less than 40 microns, cleanliness Class 7 ISO 8573-1
Air consumption (for 1 measuring channel):	depends on the setting of the System

	parameters, avg 0.5 Nl/min
Monitoring for leaks:	yes
Periodic blowing off the air tubes to remove dirt:	yes
Auto-calibration of the pressure sensors	yes
Interface/communications protocol:	2 x RS-485 (2-wire) / Modbus RTU
Data Transfer Options:	9600 bit/s, 8-bit data, no parity control, 2 stop bits.
Power supply parameters:	24 ± 20% V DC (~220 V 50 Hz optionally)
Power consumption:	5 W or less
Equipment protection degree:	IP40
– level transmitter	IP44
– air handling unit	
Dimensions (HxWxD) and weight:	
– level transmitter	114 x 245 x 81 mm, max. 1 kg
– air handling unit	600 x 600 x 210 mm, max. 20 kg
– standard System box with the air handling unit (no dryer) and one or two level transmitters (max. for 24 measurement channels)	600 x 600 x 250 mm, max. 30 kg
Connected air tubes:	
– plastic	∅6x1 mm or ∅4x1 mm
– stainless steel, copper	∅8x1 mm or ∅10x1 mm (other dimensions- optionally)

Operating temperature, °C	-20…+50 °C
Storage temperature, °C	-35…+60 °C
System operable time, min.	max. 5 minutes
Certificates	PC

***** − the accuracy of the level measurement is also influenced by the following factors leading to an additional error:

- the error of the entered value of cargo density in tanks (of the sea water for the measuring points of the draught and the level in the ballast tanks, fuel for fuel tanks);
- temperature change in the location of the System equipment installation;
- air leaks in the places of the air tubes joining.

2.1.3 System Structure

The System includes:

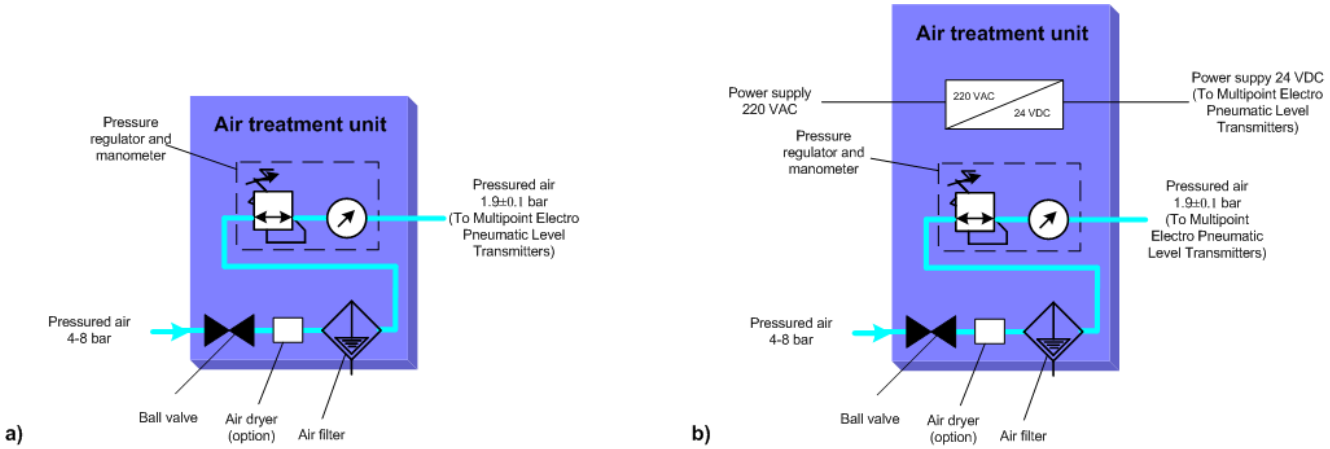
1. air handling unit
2. level transmitter (s).
3. adapter unit.

The air handling unit (Pic. 2) is designed for the compressed air preparation with parameters suitable for the operation of level transmitter(s). The air handling unit is a wall-mounted box. A standard complete set of the air handling unit consists of (air handling unit BVP-1):

1. Ball shut-off valve to shut of the air from the main line (the compressor).
2. Air filter.
3. Pressure regulator.

Optionally, an air dryer can be mounted in the air handling unit (air handling unit BVP−1−O).

Also, in the absence of the option of a 24V DC power supply to level transmitters directly from the available power sources, a secondary power source to supply the level transmitters (air handling unit BVP-2/ BVP-2-) can be installed.

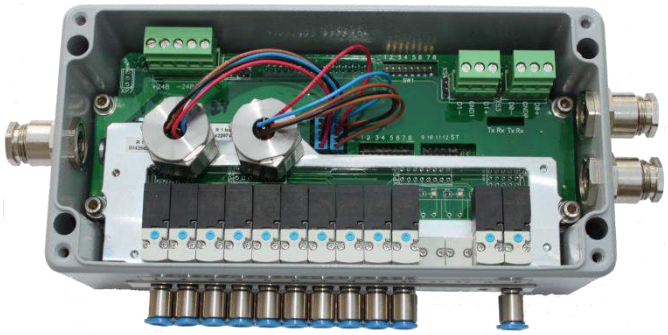


Pic. 2. Air handling unit (a - BVP-1/BVP-1-O, b - BVP-2/BVP-2-O).

The level transmitters pumps air into the air tubes, measures the steady pressure and calculation of required parameters (level/density/draught).

The level transmitter (Pic. 3) is a metal or plastic box (depending on the version) with the following equipment:

1. Manifold with pressure gauges and valves.
2. Control board.
3. Cable inputs.
4. Terminal blocks for the power supply connection.
5. Terminal blocks for the interface cables connection.



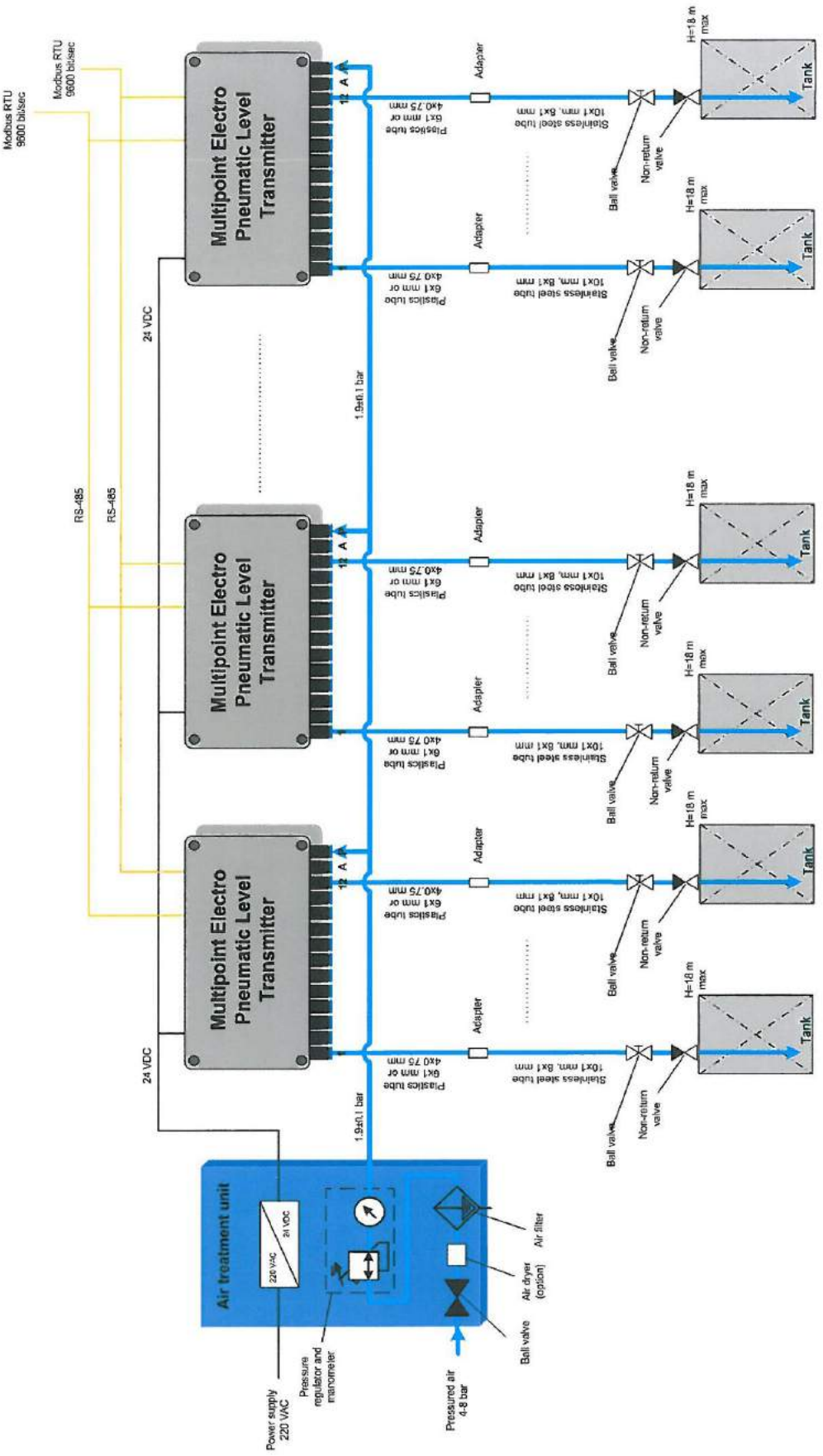
Pic. 3. The Multipoint Electro Pneumatic Level Transmitter (Level Transmitter).

Only plastic air tubes ∅6x1 mm or ∅4x1 mm can be connected directly to the level transmitter. If it is necessary to use the air tubes made from stainless steel or copper, adapter units, allowing the transition from plastic tubes, connected to the level transmitters, to the metal tubes, leading into the tanks (to air main line), must be used. Standardly, fittings enabling to connect pipes from copper or stainless steel ∅8x1 mm or ∅10x1 mm are used. On request, the application of fittings for pipes of larger diameter is possible.

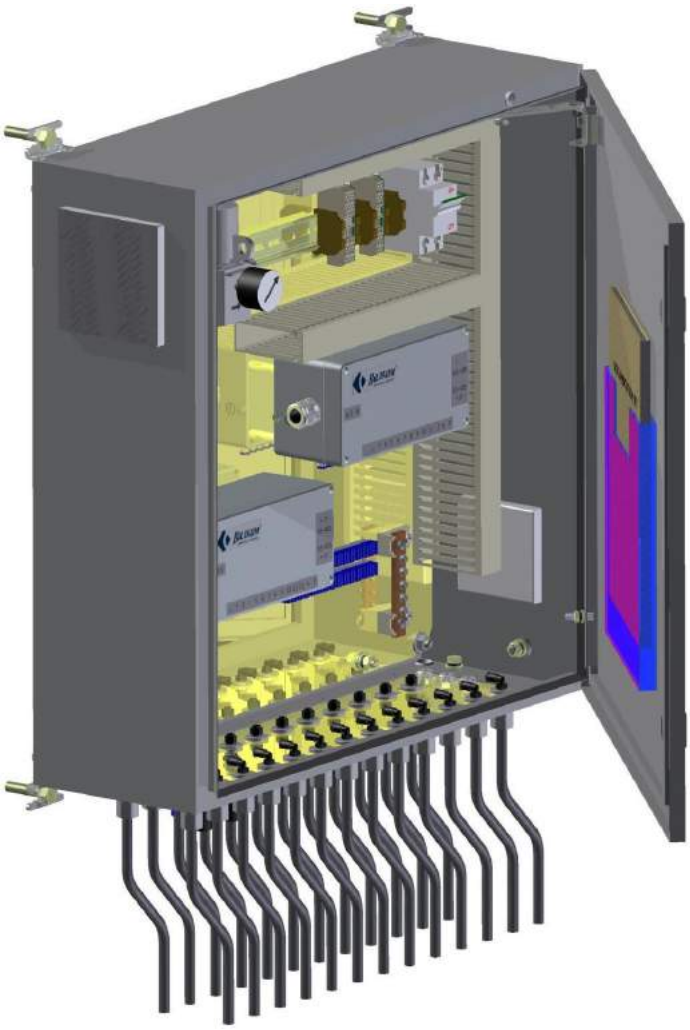
Pic. 4 shows a typical block diagram of the BMS4 system.

The air handling unit, level transmitters and adapter unit can be combined into a single structural element - a wall-mounter box. A typical LTS4 cabinet of the BMS4 system includes the air handling unit, consisting of a shut-off valve, a filter and a pressure regulator, a 220/24 V power supply unit (if necessary), two level transmitters and an adapter unit, located in the bottom of the box (Pic. 5).

This box enables connecting a maximum of 24 level measuring channels (pressure, draught).



Pic. 4. Structural diagram of the BMS4 system



Pic. 5. LTS4 cabinet of the TSS / BMS system

2.1.4 Description and operation

Compressed air from the main line or the compressor is supplied to the air handling unit, where its treatment (and drainage if necessary) and pressure lowering to a level required for the ensuring of the level transmitters operability (1.9±0.1 bar) is carried out.

From the air handling unit, the compressed air is supplied to the input of the level transmitters.

Through a system of valves installed on the manifold in the level transmitter, air can alternately be supplied into each of the twelve measuring channels, which are connected to the air tubes going to the tanks (to the points of the draught measurement). In this case, the pumping of the air into the tubes is carried out. To minimize the air-flow rate, the duration of the air pumping is changed adaptively depending on the current level of the liquid in it. When the tank is empty, the pumping impulse duration is minimal, which practically ensures a zero air flow rate, thus allowing to track the change in pressure in case the level is increased. When the level in the tank increases, the impulse duration becomes longer to overcome the increasing counter pressure in the tube. When the tank is full, the impulse duration reaches its maximum value.

After the air supply into the tube is stopped, the excess air pressure is charged through the open end of the tube, located at the bottom of the tank (at the point of the draught measurement), and the pressure in the tube is equal to the hydrostatic pressure of the liquid column in the tank. Then the channel is connected to a pressure sensor for measuring the steady pressure of the air in the tube, and then the level/draught calculation acc. to the measured pressure and given cargo density value in the tank is performed.

All channels of the level transmitter are scanned in turn. If the level transmitter detects the level has changed in any channel (tank), the channel is then scanned more often for the faster tracking of the dynamics of filling/drying.

The level transmitter continuously monitors the air pressure at the inlet. When the pressure falls below a predetermined threshold, it produces the "Low air pressure at the inlet" APS signal and all valves in the level transmitter are closed to prevent possible liquid intake from the tanks through the air tubes into the level transmitter and into the air main line.

To minimize measurement error in the level transmitters, a periodic auto-calibration of the pressure sensors by connecting them to the atmosphere and to the atmospheric pressure measurement is carried out. The measured value of the pressure is taken into account as a shift of "zero" of the sensor.

Since the accuracy of the level measurement with the level transmitters largely depends on the tightness of the air tubes, the System scans the tubes for leaks - "Leak test". The leak test runs on the operator's command, transmitted through the interface.

All configuration settings and commands for the level transmitter control can be read/written according to the Modbus RTU protocol using any of the sequential interfaces of the unit. Also, the reading of the measured values of pressure and levels through the channels can be carried out.

The list of configurable parameters and control commands of the level transmitters is given in Section 7 of this operating manual. Modbus register map is shown in Appendix D.

2.2 Description and operation of the system component parts

2.2.1 The air handling unit

2.2.1.1 Overview

The air handling unit (Pic. 2) is a wall-mounted box. The air handling unit includes:

1. Shut-off ball valve.
2. Air filter.
3. Pressure regulator with pressure gauge.
4. Air dryer (optionally).

The System design with the placement of the air handling unit and the level transmitters in the same box is possible. This box has dimensions 600x600x210 mm enabling the installation of 2 level transmitters and connecting up to 24 measurement channels.

2.2.1.2 Operation

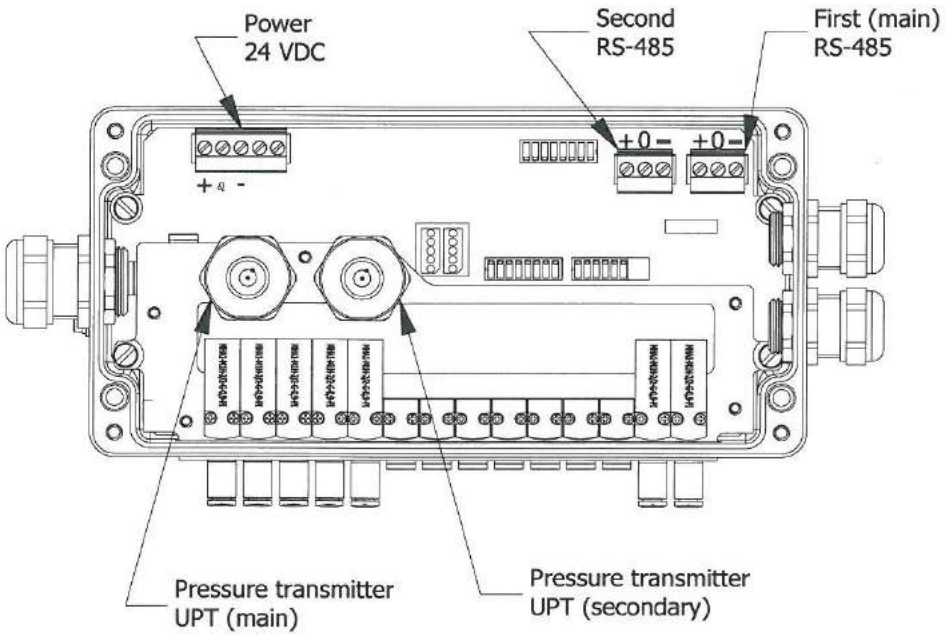
The air compressed with the pressure of 8.4 bar is supplied from the main line or the compressor to the input of the air handling unit. The ball shut-off valve is installed at the input of the air handling unit. If the ball valve is opened, the air passes through the air dryer (if installed), air filter and is supplied to the pressure regulator. On the pressure regulator, the air pressure 1.9±0.1 bar is set. The purified and dried air is supplied to the output of the air handling unit and further to the level transmitters.

2.2.2 Multipoint Electro Pneumatic Level Transmitter (Level Transmitter)

2.2.2.1 Overview

The level transmitter (Pic. 6) includes:

1. Manifold with the valves block and pressure gauges.
2. Electronic control board.



Pic. 6. The multipoint electro pneumatic level transmitter internal structure.

The level transmitter provides the measurement of pressure, the level in tanks, and the density (optional).

The level transmitter has two independent RS-485 interface communication lines, through which the collection of the measured pressure/level values as well as setting of the operational parameters and diagnostics of the level transmitter operation is carried out.

Interaction with the level transmitter is performed via the Modbus RTU protocol, the level transmitter is a slave device on the bus.

Data collection, configuration and diagnostics for the level transmitter can be implemented as from the automation systems software, in which the level transmitters are used, so as from the software "*BMS Utility"*, which is part of the supply of the pneumatic system. A description of the *"BMS Utility"* program can be found in section 7 of this operating manual.

2.2.2.2 Operation

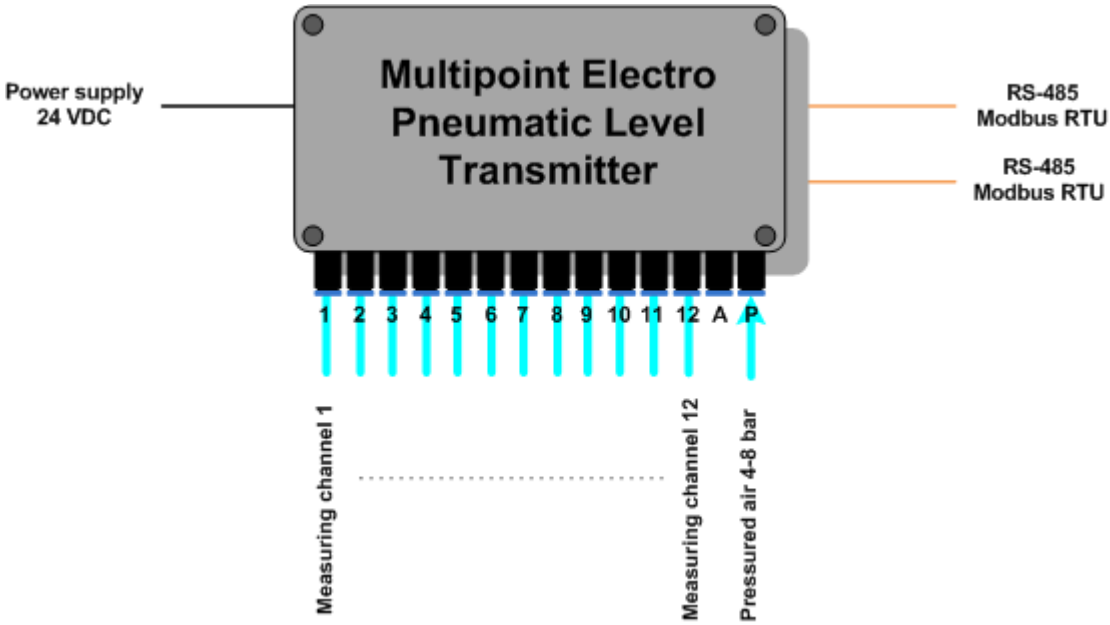
The compressed air from the air handling unit is supplied to the input "P" of the level transmitters (Pic. 7) under a pressure of 1.9 ± 0.1 bar. The air tube going to the tanks (to the point of the draught measuring) are connected to the channels 1-12. After the power supply, the level transmitter starts with the following:

1. Calibration of the pressure sensors.
2. Initial pumping of air tubes.
3. Measurement mode.
4. Leak test (by operator).

2.2.2.2.1 Calibration of pressure sensors

Calibration of the pressure sensors is performed to eliminate the effect of zero drift of the measurement accuracy sensor.

Sensor calibration is performed as follows: sensors are connected to the measurement of the atmospheric pressure through the valve of the "A" channel of the level transmitter. The measured value of the pressure is taken as "zero shift" of the sensor and is taken into account for the subsequent measurements (is subtracted from each measurement of the pressure value).



Pic. 7. The Multipoint Electro Pneumatic Level Transmitter.

2.2.2.2.2 Initial pumping of air tubes

When the level transmitter is turned on, the air is pumped into each channel 1 - 12 for the period of time sufficient for the complete displacement of the liquid from the air tubes; the overpressure is discharged through the open end of the tubing, located at the bottom of the tank. This step ensures that the pressure set in the tubes is equal to the hydrostatic pressure of the liquid in the appropriate tanks and the measurement mode can be started.

2.2.2.2.3 Measurement mode

Measurement mode is the primary mode of operation of the level transmitter. In this mode, air is pumped into each channel 1 - 12, the steady-state pressure measurement and the calculation of the current level of loading (draught) is carried out. Channels scanning (the air pumping - pressure measurement - calculation of the level/draught) is performed alternately: 1-2-3-…-1-2-3-…1-2-…. If a change of pressure in any of the channels is detected (which indicates the filling of the tank when the pressure was increased and the drainage of the tank or the leakage in the air tube - at a decrease of

pressure), this channel is then scanned more frequently, which allows to monitor the dynamics of the filling/drainage of the tank or to parry the air leak from the pipe, if detected.

For example, if the level changes is detected in the channel 3, then the scanning will be as follows: 1-3-2-3-4-3 ... -3-12-3-1-3 - ... if the filling is carried out into two tanks at once, for example, 3 and 7, then the scanning diagram will be as follows: 1-3-7-2-3-7-4-3-7 ... -3-7-12-3-7-1-3-7 - ... and so on.

The level transmitter continuously monitors the air pressure at inlet "P". If the air pressure at the inlet falls below the predetermined threshold, the valves of channels 1 - 12 are closed and the channel scanning is stopped. In this case, the level transmitter valves operate as non-return valves preventing the possible penetration of liquid from the tanks through the air tubes into the level transmitter and into the air main line. This feature of the level transmitter allows stopping usage of the non-return valves, mounted directly on the tanks, especially if the level transmitters are installed above the maximum filling of the tanks.

Note: *however, in many cases the installation of the non-return valves on certain tanks (fuel tanks, etc.) is the mandatory requirement of supervisory bodies (marine classification societies - RMRS, DNV - and so on). Therefore, when making a decision about installing a non-return valve, the requirements of the relevant supervisory authorities must be pre-eminently followed.*

2.2.2.2.4 Leak test

The greatest influence on the accuracy of the measurement via the piezometric method has the tightness of the air tubes running from the level transmitter to the tanks.

To diagnose the state of measurement channels in the level transmitter, the leak test mode is provided. It helps to assess the tightness of the tubes during the System operation process.

The command to start the leak test can be transferred to the level transmitter through any of two interface communication lines.

When receiving the command to start the leak test, air is pumped once into each channel and the current air pressure P_1 for the channel is remembered. Then the level transmitter is set to standby mode for 1 minute, during this time air is not pumped into the tube.

After the waiting period, the level transmitter re-measures pressure P_2 in each tube.

If the leakage occurs during the waiting period, air in the tubes will be discharged through the untight joining, as a result pressure P_2 will be lower than the initial air pressure in pipe P_1.. At $\Delta P=P_1-P_2>0$ in any of the tubes, the level transmitter signals leakage in the tube.

Note: *for the maximum reliability of the leak test, it is necessary to create the greatest possible pressure in the measuring channels. This can be achieved either by setting shut off valves (see p.p. 3.9) - in case the valves are closed, the pressure in the pipes will be equal to the air pressure at the inlet of the level transmitter, or by performing the leak test with fully filled tanks - in this case the pressure in the tubes will be equal to the hydrostatic pressure of the liquid column in the tank.*

3 Installation and commissioning

3.1 Requirements for installation

The air handling unit and level transmitters must be mounted in rooms with ambient temperatures ranging from 0 to +55 ˚C.

It is not recommended to install level transmitters in rooms where the staff permanently works (control rooms, watch rooms, central control rooms, etc.) - when the System is on, level transmitters are the source of noise caused by the constant switching of electromagnetic valves, which may be discomforting for the staff.

The dimensions of the level transmitters, the air handling unit, the standard box of the System for 24 measuring channels are defined in Appendix A.

3.2 Requirements for supplied air

Dried air compressed by a pressure of 1.9±0.1 bar with a purity of no less than 40 microns air MCI must be supplied to the level transmitters. The degree of air drying depends on the weather conditions in rooms and spaces in which the level transmitters are placed and the air tubes are laid.

During the installation of the level transmitters and the tubes laying inside the industrial premises, the dew point of the supplied compressed air should be max. -3˚C in the compartments and spaces of the vessel, etc. with normal climatic conditions.

If the tubes are laid fully or partially on open decks or in unheated ballast tanks, in unheated rooms or outdoors, then the compressed air with the dew point max. -20 - -40˚C must be used, depending on the ambient temperature.

In case the compressed air with the specified parameters is not available, an air handling unit must be installed. When ordering the air handling unit, the parameters of the available compressed air must be specified.

The average air consumption is about ~0.5 Nl/min/channel.

3.3 Electrical connections

Power supply of the level transmitter - 24 V. Power consumption 5 W or less. If necessary, the secondary power supply units permitting the power supply from the

alternating-current sources~220V 50Hz or other can be used in the System. A three-wire cable with the cross-section of at least 1 mm^2 must be used for the power supply.

A shielded cable "twisted pair" 2x2x0.5 mm^2 must be used for the interface connections.

A diagram of the electrical connections is given in Appendix B.

3.4 The air tubes

Only plastic air tubes ∅6x1 mm or ∅4x1 mm can be connected directly to the level transmitter through the quick-split fittings. If it is necessary to use a larger diameter tubing and/or other material (stainless steel, copper), adapter units should be used.

The use of the plastic tubes is most convenient because of their greater flexibility and easy installation. The plastic tubing can be laid by segments longer than the metal pipes, even a solid segment of a plastic tube without any intermediate can be laid from the level transmitter to the tank. The intermediate pieces are mainly the cause of the leakage of the air tubes and, consequently, the level measurement error. Plastic tubes can be installed in the cable routings and fixed similarly by the electrical cables.

For tanks with flammable, explosive atmospheres, tubes made of the conductive plastic or metal must be used (stainless steel, copper).

During the installation of the tubes, it is necessary to pay special attention to the proper tightening of all pipes and intermediates. After the completion of the installation, before the connection of the tubes to the level transmitters, it is required to perform the hydrostatic test on the tubes by the compressed air by applying a pressure of at least 5 bar. The maximum permissible air leakage during the hydrostatic test shall not be more than 0.1 bar/h.

The tubes must be installed in order to form a falling line without negative slopes from the level transmitters to the lowest point of the tank, so that the liquid which can penetrate into the tubes in some cases could leave it freely when applying pressure. Negative slopes can lead to the formation of hydroseals, which will collect the liquid that gets into the tube, resulting in the instability of the measurements.

Note: *when choosing the air tubes, except those specified in this section, the requirements of the relevant supervisory authorities and classification societies must be followed.*

3.5 The air tubes inside the tank

The installation of tubes inside the tank should be implemented so that the open end of the tube is located as close as possible to the bottom of the tank, but the minimum clearance between the bottom and the open end of the tube must be at least 50 mm.

The inlet of the tube into the tank can be carried out through the top (Appendix C, drawing xxx), or side penetration of the tube into the tank (Appendix C, drawing xxx).

For the tanks with flammable, explosive atmospheres, the tubes made of the conductive plastic or metal must be used (stainless steel, copper).

Note: *when choosing the air tubes except those specified in this section, the requirements of the relevant supervisory authorities and classification societies must be followed.*

3.6 Measurement of the vessel draught

Requirements for the installation and choice of tubes to measure the vessel draught are similar to those of § 3.5.

The tube for the draught measurement must be connected to the vessel hull via the shutoff valve (Appendix C, drawing xxx).

3.7 Pressure repeaters

When measuring the level of certain environments (e.g. drinking water), air flowing directly into the tank is prohibited. In this case, a pressure repeater 1:1 can be used (Appendix C, drawing xxx).

3.8 Non-return valves (shutoff valves)

A solenoid valve is set in the level transmitters on each measuring channel, it is normally closed and opens only when pumping the air into the tube and when measuring the pressure in the tube.

During operation, the level transmitter monitors the pressure applied to the input of this unit. By reducing the pressure at the inlet below a certain, predetermined threshold, the level transmitter forms APS signal "Low pressure at the inlet", transmitted through the interface communication lines into the automation system (or operator station), and the level transmitter stops pumping the air into the tubes and measuring pressure in the tubes - electromagnetic valves are closed and act as non-return valves preventing the possible penetration of the liquid through the tubes into the level transmitter and into the air main line.

After the resumption of the supply of the compressed air with the required pressure, the level transmitter carries out the air pumping into the tubes similar to the one that runs when the level transmitter turns on. This allows to displace the liquid from the tubes in case of its possible penetration (before the level transmitter) during the time of the pressure was unavailable.

This algorithm allows operation without additional non-return valves, mounted directly at the entry of the tube into the tank, but in some cases installation of the non-return valves is a required (for example, when measuring the level in the fuel tanks) or desirable (using a side-entry of the tube into the tank and installation of the level transmitters below the highest possible level of filling the tanks etc.) condition.

Note: *when making a decision about the need to install non-return valves, the requirements of relevant regulatory authorities and classification societies should be followed.*

A drawing of the non-return valve is shown in Appendix C.

3.9 Ball shutoff valves

Installing shutoff valves on each measuring channel directly at the entry of the air tube into the tank is not required for the normal operation of the System, but their use has several advantages:

1. The use of shutoff valves helps to check the tightness of the measuring channel from the level transmitter to the entry into the tank. To check the tightness, the ball valve is closed and the level transmitter is set to leak test mode. In this mode, air is pumped

into the tube and the level transmitter carries out constant pressure measurement in the channel. If the channel is leak proof, the measured pressure will be constant and equal to the pressure at the inlet of the level transmitter. The pressure drop in the channel will indicate leakage; in this case, the level transmitter calculates the average leak value. For more information about the leak test see p. 2.2.2.2.4.

2. In cases, when compressed air is not supplied to the level transmitters for a longer period of time, the closing of the shutoff valves eliminates the penetration of the liquid into the air tubes. This is especially actual when using the side penetration of the tube into the tank (below the highest level of filling).

A drawing of the shutoff valve installation is shown in Appendix C.

Note: *when making a decision about the need to install the shutoff valves, the requirements of relevant regulatory authorities and classification societies should be followed.*

3.10 Commissioning

3.10.1 Commissioning

By the time of commissioning, the installation of the air handling units, the level transmitters (boxes) must be completed and the hydrostatic test of the air tubes by the high pressure (5-8 bar), electrical and pneumatic connections according to wiring diagram must be performed.

The hydrostatic test of air tubes should be carried out prior to their connection to the level transmitters to avoid damage to the valves and sensitive elements of the sensors installed in the level transmitters. According to the results of the hydrostatic test, the report with the specification of the test pressure, test duration and the leakage value for each channel is drawn up.

During the commissioning process, the following actions are performed:

1. On the outlet of the air handling unit, the air pressure 1.9±0.1 bar is set.

2. The correctness of the electrical connections is checked and the power to the level transmitters is supplied.

3. The correctness of the installation, parameters of the compressed air supply, correct installation of the shutoff and non-return valves, pressure repeaters, air tube gaskets, etc. in accordance with the recommendations and requirements of sections 3.1-3.9 of this manual is checked.

4. The bottom clearance (displacement of the tank bottom to the lower end of the tube) for each measuring channel for further input into the level transmitters is measured.

After performing the above actions, the setting of the level transmitters using the software "*BMS Utility"* is carried out. The following parameters are specified for the setting:

- Number of the involved measuring channels;
- Bottom clearance on each channel measurement;
- Cargo density in the respective tank.

For more information on the "*BMS Utility"* software, see Section 7 of this operating manual.

At the final stage of commissioning, conformity of the measured and the actual level of filling of the tank on each measuring channel is checked. In case there are large discrepancies between the measured and actual filling level, in the first place it is necessary to check tightness of the proper measuring channel.

4 Usage for the purpose intended

4.1 Preparation of the product for use

Before turning the system on, you shall check the air pressure at the outlet of the air handling unit and adjust it, if necessary. After the power supply, all the necessary preparatory steps (testing and calibration of sensors, the air pumping into the tubes,

etc.) will be executed automatically, after which the system will be set in the measurement mode.

4.2 Stop

To stop the System, the power supply and if necessary the air supply must be stopped.

4.3 Utilization

The level transmitters operate in automatic mode. The current measured values of the levels (density, draught) are read by top-level automation devices (controllers, operator stations, etc.) on the Modbus RTU protocol via primary or backup communication line and are used to manage and for the indication of the values at the displays of the operator stations.

5 Maintenance

The System requires no maintenance during the entire period of operation.

If the air supplied to the air handling unit contains dirt or is not dry enough, the air handling unit filter can get clogged and the filter container may be filled with condensate. Filters used in the air handling units have automatic drainage devices discharging condensate during filling the container.

Periodically (once a month), it is recommended to check if the air handling unit filter is not clogged and the liquid in the filter container is absent.

6 Current repairs

The level transmitters are unmendable products and in case of faultiness must be replaced entirely.

The repair of the air handling unit is carried out by changing the failed elements (filter, pressure regulator) with new ones (operable). In the case of the air handling unit filter clogging, the filtering element must be changed.

7 “BMS Utility” software

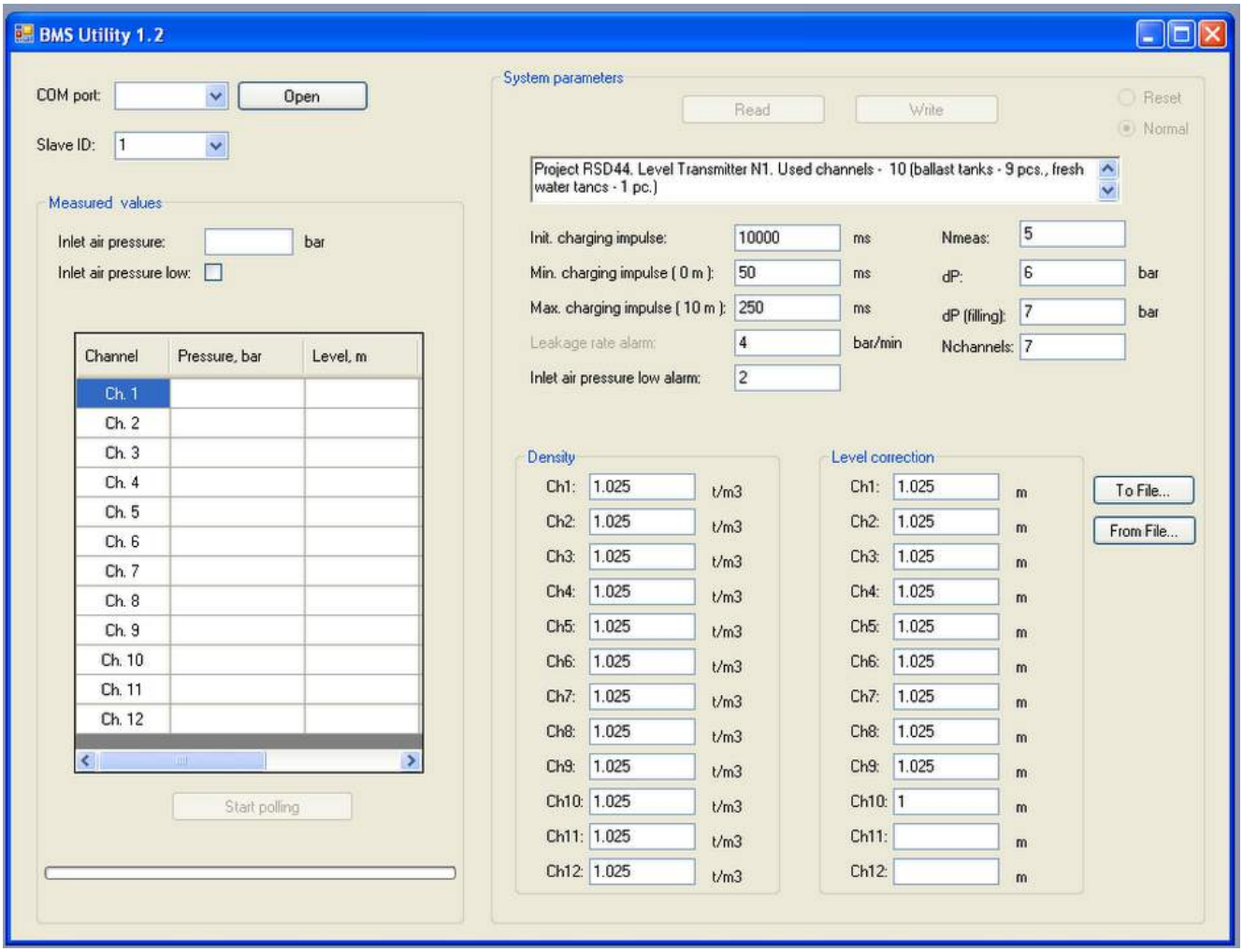
7.1 Overview

The *“BMS Utility”* software is designed for the level transmitters operation setup and diagnostics.

Features of the software *“BMS Utility”*:

1. Pressure monitoring at the entrance into the level transmitter.
2. Control of the current readings of pressure and level on each channel.
3. Setting of the operational parameters of the level transmitter.
4. Entering of the density and the bottom clearance for each measuring channel.
5. Saving/reading in/from the file of the configuration parameters of the level transmitter.

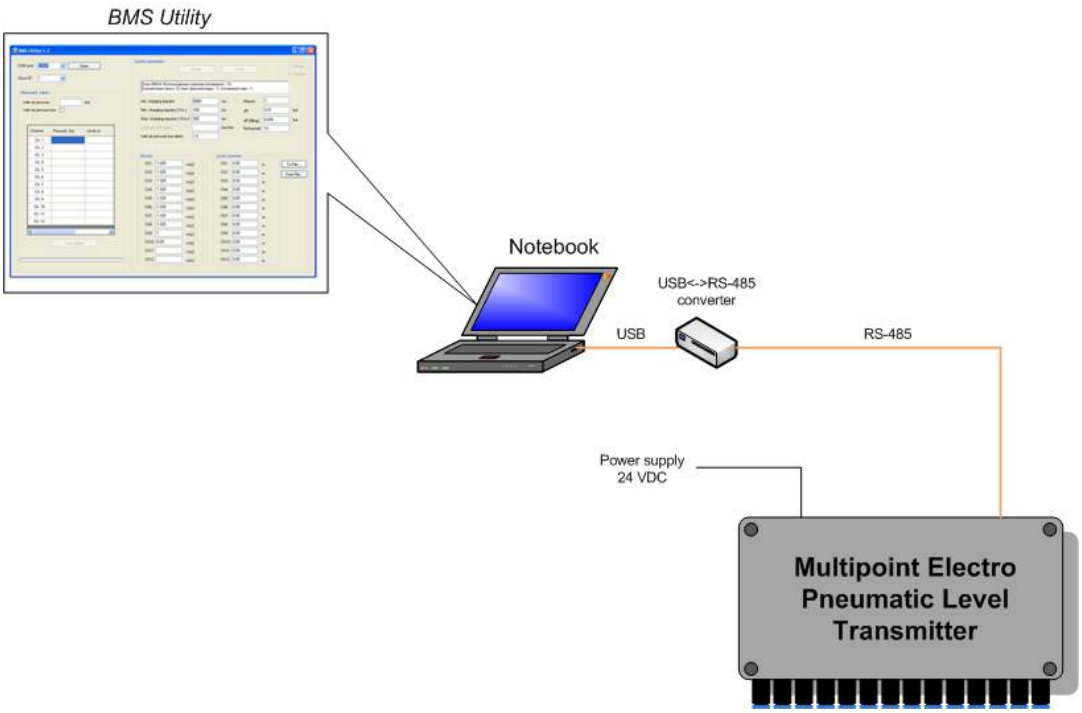
The program window is shown in Pic 8.



Pic. 8 "*BMS Utility"* Program window.

7.2 Connection to the multipoint electro pneumatic level transmitter

A block diagram of connecting of the computer (laptop) to the level transmitter is shown in Pic. 9. For the connection, one of two interfaces RS-485 of the level transmitter (primary or backup) can be used.



Pic. 9. Connection to the Multipoint Electro Pneumatic Level Transmitter

After the "*BMS Utility"* program starts, select the COM-port of your computer/laptop in the field "COM port", through which the connection is performed and click "Open".

Then indicate the address of the level transmitter on the bus Modbus in the "Slave ID" field.

Check the connection with the level transmitter by clicking the button "Read" in the frame "System parameters". With a connection established, the configuration parameters of the level transmitter will be read.

7.3 Multipoint electro pneumatic level transmitter readings check

After establishing a connection with the level transmitter, click the button "Start polling" in the "Measured values" frame. In the table above the button, the current measured values of the pressure and the level readings for each channel of the level transmitter will be displayed.

The field "Inlet air pressure" will show the current value of the air pressure at the inlet into the unit, at the value of the pressure at the inlet of the below setting the field «Inlet air pressure low will be marked by "check".

7.4 Configuration of the multipoint electro pneumatic level transmitter

The current configuration of the level transmitter can be read by pressing the button "Read" in the "System parameters" frame. Further, the read configuration can be corrected if necessary and written in the level transmitter by pressing the "Write" button.

Also, the configuration of the level transmitter can be saved as an XML file by pressing the button "To File ..." of the frame "System parameters". Further, this configuration can be read from the file (the button "From File ...") and written in the level transmitter.

Adjustable parameters:

–***Init. charging impulse*** − the duration of the pulse of the original air pumping into the tube, in milliseconds (2000 - 30000 ms);

–***Min. charging impulse (0 m)*** − the duration of the pumping pulse at the empty tank, in milliseconds (50-2000 ms);

–***Max. charging impulse (10 m)*** − the duration of the pumping pulse at the level of 10 m in the tank, in milliseconds (50-2000 ms);

–***Inlet air pressure low alarm*** − APS setting at a low air pressure; at the inlet of the BMS4 unit, in bars;

–***Nmeas*** − must be 1 or 2;

–***dP*** − to describe;

–***dP (filling)*** − to describe;

–***Nchannels*** − number of the used measuring channels of the BMS4 units (1-12);

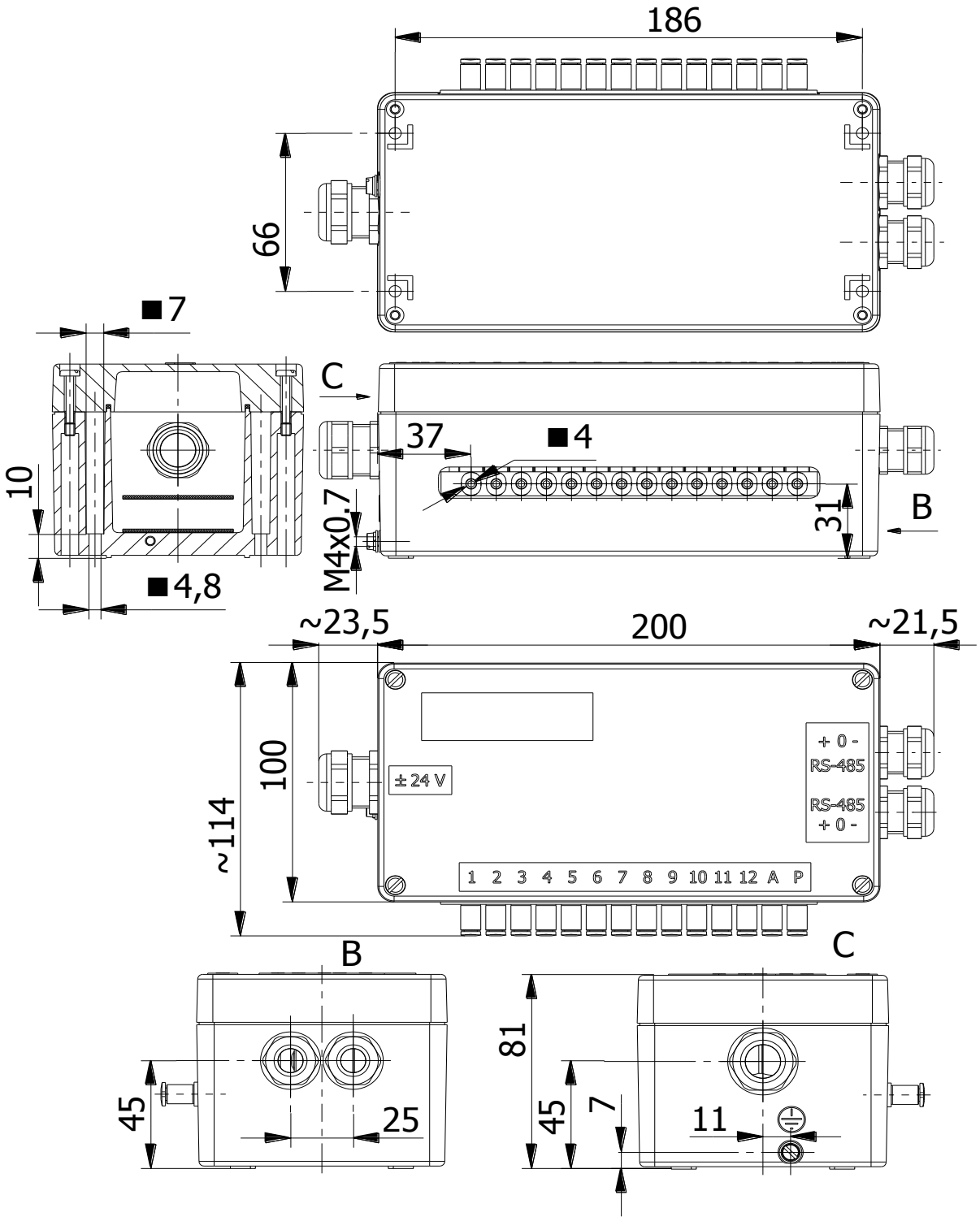
–***Density*** − the density of the cargo in the tank, separate for each measuring channel, in t/m^3;

–***Level correction*** − the value of bottom clearance, in meters.

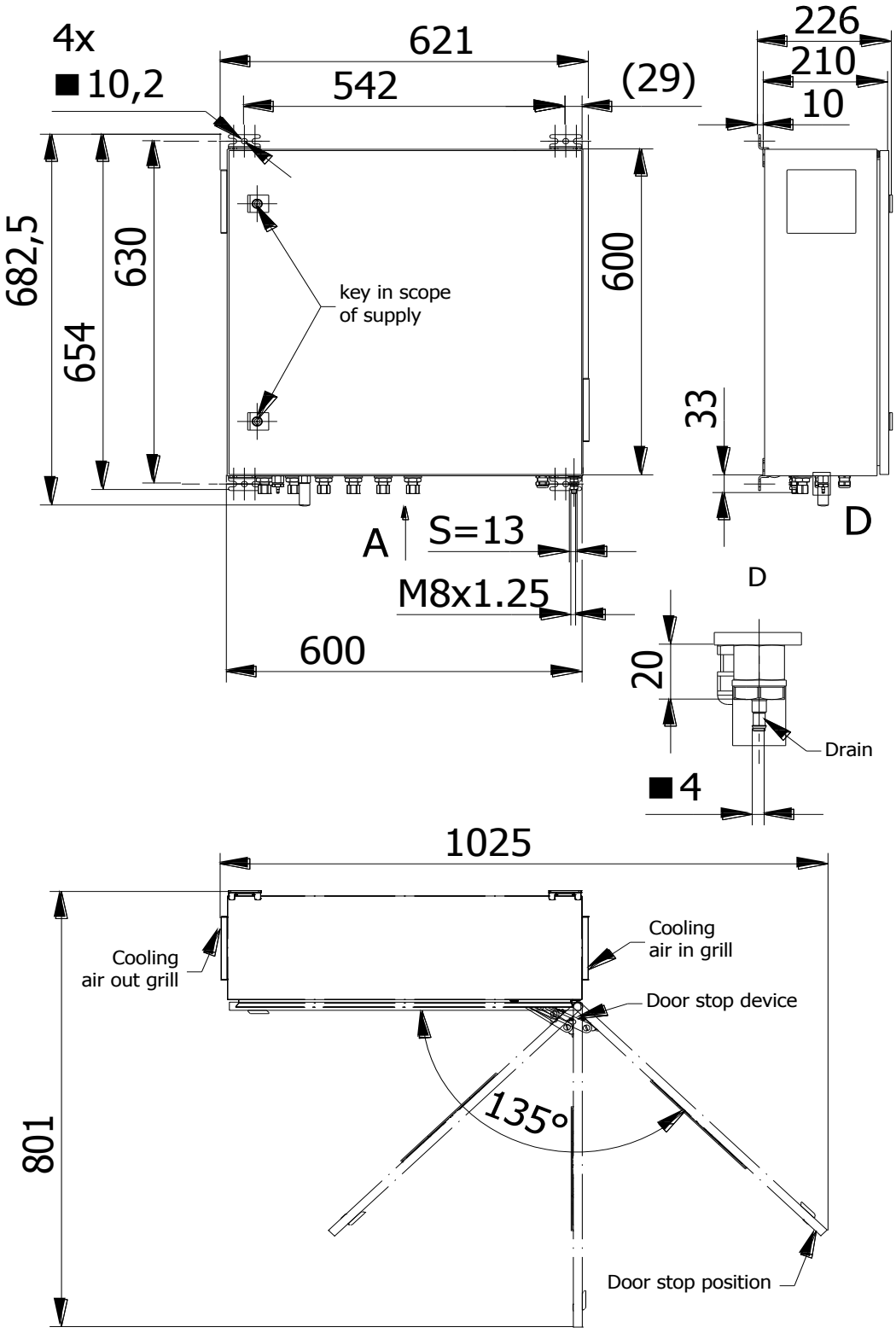
If necessary to restart the level transmitter, set the switch "Reset/Normal" in the Reset position.

At the end of the work with the software "*BMS Utility*" close the used port of the computer/laptop by clicking the button "Close".

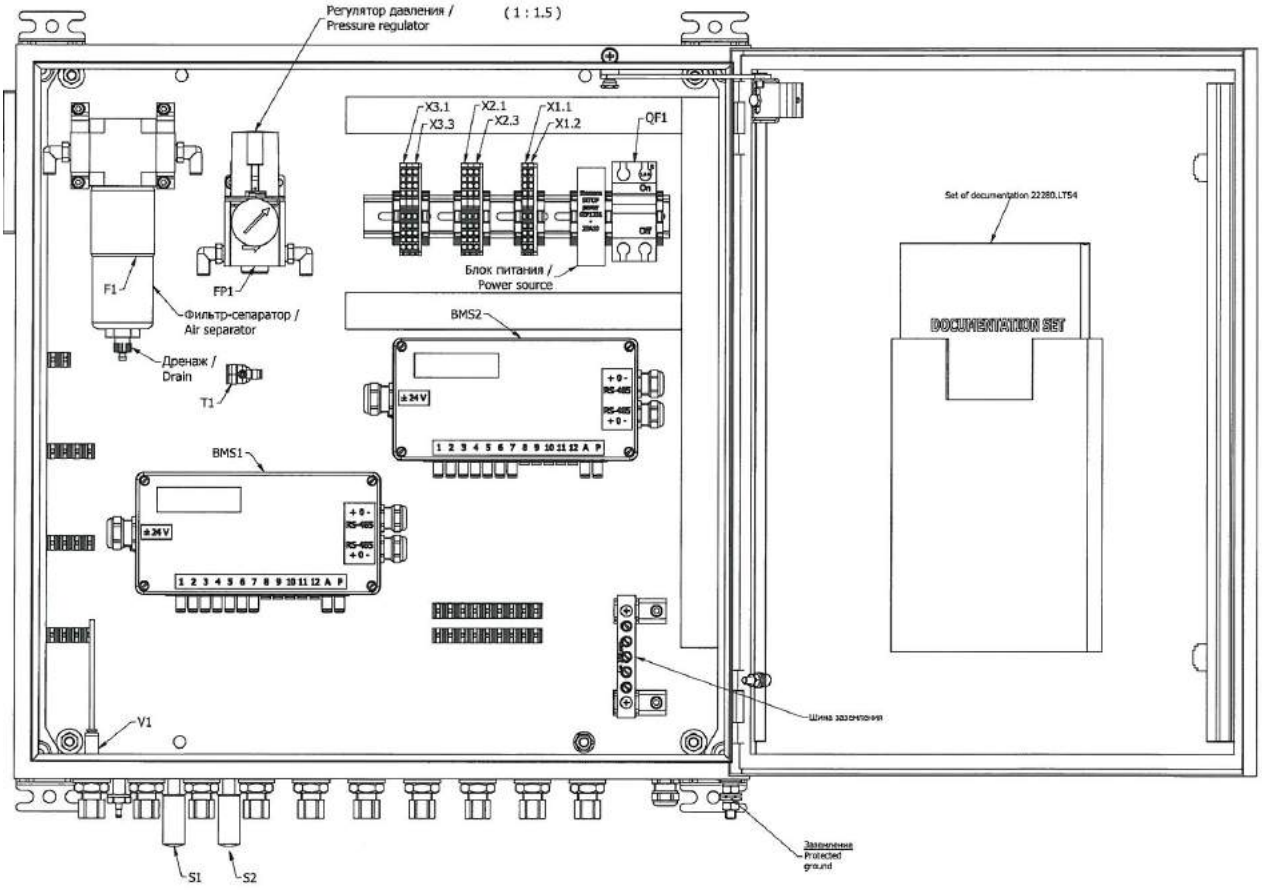
8 Appendix A. Overall and mounting dimensions of the BMS4 system equipment.



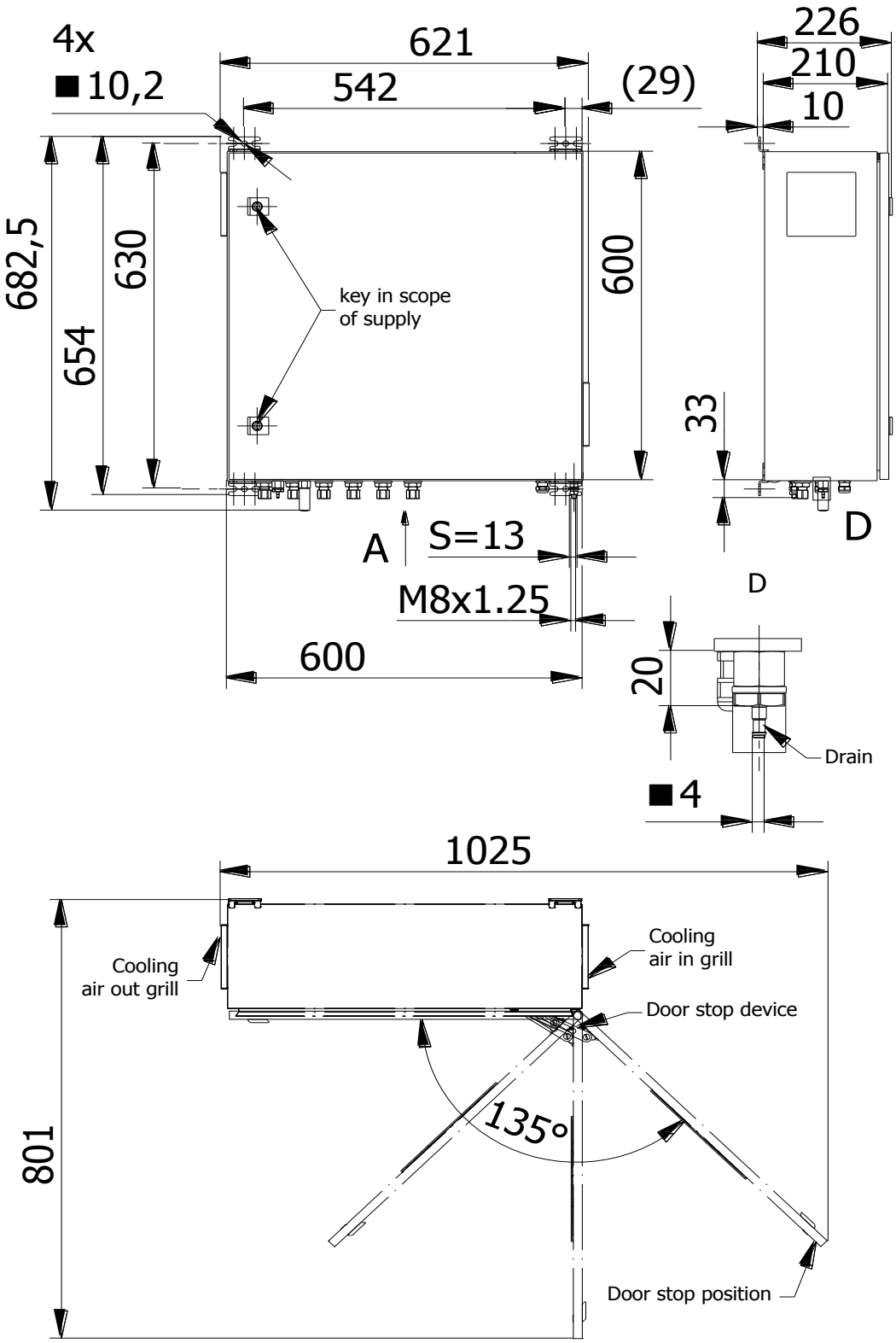
Pic. 10 The multipoint electro pneumatic level transmitter. Overall and mounting dimensions.


4x
■10,2
621
542
(29)
226
210
10
682,5
630
654
600
key in scope
of supply
33
D
A
S=13
M8x1.25
600
D
20
Drain
■4
1025
Cooling
air out grill
Cooling
air in grill
Door stop device
135°
801
Door stop position

Pic. 11 Model LTS4 cabinet for max. 24 measuring channels

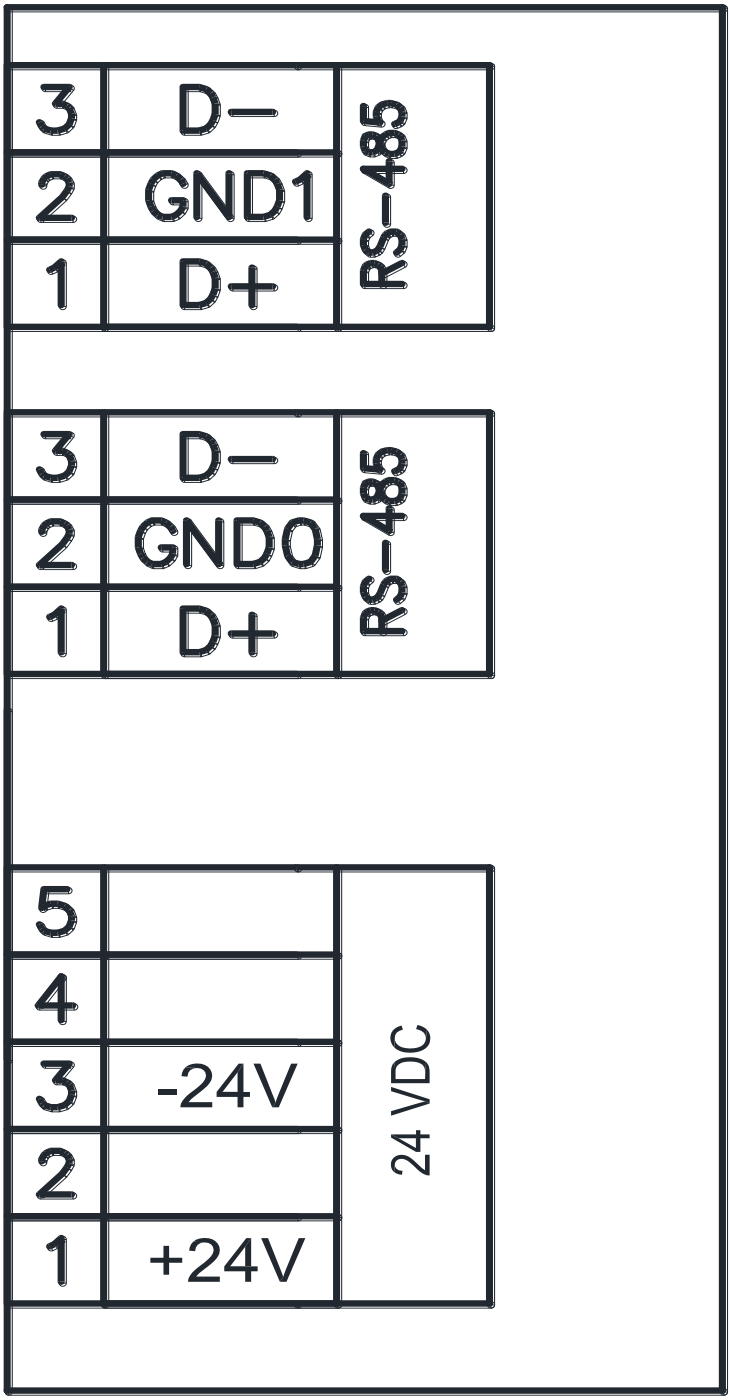


Pic. 12 Model LTS4 cabinet for max. 24 measuring channels. Internal structure



Pic. 13. The air handling unit BPV-1 (BPV-2). Overall and mounting dimensions.

9 Appendix B. Electrical wiring diagram



Pic. 14 Electrical wiring diagram of the Multipoint Electro Pneumatic Level Transmitter.

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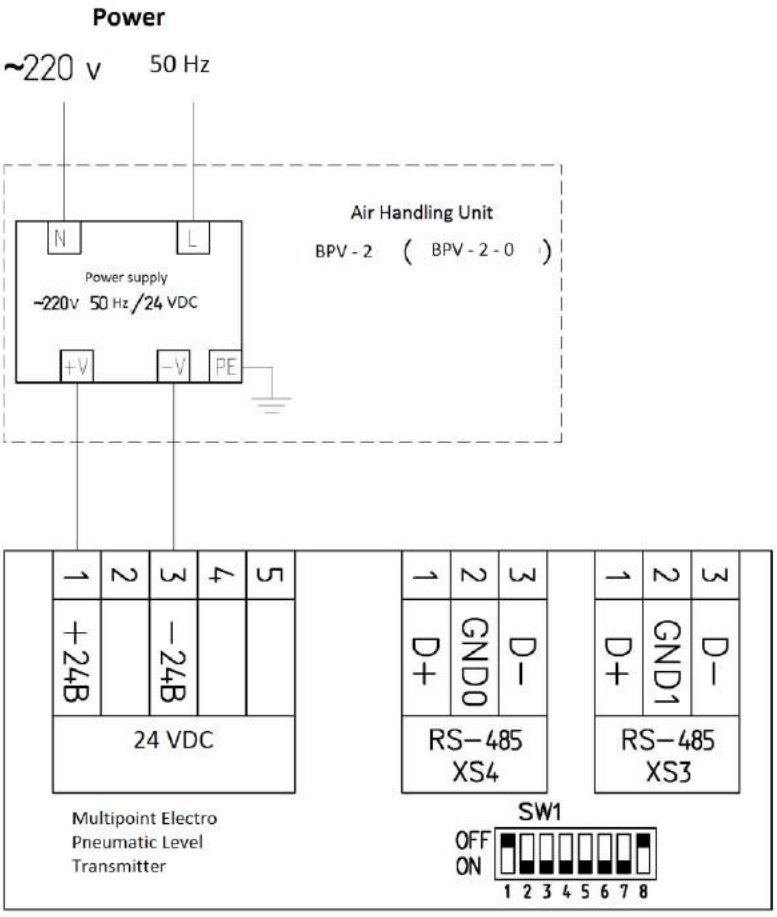

Pic. 15 Electrical wiring diagram of the multipoint electro pneumatic level transmitter unit when using the secondary power source.

10 Appendix C. Variants of air tubes and fittings assembly

To be advised depending on option used

11 Appendix D. Communication parameters, Modbus register map

11.1 Overview

Multipoint electro pneumatic level transmitters operate as a slave Modbus device. The data exchange should be carried out via Modbus RTU protocol.

Communication parameters: rate 9600 bit/s, 8-bit data, no parity control, 2 stop bits.

Used data types:

- Word - unsigned integer, 2 bytes;
- Float - single-precision floating-point in IEEE-754 format (4 bytes);
- Bool - 1 bit (true/false).

Example of a function for receiving floating point numbers from an array of bytes in the language C#:

```
public static float getFloat(byte[] b, int startInd)
                    {
                                                    byte[] floatVal=new byte[4];
floatVal[1]=b[startInd+0];                                  floatVal[0]=b[startInd+1];
floatVal[3]=b[startInd+2];                                  floatVal[2]=b[startInd+3];
return BitConverter.ToSingle(floatVal, 0);
                    }
```

Functions Modbus used:

- FC3 - registers reading (Read multiple registers);
- FC4 - input registers reading (Read multiple input registers);
- FC6 − single register writing (Write single register);
- FC16 - registers writing (Write multiple registers);

11.2 Modbus-address of the level transmitter setting

The address of the level transmitter is set by switch SW1.

11.3 Modbus register map of the level transmitter

NN	Parameter	The data type	Operation, function code	Initial registers address
1	Pressure, channel 1 (bar)	Float	Reading, FC4	64
2	Pressure, channel 2 (bar)	Float	Reading, FC4	66
3	Pressure, channel 3 (bar)	Float	Reading, FC4	68
4	Pressure, channel 4 (bar)	Float	Reading, FC4	70
5	Pressure, channel 5 (bar)	Float	Reading, FC4	72
6	Pressure, channel 6 (bar)	Float	Reading, FC4	74
7	Pressure, channel 7 (bar)	Float	Reading, FC4	76
8	Pressure, channel 8 (bar)	Float	Reading, FC4	78
9	Pressure, channel 9 (bar)	Float	Reading, FC4	80
1	Pressure, channel 10 (bar)	Float	Reading, FC4	82
1	Pressure, channel 11 (bar)	Float	Reading, FC4	84
1	Pressure, channel 12 (bar)	Float	Reading, FC4	86
1	The air pressure at the inlet to the BMS4 unit	Float	Reading, FC4	94
1	Level, channel 1 (m)	Float	Reading, FC4	100
1	Level, channel 2 (m)	Float	Reading, FC4	102
1	Level, channel 3 (m)	Float	Reading, FC4	104
1	Level, channel 4 (m)	Float	Reading, FC4	106
1	Level, channel 5 (m)	Float	Reading, FC4	108
1	Level, channel 6 (m)	Float	Reading, FC4	110
2	Level, channel 7 (m)	Float	Reading, FC4	112
2	Level, channel 8 (m)	Float	Reading, FC4	114
2	Level, channel 9 (m)	Float	Reading, FC4	116
2	Level, channel 10 (m)	Float	Reading, FC4	118
2	Level, channel 11 (m)	Float	Reading, FC4	120
2	Level, channel 12 (m)	Float	Reading, FC4	122

2	APS "Low air pressure at the inlet to the BMS4 unit"	Word	Reading, FC4 (register value = 0 - with APS, register value = 0 - without APS)	135
2	The command to restart the level transmitter (to restart the level transmitter, value 1 must be written in the register, after the restart of the level transmitter the register value is set to 0)	Word	Writing, FC16/Reading, FC3	1025
2	Density, channel 1 (t/m^3)	Float	Writing, FC16/Reading, FC3	1688
2	Density, channel 2 (t/m^3)	Float	Writing, FC16/Reading, FC3	1690
3	Density, channel 3 (t/m^3)	Float	Writing, FC16/Reading, FC3	1692
3	Density, channel 4 (t/m^3)	Float	Writing, FC16/Reading, FC3	1694
3	Density, channel 5 (t/m^3)	Float	Writing, FC16/Reading, FC3	1696
3	Density, channel 6 (t/m^3)	Float	Writing, FC16/Reading, FC3	1698
3	Density, channel 7 (t/m^3)	Float	Writing, FC16/Reading, FC3	1700
3	Density, channel 8 (t/m^3)	Float	Writing, FC16/Reading, FC3	1702
3	Density, channel 9 (t/m^3)	Float	Writing, FC16/Reading, FC3	1704
3	Density, channel 10 (t/m^3)	Float	Writing, FC16/Reading, FC3	1706
3	Density, channel 11 (t/m^3)	Float	Writing, FC16/Reading, FC3	1708

3	Density, channel 12 (t/m^3)	Float	Writing, FC16/Reading, FC3	1710
4	Bottom clearance (correction to the measured level), Channel 1 (m)	Float	Writing, FC16/Reading, FC3	1712
4	Bottom clearance (correction to the measured level), Channel 2 (m)	Float	Writing, FC16/Reading, FC3	1714
4	Bottom clearance (correction to the measured level), Channel 3 (m)	Float	Writing, FC16/Reading, FC3	1716
4	Bottom clearance (correction to the measured level), Channel 4 (m)	Float	Writing, FC16/Reading, FC3	1718
4	Bottom clearance (correction to the measured level), Channel 5 (m)	Float	Writing, FC16/Reading, FC3	1720
4	Bottom clearance (correction to the measured level), Channel 6 (m)	Float	Writing, FC16/Reading, FC3	1722
4	Bottom clearance (correction to the measured level), Channel 7 (m)	Float	Writing, FC16/Reading, FC3	1724
4	Bottom clearance (correction to the measured level), Channel 8 (m)	Float	Writing, FC16/Reading, FC3	1726
4	Bottom clearance (correction to the measured level), Channel 9 (m)	Float	Writing, FC16/Reading, FC3	1728
4	Bottom clearance (correction to the measured level), Channel 10 (m)	Float	Writing, FC16/Reading, FC3	1730
5	Bottom clearance (correction to the measured level), Channel 11 (m)	Float	Writing, FC16/Reading, FC3	1732
5	Bottom clearance (correction to the measured level), Channel 12 (m)	Float	Writing, FC16/Reading, FC3	1734
5	Duration of the pumping impulse at the empty tank, in ms (*Min. charging impulse (0 m)*)	Word	Writing, FC16/Reading, FC3	1736
5	Duration of the pumping impulse with the level in the tank 10 m, in ms (*Max. charging impulse (10 m)*)	Word	Writing, FC16/Reading, FC3	1737

5	*Nmeas*	Word	Writing, FC16/Reading, FC3	1738
5	Duration of the initial air pumping impulse into the tube, in ms (*Init. charging impulse*)	Word	Writing, FC16/Reading, FC3	1739
5	Number of the used measuring channels of the level transmitter (nChannels)	Word	Writing, FC16/Reading, FC3	1740
5	dP	Float	Writing, FC16/Reading, FC3	1743
5	*dP (filling)*	Float	Writing, FC16/Reading, FC3	1745
5	APS setting for the low air pressure at the inlet to the level transmitter, bar (*Inlet air pressure low alarm*)	Float	Writing, FC16/Reading, FC3	1747

Note: *the bottom clearance value (correction to the measured level) should be entered in the level transmitter as a negative number. For example, if the value of the bottom clearance is 0.05 m, the value to enter in the level transmitter must be -0.05 m*