НЕФТЕПРОМАВТОМАТИКА

CONTROLLER BRIG-015-C001

Information-management unit in explosion-proof design.

Operation manual

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CONTENTS

This document contains data on construction, operating principle, technical characteristics of BRIG-015-C001 unit. Operation manual is intended to inform on regulations that are necessary for correct and safe operation of the unit (its proper use, technical maintenance, operation maintenance, storage and transporting) as well as for evaluation its technical conditions in order to define whether it requires maintenance.

Only staff that have studied the operations manual and hold no less than III group on electrical safety in accordance with Appendix №1 to Guidance on job safety during usage of electronic equipment adopted by Department of Labor of Russian Federation on 24.07.2013 N 328n are allowed to perform works on installation, mounting and service of unit BRIG-015-C001.

Manufacturer reserves the right to make alterations in operation manual and unit's design related to its technical characteristics improvement without preliminary notification. All alterations will be published in a revised version of operation manual on manufacturer's site: http://www.npaufa.ru.

1. DESCRIPTION AND FUNCTIONING

1.1. Product designation

1.1.1. The unit is designed to control equipment for oil or other petrochemical products loading loade into tank lorries or railway tanks and to display technological process status. It is possible to install and run the unit in explosion hazardous zoned in accordance with marking that is located on the housing of the unit. The unit can be used with indicator BRIG-015-I001 (as well as indicator MS-UITV-V3-K).

1.1.2. The unit has explosion proofing for electrical equipment marking type 1ExdIIBT3 in accordance with GOST R 30852.0-2002 (IEC 60079-0:1998) «Explosion-proof electronic equipment. Part 0. General requirements» and is designed for usage in explosion hazardous zones of 1st and 2nd classes installed on stationary objects in accordance with GOST R 30852.0-2002 (IEC 60079-0:1998) «Explosion-proof electronic equipment. Part 0. General requirements», GOST R 30852.9-2002 (IEC 60079-10:1995) «Explosion-proof electronic equipment. Part 10. Classification of explosion hazardous zones», GOST R 30852.13-2002 (IEC 60079-14:1996) « Explosion-proof electronic equipment. Part 14. Electrical installations in explosion hazardous zones (with exception of underground working)».

1.1.3. The unit conforms with Federal norms and regulations in the sphere of industrial security “General rules of explosion-proofing for explosion hazardous chemical, petro-chemical and oil-processing plants” that were adopted by order of Federal service on ecological, technological and atomic supervision on March 11th 2013 №96

1.1.4. Unit functions under control of a master device (for example PC) in dialogue mode according to MODBUS RTU exchange protocol. EIA-485 interface is used for data exchange with master device.

1.1.5. The unit is designed for long-term continuous operation.

1.1.6. Range of application.

The unit is designed to be used as a part of fuel-supply complex on oil-loading posts that are located in explosion hazardous zones.

1.1.7. Unit operation conditions:

· on degree of protection from environmental impact IP65 in accordance with GOST 14254-96 (IEC 529-89) «Protection degrees provided by casing (IP code)»;

· on endurance and durability to sinusoidal vibrations impact – in accordance with GOST R 52931-2008 meets N3 «Technological processes control and regulation devices. General technical conditions»;

· on durability to ambient air temperature and humidity impact in accordance with GOST 15150-69 meets U1 «Machines, devices and other technical products. Designs for different climatic zones. Categories, operation conditions, storing and transporting conditions in the sphere of climatic environmental factors impact».

1.1.8. During purchasing and for other products' documentation where the unit can be used the unit must be indicated as follows: "Programmable controller BRIG-015-C001".

1.1.9. Unit's service life – 10 years.

1.1.10. Unit does not bear any danger to health or life and environment. Unit should be utilized after service life in accordance with technology that is accepted on the plant that uses the unit.

1.1.11. Warranty operation period is 12 months from manufacturer shipping date.

1.1.12. If the user does not follow operation rules and requirements listed in operation manual manufacturer does not bear warranty obligations in case user-caused unit's failure or housing integrity damage.

1.2. Technical characteristics

Product design is shown in picture 1.

Picture 1. Unit BRIG-015-C001.

Main technical characteristics of the unit are as follows:

Supply voltage:	220 V+10%.
Power supply type:	AC, 50 Hz
Power consumption, no more than:	150 W
Indicator type:	LED
BRIG-015-I001 connection interface:	Provided
Discrete inputs quantity (24 W, DC):	8
Discrete relay outputs quantity (24 W 2A, DC, 220 W 1A AC):	11
Galvanic isolation of discrete inputs:	Optic
Communications interface with master device:	EIA-485
Communication protocol to master device:	Modbus RTU
Slave device type	Density indicator Plot-3M or mass meter Promass 83
Cable entry quantity	2 (4)
Working mode:	Continuous, twenty-four-hour
Degree of protection from environmental impact:	IP 65
Explosion proofing marking:	1ExdIIBT3
Ambient temperature during operation:	-50..+60°C
Relative air humidity during operation, no more than:	100%
Weight, no more than:	2 kg.

Dimensions, WxHxD:	290x228x109 mm.

1.3. Composition of the unit and package contents

1.3.1. Unit delivery set includes:

· Programmable controller BRIG-015-C001.

· operation documentation: 1 set;

· transport packaging: 1 set;

1.3.2. Operation documentation includes:

· Operations manual;

· Passport.

1.4. Unit design

1.4.1. Design.

Design of the unit includes metal case with glass front panel, electronic components boards are located inside the housing of the unit.

Cable glands are located on the side of the unit.

Grounding device with corresponding marking is located on the outer side of the unit.

The unit consists of the following parts:

- Indicator
- Master controller
- Power unit

1.4.2. Indicator.

LED indicator is located on the front panel and allows displaying state of discrete inputs and outputs of the unit.

The following inputs state is displayed:

- START/STOP button;
- Prohibited;
- STOP button;
- Overloaded;
- Ready;
- Tip in parking mode;
- Flow sensor (frequency);
- Grounding.

The following outputs state is displayed:

- Small-flow valve;
- Large-flow valve;
- Pump magnetic contactor;
- Signal lights;

- Shut-off electromagnetic valve;
- Selection 1… Selection 5;
- Indication (BRIG-015-I001 interface).

1.4.3. Master controller.

Master controller is designed to control technological process of oil/petrochemical products loading. Controller receives signals from fuel-supply complex sensors and provides control actions on actuating mechanisms in accordance with technical algorithm. Technical algorithm is set during manufacturing the unit but it is possible to change (update) it during unit operation. Controller has an EIA-485 interface to connect with slave devices.

1.4.4. Power unit.

Power unit provides power supply to unit's components (=5V 0.25A), as well as valves of fuel-loading complex and indicator BRIG-015-I001 (=12V 1A). Power input voltage is~ 200 V 50 Hz.

1.5. Marking

An engraved nameplate that is located on the unit's front bottom contains the following information:

- Common product commercialization mark in the market of Customs Union member-states
- Special explosion proof marking
- Type of explosion proofing
- Degree of protection from environmental impact
- Manufacturer's name
- Serial number.

Marking remains strong for the whole service life of the unit, mechanically strong and cannot be wiped off (washed off) by liquids that are used during operation and technical maintenance.

1.6. Packing

The unit is wrapped in paper and then packed into polyethylene bag. Documentation and compact disk with software are packed into polyethylene bag. Then the package is packed into cardboard box. Hollow space is filled with corrugated cardboard or synthetic filler.

1.7. Provision of explosion proofing

Explosion proofing type «d» (explosion-proof cover) in accordance with GOST 30852.1-2002 (IEC 60079-1:1998) «Part 1. Explosion proofing type «explosion-proof cover».

Categories and groups of explosion hazardous zones environment where the unit is to be installed should correspond or be less dangerous than categories and groups of explosion proofing stated in explosion proofing marking of the unit

Installing and energy supply should be performed in accordance with current operation manual, "Rules on electrical devices installation" (REDI) chapters 7.3, 7.4 and "Rules of electrical devices

operation” (REDR) chapter Э3.4, Technical safety rules, other executive directives that regulate installation of electrical equipment in explosion hazardous zones

Plugging in of the unit should be done through cable. Cable must not have any failures both of isolation and separate wires.

Reparation of the unit should be performed in accordance with GOST 51330.18-99 “Explosion-proof electronic equipment. Part 19. Maintenance and verification of electronic equipment used in explosion hazardous gaseous medium (with exception of underground working or appliances related to explosives processing and producing)».

2. INTENDED USE

2.1. Unit precommissioning

2.1.1. Unpacking.

Upon receiving the unit integrity of packing should be checked. After the box is opened the unit should be taken out of package material and wiped. Package contents should be checked against paragraph 1.3.

2.1.2. Safety precautions.

Only staff that have studied current manual and possess necessary qualifications should have access to installing, operation, technical maintenance and service of the unit.

Installing, operation, technical maintenance and service of the unit should be performed in accordance with requirements of “Users rules on electrical devices technical maintenance” and “Users safety measures during electrical devices operation”, as well as other department and sectoral norms that are implemented on the operation facility.

Installing, operation, technical maintenance, faults removal and plugging in connecting cables are allowed to perform only if the supply voltage is off.

The unit must obligatory be grounded, this should be done before other cables are plugged in. Ground loop is connected to the grounding device that is located on the outer side of the unit’s housing and is marked correspondently.

2.1.3. Installation of the unit.

Fastening of the unit is performed with fastening brackets that are located on the flanks of the unit.

Overall and connection dimensions are shown on the sketch in Appendix 1.

To plug cables in it is necessary to take of the front panel by unscrewing studs that are located along its perimeter.

Cables are to be traced through input glands, after they are connected to unit’s terminals input nuts should be screwed.

Before connecting cables it is necessary to make sure they are cut off power and protection grounding has been arranged.

Cables should be plugged in accordance with plug-in table (Appendix 2).

EIA-485 net interconnection should be performed in accordance with requirements of this standard.

After plugging in front panel must be closed and studs that are located along its perimeter must be screwed. Front panel should be car sealed.

Installation and plugging in must be performed in accordance with safety requirements (paragraph 2.1.2).

2.2. Comissioning procedures

After installation works are finished and the unit is powered the unit is ready to work. Using the unit as a part of automated systems may require changing Modbus address as well as other configurational parameters and process settings. This should be done with configurational software that is included in package set. Instruction manual to the software is provided in Appendix 3. Description of configurational parameters and process settings is provided in Appendix 3 as well.

2.3. Maintenance check

Maintenance check provides visual examination that is performed to make sure there cables do not have any breakages or damages, jacks and plugs are safely connected, there have been no mechanical damages to the housing of the unit and that plates with explosion proofing marking are provided. Safety of grounding should also be checked. Operation the device with deviations from requirements listed above is not permitted.

2.4. Technical maintenance

Technical maintenance is conducted in order to provide normal operation and maintenance of operational and technical characteristics of the unit during service life.

Technical maintenance consists of periodical control of technical state and of emerging malfunctions repair.

During conducting all kinds of technical maintenance safety measures listed in paragraph 2.1.2 must be followed.

Technical maintenance should be conducted no less than once a quarter. During the maintenance requirements in paragraph 2.3 should be followed.

During technical maintenance it is necessary to remove contaminations from surface of the housing; it is prohibited to use corrosive fluids of solvents.

Maintenance (as well as warranty repairs) is performed by manufacturer.

2.5. Using the unit

The unit works as a slave unit in relation to PC or higher level controller in accordance with Modbus RTU protocol. Master device performs transmission of control commands in accordance with its initiative as well as reading variables that describe current state of technological process.

EIA-485 interface is used for connection to master device.

For automatic mass calculation density indicator Plot-3M or Coriolis mass meter Promass 83 can be connected to the unit as slave devices.

Description of communication parameters that are used by Modbus, connection principles and register map are provided in Appendix 4.

2.6. List of possible malfunctions during operation

List of possible malfunctions during operation, their cause and directions on their removal are provided in Appendix 5.

In case of unit's failure it is necessary to stop it and shut down power supply system that uses the device.

2.7. List of critical failures, possible human (user's) errors that lead to emergency state of the unit and actions that prevent such errors

Incorrect connection. Can lead to failure during power supply.

Visual indication of the failure: total absence of light indication.

Incorrect connection to relay output of the unit. It can lead to exceeding of acceptable level of oil products in the tank during loading with oil product overloading outside of a cistern.

In case of unit failure it is necessary to check technical state of the unit in accordance with paragraph 2.3. If solving cause of a failure did not lead to proper operation of the device it is necessary to stop using the device and sent it to manufacturer to be repaired.

In case of failure during operation the unit it is necessary to stop using the device and to shut down power supply system that uses the device.

2.8. Parameters of limit states

It is prohibited to run the unit under at least one of the following circumstances:

· The unit reached the limit of service life (10 years)

· Mechanical damage that prevent the unit from normal operation as well as other damage that interferes with providing explosion proofing (see paragraph 1.7).

· Disruption of components caused by corrosion, erosion and material degradation.

2.9. Rules of storing and transporting

Transporting and storing should be performed in accordance with GOST 15150-69 «Machines, devices and other techware. Designs for different climatic zones. Categories, terms of operation, storing and transporting in the sphere of environmental factors impact» (terms of storing 3). Before being put into operation unit should be stored in a warehouse in factory packing at temperature -40...50 °C and relative humidity up to 90% (at temperature 25 °C).

Transportation of the unit should be performed in its factory packing. Keeping time for the unit in factory packing in warehouse, including time of transportation, is 3 years.

2.10. Conservation guidelines (depreservation, reconservation)

2.10.1. Conservation

Conservation is a set of measures of unit temporary protection from environmental impact. Only serviceable unit can be conserved. Conservation of a unit should be performed in accordance with the method provided below.

Conservation is performed directly before the unit is being placed into storage in a specially equipped dry room, isolated from noxious gases permeation, vapors of acids and caustic, relative humidity no more than 70% and temperature no lower than 288 K (15 °C). Increase of relative humidity up to 80% can be accepted at time when temperature drop in the premises is no greater than 5 K (5 °C).

All materials used for conservation must be clean and dry and providing the unit a necessary protection against environment impact during storing. Unit should come in to preservation without corrosion damages on metal and metal covers.

Before conservation it is necessary to check operability in accordance with paragraph 2.3 of the current operation manual.

Conservation is performed by method of static air dehumidification. The unit is placed into polyethylene bag with silica gel and hermetically car sealed. Bag with indicating silica gel should be placed so after packed unit is put into long-term storing box it was located in front of inspection window. Visual control of bag and its welded seams integrity is performed. Welded seams must not have openings, faulty fusions, bulging, foreign inclusions and burn outs. Time between placing silica gel on the unit and finishing welding bag’s last seam should not exceed 2 hours. For air dehumidification finely porous lump or granulated silica gel is used. A special bag is filled with 0,1 kg silica gel and placed into the bag. To control humidity inside the bag a bag with indicating silica gel is used. Blue and purple colours of indicating silica gel indicate acceptable humidity inside the bag. In case silica gel is pink it is necessary to open the bag and change silica gel.

2.10.2. Depreservation

Depreservation is a complex of measures on removing all means of temporary anticorrosive protection from the unit. Depreservation is performed directly before putting the unit into use or when term of conservation has expired.

Depreservation works should be performed in the following order – examine long-term storage packing in which the unit is stored and make sure that seals on packing box are untouched and that there are no damages; - take off seals and open long-term storage packing. Take out compacting cardboard and paper; - take out the unit packed in polyethylene bag from the long-term storage box; - unfasten the bag with indicating silica gel; - open the polyethylene bag, take out the unit that is packed in its bag and bags with silica gel. While opening the bag cut off the narrowest possible stripe with the welded seam; remove the tape and wrapping paper. Conservation materials should be put into long-term storage box; - conduct a thorough examination in order to make sure the main block housing bears no damage and there are no dents, scratches or other mechanical damage, no faults in paint-and-lacquer coating, no traces of oxides and corrosion, and to remove faults that are found; - check composition of the set; - check unit operability in accordance with requirements listed in current operation manual;

Measures of temporary anticorrosive protection, packing materials and long-term storage packing should be stored for reconcervation of the unit.

2.10.3. Reconservation

Reconservation is a process of restoring favorable conditions for storing the unit; it consists of changing (drying) damp silica gel and restoring damaged means of conservation (bags).

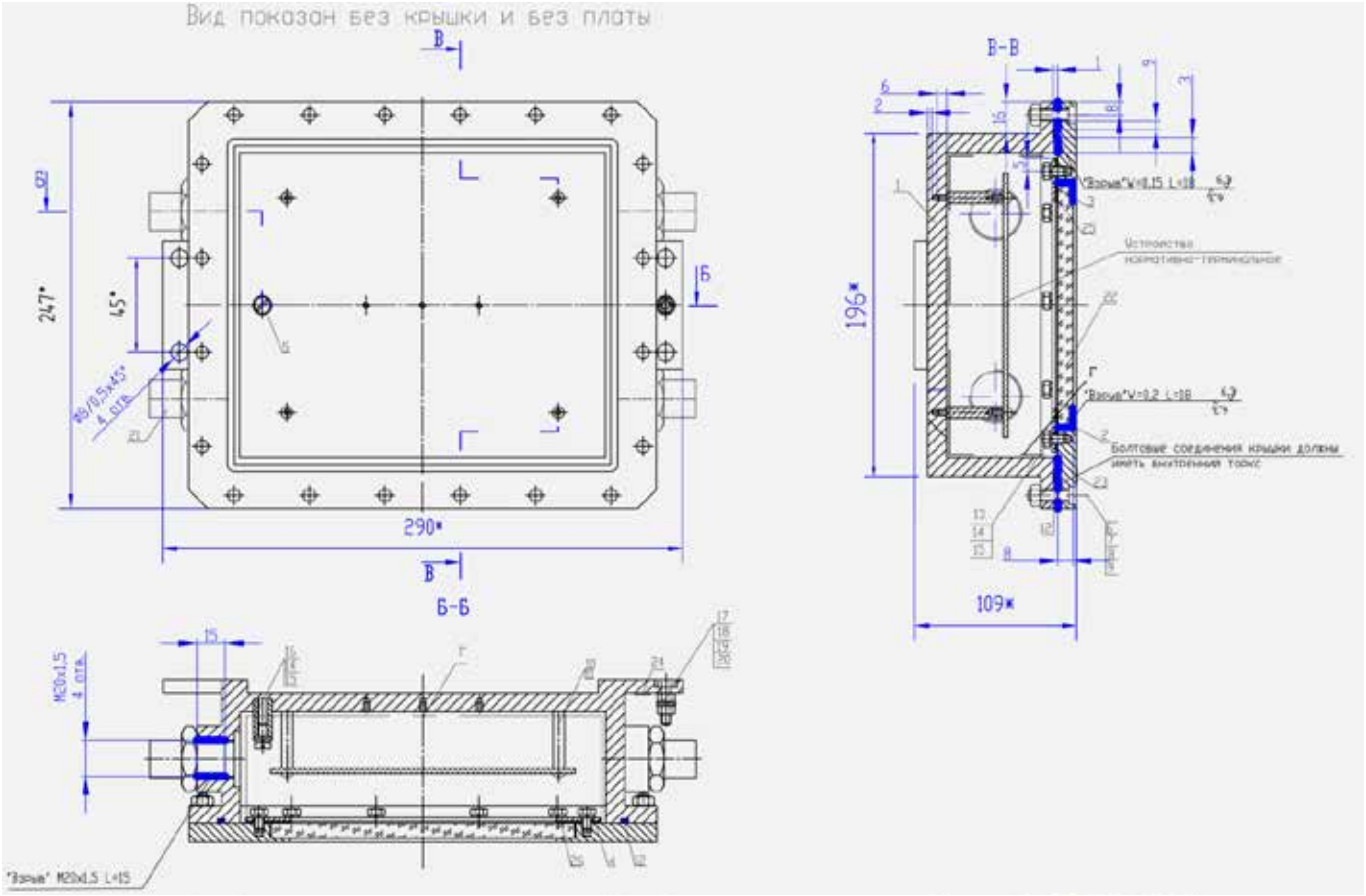
The same version of temporary protection and inner packing that is used for conservation of the unit is used for its reconservation (ВЗ-10 in accordance with GOST 9.014-78 «General system of anticorrosive and antiageing protection. Temporary anticorrosive protection of products. General requirements»). During reconservation it is possible to reuse undamaged inner packing that was used during previous conservation, as well as means of temporary anticorrosive protection after restoring their protection capability.

Reconservation of the unit is conducted: - after term of conservation (three years) set up by maintenance documentation has expired; - in case failures in conservation were found on checkup during storing; at other circumstances that require unsealing stored unit.

Reconservation is performed in the following order: - examine long-term storage packing in which the unit is stored and make sure that seals on packing box are untouched and that there are no damages; - take off seals and open long-term storage packing; - perform partial opening of polyethylene bag and change (dry) bags with silica gel; - perform re-sealing of the polyethylene bag.

APPENDIX №1

Overall and connection dimensions



Picture 2. Overall and connection dimensions.

APPENDIX №2

Unit connection

Cable №1 (interfaces)

Core №	Signal (designation)	Signal (function)	Connection to controller (board, terminal block)	Terminal №
1	A0	RS-485 PC	RB, X3	13
2	B0	RS-485 PC	RB, X3	14
3	GND0	RS-485 PC (display)	RB, X3	15
4	A1	RS-485 Density indicator/mass meter	RB, X3	16
5	B1	RS-485 Density indicator/mass meter	RB, X3	17
6	GND1	RS-485 Density indicator/mass meter (display)	RB, X3	18

Cable №2 (sensors/controller inputs)

Core №	Signal (designation)	Signal (function)	Connection to controller (board, terminal block)	Terminal №
1	ZAP	Start prohibited (failure)	RB, X3	11
2	STOP	STOP button	RB, X3	10
3	ZAZ	Grounding	RB, X3	5
4	GAR	Tip in parking mode	RB, X3	7
5	GOT	Arm ready (tip location sensor)	RB, X3	8
6	P/S	START/STOP button	RB, X3	12
7	PER	Overload	RB, X3	9
8	DL	Litres sensor (frequency input – volume flow rate)	RB, X3	6
9	IND	Indication (interface output to MC-UITV-V3-T display)	RB, X3	4

Cable №3 (relay contacts, sensors and valves supply)

Core №	Signal (designation)	Signal (setting)	Connection to controller (board)	Terminal block, terminal №
1	-12V	Sensors supply, display	RB	X2.18
2	+12V	Sensors supply, display	RB	X1.18
3	+24V	Valves supply	SB	X5. 1,2
4	-24V	Valves supply	SB	X4. 1,2,3
5	PR NO	Receive mode NO	RB	X1.13
6	PR COM	Receive mode COM	RB	X2.13
7	KBR	Large-flow valve	RB	X2.14
8	KBR COM	Large-flow valve COM	RB	X1.15
9	KMR	Small-flow valve	RB	X1.16
10	KMR COM	Small-flow valve COM	RB	X2.16
11	VIB5	Selection 5	RB	X2.2
12	VIB5 COM	Selection 5 COM	RB	X1.3

Cable №4 (relay contacts, controller supply)

Core №	Signal (designation)	Signal (setting)	Connection to controller (board)	Terminal block, clamp №
1	SV COM	Signal lights COM	RB	X2.10
2	L	Controller supply ~220V Phase	SB	X3. 1,2,3
3	N	Controller supply ~220V Neutral	SB	X2. 1,2,3
4	PE	Protective grounding	SB	X1. 1,2,3
5	SVK	Red signal lights	RB	X1.10
6	SVZ	Green signal lights	RB	X1.11
7	NAS	Pump magnetic contactor	RB	X2.11
8	NAS COM	Pump magnetic contactor COM	RB	X1.12
9	KEO	SEV	RB	X2.8
10	KEO COM	SEV COM	RB	X1.9
11	VIB1	Selection 1	RB	X1.7
12	VIB1 COM	Selection 1 COM	RB	X2.7
13	VIB2	Selection 2	RB	X1.1
14	VIB2 COM	Selection 2 COM	RB	X2.1
15	VIB3	Selection 3	RB	X2.5
16	VIB3 COM	Selection 3 COM	RB	X1.6
17	VIB4	Selection 4	RB	X1.4
18	VIB4 COM	Selection 4 COM	RB	X2.4

Note: RB – relay board, SB – supply board, **X1-X3 ПР** terminal numbers from **RIGHT** to **LEFT.**

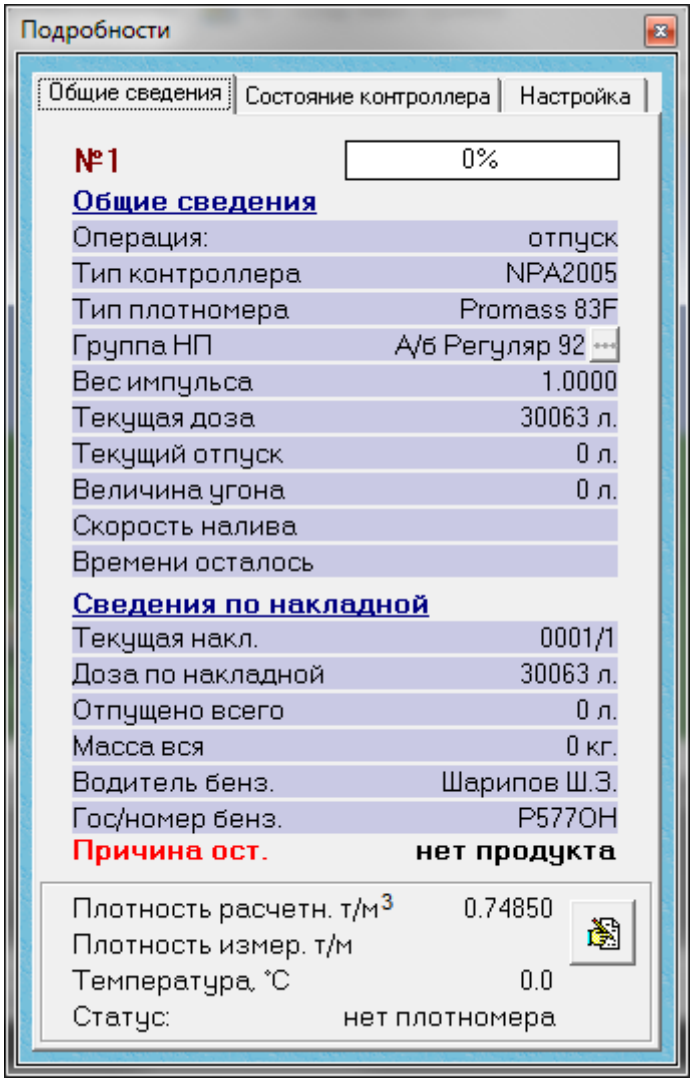
APPENDIX №3

Configuration software. Operating instructions.

Controller configuration is performed with special function of «Software oil products loading operator». Description of this software is provided in its instruction manual. Extracts from this document are provided below.

«Details» window.

“Details” window provides additional information on loading arms that were not displayed on the control unit. This window is shown in picture 3.



Picture 3 – “Details” window in loading mode.

This window has 3 bookmarks: *General information*, *Controller status* and *Settings*. *General information* bookmark provides data on current state of loading, bill of loading data, default fuel on

loading unit can be changed by clicking *Группа НП* field. If a density indicator was not set up for a loading unit, density and temperature of the product can be set up by clicking  .

Controller state bookmark provides inputs and outputs values and internal state of the controller. Settings bookmark is accessible to the user with Administrator rights and allows setting up parameters valves operating values and loading stop. It is also possible to change loading total counter value. To change these parameters it is necessary to request them by clicking “Count all”, after changing necessary parameter press  .

All actions on parameters changing in “Details” window will be commented in message field and written in database. They can be later found in *Events journal*.

Parameters of BRIG-015-C001 (are set up on “Settings” bookmark of “Details” window):

- *SFV opening after SEV opening delay [ms]* – defines period of time after which the small-flow supply valve will be opened after SEV at the beginning of loading.

- *Pump switching on after SFV opening delay [ms]* – defines period of time after small-flow supply valve opening in which pump will be switched on.

- *Product loading [l] for open LFV after pump is switched on* – defines the amount of product that should be loaded in the beginning of loading after switch to large-scale loading and pump starting.

- *Remainder of amount [l] for switch to small-scale loading* (only for loading mode) – defines the amount of non-loaded product when it is necessary to switch from large-scale loading to small-scale loading.

- *Remainder of amount [l] for stopping the loading* (only for loading mode) – this parameter controls preliminary valves shutting off. During the loading the control decides to close valves when number of product impulses left to load is equal to this parameter. It is done in because some valves cannot be closed immediately, so in order to prevent overload it is necessary to start closing valves before full amount is loaded.

- *SEV closing delay [ms] after amount is loaded* (only for loading mode) – defines time after which SEV will be closed when the amount is loaded.

- *Delay [ms] of air valve opening after SEV is closed* - defines time after which air valve will be opened after SEV is closed.

- *Time [ms] of air valve opening* - defines time during which the air valve is opened when the amount is loaded.

- *Time [ms] of waiting for the 1st impulse after SFV is opened* - defines time during which controller would expect the 1st impulse of litres counter after giving “Start” command (time reading starts after *SFV*

is opened), upon the expiration of this time in case there is no impulse the controller will close the valve and shut down the pump due to absence of product.

- *Time [ms] of waiting for the next impulse* - defines time during which the controller would wait for another impulse from litres counter after previous impulse, upon the expiration of this time in case there is no impulse the controller will close the valve and shut down the pump due to absence of product.

- Controller working mode – in manual start mode loading unit pomp can be switched on only by place of clicking “Start”; in stop automatic adjustment mode controller controls the parameter *Underfilling in impulses for loading stop*; in case parameter of *Plot-3M* is set up the controller reads density and temperature from the density indicator Plot-3M, otherwise the controller will try to read value of mass counter, density and temperature from mass meter Promass 83F.

- *Maximum amount [l] for filling-up mode* (only for loading mode) – if a “Start” command is given when the remains of amount is lesser than this parameter then the valves will be closed when the whole amount goes through the counter without preliminary valves closing (thus parameter *Remainder of amount [l] for stopping the loading* will not work)

- *Maximum accepted value of underfilling [l] after correction* (only for loading mode) – if controller is in automatic correction mode then after loading during amount reading [снятии дозы] controller will try to adjust parameter *Remainder of amount [l] for stopping the loading*. This parameter sets up maximum value for parameter *Remainder of amount [l] for stopping the loading*, that can be settled after correction.

- *Controller address* – Modbus address of this controller.

- *Density indicator address* – address of density indicator Plot-3M or mass meter Promass 83F, that are directly connected to the controller.

- *Total loading [l], Total loading [kg], Total reception [l], Total reception [kg]* provide information on general amount of product that has been let out of a selected plant.

- *Loading volume coefficient, Loading mass coefficient, Reception volume coefficient, Reception mass coefficient* – volume coefficients in this list represent weight of an impulse for loading and reception modes. Mass coefficients perform adjustment of density (as well as value of general mass counter that is received if Promass 83F unit is connected).

- Software version – version of lower level software that is applied to this controller.

APPENDIX №4

Exchange protocol.

1. Introduction

This protocol describes interaction of controller BRIG-015-C001 with software of upper level.

1.1 Controller work

During the work controller analyzes discrete input signals from sensors located on loading unit, internal state and, therefore, changes its internal state and output signals that are sent to different actuating mechanisms (pump, valve).

Controller that controls loading unit can be both in loading mode and in reception mode. When controller is on loading mode and has a set amount its aim is to control realization of the amount. Controller counts impulses that are issued by litres counter installed in loading unit and when the amount will be close to the limit – provides closing of valves and shutting down the pump in accordance with given algorithm. When the controlled is in reception mode it tries to pump out all product that is being pumped out while the counter counts it, signals from overspill and readiness of loading unit are not taken into account during the operation.

To perform the loading it is necessary to send the amount to the controller and give starting command. If the controller is on manual start mode (see table 3.1.5 – bit 0 in MODE_REG register), then the loading will start at pressing “Start” button if there are no inhibiting signals. In normal mode the loading starts after the command with code 201 (see chapter 3.4) is sent to the controller if there are no inhibiting signals. Inhibiting signals are as follows: absence of grounding signal, inhibiting signal 1, absence of loading unit (in loading mode) readiness signal, Overload signal (in loading mode) (for controller that controls lower level of loading it is a high pressure signal), “Stop” button is pressed (see table 3.1.7).

Connection of one density indicator Plot-3M or mass meter Promass 83F (type of connected units is defined by bit 2 in MODE_REG register).

In case during the process (loading or reception) one of inhibiting signals occurs the process is immediately stopped: shut-off electromagnetic valve (SEV), SFV (small-flow valve), LFV (large-flow valve) valves are closed, pump is shut down. After removal of stopping cause process can be continued with one of starting commands.

Process (in loading mode) can be tracked by the following order of events:

1. Sending the amount to the controller (possible with opening 1 additional valve).

2. Choosing the first of 5 direction of unit connection (opening one of five additional valves if they have not been preliminary opened).
3. Check of plant readiness – that is absence of inhibiting signals.
4. Sending a command for loading start after which the controlled will start working automatically
5. Controller opening SEV right after command on loading start.
6. After set time – SFV opening (small-flow valve).
7. After set time – pump starting by controller.
8. After set volume of loaded products – LFV opening (large-flow valve) by controller.
9. On set volume of non-loaded product before the end of loading – LFV closing.
10. On set volume of non-loaded product before the end of loading – SFV closing and shutting down the pump
11. After set time after event 10 – SEV closing.
12. After set time after SEV opening – air valve opening by controller.
13. After set time – air valve closing (at the state “amount is loaded”).
14. Loaded amount reading.
15. Additional valve can be closed if necessary.

In reception mode the following chain of events is typical:

1. Check of plant readiness – that is absence of inhibiting signals.
2. Sending a command for pumping start after which the controlled will start working automatically
3. Controller opening SEV right after command on pumping start.
4. After set time – SFV opening.
5. After set time – pump starting by controller.
6. After set volume of loaded products – LFV opening by controller.
7. When the product will stop coming (time of waiting for an impulse will run off) – shutting down all valves and pump.
8. Accepted amount reading.

2. Connection parameters

Setting up parameters for Com-port see in table 2.1. For exchanging information with the controller Modbus RTU protocol is used.

Parameter	Value
Connection speed, baud	9600
Quantity of bit data	8

Parity control	none
Stop bit quantity	2
Operation mode	asynchronous

Table 2.1 – connection parameters

3. Description of controller commands

3.1 Controller registers

All controller's registers accessible for reading and writing are provided in table 3.1.1. Note that some registers are open only for reading, some – only for writing functions with 06 code (writing one register) and 16 (writing a number of registers).

Arrangement: order b1-b0-b3-b2 means that the number (integer or real number) takes 2 adjoining registers, lower byte of lower register contains b0, upper byte of lower register has b1, lover byte of upper register b2, upper byte of upper register has b3, while b0, b1, b2, b3 are number byte from lower to upper.

Table 3.1.1 – Registers of loading controller

Register address	**Access**	**Name**	**Description**
0	r/w	DELAY_KMR_OPEN	Small-flow valve *(SFV) opening delay [ms] after* shut-off electromagnetic valve (*SEV) opening*
1	r/w	DELAY_VKL_PUMP	*Pump switching on delay after SFV [ms] opening*
2	r/w	LTR_MAX_ON	*Product loading [l] for open* LFV *after* LFV is opened.
3	r/w	LTR_MAX_OFF	*Remainder of amount [l] for LFV closing*.
4	r/w	LTR_ALL_OFF	*Remainder of amount [l] for stopping the loading (closing SFV, LFV, shutting down the pump. Controller prematurely stops the loading (without fully loading the product) in prevention of overload, because valves cannot be closed immediately*
5	r/w	TM_HOLD_KEO	Time [ms] of opening SEV after the loading has stopped
6	r/w	DELAY_AIRVALVE_OPEN	*Delay [ms] of air valve opening after SEV is closed*
7	r/w	TIME_AIRVALVE_OPEN	Time [ms] *of air valve opening*
8	r/w	WAITING_FIRST_IMP	*Time [ms] of waiting for the 1st impulse from the counter after SFV is opened* If upon the expiration of this time in case there is no impulse the loading will be stopped due to absence of product.
9	r/w	WAITING_NEXT_IMP	*Time [ms] of waiting for the next impulse* after previous impulse. If upon the expiration of this time there is no impulse

Register address	Access	Name		Description
				the loading will be stopped due to absence of product.
10	r/w	MODE_REG	Lower byte	If a 0 register bit is set the controller works in manual start mode, of 1st register bit is set then in the end of loading during issued amount reading and fulfilling automatic adjustment terms value of LTR_ALL_OFF will be automatically adjusted. If a 2nd register bit is set then the volume flowmeter is used instead of counter input (for Rotamass and Emerson).
			Upper byte	Mass meter type: 0- Plot 3M 1- Promass 83F 2- Mass meter MIR 3- Rotamass 4- Emerson
11	r/w	AMOUNT_TO_DOLIV		Maximum amount remains for which premature shutdown is not used upon starting loading (register LTR_ALL_OFF is not used)
12	r/w	MAX_CORR_VALUE		*Maximum accepted value of underfilling for premature loading shutdown. If automatic correction mode is used (bit 1* MODE_REG register), then the value of register LTR_ALL_OFF after adjustment cannot be bigger after this value.
13	r/w	ADDR		Controller Modbus address.
14	r/w	ADDR_PLOT		Density indicator Plot-3M or mass meter Promass 83F Modbus address.
15	r/w			Register is not used.
16	r/w			Register is not used.
17	read	SUMM_L_OUTP		Gross volume (litres) product counter counted by controller in loading mode. Number: unsigned integer, bytes order: b1-b0-b3-b2.
18	read			
19	read	SUMM_M_OUTP		Gross mass (kg) product counter counted by controller in loading mode. Standard: IEEE 754 (Single), bytes order: b1-b0-b3-b2.
20	read			
21	read	SUMM_L_INP		Gross volume (litres) product counter counted by controller in receive mode. Number: unsigned integer, bytes order: b1-b0-b3-b2.
22	read			
23	read	SUMM_M_INP		Gross mass (kg) product counter counted by controller in receive mode. Standard: IEEE 754 (Single), bytes order: b1-b0-b3-b2.
24	read			
25	read	KOEFF_L_OUTP		Impulse weight defines number of litres that stands for 1 impulse that arrives at controller counting input in loading mode. Standard: IEEE 754 (Single), bytes order: b1-b0-b3-b2.
26	read			
27	read	KOEFF_M_OUTP		Adjustment (coefficient) of density value, and if using Promass 83F – also value of total counter in loading mode. Standard: IEEE 754 (Single), bytes order: b1-b0-b3-b2.
28	read			
29	read	KOEFF_L_INP		Impulse weight defines number of litres that stands for 1 impulse that arrives at controller counting input in receiving mode. Standard: IEEE 754 (Single), bytes order: b1-b0-b3-b2.
30	read			

Register address	Access	Name	Description
31	read	KOEFF_M_INP	Adjustment (coefficient) of density value, and if using Promass 83F – also value of total counter in receiving mode. Standard: IEEE 754 (Single), bytes order: b1-b0-b3-b2.
32	read		
33	read	Version	Lower level program version
34	read	InspCntr	Inspecting counter, increases with each change of coefficient or counter.
35	read		
36	read		
37	r/w	COM_REG	Command register. In this register of upper level software a command with code from table 3.1.2. should be written. At the same time as writing this register upper level software can update values of PARAM1, PARAM2, PARAM3, PARAM4 registers (using function with code 16 – write multiple registers), these registers can be parameters for performed command. Result of performing the command can be read with the next request from COM_STAT, code deciphering for it is provided in table 3.1.3.
38	r/w	PARAM1	Parameters of upper level software commands.
39	r/w	PARAM2	
40	r/w	PARAM3	
41	r/w	PARAM4	
42	read	COM_STAT	Result of performing command to a controller. See table 3.1.3.
43	read	FLAG	Controller status flag
44	read	LAST : INP	Cause of last stop of amount dispatch process and controller input values.
45	read	OUTP : OUTP2	Controller output values.
46	read	ZAD_L	Value of amount set for loading in litres. Number: unsigned integer from 1 to 1000000, bytes order: b1-b0-b3-b2.
47	read		
48	read	OTP_L	In loading mode: value of loaded amount in litres. In receiving mode – value of accepted amount in litres. Number: unsigned integer from 1 to 1000000, bytes order: b1-b0-b3-b2.
49	read		
50	read	OTP_M	In loading mode: value of loaded amount in kilograms. In receiving mode – value of accepted amount in kilograms. Standard: IEEE 754 (Single), bytes order: b1-b0-b3-b2.
51	read		
52	read	Dens	Product density [g/l] (100..2000) received from density indicator (Plot-3M, Promass 83F etc.)
53	read		

Register address	Access	Name	Description
54	read	Temp	Product temperature [°C] (-100..120) received from density indicator (Plot-3M, Promass 83F etc.)
55	read		
56	read	DensTempStat	Status of last data on density and temperature from density indicator (Plot-3M, Promass 83F etc.).
57	read	LAST_OTP_L	Value of OTP_L register is copied here after clear command for received/loaded dose.
58	read		
59	read	LAST_OTP_M	Value of OTP_M register is copied here after clear command for received/loaded dose.
60	read		

Table 3.1.2 – Controller commands codes. Possible values for writing in the register COM_REG with the help of Modbus functions 06 and 16.

Code	Description
201	Start from PC. Command for starting loading. If the controller has an unremitted amount or is in receive mode, if it is not in manual start mode, no input signals that inhibit loading, 1 of 5 directions of loading is chosen (in loading mode) then sending this command initiates loading process.
220	Start from PC and opening 1st direction (1st direction valve) for product loading. In other aspects the command is analogue to 201.
202	Stop from PC. By command from the PC loading is stopped – SEV, SFV, LFV closing, shutting down the pump. After performing this command loading can be continued with command 201 or 220. This command works even if the controller is in manual starting mode (see description of MODE_REG register).
211	Open additional valve. This command chooses a direction (1-5) of product loading. Direction number should be preliminary written (using function with code 6) or in the moment of performing this command (using function with code 16) in PARAM1 register.
212	Clove additional valve. This command closes the valve that is opened in the moment.
213	Lock controller. This is a way to mark controller loading unit as a non-working. For this command to be successfully performed the controller should have a amount in loading mode or opened SEV in receiving mode.
214	Unlock controller
203	Setting a amount. This command is used for transferring a amount from registers PARAM1, PARAM2. To send the amount to controller it is recommended to use command with code 16 (Write multiple registers) that would write number 203 in COM_REG register and corresponding values in registers PARAM1, PARAM2 in one action. PARAM1 and PARAM2 registers should contain amount value. Number: unsigned integer, bytes order: b1-b0-b3-b2.
221	Setting an amount and opening 1st direction for product loading. This command is analogue to 203. Is the unit loadings the product only in one direction it is recommended to use this command, not 203. At the same time it is not necessary to use commands with codes 220, 211 and 212. This command is recommended to be used in pair with 222.
204	Clear loaded dose from the controller. After performing this command values of registers OTP_L and OTP_M are copied to registers LAST_OTP_L and LAST_OTP_M, after that registers OTP_L and OTP_M are nullified. When the amount снята с контроллера the results of last loading can be read in registers LAST_OTP_L and LAST_OTP_M
222	Clear loaded dose from the controller and close additional valve (valve of direction choosing for product loading that is opened on the moment of performing the command). This command is analogue to 204. If the unit loadings the product only in one direction it is recommended to use this command in pair with 221.
223	Switch to receiving mode
224	Switch to receiving mode and open 1st direction valve.

Code	Description
225	Switch to loading mode.
226	Switch to loading mode and close the additional valve (valve of direction choosing for product loading that is opened on the moment of performing the command).
227	Set the value of SUMM_L_INP. Registers PARAM1 and PARAM2 should contain a new value of the counter. Number: unsigned integer, bytes order: b1-b0-b3-b2. Register PARAM3 should contain operator's parole for counter changing, register PARAM4 – second parole for counter changing.
228	Set the value of KOEFF_L_INP. Registers PARAM1 and PARAM2 should contain a new value of the coefficient. Number: standard - IEEE 754 (Single), bytes order: b1-b0-b3-b2. Register PARAM3 should contain operator's parole for coefficient changing. On the moment of coefficient changing SEV should be shut down and there should be no received amount.
229	Read loaded dose from the controller. After performing this command values of registers OTP_L and OTP_M are copied to registers LAST_OTP_L and LAST_OTP_M, after that registers OTP_L and OTP_M are nullified. When the amount cleared from the controller the results of last loading can be read in registers LAST_OTP_L and LAST_OTP_M.
208	Set the value of SUMM_L_OUTP. Registers PARAM1 and PARAM2 should contain a new value of the counter. Number: unsigned integer, bytes order: b1-b0-b3-b2. Register PARAM3 should contain operator's parole for counter changing, register PARAM4 – second parole for counter changing.
210	Set the value of KOEFF_L_OUTP. Registers PARAM1 and PARAM2 should contain a new value of the coefficient. Number: standard - IEEE 754 (Single), bytes order: b1-b0-b3-b2. Register PARAM3 should contain operator's parole for coefficient changing. On the moment of coefficient changing SEV should be shut down and there should be no amount in the controller.
230	Set the value of SUMM_L_OUTP. Registers PARAM1 and PARAM2 should contain a new value of the counter. Number: standard - IEEE 754 (Single), bytes order: b1-b0-b3-b2. Register PARAM3 should contain operator's parole for coefficient changing, register PARAM4 – second parole for counter changing.
231	Set the value of KOEFF_L_OUTP. Registers PARAM1 and PARAM2 should contain a new value of the coefficient. Number: standard - IEEE 754 (Single), bytes order: b1-b0-b3-b2. Register PARAM3 should contain operator's parole for coefficient changing, register PARAM4 – second parole for coefficient changing. On the moment of coefficient changing there should be no amount in the controller.
232	Set the value of SUMM_M_INP. Registers PARAM1 and PARAM2 should contain a new value of the coefficient. Number: standard - IEEE 754 (Single), bytes order: b1-b0-b3-b2. Register PARAM3 should contain operator's parole for coefficient changing, register PARAM4 – second parole for counter changing.
233	Set the value of KOEFF_M_INP. Registers PARAM1 and PARAM2 should contain a new value of the coefficient. Number: standard - IEEE 754 (Single), bytes order: b1-b0-b3-b2. Register PARAM3 should contain operator's parole for coefficient changing, register PARAM4 – second parole for coefficient changing. On the moment of coefficient changing there should be no amount in the controller.
234	Change operator's parole on coefficient changing. Register PARAM1 should contain new operator's parole on coefficient changing, register PARAM3 – should contain old parole.
235	Change the second parole on coefficient changing. Register PARAM1 should contain new second parole on coefficient changing, register PARAM3 – should contain old parole.
236	Change operator's parole on counter changing. Register PARAM1 should contain new operator's parole on counter changing, register PARAM3 – should contain old parole.
237	Change the second parole on counter changing. Register PARAM1 should contain new second parole on counter changing, register PARAM3 – should contain old parole.
239	Set density and temperature of the product. Registers PARAM1 and PARAM2 should contain a new density value [g/l] more than 100 and less than 2000. Number: standard - IEEE 754

Code	Description
	(Single), bytes order: b1-b0-b3-b2. Registers PARAM3 and PARAM4 should contain a new temperature value [°C] more than -100 and less than 120. Number: standard - IEEE 754 (Single), bytes order: b1-b0-b3-b2.

Table 3.1.3 – Error codes. Deciphering values of COM_STAT register

Code	Value
0	Will be done
1	Unacceptable amount issued
2	Amount present
3	Absent amount
4	Loading in process
5	Stop of loading in process
6	Loading is not performed
7	Amount is issued
8	Loading unit not ready
9	No grounding
10	Overload (or high pressure) sensor signal
11	Inhibiting signal 1
12	Inhibiting signal 2 (in some cases signal from trap)
13	“Stop” is pressed
14	Manual start mode
15	- / -
16	Controller locked
17	Controller unlocked
18	All additional valves are closed
19	One of valves is open
20	Loading mode
21	Receiving mode
22	Data on receiving are presented
23	Operator’s parole is incorrect
24	2nd parole (or parole) is incorrect
25	Parameter is incorrect
26	Test mode
255	Incorrect command code

During using functions with codes 03 and 04 the maximum number of registers that are allowed to read is 23 due to insufficient size of read/write buffer in controller’s memory.

In table 3.1.1 it is shown that registers with addresses 17-36, 42-60 are available only for reading via Modbus functions with codes 03 and 04; registers with addresses 0-16, 37-41 are available both for reading via functions with codes 03 and 04, and for writing via functions with codes 06 – Write single register and 16 – Write multiple registers.

If you break rules described in previous paragraph the controller would return mistake with code 02 – Illegal Data Address. Also if you use other functions of Modbus protocol controller will return mistake 01 – Illegal function. In some cases controller can return a mistake with code 03 – Illegal data value.

In case upper level software want to send a command to a controller it should write a code of necessary command in the register COM_REG (see table 3.1.2) using function 06 or 16 (in case it is

necessary to setup additional parameters of the command). After the command is send to the controller upper level software wan read controller's answer from register COM_STAT (see table 3.1.3).

Now we will explain what impulses are and why the controller uses counting in impulses. In Russia the most common counter are litres, tenth of litres and 200-millilitres. Take for example 200-millilitres counter, it works in the following way: when an amount of 200 ml goes through it, it generates one rectangular impulse, therefore if an amount of 1 liter goes through the controller there would be 5 rectangular impulses. Thus coefficient of this counter (impulse weight) – 0,2 liter per impulse. During loading process controller counts number of these impulses, if an amount of 2000 l is set the controller has to count 10000 impulses (2000 [l]/0,2[l/imp]) and in the end of the loading it should provide closing the valves and shutting down the controller. In fact after calibrating the counter it can occur that coefficient is not equal to 0,2 liter per impulse, but 0,2087 liter per impulse, and we have to work with this number.

Controller status flags allow to define the phase in which product loading currently is. Deciphering of bits is provided in table 3.1.4.

Table 3.1.4 – Controller status flags –FLAG register

№ bit	**If the bit is set then:**
0	Final small-flow loading
1	Beginning small-flow loading
2	Refill
3	Stop of amount loading is in process (delay of SEV closing or pause before opening air valve or a valve is open)
4	Use density. If a mass meter is connected to the controller and prior to starting command "Start" mass meter's total mass counter was not refreshed then for the counting of issued or accepted mass density would be used
5	Waiting for refreshing total mass counter in mass meter
6	Amount is issued, loading is completely finished
7	Amount is presented (can be either issued or not issued)
8	Manual start mode. loading (dispatch of receiving) begins at pressing "Start" on loading unit
9	Automatic adjustment mode. During refreshing of amount at the end of product dispatch parameter of untimely loading stop is adjusted automatically in order to compensate underfilling/overloading that were caused by valve's movement lag.
10	Not used.
11	Verified data on temperature are received from mass meter (Plot-3M, Promass 83F etc.) during final cyclic request
12	Verified data on density are received from mass meter (Plot-3M, Promass 83F etc.) during final cyclic request
13	Verified data on mass counter value from mass meter during final cyclic request
14	Presence of connection to mass meter (Plot-3M, Promass 83F etc.) during final cyclic request although some data may not be reliable
15	Controller is locked

Register of last stop allows defining cause due to which the stop took place. For deciphering see table 3.1.5.

Table 3.1.5 – Cause of last loading stop – LAST register

Value	Description of last loading stop cause
1	Amount is loaded
2	“Stop” is pressed
3	Inhibiting signal 1 (for program controlling lower level loading – low pressure signal)
4	Overload sensor active (for program controlling lower level loading – high pressure signal)
5	“Stop” command is received from PC
6	No product (waiting time expired)
7	Not ready (loading unit is up)
8	No grounding

In table 3.1.6 see input signals deciphering, in table 3.1.7 see output controller signals deciphering.

Table 3.1.6 – Description of input controller signals – register INP

№ bit	It installed then:
0	Signal from litres counter
1	Grounding signal active
2	“Start” is pressed
3	Inhibiting signal 1 (for program controlling lower level loading – low pressure signal)
4	Loading unit readiness signal
5	Overload sensor active (for program controlling lower level loading – high pressure signal)
6	“Stop” is pressed
7	Trap signal

Table 3.1.7 – Description of controller output signals – registers OUTP and OUTP2

№ bit	It installed then:
OUTP	
0	Small-flow valve open
1	Large-flow valve open
2	Air valve open
3	Pump is on
4	Red signal light is on
5	SEV is open
6	Additional valve 1 is open (direction 1 is chosen)
7	Signal to indication board КУП-40
OUTP2	
0	Additional valve 2 is open (direction 2 is chosen)
1	Additional valve 3 is open (direction 3 is chosen)
2	Additional valve 4 is open (direction 4 is chosen)
3	Additional valve 5 is open (direction 5 is chosen)

APPENDIX №5

List of possible malfunctions during operation, their cause and directions on their removal

Description of malfunctions and damages consequences	Possible causes	Directions on malfunctions and damages consequences determination	Directions on malfunctions and damages consequences removal
Total absence of indication	The unit does not receive supply voltage	Check supply voltage on the supply cable input	Remove the cause of supply voltage lack
	Power cable is damaged	Check cable integrity	
	The unit is faulty	-	Hand the unit over for maintenance*
Relay output is not working when light indication is working	The unit is faulty	-	Hand the unit over for maintenance*
Neither relay output, not light indication are not working	The unit is faulty	-	Hand the unit over for maintenance*

* Maintenance of the unit (including warranty maintenance) is conducted by manufacturer.