“Optosense” LLC

SMALL-SIZE EXPLOSIVE GAS MEASURING TRANSDUCER MIPEX-02-X-X-X.1 X

USER MANUAL

ESAT.413347.005 UM

REV 1.21 Date 22 March 2013

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List of abbreviations:

LEL – Lower Explosive Limit;
CGM – Control Gas Mixture;
UART - Universal Asynchronous Receiver/Transmitter;
NDIR - Non-Dispersive Infra-Red.

INTRODUCTION

MIPEX-02-X-X-X.1 X (hereinafter - transducer or MIPEX-02) is the gas sensor, which is intended for automatic continuous measurement of concentration of hydrocarbons in explosive areas and carbon dioxide.

Transducer can be used as part of gas-analyzing equipment of groups I and II in the explosion-hazardous zones of classes 0, 1, 2 according to IEC 60079-10:2002, IEC 60079-10-1-2008, and Class I, Division 1 according to UL913 7th Edition, CAN/CSA-C22.2 No. 157-92.

Optosense LLC reserves the right to update and change current UM in parts exclude intrinsic safety parameters and accompanied information specified below.

1. DESCRIPTION

The principle of transducer operation is based on NDIR technology.

The infrared radiation of a light-emitting diode permeates a measuring diffusion-type gas cell and gets at 2 light-sensitive cells; one of them is responsive to radiation in the range of wavelength of 3.25 to 3.45 μm only, while the other one registers radiation in the range of wavelength of 3.1 to 3.25 and 3.45 to 3.7 μm. The investigated gas present in the cell absorbs radiation of the operating wavelength (λo) and does not affect radiation of the reference operating wavelength (λr). The amplitude Io of the light-sensitive cell operating signal changes upon changing concentration in accordance with equation:

$$Io/Ir = exp\ \{-[K(\lambda o) - K(\lambda r)]CL\}; \quad (1)$$

where:

$K(\lambda)$ – coefficient of absorption at a given wavelength;

L – optical length of cell;

C – measured concentration of gas;

Io, Ir – amplitude of signals at light-sensitive cell.

The concentration of gas is:

$$C = -Ln\ (Io/Ir)/(L\ [K(\lambda o) - K(\lambda r)]); \quad (2)$$

Using differential dual wavelength method of registration allows eliminating influence of water vapour, contamination of optical elements and other non-selective hindrances affecting both channels similarly.

The transducer structure contains an optical cell with a mirror system, infrared light-emitting diode (LED), LED driver, receivers of Signal and Reference channels, analog amplifiers, microcontroller and supply voltages unit.

The microcontroller of the transducer performs:

- storage of unique calibration constants;
- calculation of gas concentration based on mesured results;
- communication though UART intreface.

The transducer is enabled on power is up and disabled on power is down.

2. TECHNICAL SPECIFICATIONS

Table 1

General	**Gas sampling method:**	Diffusion
	Operating principle:	Non-Dispersive Infra-Red (NDIR)
	Target gas *	CH_4
		CH_4 /CH_4 +C_2H_6
		C_3H_8
		$C0_2$
	Operating conditions:	
	Relative humidity	up to 98%
	Atmospheric pressure	80-120 kPa
	Temperature range *	-10... +40 °C
		-40... +60 °C
	Storage and transportation conditions:	
	Relative humidity	up to 98%
	Atmospheric pressure	80-120 kPa
	Temperature range	-50... +60 °C
	Overall dimensions *	ø20x16.5 mm without pins
		ø22x16.5 mm without pins
	Pins length*	5,6
		4,5
	Weight *	16,6 g
		15,5 g
		5,5 g
	Enclosure *	Stainless steel (standard and fast response versions)
		ABS (plastic)
	MTBF	10 years
Measurement	**Measurement range ***	100%Vol
		5%Vol
		2.5%Vol
		100%LEL
		1%Vol ALARM SENSOR
		50%LEL ALARM SENSOR
	Accuracy *	±0.1 % Vol or ±5 % of indication
		±3 % LEL or ±5% of indication
	Response time, T90 *	10s
		30s
		60s
	Temperature Performance	According to Appendix A
	Pressure performance	
	Humidity performance	
Electrical	**Supply Voltage Range:**	3.0 – 5.0 VDC
	Output signal :	digital, UART
	Power consumption:	<5mW
	Warm-up time:	not more than 1 min
	Degree of personal protection against electrical shock caused by the transducer	meet the requirement of class III GOST 12.2.007.0
Marking and standards compliance		**Ex ia I Ma/Ex ia IIC Ga** acc. to IEC60079-0:2011, IEC60079-11:2011, IEC60079-26:2006
		IM1/II1G Ex ia I Ma / Ex ia IIC Ga acc. to EN60079-0:2012, EN60079-11:2007,EN60079-26:2007
		Class I , Division 1 , Group A,B,C,D acc. to UL913 7th Edition, CAN/CSA-C22.2 No. 157-92

**** Available options are described. See Appendix A for detailed information***

3. INTRINSIC SAFETY

Combined intrinsically safe parameters of transducers circuits are as follows:
IECEx/ATEX: Ui = 5.0V, Ii = 450mA, Pi = 0.25W, Ci = 38.8µF, Li = 0.
CAN/CSA: Vmax = 5.0V, Imax = 450mA, Pmax = 0.25W, Ci = 38.8µF, Li = 0.

It is allowed to connect the transduce only to intrinsically safe circuits with the rated direct current output voltage (U_0) within the range of not less than 3 V and not more than 5 V, with the output power (P_0) - not less than 0.02 W and not more than 0.25 W.

The gas-analyzing equipment, which is used with MIPEX-02, must meet the requirements of IEC60079–0:2011, IEC60079–11:2011, IEC 60079-14:2002 and have parameters conforming the MIPEX-02 intrinsically safe pointed above.

PRODUCT APPROVAL:

IECEX ITS 11.0047U
ITS 11ATEX27418U
4004454 Conforms to UL Std. 913, 60079-0, 60079-11. CAN/CSA-C22.2 No. 157-92.

4. PRECAUTIONS

- ***Inspection and maintenance of the transducer shall be carried out by suitably trained personnel in accordance with the applicable code of practice (e.g. EN 60079-17).***
- ***The persons who have studied this UM, have been briefed on safety precautions when operating electrical equipment intended for operation in the explosion-hazardous zones in the established order, are admitted to operate the transducer.***
- ***Repair of the transducer shall be carried out only by personal of manufacturer or authorized by manufacturer.***
- ***it is interdict to discharge the control gas mixture (CGM) to the atmosphere during transducer calibration.***
- ***Do not allow the contact of transducer with aggressive substances e.g. acidic liquids or gases that may attack metals, or solvents that may affect polymeric materials.***

5. MAINTENANCE

WARNING!

- **MIPEX-02-X-X-3.1 X POTENTIAL ELECTROSTATIC CHARGING HAZARD – CLEAN ONLY WITH A DAMP CLOTH.**
- **The MIPEX-02-X-X-1.1 X and MIPEX-02-X-X-2.1 X models of the equipment were tested and found to hold a 15.64pF maximum capacitance.**
- **Connection should be made via PCB sockets. Soldering to the pins will seriously damage the transducer.**

6.1 Preparation

6.1.1 If the transducer has been kept in the transportation package at temperature lower than 0 ^{0}C, hold it at temperature of 10–35 ^{0}C for at least one hour.

6.1.2 Remove the packing. Check presence of the certification marking, ensure absence of mechanical injuries.

6.2 Installation

6.2.1 Perform switching of the transducer with the use of Cambion 450-3729-01-06-00-type or similar sockets.

Pin out of transducer is shown in Appendix C.

6.2.2 Provide power supply of the transducer from power sources featuring nominal range of output DC voltage of not less than 3 V and not more than 5 V, output power (P0) – not less than

0.02 W and not more than 0.25 W in accordance with requirements of standards IEC 60079–0:2004, IEC 60079–11:2006.

6.2.3 Connection diagram is shown in Figure B.1 of Appendix B.

6.2.4 The transceiver of serial interface UART should meet the requirements of standards IEC 60079–0:2004, IEC 60079–11:2006.

6.2.5 Communication parameters of TxD of UART-transceiver, are following:

- voltage of HIGH logic level not less than 1.8V and not more than 2,8V;
- voltage of LOW logic level not more than 0.9V.

6.2.6 Communication parameters of RxD of UART-transceiver, are following:

- voltage of HIGH logic level not less than 1.8V and not more than 3,3±0,033 V;
- voltage of LOW logic level not more than 0.9V.

Please note, after the dust filter from transceiver's kit was attached, setting ZERO procedure must be executed (see Appendix E for details).

It should be taken into account when designing the transducer's power supply within gas analyzers, that in spite of low average power consumption declared, maximum current through transducer may rise up to 10 mA during 60 ms pulse length (sending the F-command though UART).

6.3 Putting to use

The transducer outputs information about measured concentration value though digital serial interface UART. Data communication protocol is given in Appendix D.

The methods of setting "0" of the transducer and re-calibration are given in Appendix E.

The transducer is designed for continuous operation.

There is self-testing algorithm inside the firmware code.

Please note the following aspects, when working with transducer:

1. **After power up, during 60 s warm-up time, the transducer does not return the concentration value (the value displays as -1). After this time transducer starts to transfer measured values.**
2. **After warm-up (1 minute after power-up) the transducer makes self-diagnostic test during 2 minutes.**
3. **That is not recommended to use the transducer with more than 1 Hz sampling rate. Otherwise the temperature sensor accuracy in transducer comes down.**
4. **There is a Status Word and Status Byte in transducer's exchange protocol, with response to F command for easy define the operating mode of transducer. Listing of Status Word and Status Byte see in Appendix D.**

6. STORAGE AND TRANSPORTATION

8.1. The transportation of transducers should be performed by all means of transportation in covered transportation vehicles as well as in the heated pressurized plane compartments in accordance with the rules of cargoes transportation effective for the respective type of transportation.
8.2. The transducers in the Manufacturer's package should be kept in the Supplier's and Customer's storages under storage conditions pointed in Table 1. The atmosphere of storage premises should be free from harmful admixtures provoking corrosion.

7. WARRANTY OBLIGATIONS. MANUFACTURER'S ADDRESS

9.1. The Manufacturer guarantees compliance of the transducers with specifications and requirements stated in this UM if Customer meets conditions of operation, transportation and storage.
9.2. During the warranty period, Manufacturer has the right to replace or repair all the products that, according to his unquestionable judgement, are found to be defective, if defect is due to a fault of Manufacturer.
9.3. The warranty period is 24 months since the date of transducer shipment to a Customer. The date of shipment is registered in the ESAT.413347.002-05 DS datasheet.
9.4. Manufacturer is not responsible for the transducers failure and discontinue the warranty obligations in case of:

- violations of conditions of operation, transportation and storage stated in UM;
- transducer has marks of unauthorized repair;
- mechanical damages, appeared after handover the transducers to Customer, effect of temperature and pressure beyond conditions, chemical erosion, ingress of foreign substances inside the body of the transducer;
- defects due to electrical interface unspecified by UM and other documentation conveyed to the Customer;
- defects due to force majeure circumstances, disastrous occurrences, intended or reckless act of Customer or third party;
- defect or failure due to installing, damaging, changing or erasing of transducers firmware or changing transducers settings because of misuse of service codes via UART.
- defect or failure due to using power or signal cables unspecified by technical regulations and standards or operating the transducer with EMC influences exceeds maximums specified in IEC 61000-4-3.

9.5. Replacement or repair of defective transducer does not lead to setting a new warranty period.
9.6. The Manufacturer is not responsible for possible damages, direct or indirect inflicted to people or properties if this is happened in case of repair, storage and transportation rules violation or due to purport or reckless act of Customer or third party. The Manufacturer does not respond as well for possible damages, direct or indirect inflict to appropriate equipment as the result of change, damage or data loss.
9.7. The warranty repair or replacement is effecting in site of Manufacturer or designated representative.
9.8. Shipping and packaging charges and any other incidental expenses for the products returned to Manufacturer will be at the Customer's own risk and charged to him.
9.9. Manufacturer's address:

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27, AD, Engelsa prospect, St. Petersburg, 194156, Russia,
Tel./fax: +7 (812) 633-0594, 633-0595
web-site: http://mipex-tech.com/
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Appendix A

Types, versions and characteristics of transducer

MIPEX-02-B-C-D.1 E

Pins length version
If not specified - 5.6 mm pins;
A – 4.5 mm pins;

Output format:
1- digital, UART, 4 pins;

Construction:
1- stainless steel, “Standard” ;
2-stainless steel, with side holes, “Fast response” ;
3-ABS plastic;

Application:
I – Group I, for mines;
II – Group II, for places with a potentially;
explosive atmosphere, other than mines;

Target gas:
1 – CH_4, methane;
2 – C_3H_8, (C_nH_m, hydrocarbons) ;
3- CO_2, carbon dioxide;
4 – $CH_4/CH_4 + C_2H_6$ acc. to IEC 60079-29-1.

MIPEX model number

Table A1 Transducer’s type ranged by construction and weight.

Construction type	***MIPEX-02 type (Pins version)***	***Target gas***	***Group***	***Weight, g***
	MIPEX-02-1-I-1.1 (A)	CH_4	I	16,6
	MIPEX-02-1-II-1.1 (A)	CH_4	II	16,6
	MIPEX-02-2-II-1.1 (A)	C_3H_8	II	16,6
	MIPEX-02-3-I-1.1 (A)	CO_2	I	16,6
	MIPEX-02-3-II-1.1 (A)	CO_2	II	16,6
Standard	MIPEX-02-4-I-1.1 (A)	$CH_4/CH_4 + C_2H_6$	I	16,6
	MIPEX-02-1-I-2.1 (A)	CH_4	I	15,5
	MIPEX-02-1-II-2.1 (A)	CH_4	II	15,5
	MIPEX-02-2-II-2.1 (A)	C_3H_8	II	15,5
	MIPEX-02-3-I-2.1 (A)	CO_2	I	15,5
	MIPEX-02-3-II-2.1 (A)	CO_2	II	15,5
Fast response	MIPEX-02-4-I-2.1 (A)	$CH_4/CH_4 + C_2H_6$	I	15,5
	MIPEX-02-1-I-3.1 (A)	CH_4	I	5,5
	MIPEX-02-1-II-3.1 (A)	CH_4	II	5,5
	MIPEX-02-2-II-3.1 (A)	C_3H_8	II	5,5
	MIPEX-02-3-I-3.1 (A)	CO_2	I	5,5
	MIPEX-02-3-II-3.1 (A)	CO_2	II	5,5
Plastic	MIPEX-02-4-I-3.1 (A)	$CH_4/CH_4 + C_2H_6$	I	5,5

Table A.2 Individual specifications by type of transducer

MIPEX-02 type (Pins version)	Target gas	Group	Construction	Measurement range **	Max. response time t(90), s.	Accuracy	Additional tempreature error	Additional pressure error	Additional humidity error	Operation temperature range
MIPEX-02-1-I-1.1 (A)	CH4	I	Standard	0-5 Vol.% – measure, 5-100% Vol – indication / 0-100 % Vol – measure/ 0-2.5% Vol - alarm sensor	30	±0,1 % methane or ±5 % of indication, whichever value is greater	±0,2 % methane or ±10 % of indication from 20 °C, whichever value is greater (test: –10 °C, 20 °C, 40 °C)	±0,2 % methane or ±30 % of indication from 100 kPa (test: 80 kPa, 100 kPa, 120 kPa)	±0,2 % methane or ±15 % of indication from the indication at adjustment at 40 °C (test: 20 %RH, 50 %RH, 90 %RH)	-10...+40°C
MIPEX-02-1-I-3.1 (A)	CH4	I	Plastic							
MIPEX-02-4-I-1.1 (A)	CH4/CH4 +C2H6	I	Standard							
MIPEX-02-4-I-3.1 (A)	CH4/CH4 +C2H6	I	Plastic							
MIPEX-02-3-I-1.1 (A)	CO2	I	Standard	0-2.5 % – measure, 2.5-5% Vol – indication / 0-1% Vol - alarm sensor	60					
MIPEX-02-3-I-3.1 (A)	CO2	I	Plastic							
MIPEX-02-1-I-2.1 (A)	CH4	I	Fast response	0-5 Vol.% – measure, 5-100% Vol – indication / 0-100 % Vol – measure	10					
MIPEX-02-4-I-2.1 (A)	CH4/CH4 +C2H6	I	Fast response							
MIPEX-02-3-I-2.1 (A)	CO2	I	Fast response	0-2.5 % – measure, 2.5-5% Vol – indication	20					

Table A.2 (Continued)

MIPEX-02 type (Pins version)	Target gas	Group	Construction	Measurement range **	Max. response time t(90), s.	Accuracy	Additional tempreature error	Additional pressure error	Additional humidity error	Operation temperature range
MIPEX-02-1-II-1.1 (A)	CH4	II	Standard	0-5 % Vol. – measure, 5-100% Vol – indication / 0-100 % Vol – measure/ 0-2.5% Vol - alarm sensor	30	±0,1 % Vol or ±5 % of indication, whichever value is greater	±0,2 % Vol or ±10 % of indication from 20 °C, whichever value is greater, in temperature range from –10 °C to 40 °C (test: –10 °C, 20 °C, 40 °C ±0,4 % methane or ±20 % of indication from 20 °C, in temperature ranges from -40 °C to -10 °C and from 40 °C to 60 °C, whichever value is greater, (test: –25 °C, 20 °C, 55 °C)whichever value is greater, (test: –25 °C, 20 °C, 55 °C)	±0,2 % Vol or ±30 % of indication from 100 kPa (test: 80 kPa, 100 kPa, 120 kPa)	±0,2 % Vol or ±15 % of indication from the indication at adjustment at 40 °C (test: 20 %RH, 50 %RH, 90 %RH)	-40….+60°C
MIPEX-02-1-II-3.1 (A)	CH4	II	Plastic							
MIPEX-02-3-II-1.1 (A)	CO2	II	Standard	0-2.5 % Vol– measure, 2.5-5% Vol – indication / 0-1% Vol - alarm sensor	60		±0,2 % Vol or ±10 % of indication from 20 °C, whichever value is greater, in temperature range from –10 °C to 40 °C (test: –10 °C, 20 °C, 40 °C, unspecified in temperature ranges from -40 °C to -10 °C and from 40 °C to 60 °C			
MIPEX-02-3-II-3.1 (A)	CO2	II	Plastic							
MIPEX-02-3-II-2.1 (A)	CO2	II	Fast response		20					
MIPEX-02-1-II-2.1 (A)	CH4	II	Fast response	0-5 % Vol. – measure, 5-100% Vol – indication / 0-100 % Vol – measure/ 0-2.5% Vol - alarm sensor	10		±0,2 % Vol or ±10 % of indication from 20 °C, whichever value is greater, in temperature range from –10 °C to 40 °C (test: –10 °C, 20 °C, 40 °C ±0,4 % methane or ±20 % of indication from 20 °C, in temperature ranges from -40 °C to -10 °C and from 40 °C to 60 °C, whichever value is greater, (test: –25 °C, 20 °C, 55 °C)whichever value is greater, (test: –25 °C, 20 °C, 55 °C)			
MIPEX-02-2-II-2.1 (A)	C3H8	II	Fast response	0-100 % LEL – measure / 2.5- 0- / 0- 50% LEL – alarm sensor		±3% LEL or ±5 % of indication, whichever value is greater	±5 % LEL or ±10 % of indication from 20 °C, whichever value is greater, in temperature range from –10 °C to 40 °C (test: –10 °C, 20 °C, 40 °C) ±10 % LEL or ±20 % of indication from 20 °C, in temperature ranges from -40 °C to -10 °C and from 40 °C to 60 °C (test: –25 °C, 20 °C, 55 °C)	±5% LEL or ±30 % of indication from 100 kPa (test: 80 kPa, 100 kPa, 120 kPa	±5 % LEL or ±15 % of indication from the indication at adjustment at 40 °C (test: 20 %RH, 50 %RH, 90 %RH	
MIPEX-02-2-II-1.1 (A)	C3H8	II	Standard		30					
MIPEX-02-2-II-3.1 (A)	C3H8	II	Plastic							

Appendix B

Connection diagram of MIPEX-02-X-X

Figure B.1 —Intrinsically safe connection of MIPEX-02-X-X-X.1 X.

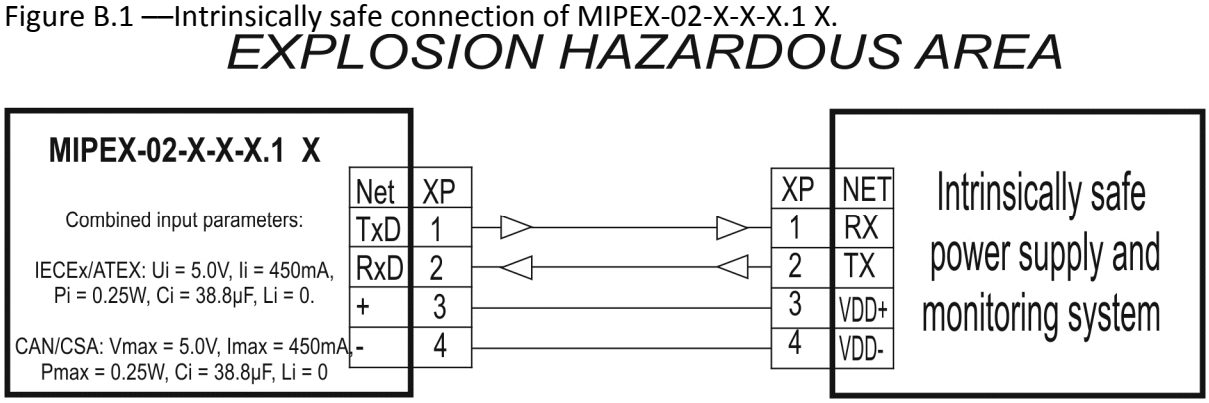
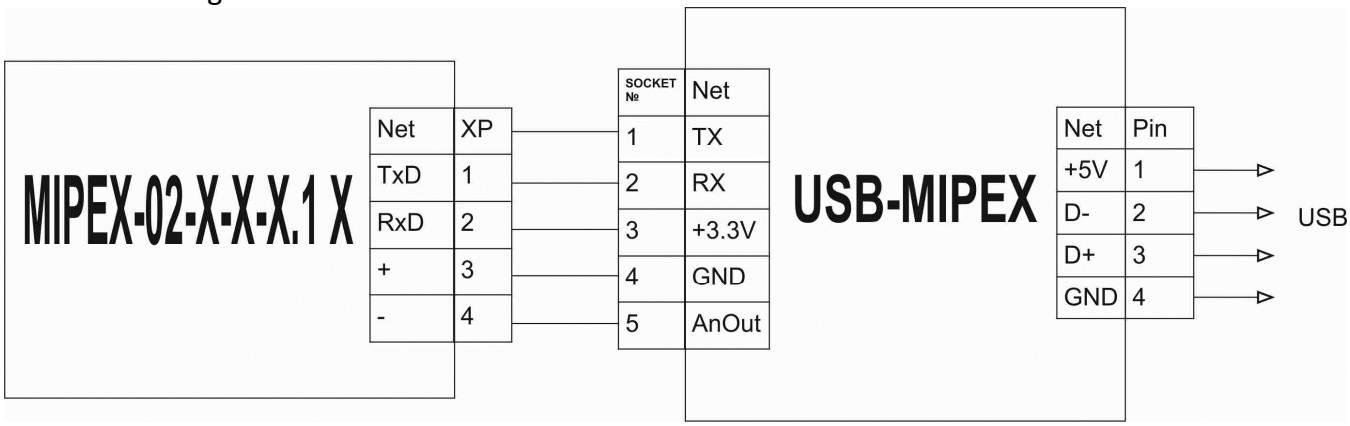


Figure B.2 —Connection diagram for MIPEX-02-X-X-X.1 X with UART interface, with USB-MIPEX converter during calibration and tests.

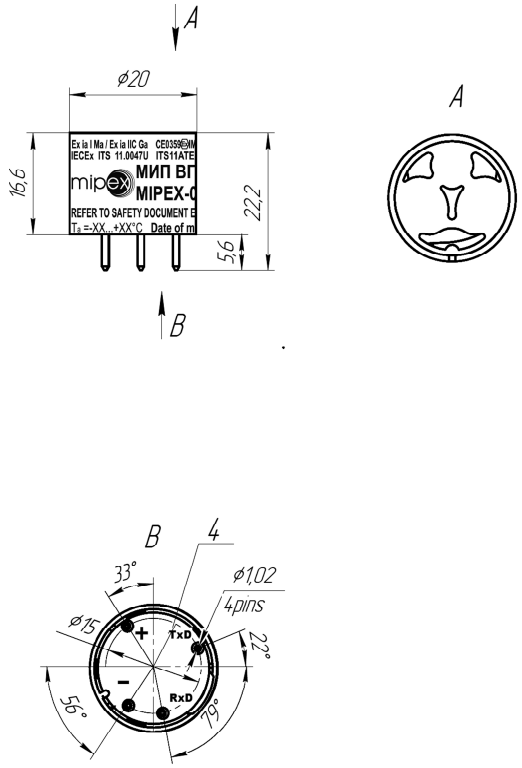


Appendix C

(mandatory)

Figure C.1 — Overall dimensions of MIPEX-02-X-X-1.1 X.

MIPEX-02-X-X-1.1



MIPEX-02-X-X-1.1 A

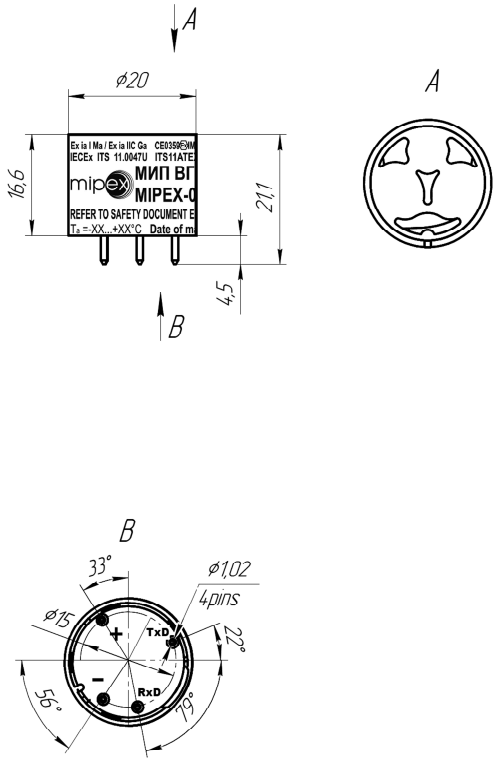
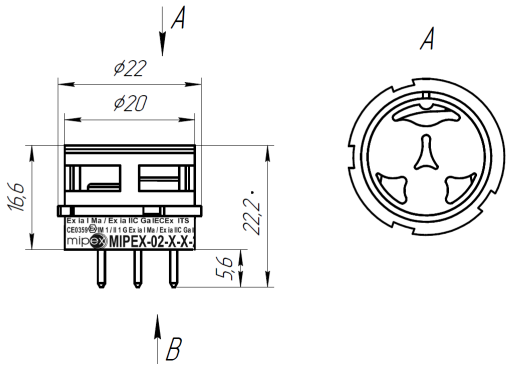


Figure C.2 — Overall dimensions of MIPEX-02-X-X-2.1 X.

MIPEX-02-X-X-2.1



MIPEX-02-X-X-2.1 A

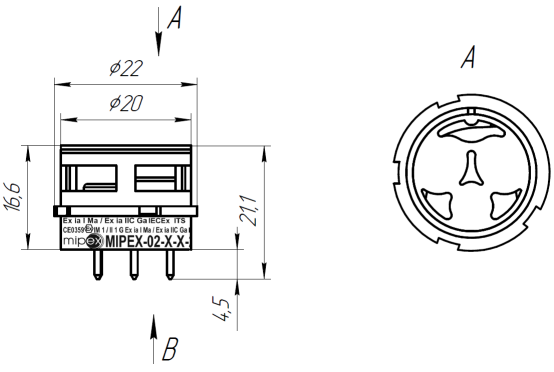


Figure C.3 — Overall dimensions of MIPEX-02-X-X-3.1 X.

MIPEX-02-X-X-3.1 MIPEX-02-X-X-3.1 A

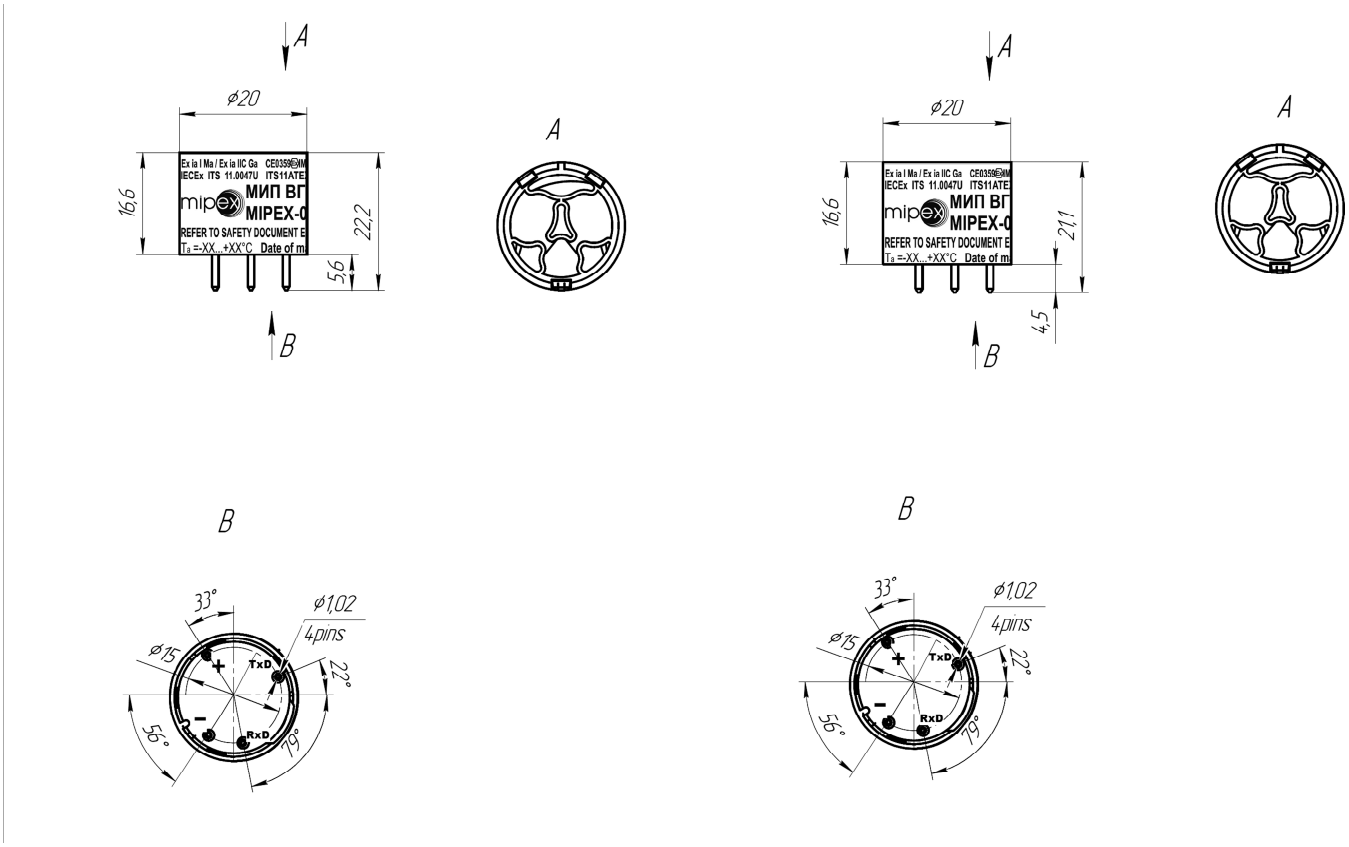
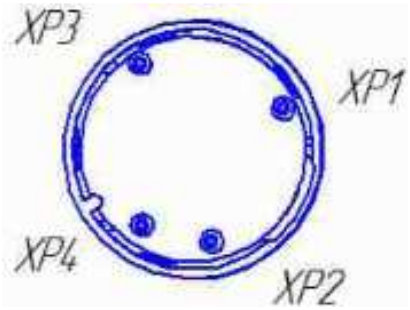


Figure C.4 Pinout of MIPEX-02-X-X-X.1 X

Pins viewed from underside



Pin №	**Connection name**
XP1	*Communication, TxD output*
XP2	*Communication, RxD input*
XP3	*Supply "+"*
XP4	*Supply "–"*

Appendix D

Communication protocol through UART for MIPEX-02-X-X-X.1 X
Rev. 6.25. for ver.24.2 and ver.25.2 firmware

CAUTION! ***ALWAYS CHECK THE COMAND SYNTAX BEFORE SENDING. THE COMMANDS, OTHER THAN SPICIFIED IN CURRENT USER MANUAL ARE NOT ALLOWED. OTHERWISE IT MIGHT BRING TO MALFUNCTION OF TRANSDUCER.***

UART characteristics:
exchange rate – 9600 baud
8-bit message
1 stop bit
without check for parity

The symbols of commands are coded in ASCII, CR (carriage return) symbol shall be put after command – (0Dh).

A response is coded with ASCII symbols. The words/figures of the response can be separated with a tabulation symbol 09h or space symbol 20h (specified below for every command). The CR (carriage return) symbol is put at the end of message – (0Dh).

1. Operation with network address

An assignment of the network address to a device is contemplated in the range of 0–FF. It allows connecting up to 256 instruments to one UART line. The instrument is assigned 00 address after enabling. The following commands have been introduced for viewing and changing address:
!** – network address interrogation. The transducer returns network address in the format of !XX,
where **XX** – address in hexadecimal form.
%XXYY – address YY is assigned to a transducer with address XX.

NETON – command, in response to which a network address is saved in the instrument memory. In case of power removal, the network address should remain.
NETOFF – command, in response to which the saving of the network address in the instrument memory is cancelled. In case of power removal, the network address equals 00h.

If a transducer is used together with the other instruments in the same UART line, it is necessary to put the prefix **#XX** before a command**,** where XX is a network hexadecimal address from 00 to FF.

2. Data interrogation

2.1 A command **DATA** is intended for outputting information on concentration.

Response is a value of concentration **Conc1** with scaling of 5-bit decimal integer number taken into account.

The concentration is expressed in % vol. with a resolution of 0.01 % vol., e.g., 1.98 % vol. – 00198 for the factory calibration.

A format of response – 5 byte of ASCII is a concentration value and a symbol of 0Dh.

Sn – serial number of instrument (8 symbols).
A command **DATA** is intended for concentration values output:

Command	Response	
	Number of byte and its value	
	1-5	6
DATA (44 41 54 41 0D)	Conc1	0Dh

Response is concentration scaled value **Conc1** 5-digits decimal integral format
-5 byte ASCII concentration value and symbol 0Dh.

2.2 A command **DATAE** is intended for concentration values output, Status byte and Check Sum, calculated as XOR

Command	Response				
	Number of byte and its value				
	1	2	3	4	5
DATAE(44 41 54 41 45 0D)	Conc1H	Conc1L	StatusByte	ControlSum	0Dh

Concentration data is 16 bit number. First byte is high-order byte Conc1H, the second is lower byte Conc1L.
StatusByte is coded as in Table D.1.
ControlSum= ControlSum^EveryByte.

2.3 There is a **@** command, to minimize exchange data length, and as a result, the power consumption.
Response is 16 bit value of concentration. First byte is high-order byte Conc1H, the second is lower byte Conc1L.

Command	Response	
	Number of byte and its value	
	1	2
@ (40 0D)	Conc1H	Conc1L

There is a **@*x**, where x – the digit from 0 to 9 (ASCII), that initiate periodical (with period (1.231+-0.06) * x, sec, for 25.2 firmware and (1,328 +-0,065) * x, sec, for 24.2 firmware) sending data through UART interface.

2.4 A command **F** is intended for detailed analysis of transducer operation.
A response to command **F**:

Comand	Response																									
	Byte in response																									
	1	2-6	7	8-12	13	14-18	19	20-24	25	26-30	31	32-36	37	38-42	43	44-48	49	50-54	55	56-60	61	62-69	70	71	72	73
F (46 0D)	0Eh	Termo	09h	<St>	09h	Signal	09h	Ref	09h	S	09h	Stz	09h	<St>zkt	09h	Conc	09h	Conc1	09h	Status	09h	Sn	09h	ControlSum	09h	0Dh

The first symbol in a message – 0Eh, data – 5 byte of ASCII, separation symbol between data – 09h, after transmission of Sn (serial number) symbol 09h follows, after that a value of control sum of the whole message follows calculated to the rule of excluding or ControlSum = ControlSum^data. Next to that symbol 09h and symbol 0Dh proceed.

, where:

Term – temperature of transducer in ADC readings;

S – relation Us/Uref taking coefficient ZERO1 into account;

Us – signal of operating receiver in ADC readings;

Uref – signal of reference receiver in ADC readings;

St – S multiplied by temperature coefficient;

St` – filtered St;

Stz – relation St` taking coefficient ZERO2 into account;

Conc – concentration (calculated according to a factory calibration);

Conc1 – scaled concentration;

Stzkt – relation Stz taking into account temperature coefficient of sensitivity;

Status - Status Word, that is coded as in the Table D.1, 00 – Ok, normal mode, static temperature;

Table D.1 Status byte and status word description and recommendations

DATAE command, Status Byte	**F command, Status Word**	**Title**	**Description**	**Influence on perfomance**	**Recommended steps for users**
Bit 0	10	Self-diagnostics	Self-diagnostics algorithm is in action during not more than 3.5 minute after power up.	Measurement accuracy might be additionally deteriorated during self-diagnostics.	1. Do not send ZERO2 or CALB commands if Conc1=-1 and Bit 0 is ON. 2. If Conc1≠-1, Bit 0 is ON and Bit 3, Bit 4, Bit 5 are OFF sending ZERO2 command is acceptable.
Bit 1	50	Abrupt change of signal	The possible reasons: 1. Abrupt change of signal 2. High noise level	Performance is according to General specification, except the situation, when bit 1 is ON permanently.	1. Do not send ZERO2 or CALB commands if Bit 1 is ON. 2. Replace sensor if bit1 is switched ON constantly (for ~20 min).
Bit 2	30	Signals level check	Low level of optical signals because of: 1. Optical mirrors in sensor hazed by dirt. 2. Optoelectronic components are degradated by time 3. Sensor's components are destructed by the high level of temperature, pressure or humidity. 4. Sensor's housing deformation	Unspecified perfomance	1. Do not send ZERO2 or CALB commands if Bit 2 is ON. 2.Mesuring accuracy need to be additionally verified, once switching ON of Bit 2 has been has been fixed. 3. Replace the sensor if Bit2 is switched ON constantly.
Bit 3	20	Slow temperature change	Temperature change rate is higher than 0.15 grad/min	Performance is according to General specification	Do not send ZERO2 or CALB commands if Bit 3 is ON.
Bit 4	21	Fast temperature change	Temperature change rate is higher than 0.6 grad/min	Measurement accuracy might be additionally deteriorated up to 0.15%Vol or ±20% of reading, whichever value is greater	Do not send ZERO2 or CALB commands during bit 4 is ON.
Bit 5	22	Sharp temperature change	Temperature change rate is higher than 2 grad/min	Unspecified perfomance	Do not send ZERO2 or CALB commands during bit 5 is ON.
Bit 6	40	Out of operation temperature range	Environmental temperature is higher than specified.	Unspecified perfomance	1. No guarantees of measurement accuracy if Bit 6 is ON. 2. Measurement accuracy need to be additionally verified, once switching ON of Bit 6 has been fixed.
Bit 7	90	Firmware corruption	The possible reasons: 1. MCU corruption. 2. Max. No. of flash writing circles is exceeded.	Unspecified perfomance	Replace the sensor if Bit7 is ON

NOTES:

1. All Status Bytes goes with AND logic (may switching separately). All Status Words goes priority logic, from higher to lower : 90, 10, 30, 40, 22, 21, 20, 50

2. Bit is regarded as ON, if it has high logic level

3. If sensor gives Status Words other, than specified above, or zero serial number on SRAL?, please contact Optosense Tech. support team to discuss the following steps.

3. User commands

On user command, if the syntax is correct, the response of the transducer produces a positive or negative opinion on each specific command. If the decision is positive, the response displays sent command with the addition of characters "OK", otherwise ending "FAULT", with a space. For example, send ZERO2 command, transducer will give ZERO2 OK response.

ZERO2 – ***setting to zero***. In case of supplying this command, concentration Conc = 0, Conc1 = 0, relation Stz is corrected to 10000. The calculated value is retained in constant Kzero2.

CALB AAAA – ***calibration according to concentration***. In response to this command the scale coefficient for concentration Conc1 is calculated. The calculated value is retained in constant Kscale. Next to that the scaled concentration Conc1 = Kscale* Conc follows., where AAAA is a value of CGM concentration normalized to 10000. (e.g. 1.98% vol. – 0198).

INIT – ***initialization of coefficients of zeroing and calibration***. The coefficients KZero2 *и* Kscale are assigned the value of 1. The transducer calibration returns to an original factory calibration.

Following commands might be used to re-calibrate transducer to the other gases (cross):

CALB1 XXXXX – writing scale coefficient for concentration range 0-5% Vol.

CALB2 XXXXX – writing scale coefficient for concentration range 5-100% Vol.

Where XXXXX – value of scale coefficient normalized to 10000.

For example: To initiate scale coefficient 0.7 within 0-5% Vol., send **CALB1 07000**.

NOTE: The scale coefficients for different gases are individual for each transducer. To achieve cross-coefficients please contact Optosense LLC.

SREV? – checking the firmware version, e.g. send **SREV?**, answer MIPEX-2_25.2.

SRAL? –checking the serial number (SN). The answer is ASCII 8 byte and 0Dh symbol.

RT? – checking the transducer's TYPE. The answer is ASCII 5-byte and 0Dh symbol (All TYPE codes listing is available upon request).

RX? – checking the transducer's characteristics (X) The answer is ASCII 2-byte and 0Dh symbol. X is coded as follows:

1st response byte	*2nd response byte*	*Calibration range*	*Gas*
0	1	100%Vol	CH4 or CH4/CH4+C2H6
0	2	5%Vol	CH4 or CH4/CH4+C2H6
0	3	2.5%Vol	CO2
0	4	100%LEL	C3H8
1	0	S- (alarm sensor)	
1	1	1%Vol (alarm sensor)	CO2
1	2	50%LEL(alarm sensor)	CH4 or CH4/CH4+C2H6 or C3H8

ID? – checking ID. Response on this command returns TYPE SN X SREV summary info.

CRC – firmware integrity check. Response is checksum, which is calculated according to CRC16 algorithm. CRC response for 24.2 is 24920, CRC response for 25.2 is 23606.

After power up, during 60 s warm-up time, the transducer does not return the concentration value (the value displays as -1). After this time transducer starts to transfer measured values.

Appendix E

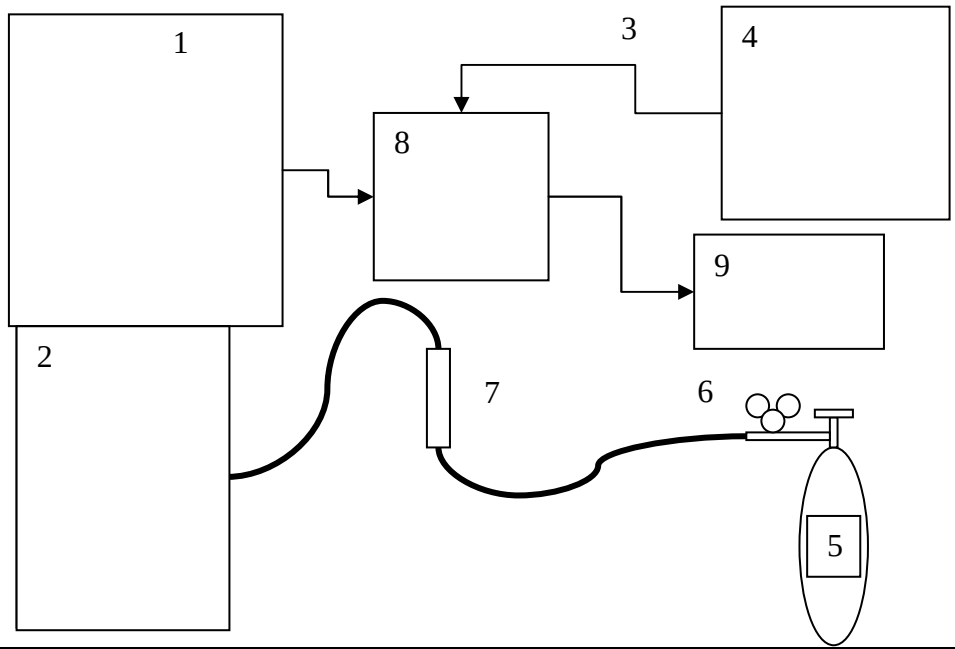
Methods of setting 0 and calibration of sensitivity of transducer MIPEX-02-X-X-X.1 X

1. The setting of 0 and calibration of transducer is performed in the course of the primary installation into a gas analyzer as well as annualy during preparation to conducting a check.
2. The devices given in Figure E.1 and in the list of CGM are used in the course of conducting operations.
3. The operations on setting 0 and calibration of transducer shall be carried out by a qualified specialist outside of the explosion-hazardous zone at normal conditions in the following sequence:
3.1 Transducer shall be connected in accordance with Figure B.2. Converter USB-MIPEX should be connected to transducer and to PC.
3.2 CGM adapter shall be installed on the transducer and a feeding hose in accordance with Figure E.1 shall be put onto pipe connection.
3.3 In 5 min after power supply the CGM No.1 (pure nitrogen N2) is connected, in 1 min after CGM supply a command ZERO2of zero setting is supplied, the transducer readings should get set to 0 with respect to digital interface in accordance with Appendix D.
3.4 The CGM No.2 is connected, in 1 min after CGM supply a CALB AAAA command is given (Ref. Appendix D), where AAAA is a value of CGM concentration (e.g. 1.98% vol. – 0198). After that the value Conc1 – (scaled concentration) should get established equal to a value assigned according to command CALB AAAA. The scale coefficient shall be stored in the module memory up to the next calibration.
3.5 The CGM No.3 is connected and the transducer readings are checked via digital serial RS-232 in accordance with Appendix D.

If the requirements to the transducer error are not fulfilled in accordance with Table A.1, the procedure of setting 0 and calibration shall be repeated. In case of a repeated non-compliance of transducer readings to the value of concentration of CGM No.3, a transducer is subject to replacement and dispatching to the Manufacturer for repair.

For transducers with operation range up to 100% Vol, two-points calibration should be done. One point for each operation range (0-5%, 5-100%). Repeat calibration 3.4 Appendix E with CGM No.4.

Figure E.1. Calibration diagram



1. Transducer MIPEX-02-X-X-X.1 X	**6. Reducer BKO–25–MG**
2. CGM Adapter	**7. Rotameter PM–A–0,063GUZ**
3. Electrical Cable	**8. USB-MIPEX converter**
4. Power Source	**9. PC**
5. CGM	

List of CGM used for checking transducers MIPEX-02-X-X-X.1 X

Note: the recalculation to % of LEL shall be effected in accordance with the following formula for concentration expressed in volume fraction, vol. %:

$$LFSCL = \frac{100 \times C}{C(h)};\%$$

where
LFSCL is % LEL
C – component content in volume fraction, vol. %;
C(h) – LEL of component, % (constant);
C(h) = 4.4 % – for methane;
C(h) = 1.7 % – for propane.

Table E.1
For MIPEX–02–1-X-X.1 X and MIPEX–02–4-X-X.1 X(CH_4 and $CH_4/CH_4+ C_2H_6$):

CGM Nos according to text	Component composition	Composition of measured component, vol. %, (% of LEL)	Permissible deviation limits, vol. %	Limits of permissible error of qualification, vol. %	Number as per State Register or Standard designation
1	N_2	100	-	-	GOST 9392-74
2	$CH_4 – N_2$	2,2 (50)	±0,25	±0,04	3883-87
3	$CH_4 – N_2$	4,15 (94)	±0,25	±0,04	3883-87
4	$CH_4 – N_2$	40	±2,5	±0,4	3892-87

Table E.2
For MIPEX–02–2-X-X.1 X(C_3H_8):

CGM Nos according to text	Component composition	Composition of measured component, vol. %, (% of LEL)	Permissible deviation limits, vol. %	Limits of permissible error of qualification, vol. %	Number as per State Register or Standard designation
1	N_2	100	-	-	GOST 9392-74
2	$C_3H_8 – N_2$	0,85 (50)	±0,05	±0,015	5328-90
3	$C_3H_8 – N_2$	1,6 (94)	±0,1	±0,05	EM 06.01.648
4	$C_3H_8 – N_2$	3,40 (200)	±1,00	±0,5	

Table E.3
For MIPEX–02–3-X-X.1 X(CO_2):

CGM Nos according to text	Component composition	Composition of measured component, vol. %, (% of LEL)	Permissible deviation limits, vol. %	Limits of permissible error of qualification, vol. %	Number as per State Register or Standard designation
1	N_2	100	-	-	GOST 9392-74
2	$CO_2 – N_2$	1	±0,05	±0,015	
3	$CO_2 – N_2$	2.5	±0,1	±0,05	