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Section “Calibration Procedure”

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# EQUIPMENT VIBROBIT 100

# Operation and Maintenance Manual

## ВШПА.421412.100 РЭ

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The Operations and Maintenance Manual (OMM) is intended for familiarization of users (consumers) with the purpose, design, basic principle of operation, specifications, design of components, rules of mounting, operation, maintenance, and calibration of VIBROBIT 100 equipment.

Additional information on the equipment is presented in the Log Book.

VIBROBIT enterprise reserves the right to replace separate parts and completing units without impairment of the equipment performance.

# 1 Description and operation

## 1.1 Designated purpose of the equipment

Vibrobit 100 equipment is intended for continuous measuring and monitoring of mechanical parameters of gas turbines, turbo-compresses, centrifugal pumps, and other machines in the course of their operation in compliance with ГОСТ Р55265.2-2012, ГОСТ Р 55263-2012, ГОСТ ИСО 10816-1-97, ГОСТ Р ИСО 7919-1-99.

The equipment measures and monitors the following parameters:

- root-mean-square (r.m.s.) value of vibration velocity of bearing supports;
- relative vibration displacement of rotating shafts and other assemblies;
- relative displacement of rotating shafts;
- relative displacement of bearing housings, positions of shutoff and regulating valves;
- rotor speed.

The equipment implements:

- measurements of parameters and their conversion into unified DC signals;
- comparison of parameters with preset levels and signaling about excessive parameters;
- generation of the equipment cutoff signals;
- generation of instantaneous parameter values signals, for the speed – reference pulse of the unit rotational speed.

The equipment complies with the requirements of ГОСТ 25804.1-83, ГОСТ ISO 2954-2014, ГОСТ Р ИСО 10817-1-99, ГОСТ 25275-82, ТУ 4277-001-27172678-12, technical requirements 1541131Д and a set of documentation in accordance with Tables 1-6.

## 1.2 Equipment components

1.2.1 The equipment components includes:

- sensors and converters;
- control boards;
- control units;
- power supply units;
- indication units;
- auxiliary assemblies and mounting accessories.

The equipment is manufactured and supplied to the consumer in compliance with the specifications that indicate the type, quantity, and version of the equipment components:

- by assembly units;
- by complete sets;
- by complexes.

The equipment is supplied to the consumer in frameworks and cabinets. The following is being used:

- “Евромеханика 19” 3U 84HP (3HE-84TE) frameworks;
- cabinets manufactured by RITTAL.

1.2.2 The complete list of main and auxiliary assemblies of the equipment is given in Tables 1 – 6.

Table 1 – Sensors, converters and comparators

| Description | Type | Designation | Note |
|---|---|---|---|
| Eddy-current sensor (inductive) | ДВТ10 | ВШПА.421412.018 | Used together with ИП34,ИП36,ИП37,К22 |
| Ditto | ДВТ10Ex | ВШПА.421412.0181 | Used together with ИП34Ex, ИП36Ex, К22Ex |
| ‘ | ДВТ20 | ВШПА.421412.034 | Used together with ИП34, К21 |
| ‘ | ДВТ20Ex | ВШПА.421412.0341 | Used together with ИП34Ex |
| ‘ | ДВТ21 | ВШПА.421412.033 | Used together with ИП34 |
| ‘ | ДВТ23 | ВШПА.421412.189 | Used together with ИП34, К21 |
| ‘ | ДВТ30 | ВШПА.421412.054 | Used together with ИП34,ИП36,К22 |
| ‘ | ДВТ40.10 | ВШПА.421412.155 | Used together with ИП42 |
| ‘ | ДВТ40.20 | ВШПА.421412.155-01 | Ditto |
| ‘ | ДВТ40.30 | ВШПА.421412.155-02 | ‘ |
| ‘ | ДВТ40.40 | ВШПА.421412.155-03 | Used together with К21 |
| ‘ | ДВТ40.50 | ВШПА.421412.155-15 | Used together with ИП42 |
| ‘ | ДВТ43.20 | ВШПА.421412.1551 | Used together with ИП43 |
| ‘ | ДВТ43.30 | ВШПА.421412.1551-10 | Ditto |
| ‘ | ДВТ43.40 | ВШПА.421412.1551-20 | Used together with К21 |
| ‘ | ДВТ43.50 | ВШПА.421412.1551-30 | Used together with ИП43 |
| ‘ | ДВТ50 | ВШПА.421412.035 | Used together with ИП34 |
| ‘ | ДВТ60.10 | ВШПА.421412.139 | Ditto |
| ‘ | ДВТ60.16 | ВШПА.421412.158 | ‘ |
| ‘ | ДВТ60.20 | ВШПА.421412.159 | ‘ |
| ‘ | ДВТ70 | ВШПА.421412.156 | Used together with ИП44 |
| ‘ | ДВТ82 | ВШПА.421412.178 | For displacement measuring |
| Sensor | ДХМ | ВШПА.421412.116 | For RPM measuring. Hall effect-based |

*Continuation of Table 1*

| Description | Type | Designation | Note |
|---|---|---|---|
| Piezoelectric sensor | ДПЭ22МВ* | ВШПА.421412.1261 | For measuring vibration velocity |
| Ditto | ДПЭ22МВ | ВШПА.421412.126-405 | Ditto. Galvanic isolation in the power circuit |
| Ditto | ДПЭ22П | ВШПА.421412.126-01 | Ditto |
| ‘ | ДПЭ22Ех* | ВШПА.421412.1262 | ‘ |
| ‘ | ДПЭ22МВТ* | ВШПА.421412.1261-100 | Ditto. Increased working temperature |
| ‘ | ДПЭ23МВ* | ВШПА.421412.1271 | For measuring RMS vibration veloci-ty |
| ‘ | ДПЭ23П | ВШПА.421412.127-01 | Ditto |
| ‘ | ДПЭ23Ех* | ВШПА.421412.1272 | ‘ |
| ‘ | ДПЭ23МВТ* | ВШПА.421412.1271-100 | Ditto. Increased working temperature |
| ‘ | ДПЭ23МВП | ВШПА.421412.1277 | For measuring absolute vibration displacement |
| ‘ | ДПЭ24 | ВШПА.421412.1251 | For measuring vibration acceleration. Used together with ИП24 |
| ‘ | 625В01 | – | For measuring vibration acceleration. Used together with ИП24 and КС24 |
| Converter | ИП24 | ВШПА.421412.353 | For measuring vibration velocity with sensors 625В01 and ДПЭ24 |
| Ditto | ИП34 | ВШПА.421412.179 | For measuring displacements, rela-tive vibration displacement |
| ‘ | ИП34Ех | ВШПА.421412.1792 | Ditto |
| ‘ | ИП36 | ВШПА.421412.183 | For RPM measuring |
| | ИП36Ех | ВШПА.421412.0832 | Ditto |
| ‘ | ИП37 | ВШПА.421412.180 | For measuring relative vibration dis-placement excursion |
| ‘ | ИП42 | ВШПА.421412.181 | For measuring displacements |
| ‘ | ИП43 | ВШПА.421412.1811 | Ditto |
| ‘ | ИП44 | ВШПА.421412.120 | For measuring surface tilt |

** Details of the piezoelectric sensor versions, external appearance and design variants (type of cable connection, fasteners etc.) see in paragraph 1.5.2, Figures C.12, C.13, C.14, C.16, Annexes H.16, H.17*

*Continuation of Table 1*

| Description | Type | Designation | Note |
|---|---|---|---|
| Comparator | K21 | ВШПА.421412.089 | For signaling equipment rotation stop.<br>For signaling protection mechanism pin operation |
| Ditto | K22 | ВШПА.421412.188 | For generation of the equipment RPM signal |
| ‘ | K22Ex | ВШПА.421412.1882 | Ditto |

Table 2 – Control boards

| Description | Type | Designation | Note |
|---|---|---|---|
| Control board | ПК10 | ВШПА.421412.101 | Board for measuring and monitoring of linear displacements. Number of control channels 1 |
| Ditto | ПК11 | ВШПА.421412.1011 | Ditto. Number of control channels 2 |
| ‘ | ПК12 | ВШПА.421412.1012 | Board for measuring and monitoring of Vibration velocity RMS (DC input signals). Number of control channels 3 |
| ‘ | ПК13 | ВШПА.421412.1014 | Ditto. Number of control channels 1 |
| ‘ | ПК20 | ВШПА.421412.102 | Board for measuring and monitoring of relative vibration displacement excursion. Number of control channels 1 |
| ‘ | ПК21 | ВШПА.421412.1021 | Ditto. Number of control channels 2 |

*Continuation of Table 2*

| Description | Type | Designation | Note |
|---|---|---|---|
| Control board | ПК30 | ВШПА.421412.103 | Board for measuring and monitoring of vibration velocity RMS (AC input signals). Number of control channels 1 |
| Ditto | ПК31 | ВШПА.421412.1031 | Ditto. Number of control channels 2 |
| ‘ | ПК32 | ВШПА.421412.1032 | Ditto. Number of control channels 3 |
| ‘ | ПК40 | ВШПА.421412.104 | Board for measuring and monitoring of the rotor RPM. Number of control channels 1 |
| ‘ | ПК51 | ВШПА.421412.105 | Board for measuring and monitoring of vibration low-frequency component. Number of control channels 8 |
| ‘ | ПК72 | ВШПА.421412.107 | Board for monitoring and logical processing of discrete output signals of vibration velocity RMS control boards. Logic ‘2 out of 2-x’.<br>Number of inputs 16 |
| ‘ | ПК73 | ВШПА.421412.108 | Ditto. With input signal memory |
| ‘ | ПК74 | ВШПА.421412.112 | Number of inputs 16. Logic LMZ |
| ‘ | ПК80 | ВШПА.421412.109 | Input signal step control board. Number of inputs 8. Signaling by applying OR circuit |
| ‘ | ПК81 | ВШПА.421412.111 | Ditto. Number of inputs 6. Logic OR signaling, ‘2 out of 2-x’ |
| ‘ | ПК90 | ВШПА.421412.110 | Board for equipment protection and signaling operation check. Number of outputs 7. Generation of input signals for parameter control boards |

Table 3 – Control units

| Description | Type | Designation | Note |
|---|---|---|---|
| Control unit | БК10 | ВШПА.421412.165 | Unit for measuring and monitoring of linear displacements. Number of control channels 1 |
| Ditto | БК11 | ВШПА.421412.166 | Ditto. Number of control channels 2 |
| ‘ | БК20 | ВШПА.421412.173 | Unit for measuring and monitoring of relative vibration displacement excursion. Number of control channels 1 |
| ‘ | БК21 | ВШПА.421412.168 | Ditto. Number of control channels 2 |
| ‘ | БК30 | ВШПА.421412.169 | Unit for measuring and monitoring of vibration velocity RMS (AC input signals). Number of control channels 1 |
| ‘ | БК31 | ВШПА.421412.170 | Ditto. Number of control channels 2 |
| ‘ | БК32 | ВШПА.421412.172 | Ditto. Number of control channels 3 |
| ‘ | БК40 | ВШПА.421412.176 | Unit for measuring and monitoring of the rotor RPM. Number of control channels 1 |

Table 4 Power supply units

| Description | Type | Designation | Note |
|---|---|---|---|
| Power supply unit | БП17 | ВШПА.421412.136 | Low-power 7 W, + 24 V; 7 W, ± 15 V |
| Ditto | БП18 | ВШПА.421412.135 | 40 W,+ 24 V; 15 W, ± 15 V |

Table 5 Indication units

| Description | Type | Designation | Note |
|---|---|---|---|
| Indication unit | БИ22 | ВШПА.421412.152 | Unit for RPM measuring and indication. Used together with К22-ДВТ10, К22Ex-ДВТ10Ex, К22-ДВТ30 and 60 teeth «pinion’ control surface |
| Ditto | БИ23 | ВШПА.421412.153 | RPM indication unit. Used together with ПК40 |

Table 6 – Auxiliary units and devices

| Description | Type | Designation | Note |
|---|---|---|---|
| Feedthrough | M20 | ВШПА.421412.041 | For passing ДВТ sensor cables through the equipment casing |
| Ditto | M24 | ВШПА.421412.042 | Ditto |
| Cable | КС10 | ВШПА.421412.057 | For extending ДВТ sensor cables |
| Ditto | КС11 | ВШПА.421412.157 | For extending ДВТ40 sensor cables |
| ‘ | КС24 | ВШПА.421412.353.02 | For connecting 625В01 sensor to ИП24 converter |
| Connector box | КР10 | ВШПА.421412.048 | For protection ДВТ sensor connectors |
| Ditto | КР20 | ВШПА.421412.049 | Ditto |
| Transducer box | КП13 | ВШПА.421412.148 | For installation one converter of type ИП |
| Ditto | КП13Р | ВШПА.421412.1488 | Ditto. Rittal box-based |
| ‘ | КП13-Пр | ВШПА.421412.1485 | Ditto.Based on the box of the company “Provento” |
| ‘ | КП13Х | ВШПА.421412.148-01 | For installation of one explosion-proof ИП34Ех, ИП36Ех, К22Ех-type converter |
| | КП13Х-Пр1 | ВШПА.421412.1485-02 | Ditto. For installation of one explosion-proof amplifier for ДПЭ sensors. Based on the box of the company “Provento” |
| ‘ | КП13ХР | ВШПА.421412.1488-03 | Ditto. Rittal box-based |
| ‘ | КП13К | ВШПА.421412.148-02 | For connection of sensor ДХМ |
| ‘ | КП13КР | ВШПА.421412.1488-04 | Ditto. Rittal box-based |
| ‘ | КП15В | ВШПА.421412.1501 | For installation of one ИП24-type converter and surge protection devices (SPD) |
| ‘ | КП15М | ВШПА.421412.1501-01 | For installation of one converter ИП34, ИП42, К22 and SPD |
| ‘ | КП23В | ВШПА.421412.149 | For installation of three converters of ИП type |
| ‘ | КП23ВР | ВШПА.421412.1492 | Ditto. Rittal box-based |
| | КП23-Пр | ВШПА.421412.1495 | Ditto.Based on the box of the company “Provento” |
| ‘ | КП23П | ВШПА.421412.149-01 | For installation of three ДПЭ sensor amplifiers |
| ‘ | КП23ПР | ВШПА.421412.1491 | Ditto. Rittal box-based |

*Continuation of Table 6*

| Description | Type | Designation | Note |
|---|---|---|---|
| Transducer box | КП23ВХ | ВШПА.421412.149-02 | For installation of three explosion-proof converters of ИП34Ех, ИП36Ех, К22Ех types |
| | КП23Х-Пр | ВШПА.421412.14952 | Ditto. For installation of three amplifies of explosion-proof sensors ДПЭ. Based on the box of the company “Provento” |
| | КП23ПХ | ВШПА.421412.149-03 | For installation of three amplifies of explo-sion-proof sensors ДПЭ |
| | КП25В2 | ВШПА.421412.1541 | For installation of two converters of ИП24 and SPD type |
| | КП25В3 | ВШПА.421412.1541-01 | For installation of three converters of ИП24 and SPD type |
| Ditto | КП25М2 | ВШПА.421412.1541-02 | For installation of two converters of ИП34, ИП42, К22 and SPD type |
| ‘ | КП25М3 | ВШПА.421412.1541-03 | For installation of three converters of ИП34, ИП42, К22 and SPD type |
| Setter | МУ10 | ВШПА.421412.044 | For installation of sensors ДВТ10, ДВТ10Ех, ДВТ20, ДВТ20Ех, ДВТ40, ДВТ43, ДВТ60 |
| Accessories set МУ10 | - | ВШПА.421412.044.10 | For installation of dial indicator ИЧ10, ИЧ50 |
| Ditto | МУ11 | ВШПА.421412.144 | For installation of sensors ДВТ10, ДВТ20 in measuring rotor bowing, axial offset |
| Accessories set МУ11 | - | ВШПА.421412.144.10 | For installation of dial indicator ИЧ10 |
| ‘ | МУ14 | ВШПА.421412.1441 | For installation of sensors ДВТ10 in meas-uring shaft vibration displacement, rotor bowing |
| Accessories set МУ11 | - | ВШПА.421412.1441.10 | For installation of dial indicator ИЧ10 |
| Metal hose | БШ24 | ВШПА.421412.000.84 | For mechanical protection of one sensor cable |
| | БШ24В | ВШПА.421412.000.84-03 | For mechanical protection of one sensor cable ДВТ40; ДВТ43 |
| Framework | “Евромеха-ника 19” 3U 84HP (3HE–84TE) | – | For installation of control boards and power supply units |
| Cabinet | ‘RITTAL’ | – | For installation of frameworks, computer equipment, relay, terminal blocks, etc. |
| Fastening ele-ments | – | – | Screws, bolts, washers and other elements |
| IS barrier | БИБ-02DP-22 | 426475.008 ПС | Ensures explosion-proof power supply and data transfer |

1.2.3 Piezoelectric sensors ДПЭ22Ex,ДПЭ23Ex; converters ИП34Ex, ИП36Ex and connected to them eddy current sensors ДВТ10Ex, ДВТ20Ex; comparator К22Ex and connected to it velocity sensor ДВТ10Ex of Vibrobit 100 equipment are explosionproof and manufactured with “intrinsically safe electrical circuit i”, comply with ГОСТ 31610.0-2014, ГОСТ 31610.11-2014, are marked with explosion protection "1Ex ib IIB T3 Gb X" and can be installed in hazardous areas of premises and outdoor installations in accordance with Chapter 7.3 ROEI (Regulations for Operation of Electrical Istallations) and other regulations governing the use of electrical equipment in hazardous areas.

Mark ‘X’ in the marking of explosionproof sensors, converters and comparators indicates the following special conditions of their safe application:

– Installed in explosion hazardous areas, vibration velocity sensors ДПЭ22Ex, ДПЭ23Ex, converters ИП34Ex and ИП36Ex, and comparators К22Ex must be made part of the intrinsically safe electrical circuits used outside explosion hazardous areas certified by explosionproof safety barriers, which explosion protection marking and intrinsically safe electrical circuit values complies with the explosion protection marking and intrinsically safe electrical circuit values of vibration velocity sensors ДПЭ22Ex, ДПЭ23Ex, converters ИП34Ex, ИП36Ex, and comparators К22Ex.

– Installed in explosion hazardous areas, eddy current sensors ДВТ10Ex, ДВТ20Ex must be made part of intrinsically safe electrical circuits of converters ИП34Ex, ИП36Ex only.

– Installed in explosion hazardous areas, velocity sensors ДВТ10Ex must be made part of the intrinsically safe electrical circuits of comparators К22Ex only.

– Amplifiers of sensors ДПЭ22Ex, ДПЭ23Ex, converters ИП34Ex, ИП36Ex, and comparators К22Ex must be installed in special metal sealed boxes КП13Х, КП13Х-Пр1, КП13ХР, КП23Х-Пр, КП23ВХ, and КП23ПХ manufactured by SPE Vibrobit LLC.

1.2.4 Operation documents:

| | |
|---|---|
| – Operations and Maintenance Manual | ВШПА.421412.100 РЭ; |
| – Logbook, certificate or label | ВШПА.421412.100.ХХХ ФО; |
| | ВШПА.421412.ХХХ ПС; |
| | ВШПА.421412.ХХХ ЭТ, |

where ХХХ – serial number of the project, order or item designation.

## 1.3 Equipment specifications and characteristics

Main equipment specifications and characteristics are given in Tables 7 – 30, The metrological characteristics are normalized for sensors that are used independently and converters completed with sensors as per Table 1.

**Tables 7 – 14 present maximum values of measurement ranges. Design of sensors and converter electrical diagrams enables measurements of any displacements within the specified ranges.**

Description and purpose of equipment external circuits is given in Annex A.

### 1.3.1 Displacement sensors and converters

Table 7

| Parameter description | Normal value | | |
|---|---|---|---|
| | ИП34, ИП34Ex | ИП42, ИП43 | ДВТ82 |
| Ranges of displacement measurements (S), mm (inclusive) | See Table 8, 9 | See Table 10 | 0–360 |
| Output signal (inclusive), mA | 1 – 5; 4 – 20 | | |
| Output signal ИП34Ex (inclusive), mA | 4-20 | | |
| Nominal value of conversion rate *(Kn)*, mA/mm:<br>— at output signal – (1 – 5) mA<br>— at output signal – (4 – 20) mA | 4/S<br>16/S | | |
| Limits conversion rate actual value deviation from the nominal value, % | ± 2.5 | | |
| Limits of the permissible basic reduced error of measurements, % | ± 2.5 | | |
| Amplitude response nonlinearity, % | See Table 8,9 | See Table 10 | ± 4.0 |

*Continuation of Table 7*

| Parameter description | Normal value | | |
|---|---|---|---|
| | ИП34, ИП34Ex | ИП42, ИП43 | ДВТ82 |
| Load resistance, Ohm, not exceeding:<br>— for output signal – (1 – 5) mA | 2000 | | |
| — for output signal – (4 – 20) mA | 500 | | |
| Limits of the permissible auxiliary reduced error of measurements caused by deviation in the gap between the ДВТ40, ДВТ43 sensor and the rotor control surface “band” by ± 0.5 mm from the nominal value, % | – | ± 2.5 | – |
| Limits of the permissible auxiliary reduced error of measurements caused by deviation of the environment temperature from the normal value to limit values of the operating temperature range, %:<br>— for ДВТ sensors | ± 4.0 | ± 4.0 | ± 2.5 |
| — for converter | ± 2.5 | ± 2.5 | – |
| Limits of the permissible auxiliary reduced error of measurements caused by the relative humidity effect on the sensor and the converter, % | ± 2.0 | | |
| Range of the ambient air operating temperature (inclusive), °C:<br>— for ДВТ82 | 0 – +70 | | |
| — for ДВТ50 | – 40 – + 125 | | |
| — for ДВТ10, ДВТ10Ex, ДВТ20, ДВТ20Ex, ДВТ21, ДВТ23, ДВТ30, ДВТ40, ДВТ43, ДВТ60 | – 40 – + 180 | | |
| — for ИП34, ИП34Ex, ИП42, ИП43 converters | – 40 – + 70 | | |
| Supply voltage, V | – (18 – 36); + (18 – 25,2)* | | |
| Consumption current, mA, not exceeding | 90; 45* | 110 | 100 |
| Convention response time, ms, not exceeding | 0.1 | 100 | 0.1 |
| * For ИП34Ex. In applying power supply through intrinsically safe barrier of type БИБ, supply voltage is from + 21,5 to + 25,2 V | | | |

1.3.2 Measurement ranges for ДВТ sensors with ИП34 converter

Table 8

| Sensor type | Zero gap, mm | Range of displacement measuring, mm (inclusive) | Amplitude response nonlinearity limit, % |
|---|---|---|---|
| ДВТ10, ДВТ30 | 0.4 ± 0.1 | 0 – 2 | ± 2.5 |
| ДВТ20 | 1.0 ± 0.1 | 0 – 4 | ± 2.5 |
| ДВТ21 | 0.5 ± 0.1 | 0 – 4 | ± 2.5 |
| ДВТ23 | 1.0 ± 0.1 | 0 – 6 | ± 2.5 |
| ДВТ50 | – | 0 – 10; 0 – 100; 0 – 160; 0 – 360 | ± 4.0 |
| ДВТ60.10 | 1.0 ± 0.1 | 0 – 8 | ± 2.5 |
| ДВТ60.16 | 3.0 ± 0.1 | 0 – 12 | ± 2.5 |
| ДВТ60.20 | 4.0 ± 0.1 | 0 – 16 | ± 2.5 |

1.3.3 Measurement ranges of sensors ДВТ10Ex, ДВТ20Ex with converter ИП34Ex

Table 9

| Sensor type | Zero gap, mm | Range of displacement measuring, mm (from and to, inclusive) | Amplitude response nonlinearity limit, % |
|---|---|---|---|
| ДВТ10Ex | 0.4 ± 0.1 | 0 – 2; (0 – 2,5)* | ± 2.5 |
| ДВТ20Ex | 1.0 ± 0.1 | 0 – 4; 0 – 5 | ± 2.5 |
| * For range of (0-2.5) mm, the zero gap is $S_O$=0.25 mm, preset gap is $S_Н$=1.5 mm, ref. Annex D. | | | |

1.3.4 Measurement ranges of sensors ДВТ with converter ИП42, ИП43

Table 10

| Sensor type | Range of displacement measuring (inclusive), mm at “band” (“ridge”) width in mm | | | | | | | | | Amplitude response nonlinearity limit,% |
|---|---|---|---|---|---|---|---|---|---|---|
| | 80 | 65 | 55 | 40 | 35 | 30 | 25 | 20 | 10 | |
| ДВТ40.10 | – | – | – | 0 – 16 | 0 – 20 | 0 – 20 | 0 – 16 | 0 – 10 | – | ± 2,5 |
| ДВТ40.20, ДВТ43.20 | – | – | – | 0 – 10. 0 – 16 | 0 – 20 | 0 – 20 | 0 – 25 | 0 – 30 | 0 – 40 | ± 2,5 |
| ДВТ40.30, ДВТ43.30 | – | 0 – 8 | 0 – 15 | 0 – 30 | 0 – 35 | 0 – 40 | 0 – 45 | 0 – 50 | – | ± 2,5 |
| ДВТ40.50, ДВТ43.50 | 0 – 20 | 0 – 25 | 0 – 10 | – | – | – | – | – | – | ± 2,5 |

Notes

1 The value of the installation gap between the sensor ДВТ40, ДВТ43 and the ‘band’ equals to (1,5 ± 0.2) mm.

2 For ‘band’ with a width of 10 mm, the gap is 1,0 mm.

1.3.5 Vibration displacement sensors and converters

Table 11

| Parameter description | Normal value | | |
|---|---|---|---|
| | ДВТ10 with ИП34, ДВТ10Ex with ИП34Ex | ДВТ10 with ИП37 | ДПЭ23МВП |
| Displacement measurement range (inclusive), (S), mm | 0 – 2 | 0 – 2 | – |
| Measurement ranges of vibration displacement (from and to, inclusive), (Sr), µm: | | | |
| — vibration displacement excursion (DC output) | – | 25 – 500 | 10 – 250; 10 – 500 |
| — vibration displacement (AC output) | 10 – 1000 | 10 – 1000 | – |
| Frequency range , Hz:: | | | |
| — vibration displacement excursion | – | 0.05 – 100; 5 – 500 | 5 – 200 |
| — vibration displacement | 0.05 – 1500 | 0.05 – 1500 | – |
| Output signal (from and to, inclusive) of, mA: | | | |
| — vibration displacement excursion | – | 1 – 5; 4 – 20 | 1 – 5; 4 – 20 |
| — displacement, vibration displacement | 1 – 5; (4 – 20)* | 1 – 5 | – |
| Nominal value of displacement conversion rate *(Kn)*, mA/mm: | | | |
| — at output signal of (1 – 5) mA | 2 | | – |
| — at output signal of (4 – 20) mA | 8 | | – |
| Deviation limits of actual value of displacement conversion rate from the nominal value, % | ± 2.0 | | – |
| Limits for the permissible main reduced displacement measurement error, vibration displacement at base frequency, % | ± 2.0 | | ± 2.5 |
| Limits for the permissible main relative vibration displacement measurement error at base frequency and displacement of 1 mm, %: | | | |
| — vibration displacement excursion | – | ± 4.0 | – |
| — vibration displacement | ± 4.0 | | – |
| Nominal value of sinusoidal vibration displacement conversion rate, (*Kn*), mA/mm: | | | |
| — vibration displacement excursion | – | 8; 32 | 16; 64<br>8;32 |
| — vibration displacement | 0.707; 2.828* | 0.707 | – |

*Continuation of Table 11*

| Parameter description | Normal value | | |
|---|---|---|---|
| | ДВТ10 with ИП34, ДВТ10Ex with ИП34Ex | ДВТ10 with ИП37 | ДПЭ23МВП |
| Deviation limits of actual value of vibration displacement conversion rate from the nominal value at base frequency and displacement of 1 mm, %: | | | |
| — vibration displacement excursion | – | ± 4.0 | |
| — vibration displacement | ± 4.0 | | – |
| Amplitude response nonlinearity of vibration displacement at base frequency, at displacement of 1 mm (for ДВТ10, ДВТ10Ex), % | ± 4.0 | | |
| Frequency-response ripple, %: | | | |
| — vibration displacement excursion | – | + 2.5; – 20,0 | + 5.0; – 15.0 |
| — vibration displacement | ± 2.5 | ± 2.5 | – |
| Limits for the permissible main relative measurement error of vibration displacement excursion at base frequency within the limits of working displacement range (S) from 0.3 to 1,7 mm, %, not more than: | | | |
| — vibration displacement excursion | – | ± 6.0 | – |
| — vibration displacement | ± 6.0 | ± 6.0 | – |
| Load resistance, Ohm, not more than: | | | |
| — for output signal (1 – 5) mA | 2000 | | |
| — for output signal (4 – 20) mA | 500 | | |
| Inherent noise level, below minimum value of AC output measurement range, dB, not less than: | 20 | | |
| Range of ambient air working temperatures (from and to, inclusive), °C: | | | |
| — for sensor | – 40 – + 180 | | |
| — for converter | – 40 – + 70 | | |
| Limits for permissible complimentary vibration displacement measurement error caused by relative humidity affect on the sensor and converter, % | ± 2.0 | | |

*Continuation of Table 11*

| Parameter description | Normal value | | |
|---|---|---|---|
| | ДВТ10 with ИП34, ДВТ10Ex with ИП34Ex | ДВТ10 with ИП37 | ДПЭ23МВП |
| Limits for permissible complimentary vibration displacement measurement error caused by ambient air temperature fluctuation from normal to limit values of the working temperature range, %: | | | |
| — for sensor | ± 4.0 | | |
| — for converter | ± 2.0 | | |
| Convention time constant, msec, not more than | | | |
| — vibration displacement excursion | 0.1 | 8000.0; 2.0 | 8000.0 |
| — vibration displacement | 0.1 | 0.1 | – |
| Limits for permissible complimentary reduced measurement error caused by effect of power supply frequency varying magnetic field, %: | | | |
| — for sensor | ± 0.5 | | |
| — for converter | ± 0.5 | | |
| Measurement base frequency, Hz | (10 ± 1)**; 80 ± 1 | | 16 ± 1 |
| Supply voltage, V | + (18 – 36); + (18,0 – 25,2)*** | | |
| Consumption current, mA, not more than | 90; 45* | 115 | 70 |

* For ИП34Ex.
** For ДВТ10 and ИП37 with frequency range (0.05 – 100) Hz.
*** For ИП34Ex and ДПЭ23МВП. In applying power supply through intrinsically safe barrier of БИБ type, supply voltage – from + 21,5 to + 25,2 V.

1.3.6 Vibration velocity sensors

Table 12

| Parameter description | Normal value | | |
|---|---|---|---|
| | ДПЭ22МВ, ДПЭ22МВТ ДПЭ22П, ДПЭ22Ex | ДПЭ23МВ, ДПЭ23МВТ, ДПЭ23П, ДПЭ23Ex | ДПЭ24, 625В01 с ИП24 |
| Measurement ranges of vibration velocity (V) (from and to, inclusive), mm/s:[1)] | | | |
| — Vibration velocity RMS (DC output) | – | 0.4 – 12<br>0.4 – 15<br>0.8 – 30<br>1.6 – 60 | – |
| — vibration velocity (AC output) | 0.3 – 12<br>0.3 – 15<br>0.4 – 30<br>0.7 – 50<br>1.0 – 100 | 0.3 – 12<br>0.3 – 15<br>0.4 – 30<br>0.7 – 50<br>1.0 – 100 | 0.3 – 12<br>0.3 – 15<br>0.4 – 30<br>0.5 – 50<br>0.5 – 100 |

*Continuation of Table 12*

| Parameter description | Normal value | | |
|---|---|---|---|
| | ДПЭ22МВ, ДПЭ22МВТ ДПЭ22П, ДПЭ22Ex | ДПЭ23МВ, ДПЭ23МВТ, ДПЭ23П, ДПЭ23Ex | ДПЭ24, 625В01 with ИП24 |
| Frequency range (from and to, inclusive), Hz | 2 – 1000*<br>10 – 1000 | 10 – 1000 | 2 – 1000*<br>10 – 1000 |
| Output signal (from and to, inclusive), mA: | | | |
| — Vibration velocity RMS | – | 1 – 5; 4 – 20 | – |
| — vibration velocity | 1 – 5 | 1 – 5 | 1 – 5 |
| Limits for the permissible main relative measurement error of at base frequency, %: | | | |
| — Vibration velocity RMS | – | ± 2.5 | – |
| — vibration velocity | ± 2.5 | ± 2.5 | ± 2.5 |
| Nominal value of conversion rate ($Kn$), mA• s/mm: | | | |
| — Vibration velocity RMS | – | 4/V; 16/V | – |
| — vibration velocity for measurement range: | | | |
| — (0 – 12) mm/s | 0.05 | 0.05 | 0.05 |
| — (0 – 15) mm/s | 0.05 | 0.05 | 0.05 |
| — (0 – 30) mm/s | 0.025 | 0.025 | 0.025 |
| — (0 – 50) mm/s | 0.015 | 0.015 | 0.025 |
| — (0 – 100) mm/s | 0.010 | 0.010 | 0.0125 |
| Deviation limits of conversion rate actual value from nominal at base frequency, %: | | | |
| — Vibration velocity RMS | – | ± 2.5 | – |
| — vibration velocity | ± 2.5 | | |
| Amplitude response nonlinearity of at base frequency, % | ± 1.0 | | |

*Continuation of Table 12*

| Parameter description | Normal value | | |
|---|---|---|---|
| | ДПЭ22МВ, ДПЭ22МВТ, ДПЭ22П, ДПЭ22Ех | ДПЭ23МВ, ДПЭ23МВТ, ДПЭ23П, ДПЭ23Ех | ДПЭ24, 625В01 with ИП24 |
| Frequency-response ripple within frequency range, %: | | | |
| — (2 – 5) Hz; (10 – 20) Hz | + 2.5; – 20.0 | | +2.5; – 20.0 |
| — (5 – 500) Hz; (20 – 500) Hz | ± 2.5 | | ± 2.5 |
| — (500 – 1000) Hz | + 2.5; – 200 | | + 2.5; – 10.0 |
| Relative rate of transverse conversion at base frequency *(Kon)*, not more than, % | 5.0 | | |
| Load resistance, not more than, Ohm: | | | |
| — for output signal (1 – 5) mA | 2000 | | |
| — for output signal (4 – 20) mA | 500 | | |
| Ambient air working temperature range (from and to, inclusive), °C: | | | |
| — for piezoelectric sensors of ДПЭ sensor | – 40 – + 180; – 40 – + 200** | | – |
| — for amplifiers of ДПЭ sensors, converter ИП24 | – 40 – + 70 | | |
| — for sensor ДПЭ24 | – | | – 40 – + 85 |
| — for sensor 625В01 | – | | – 40 – + 120 |
| Limits for permissible complimentary measurement error caused by ambient air temperature fluctuation from normal to limite values of the working temperature range, %: | | | |
| — for piezoelectric sensors, sensors | ± 8.0 | | ± 4.0 |
| — for amplifiers of ДПЭ sensors, converter ИП24 | ± 2.0 | | |

*Continuation of Table 12*

| Parameter description | Normal value | | |
|---|---|---|---|
| | ДПЭ22МВ, ДПЭ22МВТ, ДПЭ22П, ДПЭ22Ex | ДПЭ23МВ, ДПЭ23МВТ, ДПЭ23П, ДПЭ23Ex | ДПЭ24, 625B01 with ИП24 |
| Limits for permissible complimentary reduced measurement error caused by effect of power supply frequency varying magnetic field, %: for piezoelectric sensors, sensors | ± 0.5 | | |
| — for amplifiers of ДПЭ sensors, converter ИП24 | ± 0.5 | | |
| Limits for permissible complimentary measurement error caused by relative humidity affect on the sensor and converter, % | ± 2.0 | | |
| Limits for permissible complimentary measurement error of RMS vibration velocity regarding to DC output at base frequency at signal amplitude rate $Ka$=5, % | – | ± 4.0 | – |
| Inherent noise level below the minimum value for the measurement range, dB, not less than | 20 | | |
| Convention time constant, msec, not more than<br>— Vibration velocity RMS | – | 250 | – |
| — vibration velocity | 0.1 | 0.1 | 0.1 |
| Measurement base frequency, Hz | 80.0 ± 1.0; (10.0 ± 0.5)* | 80.0 ± 1.0 | 80.0 ± 1.0; (10.0 ± 0.5)*; |
| Supply voltage, V | + (18 – 36); + (18.0 – 25.2)*** | | + (18 – 30) |
| Consumption current, mA, not more than | 50; 45*** | 70; 45*** | 50 |

[1)] Measurement range with normalized metrological characteristics. Actual measurement range from 0.1 mm/s.
* For component versions with frequency range (2 – 1000) Hz.
** For sensors ДПЭ22МВТ, ДПЭ23МВТ. It is permissible to operate at temperature equaling to + 250 °C for one hour.
*** For ДПЭ22Ex, ДПЭ23Ex. In applying power supply through intrinsically safe barrier of БИБ type, supply voltage – from + 21,5 to + 25.2 V.

Note − Sensor ДПЭ23Ex has only output signal equaling to (4 – 20) mA regarding to DC output (vibration velocity RMS). All vibration velocity parameters shall not be taken into account.

1.3.7 Sensors ДВТ10, ДВТ30 with rotor speed converter ИП36 and sensor ДВТ10Ex with converter ИП36Ex

Table 13

| Parameter description | Normal value |
|---|---|
| Measurement ranges of the rotor speed,(f), Hz**;**<br>measurement ranges of the rotor RPM (from and to, inclusive) (N), rpm | 3 – 66.66; 180 – 4000<br>4 – 100; 240 – 6000<br>6 – 133.33; 360 – 8000<br>7 – 166.66; 420 – 10000<br>160 – 4000; 160 – 4000 |
| Distance between the sensor and the control surface made of ferromagnetic metal (from and to, inclusive), mm | 0.8 – 1.5. |
| DC output signal (from and to, inclusive), mA[1)] | 1 – 5; 4 – 20 |
| AC output signal (from and to, inclusive), mA[2)]<br>– “0”<br>– “1" | <br>1.0 – 1.3<br>4.7 – 5.0 |
| Nominal value of conversion rate (Kn), mA/Hz**;** mA/rpm$^{-1}$:<br>**–** at output signal of (1 – 5) mA<br>**–** at output signal of (4 – 20) mA | <br>4/f; 4/N<br>16/f; 16/N |
| Limits for the permissible main relative measurement error of, % | ± 1.0 |
| Deviation limits of conversion rate from nominal value, % | ± 1.0 |
| Amplitude response nonlinearity of, % | ± 1.0 |
| Load resistance of DC signal, Ohm, not more than | 500 |
| Load resistance of AC signal, Ohm, not more than | 2000 |
| Ambient air working temperature range (from and to, inclusive), °C:<br>– for sensors<br>– for converters | <br>– 40 – + 180<br>– 40 – + 70 |
| Limits for permissible complimentary measurement error caused by converter ambient air temperature fluctuation from normal to limit values of the working temperature range (from and to, inclusive), % | ± 1.0 |

*Continuation of Table 13*

| Parameter description | Normal value |
|---|---|
| Limits for permissible complimentary measurement error caused by relative humidity affect on the converter, % | ± 1.0 |
| Supply voltage, V<br>- for ИП36<br>- for ИП36Ex | <br>+ (18 – 36)<br>+ (18.0 – 25.2)[3] |
| Consumption current, mA, not more than<br>- for ИП36<br>- for ИП36Ex | <br>120<br>45 |
| Convention time constant, sec, not more than | 5 |
| [1] For ИП36Ex range (4 – 20) mA only.<br>[2] Only for ИП36.<br>[3] In applying power supply through intrinsically safe barrier of БИБ type, supply voltage – from + 21,5 to + 25,2 V. | |

1.3.8 Surface tilt measuring sensor ДВТ70 with converter ИП44

Table 14

| Parameter description | Normal value |
|---|---|
| Tilt measurement range (S), mm/м | ± 1.0; ± 2.0; ± 5.0 |
| Output signal (from and to, inclusive), mA | 1 – 5; 4 – 20 |
| Limits for the permissible main reduced measurement error, %:<br>— for range± 1.0 mm/m;<br>— for range± 2.0; ± 5.0 mm/m. | <br>± 5.0<br>± 2.5 |
| Nominal value of conversion rate (Kn), not less than, mA•m/mm | 4/S; 16/S |
| Deviation limits of conversion rate actual value from nominal, %:<br>— for range± 1.0 mm/m;<br>— for range± 2.0; ± 5.0 mm/m. | <br>± 5.0<br>± 2.5 |
| Limits for amplitude response nonlinearity, % | ± 2.5 |
| Ambient air working temperature range (from and to, inclusive), °C:<br>— for sensor<br>— for converter. | <br>0 – + 125<br>0 – + 70 |

*Continuation of Table 14*

| Parameter description | Normal value |
|---|---|
| Limits for permissible complimentary measurement error caused by sensor ambient air temperature fluctuation from normal to limit values of the working temperature range, %: | |
| — for sensor: with range ± 1.0 mm/m; | ± 10.0 |
| with range ± 2.0; ± 5.0 mm/m; | ± 5.0 |
| — for converter | ± 2.5 |
| Relative rate of transverse conversion (Kon), not more than, %, | ± 5.0 |
| Load resistance, Ohm, not more than: | |
| — for output signal (1 – 5) mA | 2000 |
| — for output signal (4 – 20) mA | 500 |
| Supply voltage, V | +(18 – 36) |
| Consumption current, mA, not more than | 100 |

1.3.9 Control boards and parameter control units

Table 15

| Parameter description | Normal value | | | | | |
|---|---|---|---|---|---|---|
| | ПК10,ПК11, БК10,БК11 | ПК12, ПК13 | ПК20, БК20 | ПК21, БК21 | ПК30,ПК31, ПК32,БК30, БК31,БК32 | ПК40, БК40 |
| Ranges for displacement measuring and signaling (inclusive), (S), mm | See Table 8 - 10 | – | 0 – 2[1)] | 0 – 1[1)]<br>0 – 2[1)] | – | – |
| Discreteness of setpoint alarm setpoints of linear displacements, mm, not more than | 0,1 | – | – | – | – | – |
| Ranges for relative vibration displacement excursion measuring and signaling (inclusive), (Sr), µm | – | – | 20–400 | 10–200<br>20–400 | – | – |
| Ranges for measuring and signaling RMS of vibration velocity (inclusive), (Ve), mm/s | – | 0.4–12<br>0.4–15<br>0.8–30 | – | – | 0.4–12<br>0.4–15<br>0.8–30 | – |

*Continuation of Table 15*

| Parameter description | Normal value | | | | | |
|---|---|---|---|---|---|---|
| | ПК10,ПК11, БК10,БК11 | ПК12, ПК13 | ПК20, БК20 | ПК21, БК21 | ПК30,ПК31, ПК32,БК30, БК31,БК32 | ПК40, БК40 |
| Discretization of setpoint the alarm setpoints of the RMS vibration velocity, mm / s, not more | – | 0,1 | – | – | 0,1 | – |
| Ranges for RPM measuring and signaling (inclusive), (N), rpm:<br>— by pointer instrument and unified signals | – | – | – | – | – | 200–4000<br>250–6000<br>500–8000<br>500-10000 |
| — by digital indicator, control БИ23 digital indication unit | – | – | – | – | – | 1 – 4000<br>1 – 6000<br>1 – 8000<br>1 – 9999 |
| Frequency range (from and to, inclusive), (f), Hz | – | – | 0.05–100<br>5–500 | 5–500 | 10–1000 | – |
| Input signal measurement range:<br>— DC, mA<br>— input (+) | 1 – 5 | 1 – 5 | (1 – 5)[1)] | (1 – 5)[1)] | (1 – 6)[1)] | (1 – 5)[1)] |
| — input (–) of control boards | – (1 – 5) | – (1 – 5) | –(1 – 5)[1)] | –(1 – 5)[1)] | –(1 – 6)[1)] | – (1 – 5)[1)] |
| — sinusoidal alternating current, mA:<br>— input (+) | – | – | 0–0.2828 | 0–0.1414<br>0–0.2828 | 0–0.6<br>0–0.75 | 1.0–1.4[2)] |
| — input (–) of control boards | – | – | 0–0.2828 | 0–0.1414<br>0–0.2828 | 0–0.6<br>0–0.75 | 1.0–1.4[2)] |
| Input signal measurement range:<br>— sinusoidal AC, V:<br>— input (+) | – | – | 0–0.314 | 0–0.157<br>0–0.314 | 0–0.572<br>0–0.714 | 1.0–1.4[2)] |
| — input (–) of control boards | – | – | 0–0.566 | 0–0.283<br>0–0.566 | 0–1.2<br>0–1.5 | 2.0–2.8[2)] |
| Input resistance, Ohm:<br>— input (+) | 1110 ± 5 | 1110 ± 5 | 1110 ± 5 | 1110 ± 5 | 953 ± 4,5 | 1110 ± 5 |
| — input (–) of control boards | 2000 ± 10 | | | | | |

*Continuation of Table 15*

| Parameter description | Normal value | | | | | |
|---|---|---|---|---|---|---|
| | ПК10,ПК11,<br>БК10,БК11 | ПК12,<br>ПК13 | ПК20,<br>БК20 | ПК21,<br>БК21 | ПК30,ПК31,<br>ПК32,БК30,<br>БК31,БК32 | ПК40,<br>БК40 |
| Unified DC output signals (from and to, inclusive) , mA | 0 – 5; 4 – 20 | | | | | |
| Unified output signals of control boards (from and to, inclusive):<br>— DC, V | 0 – 10 | | | | | |
| — AC, V | – | – | 0–2.828 | 0–2.828 | 0–1.2<br>0–1.5 | 8[3)] |
| Load resistance of the output unified DC signal, Ohm, not exceeding | 2000; 500 | | | | | |
| Load resistance of the output unified DC voltage signal for control boards, Ohm, not less than | 10000 | | | | | |
| Limits of permissible basic relative measurement error at base frequency, %:<br>— by pointer instrument | $\pm 2.5\left[1+0.2\left(\frac{X_{pr}}{X}-1\right)\right]$ | | | | | |
| — by unified signal | $\pm 1.0\left[1+0.1\left(\frac{X_{pr}}{X}-1\right)\right]$ | | | | | |

*Continuation of Table 15*

| Parameter description | Normal value | | | | | |
|---|---|---|---|---|---|---|
| | ПК10,ПК11, БК10, БК11 | ПК12, ПК13 | ПК20, БК20 | ПК21, БК21 | ПК30,ПК31, ПК32,БК30, БК31,БК32 | ПК40, БК40 |
| Limits for the permissible main relative measurement error of at base frequency, %:<br>— by digital indicator | $\pm 1.0\left[1+0.4(\frac{X_{pr}}{X}-1)\right]$ | | | | | – |
| Limits of permissible absolute error of RPM measurement by БИ23 digital indication unit, rpm | – | – | – | – | – | ± 2.0 |
| Frequency-response ripple within frequency range of, %: | | | | | | |
| — (0.05 – 1) Hz; | – | – | +2.5; –5.0 | – | – | – |
| — (1 – 63) Hz; | – | – | ± 2,0 | – | – | – |
| — (63 – 100) Hz; | – | – | +2.5; –5.0 | – | – | – |
| — (5 – 10) Hz; | – | – | +2.5; –5.0 | +2.5; –5.0 | – | – |
| — (10 – 250) Hz; | – | – | ±2.0 | ±2.0 | – | – |
| — (250 – 500) Hz; | – | – | +2.5; –15 | +2.5; –15 | – | – |
| — (10 – 20) Hz; | – | – | – | – | +2.5;–5.0 | – |
| — (20 – 500) Hz; | – | – | – | – | ±2.0 | – |
| — (500 – 1000) Hz | – | – | – | – | +2.5;–15.0 | – |
| Updating time on the digital indication unit, sec:<br>— within the range of (1 – 120) rpm | – | – | – | – | – | $\frac{60}{N}$ |
| — within the range of (120–10000) rpm | – | – | – | – | – | 0.5 |
| Ambient air working temperature range (from and to, inclusive), °C | 0 – + 50 | | | | | |
| Limits for permissible relative error of alarm actuation, % | ± 1.5 | | | | | |
| Base measurement frequency, Hz | – | – | 20 ± 1<br>80 ± 1[4)] | 80 ± 1 | 80 ± 1 | – |

*Continuation of Table 15*

<table>
<tr><th rowspan="2">Parameter description</th><th colspan="6">Normal value</th></tr>
<tr><th>ПК10,ПК11, БК10,БК11</th><th>ПК12, ПК13</th><th>ПК20, БК20</th><th>ПК21, БК21</th><th>ПК30,ПК31, ПК32,БК30, БК31,БК32</th><th>ПК40, БК40</th></tr>
<tr><td>Inherent noise level below the minimum value for the measurement range, dB, not less than</td><td>–</td><td>–</td><td>20</td><td>20</td><td>20</td><td>–</td></tr>
<tr><td>Limits for complimentary measurement error of vibration velocity RMS at base frequency at vibration velocity signal amplitude rate Ка=5, %</td><td>–</td><td>–</td><td>–</td><td>–</td><td>± 4,0</td><td>–</td></tr>
<tr><td>Number of setpoints</td><td>4</td><td>3</td><td>2</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>Time measurement constant, msec, not more than</td><td colspan="6">250</td></tr>
<tr><td>Output discrete signals of control boards</td><td colspan="6">Voltage not exceeding 30 V; current not exceeding 100 mA</td></tr>
<tr><td>Limits for switching voltages and currents by electromagnetic relay contacts of control units</td><td colspan="6">240 V AC, 60 V DC<br>7 A</td></tr>
<tr><td>Supply voltage, V:<br>— control boards,</td><td colspan="6">± (15 ± 0.5)</td></tr>
<tr><td>— control units</td><td colspan="6">(175 – 242) V AC, (50 ± 0.4) Hz or (175 – 242) V DC</td></tr>
<tr><td>Consumption current of control boards, mA, not exceeding:<br>— from + 15 V source</td><td>70</td><td>90/70</td><td>65</td><td>95</td><td>70/80/90</td><td>110</td></tr>
<tr><td>— from - 15 V source</td><td>20/30</td><td>40/25</td><td>35</td><td>50</td><td>25/35/40</td><td>20</td></tr>
<tr><td>— from +24 V source</td><td colspan="6">20</td></tr>
<tr><td>Consumed power by control units, W, not more than</td><td colspan="6">10</td></tr>
<tr><td colspan="7">1) Measuring shall be performed with reference to the pointer instrument only.<br>2) Nominal value of voltage, when measuring RPM (frequency).<br>3) Amplitude of phase reference pulse with duration of 82 μs, at $R_n$≥50 kOhm .<br>4) Base frequency for the frequency range is (5-500) Hz.<br>$X_{pr}$ – input signal limit value. For DC equaling to (5-1); (6-1) mA.<br>$X$ – current value of input signal. For DC equaling to ($I_{in}$-1) mA.</td></tr>
</table>

**Customized control boards ПК10, ПК11, ПК12, ПК13, ПК20, ПК21, ПК30, ПК31 and ПК32 without digital indication are available.**

1.3.10 Control board ПК51

Table 16

| Parameter description | Normal value |
|---|---|
| Measurement range and vibration velocity signaling (from and to, inclusive) (Ve), mm/sec | 0 – 2 |
| Frequency measurement range (from and to, inclusive), Hz | 10 – 25 |
| Number of measuring channels | 8 |
| Input signal measurement range (AC voltage), V | 0 – 0.2 |
| Input resistance of inputs 1 – 8, kOhm , not less than | 23 |
| Limits for the permissible base relative measurement error at base frequency, %:<br>— by pointer instrument | $\pm 2.5\left[1+0.2(\frac{X_{pr}}{X}-1)\right]$ |
| — by digital indicator | $\pm 1.0\left[1+0.4(\frac{X_{pr}}{X}-1)\right]$ |
| Base measurement frequency, Hz | 17 ± 1 |
| Frequency-response ripple within frequency range (10 – 25) Hz, % | + 2.5; – 15 |
| Frequency response attenuation at 50 Hz, dB, not less than | 48 |
| Number of signaling setpoints | 1 |
| Ambient air working temperature range (from and to, inclusive), °C | 0 – + 50 |
| Discrete output signal:<br>— current, mA, not more than | 100 |
| — voltage, V, not more than | + 30 |
| Supply voltage, V | ± (15 ± 0.5); + (24 ± 1) |
| Consumption current, mA, not more than:<br>— From + 15 V source | 110 |
| — From -15 V source | 100 |
| — From + 24 V source | 20 |
| $X_{pr}$ – Input signal limit value.<br>$X$ – current value of input signal. | |

1.3.11 Control boards ПК72, ПК73, ПК74

Table 17

| Parameter description | Normal value | | |
|---|---|---|---|
| | ПК72 | ПК73 | ПК74 |
| Number of inputs – total, number | 16 | | 17 |
| Number of inputs with memory function | – | 8 | – |
| Input signal, conductance, cm, not less than | 0.002 | | |
| Number of output discrete signals, number | 2 | | 3 |
| Output discrete signals:<br>– Voltage, V not exceeding<br>– Current, mA not exceeding | <br>+ 30<br>100 | | |
| Signaling logic:<br>– output ΔΔ1.1 | ‘OR’ inputs 1–16 | | – |
| – output ΔΔ2& | ’AND’ by two neighboring inputs:<br>for version 1 – except 8.9;<br>for version 2 – any | | – |
| – outputs OUT1, OUT2, OUT3 | – | | ’AND’<br>input ΔΔ and any two inputs 1…16 |
| Ambient air working temperature range (from and to, inclusive), °C | 0 – + 50 | | |
| Supply voltage, V | + (15 ± 0.5); + (24 ± 1) | | |
| Consumption current, mA, not exceeding:<br>– from + 15 V source | 10 | 50 | 90 |
| – from +24 V source | 15 | 10 | 10 |

1.3.12 Control boards ПК80, ПК81

Table 18

| Parameter description | Normal value | |
|---|---|---|
| | ПК 80 | ПК 81 |
| Number of inputs | 8 | 6 |
| Input signal – DC voltage, measurement range, V | 0 – 10 | |
| Input step parameter:<br>– amplitude, V | 0.5 – 10 | |
| – acceleration time, sec, not more than | 4 | |
| – Pulse peak time, sec, not less than | 10 | |
| Input step amplitude signaling range, V | 0.5 – 5 | |
| Limits for permissible relative error of step signaling actuation regarding the amplitude, % | ± 10 | |
| Signaling logic:<br>– output ∆1.1 | ’OR’<br>inputs 1 – 8 | ’OR’<br>inputs 1 – 6 |
| – output ∆2& | – | ’AND’ inputs:<br>– for version 1<br>1,2; 1,3; 2,4; 3,4; 3,5; 4,6; 5,6<br>– for version 2<br>1,2; 2,3; 3,4; 4,5; 5,6<br>– for version 3<br>1,2; 3,4; 5,6 |
| Ambient air working temperature range (from and to, inclusive), °C | 0 – + 50 | |
| Supply voltage, V | ± (15 ± 0.5); + (24 ± 1,0) | |
| Output discrete signals of:<br>– output cascade type | Open collector | |
| – voltage, V, not more than | +30 | |
| – current, mA, not more than | 100 | |
| Consumption current, mA, not more than<br>– at voltage + 15 V | 105 | 100 |
| – at voltage – 15 V | 40 | 35 |

1.3.13 Control board ПК90

Table 19

| Parameter description | Normal value |
|---|---|
| Number of outputs | 7 |
| Output signals (from and to, inclusive): | |
| — DC voltage, V | ± (0 – 10) |
| — sinusoidal AC voltage, V | 0 – 1,5 |
| — pulse signal voltage, V | ± (2 ± 0.5) |
| Sinusoidal AC voltage frequency, Hz | 100 ± 10 |
| Pulse signal frequency range, Hz | 1 – 170; 60 – 10000 |
| Output resistance, Ohm | 510 ± 25 |
| Ambient air working temperature range (from and to, inclusive), °C | 0 – + 50 |
| Supply voltage, V | ± (15 ± 0.5) |
| Consumption current, mA, not more than: | |
| — from + 15 V source | 25 |
| — from - 15 V source | 25 |

1.3.14 Indication units БИ22, БИ23

Table 20

| Parameter description | Normal value |
|---|---|
| Number of decimal positions | 4 |
| Input signals: | |
| — for БИ22 | Periodic pulse signal with amplitude not less than +5 V frequency (0 – 10000) Hz |
| — for БИ23 | Code signal ПК40 |
| Ambient air temperature range (from and to, inclusive), °C | 0 – + 50 |
| Supply voltage range (from and to, inclusive), V | + (24 – 30) |
| Consumption current, mA, not more than | 90 |

1.3.15 Power supply units

Table 21

| Parameter description | Normal value | |
|---|---|---|
| | БП17 | БП18 |
| Output voltage limits, V | | |
| – output ‘+15’ | + (15 ± 0.3) | + (15 ± 0.3) |
| – output ‘–15’ | – (15 ± 0.3) | – (15 ± 0.3) |
| – output ‘+24’ | + (24 ± 0.6) | + (24 ± 0.6) |
| Maximum load current, mA | | |
| – output ‘+15’; ‘–15’ | 200 | 500 |
| – output ‘+24’ | 300 | 800 |
| Stabilized output ripple voltage ± 15 V, + 24 V, mV, not more than | 10 | 30 |
| Consumed power, VA, not more than | 25 | 60 |
| Input voltage range (from and to, inclusive), V: | | |
| – AC | 175 – 242, (50 ± 0.4) Hz | |
| – DC | 175 – 242 | |
| Ambient air working temperature range (from and to, inclusive), °C | 0 – + 50 | |

1.3.16 Sensors ДВТ10, ДВТ30 with comparator К22, sensor ДВТ10Ex with comparator К22Ex

Table 22

| Parameter description | Normal value | | | | |
|---|---|---|---|---|---|
| | A | B | V | C* | E |
| Distance between sensor and control surface made of ferromagnetic material (from and to, inclusive), mm | 0.8 – 1.5 | | | | |
| Output signal, (from and to, inclusive):<br>— '0' | (0.9–1.2) mA | (4–5) mA | (1–2) V | (0–0.1) mA | (0–0.5) V |
| — '1' | (4.7–5.0) mA | (19–21) mA | (20–22) V | (9.5–10.5) mA | (4.8–5.2) V |
| Load resistance, kOhm | 2.0; not more | 0.5; not more | 1.0; not less | 1.0; not more | 1,0; not less |
| Rate of operations, Hz, not less than | 4000 | | | | |
| Ambient air working temperature range (from and to, inclusive), $^{0}$C:<br>— for comparator | – 40 – + 70 | | | | |
| — for sensor | – 40 – + 180 | | | | |
| Supply voltage, V | + (18 – 36); + (18 – 25,2)** | | | | |
| Consumption current, mA, not more than | 100 | 110; 45** | 100 | 110 | 100 |

* For Vibrobit 200 equipment.

** For К22Ex.

Note - Comparator К22Ex with sensor ДВТ10Ex is manufactured in version B only.

1.3.17 Sensors ДВТ20, ДВТ40.40, ДВТ43.40 with comparator К21

Table 23

| Parameter description | Normal value |
|---|---|
| Distance to the control surface of “groove” or “key” type for operation, mm | 4 ± 0.5 |
| “Groove” or “key” width, mm, not less than | 10 |
| “Groove depth”, “key” height, mm, not less than | 3 |
| Relay time lag trip, sec: | |
| — for signaling equipment rotation | 10; 20 |
| — for signaling pin operation | 0.5 |
| Ambient air working temperature range (from and to, inclusive), $^{0}$C: | |
| — for comparator | 0 – + 70 |
| — for sensors ДВТ40.40, ДВТ43.40 | – 40 – + 180 |
| — for sensor ДВТ20 | – 40 – + 180 |
| Output relay contact parameters: | |
| — DC voltage, V, not more than | 34 |
| — AC voltage, V, not more than | 115 |
| — switching power, W, not more than | 0.35 |
| Supply voltage, V | + (24 ± 1) |
| Consumption current, mA, not more than | 55 |

1.3.18 Hall effect sensor ДХМ

Table 24

| Parameter description | Normal value |
|---|---|
| Output signal, mA: | |
| — logic '0' | 3,6 – 5,2 |
| — logic '1' | 18 – 22 |
| Load resistance, Ohm, not more than | 1000 |
| Rate of operations, Hz, not less than | 6000 |
| Distance between sensor and control surface made of ferro-magnetic material, mm | 1 – 2,5 |
| Control surface speed, mm/sec, not less than | 18 |
| Rotor speed, rpm, not less than (D – rotor diameter, mm) | 1000/(3.415*D) |
| "Groove" and key "length", "pinion" pitch, mm, not less than | 12 |
| "Groove depth", "key" height, mm, not less than | 3 |
| Operating temperature range, $^{0}$C | From + 0 to + 85 |
| Supply voltage, V | + (24 ± 1.2) |
| Consumption current, mA, not more than | 30 |

1.3.19 Displacement measurement channel, surface tilt measurement channel

Table 25

| Parameter description | Normal value | | |
|---|---|---|---|
| | Displacement | Surface tilt | |
| Measurement range, mm | See Table 7 | ± 1.0 | ± 2.0; ± 5.0 |
| Limits for the permissible base reduced measurement error, %: | | | |
| – by pointer instrument | ± 5.0 | ± 8.0 | ± 5.0 |
| – by digital indicator | ± 3.0 | ± 6.0 | ± 3.0 |
| – by unified signal | ± 3.0 | ± 6.0 | ± 3.0 |
| Limits for permissible reduced measurement error within all working temperature ranges of the sensor, converter, control board, %: | | | |
| – by pointer instrument | ± 8.0 | ± 12.0 | ± 8.0 |
| – by digital indicator | ± 6.0 | ± 10.0 | ± 6.0 |
| – by unified signal | ± 6.0 | ± 10.0 | ± 6.0 |

1.3.20 Relative vibration displacement measuring channel

Table 26

| Parameter description | Normal value |
|---|---|
| Measurement ranges, μm | 10 – 200; 20 – 400 |
| Ranges of measurement frequencies (from and to, inclusive), Hz | 0.05 – 100; 5 – 500 |
| Limits for the permissible base relative measurement error, %: | |
| – by pointer instrument | ± 8.0 |
| – by digital indicator | ± 8.0 |
| – by unified signal | ± 6.0 |
| Frequency-response ripple within the frequency range, %: | |
| – (0.05 – 1,00) Hz, (5 – 10) Hz; | + 2.5; – 5.0 |
| – (1,00 – 63,00) Hz, (10 – 250) Hz; | ± 2.5 |
| – (63 – 100) Hz, (250 – 500) Hz | + 2.5; – 20.0 |
| Limits for permissible relative measurement error within the frequency range, for all working temperature ranges of the sensor, converter, control board, %: | |
| – by pointer instrument | + 10.0; – 20.0 |
| – by digital indicator | + 10.0; – 20.0 |
| – by unified signal | + 8.0; – 20.0 |

1.3.21 Vibration velocity RMS measuring channel

Table 27

| Parameter description | Normal value |
|---|---|
| Measurement range, mm/sec | 0.4–12; 0.4–15; 0.8–30 |
| Frequency measurement range, Hz | 10 – 1000 |
| Limits for the permissible base relative measurement error, %: | |
| – by pointer instrument | ± 5.0 |
| – by digital indicator | ± 6.0 |
| – by unified signal | ± 4.0 |
| Frequency-response ripple, within the frequency range, %: | |
| – (2 – 5) Hz, (10 – 20) Hz; | + 2.5; – 20.0 |
| – (5 – 500) Hz, (20 – 500) Hz; | + 2.5; – 5.0 |
| – (500 – 1000) Hz | + 2.5; – 20.0 |
| Limits for permissible relative measurement error within frequency measurement range, for all working temperature ranges of the sensor, converter, control board, %: | |
| – by pointer instrument | + 10.0; – 20.0 |
| – by digital indicator | + 10.0; – 20.0 |
| – by unified signal | + 8.0; – 20.0 |

1.3.22 RPM measuring channel

Table 28

| Parameter description | Normal value |
|---|---|
| Measurement ranges for rotor speed, rpm; by pointer instrument; digital indicator of control boards and digital indication unit | 200 – 4000; 1 – 4000<br>250 – 6000; 1 – 6000<br>500 – 8000; 1 – 8000<br>500 – 10000; 1 – 9999 |
| Limits for permissible relative measurement error for all working temperature ranges of sensors, converters, and control boards, % | |
| – by pointer instrument | ± 5.0 |
| – by unified signal | ± 2.0 |
| Limits of permissible absolute measurement error by the digital indication unit, rpm, | ±2.0 |

1.3.23 Overall dimensions and mass of separate assemblies are given in Table 29 and outline drawings – in Annex C.

Table 29

| Type | Overall dimensions, mm | Sensor cable length, | Mass, kg, not exceeding |
|---|---|---|---|
| ДВТ10 | M10X1X50[1)] | 0.5 – 12 | 1.80 |
| ДВТ10Ex | M10X1X50[1)] | 3 – 7 | 1.00 |
| ДВТ20 | M16X1X40[1)] | 0.5 – 12 | 2.20 |
| ДВТ20Ex | M16X1X40[1)] | 3 – 7 | 1.40 |
| ДВТ21 | M27X1X82 | 3 – 10 | 0.62 |
| ДВТ23 | M20X1X52 | 0.5 – 9 | 1.80 |
| ДВТ30 | M20X1X83 | 0.5 – 12 | 0.75 |
| ДВТ40.10 | 90X50X20 | 3 – 13 | 1.20 |
| ДВТ40.20 | 90X50X20 | 3 – 12 | 1.20 |
| ДВТ43.20 | 90X50X18 | 3 – 12 | 1.15 |
| ДВТ40.30 | 110X50X20 | 3 – 12 | 1.25 |
| ДВТ43.30 | 110X50X18 | 3 – 12 | 1.20 |
| ДВТ40.40 | 90X50X20 | 3 – 12 | 1.20 |
| ДВТ43.40 | 90X50X18 | 3 – 12 | 1.15 |
| ДВТ40.50 | 140X50X20 | 3 – 12 | 1.45 |
| ДВТ43.50 | 140X50X18 | 3 – 12 | 1.40 |
| ДВТ50 without rod | 52X44X25 | 3 – 9 | 1.10 |
| ДВТ60.10 | 32X40X38 | 0.5 – 10 | 0.51 |
| ДВТ60.16 | 50X65X46 | 0.5 – 7 | 1.10 |
| ДВТ60.20 | 50X65X52 | 0.5 – 7 | 1.20 |
| ДВТ70 | 70X80X152 | 3 – 7 | 2.75 |
| ДВТ82 without rod | 101X62X43 | – | 0.50 |
| Rod ВШПА.421412.060.01 | 200,260,360;460;490[2)] | – | 0.50; 0.50; 0.60; 0.80 |
| Rod ВШПА.421412.060.03 | 473[2)] | – | 0.80 |
| Rod ВШПА.421412.060.04 | 190,250,350,450,480[2)] | – | 0,23; 0,30; 0,42; 0,54; 0,58 |
| Rod ВШПА.421412.060.10 | 189,249,349,449,479[2)] | – | 0,27; 0,34; 0,46; 0,59; 0,62 |
| ДПЭ22П, ДПЭ23П<br>ДПЭ22МВ, ДПЭ22МВТ, ДПЭ23МВ, ДПЭ23МВТ<br>ДПЭ23МВП | 30X30X50[5)];<br>33X33X45[5)];<br>101X62X30[3)] | 3 – 12 | 0.12[5)];<br>0.10[5)];<br>2.00 |
| ДПЭ22Ex, ДПЭ23Ex | 33X33X45[5)];<br>101X62X30[3)] | 7 | 0.10[5)];<br>1.50 |
| ДПЭ24 | 33X33X45[5)] | 3 – 12 | 0.10[5)];<br>2.00 |
| 625B01 | 56X36X33 | – | 0.15 |

*Continuation of Table 29*

| Type | Overall dimensions, mm | Sensor cable length, м | Mass, kg, not exceeding |
|---|---|---|---|
| ДХМ | М20Х1Х84 | 3 – 12 | 0.90 |
| ИП24 | 127Х62Х34 | – | 0.26 |
| ИП34, ИП34Ех, ИП36, ИП36Ех, ИП42, ИП43, ИП44, К21, К22, К22Ех | 127Х62Х34 | – | 0.30 |
| ИП37 | 127Х62Х44 | – | 0.60 |
| КС10 | – | 3 – 13 | 0.50 |
| КС11 | – | 3 – 12 | 0.90 |
| КС24 | – | 5 – 17 | 2.10 |
| ПК72, ПК73, ПК74, ПК80, ПК81 | 20,1x130x190 | – | 0.14 |
| ПК90 | 20,1x130x200 | – | 0.25 |
| ПК10, ПК11, ПК12, ПК13 | 40,3x130x200 | – | 0.20 |
| ПК20, ПК21, | 40,3x130x200 | – | 0.23 |
| ПК30, ПК31, ПК32, | 40,3x130x200 | – | 0.25 |
| ПК40, ПК51 | 40,3x130x200 | – | 0.25 |
| БП17 | 40,3x130x190 | – | 0.35 |
| БП18 | 60,6x130x190 | – | 0.65 |
| БИ22, БИ23 | 160x85x110 | – | 0.90 |
| БК10, БК11, БК20, БК21, БК30, БК31, БК32, БК40 | 60,6x130x260 | – | 1.53 |
| М20 | ∅30x60 | – | 0.10 |
| М24 | ∅33x60 | – | 0.11 |
| КР10 | 24x28x90 | – | 0.06 |
| КР20 | 24x50x90 | – | 0.09 |
| КП13, КП13К | 139x270x69 | – | 1.00 |
| КП13Х | 139x318x69 | – | 1.30 |
| КП13Х-Пр1 | 206x281x85[6)] | – | 2.50 |
| КП13Р | 150x238x84 | – | 1.85 |
| КП13ХР | 150x286x84 | – | 2.15 |
| КП13-Пр | 200x240x85[6)] | – | 2.20 |
| КП15 | 189x270x97 | – | 1.30 |
| КП23В, КП23П | 269x270x67 | – | 1.70 |
| КП23ВХ, КП23ПХ | 269x318x69 | – | 2.00 |
| КП23Х-Пр | 306x381x125[6)] | – | 4.50 |
| КП23ВР | 300x238x84 | – | 3.1 |
| КП23ПР | 300x238x84 | – | 3.3 |
| КП23-Пр | 300x340x125[6)] | – | 4.40 |
| КП25 | 349x270x97 | – | 2.00 |

*Continuation of Table 29*

| Type | Overall dimensions, mm | Sensor cable length, м | Mass, kg, not exceeding |
|---|---|---|---|
| МУ10 | 70x41x70 | – | 0.60 |
| МУ11 | 54x32x44; 54x43x44[4)] | – | 0.35 |
| МУ14 | 43x40x24 | – | 0.30 |
| БШ24 | М24x1.5 | 5 – 8 | 3.5 |
| “Евромеханика19” 3U 84HP (3HE–84TE) | 483x133x281 | – | 5.0 |
| TS 8 RITTAL 1800x600x600<br>2000x600x600 | 610x640x1825<br>610x640x2025 | – | 200.0 |

[1)] It is allowed to manufacture the length of the sensor housing in agreement with the customer. Minimum length is 30 mm.

[2)] Rod length.

[3)] Amplifier dimensions.

[4)] Version for ДВТ20, ДВТ20Ex.

[5)] Dimensions and mass of piezoelectric sensor without cable.

[6)] Dimensions and weight without mounting brackets.

NOTE - Limit deviations of the overall dimensions must be in accordance with the IT14 qualification in accordance with ГОСТ 25346-2013, the lengths of the sensor cables - the drawing.

1.3.24 Values for intrinsically safe electrical circuits

- piezoelectric sensors ДПЭ22Ех, ДПЭ23Ех:

  Ui : 25,2V; Ii :240 mA; Pi : 1,5 W; Ci : 100 picofarad; Li : 100 uH.

- converters ИП34Ех, ИП36Ех:

  Ui : 25,2V; Ii :240 mA; Pi : 1,5 W; Ci : 100 picofarad; Li : 100 uH.

- comparators К22Ех :

  Ui : 25,2V; Ii :240 mA; Pi : 1,5 W; Ci : 100 picofarad; Li : 100 uH.

1.3.25 Eddy current sensor winding insulation resistance regarding the body is not less than 1,0 megohm (except sensors ДВТ40, ДВТ70, ДВТ82).

1.3.26 High humidity effect

Permissible relative humidity shall be as follows for:

— Sensors, piezoelectric sensors, converters – not exceeding 95 % at 35 $^0$C and low temperatures without condensate formation;

— Control boards and units, power supply units and indication units, cabinets – not exceeding 80% at 25 $^0$C and lower temperatures without condensate formation.

1.3.27 Sensors, piezoelectric sensors are tightly sealed and resistant to vapors and splashes of water, turbine oil (OMTI fluids).

1.3.28 Values of eddy-current sensor windings active resistance

Table 30

| Sensor type | Active resistance, Ohm | |
|---|---|---|
| | Excitation winding | Signal winding |
| ДВТ10, ДВТ10Ех | (0.900+0.084·$l$*) ± 0.100 | – |
| ДВТ20, ДВТ20Ех, ДВТ21 | (0.710+0.084·$l$) ± 0.100 | – |
| ДВТ23 | (0.780+0.084·$l$) ± 0.100 | – |
| ДВТ30 | (0.900+0.084·$l$) ± 0.100 | – |
| ДВТ40.10 | (1.540+0.084·$l$) ± 0.100 | (0.860+0.190·$l$) ± 0.100 |
| ДВТ40.20 | (1.600+0.084·$l$) ± 0.100 | (0.910+0.190·$l$) ± 0.100 |
| ДВТ40.30 | (2.190+0.084·$l$) ± 0.100 | (1.110+0.190·$l$) ± 0.100 |
| ДВТ40.40 | (1.320+0.084·$l$) ± 0.100 | – |
| ДВТ40.50 | (2.100+0.084·$l$) ± 0.100 | (1.350+0.190·$l$) ± 0.100 |
| ДВТ43.20 | (1.550+0.084·$l$) ± 0.350 | (3.800+0.190·$l$) ± 0.800 |
| ДВТ43.30 | (1.700+0.084·$l$) ± 0.500 | (5.000+0.190·$l$) ± 1.000 |
| ДВТ43.40 | (1.060+0.084·$l$) ± 0.300 | – |
| ДВТ43.50 | (1.900+0.084·$l$) ± 0.300 | (4.900+0.190·$l$) ± 1.000 |
| ДВТ50 | (0.970+0.084·$l$) ± 0.100 | – |
| ДВТ60.10 | (0.330+0.084·$l$) ± 0.100 | – |
| ДВТ60.16 | (0.550+0.084·$l$) ± 0.100 | – |
| ДВТ60.20 | (0.670+0.084·$l$) ± 0.100 | – |
| ДВТ70 | (3.520+0.084·$l$) ± 0.100 | (12.440+0.190·$l$) ± 0.100 |
| *$l$ – sensor cable length, m. | | |

1.3.29 Special requirements for supply to nuclear power facilities:

— provided that the products are manufactured according to quality plans under the supervision of the Authorized Organization, the equipment should be classified as QA3 quality assurance, systems and normal operation elements that are important for safety, and have a safety class of 3H in accordance with НП-001, excluding components and materials; used in manufacturing and having a safety class 4, according to Annex M;

— in the case of manufacturing products without quality plans, the equipment should be classified as QNC quality assurance, systems and normal operation elements and have a safety class 4 in accordance with НП-001.

1.3.30 Sensors and piezoelectric sensors retain their characteristics at exposure to varying supply frequency of the magnetic field with intensity up to 400 A/m, and converters, ДПЭ sensor amplifiers, comparators, control boards – up to 100 A/m. When installing converters and ДПЭ sensor amplifiers into the КП-type transducer boxes and control boards – into the sections installed in the cabinet, they retain their characteristics at exposure to varying supply frequency of the magnetic field with intensity up to 400 A/m.

1.3.31 Readiness (warming-up) time of the equipment does not exceed 2 minutes, mode of operation – continuous.

1.3.32 Insulation electrical resistance of power supply units in ~220 V circuits, megohm, shall be not less than:

| | |
|---|---|
| – under normal operation conditions | 20; |
| – at relative humidity 80 % and temperature +35 $^{0}$C | 2. |

1.3.33 Norms for industrial interferences comply with Class A Group 1 as per ГОСТ Р 51318.11-2006.

1.3.34 Mean time to failure $T_{\alpha}$, hours, not less than (estimated):

| | |
|---|---|
| – piezoelectric sensor | 200000; |
| – sensor and displacement transducer | 150000; |
| – comparator | 150000; |
| – control board parameter (one channel) | 100000; |
| – control unit (one channel) | 75000; |
| – power supply unit | 100000; |
| – indication units | 70000. |

1.3.35 Probability of no failure operation within 10 000 times, not less than (estimated):

| | |
|---|---|
| – regarding automatic protection functionality | 0.98; |
| – regarding measurements and data display | 0.90. |

1.3.36 The following units and items shall be not subject to repair:

- Sensors ДВТ10, ДВТ10Ex, ДВТ20, ДВТ20Ex, ДВТ21, ДВТ23, ДВТ30, ДХМ, ДВТ40, ДВТ43, ДВТ60, 625В01, ДПЭ22Ex, ДПЭ23Ex, ДПЭ22МВ, ДПЭ23МВ;
- ДВТ50 and ДВТ82 sensor excitation windings;
- ИП34Ex and ИП36Ex converter;
- Comparator К22Ex.

All remaining units of the equipment are repairable.

All equipment units are interchangeable within the range of technical and metrological characteristics.

When replacing eddy current sensors, converters or a comparator, a converter and comparator calibration is required at the unit under test completed with the sensor.

1.3.37 By its resistance to external influencing factors, the equipment complies with the nominal value as per ГОСТ 30631-99 for:

– ДВТ10Ex, ДВТ20Ex sensors and piezoelectric ДПЭ sensor converter of all types - to M5 Group;
– КП-Type transducer boxes, converters, amplifiers for ДПЭ sensor of all types – to M7 Group;
– ДВТ10, ДВТ20, ДВТ30, ДВТ40, ДВТ43, ДВТ50, ДВТ60, ДВТ70, ДВТ82 sensors, comparators К21, К22, К22Ex, indication units – to M7 Group;
– Control boards, control units, power supply units, frameworks and cabinets – to M39 Group;

1.3.38 IP of units as per ГОСТ 14254-96:

– sensors ДВТ10, ДВТ10Ex, ДВТ20, ДВТ23, ДВТ20Ex, ДВТ30, ДВТ40, ДВТ43, ДВТ50, ДВТ60, 625B01 IP67;
– piezoelectric sensors for ДПЭ sensors IP67;
– sensor ДВТ21 (when installed in feeding pump) IP68;
– sensor ДВТ70 IP65;
– sensor ДХМ IP64;
– sensor ДВТ82 IP32*;
– converters of all types, comparators, amplifies of sensors ДПЭ IP32;
– control boards, power supply units (as part of a cabinet) IP20;
– indication units IP32;
– control units IP30;
– transducer boxes IP55;
– cabinet ‘RITTAL’ of type TS 8 IP55;
– connector boxes КР10, КР20 IP34.

1.3.39 Preservation of equipment for the purpose of long-term storage is not required. Long-term storage of the equipment shall be performed packed, preferably in the original packaging material, inside heated facilities complying with 1 (L) conditions, storage atmosphere type II, III as per ГОСТ 15150-69.

1.3.40 The equipment retains its characteristics at atmospheric pressure varying from 630 to 800 mm Hg.

———————

* *If IP67 is required, use the ДВТ50 sensor*.

1.3.41 Group of equipment layout at the nuclear power station as per ОТТ08042462:

– Sensors, converters, comparators, transducer boxes 4;
– Boards, control units, power supply and indication units, frameworks and cabinets 5.

Operating converters and comparators shall be enclosed in boxes.

Control boards, power supply units - in frameworks, and frameworks should be placed into cabinets.

The equipment is resistant to effect of de-activating medium.

1.3.42 Category of the equipment seismic stability

The equipment is classified as Category II by its seismic stability as per НП-031-01.

The equipment is resistant to earthquakes of 8 M as per MSK – 64.

1.3.43 Average time for the equipment restoring to working condition does not exceed 0.5 h.

Restoration to working condition shall be performed by replacing the failed items units the functional ones taken from the spare parts kit (SPTA). Failed eddy-current sensors, converters and comparators used together (as per table 1), should be changed as a set. SPTA sets must be pre-calibrated either at unit under test, or on a stand with a control surface made of steel similar to the control surface of the unit under test.

1.3.44 The equipment complies with the electromagnetic compatibility requirements of ГОСТ 32137-2013 for the version of group III by resistance to interference with the performance criterion A with an electromagnetic environment of medium severity when connecting communication lines through surge protection devices (SPD), and also complies with the emission standards for the Class A equipment. The exception is products consisting of an eddy current sensor ДВТ50, converter ИП34, a transducer box, corresponding to the electromagnetic compatibility requirements ГОСТ Р 32137-2013 version of group IV by resistance to interference with performance criterion A.

1.3.45 The designated service life of the equipment is at least 10 years. The service life of the equipment when delivered to nuclear power plants is 30 years.

1.3.46 Type of climatic version during normal operation according to ГОСТ 15150-69:

— sensors, converters, comparators,
  transducer boxes УХЛ 1, ТВ3;
— boards, control units, power supply and indication units,
  frameworks and cabinets УХЛ 4.2.

Converters and comparators during operation should be placed in boxes.

Type of atmosphere during operation should comply with ГОСТ 15150-69 – II, III.

1.3.47 Performance in electromagnetic environment according to ГОСТ 15150-69 – II, III.

1.3.48 Resistance to radio-frequency electromagnetic field according to ГОСТ 30804.4.2:

— severity 3
— performance criterion A

1.3.49 Immunity to radio frequency electromagnetic field according to ГОСТ 30804.4.3

— severity 4
— performance criterion A

1.3.50 Resistance to nanosecond impulse disturbance in the power supply network in accordance with ГОСТ 30804.4.4:

— severity 3;
— performance criterion A.

1.3.51 Resistance to microsecond impulse disturbance in the power supply network according to ГОСТ 30804.4.5:

— severity 3;
— performance criterion B.

1.3.52 Immunity to conducted interference induced by radio frequency electromagnetic fields in accordance with ГОСТ Р 51317.4.6:

— severity 3;
— performance criterion A.

1.3.53 Resistance to holes, short-term interruptions and voltage changes in accordance with ГОСТ 30804.4.11:

— severity 3;
— performance criterion A.

1.3.54 Resistance to oscillatory damped interference according to ГОСТ IEC 61000-4-12:

— severity 3;
— performance criterion A.

1.3.55 Resistance to supply voltage fluctuations according to ГОСТ Р 51317.4.14:

— severity 3;
— performance criterion A.

1.3.56 Resistance to conducted interference in the frequency band from 0 to 150 kHz according to ГОСТ Р 51317.4.16:

— severity 3;
— performance criterion A.

1.3.57 Resistance to the supply voltage frequency changes according to ГОСТ Р 51317.4.28:

— severity 3;
— performance criterion A.

1.3.58 Resistance of measuring relays and protection devices to nanosecond impulse disturbance according to ГОСТ Р 51516:

— severity 3;
— performance criterion A.

1.3.59 Resistance to oscillatory damped magnetic field according to ГОСТ Р 50652:

— severity 4;
— performance criterion A.

1.3.60 Resistance to power frequency magnetic field according to ГОСТ Р 50648:

— severity 4;
— performance criterion A.

1.3.61 Resistance to pulsed magnetic field according to ГОСТ 30336:

— severity 4;
— performance criterion A.

1.3.62 The level of the current harmonic components introduced into the power supply according to ГОСТ 30804.3.2, class A.

1.3.63 Performance under the influence of industrial interference according to the standards 8-95 available.

1.3.64 Mutual galvanic isolation between measuring channels, V, not less 250.

1.3.65 Eddy current sensor ДВТ50, converter ИП34, transducer box must be resistant to mold fungi.

1.3.66 Eddy current sensor ДВТ50, converter ИП34, transducer box must be resistant to the presence of corrosive agents in the atmosphere, defined by the following parameters:

Table 31

| Material | Concentration, mg/m$^3$ | Deposition flow, mg/(m2 • day) |
|---|---|---|
| Chlorides | 0,0212 | 18,3 |
| Sulphates | 0,058 | 50 |
| Sulphur dioxide | 0,025 | - |

1.3.67 Requirements for the cabinet, necessary for the development of layout solutions, are presented in Table 32.

Table 32

| Name | Requirement |
|---|---|
| Type of Servicing | bilateral |
| Version | floor mounted |
| Cable entry | from below |
| Mounting type | on studs |
| Heat generation, kW, not more than | 280 |
| Fire load, MJ, not more than | 2560 |
| Safety class according to НП-001 | See par. 1.3.29 |
| Seismic resistance category according to НП-031 | See par. 1.3.41 |
| Environmental requirements for normal operation:<br>– maximum temperature, °C<br>– minimum temperature, °C | <br>45<br>5 |
| Environmental requirements for emergency operation under conditions of ventilation systems failure:<br>– maximum temperature, °C<br>– minimum temperature, °C | <br>35<br>5 |

### 1.4 Equipment operation and description

1.4.1 Vibrobit 100 equipment is the set of assembly units performing typical functions of parameter measuring and control of turbo generators and other equipment installed in stationary controlling/signalling systems.

All units of equipment are operated by unified output signals with normalized metrological characteristics. This ensures their electrical compatibility both with Vibrobit 100 equipment and with other measuring instruments.

Design of the equipment functional units enables to assemble the control systems that differ by their intended purpose, composition, and scope of controlled parameters. The equipment allows assembling parameter control channels that are both self-contained and connected to the different general units for the purpose of optimization.

Composition of the equipment functional units provides for the parameter measurement within the wide range of values and working conditions of application, has a wide range of sensors, control boards, and auxiliary assemblies.

1.4.2. Block diagram of the parameter measuring channel is given in Figure 1.

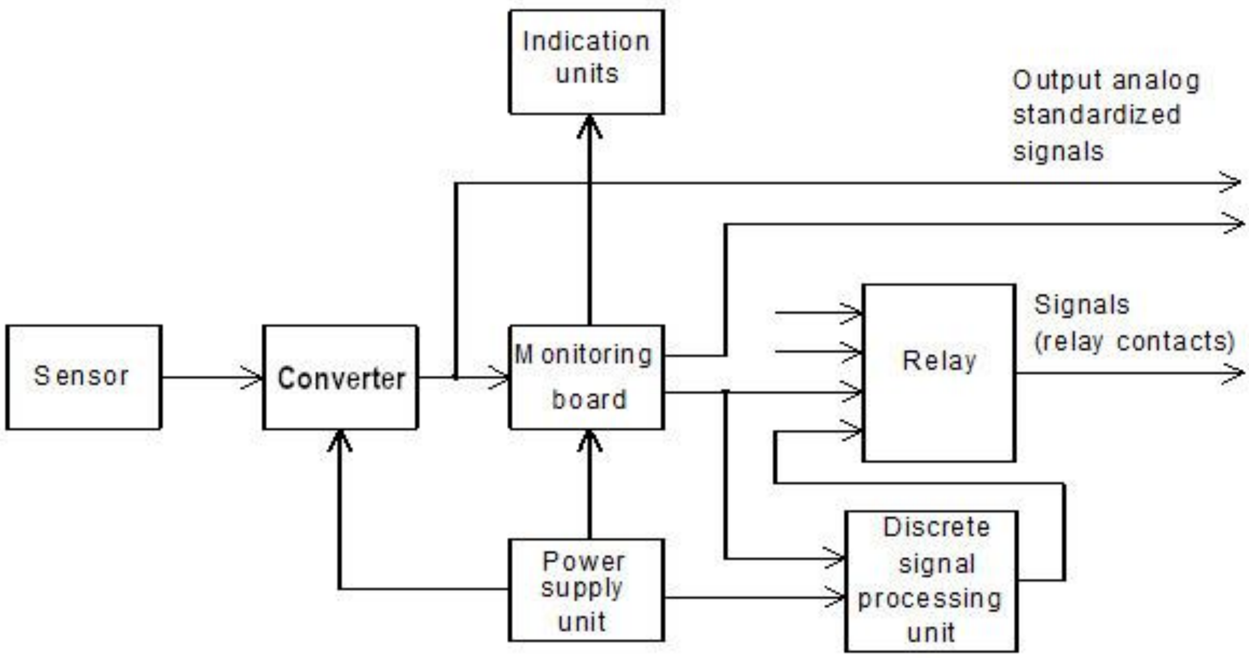



Figure 1

The controlled parameter is measured and converted by the sensor into an electric signal that is fed to the converter. The converter carries out the signal amplification, detection, linearization and converted into the unified DC signal.

Then, the sensor signal is fed to the control board where it is amplified, filtered, detected, and converted into the unified signal and compared with setpoints (control levels).

Unified output signals from the converters or control boards are used for indication, registration and processing by high-level systems.

Output discrete signals of the control boards include electromagnetic relays or are fed to the ПК72 (ПК73, ПК74) board.

ПК72 (ПК73, ПК74) board processes the signals by a certain logic.

Apart from measuring and monitoring parameters, the equipment also monitors serviceability of sensors, converters, communication lines and power sources. Any malfunction of the equipment is indicated by LEDs.

The recommended applicability of sensors and converters, as well as completeness of the equipment assembly units throughout control channels is given in Annexes F and G, respectively.

## 1.5 Equipment components operation and description

### 1.5.1 Proximity displacement sensors

Proximity eddy current displacement sensors used in the equipment generate high-frequency electromagnetic field in the environment and create eddy currents in metals resulting in the field decay. Such decay is inversely proportional to the air gap between the sensor and the metal (unit under test).

Dimensions of the sensor depend on the measurement range and dimensions of the unit under test.

The sensor is represented by the inductance coil placed close to the unit under test and connected to the electrical circuit by means of a radio-frequency table, provided that the sensor and the converter are structurally separated to comply with the operation conditions. Radio frequency connectors are coaxial, for sensors with ИП34 converter the versions with РСГ7ТВ connectors (on the converter), РС7ТВ (on the sensor) are available.

The sensor (converter) output signal is represented by the direct current (current output) linked to the parameter by the straight line, i.e. any variation of the parameter within the limits of the measurement range results in the proportional variation of the output current within the range of (1 – 5); (4 – 20) mA. Such output signal enables control of the communication lines integrity and features high degree of communication lines protection from interferences. Output characteristic of the sensor and the displacement transducer is given in Annex D.

The sensor inductance coils are connected to the neutral wire of the converter.

### 1.5.2 Vibration velocity sensors

The sensing element of the vibration velocity sensor is represented by the piezoelectric element that converts the force effecting it into an electric potential.

Application of the element that generates the potential through the bending force enables to sharply decrease the sensor sensitivity to base deformations and to reduce its lateral sensitivity.

Electric potential of the piezoelectric element is amplified, integrated, filtered, and converted into the output current signal of (1 – 5) mA, (4 – 20) mA.

All sensors have a standardized conversion coefficient, this simplifies their replacement and application in any measuring systems.

Piezoelectric sensors are represented by the variant with detachable* and non-detachable cable connection to piezoconverter and amplifier, with different types of piezoconverter attachment to the unit under test (See marking in Annex H).

Cable of the sensor is made of antivibrational material and is protected by the metal hose. Sensors with 3-meter long cable in insulated metal hose from the piezoconverter side are available.

Basic version of sensors type ДПЭ22МВ, ДПЭ22МВТ, ДПЭ23МВ, ДПЭ23МВТ, ДПЭ22Ех, ДПЭ23Ех are secured to the unit by 3 screws M4 arranged circumferentially on diameter of 30,6 mm at 120° to each other. The above sensors marked API610**have the attachment provided for by standard API 610 of the American Petroleum Institute (See Figure C.16).

1.5.3 Comparator К21

Comparator К21 reacts to the change in the gap between the sensor and the control surface relative to the actuation distance of (3 ± 0.5) mm with the preset input electromagnetic relay operation delay.

a) Version for signaling the equipment rotation

The relay is energized when the shaft is rotated at more than 3 rpm (20 s) or 6 rpm (10 s). The relay is deenergized when the shaft is rotating at speed below the specified values. At the monitored output – pulse signal for the shaft speed.

b) Version for signaling the pin operation

The relay is energized at actuation. The relay deenergizing delay time – 0.5 sec.

For both versions, if gap between the sensor and the control surface exceeds 3 mm, the monitored output provides signal ‘1’ (more than 18 V), and if gap is less than 3 mm–‘0’ (less than 1 V).

1.5.4 Comparator К22

Comparator К22 is intended for excitation of eddy current sensor windings and generation of tachometric pulse represented by unified current signal equaling to (1 – 5) mA, (4 – 20) mA.

The comparator circuit allows operation with ‘groove’ and ‘pinion ‘-type control surfaces, different rotor speed measuring ranges. For monitoring the gap between the sensor and the control surface, the comparator К22 is provided the diagnostics voltage output of (0-10 V) proportional to the air gap.

The RF connector is coaxial; there are versions with connectors РСГ7ТВ (on the comparator), РС7ТВ (on the sensor) available.

* *Version of piezoelectric sensors with detachable cables are manufactured only with a 3-meter long insulated metal hose from the piezoconverter side.*

***Version of piezoelectric sensors with API610 attachment element are manufactured only with detachable cable and insulated 3-meter long metal hose from the piezoconverter side.*

1.5.5 Sensor ДХМ

The Hall effect sensor ДХМ is intended for measuring the rotor RPM in operation with ‘groove’, ‘key’ or ‘pinion’ control surfaces that are not less than 12-mm long and not less than 3-mm deep. Control surface speed must exceed 18 mm/sec.

1.5.6 Control boards

The block diagram of control boards (one channel) is given in Figure 2.

Output signal from the sensor or the converter, depending on its polarity, is fed to one of the inputs of the input cascade.

Then, the input signal is passed and converted as follows: separating capacitor C, scaling amplifier, which rate of gain depends on the sensor signal and the measurement range, low-pass filter, signal detector, and the voltage-current converter.

Voltage from the detector output is fed to the null detectors of setpoints, where it is compared with the setpoint voltage set by variable resistors $R_{\Delta}$, $R_{\Delta\Delta}$. Should the excessive voltage is detected, positive voltage appears at the null detector output and is fed through the discrete logic circuits to the board output.

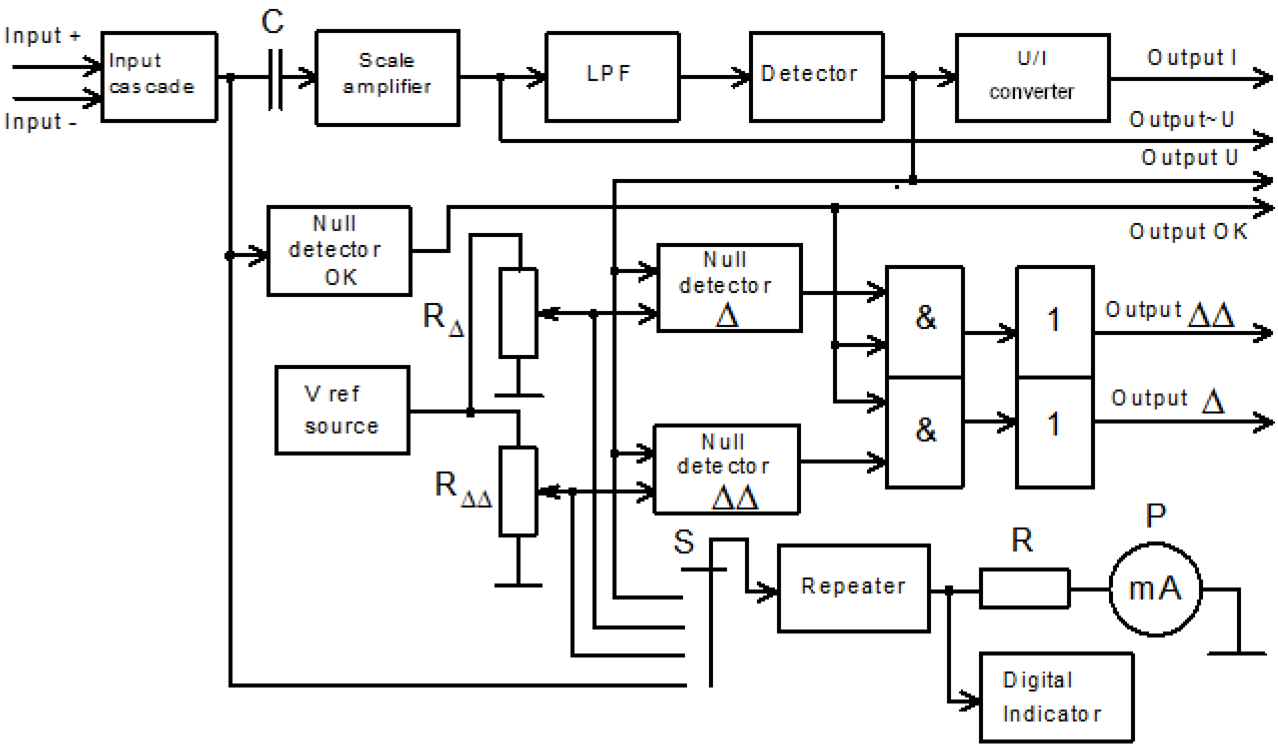



Figure 2

The range of input signal measuring is monitored by the special null detector OK. The input signal exceeding the established range limits of (1 – 5) mA results in the null detector actuation, locking the output signals, and signaling the equipment failure.

Measurements of parameters, preset setpoints, direct component of the input signal are performed through the selector switch S, the repeater, digital indicator and the pointer-type microamperemeter P.

In multi-channel control boards, the functional units used for parameter measurements in channels are separated, and null detectors, as a rule, are common; and are fed with the parameter maximum voltage.

In ПК40 board, functions of measuring, comparison with setpoints, indication and generation of unified signals are carried out by the microprocessor.

Measurement ranges and scales of control boards are given in Annex E.

Sensors and converters are used in accordance with Annex F.

1.5.7 Control board ПК20

A simple conventional method for measuring the shaft bending deflection is represented by the procedure used for measuring the rotor shaft vibration displacement excursion on the console in one cross-section specified by the equipment manufacturer. Its reliability is high at low rotor speed (up to 1500 rpm), when dynamic forces of misbalance are low, and vibration displacement excursion is determined by the shaft bowing deflection.

As RPM increases, reliability of bowing measurement decreases, and its presence is manifested by vibration in the bearing support.

1.5.8 Control units

Block diagram of the control unit is given in Figure 3

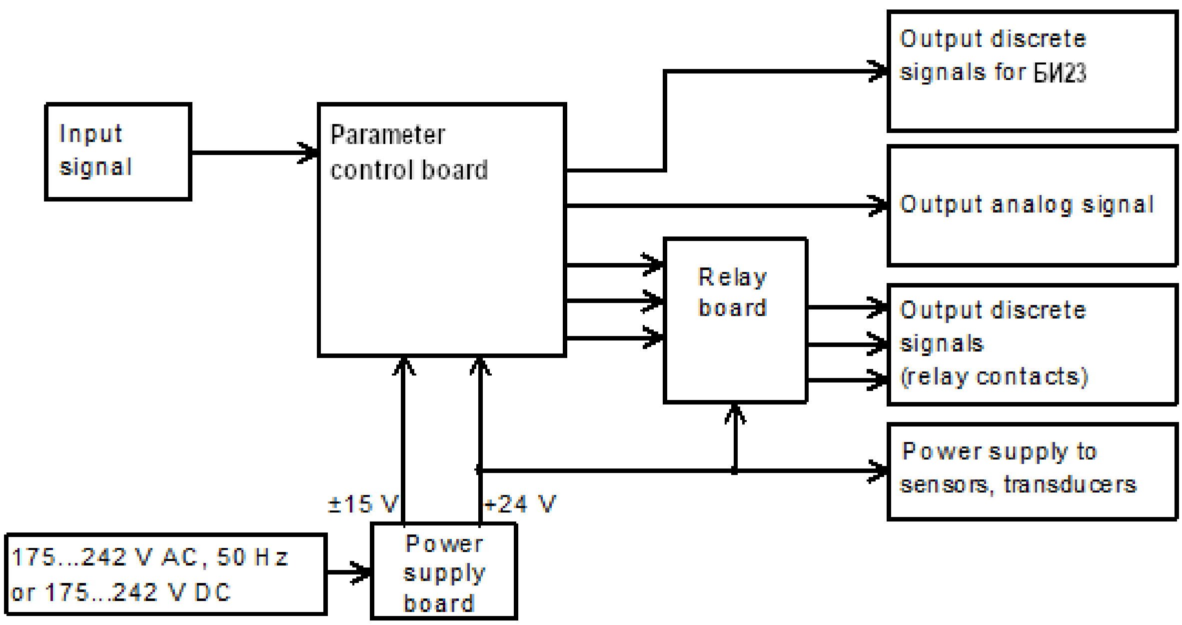



Figure 3

By its structure and design the control unit consists of the following functional units:

- power supply board;
- parameter control board;
- electromagnetic relay board.

Purpose of functional units:

Power supply board – conversion of alternating current (175 – 242) V, (50 ± 0.4) Hz or direct current (175 – 242) V into stabilized voltage of ± 15 V, + 24 V intended for power supply of the control boards, electromagnetic relays, sensors and converters.

Control board of the unit, by its electrical parameters, fully complies with control boards ПК10, ПК11 ПК20, ПК21, ПК30, ПК31, ПК32 and ПК40. The difference is only in the dimensions of front panels.

Output discrete signals of control boards energized electro magnetic relays located at a different board. Relay contacts are connected to the separate output connector of the unit.

Apart from measuring and monitoring the parameter, control unit is monitoring serviceability of sensors and converters, communication lines and power supply board. Any malfunction is displayed.

Control unit also provides test signals for checking normal operation of the control board, sensors, signaling and protection circuits.

1.5.9 Power supply units

Power supply units use the pulse voltage converters designed for input voltage (175 – 242) V AC, (50 ± 0.4) Hz or (175 – 242) V DC. At the output, stabilized voltage of ± 15 V is generated for power supply of control boards, +24 V – for power supply of sensors, converters, control boards, indication units, and electromagnetic relays.

The power supply unit control circuit signals the presence of excessive voltage beyond the present limit and also provides interlocking of the signaling output relays during equipment energizing and deenergizing, failures in power supply unit, fluctuation or disappearance of the power supply voltage.

1.5.10 Indication units БИ22, БИ23

Indication units are intended to indicate the number of the turbo-generator rotor RPM in the digital form. The БИ22 indication unit acts as a frequency meter and uses the output signal of К22 comparator when operating with ‘pinion’ control surfaces with the number of teeth Z=60

БИ23 backs up digital indicator readings of the control board ПК40 by accepting the digital signals from the latter.

1.5.11 Control board ПК51

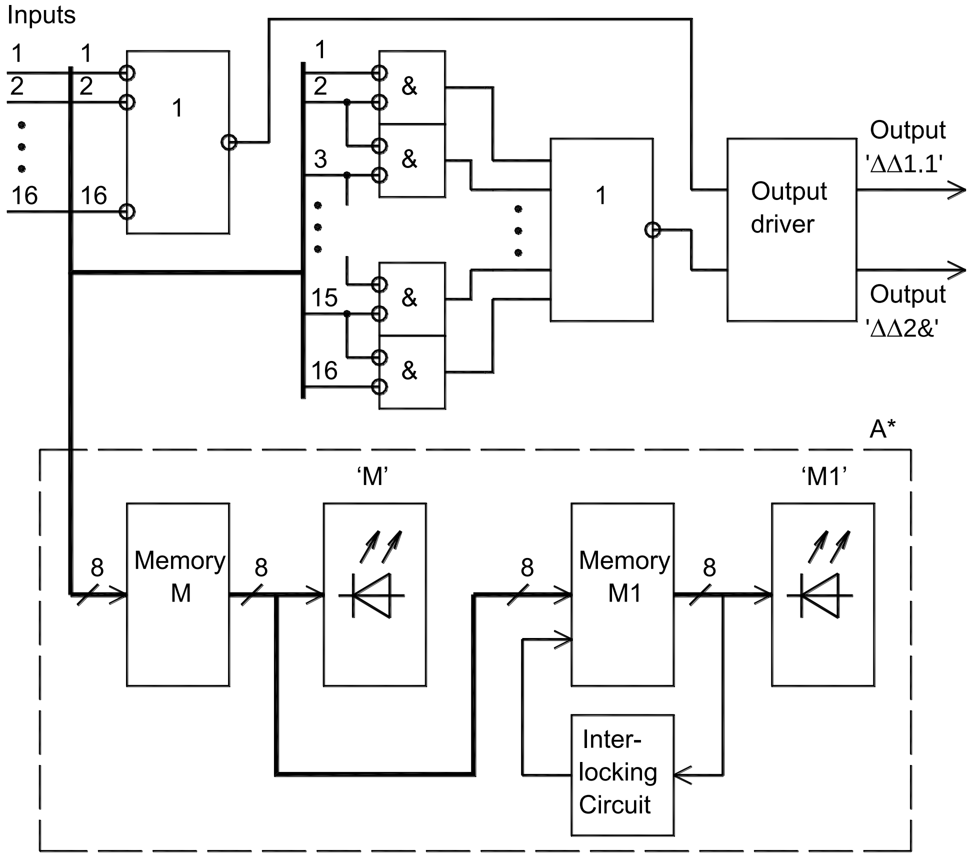
ПК51 board is intended for measuring and monitoring low-frequency component of the vibration speed.

Range of monitored frequencies (10 – 25) Hz.

The board has eight control channels. Each channel contains: low pass eighth order filter, RMS detector, DC amplifier. Maximum value of vibration velocity signal is compared with the setpoint and if it is exceeded, the LED is illuminated. They channel number with the maximum value of vibration velocity is indicated by one of the 1….8 LEDs.

1.5.12 Control boards ПК72, ПК73, ПК74

ПК72, ПК73 and ПК74 boards are intended to generate the equipment deenergizing signal. Special algorithms for vibration protection actuation are used to protect bearing supports due to unreliable operation of the measuring equipment resulting in the unreasonable equipment deenergizing. The most widely practiced procedure for improving reliability of protection operation is application of the method checking the dangerous vibration level presence of the in the neighboring bearing supports – application of the logical ‘AND’ circuit. The block diagram of control boards ПК72, ПК73, ПК74 is given in Figures 4 and 5.




* Module A is intended for ПК73 board only

Figure 4 – Block diagram of ПК72 and ПК73 boards

ПК72 and ПК73 boards have sixteen inputs and two outputs. Input signals are represented by discrete output signals of vibration control boards, and the output signals are also discrete signals, ΔΔ1.1 (‘OR’); ΔΔ2& (‘AND’). ’OR’ signal occurs in the presence of ‘0’ signal on one of the inputs, and ‘AND’ signal – in the presence of ‘0’ signal on two neighboring inputs (1-2; 2-3; 3-4;…15-16). The required protection operation algorithm is set by feeding corresponding signals to the board input from the parameter control boards.

ПК73 boards differs by its function to remember the input signals occurrence (event). Only events by eight input signals are remembered. The board has two memory registers (areas). The first register ‘M’ memorizes all eight input signals, and the second register ‘M1’ memorizes only one that was the first to occur. Availability of memory allows to monitor and decipher the equipment operation.

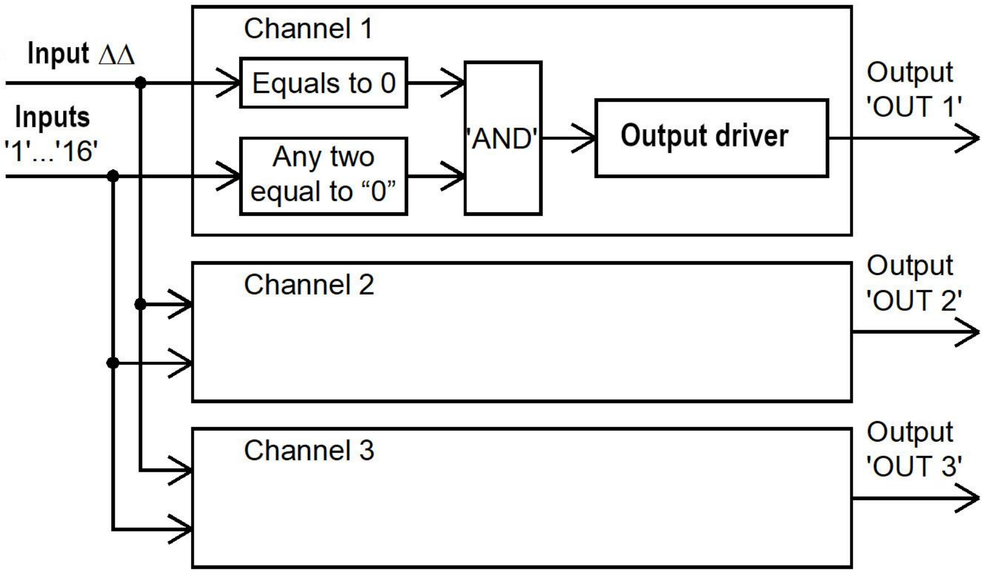



Figure 5 – block diagram of board ПК74

ПК74 board is intended for processing logic signals with reference to two input groups and generation of the output signal in compliance with the board operation logic.

To increase the board operation reliability, it has three identical channels, processing input signals simultaneously. Each channel is independent in processing input signals and generates a separate output signal with the open collector ‘OUT1… OUT3’.

Group ‘ΔΔ‘ has one input, actuation condition: occurrence of the low-level signal at the input. Group ‘1…16’ has 16 inputs, actuation condition: occurrence of low-level signals at two and more inputs. If two groups are actuates, low-level signal occurs at the output.

1.5.13 ПК80, ПК81 boards

The input signal for control boards of ПК80. ПК81 parameter step is represented by the unified output signal (DC voltage (0 – 10) V), that characterizes the value of the monitored parameter.

The ‘step’ means the abrupt irreversible change in the signal from any stable condition. Time parameters of the ‘step’:

- acceleration time – time from the signal change beginning to the moment when the change attains the signaling preset value;
- pulse peak time – the period of time when the amplitude of the change exceeds the signaling preset value;
- simultaneous occurrence of two or more parameter steps – period of time when several input signals reach the the signaling preset value.

ПК80 and ПК81 boards differ by the number of inputs and the circuit for logical processing of input signal steps.

ПК80 board has eight inputs and delivers the ‘step’ signal by any input of ‘OR’ circuit.

ПК81 board has six inputs and delivers the ‘step’ signal both by ‘OR’ and ‘AND’ circuits as per ГОСТ Р 55265.2-2012, ГОСТ Р 55263-2012.

Signals with vertical and transverse component of three bearings vibration are fed to the board inputs. It is possible to implement the algorithm by ‘AND’ circuit for one component of six bearings vibration. All signal ‘steps’ are memorized and may be reset by the operator. Interlocking is possible – disabling the boards at startup.

1.5.14 Control board ПК90

Control board ПК90 is intended for checking the equipment signaling and protection systems operation by any control channel. In conducting the check, no switching can be performed with the control channel under check. The check may be conducted at any equipment operation mode.

Control board ПК90 is the adjustable source of signals imitating the signals coming from the sensors (converters).

The section, as a rule, is manufactured to provide space for its installation. ПК90 provides connection of an appropriate signal type to one or several control boards and adjustment of its information parameter. Connection to the specific board is carried out by pressing the appropriate pushbutton. Parameter control board summarizes the check signal from ПК90 with the sensor (converter) signal. Control board ПК90 allows simultaneous performance of checks in the like channels located in seven boards of the section.

Control board ПК90 is manufactured in several variants differing in the frequency range, polarity of output pulse signals and type of control surfaces (‘groove’, ‘pinion’), as per Figure J.9.

1.5.15 Monitoring of vibration velocity sensors

Monitoring of vibration velocity sensors is carried out by ПК90 board. To check normal operation and integrity of sensors ДПЭ22МВ, ДПЭ22МВТ, ДПЭ22П, ДПЭ23МВ, ДПЭ23МВТ, ДПЭ23П, ДПЭ24 с ИП24, 625В01 with ИП24, and the entire control channel, the test signal from ПК90 board must be applied to the input of the sensor test signal. Testing may be carried out in any equipment operation mode.

The test signal allows to check integrity of the piezo element, piezo element communication lines with the converter (amplifier), and amplification factor.

In case of the sensor malfunction, the transfer coefficient changes what in its turn is a criteria for the sensor condition assessment.

In case of the piezo element circuit-disconnection fault, the test signal is not applied, and in case of a short-circuit it is increased by several times.

If the monitored sensor is subject to vibration, then the test signal is mixed with the vibration signal and transfer coefficient slightly changes. Nevertheless, it does not prevent from performing the sensor condition assessment, as the above malfunctions change the transfer coefficient by several times.

1.5.16 Surface tilt sensor ДВТ70

Pendulum sensor ДВТ70. Surface tilt is determined through displacement of the sensor sensitive element with regard to the pendulum component which is always in the vertical position. The pendulum component is 100 mm. Amplification and conversion of the sensor signal, filtration of the pendulum oscillations is performed by the converter.

1.5.17 Front panels of the control boards, control units, power supply units and imndication units are described in Annex B.

1.5.18 Arrangement and purpose of controls is specified in Annex J.

1.5.19 Explosion-proofness

Explosion-proofness of piezoelectric sensors ДПЭ22Ex; ДПЭ23Ex, converters ИП34Ex; ИП36Ex and connected eddy current sensors ДВТ10Ex, ДВТ20Ex; comparators К22Ex, and connected velocity sensors ДВТ10Ex is provided by explosion protection system ‘Intrinsically safe electrical circuit i’ as per ГОСТ 31610.11-2014 provided that safety operation conditions designated as ‘X’ in the explosion protection marking are complied, along with and design made in compliance with ГОСТ 31610.0-2014, ГОСТ 31610.11-2014.

Intrinsic safety of vibration velocity sensors ДПЭ22Ex, ДПЭ23Ex, converters ИП34Ex, ИП36Ex and comparators К22Ex is attained due to:

– voltage limitation on capacitors by voltage regulator diodes;
– using capacitors of safe capacity values;
– double-sided sealing of all electronic elements and the printed board with the compound as per ГОСТ 31610.11-2014;
– connection of protection barriers installed outside the explosion hazard areas to intrinsically safe electric circuits, which explosion protection marking comply with the values of intrinsically safe circuits of sensors, converters, and comparators.

### 1.6 Marking of equipment

Marking is applied directly onto the assembly units, covers, front panels, and other accessible places.

Information contained in the marking shall be determined in compliance with Annex H.

Marking shall contain:

– manufacturer's trademark;
– type (designation) of the assembly unit;
– serial number and the date of manufacture;
– designation or purpose of sigaling, switching and control components;
– version of the assembly unit;
– type approval mark.
– explosion protection marking of ‘1Ex ib IIB T3 Gb X’ for piezoelectric sensors ДПЭ22Ex, ДПЭ23Ex, converters ИП34Ex, ИП36Ex and connected eddy current sensors ДВТ10Ex, ДВТ20Ex, comparators К22Ex and connected velocity sensors ДВТ10Ex located in sealed boxes КП13Х, КП13Х-Пр1, КП13ХР, КП23ВХ, КП23ПХ, КП23Х-Пр;
– Maximum values of intrinsically safe electrical circuits

  piezoelectric sensors ДПЭ22Ex and ДПЭ23Ex: Ui : 25,2 V Ii :240 mA; Pi : 1,5 W; Ci : 100 picofarads; Li : 100 uH;.

  converters ИП34Ex, ИП36Ex: Ui : 25,2 V; Ii :240 mA; Pi : 1,5 W; Ci : 100 picofarads; Li : 100 uH;.

  comparators К22Ex: Ui : 25,2 V; Ii :240 mA; Pi : 1,5 W; Ci : 100 picofarads; Li : 100 uH;
– ambient air temperature - 40 $^{o}$C ≤ ta≤ +70 $^{o}$C;
– code KKS, assigned in the coding system during the design.

The equipment designated for the delivery to the nuclear power station and complying with the safety class 3 in compliance with НП-001 is marked as ‘АС-3’.

Method of marking application on the assembly units depends on the operation conditions and is specified on the drawings. The method of marking application should provide for its integrity for a long-term usage.

Marking of transit containers – as per ГОСТ 14192-96.

Manipulation marks No.1, No.3, and No.11 (No.14, No.19) shall be applied to the left top corner on the two adjacent box sides.

The type approval mark shall be applied on the technical documentation (Operations and Maintenance Manual, logbook).

## 1.7 Packaging

1.7.1 Component assemblies shall be packaged into corrugated cardboard boxes.

1.7.2 Packaged component assemblies shall be placed in boxes made according to the manufacturer's drawings. Inside surfaces of containers shall be lined with waterproof paper. Container outage shall be filled with cushioning material.

1.7.3 Operational documents are placed into polyethylene envelopes, and the cabinet must be covered with film. The cabinet placed into the container must be prevented from moving.

1.7.4 Prior to being packaged, sensor ДВТ70 must be caged by the locking screw 1 in compliance with Figure C.15. Caging operations shall be performed with the sensor in the horizontal position.

# 2 Intended use

## 2.1. Procedure for equipment installation and mounting

2.1.1 Installation and operation procedures must be performed in compliance with guidelines specified in Chapter.7.3 ROEI (Regulations for Operation of Electrical Istallations), ПОТРМ-016-2001 РД153-34.0-03.150-00 (Interbranch labor protection rules (safety regulations) for electrical installations operation), ORCEI (Operation Rules of Customer's Electrical Installations) and this OMM.

Installation of intrinsically safe electrical circuit shall be carried out in compliance with subclause 6.3.5 of ГОСТ 31610.11-2014.

Cabinets, sections, control and indication units shall be connected to the common grounding bus.

2.1.2 Installation and mounting of the equipment shall be performed with reference to the project, as a rule, developed by SPE VIBROBIT LLC.

The project shall include the following:

– general view (front panel) of section, cabinet;
– diagrams and drawings of sensors, converters and boxes installation on the equipment;
– schematic electrical diagrams of sections;
– drawings of harnesses of sections, cabinet;
– connection diagrams of sections in cabinets;
– external connection diagrams of sensors, converters, and cabinets.

2.1.3 Sensor place on the equipment

Selection of the place (control surface) for a proximity sensor is an important event. The control surface is located on the unit under test and is intended to close the sensor electromagnetic field. The control surface must be made of ferromagnetic material. Such surfaces may be: the rotor shaft journal for monitoring shaft vibration; projections, "ridge" ("band") or shaft ends for monitoring axial displacements or relative expansion of the rotor.

**Where water content in oil is increased, no КР10 and КР20 connector boxes shall be installed in the casing. Sensors should be used without intermediate connectors.**

**To prevent mutual effect of the closely located sensors intended for measuring axial offset, the distance between their axles shall be not less than 40 mm.**

**Dimensions, surface roughness, axial and radial runout of the control surface are given in Annex K and determined by the sensor dimensions and its electromagnetic field. Presence of other metal parts and surfaces within the field may result in an unregulated measurement error.**

**Installation of sensors should be performed in compliance with Annex K.**

In space-limited environment, axial offset sensor shall be secured on the setter МУ11.

Installation of M24 feedthrough should be carried out in compliance with Figure K.25.

2.1.4 Mounting of ДВТ sensors

**When performing mounting operations, serial numbers of sensors, КС cables, rods, ИП converters and K comparators should match.**

2.1.5 Installation of axial displacement sensors and relative expansion of the rotor sensors.

**Installation of sensors shall be carried out in compliance with Annex K.***

Irrespective of the sensor type and the measurement range, the output signal of the converter shall be the same (1– 5); (4 – 20) mA.

When determining the initial position of the sensor, the unit under test must be in its initial condition. Installation of sensors with regard to the rotor must be determined in compliance with the output characteristic given in Annex D.*

The sensor initial position with regard to the control surface shall be determined by the zero mark located on the scale of the device of ПК10, ПК11 (БК10, БК11) control boards (units).

When installing a relative displacement (axial offset) sensor on the unit end cover, it is recommended to set the mounting clearance by the sensor current (the sensor must be pre-calibrated on the steel control surface similar to the one of the unit under test).

Apply voltage to the converter. Check the range and measurement error by applying the setter to the dial indicator by changing the sensor position with reference to the control surface.

**As the metal grade and dimensions of the control surface of calibration stand and rotor may vary, output characteristic of the converter must be adjusted in compliance with Annex N, within the permissible basic error**.

After completion of the calibration, the sensor shall be installed into the initial installation position.

The instrument located on the control board should read zero.

Where the equipment mounting operations were not completed, power to the converter shall be fed from ПН11 instrument or from the source of stabilized voltage – + 24 V, and the output current shall be measured by the milliamperemeter.

**Reserve channel converters used for measuring the axial offset and the relative expansion also must be adjusted for operation with the installed sensors. This will allow to replace the failed converter with the spare one with minimum error.**

**Where the gap exceeds 3.0 mm or no any ДВТ40, ДВТ43 sensor available within the measuring plane of control “band”, the output signal of the ИП42, ИП43 converter is equal to 0.*

2.1.6 Installation of the bearing-mounted shaft vibration sensors, rotor shaft bending sensor

Shaft vibration sensor measures the air gap between the surface of the rotor journal and the sensor end face. Check of the gap management range and error shall be carried out by applying the setter МУ11, МУ14 and the dial indicator.

**As the metal grade and dimensions of the control surface of calibration stand and rotor may vary, output characteristic of the converter must be adjusted in compliance with Annex N, within the permissible basic error**.

When operating the machine, the **bearing play** is of importance (gap between the shaft journal and the sensor).

Monitoring the bearing play enables monitoring the rotor position.

The gap between the sensor and the shaft may vary within the range from 0.6 to 2.2 mm (from 0.2 to 1.8 mm with reference to the ПК control board scale). Adjustment of the sensor gap is carried out by the output signal of the converter, when the upper liner is on the rotor. It is recommended to adjust the output signal to (3.0 ± 0.2) mA for converters with an output signal (1-5) mA, which corresponds to the gap (1.0 ± 0.1) mm by the scale of the control board ПК. Output signal (12 ± 0.2) mA for converters with output signal (4-20) mA, corresponding to the gap (1.0 ± 0.1) mm.

When installing the sensor for measuring the bending (vibration) of the rotor shaft, the width of the control belt must be at least 25 mm. With the axial displacement of the rotor, the sensor must be within the belt, at a distance of at least 5 mm from the belt edge.

**The belt surface smoothness should not be worse than 1.6 class of roughness, the runout should not be more than 20 microns.**

The surface should be free of holes, protrusions, depressions, nicks, grooves, uneven ends of the belt, magnetized metal, etc. These surface defects prevents the reliable measurement of the shaft bending.

**In case of irreversible defects (e.g. holes) on the "bending track", it is recommended to exactly repeat the defect on the shaft opposite side (180 deg).**

2.1.7 Installation of the RPM sensor

ДВТ10, ДВТ10Ex, ДВТ30, ДХМ sensors are installed at the distance specified in Figures K.8 and K.9 from the pinion tooth or the shaft surface. The comparator K22 output signal must be ‘0’.

When the sensor is over the ‘groove’, the comparator output signal must be ‘1’. In operation, the pinion or shaft surface should not have significant (exceeding 0.5 mm) vibration displacement, as it may cause false operation of the sensor, and several current pulses may be observed on the comparator output per one rotor rotation.

If the pinion with 60 teeth is used as a control surface, then the minimum dimensions of the pinion teeth should be not less than the ones specified in Figures K.8 and K.9.

2.1.8 Installation of vibration velocity sensors

The sensor measures vibration along the axis perpendicular to the attachment plane.

The direction of vibration to be measured by parallelepiped-shaped sensors is indicated by arrow '↑' on the sensor piezoelectric converter body.

**If sensors are used for measuring not only the level of vibration, but also the phase, then, when installing them on the equipment, it is necessary to observe the established orientation (phasing).**

To position the sensor, it is recommended to use the cover of the sensor piezoelectric conveter. All sensors used for monitoring the vertical component of the bearing vibration should be attached with their cover up; sensors used for monitoring the lateral component – from the left side with the cover facing the left side of the turbo-generator, and the sensors used for monitoring the axial component – from the left side of the turbo- generator with the cover facing the generator, in compliance with the methodical instructions СО 34.35.105-2002.

The connecting cable КС24 on the side of the sensor 625В01 must be secured by four clamps, spaced 250 mm, starting from the minimum possible distance from the connector.

2.1.9 Installation of the surface tilt sensor ДВТ70 should be carried out in compliance with Figure К.24.

2.1.9.1 Measuring surface absolute tilt (with regard to the liquid level)

The sensor shall be placed on the even surface of the component facing the direction of the surface tilt measuring, and the converter output signal shall be measured. Adjustment screws of ДВТ70 shall not protrude beyond the measuring plane. Use the output signal value to determine tilt of the controlled surface in mm/m. A certain converter output signal (1 – 3 – 5) mA or (4 – 12 – 20) mA (minus N – 0 – plus N) corresponds to the monitored inclination.

The controlled surface tilt angle is designated by signs '⊕'; '⊖' on the sensor base. Converter output signal values within the range of (1 – 3) mA mean that the base side marked with '⊖' **is higher** than the base side marked '⊕'.

Should the converter output signal be within the range of (3 – 5) mA – the side marked '⊕' **is higher** than the side marked '⊖'.

The sensor caging is carried out by screwing down Screw 1 till it goes. Uncaging is carried out by unscrewing the screw from the locked position to the distance of 2 mm. Converter output signal setpoint time shall not be less than 60 seconds.

2.1.9.2 Measuring relative surface tilt

Using the block level 200 – 0.02 ГОСТ 9392-89, place the sensor ДВТ70 onto the controlled surface in the vertical position, into two mutually perpendicular directions. Uncage the sensor by undoing screw 1. Adjust the sensor position by adjustment screws so that the converter output signal was equal to $(3{,}00 \pm 0.03)$ mA.

Sensor ДВТ70 will measure changes in the controlled surface tilt during operation.

2.1.10 All sensors after their setpoint to the initial position should be secured and the fasteners must be also secured. The sensor cable must be mechanically protected and fastened both from inside and outside of the equipment, without any excessive tension, **twisting** and bending to the **radius of less than 20 mm**, and it must not hang loose.

Special attention should be paid to the sensor cable fastening inside the equipment. The cable must not be subject to air and oil flow influence and must not vibrate relative to the mounting face. The cable shall be fastened by **0.35 m-spaced** clamps or attachment clips (to the inside surface of the equipment) and passed through the fastened metal hose, pipe or duct. Outside the equipment, all cables should be laid in pipes, ducts or metal hoses.

Completeness of fasteners used for the equipment installation is given in Annex T.

**Not used unified DC signals of (0 – 5); (4 – 20) mA must be connected to the zero wire.**

2.1.11 Procedure for control unit installation and mounting

The unit must be installed directly on panels of units or local equipment control boards.

The dimensions of the rectangular opening for the unit installation: height (112+0.5) mm; width (56,2+0.5) mm.

Several units may be installed side-by-side, without any gaps into the common opening or into the framework 3U “Евромеханика 19”.

The unit casing has ventilation openings, so, to prevent water from getting inside, the unit must be canopied.

Connection of the unit electrical circuits is carried out via connectors. The connectors allow for direct connection of cable wires (conductors) with cross-section not exceeding 2.5 $mm^2$.

The unit connection to sensors and converters should be carried out in compliance with Annex S.

The unit casing must be connected to the grounding bus. Grounding conductor should be connected to terminal designated as 

2.1.12 The length of cable connections between the cabinet (secondary equipment) and the sensors, converters, indication unit - not more than 300 m with a wire cross section of 1 $mm^2$ and not more than 400 m with a wire cross section of 1.5 $mm^2$. The cable must be shielded, screen should be connected to the grounding bus of the Vibrobit equipment of the upper level. It is recommended to lay the control circuit cables separately from the power and high-voltage ones.

2.1.13 Installation of the sensors on the insulated generator bearing should be accomplished by applying insulating gaskets, in accordance with Figures K. 22, K. 23.

In this case, it is necessary to use vibration velocity sensors with insulated metal hose ДПЭ22МВ, ДПЭ22МВТ, ДПЭ22П, ДПЭ23МВ, ДПЭ23МВТ or ДПЭ23П.

Shaft vibration sensors must be used with the insulated connecting cable КС10.

Do not install transducer boxes on bearings.

## 2.2. Procedure for equipment operation

2.2.1. Designation and description of control, signaling and monitoring elements

'LIMIT' – limit, setpoint;

'OK' – unit is ON; normal condition;

'$\overline{OK}$', '$\overline{OK}$ SYS' – malfunction - faulty operation;

'IN', 'INPUT' – input, input signal;

'OUT' –parameter output, output signal;

'AXIAL' – axial offset, displacement;

'VIB' – vibration;

'GAP' – gap, distance between the control surface and the sensor; direct component of the vibration velocity sensor output signal;

'RPM' - shaft and rotor revolutions per minute;

'MAX' – maximum monitoring;

'SET' – inspecting the setpoints values (ПК40);

'Δ', '∇', 'ΔΔ', '∇∇' - designation of the monitoring null detector (resistor – setpoint the monitoring level; LED – actuation signaling; position of the selector switch –measuring level monitoring);

'ΔΔ1.1' – 'OR' circuit signal (1 of 1);

'ΔΔ2&' - 'AND' circuit signal (2 of 2);

' ~ ' – instantaneous value of the vibration signal;

'ON' – switch on, enabled;

'OFF' -switch off, disabled;

'POWER' – equipment power supply voltage;

'M', 'M1' –memory;

'RESET'– reset of the input parameter, memory; return to the signal listening mode by the-input;

'1' – '3' – parameter control channel number;

'1' – '6', '1' – '8' – input numbers (actuation signaling LED) of the board;

'1' – '7' –number (pushbutton) of the output test signal;

' = ' – DC voltage

'+', '–' – DC voltage polarity

' ~ ' – sinusoidal AC voltage

' f ' – pulse signal frequency

' ↷ ' – signal parameter adjustment.

2.2.2 Actuation

Supply voltage is fed to the equipment sections through the circuit breakers or toggle switches installed on the electrical control panel.

The equipment actuation is carried out by channels or sections by changing the position of the ‘POWER’ toggle switch located on the front panel of the power supply unit (PSU).

Output voltage from the power supply unit is fed to the sensors, converters, and control boards.

**Prior to enabling power supply unit, it is necessary to change the position of the ‘INPUT’ toggle switch to ‘$\overline{OK}$ ‘.** The toggle switch is intended for manual inputting the ‘$\overline{OK}$ ‘ signal.

’$\overline{OK}$ ‘ signal disconnects all signaling system output relays of the channel or section concerned. Presence of the signal is indicated by ‘$\overline{OK}$ SYS’ LED located on the power supply unit.

Availability of output voltages from the power supply unit is indicated by the LEDs located on the front panel.

Under normal conditions, ‘OK’ LEDs located on the control boards (CB) must be illuminated.

The toggle switch ‘INPUT’ should be switched to the ‘OK’ position after completing the status check of the power supply units, control boards and when there are no any false signaling available. ‘$\overline{OK}$ SYS’ LEDs are switched off with (7 ± 2) second delay.

**The toggle switch ‘INPUT’ should be in ‘$\overline{OK}$ ‘ position prior to disconnecting the section or replacing the control board.**

Energizing of the control unit (CU) is carried out by the toggle switch ‘POWER’ located on the back panel. LED ‘OK’ must be illuminated when sensors and converters are connected to the unit.

LED ‘TEST’ is illuminated when pushbutton ‘TEST’ is pressed down.

2.2.3 Adjustment of signaling system limits

On CB (CU), the channel selector should be switched to the position of the monitoring level measuring of the corresponding null detector. The limit value is indicated by the pointer instrument and the digital indicator of the control board. Adjustment of the required limit shall be carried out by applying the appropriate resistor located on the front panel.

On ПК40(БК40), the signaling system operation limits (setpoints) shall be set up according to the customer's requirements at the manufacturer's plant and stored in the permanent memory of the unit. Where it is required to change one or several setpoints, perform the following operations:

– Press and hold all four push buttons with the operation mode selection: ‘SET’, ‘MAX’, ‘GAP’, ‘RPM’;
– Pass the screwdriver thin blade through the hole in the front panel to press ‘RESET’ button, in this case, the control board is put into the programming mode (the digital indicator will display one of the setpoint values);

– By pressing '+' and '-' buttons, set the required value for the corresponding setpoint. To memorize the preset value, press 'M' key (the digital indicator will display a message "LOAD" - and the new value for the setpoint will be stored in the permanent memory of the unit);
– By pressing 'SET' key, select the required value for the setpoint (the digital indicator will display message "УСоо", and in 0.5 second it will switch to the digital value of the setpoint) and their corresponding hysteresis values (the digital indicator will display a message "Goo" and in 0.5 seconds it will change to the digital value of hysteresis). If necessary, repeat the previous step. The recommended values of hysteresiss:

  for speed exceeding 100 rpm – 10;

  for speed under 100 rpm – 0;
– After adjusting the setpoint values and hysteresiss, press 'RESET' button once again through the hole in the front panel to restart the unit;
– Consecutive pressing of 'SET' button will allow you to inspect the new setpoint values.

2.2.4 Measuring of parameters

CB (CU) parameters are measured by applying the pointer instrument, digital indicator and the measurement selector switch by switching it into the required position.

In ПК40 (БК40), selection of the measurement mode is carried out by pressing 'RPM', 'GAP', 'MAX', 'SET' buttons.

The multichannel CB (CU) switch, in addition to the parameters monitoring function by channels 1 – 3, has the position for measuring the maximum value – 'VIBmax'. In this position, the maximum value of the parameter with regard to control channels is measured. The number of channel with the maximum parameter value is indicated by special LEDs – '1' – '3'. If parameter value is the same for all channels, all LEDs are illuminated.

Simultaneously, the monitored parameter is connected to 'OUT' jack and may be measured by applying more accurate and specialized instruments.

Full-scale deflection of the pointer instrument corresponds to the DC voltage of +10 V at the 'OUT' jack.

The pointer instrument of the ПК20, ПК21 (БК20, БК21) control boards (units) have two scales.

The left scale ((0–0.2) mm; (0–0.4) mm) is intended for reading the relative vibration displacement excursion, and the right scale ((0–1) mm; (0–2) mm) – for reading the gap between the rotor journal surface and the sensor end face.

Gap measurements are carried out in the 'GAP' position of the switch, and this being the case, the readings of the control board digital indicator shall be multiplied by 5.

Control boards (units) ПК30, ПК31 and ПК32 (БК30, БК31 и БК32), at the switch in the 'GAP' position, measure the output DC current of the vibration velocity sensor in mm/s. 1 mA corresponds to the scale begging, and 6 mA – to the scale end. DC current measurements are accomplished for the purpose of monitoring the vibration velocity sensor and communication line operation status. Current values must be within the limit of (2 – 4) mA.

In ПК40 control boards, when the switch is in ‘GAP’ position, the indicator pointer will intermittently react to the check groove passing the sensor. When the equipment is operating, the pointer instrument indicates the average value of the comparator pulse signal. If the pointer deflects beyond the zero mark, it means that there is an open circuit or a short-circuit in the К22 circuit.

The digital RPM number is indicated on the БИ23 and ПК40 (БК40) board.

**Position of the signal selector switch has no affect on the control board (unit) operation.**

2.2.5 Signaling of the null detector status

The null detector is switched on when the parameter is approaching or exceeding the value preset for the limit. Actuation of the null detector is indicated by the CB (CU) LED. Accuracy of the null detector operation may be checked by comparing the parameter value and with the limit preset value or for control boards – by applying control boards ПК90.

If the parameter requires the command to be delivered to the system of protection and signaling, then, when the null detector energizes the relevant electromagnetic relay actuates.

In power supply units, when a certain null detector is switched on, the relevant electromagnetic relay is energized.

2.2.6 Signaling of equipment failure

Integrity of eddy current sensors and converters, communication lines, power supply sources, and reference voltages is checked in the equipment.

Control channel failure is indicated by illuminated ‘ОК’ LED located on the CP and ‘$\overline{OK}$ SYS’ LED located on the power supply unit. Illumination of ‘$\overline{OK}$ SYS’ LED is accompanied by feeding the signal to the process signaling system of the equipment – ‘Vibrobit malfunction’ and disconnecting the output relays of signaling system and protection of the corresponding channel or sections.

**Operation of the equipment with ‘$\overline{OK}$ SYS’ signal is not permissible.**

Measures should be taken to eliminate any faults. Operation of the equipment shall be restored by replacing faulty boards, units, sensors and by restoring integrity of electric circuits.

If it is impossible to eliminate the fault while the equipment is operating, the faulty parameter control channels should be put out of operation (each individual PSU or CB shall be switched off or taken out of the connector).

‘ОК’ LED located on the CB goes off, if:

- The instrument reading, when the switch is in ‘GAP’ position, exceeds the scale limit (the following units are not operating properly: sensor, converter, communication line, no supply voltage for the sensor, converter);
- Signaling limits are below the preset ones by (10 - 20) %, equal to zero or below zero (the following units are not operating properly: the source of the reference voltage used for setting the signaling limits, ПК control board).

2.2.7 Signaling of the power supply unit fault

In the power supply unit, illumination of the ‘$\overline{OK}$ SYS’ LED takes place when there is no stabilized voltage or their nominal values or ripples exceed the preset range – ± (15 ± 0.6) V; + (24 ± 1) V.

Absence of ~220 V is also signaled by a special relay located in the power supply unit that is energized when voltage is available.

2.2.8 Signaling of БК control unit and the control channel failure

Failure of the unit, sensor or the converter is indicated by the ‘OK’ LED that goes off and closure of the output contacts of $\overline{OK}$ relay.

The following is monitored in the unit:

– stabilized voltages of the power supply board;
– reference voltages;
– integrity of the unit communication lines with sensors and converters;
– integrity of eddy current sensors and converters (sensor, converter signal exceeding the pointer instrument measurement range).

**No operation with ‘OK’ LED switched off is permitted.**

Measures should be taken to eliminate faults. The equipment is restotred by replacement of faulty boards, units, sensors or restoration of electrical circuit integrity.

‘OK’ LED on the CU goes off, if:

– the instrument reading with the switch in GAP or AXIAL position is outside the scale range (faulty sensor, converter, opening or short-circuit of communication line, lack of power supply to the sensor);

– signaling system limits are below or above the settings by (10 – 20) % (faulty source of reference voltage + 10 V, faulty parameter control board).

–one of the voltages ± 15 V; + 24 V is lacking on the power supply board or their value exceeds the preset limit;

– ± 15 V; + 24 V voltage ripple;

– lack of ~220 V voltage.

2.2.9 Check of БК control unit operation

Check of the control unit operation is performed by the ‘TEST’ switch and resistor.

Number of ‘TEST’ buttons corresponds to the number of measuring channels.

When ‘TEST’ button is pressed, test signal represented by DC or AC voltage is applied to the additional input of the channel input cascade. Voltage value is set by the resistor. By rotating the resistor it is possible to set any parameter value and thus to check operation of all БК assemblies.

In БК40, the AC voltage of the power supply circuit is used as the test signal. The digital indicator displays the supply frequency value multiplied by 60.

2.2.10 Monitoring the actuation of signaling and protection systems on ‘Vibrobit 100’ equipment

**To check monitoring of protection system actuation, toggle switch ‘INPUT’ of the power supply unit must be in ‘OK’ position.**

Monitoring of signaling and protection system actuation is performed by ПК90 board that must be installed into the relevant compartment of the section under test.

The check shall be performed at the nonoperational assembly after connecting the sensors and converters set to the initial position.

**Switches of the control boards must be set in the position to measure parameters ‘AXIAL’ (‘AXIAL MAX’), ‘VIB’ (‘VIB MAX’) or ‘RPM’.**

Test signal from the ПК90 and the signal from the sensor (converter) is applied to two different inputs ‘input +’ and ‘input **–**’ of one channel of the control board.

Control board connection is performed by pressing one of ‘1’ – ‘7’ buttons located on the ПК90. Button ‘1’ relates to the first compartment of the control board starting from the left to the right, button ‘2’ — to the second compartment, etc. If the compartment holds the double-channel board, then the check signal from ПК90 is applied to two input channels simultaneously. If the compartment holds the three-channel board, then the signal to the third channel is applied from the second board ПК90 installed to the right from the first one by pressing the button that corresponds to the selected compartment.

Selection of the test signal shape and polarity for all outputs of ПК90, as well as its information parameter value adjustment is carried out by toggle switches and ‘ ’ regulator in compliance with Figure B.2. Toggle switches position and the adjusted output parameter of ПК90 for various control boards are specified in Table 33.

Table 33

<table>
<tr><th colspan="2" rowspan="2">Control board</th><th colspan="3">Toggle switch position</th><th rowspan="2">Adjusted output parameter of ПК90</th></tr>
<tr><th>‘~’ / ‘=,f ‘</th><th>‘+’ / ‘–,f ‘</th><th>‘~,=‘ / ‘ f ‘</th></tr>
<tr><td rowspan="2">ПК10, ПК11, ПК12, ПК13</td><td>Input ‘+’</td><td rowspan="2">‘=,f ‘ (‘=‘)</td><td>‘–,f ‘ (‘–’) *</td><td rowspan="2">‘~,=‘</td><td rowspan="2">DC voltage</td></tr>
<tr><td>Input ‘–’</td><td>‘+’ *</td></tr>
<tr><td colspan="2">ПК20, ПК21</td><td>‘~’</td><td>-</td><td>‘~,=‘</td><td>AC voltage</td></tr>
<tr><td colspan="2">ПК30,ПК31,ПК32</td><td>‘~’</td><td>-</td><td>‘~,=‘</td><td>AC voltage</td></tr>
<tr><td colspan="2">ПК40</td><td>‘=,f ‘</td><td>‘–,f’</td><td>‘ f ‘</td><td>Pulse signal frequency</td></tr>
<tr><td colspan="6">* If zero is in the middle of the scale, then, to check the range from zero to the lower limit, toggle the switch</td></tr>
</table>

In vibration velocity sections, the test signal must be applied to the test signal input of sensors ДПЭ22МВ, ДПЭ22МВТ, ДПЭ22П, ДПЭ23МВ, ДПЭ23МВТ, ДПЭ23П, ДПЭ24, 625В01. In this case, normal operation and the signaling system actuation is checked for the whole vibration velocity RMS measuring channel.

Monitoring the process of the signaling system actuation is performed by smoothly changing the output signal information parameter value by ‘ ‘ regulator starting from zero by the scale of the pointer instrument till LEDs of the signaling system setpoints are illuminated — preliminary ‘∆‘, ‘∇‘ and emergency ‘∆∆‘, ‘∇∇‘.

To simulate the ‘step’ on the vibration velocity RMS measuring boards, the test signal level must be increased, within the period of time not exceeding 2 seconds from any previously preset value, by not less than 1 mm/sec and maintain it for not less than 10 seconds.

The logic protection circuit operates by applying output signals of control boards to the corresponding inputs of boards ПК72 (ПК73, ПК74), or — to external relays installed in the section and determined by the project specifically for each control channel.

**Upon completing the tests, it is necessary to return ‘1’ – ‘7’ buttons to the depressed position or remove ПК90 board from the connector and cover the compartment with the panel.**

**ATTENTION! It is strictly prohibited to check operation of vibrosensors by striking piezoconverter, place of installation with metal or nonmetal items (hammer, rod, bar, etc.), as well as knocking the piezoconverter against metal structure. This may result in the piezoelement damage and the sensor malfunction. It is permissible to check the vibrosensor serviceability by conducting the vibration testing only at the vibration control stand or by shaking the piezoconverter by hand.**

2.2.11 Digital indicators of the control boards may be disconnected by ‘INDICATORS’ toggle switch located in the БП18 power supply unit. This mode is used to reduce the load on the power supply unit and to turn off the red light of indicators that may irritate the operator. Disconnection of the digital indicator does not affect the control boards operation.

# 3 Maintenance

## 3.1 Equipment maintenance

Maintenance is carried out to provide normal operation of the equipment in the course of its service life.

3.1.1 Recommended types and frequency of the equipment maintenance:

- preventive inspection – on a monthly basis;
- scheduled maintenance – during the equipment repair operations;
- periodic calibration in compliance with the section 3.3;
- withdrawal from service.

3.1.2 Preventive inspection includes:

- exterior inspection of sections, transducer boxes, converters, sensors, control boards and units and sensor connecting cables;
- assessment of the equipment operation.

All units of the equipment must be dry, undamaged and reliably secured. The sensor cables must be protected and secured. There should be no any oil leaks through feedthroughs.

Assessment of the equipment operation shall be based on information received from computers, self recording devices, operation of the signaling system, and through measuring parameters by applying other measuring instruments. Deviation of parameters from the established values shall be detected. All cases of zero parameter values of the operating equipment shall be investigated. The discovered faulty units must be replaced.

3.1.3 Scheduled maintenance includes:

- dismantling of sections, control units, sensors, converters;
- inspection and cleaning of equipment;
- detection and replacement of faulty units;
- calibration, verification of units.

Dismantling of sensors and converters shall be performed, if it is impossible to check the equipment condition and technical characteristics, while it is secured in place.

Cleaning of the equipment components shall be performed depending on the contamination degree using a brush, cloths or cleaning rags wetted with alcohol. Dust from the control boards shall be removed by a brush or compressed air preliminary treated to remove metal particles, oil and moisture. Equipment components serviceability shall be checked on control stands. Detected defects shall be eliminated.

Check output voltages of ± 15 V, + 24 V in control units.

3.1.4 Withdrawal from service includes disconnection of the equipment from the power supply source and its dismantling. There are no additional requirements to disposal, as the equipment does not contain any harmful substances.

## 3.2 Routine repairs

Routine repairs shall be conducted when the equipment malfunction have been detected by replacing the faulty units. The equipment malfunction signals are specified in paragraphs 2.2.6, 2.2.7, 2.2.8 and troubleshooting is given in Table 34.

Repair of faulty equipment components shall be carried out by the manufacturer only.

Table 34

| Fault | Possible cause | Corrective actions |
|---|---|---|
| When power supply unit is enabled, no indication of any voltage | 1 Power supply unit fuse has blown.<br>2 No voltage ~220 V | Check and replace the fuse; determine absence and restore ~220 V |
| When power supply unit is enabled, no indication of a certain voltage, '$\overline{OK}$ sys' LED is illuminated. | 1. Short-circuit in the load circuits.<br>2 Faulty power supply unit | Check load resistance of the power supply unit, eliminate the short-circuit, replace the faulty power supply unit |
| '$\overline{OK}$ sys' LED on the power supply unit is illuminated, and 'ОК' LED located on the control board is off. | 1 Faulty sensor or converter.<br>2 Faulty control board.<br>3 Faulty communication line | Check serviceability of the sensor, converter, control board, integrity of communication lines . |
| '$\overline{OK}$ sys' LED on the power supply unit is illuminated. | 1 Ripple of one of stabilized voltages.<br>2 Deviation of one of the stabilized voltages of ± 15 V; + 24 V beyond the limits of the established tolerance as per paragraph 1.3.15 | Check stabilized voltage values. Replace the power supply unit. |

*Continuation of Table 34*

| | | |
|---|---|---|
| When the control unit is on , 'OK' LED is not illuminated<br>Sensors and converters are connected, test signals turned off. | 1 ~220 V not available.<br>2 Blown fuse of the unit.<br>3 No one of ±15 V, +24 V voltages, voltage ripple and one of the voltages exceeds the preset limit.<br>4 Faulty parameter control board.<br>5 Faulty sensors or converters of one of the channels.<br>6 Fault in communication lines | Replace faulty elements or assemblies.<br>Restore integrity of communication lines |
| When the unit is operating, the control board (unit) readings are equal to zero or do not reflect the actual condition | 1 Faulty sensor.<br>2 Faulty control board | Replace the sensor or the control board |
| The control board (unit) reading exceeds the setpoint, and the setpoint LED is not illuminated or the LED located below the setpoint is illuminated | 1 Faulty control board. | Replace the control board. |

### 3.3 Calibration procedure

This section establishes the procedure for the initial and periodic calibrations of the equipment.

The periodical calibration shall be conducted when the equipment is in service, during the scheduled repair or overhaul of the turbo-generator – once in every two years.

Determination of the actual conversion rate, measurement error of eddy-current displacement instruments, vibration displacement of the rotor shaft, which sensors are installed inside the operating equipment, shall be conducted once in every four years, provided that the check of active resistance, the sensor winding insulation resistance and the frequency response is performed at least once in every two years.

The equipment is modular and interchangeable.

Calibration of ДПЭ type sensors, ДВТ82 sensor, sensors sets (converter with the corresponding eddy-current sensor according to table 1), control boards is carried out separately.

Calibration of sensors, converters and control boards serviceability shall be conducted separately.

It is permissible to calibrate the equipment as part of the parameter measurement channel and directly mounted on the controlled equipment.

3.3.1 Calibration of sensors and converters

3.3.1.1 Calibration stages

In conducting calibration, the following operations specified in Table 35 shall be performed.

Table 35

| Operation description | Calibration item No. | Operations to be performed during | |
|---|---|---|---|
| | | Initial calibration | Periodic calibration |
| 1. Exterior inspection | 3.3.1.5.1 | Yes | Yes |
| 2 Try-out | 3.3.1.5.2 | Yes | Yes |
| 3 Determination of the main measurement error, actual value of conversion rate, amplitude response nonlinearity | 3.3.1.5.3.1<br>3.3.1.5.3.2<br>3.3.1.5.3.3<br>3.3.1.5.3.4<br>3.3.1.5.3.5<br>3.3.1.5.3.7 | Yes | Yes |
| 4 Determination of frequency response ripple of vibration velocity and vibration displacement sensors | 3.3.1.5.3.8 | Yes | Yes |
| 5 Check of eddy-current sensor winding electrical insulation resistance | 3.3.1.5.3.9 | Yes | Yes |
| 6 Check of eddy-current sensor winding active resistance | 3.3.1.5.3.10 | Yes | Yes |

3.3.1.2 Calibration means

In conducting calibration, the following means specified in Table 34 shall be applied.

Table 36

| Calibration item No. | Description and type of the main or auxiliary calibration mean; designation of the technical requirements regulatory document and (or) metrological and basic technical characteristics of the calibration mean |
|---|---|
| 3.3.1.5.1<br>3.3.1.5.2<br>3.3.1.5.3.1<br>3.3.1.5.3.2<br>3.3.1.5.3.3<br>3.3.1.5.3.4<br>3.3.1.5.3.5<br>3.3.1.5.3.7<br>3.3.1.5.3.8<br>3.3.1.5.3.9<br>3.3.1.5.3.10 | 1 Stands СП10 (ВШПА.421412.047), СП20 (ВШПА.421412.061).<br>2 Vibration stand:<br>• Parameter setting error shall not exceed 2.0 %;<br>• Frequency range (2 – 1000) Hz.<br>3 Vibration measuring channel:<br>• Vibroconverter of 8305 ‘Brul & Cier’ type;<br>• Charge amplifier of 2635 ‘Brul & Cier’ type.<br>4 DC milliamperemeter Class 0.2.<br>5 AC Voltmeter B7-78/1 Class 0.5.<br>6 Resistance box P4831 Class 0.1 ГОСТ 23737-79.<br>7 Stabilized DC voltage source (24.0 ± 0.5) V, 100 mA.<br>8 Devices СП50 (ВШПА.421412.164), СП60 (ВШПА.421412.056).<br>9 Generator (0.01 – 10000) Hz.<br>10 Dial test indicators ИЧ02, ИЧ10. ИЧ25, ИЧ50 Class 1 ГОСТ 577-68.<br>11 Micrometric depth-gauge ГМ100 Class 1 ГОСТ 7470-92.<br>12 Ohmmeter Class 0.5 as per ГОСТ 23706-93.<br>13 Megohmmeter as per ГОСТ 23706-93.<br>14 Block level 200 – 0.02 ГОСТ 9392-89.<br>15 Ruler - 500 д ГОСТ 427-75. Error ± 0.15 mm. |
| Notes:<br>1 It is permissible to replace the instruments and equipment with the similar ones regarding their metrological characteristics.<br>2 Frequency range of the vibration stand must correspond to the frequency range of the sensor under test. | |

3.3.1.3 Safety requirements

Calibration instruments, as well as auxiliary equipment should have protection grounding.

3.3.1.4 Calibration conditions

In conducting calibration, the following conditions shall be observed:

– ambient air temperature range – from plus 18 to plus 25 °C;
– relative air humidity – from 45 to 80 %;
– atmospheric pressure – not specified;
– supply voltage – from plus 23.5 to plus 24.5 V;
– sound pressure level – not exceeding 65 dB;
– load resistance for output signal:

| | |
|---|---|
| (1 – 5) mA | (2.000 ± 0.005) kOhm ; |
| (4 – 20) mA | (500 ± 1) Ohm; |

– levels of external electrical and magnetic fields, as well as vibration effect at the place of the measuring instruments, matching devices and measuring means installation shall not exceed the norms established by related regulatory documents;
– serial numbers of sensors, cables, converters (ИП) or comparators (K) should be the same;
– calibrated are:
  - eddy-current displacement measuring instruments on stands СП10, СП20 in compliance with Figures L.1 – L.3 or directly on the monitored equipment in compliance with Figures K.27 – K.30;
  - sensors measuring vibration velocity and vibration displacement on the vibration stand, in compliance with Figures L.4 and L.5;
  - eddy-current RPM measuring instruments on СП50 device in compliance with Figure L.6;
  - tilt sensor on СП60 device in compliance with Figure L.7.
– metal grade and dimensions of the reference sample tested on the stand СП10, СП20 must be identical to the calibration control stand and the control surface of the monitored equipment.

3.3.1.5 Calibration procedure

In conducting calibration, it is necessary to keep the protocol of test results (calibration record). The protocol may be completed in arbitrary form.

3.3.1.5.1 External inspection

In conducting external inspection the following shall be checked:

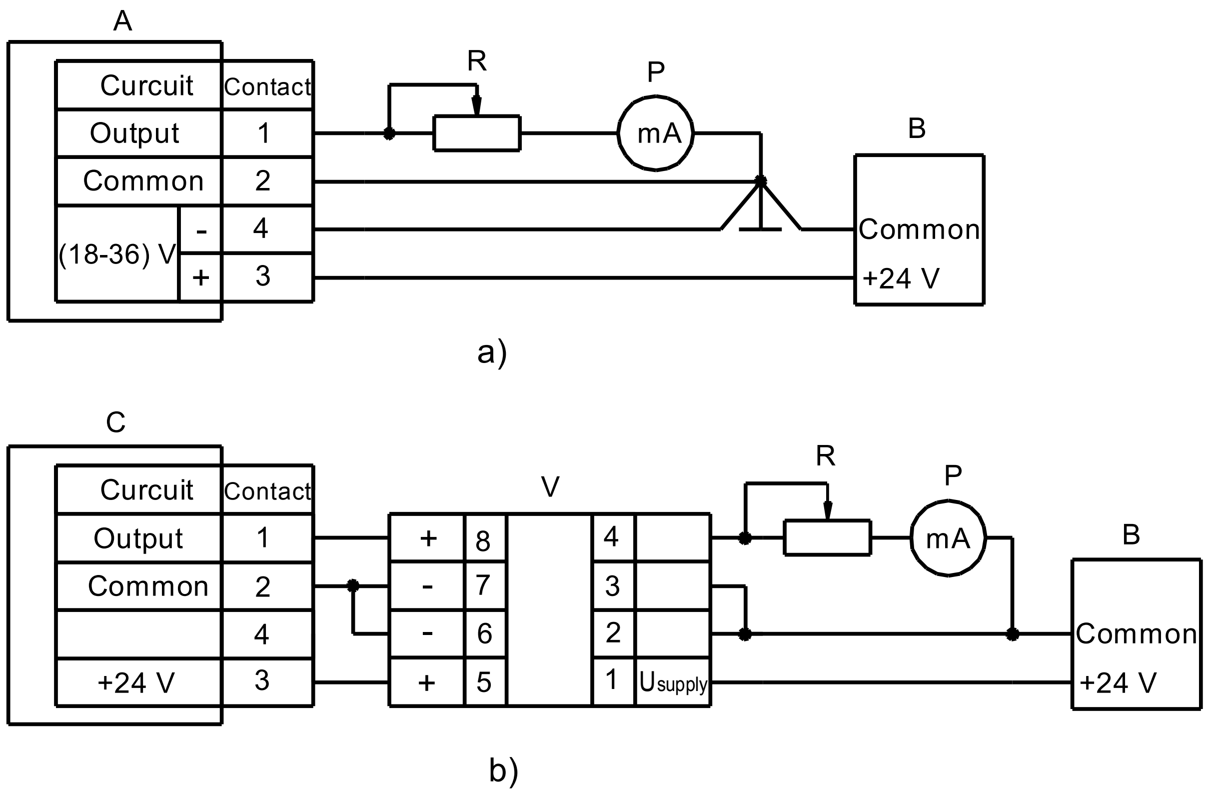
– Completeness and cleanliness of the checked sensor, converter to;
– Presence of markings;
– Absence of damage to casing, connectors (terminal blocks).

3.3.1.5.2 Try-out

For the purpose of trying out, the following shall be performed:

– Rig up the electrical circuit for the tryout in compliance with Figures 6 – 9;
– Secure the sensor on the stand or the equipment under test;
– Connect the power supply source and, by setting the parameter on the stand or equipment, test operation of the sensor or converter.

The schematic electrical diagram for testing the ДВТ82 sensor, sensors with converters ИП34, ИП42, ИП43 and ИП44, and sensors with ИП34Ex converters is given in Figure 6.




A – sensor, converter;

V – intrinsically safe barrier БИБ – 02DP-22;

C – converter ИП34Ex;

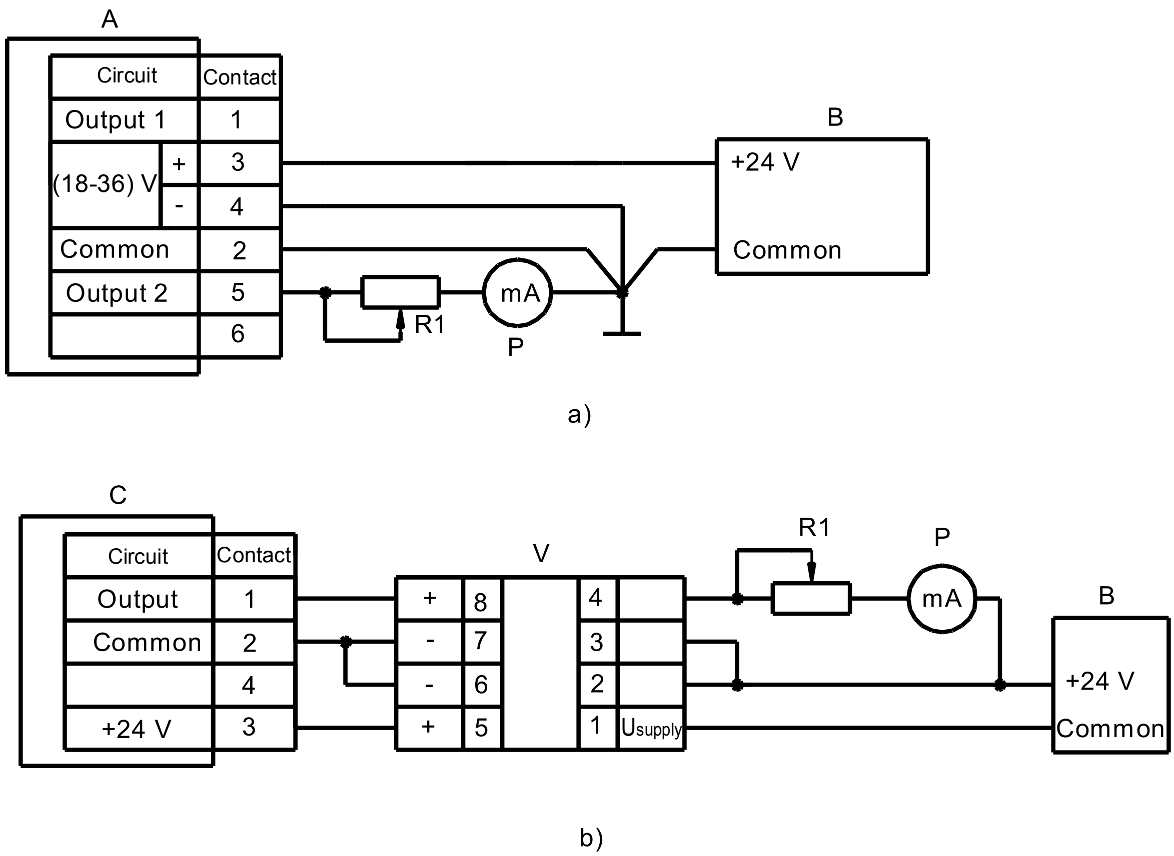
R – resistance box, Class 0.1; (0 – 10) kOhm ;

P – DC milliamperemeter, Class 0.2;

B – power supply unit БП18

Figure 6

The schematic electrical diagram for testing the vibration velocity sensors ДПЭ23МВ, ДПЭ23МВТ, ДПЭ23П, ДПЭ23Ex (DC output); vibration displacement sensor ДПЭ23МВП; RPM converters ИП36, ИП36Ex, and vibration displacement converter ИП37 (DC output) is given in Figure 7.




A – sensor, converter;

V – intrinsically safe barrier БИБ – 02DP-22;

C – sensor ДПЭ23Ex, ИП36Ex, ДПЭ23МВП (connected without intrinsically safe barrier)

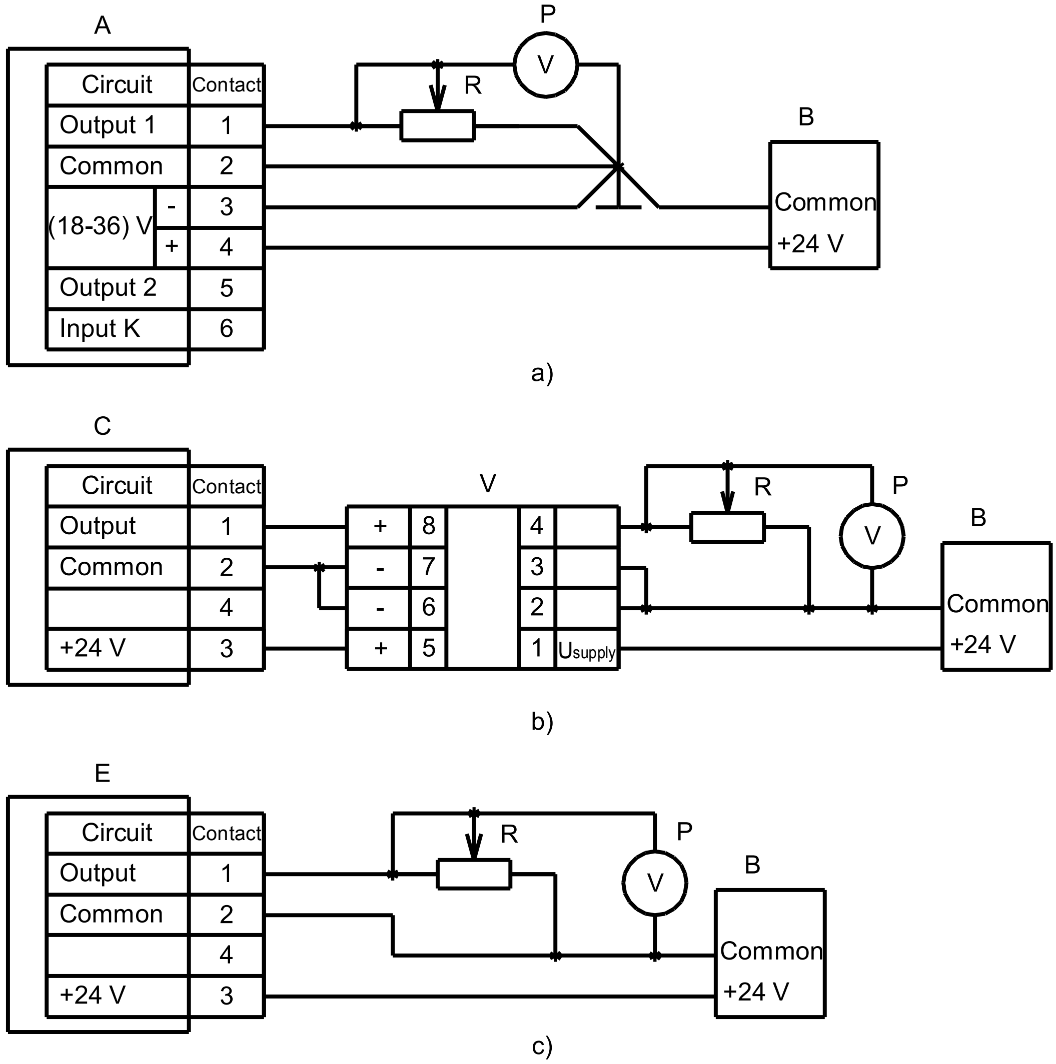
R1 – resistance box, Class 0.1; (0 – 10) kOhm ;

P – DC milliamperemeter, Class 0.2;

B – power supply unit БП18.

Figure 7

The schematic electrical diagram for testing vibration velocity sensors ДПЭ22МВ, ДПЭ22МВТ, ДПЭ22П, ДПЭ22Ex, ДПЭ23МВ, ДПЭ23П, 625В01 with ИП24, ДПЭ24 with ИП24 (AC output) and vibration displacement converters ИП34, ИП37 (AC output) is given in Figure 8.




A – sensor, converter;

V – intrinsically safe barrier БИБ – 02DP-22;

C – sensor ДПЭ22Ex;

R – resistance box, Class 0.1; (0 – 10) kOhm;

P – AC voltmeter with input resistance 1 Mohm, Class 0.5;

B – power supply unit БП18;

E – converter ИП24.

Figure 8

3.3.1.5.3 Determination of metrological characteristics

3.3.1.5.3.1 Determination of the basic reduced measurement error, conversion rate, amplitude response nonlinearity of sensors and displacement converters.

Set the parameter value equal to zero determined on the stand or equipment.

The parameter zero value is as follows:

– for sensors ДВТ10, ДВТ10Ex, ДВТ20, ДВТ21, ДВТ23, ДВТ20Ex, ДВТ30, ДВТ60 – zero gap in accordance with tables 8,9;

– for ДВТ40, ДВТ43 - the control surface (band) middle part in the left part of the sensor scale at a distance of 0.5 of the measurement range from the zero mark;

– for ДВТ50 and ДВТ82 sensors – the sensor rod zero position (the middle of the ‘0’ mark on the rod scale shall be aligned with the sensor site surface plane) in compliance with Figures K.12, K.13 and K.15.

On the stand, for sensor ДВТ50 or ДВТ82, set a number of displacement values equal to 12.5; 25; 50; 75; and 100 % of the measurement range, and by using the milliamperemeter (P), determine the output signal value. ДВТ50 and ДВТ82 sensor rod displacement values shall be set by the ruler.

The basic reduced measurement error is calculated by formula (1)

$$\delta_i = \frac{\frac{I_i - I_0}{K_n} - S_i}{S} \cdot 100\% \qquad (1)$$

Where,

$S_i$ - parameter value determined on the stand or equipment, mm;

$S$ - parameter measurement range, mm;

$I_i$ - output signal by the milliamperemeter for value *Si*, mA;

$I_0$ - initial value of the output signal – 1 ( 4) mA;

$K_n$ - nominal value of the conversion rate, mA/mm.

Nominal value of the conversion rate is calculated by formula:

– at output signal (1 – 5) mA:

$$K_n = \frac{4}{S}\text{, mA/mm} \qquad (2)$$

– at output signal (4 – 20) mA:

$$K_n = \frac{16}{S}\text{, mA/mm} \qquad (3)$$

Conversion rate at i-value of the parameter is calculated by formula:

$$K_i = \frac{I_i - I_0}{S_i}\text{, mA/mm} \qquad (4)$$

Average value of the conversion rate is calculated by formula:

$$K_{cp} = \frac{\sum_{i=1}^{n} K_i}{n}\text{, mA/mm} \qquad (5)$$

Where,

$n$ - number of measurements.

Amplitude response nonlinearity is calculated by formula:

$$\delta_a = \frac{K_i - K_{cp}}{K_{cp}} \cdot 100\% , \qquad (6)$$

Deviation of the conversion rate from the nominal value is calculated by formula:

$$\delta_k = \frac{K_g - K_n}{K_n} \cdot 100\% \qquad (7)$$

Where,

$K_g$ - conversion rate of the sensor, converter determined at the value of the parameter equal to 0.75 *S*, mm

The maximum value of the measurement error, amplitude response nonlinearity and deviation of the conversion rate from the nominal value should not exceed the values specified in paragraph 1.3.1.

3.3.1.5.3.2 Determination of the basic relative measurement error, conversion rate, amplitude response nonlinearity of the vibration velocity sensors for AC output (vibration velocity).

On the vibration stand, set to the base frequency, in turn, set a number of vibration velocity values equal to 12.5; 25; 50; 75; and 100 % of the measurement range, and by applying the AC voltmeter determine the output signal value.

The basic relative measurement error is calculated by formula:

$$\delta_i = \frac{\frac{U_i}{R \cdot K_n} - V_i}{V_i} \cdot 100\% \qquad (8)$$

Where,

$V_i$ - value of the vibration velocity (parameter) determined on the stand, mm/s;

$U_i$ - output signal measured by the voltmeter, V;

$R$ - load resistance, 2 kOhm ;

$K_n$ - nominal value of the conversion rate, mA•s/mm.

Conversion rate at $i$-value of the parameter is calculated by formula:

$$K_i = \frac{U_i}{V_i \cdot R} \text{, mA•s/mm} \qquad (9)$$

Average value of the conversion rate, amplitude response nonlinearity and deviation of the conversion rate from the nominal value shall be calculated by formulas (5), (6), (7).

The maximum value of the measurement error, amplitude response nonlinearity and deviation of the conversion rate from the nominal value should not exceed those specified in paragraph 1.3.6.

3.3.1.5.3.3 Determination of the basic relative measurement error, conversion rate, amplitude response nonlinearity of the vibration velocity sensor regarding to DC output (vibration velocity RMS).

Calibration is performed on the vibration stand at base frequency. A number of vibration velocity values equaling to 12,5; 25; 50; 75; 100 % of the measurement range is set on the vibration stand, and the output signal is measured by applying the milliamperemeter in the DC current circuit.

The basic relative measurement error is calculated by formula (10)

$$\delta_i = \frac{\frac{I_i - I_0}{K_n} - V_i}{V_i} \cdot 100\% \qquad (10)$$

Where,

$V_i$ - vibration velocity value (parameter) by the vibration stand, mm/sec (mm);

$I_i$ - output signal of the sensor, mA;

$I_0$ - initial output signal value, 1 mA or 4 mA;

$K_n$ - nominal value of conversion rate regarding to DC output, mA•s/mm (mA/mm).

Conversion rate at parameter i- value is calculated by formula:

$$K_i = \frac{I_i - I_0}{V_i} \text{, mA•s/mm (mA/mm)} \qquad (11)$$

Mean value of the conversion rate, amplitude response nonlinearity and conversion rate deviation from the nominal value is determined by formulas (5), (6), (7).

Maximum value of the measurement error, amplitude response nonlinearity and conversion rate deviation from the nominal value shall not exceed the values specified in paragraph 1.3.6.

3.3.1.5.3.4 Determination of the basic measurement error, conversion rate, amplitude response nonlinearity of the converters regarding vibration displacement.

Calibration shall be performed on the vibration stand at the base frequency at displacement 1 mm (for ДВТ10, ДВТ10Ex).

Testing of sensors and converters shall be performed by applying the procedure set forth in paragraph 3.3.1.5.3.2, where the parameter is represented by the excursion (doubled amplitude) of vibration displacement, and output AC – by applying the procedure set forth in paragraph 3.3.1.5.3.2, where the parameter is represented by vibration displacement.

**Value of the conversion rate of the relative vibration displacement of the eddy-current vibration converter is assumed to be the same for measuring displacements and static positions (gaps).**

**It is permissible to determine the basic measurement error and the conversion rate of the relative vibration displacement of the eddy-current converter by AC aoutput applying static methods set forth in paragraph 3.3.1.5.3.1 (as per paragraph 10.11.5 of ГОСТ Р 8.669-2009).**

The maximum value of the measurement error, amplitude response nonlinearity and deviation of the conversion rate from the nominal value should not exceed the values specified in paragraph 1.3.5.

3.3.1.5.3.5 Determination of the basic measurement error, conversion rate, amplitude response nonlinearity of the absolute vibration displacement sensor.

Calibration shall be carried out on the vibration stand at base frequency.

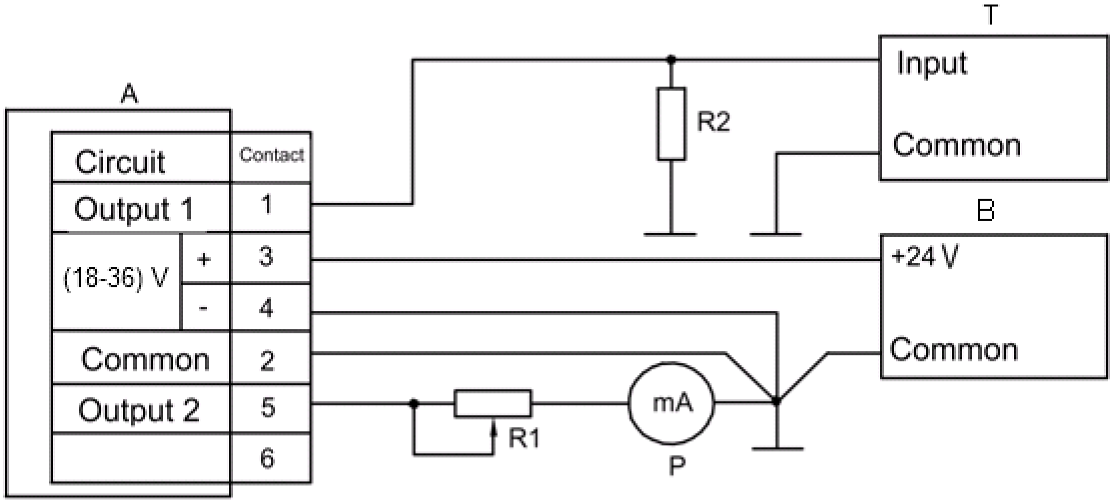
Testing of the sensor ДПЭ23МВП regarding DC output shall be carried out by applying the procedure set forth in paragraph 3.3.1.5.3.1, where the parameter is represented by excursion (doubled amplitude) of vibration displacement (in the formula (10) instead vibration velocity Vi, displacement Si – value by stand, μm, similarly for formula (11)).

Maximum value of the measurement error, amplitude response nonlinearity and conversion rate deviation from the nominal value shall not exceed the values specified in paragraph 1.3.5.

3.3.1.5.3.6 Determination of the basic relative measurement error, conversion rate, amplitude response nonlinearity of the rotor speed converter.

**It is permissible to carry out calibration of the converter by applying any sensor ДВТ10, ДВТ30 with the cable lengths similar to the one used for regular installation.**

Calibration shall be carried out on the device СП50 by applying the electric circuit rigged up in compliance with Figure 9.




A – converter;

R1 – resistance box, Class 0.1; (0 – 10) kOhm;

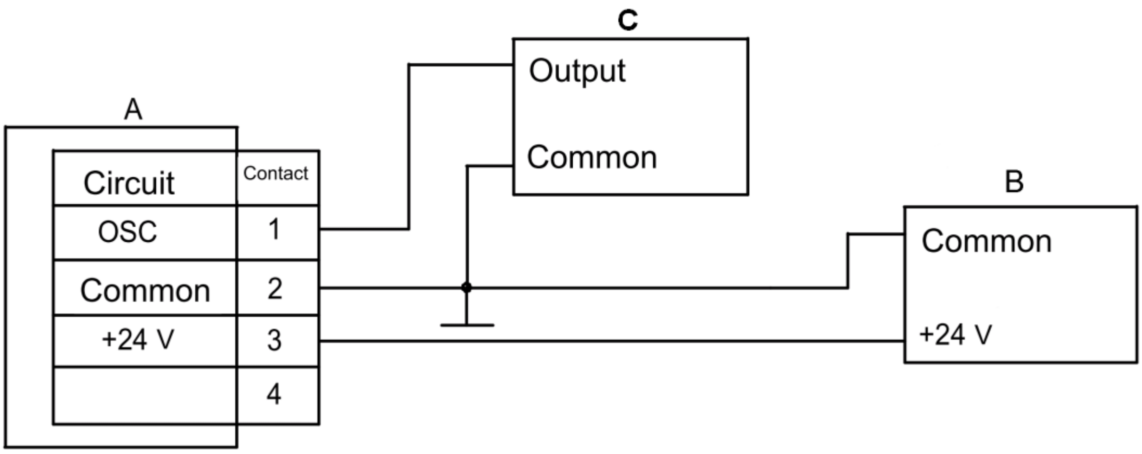
R2 – resistor 2 kOhm, 0.5 W;

P – DC milliamperemeter, Class 0.2;

B – power supply unit БП18;

T – electronic frequency meter (1 – 10000) Hz.

Figure 9




A – device СП50;

B – power supply unit БП18;

C – low-frequency harmonics signals generator with (1 – 10000) Hz range.

Figure 10

1) Device СП50 shall be connected to the generator and the power supply source by referring to electric diagram in compliance with Figure 10.

At the generator output, set the sinusoidal signal with RMS voltage equaling to 1 V and frequency equaling to 12,5 % of the measuring range in Hz.

The sensor ДВТ10 (ДВТ10Ex), ДВТ30 shall be inserted into the device СП50 and fastened by the locking screw. The sensor shall be inserted into the device till generator (C) frequency pulses measured by the frequency meter (T) connected in compliance with Figure 9 appear at the output 1 on the converter. Frequency meter readings must correspond to the generator frequency.

2) On the generator, set the number of oscillation frequencies equaling to 12,5; 25; 50; 75; 100 % of the measurement range in Hz, and by applying the milliamperemeter determine the value of the output signal.

The basic relative measurement error of speed is calculated by formula:

$$\delta_i = \frac{\frac{I_i - I_0}{K_n} - f_i}{f_i} \cdot 100\% \qquad (12)$$

Where,

$f_i$ – speed (parameter) by the frequency meter, Hz;

$I_i$ – output current of the converter, mA;

$I_0$ – initial value of the output current, 4 mA;

$K_n$ – nominal value of conversion rate, mA / Hz.

Actual value of the conversion rate shall be calculated by formula:

$$K_i = \frac{I_i - I_0}{f_i}, \text{mA/rpm min}^{-1} \qquad (13)$$

Mean value of the conversion rate, deviation of the actual conversion rate from the nominal, amplitude response nonlinearity shall be determined by formulas (5) – (7).

Maximum value of the measurement error, amplitude response nonlinearity and conversion rate deviation from the nominal value shall not exceed the values specify the paragraph 1.3.7.

3.3.1.5.3.7 .Determination of the basic reduced measurement error, conversion rate, amplitude response nonlinearity of the sensor ДВТ70.

Set the control surface СП60 into the horizontal (zero) position.

On the device, set the number of values for surface tilt:

- 1,0; - 0.5; 0; + 0.5; + 1,0 mm/m - measurement range 2 mm/m (- 0.25; - 0.12; 0; + 0.12; + 0.25 mm determined by the indicator, respectively);

- 2,0; - 1,0; 0; + 1,0; + 2,0 mm/m - measurement range 4 mm/m (- 0.5; - 0.25; 0; + 0.25; + 0.5 mm determined by the indicator, respectively);

- 5,0; - 2,5; 0; + 2,5; + 5,0 mm/m - measurement range 10 mm/m (- 1,25; - 0.62; 0; + 0.62; + 1,25 mm determined by the indicator, respectively)

and record the value of the converter output current.

The basic reduced measurement error is calculated by formula:

at output signal of (1 – 5) mA:

$$\delta = \frac{\frac{S}{4}(I-3) - S_i}{S} \cdot 100\% \qquad (14)$$

at output signal of (4 – 20) mA:

$$\delta = \frac{\frac{S}{16}(I-12) - S_i}{S} \cdot 100\%, \qquad (15)$$

Where,

$S_i$ – surface tilt by the device in mm/m with the tilt direction sign;

$I$ – output current of the converter, mA;

$S$ – measurement range 2; 4; 10 mm/m.

Nominal value of conversion rate is calculated by formula:

– at output signal of (1 – 5) mA:

$$K_n = \frac{4}{S}\text{, mA•m/mm} \quad (16)$$

– at output signal of (4 – 20) mA:

$$K_n = \frac{16}{S}\text{, mA•m/mm} \quad (17)$$

Conversion rate at parameter i-value is calculated by formula:

at output signal of (1 – 5) mA:

$$K_i = \frac{I-3}{S_i}\text{, mA•m/mm} \quad (18)$$

at output signal of (4 – 20) mA:

$$K_i = \frac{I-12}{S_i}\text{, mA•m/mm} \quad (19)$$

Mean value of the conversion rate is calculated by formula:

$$K_{cp} = \frac{\sum_{i=1}^{n} K_i}{n}\text{, mA/mm} \quad (20)$$

Where, $n$ - number of measurements.

Amplitude response nonlinearity is calculated by formula:

$$\delta a = \frac{K_i - K_{cp}}{K_{cp}} \cdot 100\% \quad (21)$$

Conversion rate deviation from the nominal value is calculated by formula:

$$\delta k = \frac{K_g - K_n}{K_n} \cdot 100\%, \quad (22)$$

Where,

$K_g$ - conversion rate of the sensor, converter determined at the parameter value equaling to 0.75 $S$, mm.

Maximum value of the basic reduced measurement error, conversion rate deviation and amplitude response nonlinearity must not exceed the values specified in paragraph 1.3.8.

3.3.1.5.3.8 Determination of frequency-response (FR) ripple of the vibration velocity sensor and sensors, vibration displacement converters.

**Determination of the relative vibration displacement of the eddy-current converter FC ripple can be performed by applying any ДВТ10 sensor with the cable length equal to the standard one.**

Testing by applying the vibration stand

Install the sensor on the vibration stand, reproduce oscillations with frequency and amplitude of vibration velocity RMS or vibration displacement in compliance with Table 37 and take the voltmeter (ampermeter) readings.

Table 37

<table>
<tr><td rowspan="3">Parameter description</td><td colspan="19">Oscillation frequency of the vibration stand, Hz**</td></tr>
<tr><td colspan="2">5</td><td colspan="3">10</td><td colspan="2">16</td><td colspan="2">30</td><td colspan="2">45</td><td colspan="2">80</td><td colspan="2">120</td><td colspan="2">160</td><td colspan="2">200</td></tr>
<tr><td>2</td><td colspan="2">3,5</td><td>5</td><td colspan="2">10</td><td>20</td><td>40</td><td colspan="2">80</td><td>160</td><td>315</td><td colspan="2">500</td><td colspan="2">630</td><td colspan="2">800</td><td>1000</td></tr>
<tr><td>Value of the of ibration velocity RMS determined on the vibration stand mm/s;*</td><td>5</td><td colspan="2">5</td><td>5</td><td colspan="2">5</td><td>5</td><td>5</td><td colspan="2">5</td><td>5</td><td>5</td><td colspan="2">5</td><td colspan="2">5</td><td colspan="2">5</td><td>5</td></tr>
<tr><td>Value of the relative vibration displacement determined on the vibration stand, μm*</td><td>10</td><td colspan="2">10</td><td>10</td><td colspan="2">10</td><td>10</td><td>10</td><td colspan="2">10</td><td>10</td><td>10</td><td colspan="2">10</td><td colspan="2"></td><td colspan="2"></td><td></td></tr>
<tr><td>Absolute vibration displacement value measured on the vibration stand, μm</td><td colspan="2">25</td><td colspan="3">25</td><td colspan="2">25</td><td colspan="2">25</td><td colspan="2">25</td><td colspan="2">25</td><td colspan="2">25</td><td colspan="2">25</td><td colspan="2">25</td></tr>
<tr><td>Voltmeter reading, ($U_i$), V</td><td></td><td colspan="2"></td><td></td><td colspan="2"></td><td></td><td></td><td colspan="2"></td><td></td><td></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td></td></tr>
<tr><td>Ampermeter reading, ($I_i$), mA</td><td></td><td colspan="2"></td><td></td><td colspan="2"></td><td></td><td></td><td colspan="2"></td><td></td><td></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td></td></tr>
<tr><td>FR ripple, %</td><td></td><td colspan="2"></td><td></td><td colspan="2"></td><td></td><td></td><td colspan="2"></td><td></td><td></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td></td></tr>
<tr><td colspan="20">* It is permissible to set other values depending on technical characteristics of the vibration stand.<br>** Values of the vibration stand oscillation frequencies shall be selected based on the item frequency range.</td></tr>
</table>

FR ripple with regard to AC output is calculated by formula (23), and regarding to DC output – by formula (24):

$$\delta = \frac{U_i - U_b}{U_b} \cdot 100\% \qquad (23) \qquad\qquad \delta = \frac{I_i - I_b}{I_b - I_o} \cdot 100\% \qquad (24)$$

Where, $U_i$ - output voltage of the sensor (converter), V;

$U_b$ - output voltage of the sensor (converter) at base frequency, V;

$I_i$ - output current of the sensor (converter), mA;

$I_b$ - output current of the sensor (converter) at base frequency, mA;

$I_o$ – initial value of the sensor (converter)output signal, 1(4) mA.

If vibration stand is unable to provide the required vibration velocity or vibration displacement amplitude at high frequencies, it is permissible to set other values, and calculation of the sensor (converter) output voltage to be carried out by formulas (25) and (27), of output current – by formulas (26) and (28):

$$U_{ip} = \frac{V_{eb}}{V_{ef}} \cdot U_i \text{, V} \qquad (25) \qquad I_{ip} = \frac{V_{eb}}{V_{ef}} \cdot I_i \text{, mA} \qquad (26)$$

$$U_{ip} = \frac{S_b}{S_f} \cdot U_i \text{, V} \qquad (27) \qquad I_{ip} = \frac{S_b}{S_f} \cdot I_i \text{, mA} \qquad (28)$$

Where, $V_{eb}$ ($S_b$) - value of the of vibration velocity (vibration displacement) RMS at base frequency;

$V_{ef}$ ($S_f$) - value of the of vibration velocity (vibration displacement) RMS at the current frequency;

$U_{ip}$ - design value of the output voltage of the sensor (converter);

$I_{ip}$ - design value of the output current of the sensor (converter).

FR of the relative vibration displacement eddy-current converters can be determined by using СП50 device.

Test carried out by applying СП50 device

Insert the ДВТ10 sensor into the device. Connect the device to the generator of harmonic signals and the power supply source by referring to Figure 10. Rig up the electrical circuit by referring to Figure 6. Set direct current equaling to (3.0 ± 0.5), (12 ± 1) mA at the converter output. The current value shall be set by moving the sensor inside the device. Secure the sensor position by fixing it with a locking screw.

Rig up the electrical circuit by referring to Figure 8. At base frequency, set the amplitude of the generator signal equaling to 0.8 of the converter AC output voltage measuring limit. By maintaining the generator signal amplitude unchanged, set the number of frequencies by referring to Table 32 or paragraph 1.3.5 and record voltmeter (ampermeter) readings. Calculate FR ripple by formula (23) or (24).

To determine FR within the range of (0.05 − 20) Hz, use the control unit ПК20 or ВМ32. Converter ИП34 shall be connected to the unit БК20 according to the diagram S1 specified in Annex S.

FR ripple within the range of (0.05 − 1) Hz measured by applying БК20 should not exceed minus 5 %.

The maximum value of the frequency-response ripple shall not exceed the values specified in paragraphs 1.3.5 and 1.3.6.

3.3.1.5.3.9 Check of electrical resistance of eddy-current sensor winding insulation (except ДВТ40 and ДВТ70 sensors).

Resistance measurements shall be performed by applying the connector modular section with wires.

Purpose of sensor circuits is specified in Annex A.

Electrical resistance of eddy-current sensor winding insulation is measured by the megohmmeter by applying voltage not exceeding 500 V relative to the sensor casing or the equipment under test. Megohmmeter shall be connected to the sensor windings in the connector.

Minimum value of insulation resistance must comply with the value specified in paragraph 1.3.25.

3.3.1.5.3.10 Check of eddy-current sensor windings active resistance.

Resistance measurements shall be conducted by applying the connector modular section with wires.

Purpose of sensor circuits is specified in Annex A.

Active resistance of eddy-current sensor winding insulation is measured by the ohmmeter at the sensor connector.

Active resistance should not exceed the values specified in paragraph 1.3.28.

3.3.2 ПК20 Calibration of control boards and units

3.3.2.1 Calibration procedures

In conducting calibration, operations specified in Table 38 shall be performed.

Table 38

| Operation description | Calibration item No. | Procedures for | |
|---|---|---|---|
| | | primary calibration | periodica alibration |
| 1 External inspection | 3.3.2.5.1 | Yes | Yes |
| 2 Try-out | 3.3.2.5.2 | Yes | Yes |
| 3 Calibration of control unit insulation electrical resistance | 3.3.2.5.3.1 | Yes | Yes |
| 4 Determination of the basic measure-ment error | 3.3.2.5.3.2<br>3.3.2.5.3.3<br>3.3.2.5.3.4<br>3.3.2.5.3.5 | Yes | Yes |
| 4 Determination of frequency response ripple | 3.3.2.5.3.6 | Yes | Yes |

3.3.2.2 Calibration means

In performing calibration, calibration means specified in Table 37 shall be applied.

Table 39

| Calibration item No. | Description and type of the main or axiliary calibration means; designation of the document regulating technical requirements and (or) metrological and basic tech-nical characteristics of the calibration means |
|---|---|
| 3.3.2.5.1<br>3.3.1.5.2<br>3.3.2.5.3.1<br>3.3.2.5.3.2<br>3.3.2.5.3.3<br>3.3.2.5.3.4<br>3.3.2.5.3.5<br>3.3.2.5.3.6 | 1 AC voltmeter B7-78/1 Class 0.5.<br>2 DC Milliamperemeter Class 0.2.<br>3 Generator (0.01 – 10000) Hz.<br>4 Resistance box P4831 Class 0.1 ГОСТ 23737-79.<br>5 Stabilized DC voltage source ± (15 ± 0.5) V, 100 mA.<br>6 Megohmmeter as per ГОСТ 23706-93. |
| Note: It is permissible to replace the instruments and equipment with the ones with similar met-rological characteristics. | |

3.3.2.3 Safety requirements

In conducting calibration, the instruments under test, calibration means, as well as the auxiliary equipment must have protective grounding.

3.3.2.4 Calibration conditions

In conducting calibration, the following conditions must be complied with:

– Ambient air temperature – from plus 18 to plus 25 °C;
– Relative air humidity – from 45 to 80 %;
– Atmospheric pressure – not specified;
– Supply voltage for control boards ± (15.0 ± 0.3) V;<br>+ (24.0 ± 0.5) V;
– Supply voltage of the power supply network for control units – from 215.6 to 224.4 V;
– Power supply network AC frequency for control units – from 49.5 to 50.5 Hz;
– Sound pressure level – not exceeding 65 dB;
– Unified single load resistance (2.00 ± 0.02) kOhm ; (500 ± 5) Ohm);
– External electrical and magnetic field levels, as well as vibration effect at the place of the measuring instruments, matching and measuring devices installation must not exceed the standards set by their regulatory documents;

3.3.2.5 Calibration procedure

In conducting calibration, it is necessary to keep the protocol of test results (calibration record). The protocol may be completed in arbitrary form.

3.3.2.5.1 External examination

When performing external examination the following must be checked:

– Cleanliness of boards, conditions of front panel, pointer instruments, digital indicator, control elements and absence of damage;

– Presence of marking.

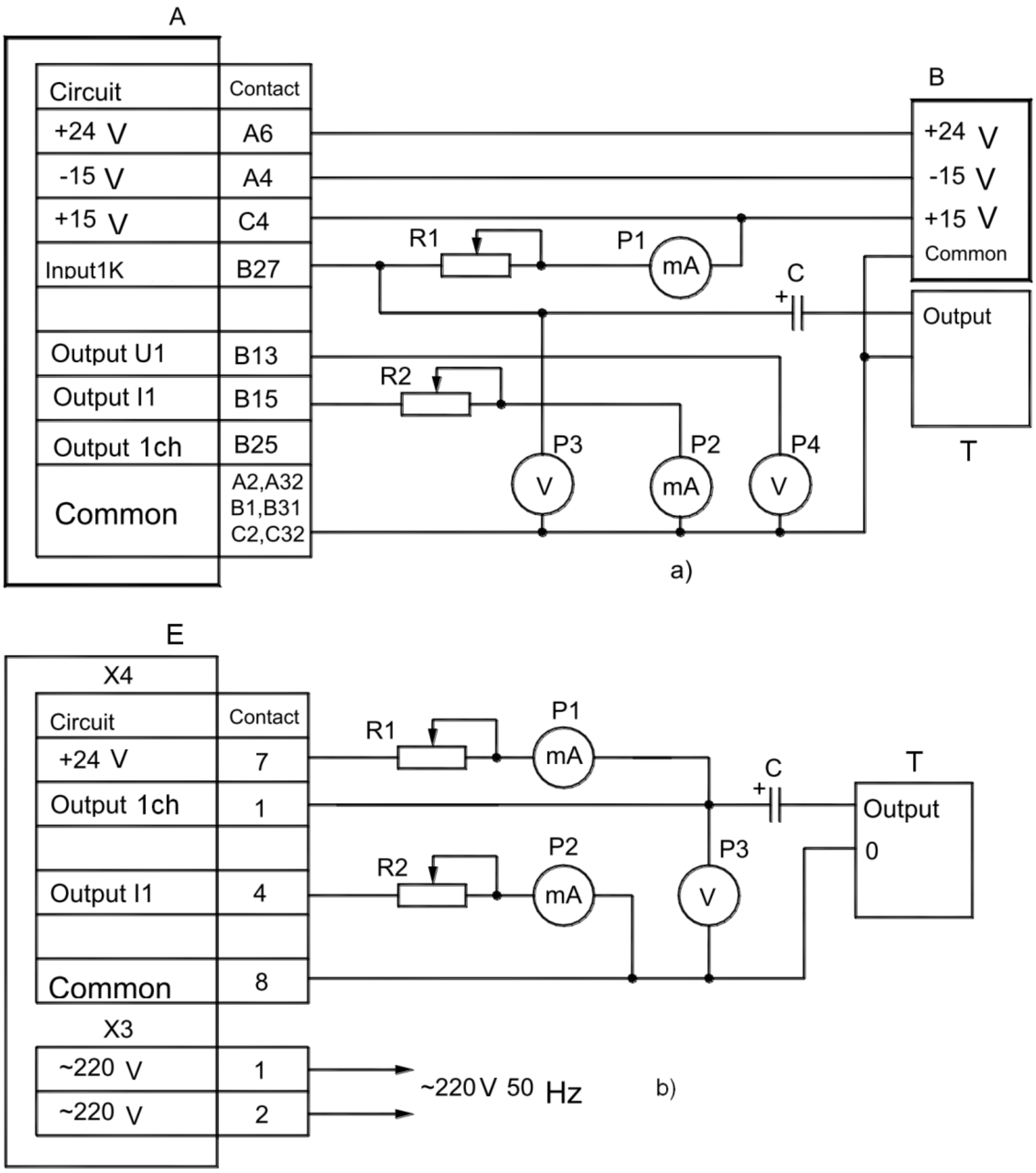
3.3.2.5.2 Try-out

To try-out control board (units), perform the following operations:

– Rig up the electrical circuit in compliance with with Figures 11 and 12 (when calibrating the boards and units with DC input signals, the generator (C) and voltmeter (P3) are not used);

– Apply input signal and check operation of the control board (units).

In calibrating the measuring channel of the multichannel control board (unit) ( except ПК51), direct current amounting to (3.0 ± 0.5) mA must be applied to the input of all other channels.




A – control board;

E – power supply unit;

B – power supply unit БП18;

T – low-frequency generator, Class 2.0 (when testing ПК40 (БК40)) frequency setting error must not exceed 0.01 Hz);

C – capacitor with the capacity of not less than 1000 microfarad, voltage – 16 V (when measuring FR of the ПК20 (БК20) – not less than 50000 microfarad);

P1, P2 – DC milliamperemeter, Class 0.2;

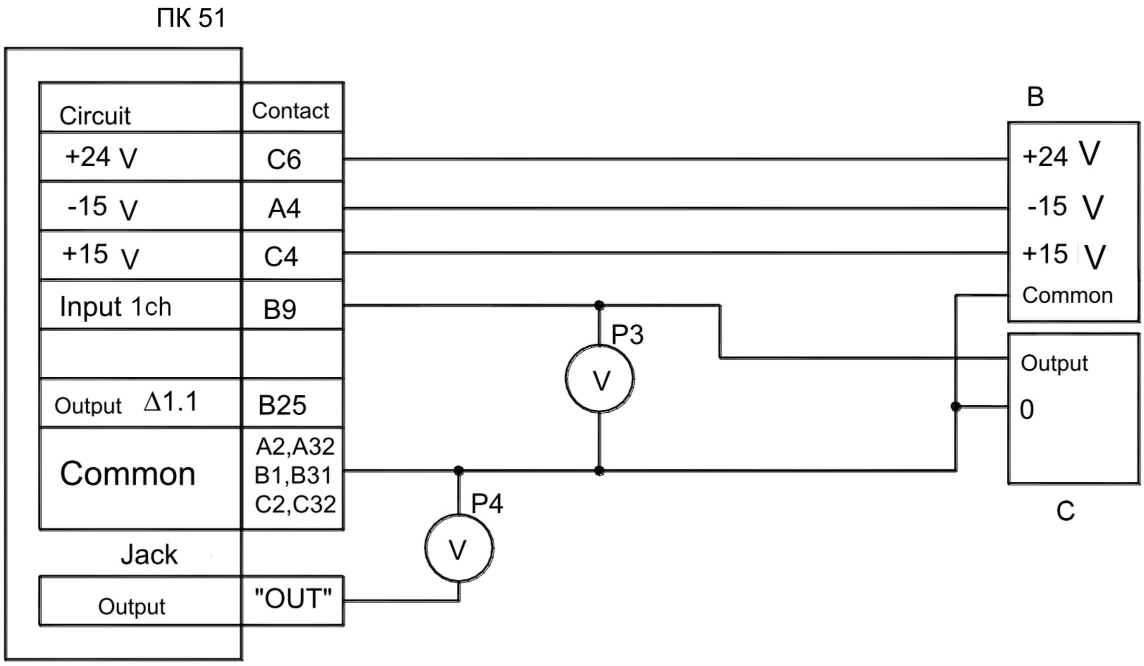
P3 – AC voltmeter with input resistance of 1 Mohm, Class 0.6;

P4 – DC voltmeter, Class 0.2;

R1, R2 – resistance box.

Note – when applying the generator with adjustment of constant displacement, it is permissible not to use capacitor C.

Figure 11




B – power supply unit БП18;

C – low frequency generator, Class 2,0;

P3 – AC voltmeter with input resistance 1 Mohm, Class 0.6;

P4 – DC Voltmeter, Class 0.2.

Figure 12

3.3.2.5.3 Determination of metrological characteristics

3.3.2.5.3.1 Check of insulation electrical resistance

Check of the insulation electrical resistance of the control units is performed by applying teraohm-meter between the contacts of the power supply connector (X3) and the unit casing. The toggle switch ‘POWER’ must be in the ‘On’ position.

Insulation electrical resistance of the power supply units, control units in ~220 V circuits must be not less than 20 Mohm.

3.3.2.5.3.2 Determination of the basic relative measurement error of the control boards and units with DC input signals.

Use resistance box (R1) to set the range of DC values equal to 12.5 (15); 25; 50; 75; and 100 % of the measurement range by the digitized scale marks of the pointer instrument located on the control board (unit) in compliance with Figure M.1 and by applying the milliamperemeters (P1, P2), voltmeter (P4) determine the corresponding value of the input current, unified signals, parameter.

If zero of the pointer instrument scale is in the middle of the scale, then the measurement range $S$ is equal to the sum of limit values of the instrument scale and the input current is set with reference to the arbitrary scale, with zero located at the scale end (at the bottom):

$$S = |S_н| + S_b, \text{ mm} \qquad (29)$$

Where,

$S_н$ – limit value of the lower section of the pointer instrument scale, mm;

$S_b$ – limit value of the upper section of the pointer instrument scale, mm.

The value of the basic relative measurement error shall be calculated by formulas:

– for the pointer instrument and digital indicator

$$\delta_i = \frac{\frac{4\cdot(|S_H| + S_i)}{S} - (I_i - 1)}{I_i - 1} \cdot 100\% \tag{30}$$

– for the unified output signal (0 – 5) mA

$$\delta_i = \frac{0{,}8 \cdot I_y - (I_i - 1)}{I_i - 1} \cdot 100\% \tag{31}$$

– for the unified output signal (4 – 20) mA

$$\delta_i = \frac{0{,}25 \cdot (I_y - 4) - (I_i - 1)}{I_i - 1} \cdot 100\% \tag{32}$$

– for the unified output signal of control boards (0 – 10) V

$$\delta_i = \frac{0{,}4 \cdot U_y - (I_i - 1)}{I_i - 1} \cdot 100\% \tag{33}$$

Where, $I_i$ - input current measured by the milliamperemeter (P1), mA;

$S_i$ – readings of the pointer instrument and digital indicator, mm;

$S_н$ – limit value of the lower section of the pointer instrument scale, mm;

$S$ – measurement range of board (unit), mm;

$I_y$ – unified signal measured by the milliamperemeter (P2), mA;

$U_y$ – unified signal measured by the voltmeter (P4), V (for control boards).

Maximum values of measurement error must not exceed the values specified in paragraph 1.3.9.

3.3.2.5.3.3 Determination of the basic relative measurement error of relative vibration displacement excursion and vibration velocity RMS boards and units.

Use the resistance box (R1) to set direct current (3.0 ± 0.5) mA by applying the milliamperemeter (P1).

The use generator (C) with the base frequency to set the range of AC voltage values equal to 12.5; 25; 50; 75; and 100 % or 20; 40; 60; 80; 100 % of the measurement range by the digitized scale marks of the pointer instrument located on the control board (unit) and by applying the voltmeters (P3, P4), milliamperemeter (P2) and digital indicator of control board (unit) determine the corresponding value of the input voltage, unified outpu signals, parameter.

The value of the basic relative measurement error shall be calculated by formulas:

– for the pointer instrument

$$\delta_c = \frac{\frac{S_n}{S_r} \cdot U_c - U_i}{U_i} \cdot 100\% \quad (34)$$

$$\delta_c = \frac{\frac{V_n}{V_e} \cdot U_c - U_i}{U_i} \cdot 100\% \quad (35)$$

– for the unified output signal (0 – 5) mA

$$\delta_i = \frac{0{,}2 \cdot I_y \cdot U_c - U_i}{U_i} \cdot 100\% \quad (36)$$

– for the unified output signal (4 – 20) mA

$$\delta_i = \frac{0{,}0625 \cdot (I_y - 4) \cdot U_c - U_i}{U_i} \cdot 100\% \quad (37)$$

– for the unified output signal (0 – 10) V

$$\delta_i = \frac{0{,}1 \cdot U_y \cdot U_c - U_i}{U_i} \cdot 100\% \quad (38)$$

Where,

$U_i$ - input AC voltage measured by the voltmeter (P3), V;

$U_c$ - measurement range for input AC voltage, V;

$S_n$ $(V_n)$ - reading of the pointer instrument and digital indicator, mm (mm/s);

$S_r$ $(V_e)$ - upper limit of the measurement range, mm (mm/s);

$I_y$ - unified signal measured by the milliamperemeter (P2), mA;

$U_y$ - unified signal measured by the voltmeter (P4), V (for control boards).

Determination of the DC input signal (1 – 5), (1 – 6) mA measurement error shall be performed by the pointer instrument using procedure specified in paragraph 3.3.2.5.3.2.

Maximum values of measurement errors must not exceed the values specified in paragraph 1.3.9.

3.3.2.5.3.4 Determination of the basic relative measurement error of control board ПК51.

Use generator (C) at base frequency to set the range of AC voltage values equaling to 20; 40; 60; 80; 100 % of the measurement range by the digitized marks of the pointer instrument scale installed on the control board, and by voltmeter (P3) and the digital indicator of the control board determine the corresponding value for the input voltage and parameter.

The value of the basic relative measurement error is calculated by the formula (35):

Maximum value of measurement error must not exceed the values specified in paragraph 1.3.10.

3.3.2.5.3.5 Determination of the basic relative measurement error of the RPM control boards and units.

Connect the indication unit БИ23 to ПК40 board (БК40 unit).

Use the resistance box (R 1) to set direct current (3 ± 0.5) mA by the milliamperemeter (P1).

Use generator (C), in turn, to set the range of speed values in RPM equal to 12.5; 25; 50; 75; 100 % (20; 40; 60; 80; 100 %) of the measurement range by the digitized marks on the pointer instrument scale located on the control board (unit) and by applying the generator (C) use instruments (P2), (P4), БИ23 and digital indicator of board or unit to determine the corresponding frequency values of the input signal, unified output signals and RPM.

Value of the board input voltage – (1.0 – 1.4) V.

Preset number of RPM is calculated by formula:

$$N_i = 60 \bullet f, \text{ rpm} \quad (39)$$

Where,

$f$ – frequency, Hz.

Absolute measurement error of RPM performed by the digital indicator of the control board or indication unit БИ23 is calculated by formula:

$$\Delta N = N_n - N_i \quad (40)$$

Where,

$N_i$ - speed by formula (39) ;

$N_n$ - speed displayed on the digital indicator of the control board or indication unit БИ23.

Relative measurement error shall be calculated by formulas:

– for the pointer instrument

$$\delta_c = \frac{N_n - N_i}{N_i} \cdot 100\% \qquad (41)$$

– for the unified output signal (0 – 5) mA

$$\delta_i = \frac{0,2 \cdot I_y \cdot N - N_i}{N_i} \cdot 100\% \qquad (42)$$

– for the unified output signal (4 – 20) mA

$$\delta_i = \frac{0,0625 \cdot (I_y - 4) \cdot N - N_i}{N_i} \cdot 100\% \qquad (43)$$

– for the unified output signal (0 – 10) V

$$\delta_i = \frac{0,1 \cdot U_y \cdot N - N_i}{N_i} \cdot 100\% \qquad (44)$$

Where,

$N_i$ – preset number, rpm;

$N_n$ – reading of the pointer instrument, rpm;

$N$ - upper limit of the RPM measurement range, rpm;

$I_y$ - unified signal measured by the milliamperemeter (P2), mA;

$U_y$ - unified signal measured by the voltmeter (P4), V.

Maximum value of measurement error must not exceed the values specified in paragraph 1.3.9.

3.3.2.5.3.6 Determination of frequency-response ripple of the relative vibration displacement excursion and vibration velocity RMS of the control boards (units).

Use generator (C) to set the range of values for input voltage frequency of the control board as per Table 40. The generator voltage must remain unchanged and amount to 0.8 of the input voltage range of the control board (unit). Determine the corresponding value of the unified output signal:

– for control boards – measured by the voltmeter (P4):

– for control units – measured by the milliamperemeter (P2).

For control board ПК51, output voltage is measured at ‘OUT’ jack.

Table 40

| Parameter description | Generator frequency, Hz | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.05 | 0.1 | 0.5 | 1.0 | 10 | 20 | 40 | 63 | 80 | 100 |
| | 5 | 10 | 20 | 40 | 80 | 125 | 250 | 315 | 400 | 500 |
| | 10 | 20 | 40 | 80 | 160 | 315 | 500 | 630 | 800 | 1000 |
| | 10 | 15 | 17 | 20 | 25 | 30 | 35 | 40 | 45 | 50 |
| Generator voltage, V | | | | | | | | | | |
| Voltage of the unified output signal of the control board, V | | | | | | | | | | |
| Current of the unified output signal of the control unit, mA | | | | | | | | | | |
| FR ripple, % | | | | | | | | | | |

FR ripple of the control boards shall be calculated by formula (23),

Where,

$U_i$ – output voltage;

$U_b$ – output voltage at base frequency, V.

FR ripple of the control units shall be calculated by formula (24),

Where, $I_i$ – output current of the unit by milliamperemeter P2, mA;

$I_b$ – output current of the unit at base frequency, mA;

$I_o$ – initial output signal value of the unit, 1(4) mA.

For ПК51, FR attenuation at frequency of 50 Hz is calculated by formula:

$$Z = 20 \cdot lg\left(\frac{U_b}{U_{50}}\right), \text{dB} \tag{45}$$

Where,

$U_{50}$ – output voltage at frequency of 50 Hz, V;

$U_b$ –output voltage at base frequency, V.

Maximum values for FR ripple and attenuation must not exceed the values specified in paragraphs 1.3.9 and 1.3.10.

### 3.3.3 Calibration of the parameter measuring channel

#### 3.3.3.1 Calibration procedure

In conducting calibration, procedure specified in Table 40 shall be performed.

Table 41

| Operation description | Calibration item No. | Procedures for | |
|---|---|---|---|
| | | Initial calibration | Periodical calibration |
| 1 External examination | 3.3.3.5.1 | Yes | Yes |
| 2 Try-out | 3.3.2.5.2 | Yes | Yes |
| 3 Determination of the basic measurement error | 3.3.3.5.3.1<br>3.3.3.5.3.2<br>3.3.3.5.3.3 | Yes | Yes |
| 4 Check of measurement range, determination of the basic measurement error of the vibration displacement measuring channel | 3.3.3.5.3.4 | Yes | Yes |
| 5 Determination of frequency response ripple | 3.3.2.5.3.5<br>3.3.2.5.3.6 | Yes | Yes |

#### 3.3.3.2 Calibration means

In conducting calibration, the following calibration means specified in Tables 34, 37 shall be applied.

#### 3.3.3.3 Safety requirements

In conducting calibration, the following safety requirements specified in paragraphs 3.3.1.3, 3.3.1.4 shall be complied with.

#### 3.3.3.4 Calibration conditions

In conducting calibration, the following calibration conditions specified in paragraphs 3.3.2.3, 3.3.2.4 must be complied with.

3.3.3.5 Calibration procedure

In conducting calibration, it is necessary to keep the protocol of test results (calibration record). The protocol may be completed in arbitrary form.

3.3.3.5.1 External inspection

External inspection must be conducted in compliance with paragraphs 3.3.1.5.1, 3.3.2.5.1.

3.3.3.5.2 Try-out

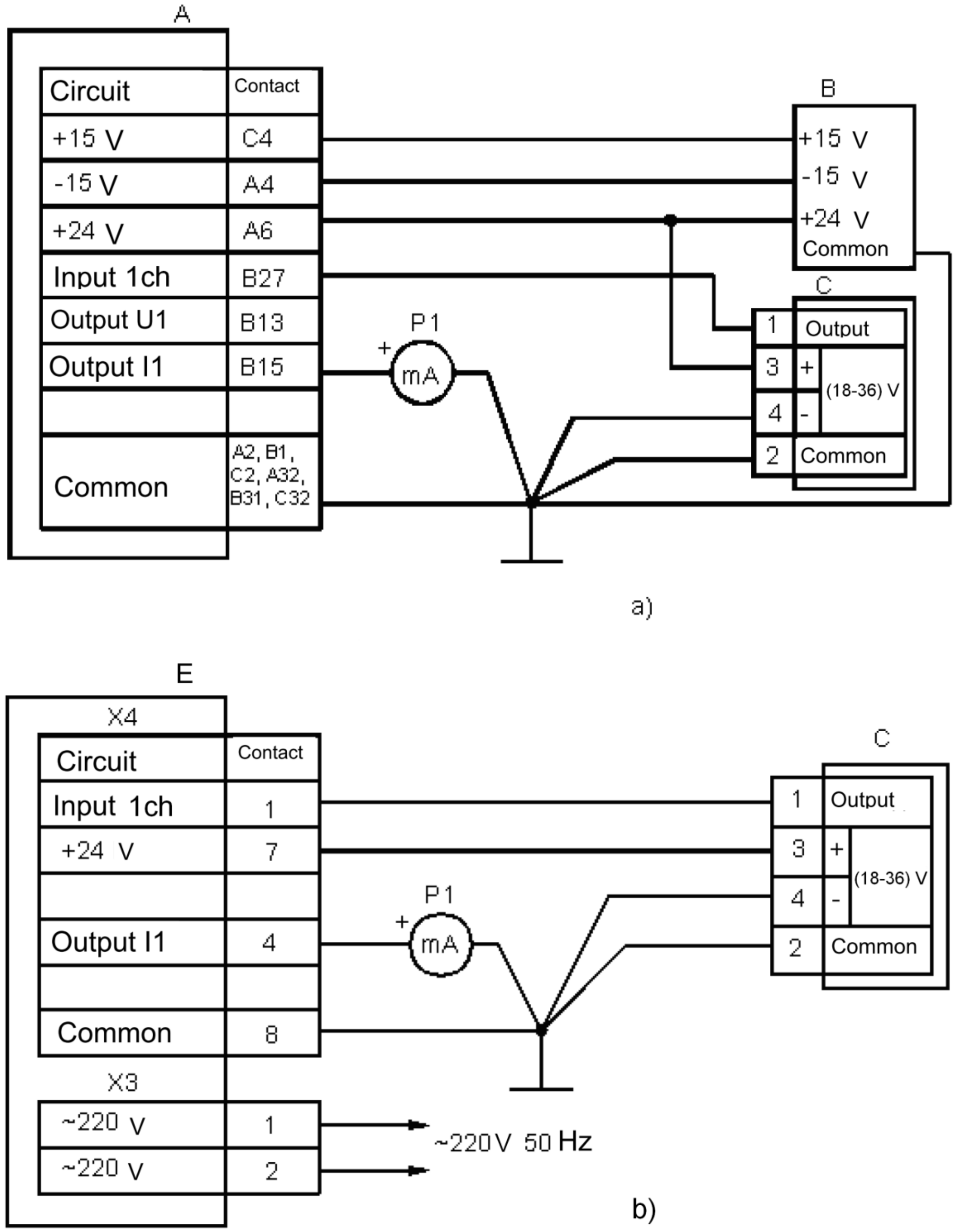
In trying out, perform the following operations:

– Secure the sensor on the vibration stand or the equipment under test;

– Rig up the electrical circuit in compliance with Figures 13 and 14;

– Energize the power supply source and try out the operation of the parameter measuring channel by changing parameters on the vibration stand or equipment,.

Calibration of the entire channel must be carried out by referring to the schematic electrical diagram given in Figure 13, and calibration of the entire channel by applying explosionproof sensors, converters and comparators – by referring to the electrical diagram shown in Figure 14.




A – control board;

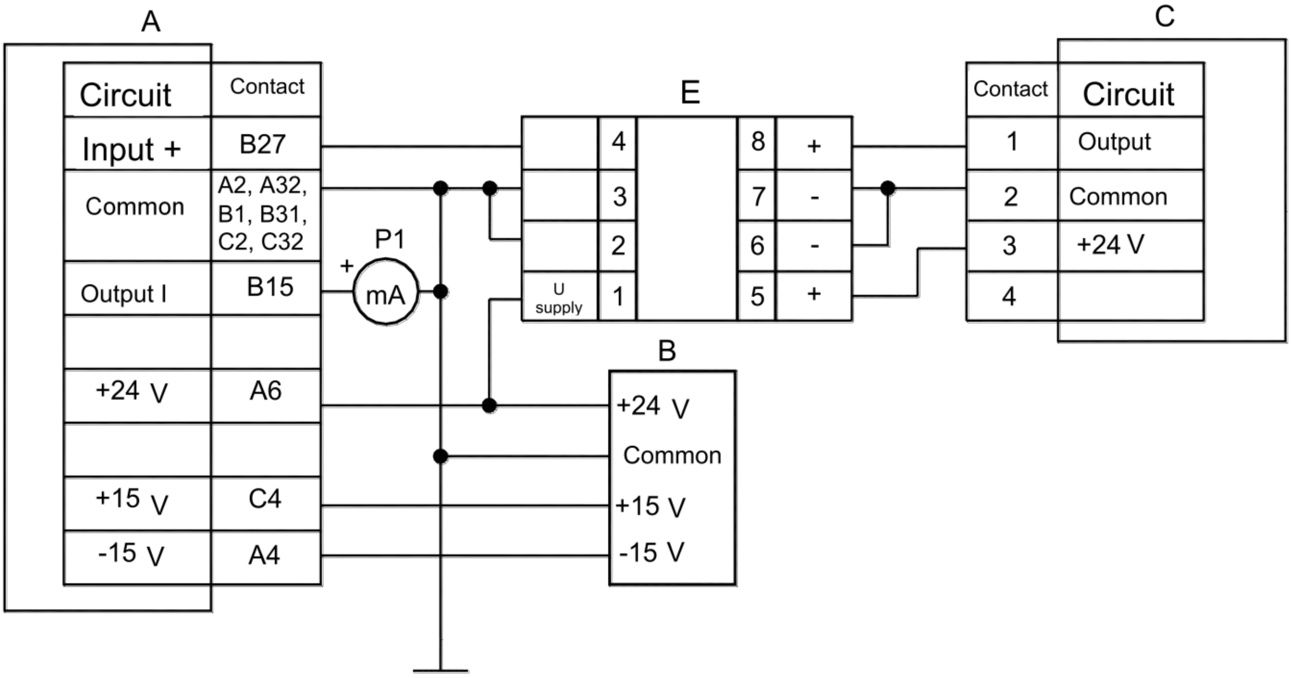
E – control unit;

B – power supply unit БП18;

C – sensor, converter, comparator;

P1 – DC milliamperemeter, Class 0.2.

Figure 13




A – control board;

E – intrinsically safe barrier БИБ – 02DP-22;

B – power supply unit БП18;

C – explosion-proof sensor, converter, comparator (ДПЭ22Ех, ДПЭ23Ех, ИП34Ех, ИП36Ех, К22Ех);

P1 – DC milliamperemeter, Class 0.2.

Figure 14

3.3.3.5.3 Determination of metrological characteristics

3.3.3.5.3.1 Determination of the basic measurement error of the displacement measuring channel, surface tilt.

Measurement range of the sensor and converter must be within the range of the pointer instrument scale located on the control board (unit).

The sensor shall be secured on the stand or equipment in the position at which the reading of the pointer instrument on the board equals to 0.

This position of the sensor is considered as zero. Displacement readings shall be taken starting from the zero position.

Then, on the stand or equipment set the range of values for displacements approximately equal to 0; 25; 50; 75; 100 % (minus 50; minus 25; 0; 25; 50 %) of the measurement range by the digitized marks of the pointer instrument scale, and use the stand, instrument, digital indicator to determine the corresponding values of displacement and unified signal.

If zero of the pointer instrument scale is in the middle of the scale, then the measurement range of the channel is equal to the sum of limit values of the instrument scale.

$$S = |S_н| + S_b \text{, mm (mm/m)} \qquad (46)$$

Where, $S_н$ – limit value of the lower section of the pointer instrument scale;

$S_b$ – limit value of the upper section of the pointer instrument scale.

Basic reduced measurement error shall be calculated by formulas:

– for the pointer instrument

$$\delta_n = \frac{|S_n| - |S_i|}{S} \cdot 100\% \qquad (47)$$

– for unified signal (0 – 5) mA

$$\delta_y = \frac{0,2 \cdot S \cdot I_y - (|S_н| + S_i)}{S} \cdot 100\% \qquad (48)$$

– for unified signal (4 – 20) mA

$$\delta_y = \frac{0,0625 \cdot S \cdot (I_y - 4) - (|S_н| + S_i)}{S} \cdot 100\% \qquad (49)$$

Where,

$S_n$ – reading of the pointer instrument, digital idicator, mm (mm/m);

$S_i$ – displacement by the vibration stand or equipment, mm (mm/m);

$S$ – measurement range, mm (mm/m);

$I_y$ – unified DC signal, mA

Maximum values of measurement error must not exceed the values specified in paragraph 1.3.19.

3.3.3.5.3.2 Determination of the basic measurement error of vibration velocity RMS measuring channel.

Measurement range of the vibration velocity sensor must be within the range of the pointer instrument scale on the control board or exceed it by (2 – 5) %.

The sensor shall be secured on the vibration stand and set the range of values for vibration velocity equal to 12.5; 25; 50; 75; 100 % of the measurement range, at base frequencyby the pointer instrument scale marks. Record the readings of stand, pointer instrument, digital indicator and instruments in unified signal circuits.

Basic relative measurement error shall be calculated by formulas:

– for the pointer instrument

$$\delta_c = \frac{V_n - V_i}{V_i} \cdot 100\% \qquad (50)$$

– for unified signal (0 – 5) mA

$$\delta_y = \frac{0,2 I_y \cdot V_e - V_i}{V_i} \cdot 100\% \qquad (51)$$

– for unified signal (4 – 20) mA

$$\delta_y = \frac{0{,}0625 \cdot (I_y - 4) \cdot V_e - V_i}{V_i} \cdot 100\% \qquad (52)$$

Where,

$V_n$ – reading of the pointer instrument, digital indicator, mm/s;

$V_i$ – value of the of vibration velocity RMS by vibration stand, mm/s;

$V_e$ – upper limit of the measurement range, mm/s;

$I_y$ – unified DC signal, mA.

The maximum value of the measurement error must not exceed the values specified in paragraph 1.3.21.

3.3.3.5.3.3 Determination of the basic measurement error of the RPM measuring channel.

Connect indication units БИ23 to the control board (unit).

Calibration shall be performed by applying СП50.

Connect СП50 device to the power source and the generator with reference to the electric diagram shown in Figure 10.

Set voltage of 1 V at the generator output. Secure the sensor from the kit in the СП50 device by referring to Figure L.7. The depth of the sensor installation in the СП50 must be sufficient to enable the reading of the pointer instrument the gap measuring mode, at the generator frequency exceeding 20 Hz, to be within the limits of (40 − 60) % of the scale.

Perform measurements and calculate the measurement errors by applying the procedure set forth in paragraph 3.3.2.5.3.5.

The maximum value of the measurement error must not exceed the values specified in paragraph 1.3.22.

3.3.3.5.3.4 Calibration of the measurement range, determination of the basic measurement error of the vibration displacement measuring channel.

Displacement measurement ranges of the converter and the control board/unit (mm) must be the same.

Calibration shall be performed by procedures set forth in paragraph 3.3.3.5.3.2, where the parameter is represented by the excursion (amplitude) of vibration displacement. Maximum value of the measurement error must comply with the requirement specified in paragraph 1.3.20.

3.3.3.5.3.5 Determination of frequency-response ripple of vibration velocity RMS measuring channel.

Calibration shall be performed by procedures set forth in paragraph 3.3.1.5.3.8, where the unified signal current is measured as the output parameter. Maximum value of the ripple must comply with the requirement specified in paragraph 1.3.21.

3.3.3.5.3.6 Determination of frequency-response ripple of the vibration displacement measuring channel.

Calibration shall be performed by procedures set forth in paragraph 3.3.1.5.3.8, where the unified signal current is measured as the output parameter.

The maximum value of the ripple must comply with requirements set forth in paragraph 1.3.20.

Calibration of the measuring channel FR with the control board (unit) ПК20 (БК20) within the frequency range (0.05 – 20) Hz shall be performed by applying СП50 device.

3.3.4 Presentation of calibration results

Positive calibration results shall be entered into the logbook and formalized as a calibration certificate.

# 4 Transportation and Storage

## 4.1 Equipment Transportation

4.1.1 Packaged equipment may be transported to any distances by railway or road (in enclosed vehicles), by sea (in ship holds), by air (in pressurized compartments).

Transport conditions– Ж as per ГОСТ 25804.4–83.

4.1.2 Packaged equipment withstands the following transportation conditions:

— temperature – from minus 50 °C to plus 50 °C;

— relative humidity – 95 % at 35 °C;

— vibration (acting along the three mutually non-perpendicular axes of the container) when transported by railway, motor vehicle and aircraft within the frequency range (10 – 55) Hz at the amplitude of the vibration displacement of 0.35 mm and vibration acceleration of 5g;

— impacts with the shock acceleration peak value 10g, shock pulse duration 10 ms, number of impacts (1000 ± 10) in the direction indicated on the container.

## 4.2 Equipment Storage

4.2.1 Equipment storage conditions as to environment climatic aspects influence must comply with the conditions 3 (Ж3) as per ГОСТ 15150–69. Storage period shall not exceed 24 months from the date of manufacturing.

4.2.2 Long-term storage of equipment shall be carried out in the packaging material inside the heated premises meeting the requirements specified in 1 (Л), type of storage atmosphere II, III as per ГОСТ 15150–69.

## 5 Manufacturer's Guarantees

5.1 The manufacturer warrants the equipment compliance to technical requirements provided that operation, storage, transportation and installation conditions are complied with.

5.2 The warranty period of storage is 24 months from the date of manufacturing.

5.3 The warranty period of operation is 24 months from the date of commissioning, but not more than 48 months from the date of manufacturing.

5.4 Should the assembly unit is to be returned for warranty repair to the manufacturer, it is necessary to specify the detected fault.

5.5 During the warranty period, the Manufacturer undertakes to replace or repair the equipment free of charge if the Consumer finds a malfunction or non-compliance with its technical data. Defective equipment is sent to the manufacturer for repair, with a cover letter on the letterhead containing the following information:

- name of equipment, designation serial number or year of manufacturing;
- the nature and manifestation of the malfunction;
- name of the operating organization, mailing address, TIN;
- Name of contact person, phone, e-mail;
- the mailing address of the equipment return.

The completed letter of the equipment acceptance for repair, in 2 copies, in the form, see Annex V, is attached to the cover letter.

Return of equipment after repair is formalized by the fault detection and repair report.

5.6 The consumer loses the right for free warranty servicing in case of the equipment installation by experts of other companies without obtaining the prior consent of the Manufacturer, presence of mechanical damage and defects caused by non-compliance with operation, storage and transportation conditions.

## 6 Disposal

6.1 The equipment does not contain substances hazardous for humans and the environment.

6.2 Disposal of the equipment shall be carried out through disassembly. Metal, electrical-installation, cables items are used for recycling.

## Annex A
(informative)

## Description and purpose of the equipment external circuits

A.1 Sensors, converters, comparators

Table A.1 – ДВТ82, ИП34, ИП42, ИП43, ИП44, К22

| Contact | Circuit | |
|---|---|---|
| 1 | Output 1 (Main) | |
| 2 | Common | |
| 3 | + | (18 – 36) V |
| 4 | - | |
| 5 | Output 2 1) | |
| 6 | – | |

1) For К22 (voltage proportional to gap).

Table A.2 – ДПЭ22МВ, ДПЭ22МВТ, ДПЭ22П, ДПЭ23МВ, ДПЭ23МВТ, ДПЭ23П

| Contact | Circuit | |
|---|---|---|
| 1 | Output 1(AC) | |
| 2 | Common | |
| 3 | + | (18 – 36) V |
| 4 1) | - | |
| 5 | Output 2 (DC) 2) | |
| 6 | Test signal input | |

1) For versions without galvanic isolation, contact 4 is not used.
2) For ДПЭ23МВ, ДПЭ23МВТ, ДПЭ23П.

Table A.3 – ИП36, ИП37

| Contact | Circuit | |
|---|---|---|
| 1 | Output 1 (AC) 1) | |
| 2 | Common | |
| 3 | + | (18 – 36) V |
| 4 | - | |
| 5 | Output 2 (DC) | |
| 6 | – | |

1) - For ИП36 - pulse signal (0 – 5) mA, with rotor speed.

Table A.4 – К21

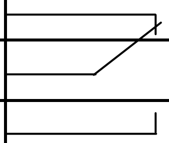
| Contact | Circuit |
|---|---|
| 1 | Output (gap monitoring) |
| 2 | Common |
| 3 | +24 V |
| 4 |  |
| 5 | |
| 6 | |

Table A.5 – ДВТ40.10, ДВТ40.20, ДВТ40.30, ДВТ40.50, ДВТ70

| Contact | Circuit |
|---|---|
| 1 | Excitation winding |
| 2 | |
| 3 | Signal winding |
| 4 | |

Table A.6 – ДВТ10, ДВТ20, ДВТ21, ДВТ23, ДВТ30, ДВТ40.40, ДВТ43.40, ДВТ50, ДВТ60

| Contact | Circuit |
|---|---|
| Central | Excitation winding |
| Casing | Common |

Table A.6.1 – ДВТ10, ДВТ20, ДВТ21, ДВТ30, ДВТ50, ДВТ60.10 with PC7TB connector

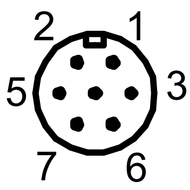
| Contact | Circuit | Note |
|---|---|---|
| 2 | Excitation winding |  |
| 5 | | |
| 1 | Common | |
| 3 | Common | |
| 6 | GND | |
| 7 | GND | |

Table A.7 – ИП34Ex, К22Ex, ДПЭ22Ex, ДПЭ23Ex, ДПЭ23МВП, ИП24, ИП36Ex, ДХМ

| Contact | Circuit |
|---|---|
| 1 | Output |
| 2 | Common |
| 3 | +24 V |
| 4 | Output 2[1)]<br>Test signal input[2)] |
| [1)] For К22Ex (voltage proportional to gap), ИП36Ex.<br>[2)] For ИП24. | |

Table A.8 – Sensor ДВТ43.20, ДВТ43.30, ДВТ43.50

| Contact | Circuit |
|---|---|
| 1 | Common |
| 2 | |
| 3 | Signal winding |
| 5 | |
| 6 | Excitation winding |
| 7 | |

A.2 Power supply units

Table A.9 – БП17

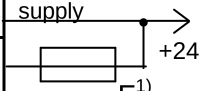
| Contact | Circuit |
|---|---|
| A2,B1,C2<br>A32,B31,C32 | Common |
| A4,B3,C4 | +15 V |
| A8,B7,C8 | –15 V |
| A10,B9,C10 | +24 V |
| A20,B19,C20 | |
| A18,B17,C18 | FG |
| B11 | Input $\overline{OK}$ |
| C14 | ~220 V |
| C16 | ~220 V |
| C26 | $\overline{OK}$ |
| C28 | |
| B25 | ОК |
| C30 | $\overline{OK}$ |
| B27 | |
| B29 | ОК |

Table A.10 – БП18

| Contact | Circuit |
|---|---|
| A2,B1,C2<br>A32,B31,C32 | Common |
| A4,B3,C4 | +15 V |
| A8,B7,C8 | –15 V |
| A10,B9,C10 | +24 V |
| A6,B5,C6 | +24 V |
| A18,B17,C18 | FG |
| B11 | Input $\overline{OK}$ |
| C14 | ~220 V |
| C16 | ~220 V |
| C26 | $\overline{OK}$ |
| C28 | |
| B25 | ОК |
| C30 | $\overline{OK}$ |
| B27 | |
| B29 | ОК |

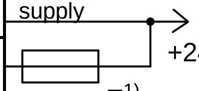
## A.3 Control boards

Table A.11 – ПК10

| Contact | Circuit |
|---|---|
| A2,A32, B1,B31, C2,C32 | Common |
| A4 | –15 V |
| C4 | +15 V |
| C6 | +24 V |
| A6 | Digital indicator power supply |
| B5 |  +24 V F[1)] |
| A18 | Output $\overline{OK}$ |
| B7 | Output ОК |
| B27 | Input “+” |
| B29 | Input “–” |
| B13 | Output =U |
| B15 | Output I |
| A10 | Output ∆ |
| A12 | Output ∇ |
| A14 | Output ∆∆ |
| A16 | Output ∇∇ |

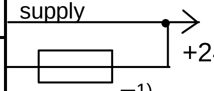
[1)] Customized

Table A.12 – ПК11

| Contact | Circuit |
|---|---|
| A2,A32, B1,B31, C2,C32 | Common |
| A4 | –15 V |
| C4 | +15 V |
| C6 | +24 V |
| A6 | Digital indicator power supply |
| B5 |  +24 V F[1)] |
| A18 | Output $\overline{OK}$ |
| B7 | Output ОК |
| B27 | Input “+” 1 channel |
| B29 | Input “–” 1 channel |
| C28 | Input “+” 2 channel |
| C30 | Input “–” 2 channel |
| B13 | Output =U 1 channel |
| B15 | Output I 1 channel |
| C14 | Output =U 2 channel |
| C16 | Output I 2 channel |
| A10 | Output ∆1 |
| A12 | Output ∇1 |
| A14 | Output ∆2 |
| A16 | Output ∇2 |

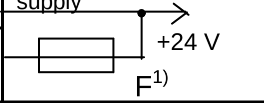
[1)] Customized.

Table A.13 – ПК12

| Contact | Circuit |
|---|---|
| A2,A32, B1,B31, C2,C32 | Common |
| A4 | –15 V |
| C4 | +15 V |
| C6 | +24 V |
| A6 | Digital indicator power supply |
| B5 |  +24 V F[1)] |
| A18 | Output $\overline{OK}$ |
| B7 | Output ОК |
| B27 | Input “+” 1 channel |
| B29 | Input “–” 1 channel |
| C28 | Input “+” 2 channel |
| C30 | Input “–” 2 channel |
| B13 | Output =U 1 channel |
| B15 | Output I 1 channel |
| C14 | Output =U 2 channel |
| C16 | Output I 2 channel |
| A10 | Output ∆1 |
| A12 | Output ∆2 |
| A14 | Output ∆∆ |
| A26 | Output =U 3 channel |
| A28 | Input “+” 3 channel |
| A30 | Input “–” 3 channel |
| B19 | Output I 3 channel |

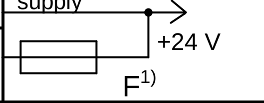
[1)] Customized

Table A.14 – ПК13

| Contact | Circuit |
|---|---|
| A2,A32, B1,B31, C2,C32 | Common |
| C4 | +15 V |
| A4 | –15 V |
| C6 | +24 V |
| A6 | Digital indicator power supply |
| B5 |   |
| A18 | Output $\overline{OK}$ |
| B7 | Output ОК |
| B27 | Input “+” |
| B29 | Input “–” |
| B13 | Output =U |
| B15 | Output I |
| A10 | Output Δ1 |
| A12 | Output Δ2 |
| A14 | Output ΔΔ |

[1)] Customized.

Table A.15 – ПК20, ПК30

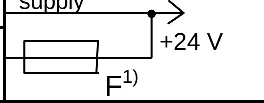
| Contact | Circuit |
|---|---|
| A2,A32, B1,B31, C2,C32 | Common |
| C4 | +15 V |
| A4 | –15 V |
| C6 | +24 V |
| A6 | Digital indicator power supply |
| B5 |   |
| A18 | Output $\overline{OK}$ |
| B7 | Output ОК |
| B27 | Input “+” |
| B29 | Input “–” |
| B13 | Output =U |
| B15 | Output I |
| A10 | Output Δ1 [2)] |
| A12 | Output Δ2 |
| A14 | Output ΔΔ |
| B25 | Output ~U 1channel |
| B17 | Output S [3)] |

[1)] Customized.

[2)] For ПК30,

[3)] Gap for ПК20,

Table A.16 – ПК21, ПК31

| Contact | Circuit |
|---|---|
| A2,A32, B1,B31, C2,C32 | Common |
| C4 | +15 V |
| A4 | –15 V |
| C6 | +24 V |
| A6 | Digital indicator power supply |
| B5 |   |
| A18 | Output $\overline{OK}$ |
| B7 | Output ОК |
| B27 | Input “+” 1channel |
| B29 | Input “–” 1channel |
| B13 | Output =U 1channel |
| B15 | Output I 1channel |
| A10 | Output Δ1 [2)] |
| A12 | Output Δ, (Δ2) [2)] |
| A14 | Output ΔΔ |
| B25 | Output ~U 1channel |
| B17 | Output S 1channel [3)] |
| C28 | Input “+” 2channel |
| C30 | Input “–” 2channel |
| C14 | Output =U 2channel |
| C16 | Output I 2channel |
| C24 | Output ~U 2channel |
| C18 | Output S 2channel [3)] |

[1)] Customized.

[2)] For ПК31.

[3)] Gap for ПК21.

Table A.17 – ПК32

| Contact | Circuit |
|---|---|
| A2,A32, B1,B31, C2,C32 | Common |
| C4 | +15 V |
| A4 | –15 V |
| C6 | +24 V |
| A6 | Digital indicator power supply |
| B5 | +24 V F[1] |
| A18 | Output $\overline{OK}$ |
| B7 | Output OK |
| B27 | Input "+" 1channel |
| B29 | Input "–" 1channel |
| B13 | Output =U 1channel |
| B15 | Output I 1channel |
| A10 | Output Δ1 |
| A12 | Output Δ2 |
| A14 | Output ΔΔ |
| B25 | Output ~U 1channel |
| C28 | Input "+" 2channel |
| C30 | Input "–" 2channel |
| C14 | Output =U 2channel |
| C16 | Output I 2channel |
| C24 | Output ~U 2channel |
| A28 | Input "+" 3channel |
| A30 | Input "–" 3channel |
| A26 | Output =U 3channel |
| B19 | Output I 3channel |
| B17 | Output ~U 3channel |

[1] Customized.

Table A.18 – ПК40

| Contact | Circuit |
|---|---|
| A2,A32, B1,B31, C2,C32 | Common |
| C4 | +15 V |
| A4 | –15 V |
| C6 | +24 V |
| A6 | Digital indicator power supply |
| B5 | +24 V F[1] |
| A18 | Output $\overline{OK}$ |
| B7 | Output OK |
| C20 | |
| C22 | |
| B27 | Input "+" |
| B29 | Input "–" |
| B13 | Output =U |
| B15 | Output I |
| B25 | Output pulse phase |
| A26 | Output pulse phase |
| C8 | CLOCK (output) |
| C10 | LATCH (output) |
| C12 | DATA (output) |
| A10 | Output ∇∇ |
| A12 | Output Δ1 |
| A14 | Output ΔΔ |
| A16 | Output Δ2 |
| A22 | Output 0 (shutdown) |

[1] Customized

Table A.19 – ПК51

| Contact | Circuit |
|---|---|
| A2,A32, B1,B31, C2,C32 | Common |
| C4 | +15 V |
| A4 | –15 V |
| C6 | +24 V |
| B9 | Input 1 |
| B11 | Input 2 |
| B7 | Input 3 |
| C18 | Input 4 |
| C24 | Input 5 |
| C30 | Input 6 |
| C8 | Input 7 |
| C10 | Input 8 |
| A12 | Output Δ |
| C14 | Interlocking |

Table A.20 – ПК72,ПК73

| Contact | Circuit |
|---|---|
| A2,A32, B31,B1, C2,C32 | Common |
| C4 | +15 V |
| C6 | +24 V |
| C16 | Input 1 |
| B15 | Input 2 |
| C14 | Input 3 |
| B13 | Input 4 |
| C12 | Input 5 |
| B11 | Input 6 |
| C10 | Input 7 |
| B9 | Input 8 |
| C24 | Input 9 |
| B23 | Input 10 |
| C22 | Input 11 |
| B21 | Input 12 |
| C20 | Input 13 |
| B19 | Input 14 |
| C18 | Input 15 |
| B17 | Input 16 |
| B25 | Input OK |
| A12 | Output ΔΔ1.1 (OR) |
| A14 | Output ΔΔ2& (AND) |
| A16 | Reset [1] |
| [1] For ПК73. | |

Table A.21 – ПК74

| Contact | Circuit |
|---|---|
| A2,A32, B31,B1, C2,C32 | Common |
| C4 | +15 V |
| C6 | +24 V |
| C16 | Input 1 |
| B15 | Input 2 |
| C14 | Input 3 |
| B13 | Input 4 |
| C12 | Input 5 |
| B11 | Input 6 |
| C10 | Input 7 |
| B9 | Input 8 |
| C24 | Input 9 |
| B23 | Input 10 |
| C22 | Input 11 |
| B21 | Input 12 |
| C20 | Input 13 |
| B19 | Input 14 |
| C18 | Input 15 |
| B17 | Input 16 |
| C8 | Input ΔΔ |
| A12 | Output “OUT 1” |
| A14 | Output “OUT 2” |
| A10 | Output “OUT 3” |

Table A.22–ПК80,ПК81

| Contact | Circuit |
|---|---|
| A2,A32, B31,B1, C2,C32 | Common |
| C4 | +15 V |
| A4 | –15 V |
| C6 | +24 V |
| B9 | Input 1 |
| B11 | Input 2 |
| B7 | Input 3 |
| C18 | Input 4 |
| C24 | Input 5 |
| C30 | Input 6 |
| C8 | Input 7 [1] |
| C10 | Input 8 [1] |
| A12 | Output Δ1.1 (OR) |
| A14 | Output Δ2& (AND)[2] |
| C14 | Reset |
| [1] For ПК80.<br>[2] For ПК81. | |

Table A.23 – ПК90

| Contact | Circuit | Contact | Circuit |
|---|---|---|---|
| A1,A32,B1, B31,C2,C32 | Common | C14 | Output 6-1 |
| | | B15 | Output 7-1 |
| C4 | +15 V | C16 | Output 1-2 |
| A4 | –15 V | B17 | Output 2-2 |
| B9 | Output 1-1 | C18 | Output 3-2 |
| C10 | Output 2-1 | B19 | Output 4-2 |
| B11 | Output 3-1 | C20 | Output 5-2 |
| C12 | Output 4-1 | B21 | Output 6-2 |
| B13 | Output 5-1 | C22 | Output 7-2 |

## A.4 Indication units

Table A.24 – БИ22

| Contact | Circuit |
|---|---|
| 1 | |
| 2 | |
| 3 | Input СЧ (count) |
| 4 | Common |
| 5 | +24 V |
| 6 | |
| 7 | |

Table A.25 – БИ23

| Contact | Circuit |
|---|---|
| 1 | DATA (input) |
| 2 | LATCH (input) |
| 3 | CLOCK (input) |
| 4 | Common |
| 5 | +24 V |
| 6 | |
| 7 | |

## A.5 Control units

Table A.26 –
Connector X3

<table>
<tr><th>Contact</th><th>Circuit</th></tr>
<tr><td>1</td><td rowspan="2">~ 220 V</td></tr>
<tr><td>2</td></tr>
</table>

Table A.27 –
Connector X4 БК10,БК30

| Contact | Circuit |
|---|---|
| 1 | Input |
| 4 | Output I |
| 7 | +24 V |
| 8 | Common |

Table A.28 –
Connector X4 БК20

| Contact | Circuit |
|---|---|
| 1 | Input |
| 3 | Output S |
| 4 | Output I |
| 7 | +24 V |
| 8 | Common |

Table A.29 –
Connector X4 БК11, БК31

| Contact | Circuit |
|---|---|
| 1 | Input 1 channel |
| 2 | Input 2 channel |
| 4 | Output I 1 channel |
| 5 | Output I 2 channel |
| 7 | +24 V |
| 8 | Common |

Table A.30 –
Connector X4 БК21

| Contact | Circuit |
|---|---|
| 1 | Input 1 channel |
| 2 | Input 2 channel |
| 3 | Output S 1 channel |
| 4 | Output I 1 channel |
| 5 | Output I 2 channel |
| 6 | Output S 2 channel |
| 7 | +24 V |
| 8 | Common |

Table A.31 –
Connector X4 БК32

| Contact | Circuit |
|---|---|
| 1 | Input 1 channel |
| 2 | Input 2 channel |
| 3 | Input 3 channel |
| 4 | Output I 1 channel |
| 5 | Output I 2 channel |
| 6 | Output I 3 channel |
| 7 | +24 V |
| 8 | Common |

Table A.32 –
Connector X4 БК40

| Contact | Circuit |
|---|---|
| 1 | Input |
| 2 | DATA (output) |
| 3 | CLOCK (output) |
| 4 | Output I |
| 5 | LATCH (output) |
| 6 | REF PHASE (Pulse phase output ⎍) |
| 7 | +24 V |
| 8 | Common |

Table A.33 –
Connector X5 БК10

| Contact | Circuit |
|---|---|
| 1 | Output $\overline{OK}$ |
| 2 | |
| 3 | Output Δ |
| 4 | |
| 5 | Output ∇ |
| 6 | |
| 7 | Output ΔΔ |
| 8 | |
| 9 | Output ∇∇ |
| 10 | |

Table A.34 –
Connector X5 БК11

| Contact | Circuit |
|---|---|
| 1 | Output $\overline{OK}$ |
| 2 | |
| 3 | Output Δ 1 |
| 4 | |
| 5 | Output ∇ 1 |
| 6 | |
| 7 | Output Δ 2 |
| 8 | |
| 9 | Output ∇2 |
| 10 | |

Table A.35 –
Connector X5 БК20, БК21

| Contact | Circuit |
|---|---|
| 1 | Output $\overline{OK}$ |
| 2 | |
| 3 | Output Δ |
| 4 | |
| 5 | Output ΔΔ |
| 6 | |

Table A.36 –
Connector X5
БК30,БК31,БК32

| Contact | Circuit |
|---|---|
| 1 | Output $\overline{OK}$ |
| 2 | |
| 3 | Output Δ 1 |
| 4 | |
| 5 | Output Δ 2 |
| 6 | |
| 7 | Output ΔΔ |
| 8 | |
| 9 | Output $\overline{OK}$ |
| 10 | |

Table A.37 –
Connector X5 БК40

| Contact | Circuit |
|---|---|
| 1 | Output $\overline{OK}$ |
| 2 | |
| 3 | Output Δ 1 |
| 4 | |
| 5 | Output ∇∇ |
| 6 | |
| 7 | Output Δ 2 |
| 8 | |
| 9 | Stop <0> |
| 10 | |

## A.6 Transducer boxes КП15 and КП25

Table A.38 – КП15В

SPD Z1

| Contact | Circuit |
|---|---|
| 1 | Output |
| 2 | +24 V |

SPD Z4

| Contact | Circuit |
|---|---|
| 1 | Test |

Terminal XS2

| Contact | Circuit |
|---|---|
| 1 | Common |

Connector XS4

| Contact | Circuit |
|---|---|
| 1 | Output |
| 2 | Common |
| 3 | +24 V |
| 4 | Test |

Table A.39 – КП15М

SPD Z1

| Contact | Circuit |
|---|---|
| 1 | Output |
| 2 | +24 V |

Terminal XS2

| Contact | Circuit |
|---|---|
| 1 | Common |

Connector XS4

| Contact | Circuit |
|---|---|
| 1 | Output |
| 2 | Common |
| 3 | +24 V |
| 4 | Common -24 V |

Table A.40 – КП25В2

SPD Z1

| Contact | Circuit |
|---|---|
| 1 | 1К Output |
| 2 | 1К +24 V |

Terminal XS1

| Contact | Circuit |
|---|---|
| 1 | Common 1 |
| 2 | Common 2 |

SPD Z2

| Contact | Circuit |
|---|---|
| 1 | 2К Output |
| 2 | 2К +24 V |

SPD Z4

| Contact | Circuit |
|---|---|
| 1 | 1К Test |
| 2 | 2К Test |

Connector XS4

| Contact | Circuit |
|---|---|
| 1 | 1К Output |
| 2 | 1К Common |
| 3 | 1К +24 V |
| 4 | 1К Test |

Connector XS5

| Contact | Circuit |
|---|---|
| 1 | 2К Output |
| 2 | 2К Common |
| 3 | 2К +24 V |
| 4 | 2К Test |

Table A.41 – КП25В3

SPD Z1

| Contact | Circuit |
|---|---|
| 1 | 1K Output |
| 2 | 1K +24 V |

SPD Z2

| Contact | Circuit |
|---|---|
| 1 | 2K Output |
| 2 | 2K +24 V |

SPD Z3

| Contact | Circuit |
|---|---|
| 1 | 3K Output |
| 2 | 3K +24 V |

SPD Z4

| Contact | Circuit |
|---|---|
| 1 | 1K Test |
| 2 | 2K Test |

SPD Z5

| Contact | Circuit |
|---|---|
| 1 | 2K Test |

Terminal XS1

| Contact | Circuit |
|---|---|
| 1 | Common 1 |
| 2 | Common 2 |

Connector XS4

| Contact | Circuit |
|---|---|
| 1 | 1K Output |
| 2 | 1K Common |
| 3 | 1K +24 V |
| 4 | 1K Test |

Connector XS5

| Contact | Circuit |
|---|---|
| 1 | 2K Output |
| 2 | 2K Common |
| 3 | 2K +24 V |
| 4 | 2K Test |

Connector XS6

| Contact | Circuit |
|---|---|
| 1 | 3K Output |
| 2 | 3K Common |
| 3 | 3K +24 V |
| 4 | 3K Test |

Table A.42 – КП25М2

SPD Z1

| Contact | Circuit |
|---|---|
| 1 | 1K Output |
| 2 | 1K +24 V |

SPD Z2

| Contact | Circuit |
|---|---|
| 1 | 2K Output |
| 2 | 2K +24 V |

Terminal XS1

| Contact | Circuit |
|---|---|
| 1 | Common 1 |
| 2 | Common 2 |

Connector XS4

| Contact | Circuit |
|---|---|
| 1 | 1K Output |
| 2 | 1K Common |
| 3 | 1K +24 V |
| 4 | 1K Common -24 V |

Connector XS5

| Contact | Circuit |
|---|---|
| 1 | 2K Output |
| 2 | 2K Common |
| 3 | 2K +24 V |
| 4 | 2K Common -24 V |

Table A.43 – КП25М3

SPD Z1

| Contact | Circuit |
|---|---|
| 1 | 1К Output |
| 2 | 1К +24 V |

SPD Z2

| Contact | Circuit |
|---|---|
| 1 | 2К Output |
| 2 | 2К +24 V |

SPD Z3

| Contact | Circuit |
|---|---|
| 1 | 3К Output |
| 2 | 3К +24 V |

Terminal XS1

| Contact | Circuit |
|---|---|
| 1 | Common 1 |
| 2 | Common 2 |

Connector XS4

| Contact | Circuit |
|---|---|
| 1 | 1К Output |
| 2 | 1К Common |
| 3 | 1К +24 V |
| 4 | 1К Common -24 V |

Connector XS5

| Contact | Circuit |
|---|---|
| 1 | 2К Output |
| 2 | 2К Common |
| 3 | 2К +24 V |
| 4 | 2К Common -24 V |

Connector XS6

| Contact | Circuit |
|---|---|
| 1 | 3К Output |
| 2 | 3К Common |
| 3 | 3К +24 V |
| 4 | 3К Common -24 V |

# Annex B
(Informative)

## Front panels of control boards, control units, power supply units and indication units

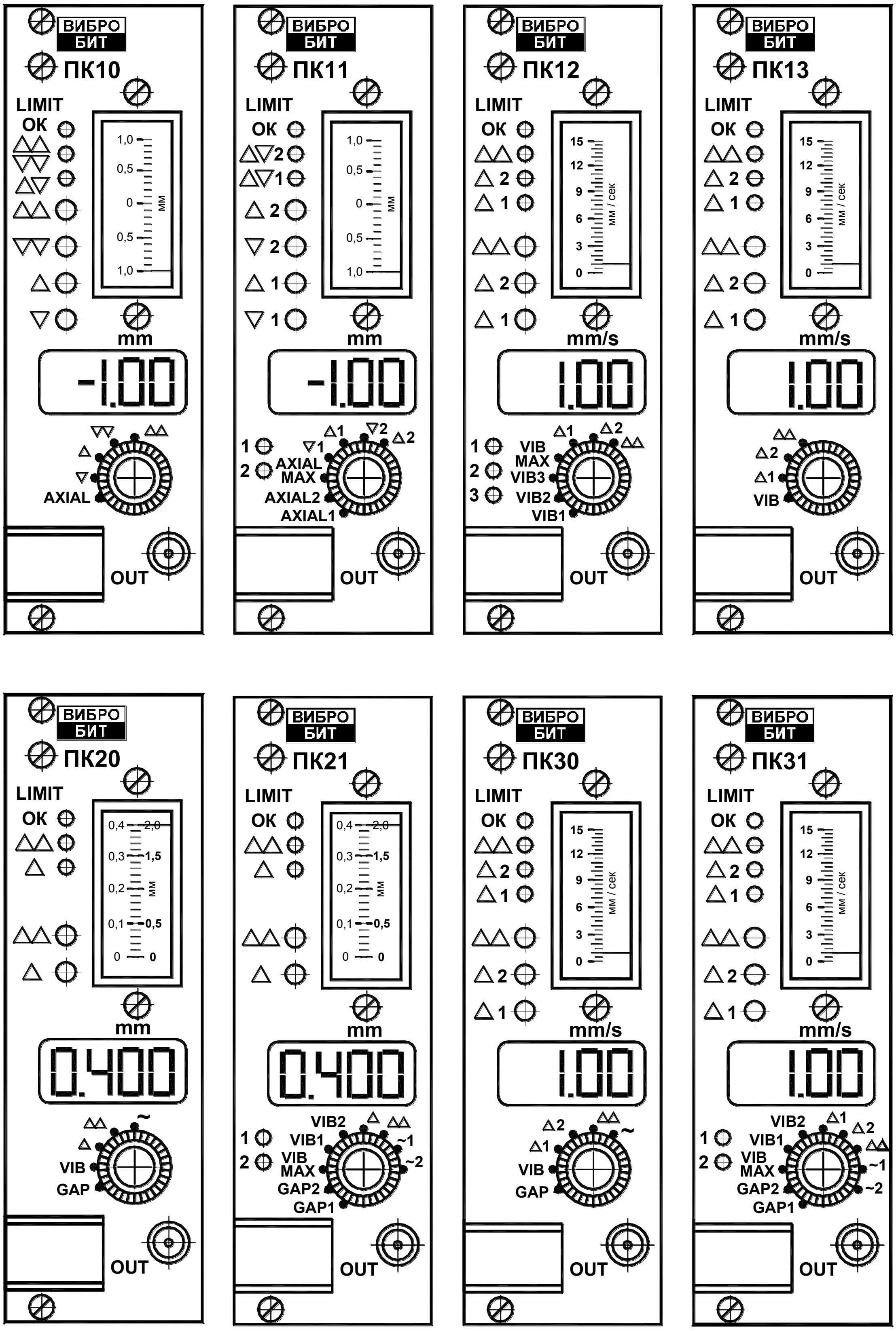



Figure B.1 – Control boards ПК

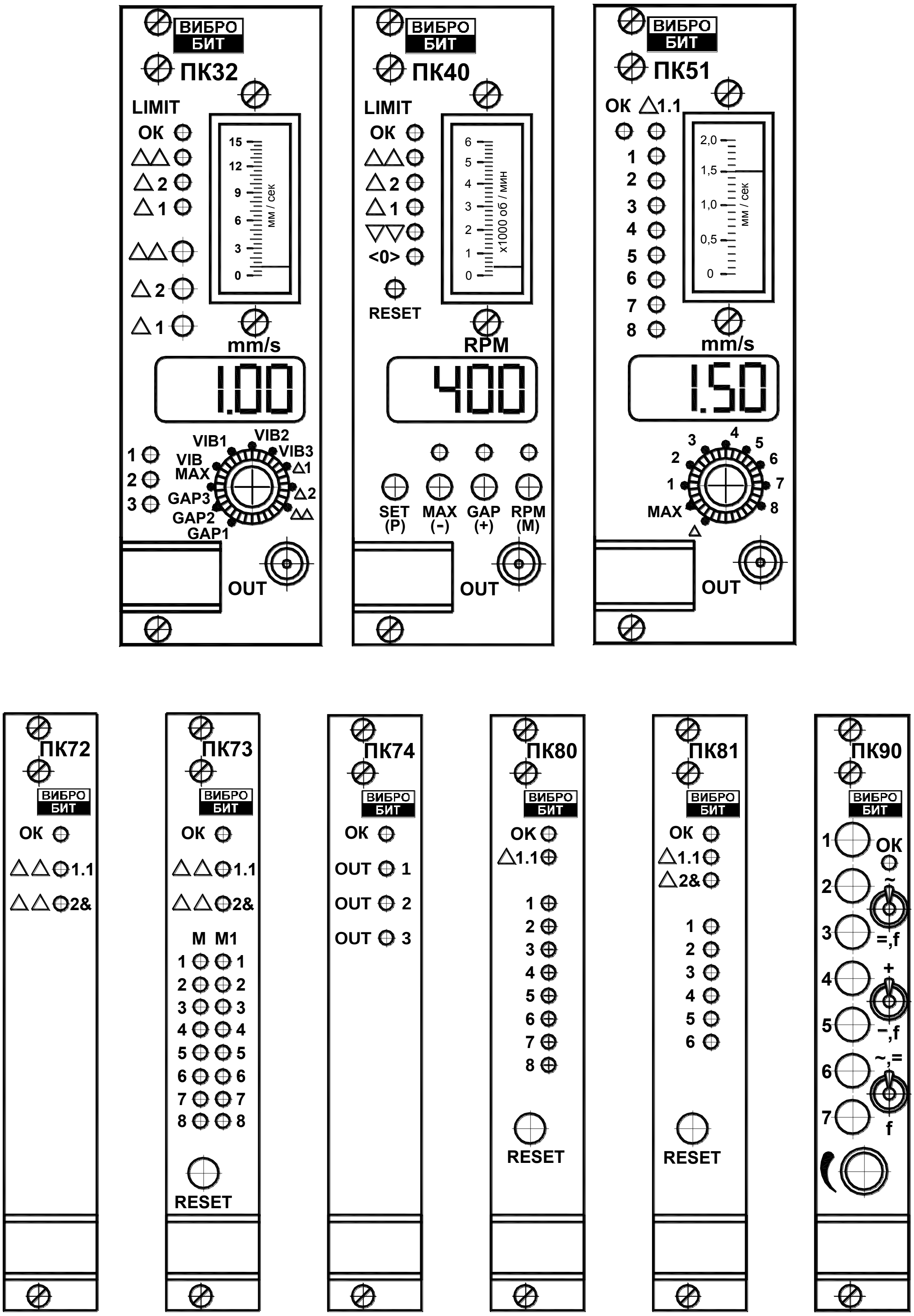



Figure B.2 – Control boards ПК

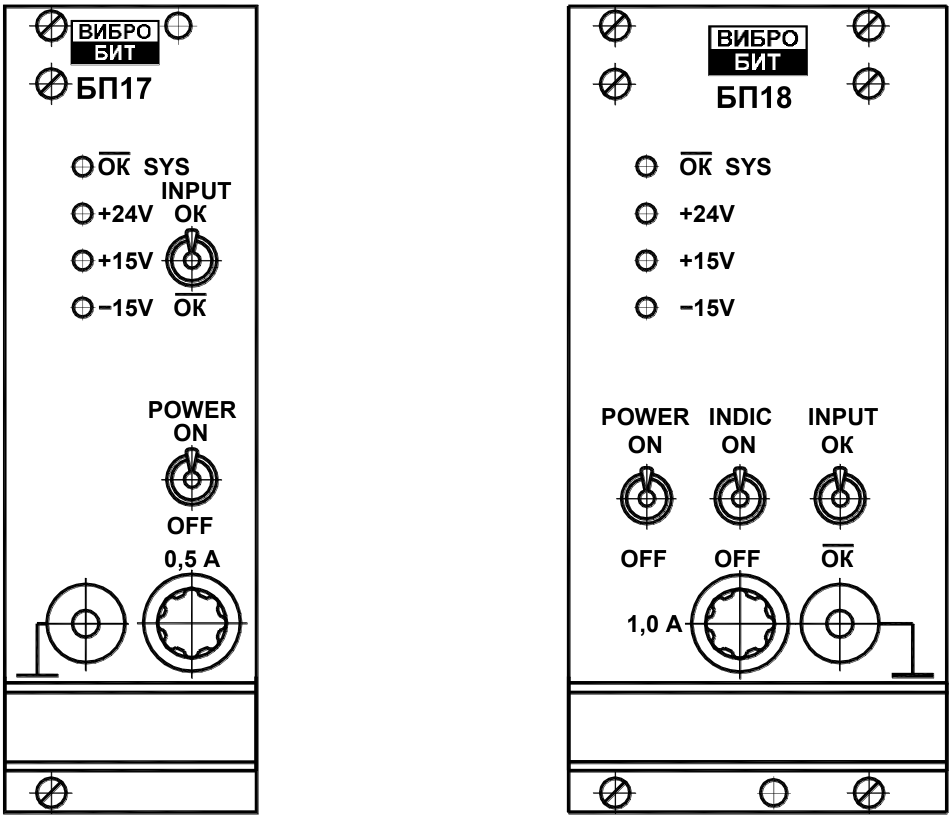



Figure B.3 – Power supply units БП

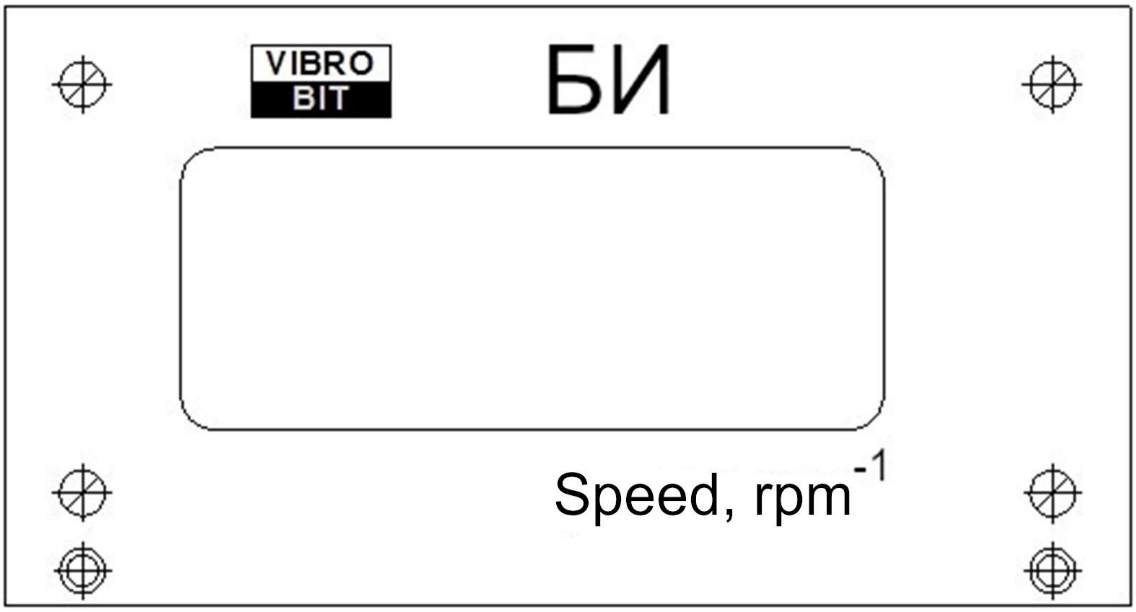



Figure B.4 – Indication units БИ22, БИ23

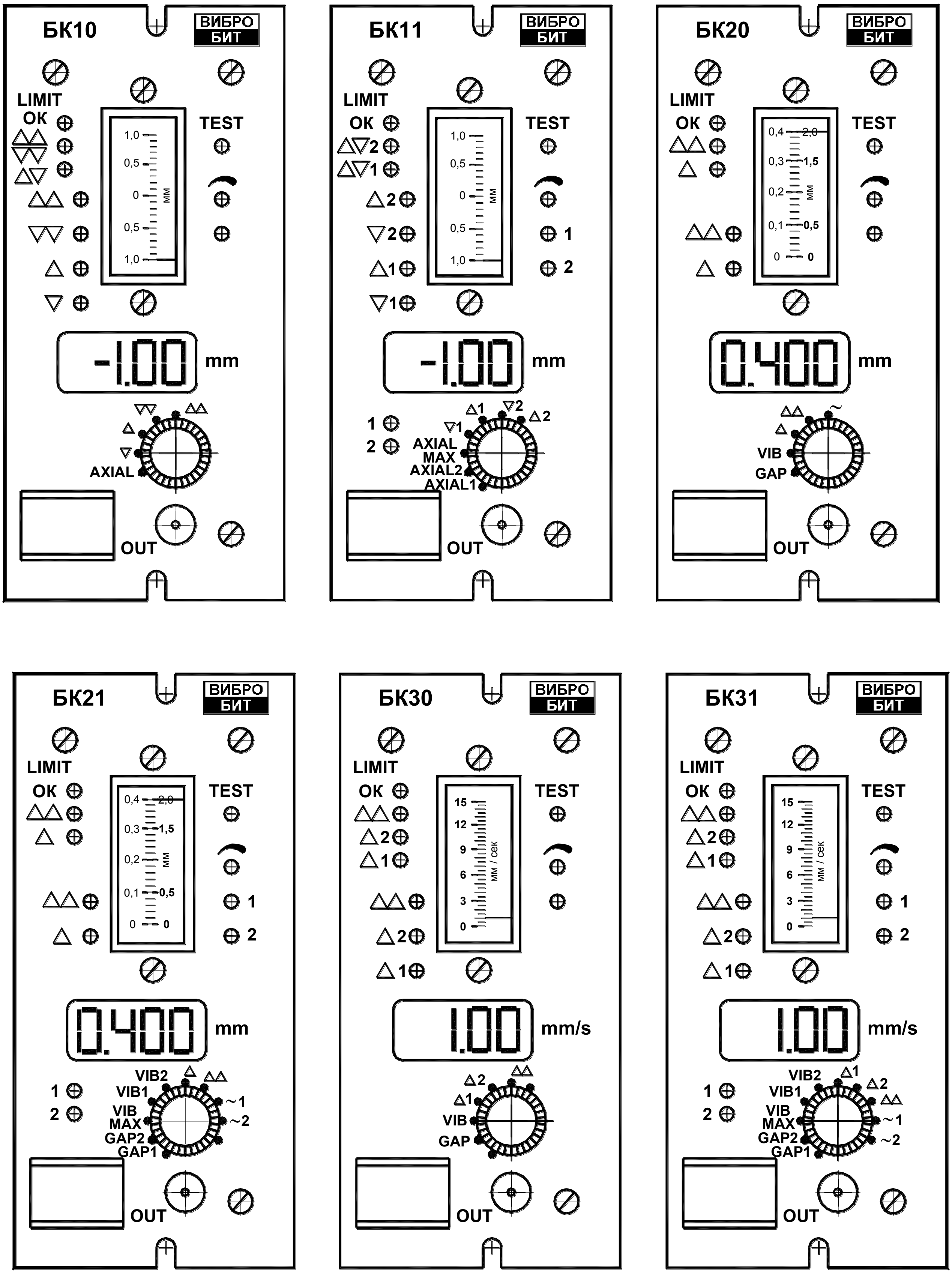



Figure B.5 – Control units

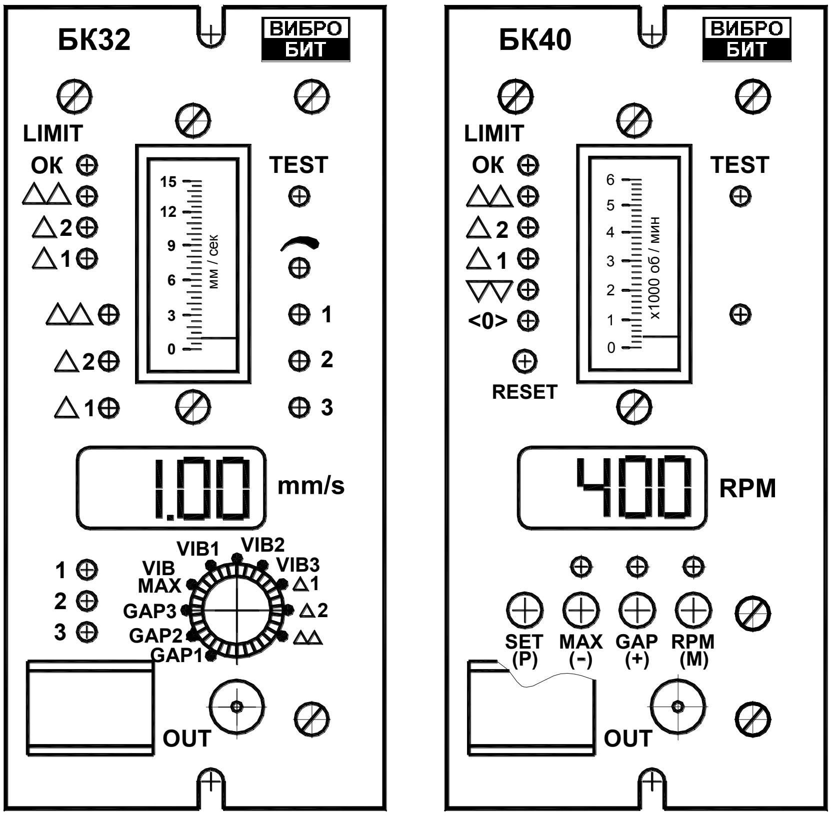



Figure B.6 – Control units

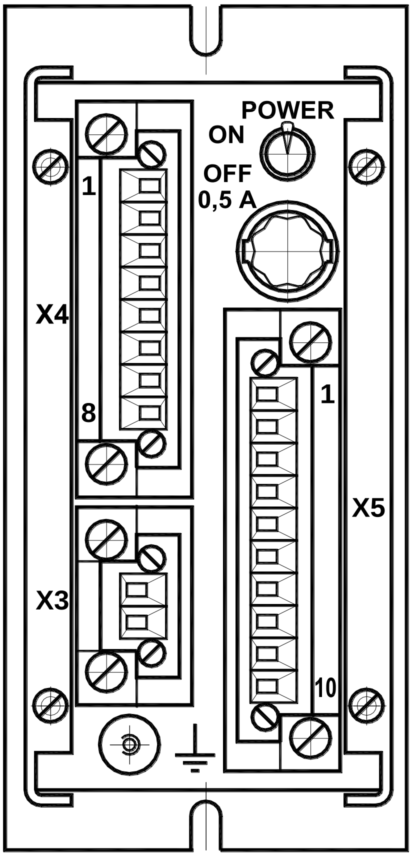



Figure B.7 – Arrangement of connectors at БК unit back panel

## Annex C
(Informative)

### Overall dimensions of the assemblies*

ДВТ10, ДВТ20, ДВТ30, ДВТ21, ДВТ50, ДВТ60.16 **sensors are available with two types of connectors**:

- **coaxial (shown in figures** C.1, C.2, C.3, C.4, C.9, C.10);
- РС7ТВ

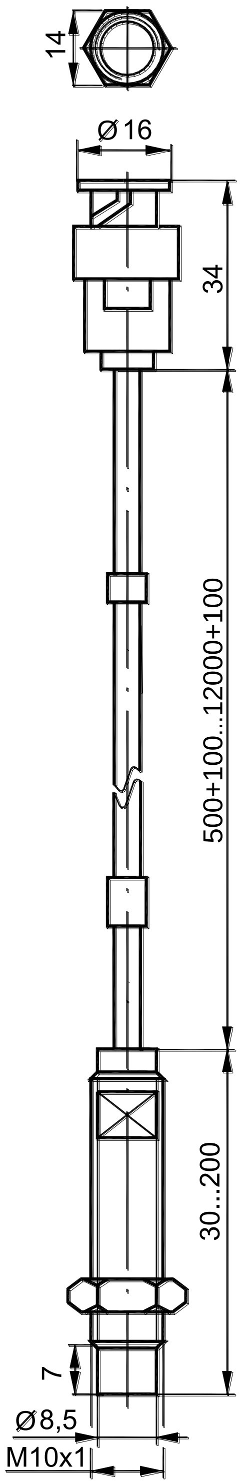



Figure C.1–Sensor ДВТ10, ДВТ10Ex

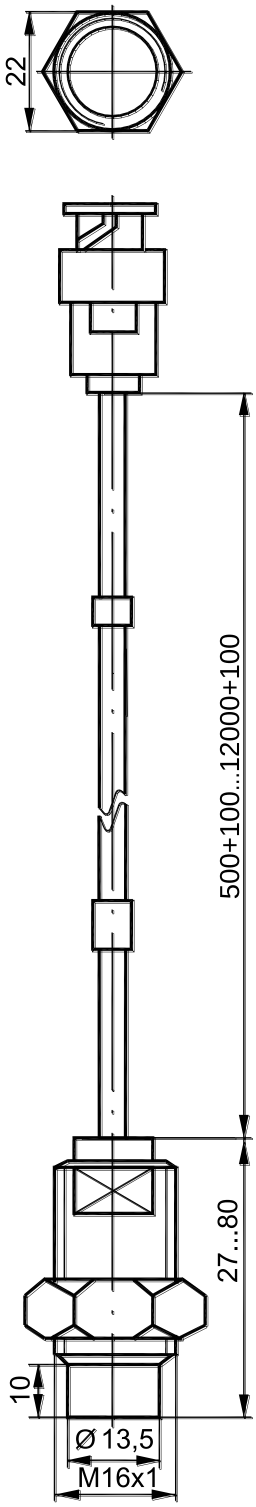



Figure C.2–Sensor ДВТ20, ДВТ20Ex

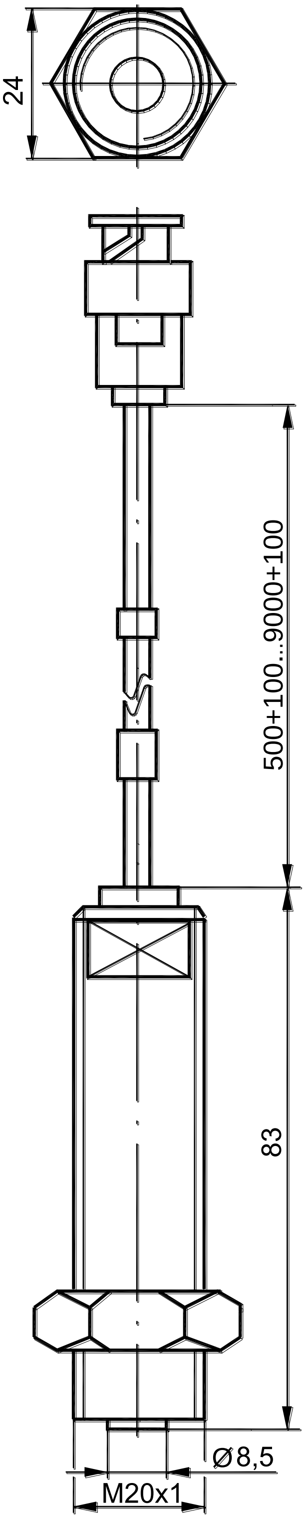



Figure C.3–Sensor ДВТ30

* Sensors with cable protected by the metal hose are available.

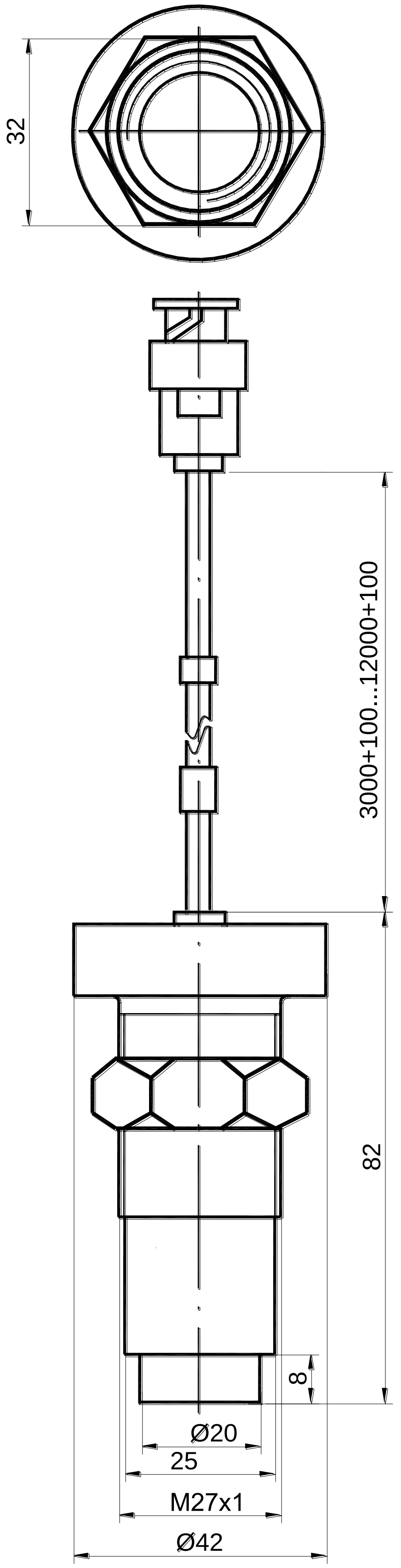



Figure C.4 - Sensor ДВТ21

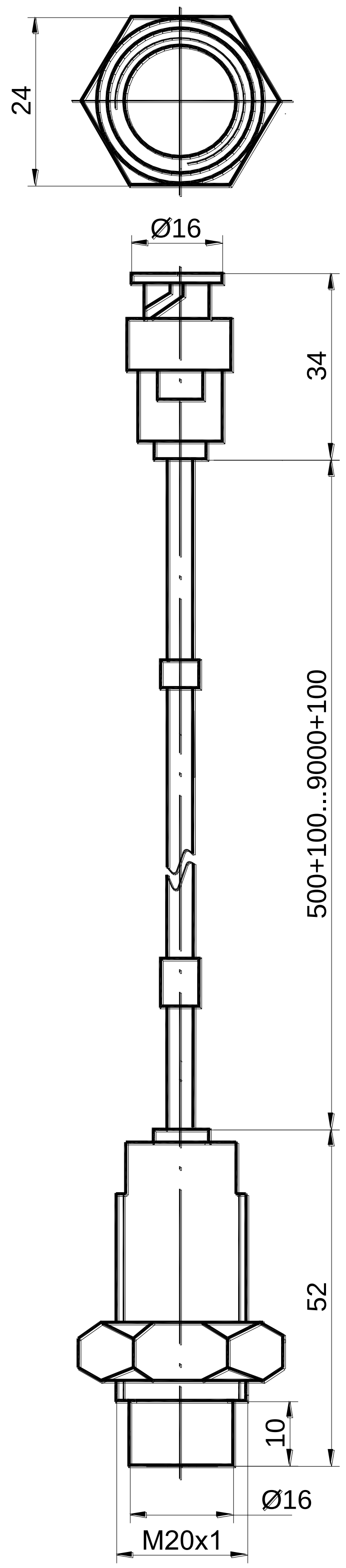



Figure C.5 - Sensor ДВТ23

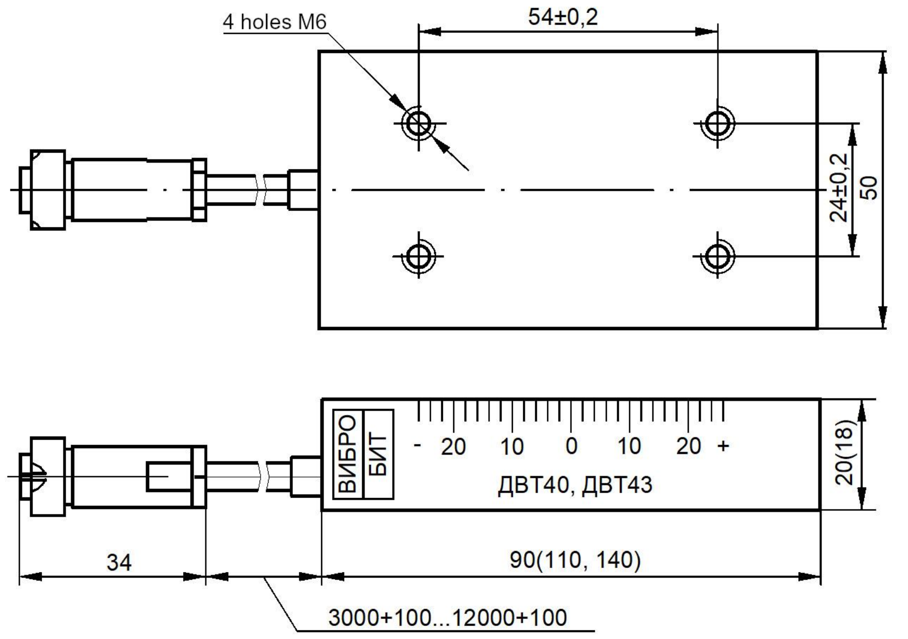



Figure C.6 – Sensors ДВТ40.10, ДВТ40.20, ДВТ43.20, ДВТ40.30, ДВТ43.30, ДВТ40.50, ДВТ43.50

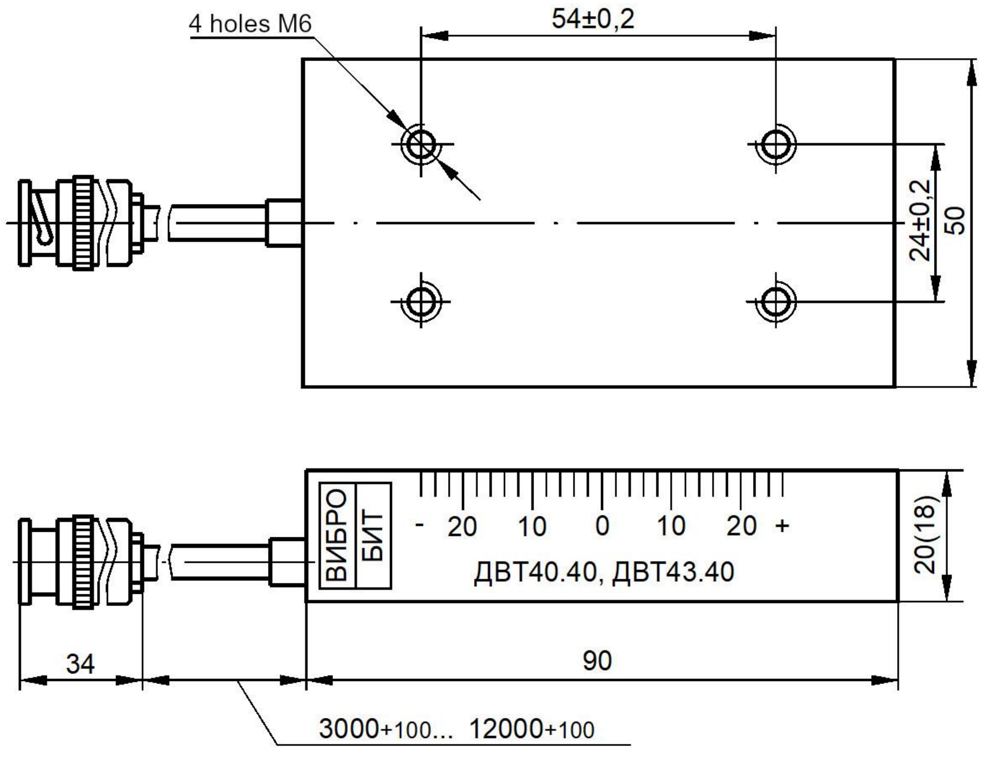



Figure C.7 - Sensors ДВТ40.40, ДВТ43.40

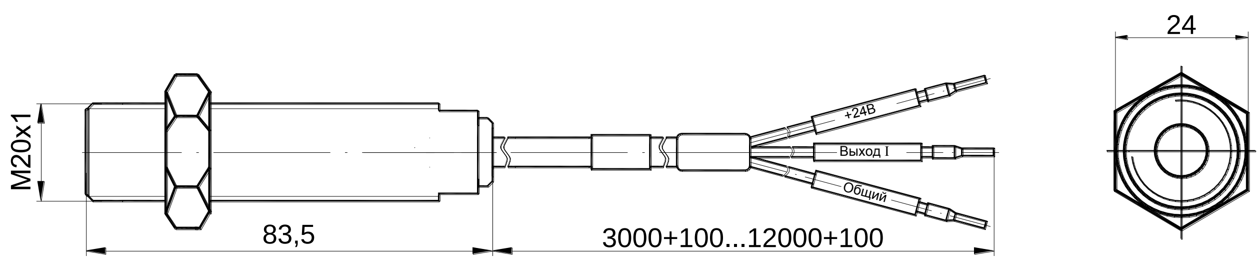



Figure C.8 - Sensor ДХМ

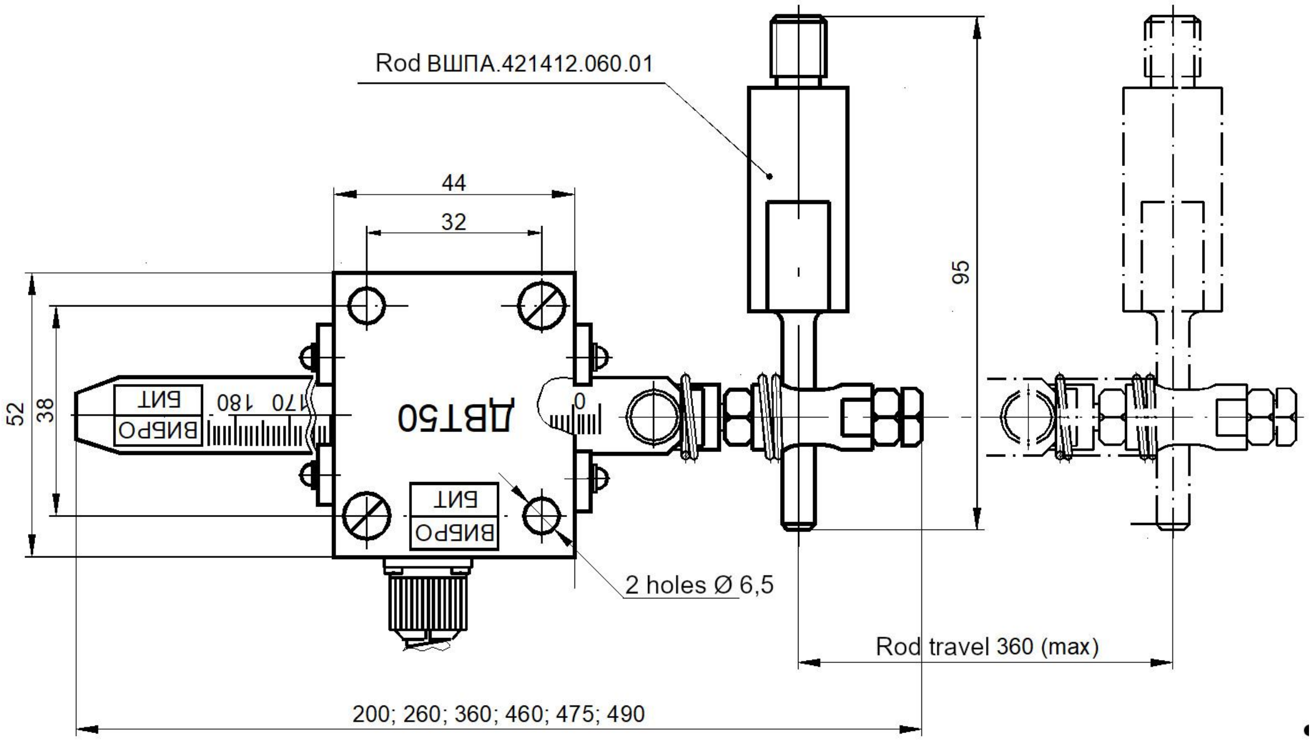



Figure C.9 – Sensor ДВТ50 with rod ВШПА.421412.060.01

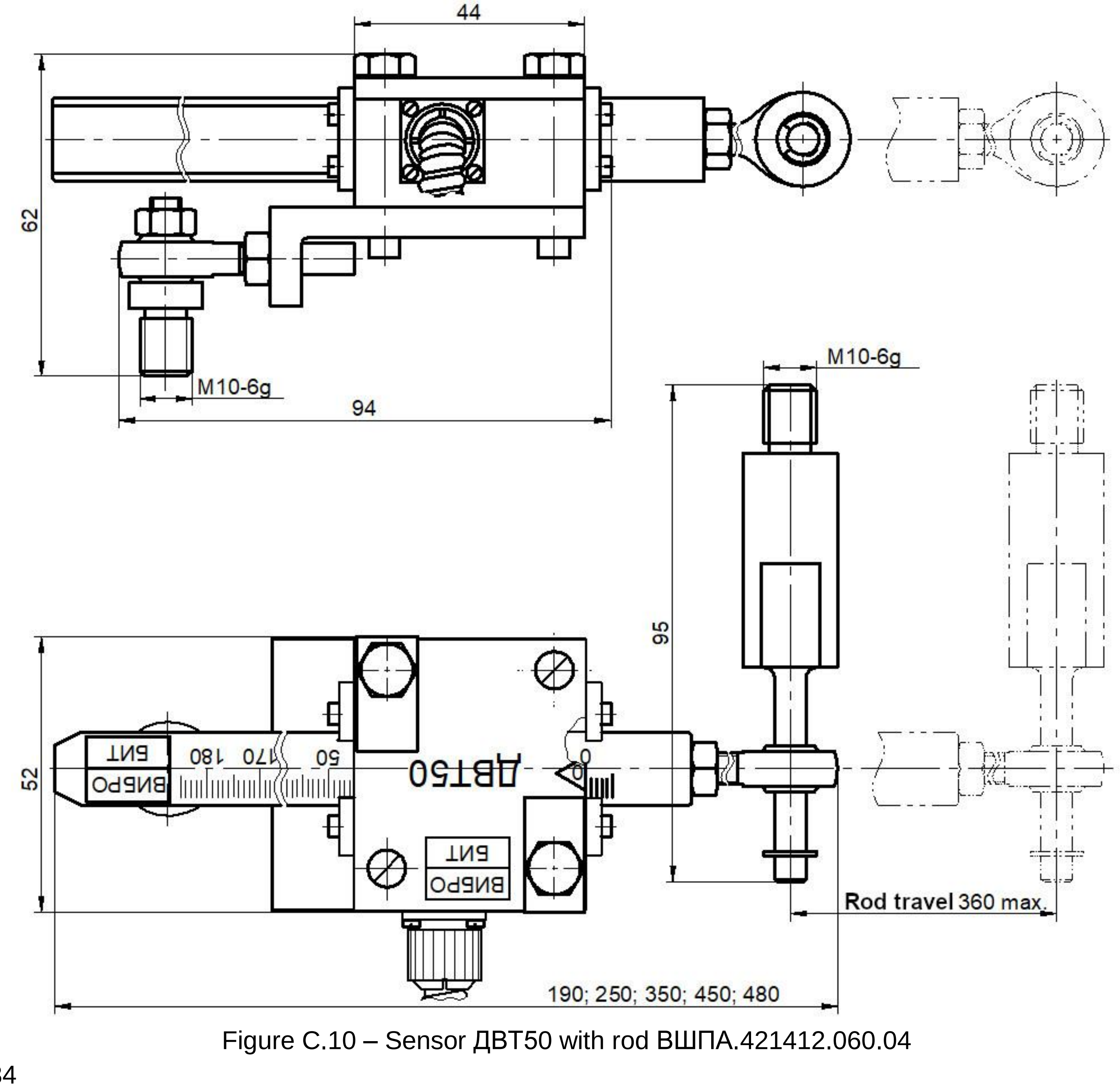



Figure C.10 – Sensor ДВТ50 with rod ВШПА.421412.060.04

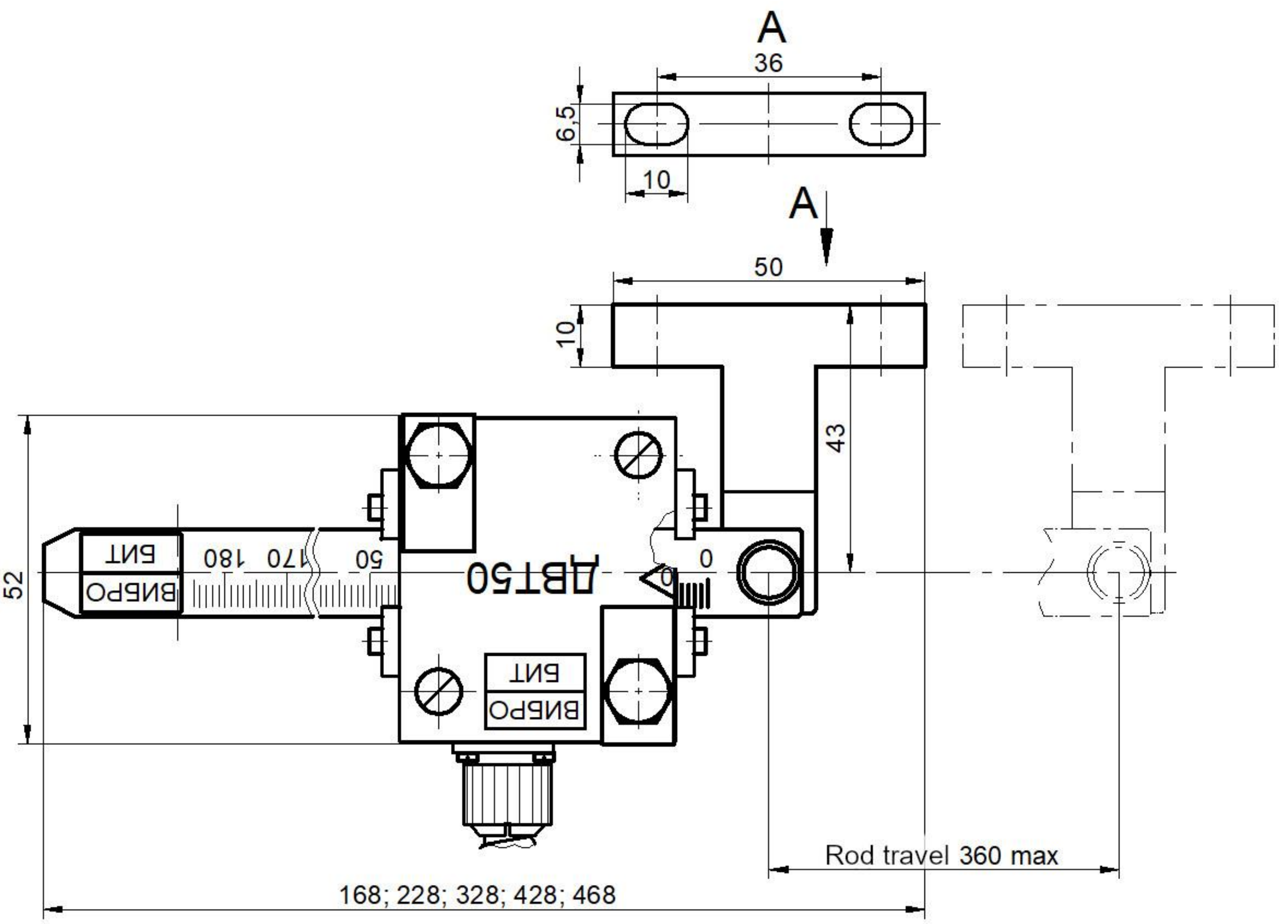
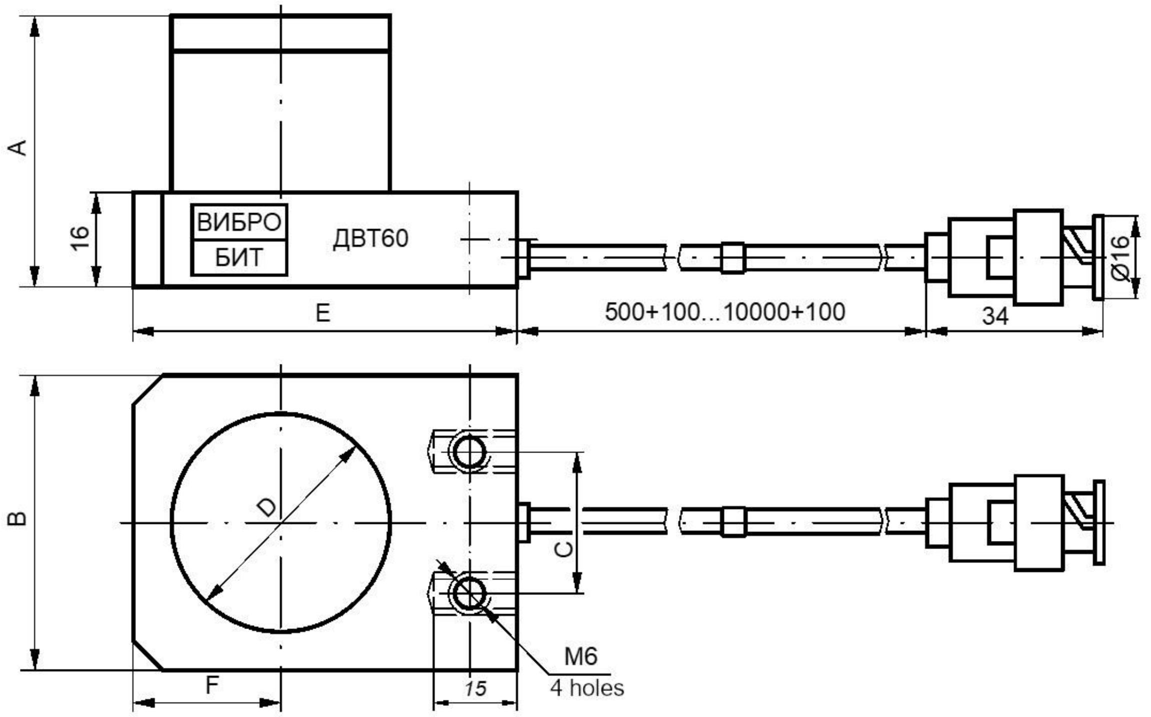



Figure C.11 – Sensor ДВТ50 with rod ВШПА.421412.060.10




| Sensor | Dimensions, mm | | | | | |
|---|---|---|---|---|---|---|
| | A | B | C | D | E | F |
| ДВТ60.10 | 38 | 32 | 20±0,2 | 25 | 40 | 15 |
| ДВТ60.16 | 46 | 50 | 24±0,2 | 37 | 65 | 25 |
| ДВТ60.20 | 52 | 50 | 24±0,2 | 45 | 65 | 25 |

Figure C.12 – Sensors ДВТ60

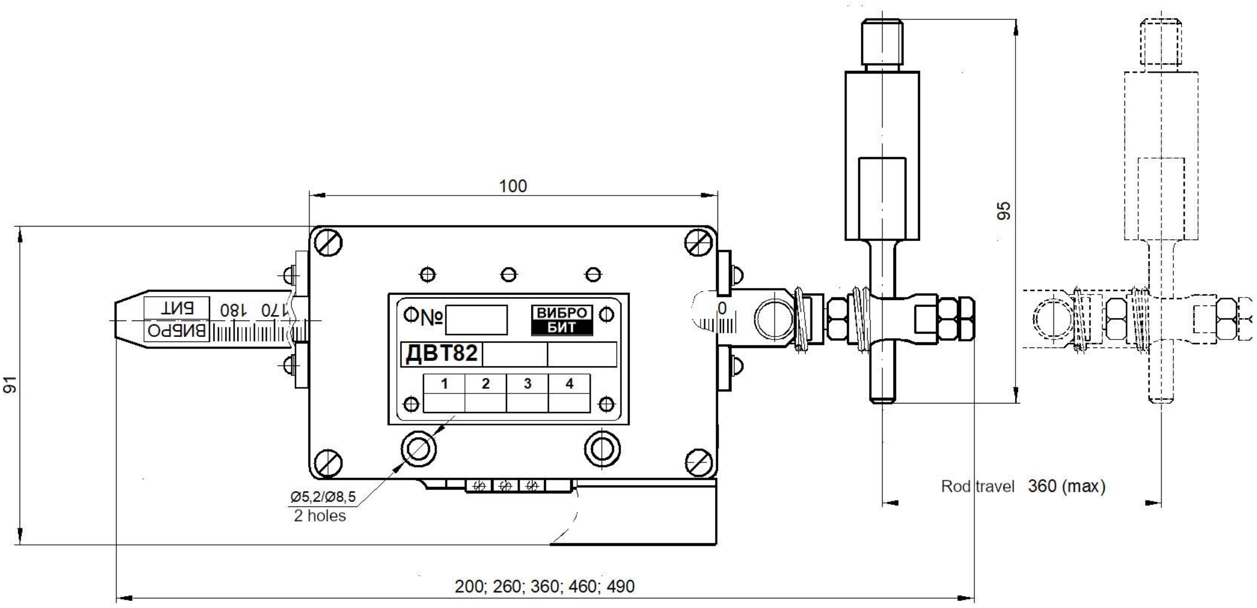
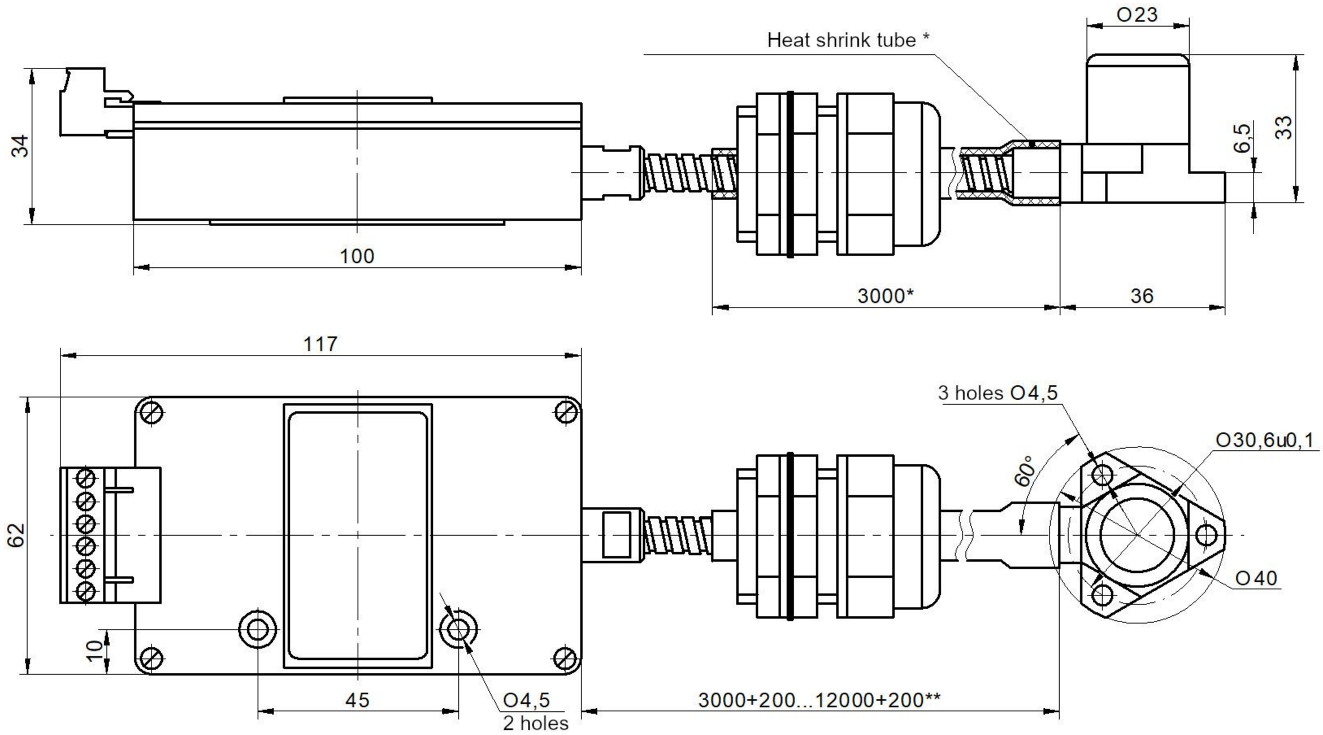


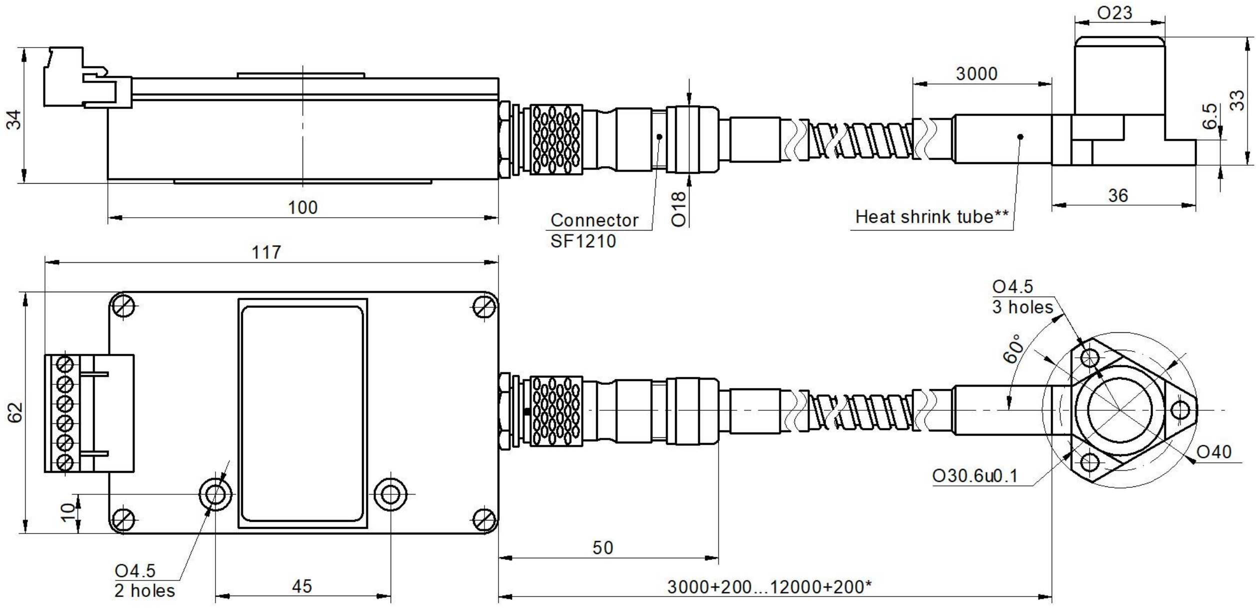

Figure C.13 – Sensor ДВТ82




* For component versions with insulated metal hose

** Customized length possible

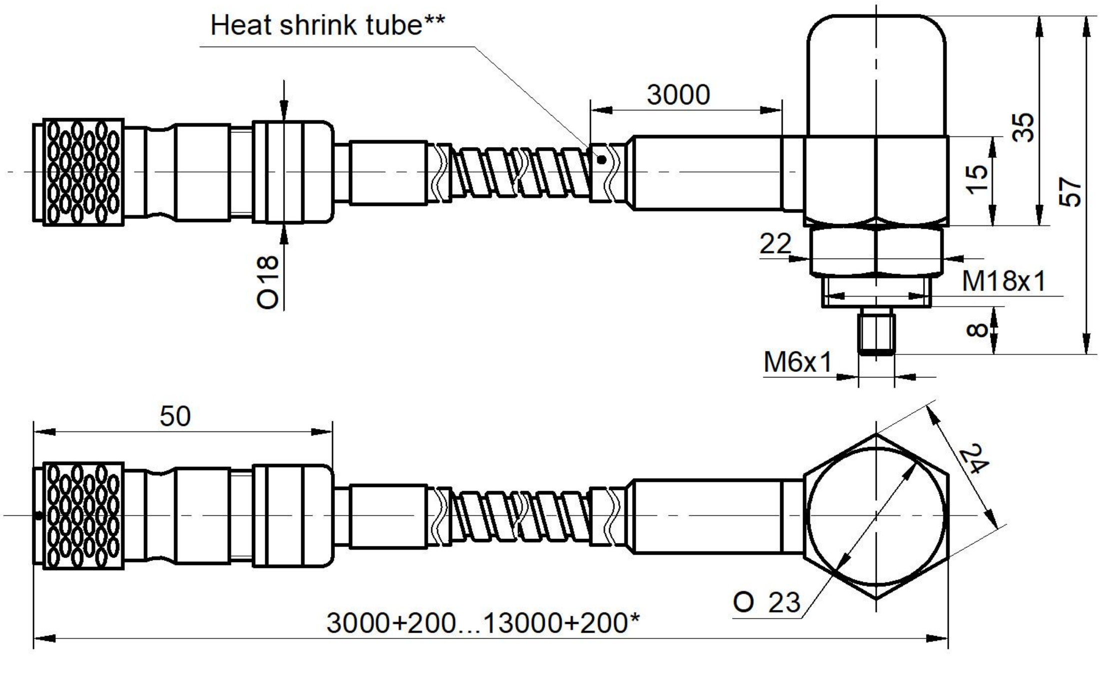
Figure C.14 – Sensors ДПЭ22МВ, ДПЭ22МВТ, ДПЭ23МВ, ДПЭ23МВТ




* Customized length possible.

** Sensor versions with detachable cable only with insulated 3-meter metal hose from the piezoconverter side.

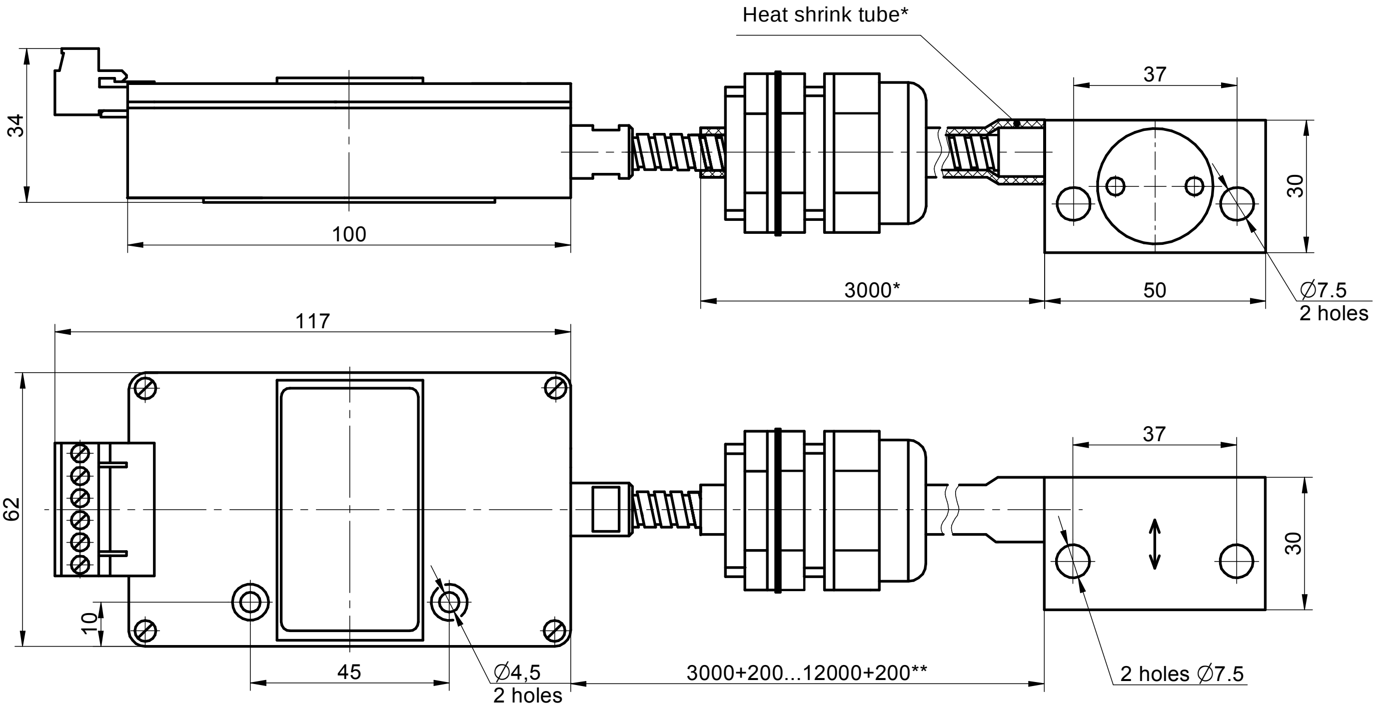
Figure C.15 – Sensors ДПЭ22МВ, ДПЭ22МВТ, ДПЭ23МВ, ДПЭ23МВТ, ДПЭ22Ex, ДПЭ23Ex with detachable cable connector




* Customized length possible

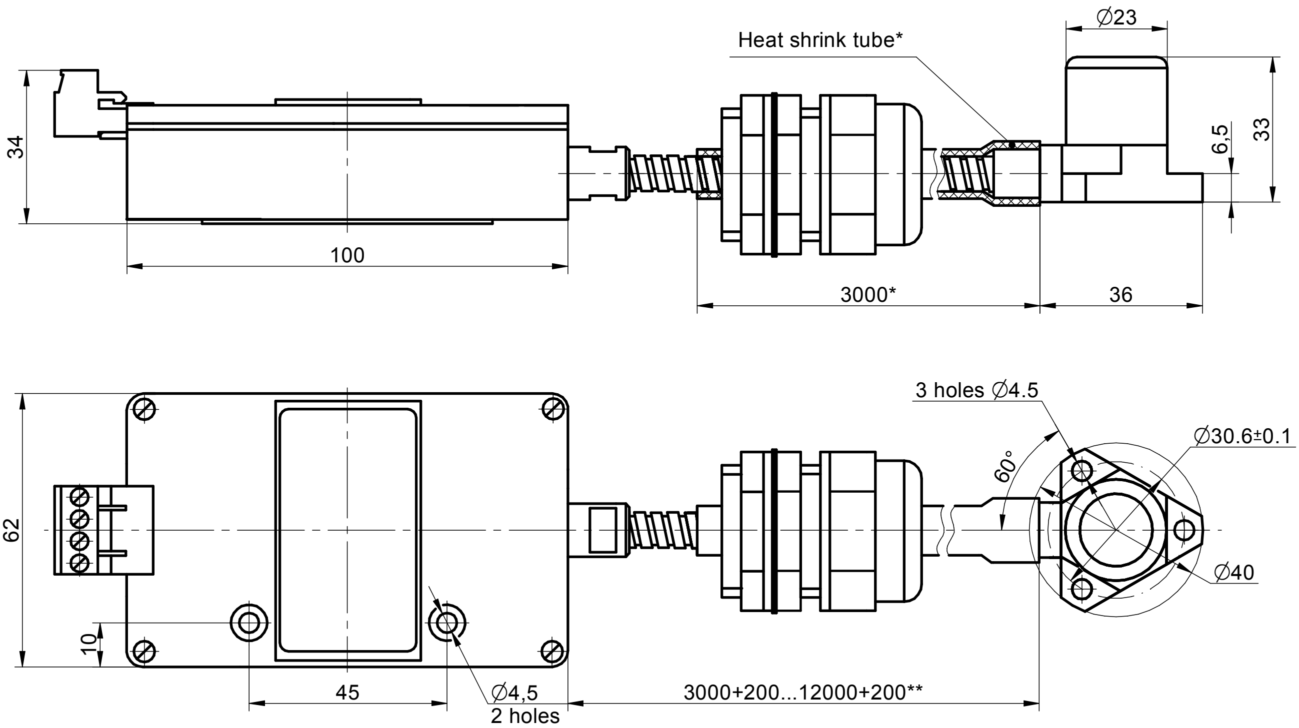
** Sensor versions with API610 type attachment are manufactured only with the detachable cable connector and insulated 3-meter metal hose from the piezoconverter side

Figure C.16 – Sensors ДПЭ22МВ, ДПЭ22МВТ, ДПЭ23МВ, ДПЭ23МВТ, ДПЭ22Ex, ДПЭ23Ex with API610 type attachment



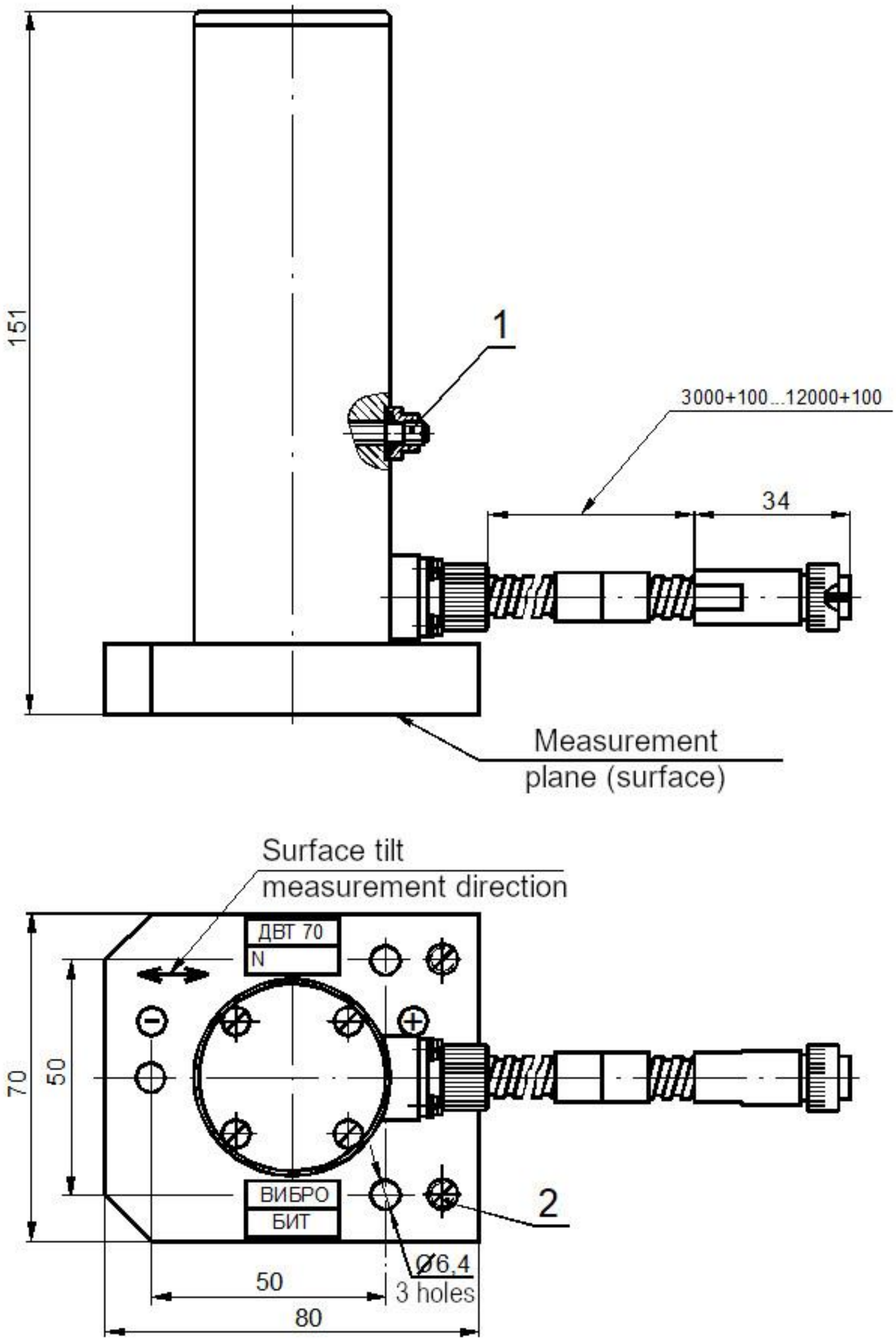

*For component versions with insulated metal hose.
**Customized length possible.

Figure C.17 – Sensors ДПЭ22П, ДПЭ23П




*For component versions with insulated metal hose.
**Customized length possible.

Figure C.18 – Sensor ДПЭ22Ex, ДПЭ23Ex, ДПЭ23МВП




1 – caging screw;

2 – adjustment screw.

Figure C.19 – Sensor ДВТ70

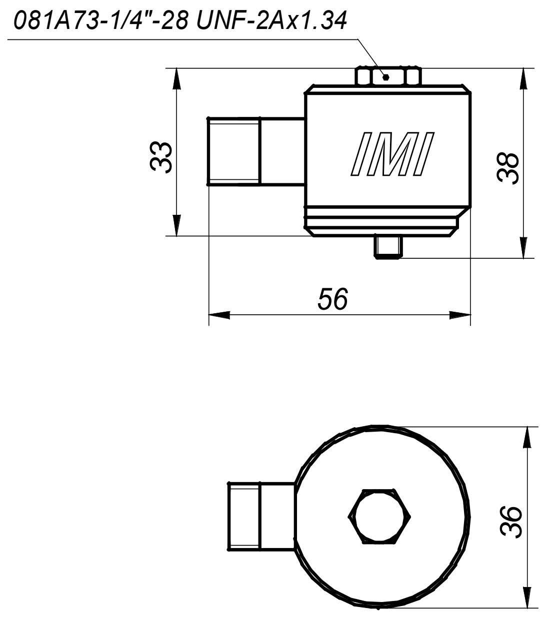
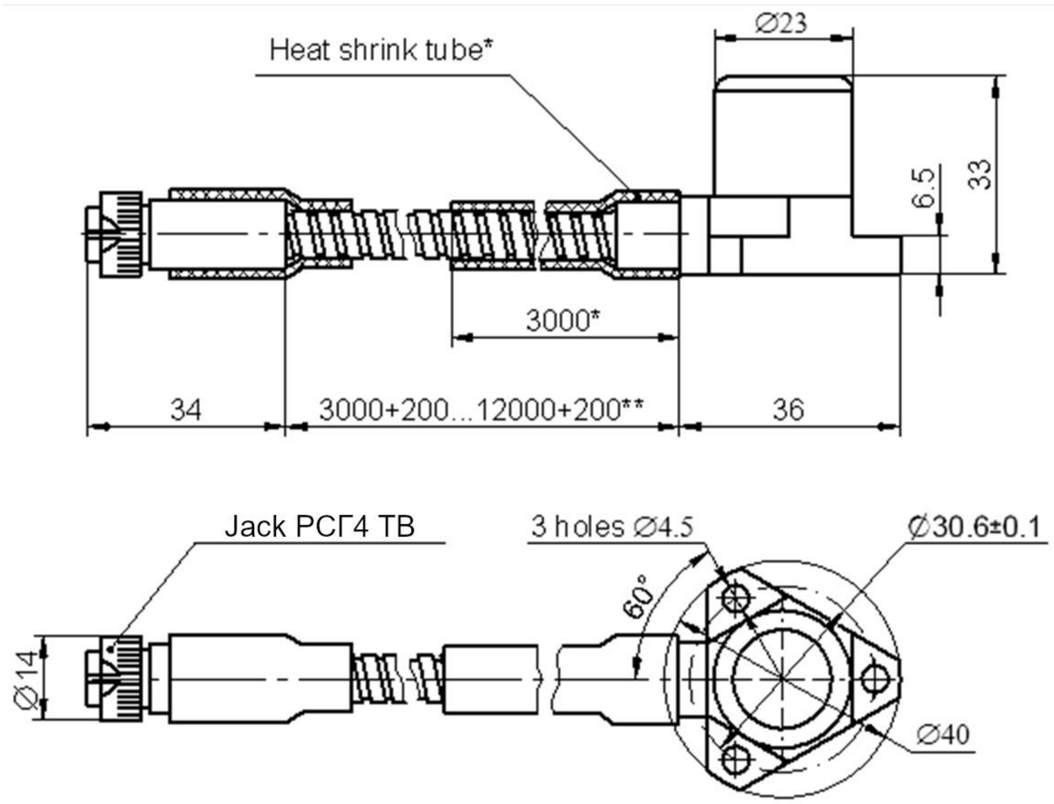


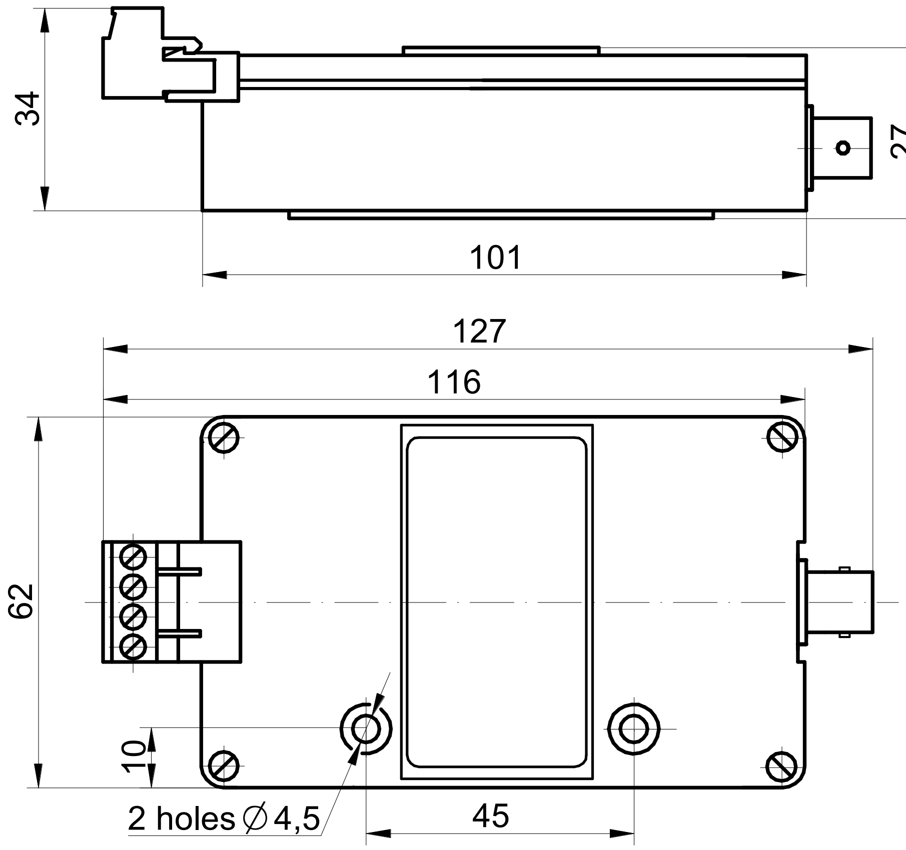

Figure C.20 – Sensor 625B01




* For component versions with insulated metal hose

** Customized cable length possible

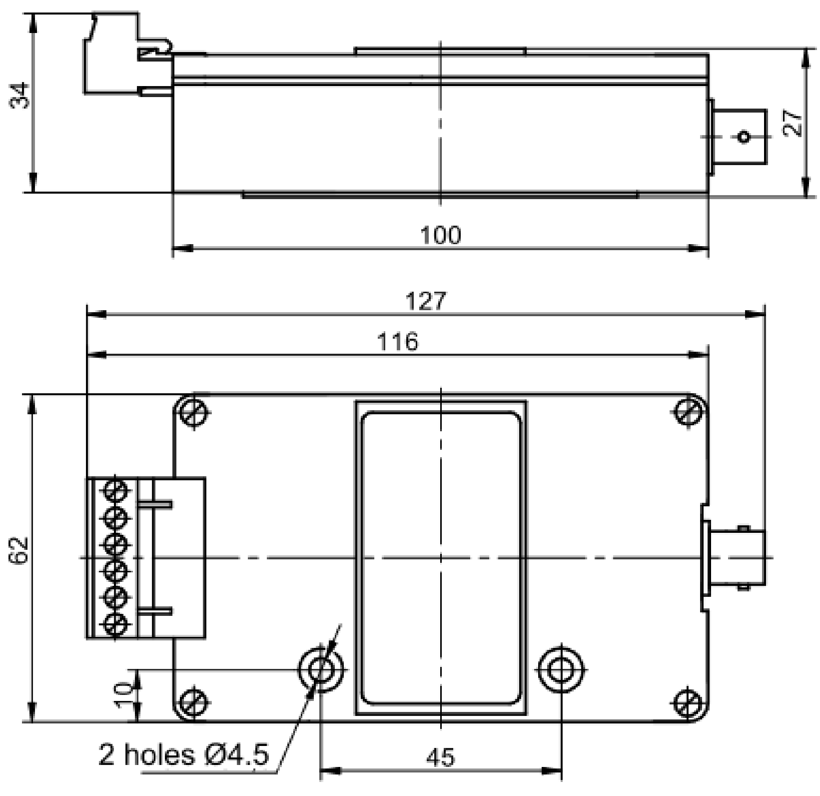
Figure C.21 – Sensor ДПЭ24




***** - ИП34 converter is available with two types of connectors:

- coaxial (shown in the figure);
- РСГ7ТВ

Figure C.22 – Converters ИП34, ИП34Ex, ИП36Ex and comparator К22Ex




***** - К22 comparator is available with two types of connectors:

- coaxial (shown in the figure);
- РСГ7ТВ

Figure C.23 – Converter ИП36, comparators К21 and К22

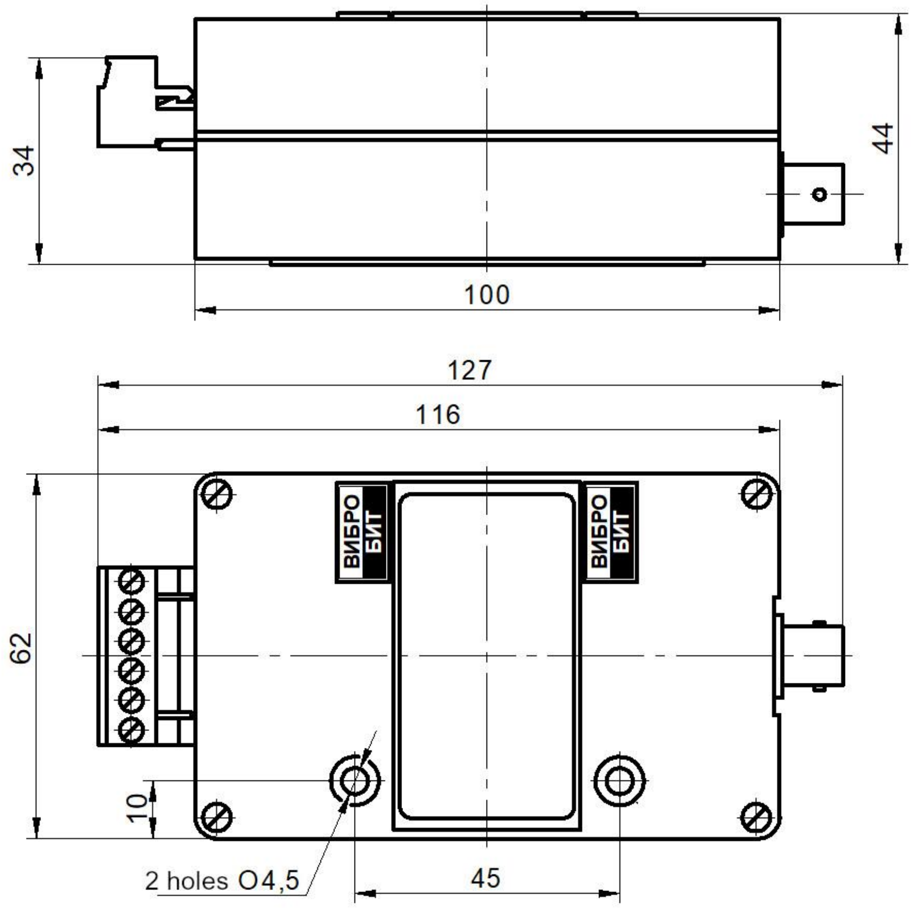



Figure C.24 – Converter ИП37

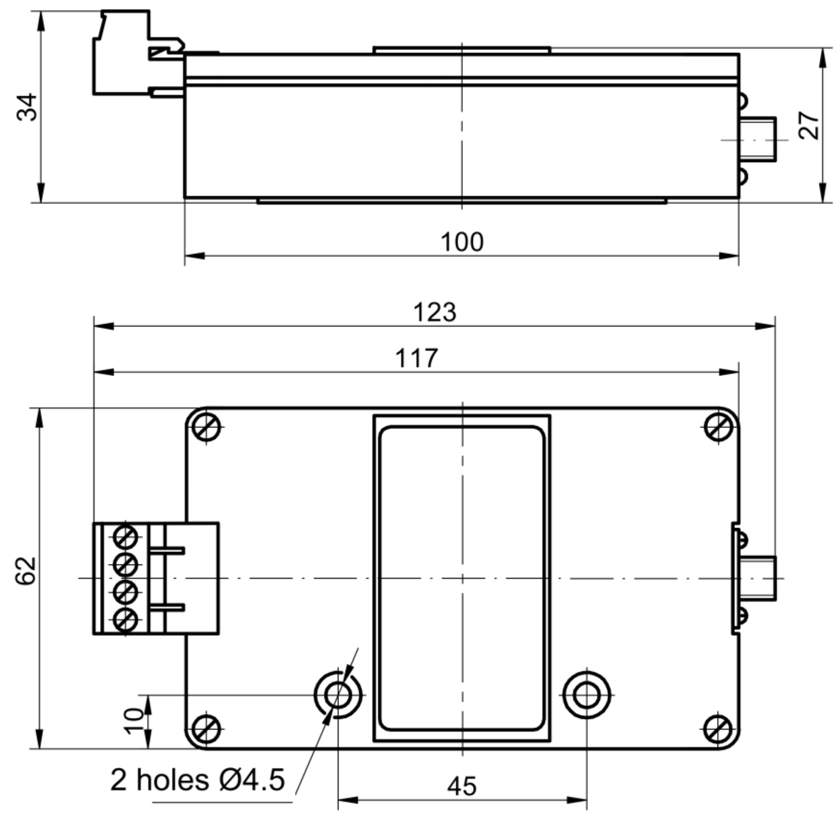
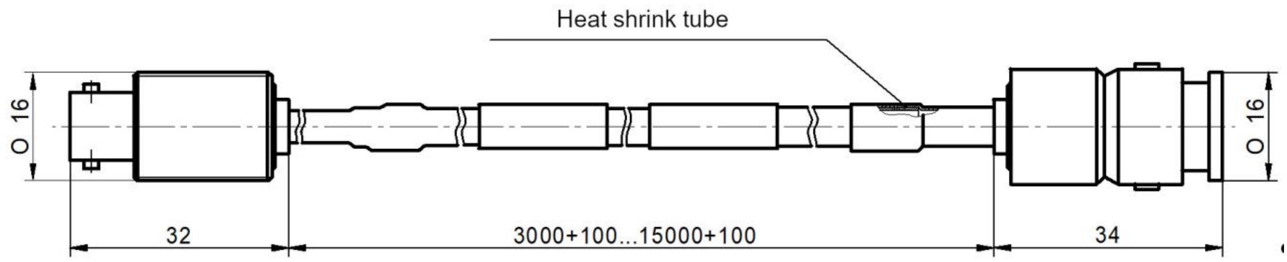
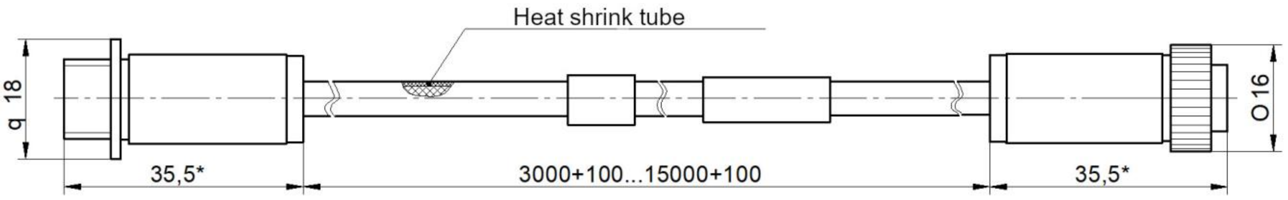


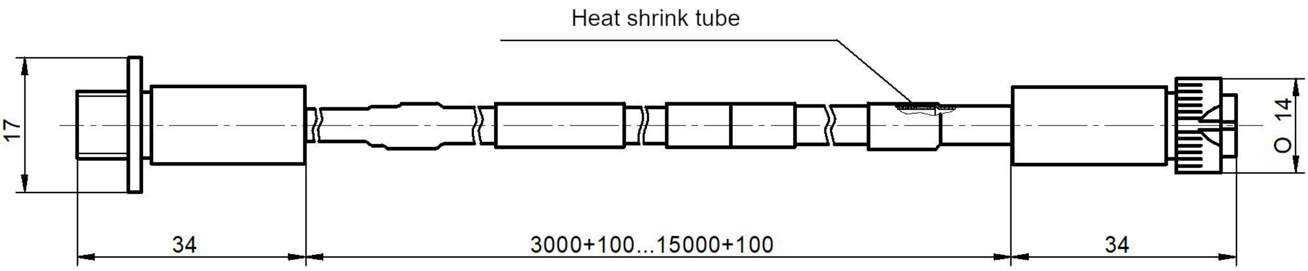

Figure C.25 – Converters ИП24, ИП42, ИП43, ИП44




**a)**




**b)**




**c)**

Figure C.26 – Connection cables

a) КС10 with coaxial connectors

b) КС10 with connectors РСГ7ТВ (plug), РС7ТВ (socket)

c) КС11

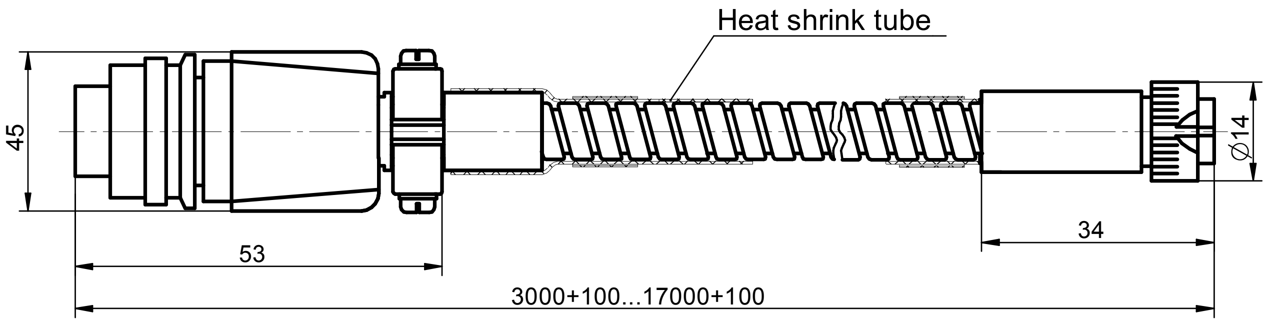



Figure C. 27 – Connection cable КС24

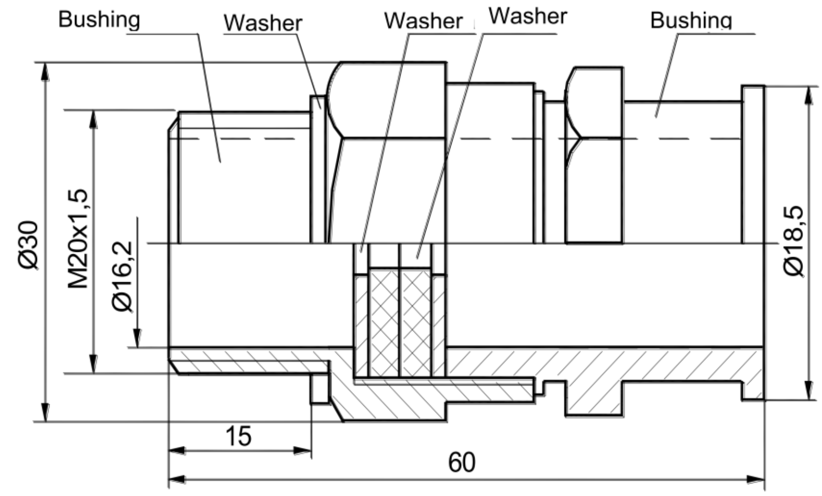



Figure C.28 – Feedthrough M20

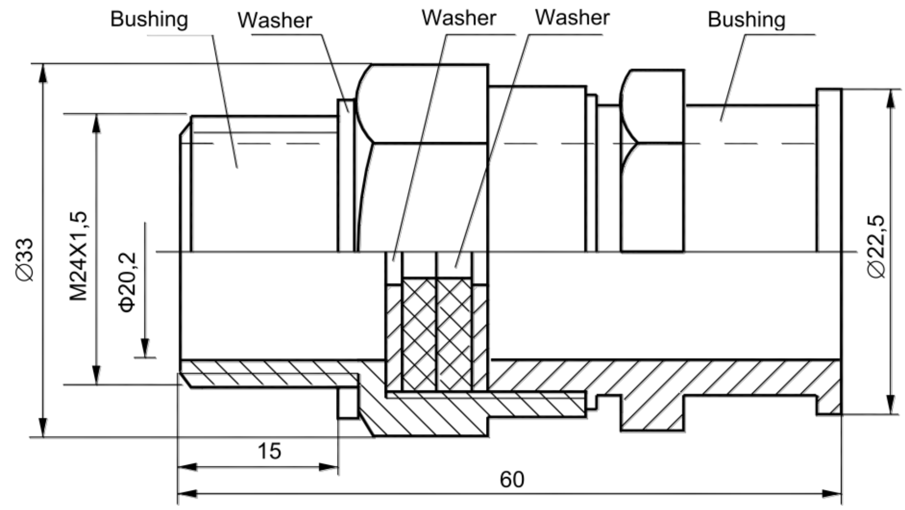
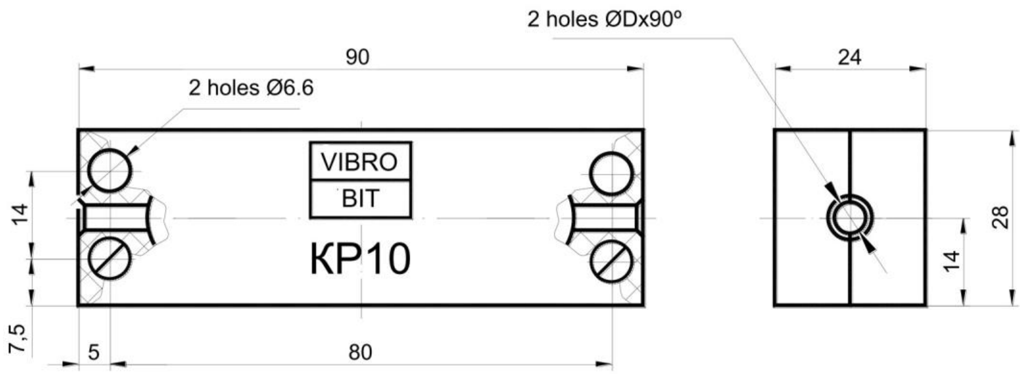



Figure C.29 – Feedthrough M24




| Designation | d / D, mm | Note |
|---|---|---|
| ВШПА.421412.048 | 5 / 7 | for sensors ДВТ with КС10 |
| - 01 | 6,8 / 9 | for sensors ДВТ40, ДВТ43 with КС11 |

Figure C.30 – Connector box КР10

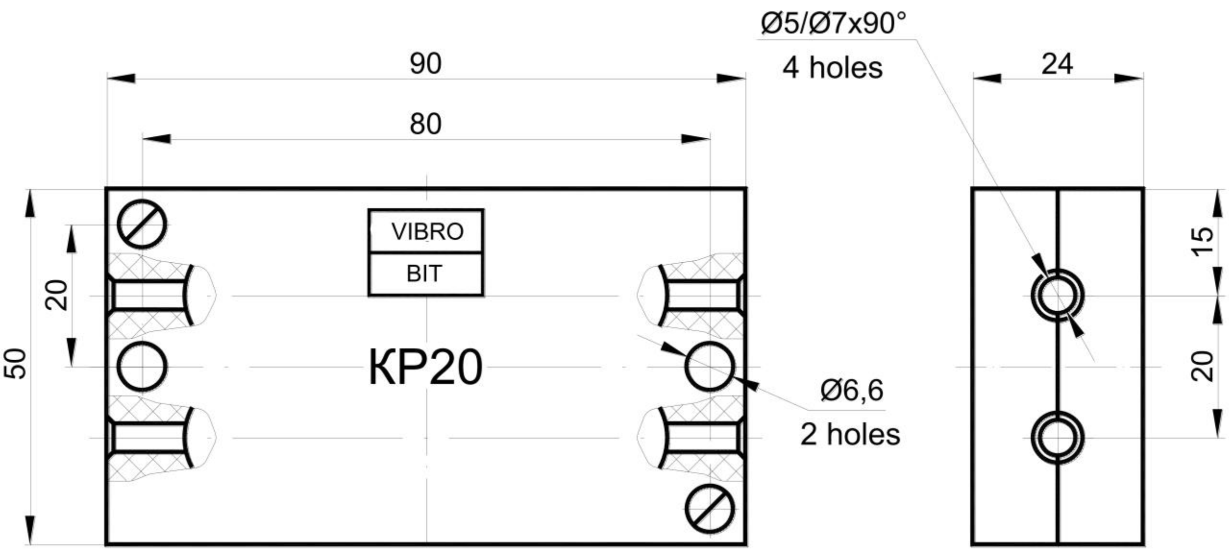



Figure C.31 – Connector box КР20

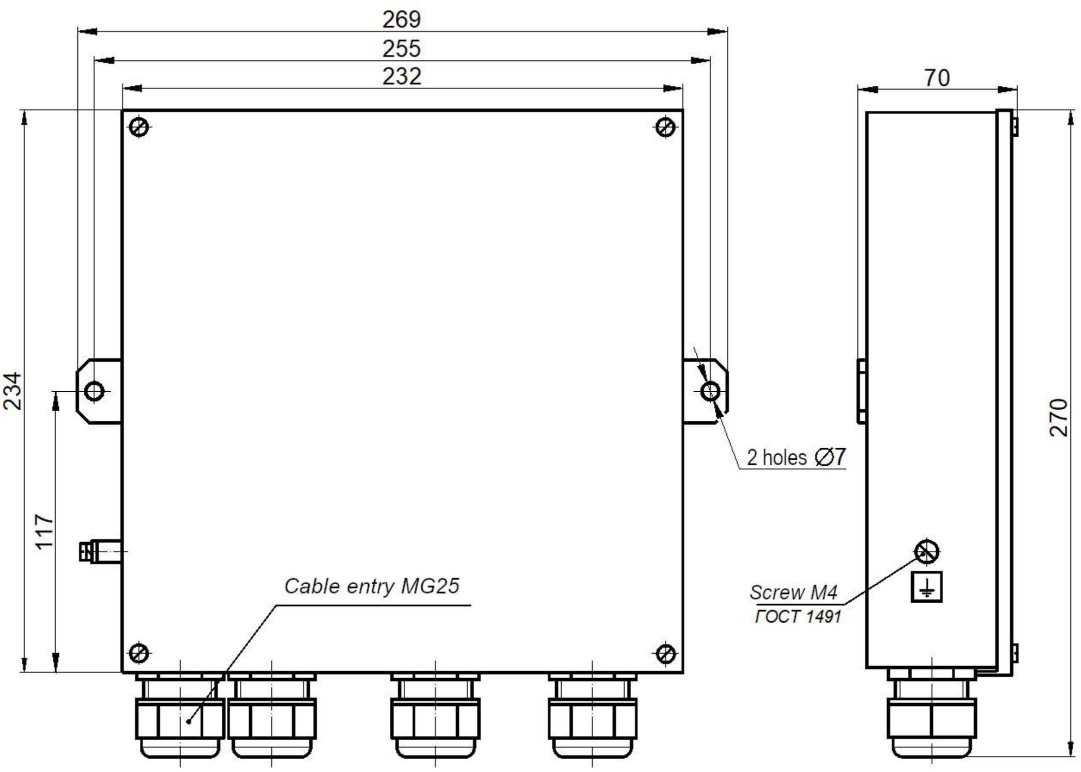



Figure C.32 – Transducer box КП23В

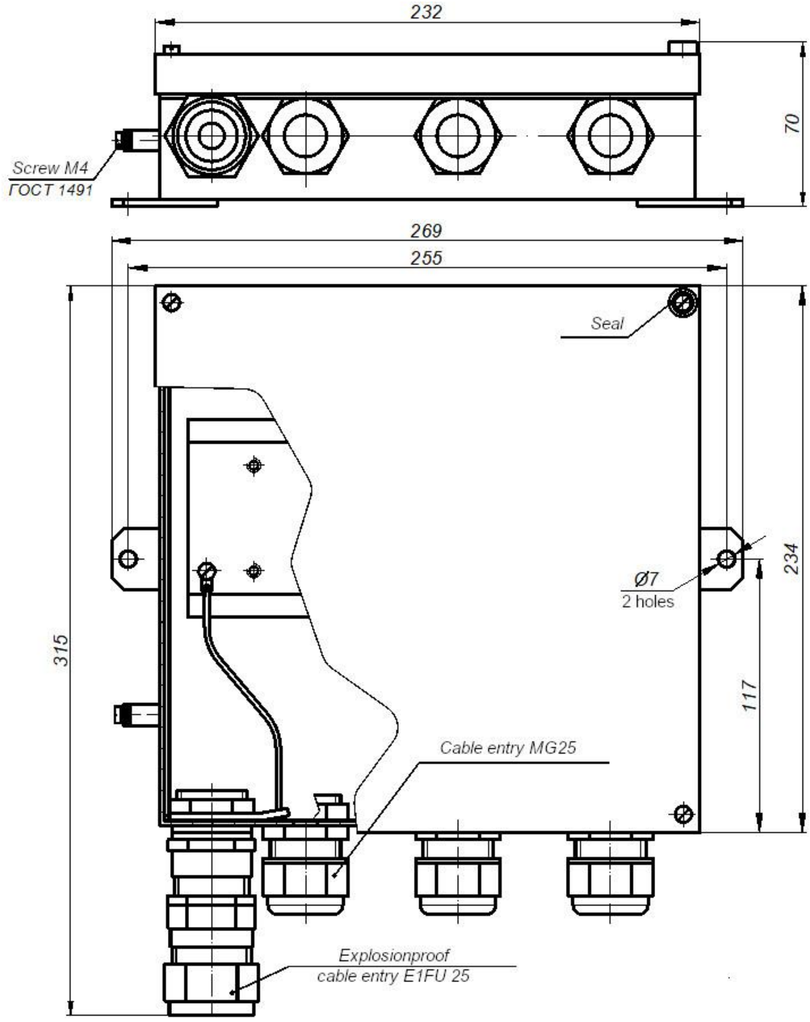



Figure C.33 – Transducer box КП23ВХ

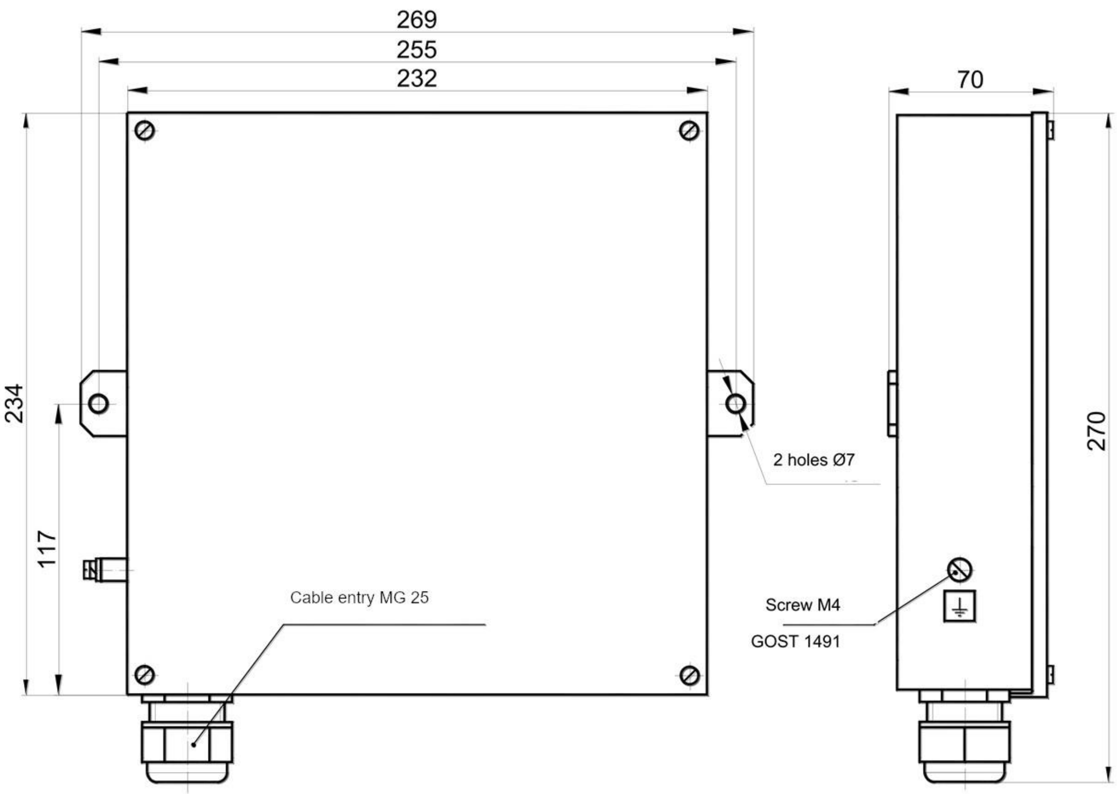



Figure C.34 – Transducer box КП23П

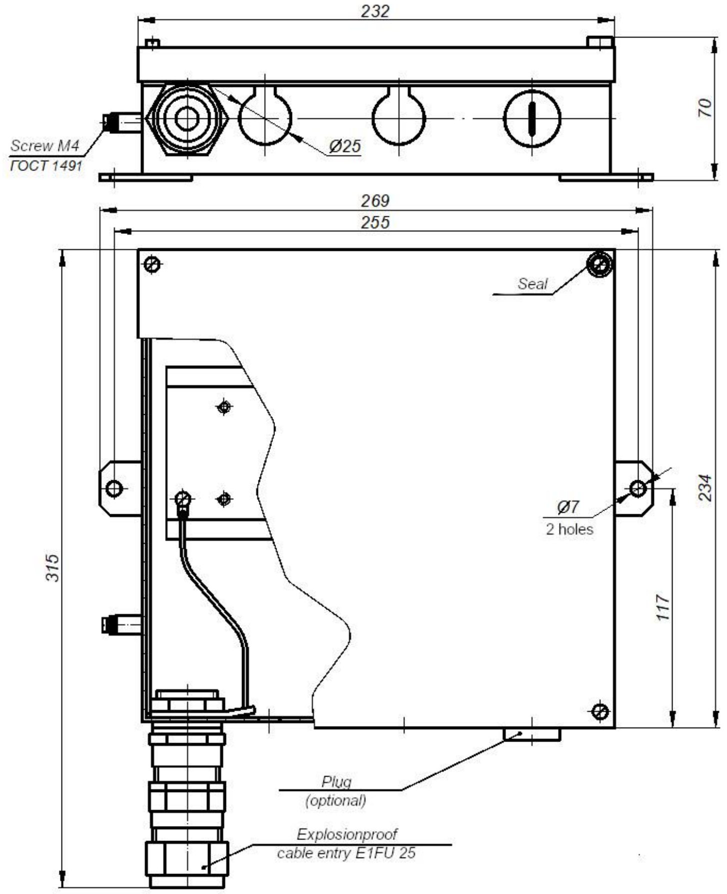



Figure C.35 – Transducer box КП23ПХ

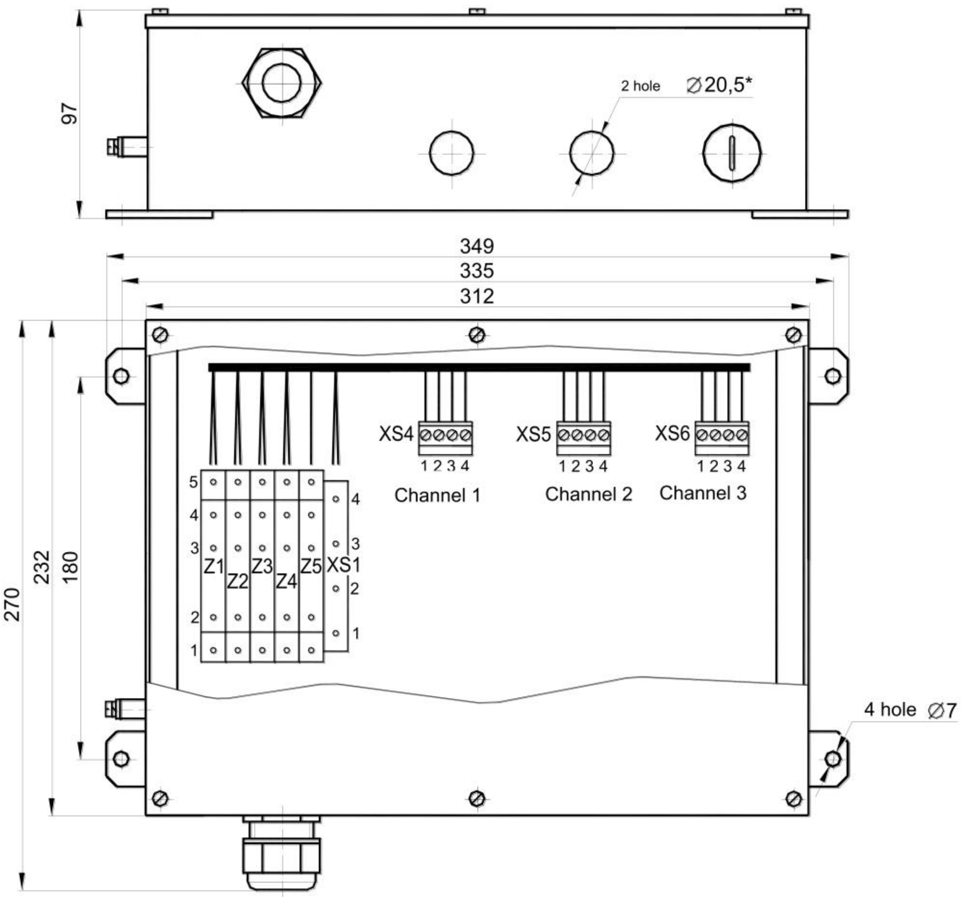



Figure C.36 – Transducer box КП25

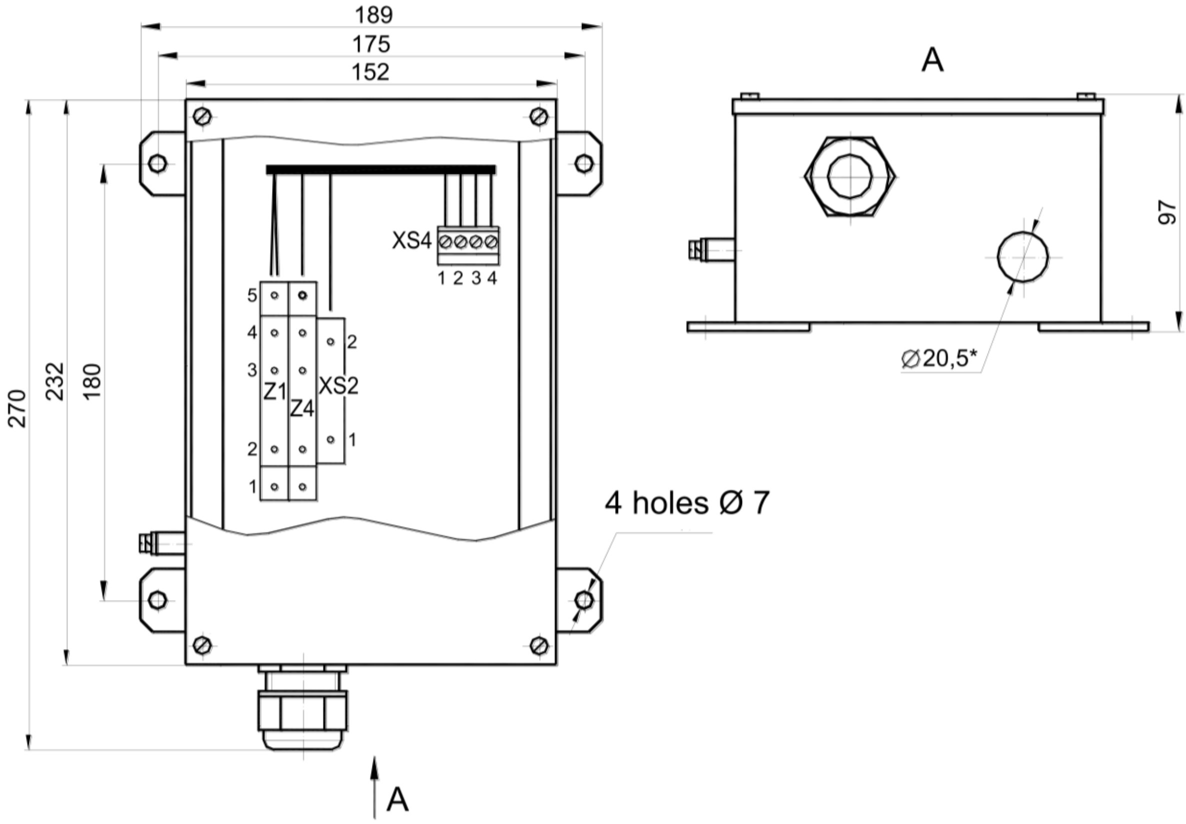



Figure C.37 – Transducer box КП15

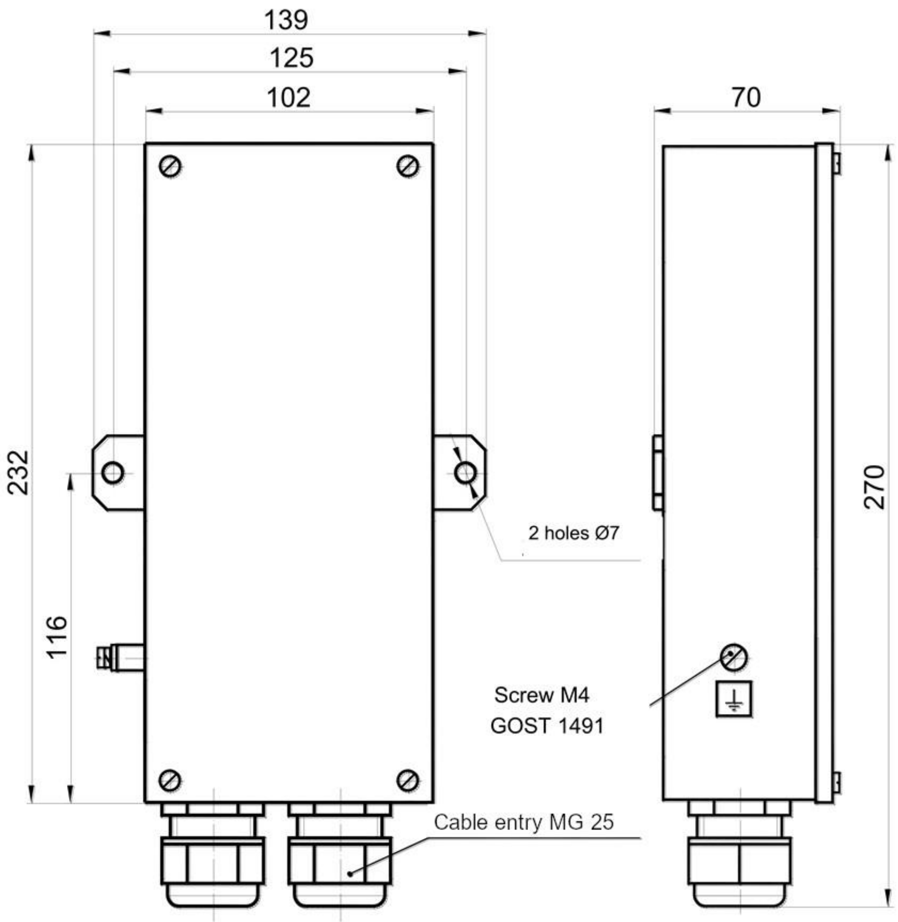



Figure C.38 – Transducer box КП13, КП13К

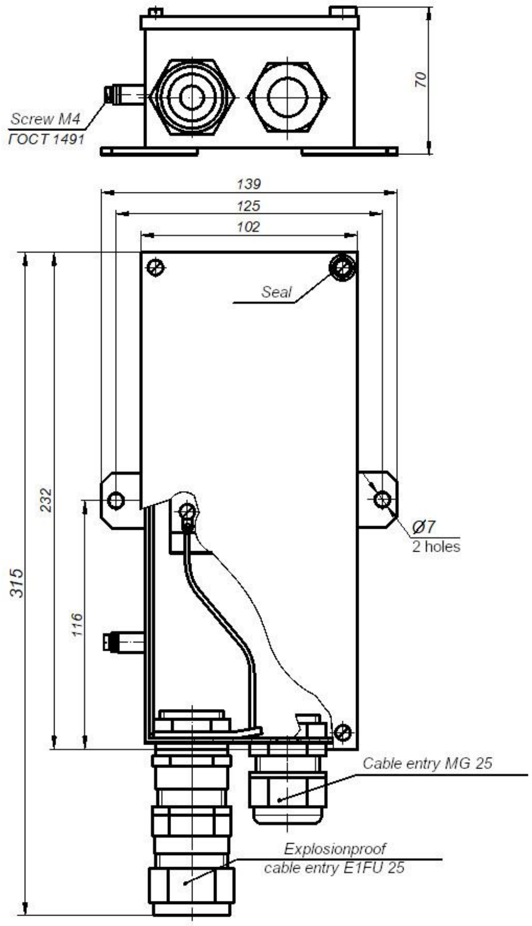



Figure C.39 – Transducer box КП13Х

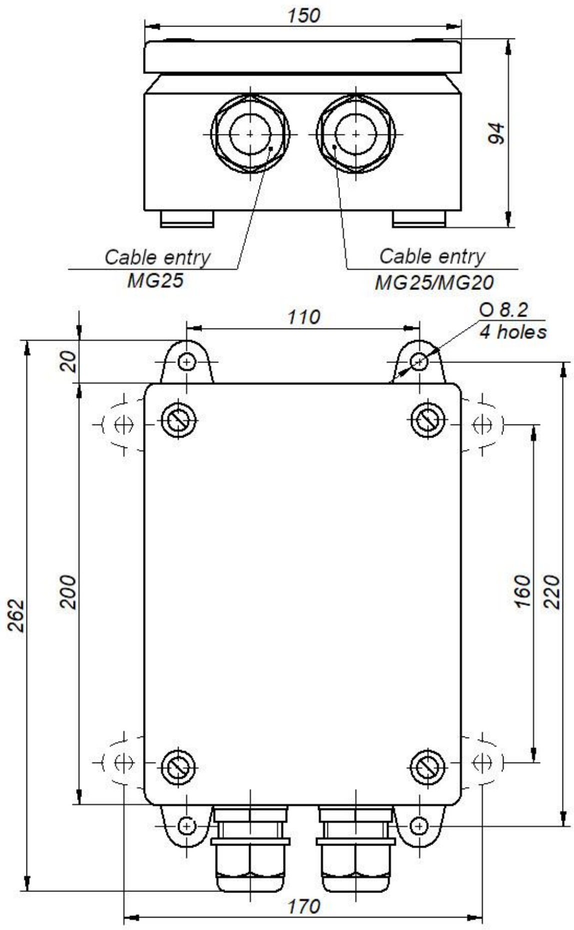



Figure C.40 – Transducer boxes КП13Р, КП13КР

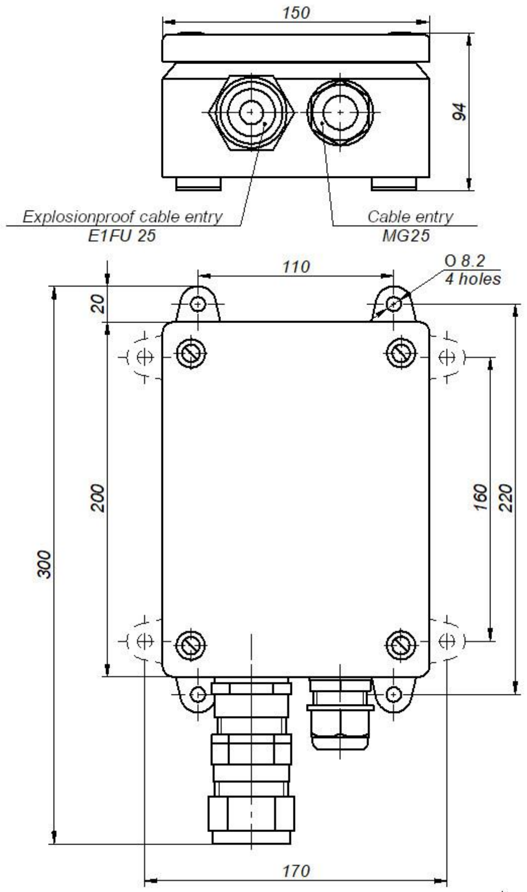



Figure C.41 – Transducer box КП13ХР

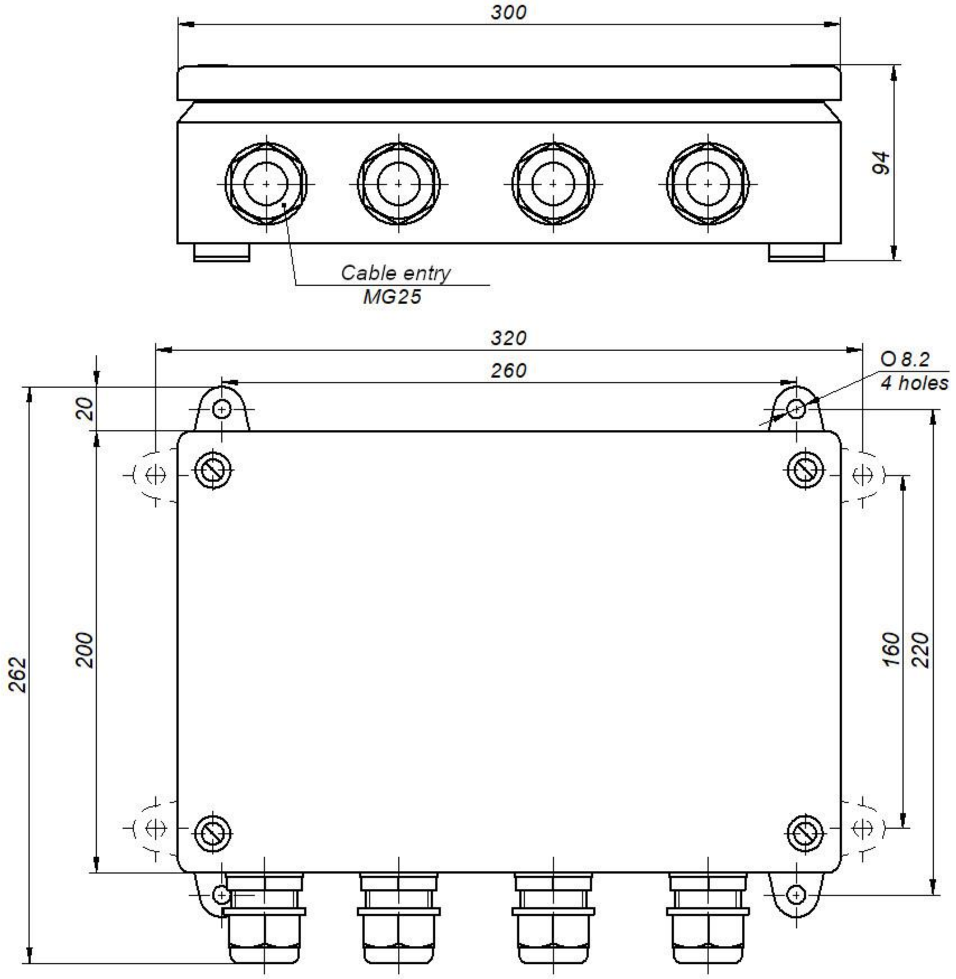



Figure C.42 – Transducer box КП23ВР

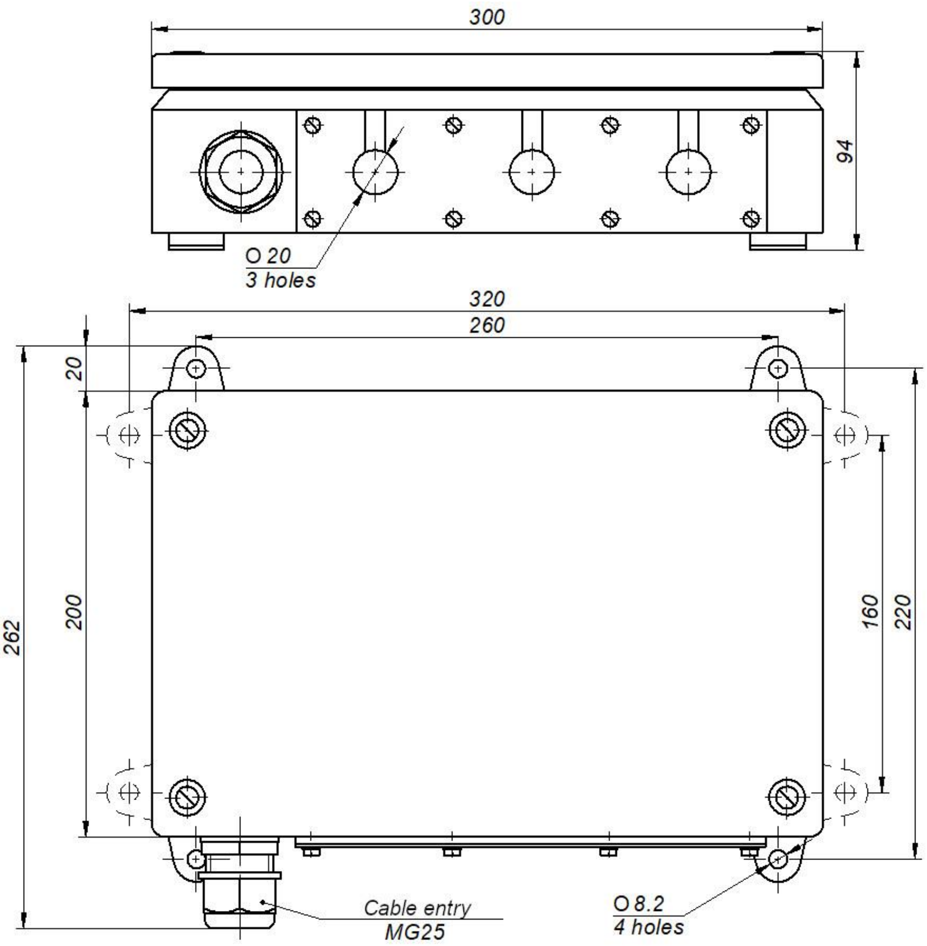



Figure C.43 – Transducer box КП23ПР

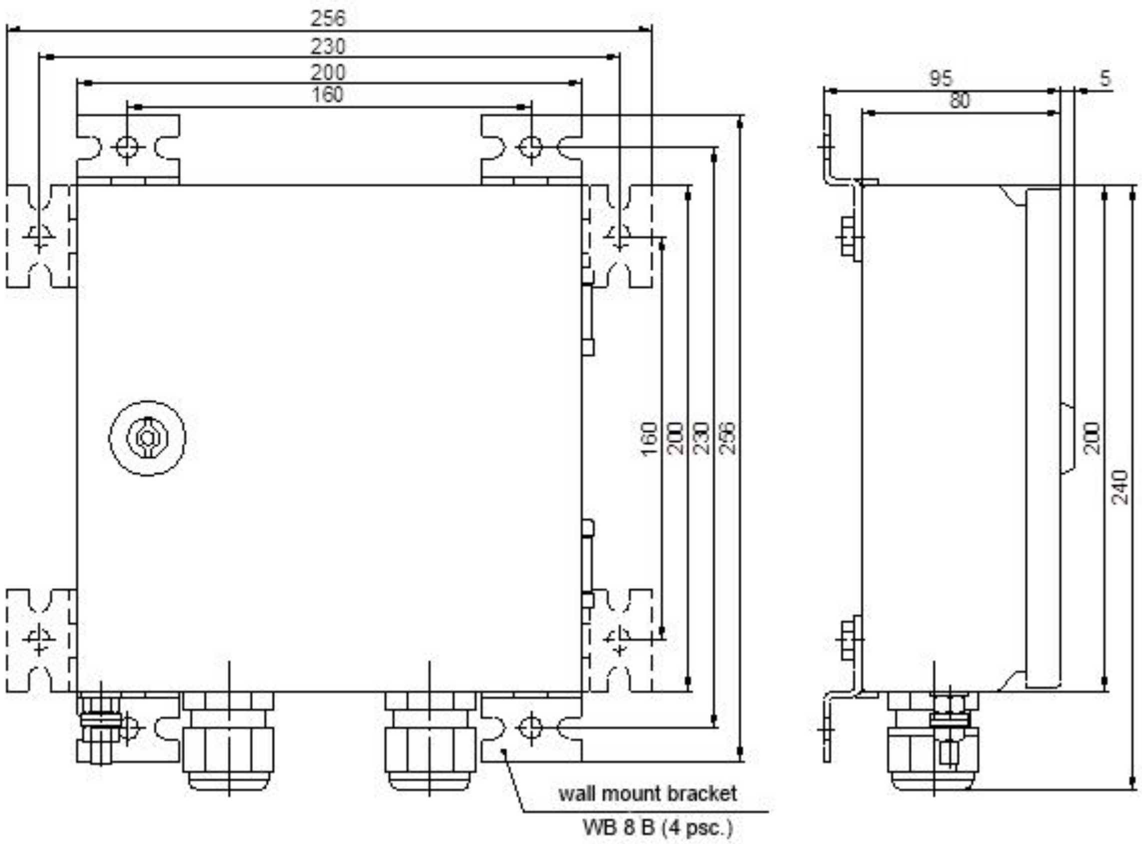



Figure C.44 – Transducer box КП13-Пр

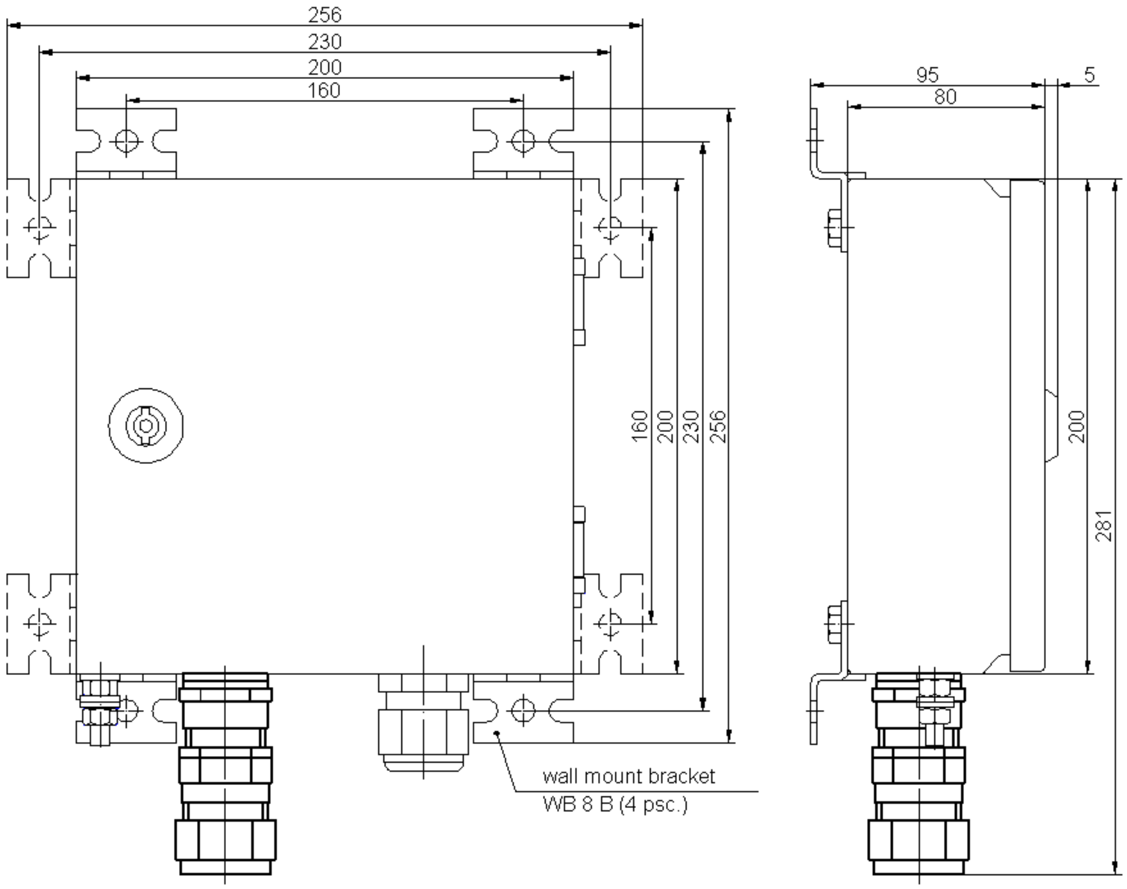



Figure C.45 – Transducer box КП13Х-Пр1

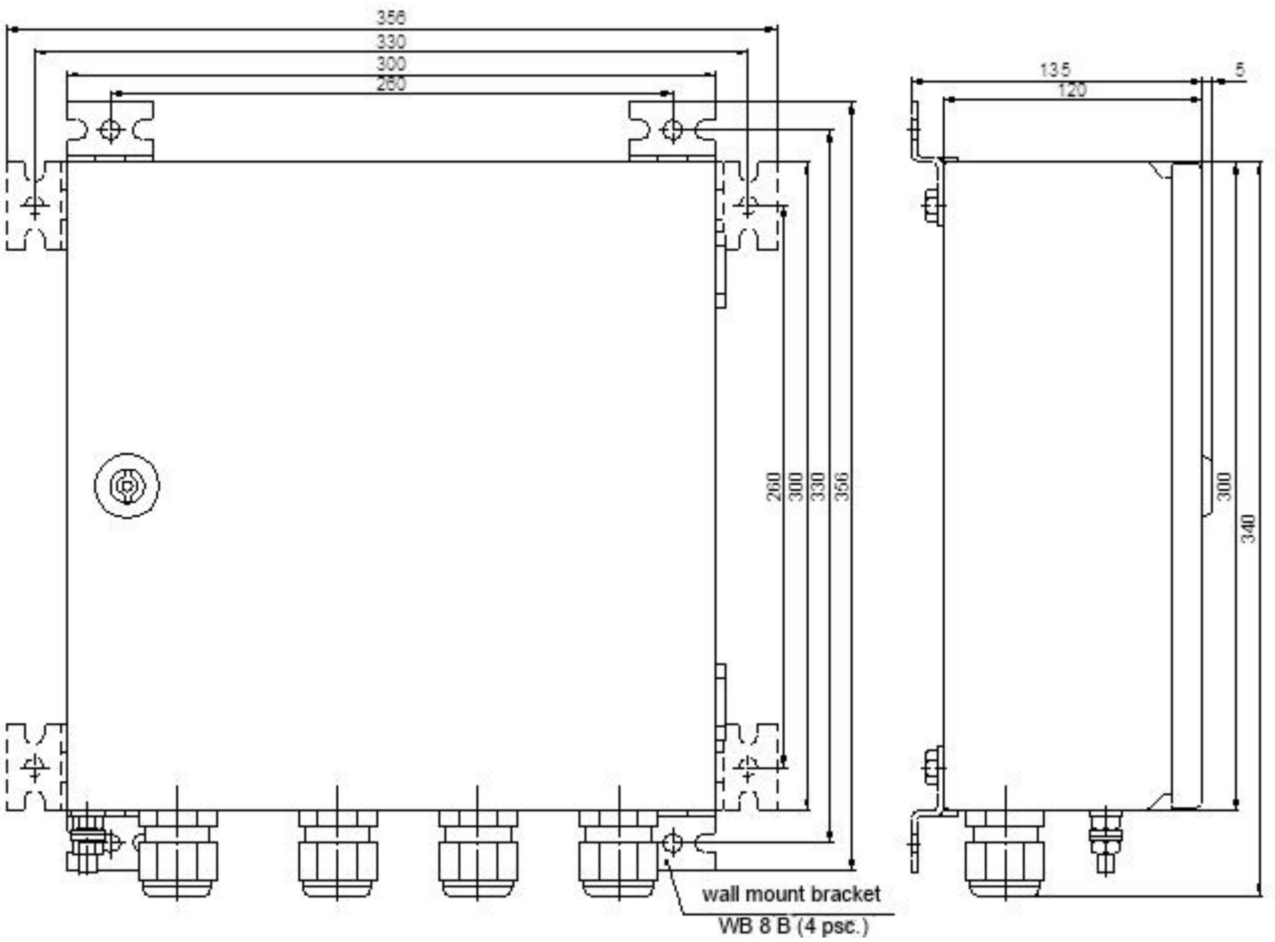



Figure C.46 – Transducer box КП23-Пр

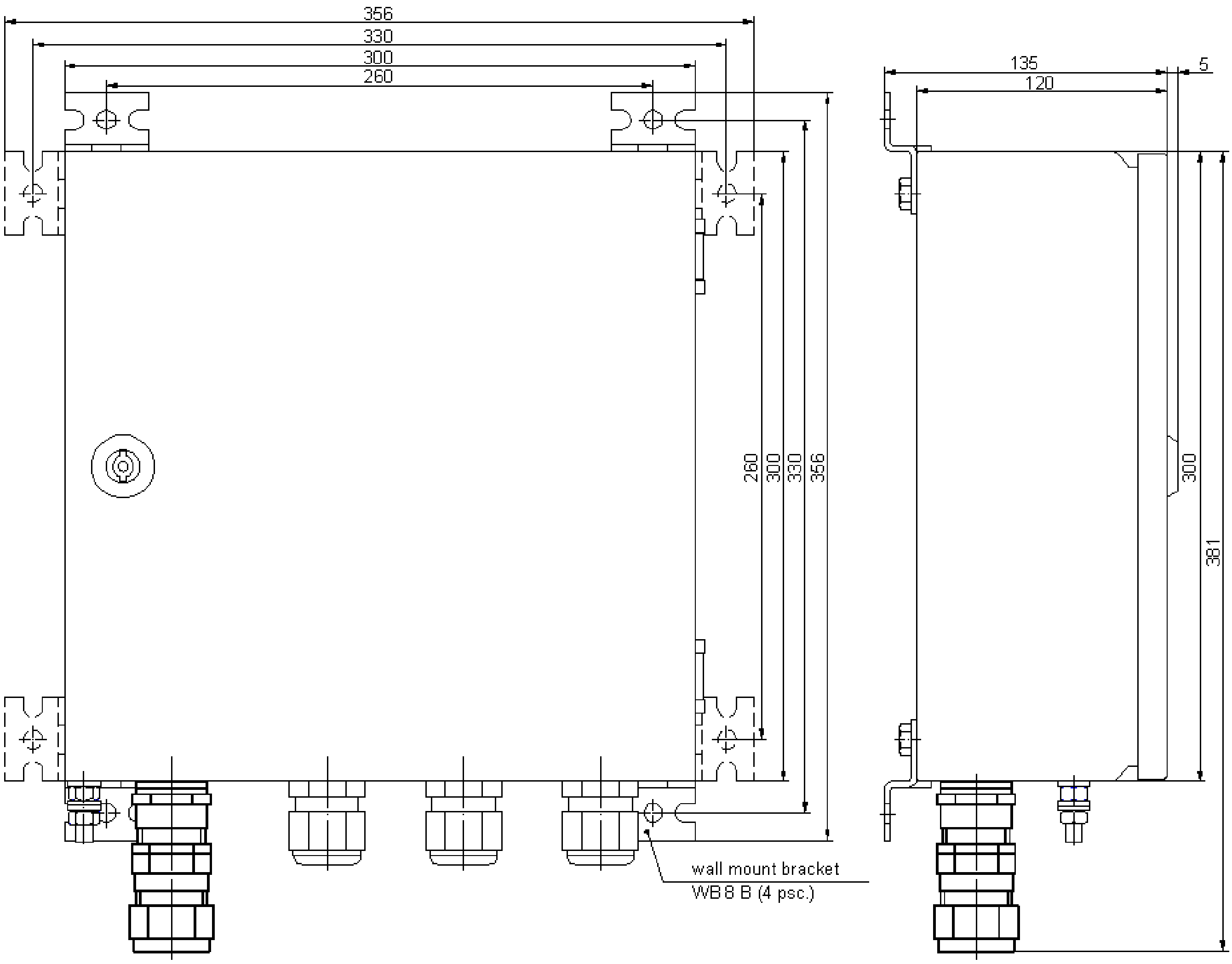
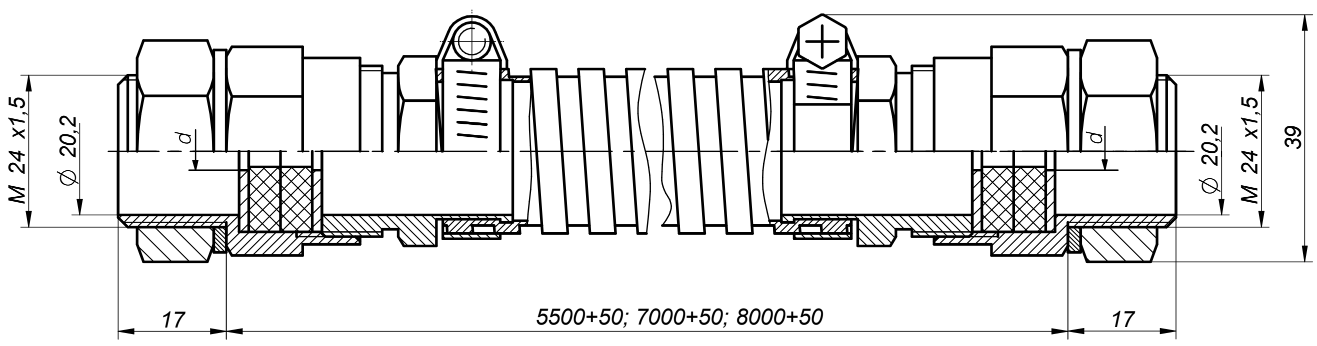



Figure C.47 – Transducer box КП23Х-Пр




| Type of metal hose | d, mm |
|---|---|
| БШ24 | 6 |
| БШ24В | 7,5 |

Figure C.48 – Metal hose БШ24

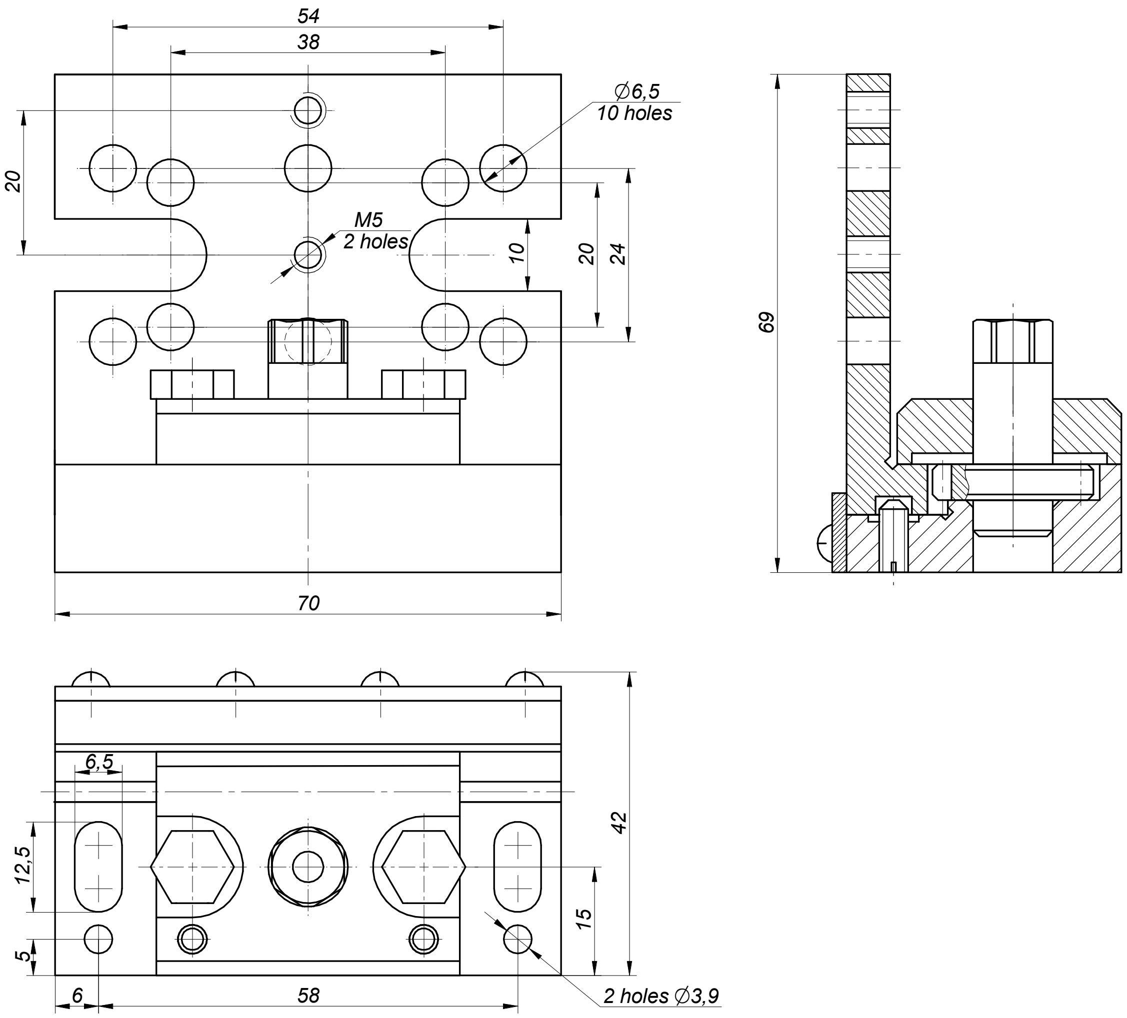
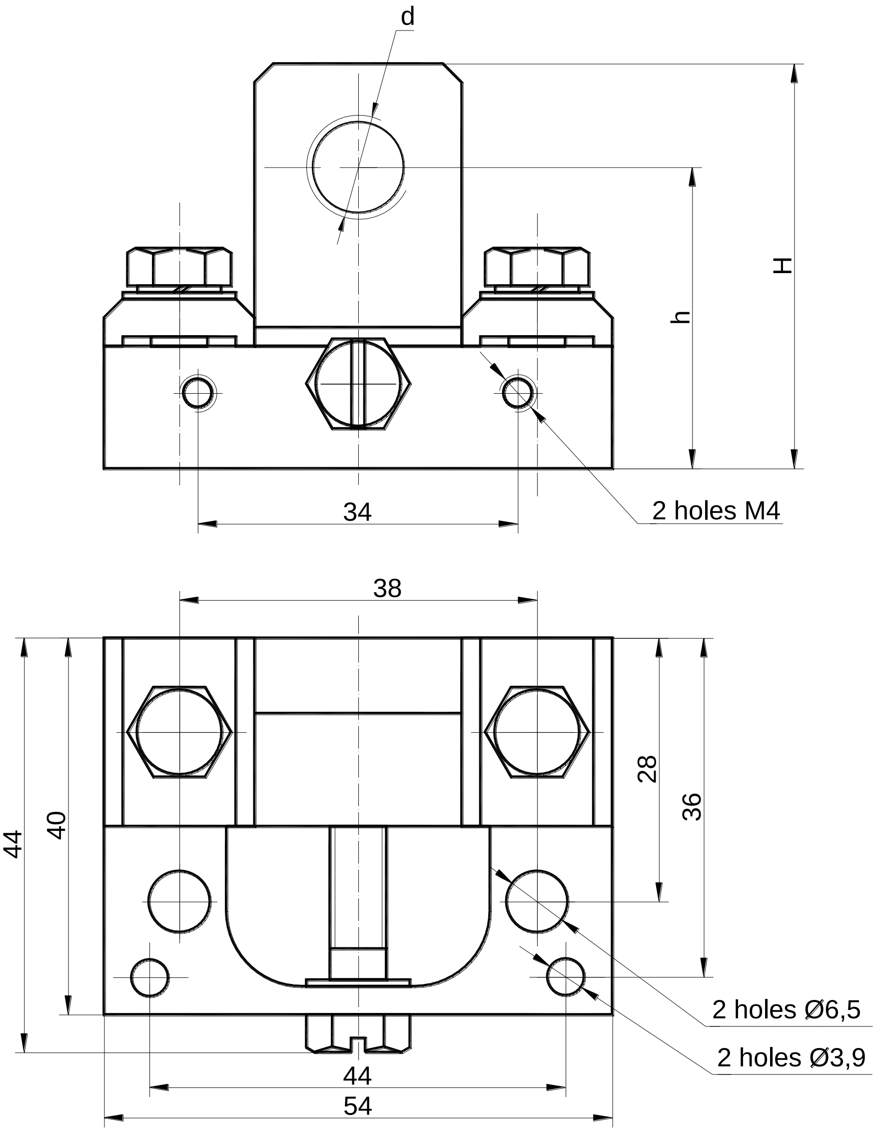



Figure C.49 – Setter МУ10




| Version | Dimensions, mm | | |
|---|---|---|---|
| | H | h | d |
| For ДВТ10 | 32 | 23±0.2 | M10x1 |
| For ДВТ20 | 43 | 32±0.2 | M16x1 |

Figure C.50 - Setter МУ11

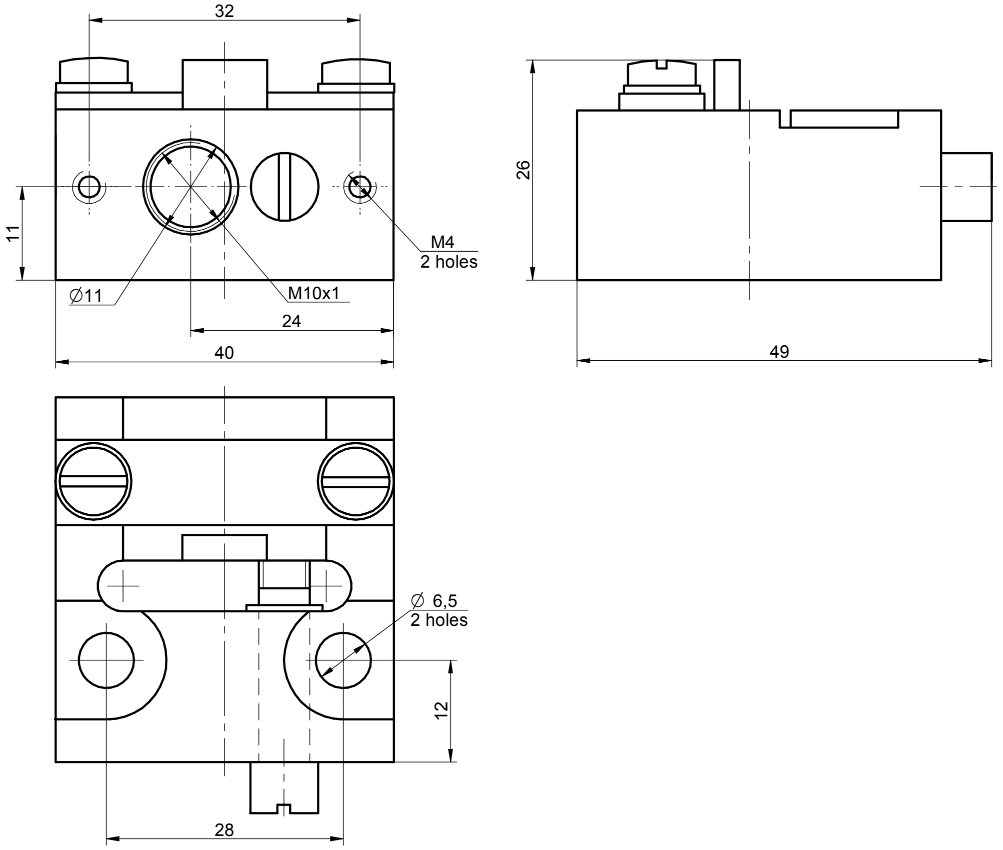



Figure C.51 - Setter МУ14

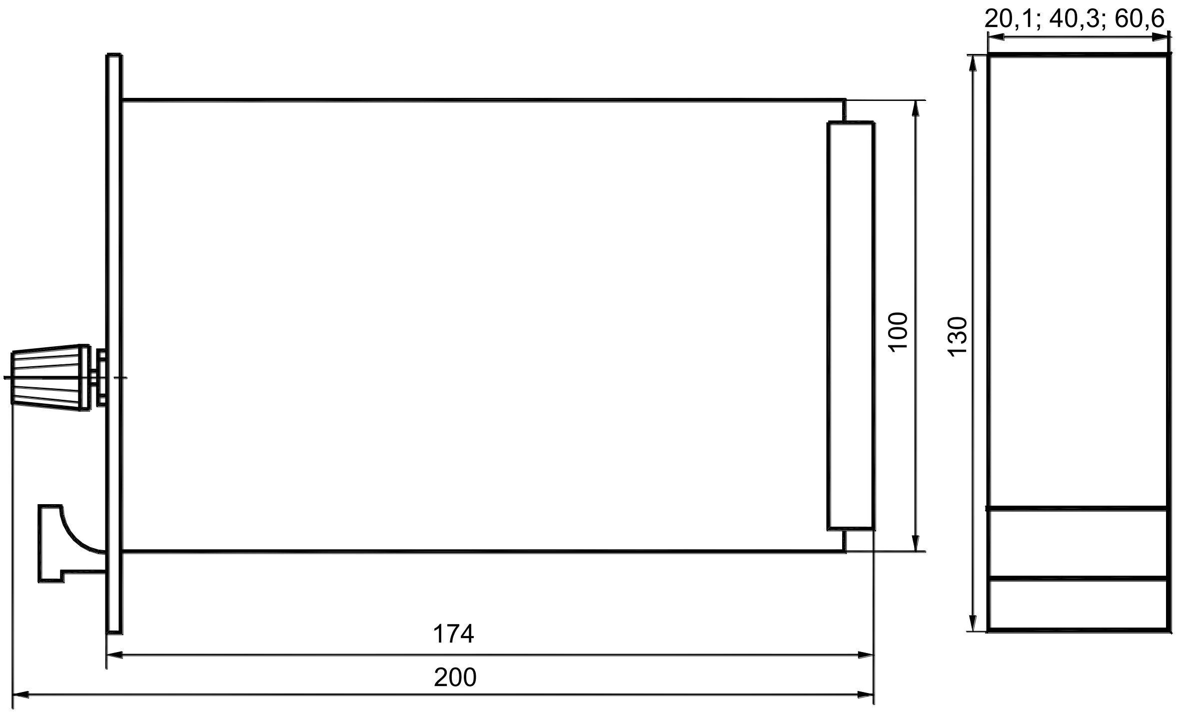
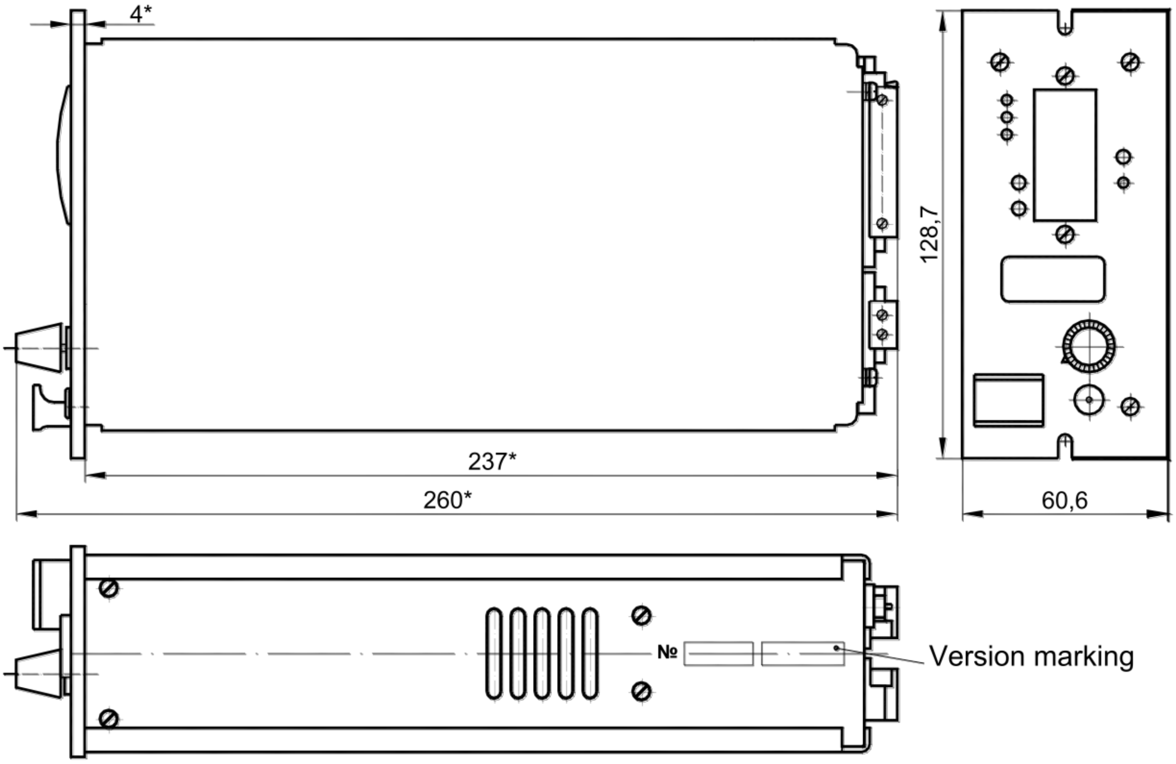



Figure C.52 – Control boards, power supply units




Opening for installation

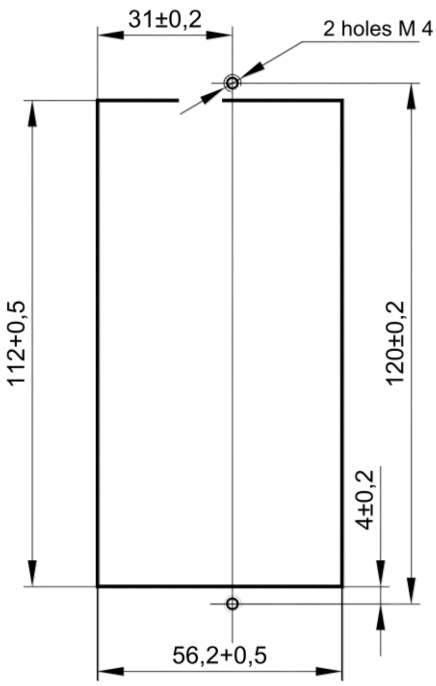



Figure C.53 – Control units БК

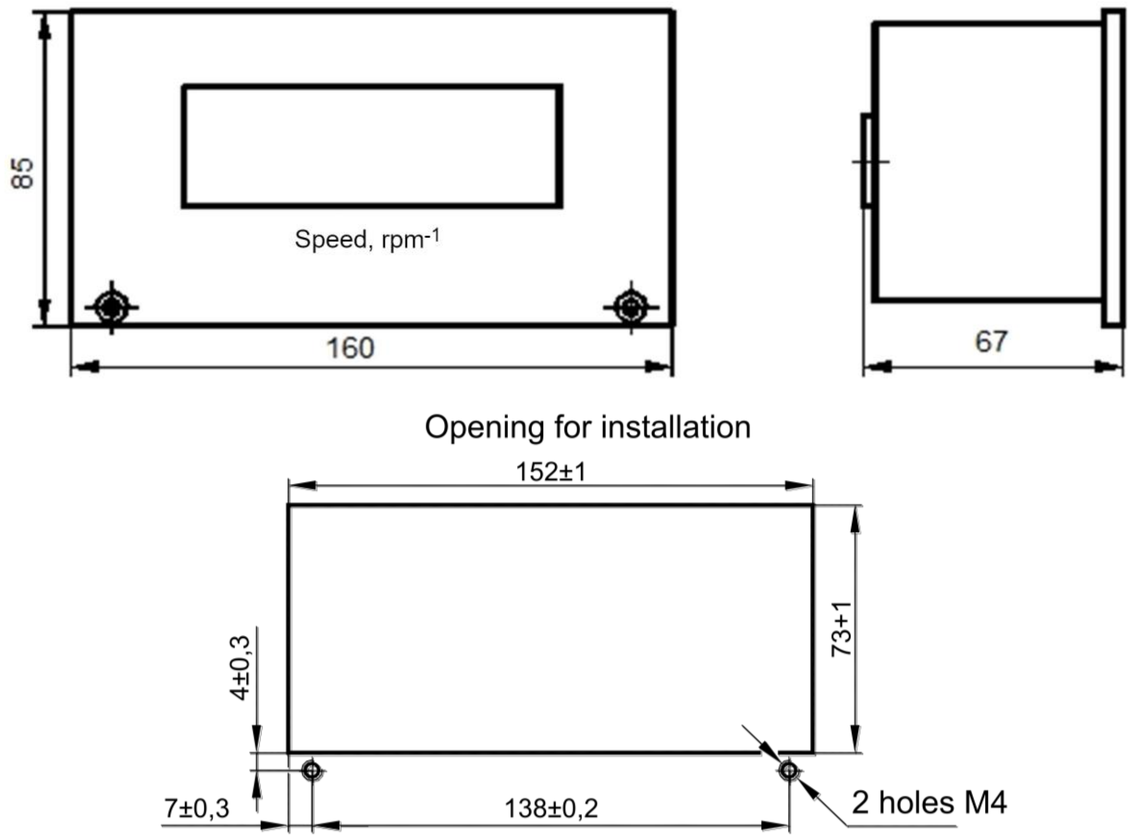
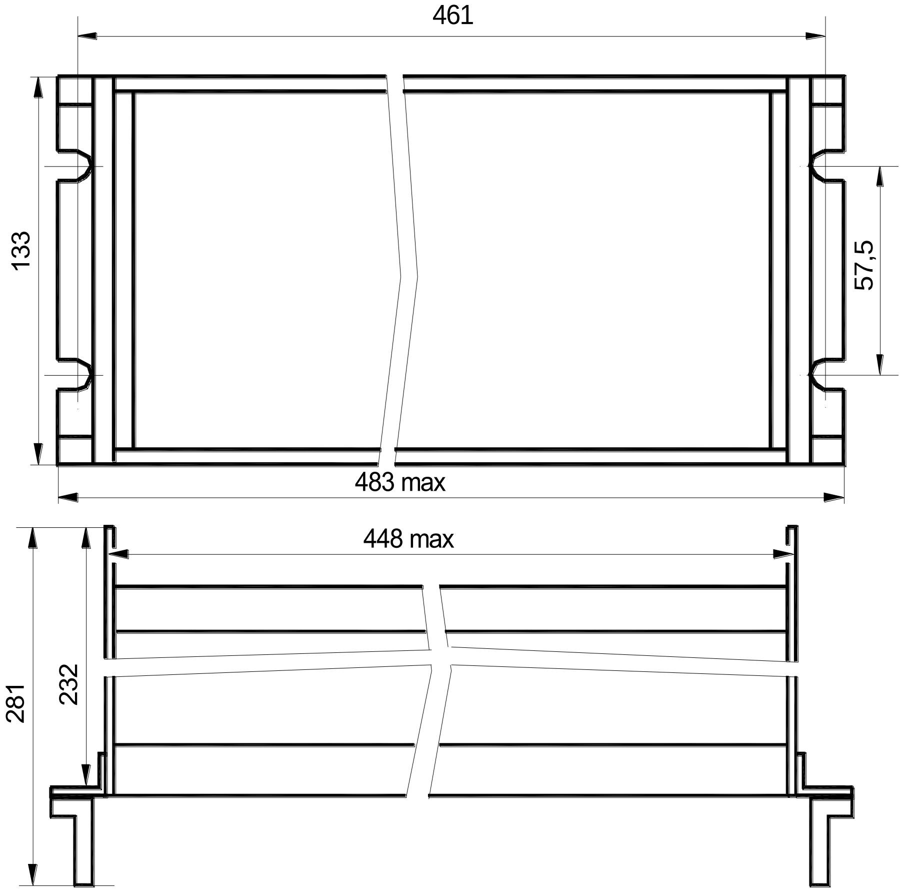
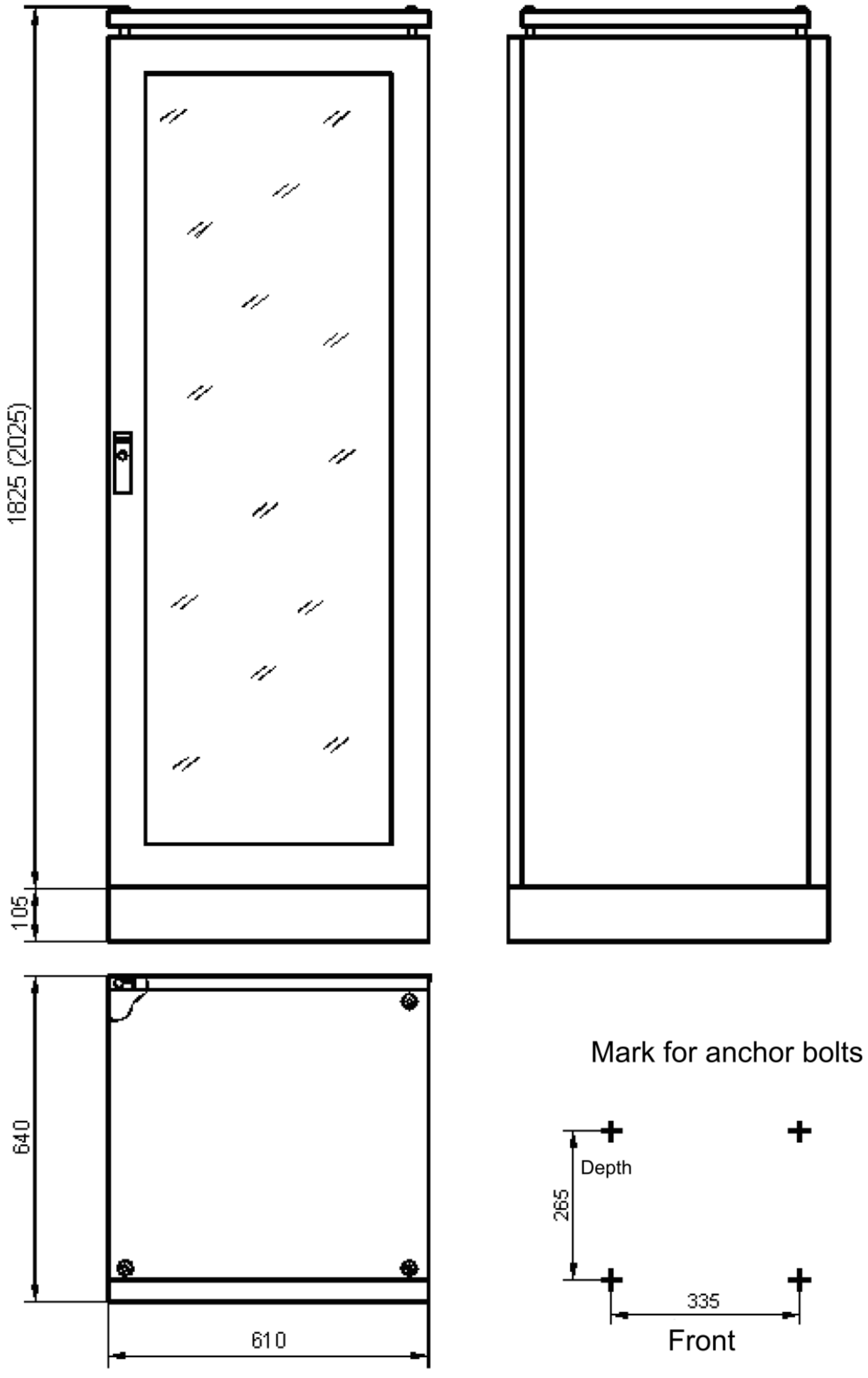



Figure C.54 – Indication unit БИ22, БИ23




Opening for installation of framework 134x449 mm (max)

Figure C.55 – Framework



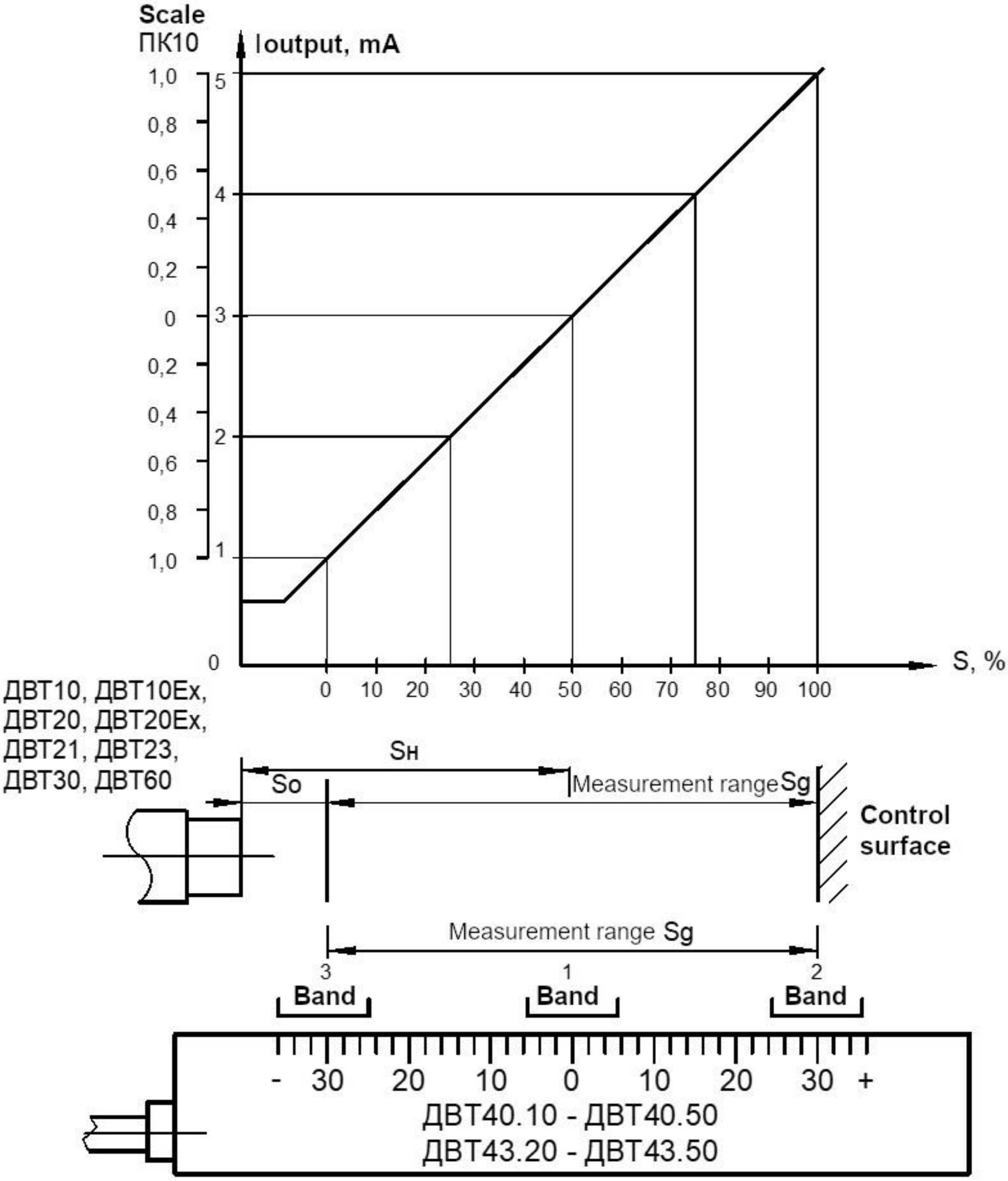

Anchor bolts M10 – (60±0.5) mm height above the concrete foundation.

Figure C.56 – Cabinet 1800(2000)x600x600 by ‘RITTAL’

**Annex D**

(Informative)

**Output characteristic of the sensor, displacement converter**




1 – Rotor band zero position

2 – Band position in extended rotor state

3 – Band position in shortened rotor state

S – gap, mm (%);

Sн – initial (preset) gap;

So – zero gap (beginning of measurement range);

Sg – measurement range

**Annex E**
(Informative)

**Measuring ranges and scales of control boards**

Table E. 1 – Displacement measurements

| Measurement range (from and to inclusive), mm | Zero gap (So), mm | Type of set: sensor – converter | Scales of displacement control boards and units, mm | | |
|---|---|---|---|---|---|
| | | | Single-sided | Symmetrical | Asymmetrical |
| 0 – 1 | 0.4 | ДВТ10 – ИП34 | 0 – 1 | 0.5 – 0 – 0.5 | - |
| 0 – 2 | 0.4 | ДВТ10 – ИП34<br>ДВТ10Ex–ИП34Ex | 0 – 2 | 1.0 – 0 – 1.0 | - |
| 0 – 4 | 1.0<br>1.0<br>0.5 | ДВТ20 – ИП34<br>ДВТ20Ex–ИП34Ex<br>ДВТ21 – ИП34 | 0 – 4 | 2 – 0 – 2 | 2.5 – 0 – 1.5<br>1,5 – 0 – 2.5<br>1.5 – 0 – 2.5 |
| 0 – 6 | 1.0 | ДВТ23 – ИП34 | 0 – 6 | 3 – 0 – 3 | 2 – 0 – 4 |
| 0 – 8 | -<br>1.0 | ДВТ40.30 – ИП42<br>ДВТ43.30 – ИП43<br>ДВТ60.10 – ИП34 | 0 – 8 | - | 3 – 0 – 5 |
| 0 – 10 | -<br>-<br>3.0 | ДВТ40.10 – ИП42<br>ДВТ43.20 – ИП43<br>ДВТ60.16 – ИП34 | 0 – 10 | 5 – 0 – 5 | 4 – 0 – 6 |
| 0 – 16 | -<br>4.0 | ДВТ40.10 – ИП42<br>ДВТ60.20 – ИП34 | 0 – 16 | 8 – 0 – 8 | 6 – 0 – 10 |
| 0 – 20 | - | ДВТ40.20 – ИП42<br>ДВТ43.20 – ИП42<br>ДВТ40.50 – ИП42<br>ДВТ43.50 – ИП43 | 0 – 20 | 10 – 0 – 10 | 8 – 0 – 12<br>6 – 0 – 14 |
| 0 – 50 | - | ДВТ40.30 – ИП42<br>ДВТ43.30 – ИП43<br>ДВТ50 – ИП34<br>ДВТ82 | 0 – 50 | - | - |
| 0 – 100<br>0 – 160<br>0 – 320 | - | ДВТ50 – ИП34<br>ДВТ82 | 0 – 100<br>0 – 160<br>0 – 320 | - | - |

Table E. 2 – Vibration displacement measurements

| Displacement measurement range, mm | Type of set: sensor – converter | Scales of vibration displacement control boards, mm |
|---|---|---|
| 0 – 1.0 | ДВТ10 – ИП34<br>ДВТ10 – ИП37 | 0 – 0.2<br>0 – 0.5 |
| 0 – 2.0 | ДВТ10 – ИП34<br>ДВТ10 – ИП37<br>ДВТ10Ех – ИП34Ех | 0 – 0.4<br>0 – 0.5<br>0 – 0.4 |
| – | ДПЭ23МВП | 0 – 0.2<br>0 – 0.5 |

The measurement range and scales of vibration velocity RMS and speed control boards are specified in paragraph 1.3.9.

It it possible to manufacture equipment with other parameter measurement ranges.

# Annex F
(Recommended)

## Recommended applicability of sensors and converters

Table F.1

| Set: sensor – converter | Main purpose | Additional application | Type of measuring channel |
|---|---|---|---|
| ДВТ10 – ИП34<br>ДВТ10 – ИП37<br>ДВТ10Ех – ИП34Ех | Measurement of vibration displacement, shaft bending (bowing) | Axial offset. Displacement of parts and units. | Relative vibration displacement, displacement of rotating shafts, components and assemblies |
| ДВТ20 – ИП34<br>ДВТ20Ех – ИП34Ех<br>ДВТ21 – ИП34 | Measurement of rotor axial offset | Vibration displacement of the shaft. Relative expansion of the rotor. Displacement of components and assemblies | Relative vibration displacement, displacement of rotating shafts, components and assemblies |
| ДВТ10, ДВТ30 – К22;<br>ДВТ10, ДВТ30 – ИП36;<br>ДВТ10Ех – К22Ех;<br>ДВТ10Ех – ИП36Ех;<br>ДХМ | Measurement of speed | Proximity switch | RPM |
| ДВТ40 – ИП42,<br>ДВТ43 – ИП43 | Measurement of rotor relative expansion with low band (ridge) | Measurement of expansion (displacement) of the cylinder, components and assemblies | Relative displacement of rotating shafts, components and assemblies |
| ДВТ50 – ИП34 | Measurement of the cylinder expansion, position of the actuating device. Ambient temperature for the sensor operation – up to + 125 °С | – | Relative displacement of rotating shafts, components and assemblies |
| ДВТ60 – ИП34 | Measurement of rotor relative expansion with high band (ridge). | Measurement of displacement of components and assemblies | Relative displacement of rotating shafts, components and assemblies |
| ДВТ82 | Functions of ДВТ50 – ИП34. Ambient temperature for the sensor operation – up to +70 °С | – | Relative displacement of rotating shafts, components and assemblies |
| ДПЭ22МВ, ДПЭ22МВТ, ДПЭ22П, ДПЭ23МВ, ДПЭ23МВТ, ДПЭ23П, ДПЭ22Ех, ДПЭ23Ех | Measurement of the bearing vibration | – | Vibration velocity |
| ДПЭ23МВП | Measurement of absolute vibration displacement | – | Absolute vibration displacement |
| 625В01 – КС24 – ИП24 | Measurement of the bearing vibration | – | Vibration velocity |

*Continuation of Table F.1*

| Set: sensor – converter | Main purpose | Additional application | Type of measuring channel |
|---|---|---|---|
| ДПЭ24 – ИП24 | Low frequency vibration measurement | – | Vibration velocity |
| ДВТ23 – ИП34,<br>ДВТ40.40 – К21,<br>ДВТ43.40 – К21 | Monitoring position of the rotor protection mechanism pins | Displacement of units and assemblies.<br>Proximity switch | Relative displacement of components and assemblies, position of the rotor protection mechanism pins |
| ДВТ70 – ИП44 | Surface tilt measurement | – | Surface tilt |

## Annex G
(Informative)

## Complete set of equipment assembly units throughout control channels and sets

Table G.1 – Complete set of equipment assembly units throughout control channels

| Description of control channel | Type of equipment units | | |
|---|---|---|---|
| | Sensors and converters | Control boards | Auxiliary units and mounting devices |
| Rotor axial offset | ДВТ10 – ИП34*<br>ДВТ20 – ИП34*<br>ДВТ10Ex – ИП34Ex*<br>ДВТ20Ex – ИП34Ex* | ПК10, ПК11 | М24; МУ10 (МУ11); КР10; КС10; КП13; КП13Х, КП13Х-Пр1 |
| Rotor relative expansion | ДВТ40 – ИП42*<br>ДВТ43 – ИП43* | ПК10, ПК11 | М24;МУ10;КР10 (КР20); КС11; КП13 |
| | ДВТ60 – ИП34* | | М24;МУ10;КР10 (КР20); КС10; КП13 |
| Shaft vibration displacement (runout, bending, bowing) | ДВТ10 – ИП34<br>ДВТ10 – ИП37*<br>ДВТ10Ex – ИП34Ex | ПК20, ПК21 | М24; КР10 (КР20); КС10; КП13, КП13Х, КП13Х-Пр1, КП23В, КП23ВХ, КП23Х-Пр |
| Vibration velocity of bearing housings | ДПЭ22МВ, ДПЭ22МВТ, ДПЭ22П, ДПЭ23МВ*, ДПЭ23МВТ*, ДПЭ23П*, ДПЭ22Ex, ДПЭ23Ex* | ПК30, ПК31, ПК32, ПК13, ПК12 | КП23П, КП23ПХ, КП23Х-Пр |
| Rotor speed | ДВТ10, ДВТ30 – К22;<br>ДВТ10, ДВТ30 – ИП36*<br>ДВТ10Ex – К22Ex,<br>ДВТ10Ex – ИП36Ex,<br>ДХМ | ПК40 | М24; КР10; КС10; КП13; БИ23; КП13Х, КП13Х-Пр1 |
| Cylinder thermal expansion, servomotor position | ДВТ50 – ИП34*<br>ДВТ82* | ПК10, ПК11 | – |
| Surface tilt measurement | ДВТ70 – ИП44* | ПК10, ПК11 | КП13, КП23В |

* May be used independently as converters with unified output signal.

Table G.2 – Sets of equipment based on control units

| Set description | Types of equipment assemblies | | |
|---|---|---|---|
| | Sensors and converters | Control units | Auxiliary assemblies and mounting devices |
| Set for measuring rotor axial offset **B10** | ДВТ20 – ИП34 | БК10 | М24; МУ10; КР10; КС10; КП13; fasteners |
| Set for measuring rotor axial offset **B11** | ДВТ20 – ИП34 (2 pcs.) | БК11 | М24; КР20; КС10 - 2 pcs.; МУ10; КП23В; fasteners |
| Set for measuring rotor relative expansion **B12** | ДВТ40 – ИП42 ДВТ43 – ИП43 | БК10 | М24; МУ10; КП13; fasteners |
| Set for measuring rotor relative expansion **B13** | ДВТ40 – ИП42 ДВТ43 – ИП43 (2 pcs.) | БК11 | М24; МУ10 – 2 pcs; КП23В; fasteners |
| Set for measuring cylinder thermal expansion or position of final control element **B14** | ДВТ82 ДВТ50-ИП34 | БК10 | КП13 (for ДВТ50); fasteners; |
| Set for measuring cylinder thermal expansion or position of final control element **B15** | ДВТ82 ДВТ50-ИП34 (2 pcs. each) | БК11 | КП13-2 pcs (for ДВТ50); fasteners |
| Set for measuring relative vibration displacement or rotor shaft bowing **B20** | ДВТ10 – ИП34 | БК20 | М24; МУ11; КР10; КС10; КП13, fasteners. |
| Set for measuring of rotor shaft relative vibration displacement **B21** | ДВТ10 – ИП34 (2 pcs.) | БК21 | М24; КР20; КС10 – 2 pcs; КП23В, fasteners. |
| Set for measuring bearing support vibration velocity **B30** | ДПЭ22МВ | БК30 | КП23; fasteners |
| Set for measuring bearing support vibration velocity **B31** | ДПЭ22МВ (2 pcs.) | БК31 | КП23П; fasteners |
| Set for measuring bearing support vibration velocity **B32** | ДПЭ22МВ (3 pcs.) | БК32 | КП23П; fasteners |
| Set for measuring rotor RPM **B40** | ДВТ10– К22 ДВТ30 – К22 ДХМ | БК40 | М24; КР10; КС10; КП13; БИ23 –1(2)pcs; fasteners |

## Annex H
(Mandatory)

### Marking of the equipment version

Equipment is designated for the delivery to the nuclear power station classified as belonging to the 3-rd Group of Safety as per НП-001, at the request of the Customer has an additional marking "АС-3" after the marking of the version.

Example of marking converter ИП34 delivered to the nuclear power station with unified output signal of (1–5) mA, measurement range from 0 to 4 mm applied for sensor ДВТ20 with a 7-meter long cable:

| | | | | | |
|---|---|---|---|---|---|
| ИП34 | А | 04 | 20 | 7 | АС-3 |

When specifying the equipment version variant (marking) in documents, indicate as follows: ИП34*А*04*20*7*АС-3.

H.1 Control boards and units ПК10, ПК11, БК10, БК11

| DC output signal | Pointer instrument scale | Availability of the digital indicator |
|---|---|---|
| А – (0 – 5) mA<br>В – (4 – 20) mA | See Table E.1 | И |

The example of the board marking with unified DC output signal (4–20) mA, displacement measurement range – from –3 to 5 mm: with the digital indicator:

| | | |
|---|---|---|
| В | 3 - 0 - 5 | И |

H.2 Control boards and units ПК20, ПК21, БК20, БК21

| DC output signal | Scale of the instrument on the board | | Frequency measurement range | Availability of the digital indicator |
|---|---|---|---|---|
| | Vibration displacement measurement range | Displacement measurement range | | |
| А – (0 – 5) mA<br>В – (4 – 20) mA | 0.2 – (0 – 0.2) mm<br>0.4 – (0 – 0.4) mm | 1 – (0 – 1) mm<br>2 – (0 – 2) mm | 1 - (0.05 – 100) Hz<br>2 - (5 – 500) Hz | И |

The example of the board marking with unified DC output signal (4 – 20) mA, vibration displacement measurement range (0 – 0.4) mm, displacement measurement range (0 – 2) mm, frequency range (5 – 500) Hz: with the digital indicator:

| | | | |
|---|---|---|---|
| В | 0.4 / 2 | 2 | И |

H.3 Control boards and units ПК12, ПК13, ПК30, ПК31, ПК32, БК30, БК31, БК32

| DC output signal | Instrument scale on the board (vibration velocity measurement range) | Availability of the digital indicator |
|---|---|---|
| A – (0 – 5) mA<br>B – (4 – 20) mA | 12 – (0 – 12) mm/sec<br>15 – (0 – 15) mm/sec<br>30 – (0 – 30) mm/sec | И |

The example of the board marking with unified DC output signal (4–20) mA, vibration velocity measurement range (0 – 15) mm/s: with the digital indicator:

| | | |
|---|---|---|
| B | 15 | И |

H.4 Control board and unit ПК40, БК40

| DC output signal | Pointer instrument scale (RPM measurement range) | Frequency range | |
|---|---|---|---|
| | | Groove | Pinion |
| A – (0 – 5) mA<br>B – (4 – 20) mA | 4000 – (0 – 4000) rpm<br>6000 – (0 – 6000) rpm<br>8000 – (0 – 8000 rpm<br>10000 – (0 – 10000) rpm | 66.6 – (0 – 66.6) Hz<br>100 – (0 – 100.0) Hz<br>133.3 – (0 – 133.3) Hz<br>166.6 – (0 – 166.6) Hz | 400 – (0 – 400) Hz<br>4000 – (0 – 4000) Hz<br>4800 – (0 – 4800) Hz<br>6000 – (0 – 6000) Hz<br>8000 – (0 – 8000) Hz<br>9999 – (0 – 9999) Hz |

The example of the board marking with unified DC output signal (0 – 5) mA, rpm measurement range (0 – 8000) rpm, frequency range (0 – 133.3) Hz:

| | | |
|---|---|---|
| A | 8000 | 133.3 |

Note – frequency ranges of 66.6 – 166.6 are used for the ‘groove’ control surface, and frequency ranges of 400 – 9999 are used for ‘pinion’ control surface.

**Marking of control units and the serial number are applied on the unit casing.**

H.5 ПК72, ПК73 boards

1– version 1;

2– version 2.

H.6 Board ПК81

Marking determinants the signaling logic version ’AND’:

1 – Version 1;

2 – Version 2;

3 – Version 3.

H.7 Board ПК90

Marking determines the pulse signal used for the testing of ПК40 boards.

| Marking variant | Frequency adjustment range | Signal polarity | Control surface |
|---|---|---|---|
| 1 | (1 – 170) Hz | Negative | groove |
| 2 | (1 – 170) Hz | Positive | groove |
| 3 | (60 – 10000) Hz | Negative | pinion Z=60 |
| 4 | (60 – 10000) Hz | Positive | pinion Z=60 |

Example of ПК90 boards marking with negative polarity pulse signal and frequency adjustment range (60 – 10000) Hz:

| | |
|---|---|
| ПК90 | 3 |

**Marking of control boards and the serial number are applied on the connector.**

H.8 Converters ИП34, ИП34Ex

| DC output signal | Measurement range | Type of sensor | Sensor cable length |
|---|---|---|---|
| A – (1 – 5) mA<br>B – (4 – 20) mA | 01 – (0 – 1) mm<br>02 – (0 – 2) mm<br>04 – (0 – 4) mm<br>06 – (0 – 6) mm<br>08 – (0 – 8) mm<br>etc. up to<br>360 – (0 – 360) mm | 10 - ДВТ10<br>20 - ДВТ20<br>21 - ДВТ21<br>23 - ДВТ23<br>30 - ДВТ30<br>50 - ДВТ50<br>60 - ДВТ60 | 0.5 - 0.5 m<br>etc. Up to<br>12 - 12 m |

The example of the converter ИП34 marking with unified output signal (1– 5) mA, measurement range (0 – 2) mm, applied with sensor ДВТ30 with 5-meter long cable:

| | | | |
|---|---|---|---|
| A | 02 | 30 | 5* |

** For versions ИП34 with РСГ7ТВ connector, the letters “pc” are added to the marking.*

H.9 Piezoelectric sensor ДПЭ24

| Cable length | | Cable type |
|---|---|---|
| 3 – 3 m<br>5 – 5 m<br>7 – 7 m | 9 – 9 m<br>10 – 10 m<br>12 – 12 m | И – insulated |

Example of ДПЭ24 sensor marking with a 5-m long cable and insulated metal hose:

| | |
|---|---|
| ДПЭ24 | 5И |

**Marking and serial number of the sensor are applied onto the cable tag.**

H.10 Converter ИП36, ИП36Ex

| Output signal | Sensor type | Measurement range | Frequency range | Sensor cable length |
|---|---|---|---|---|
| A – (1 – 5) mA<br>B – (4 – 20) mA | 10 – ДВТ10<br>ДВТ10Ex<br>30 – ДВТ30 | 4000 – (0 – 4000) rpm<br>6000 – (0 – 6000) rpm<br>8000 – (0 – 8000 rpm<br>10000 – (0 – 10000) rpm | 66.6 – (0 – 66.6) Hz<br>100 – (0 – 100.0) Hz<br>133.3 – (0 – 133.3) Hz<br>166.6 – (0 – 166.6) Hz<br>400 – (0 – 400) Hz<br>4000 – (0 – 4000) Hz<br>4800 – (0 – 4800) Hz<br>6000 – (0 – 6000) Hz<br>8000 – (0 – 8000) Hz<br>9999 – (0 – 9999) Hz | 0.5 - 0.5 m<br>etc. up to<br>12 - 12 m |

Example of marking of the converter with unified output signal (1 – 5) mA, with measurement range of (0 – 4000) rpm, with frequency range of (0 – 4000) Hz applied with sensor ДВТ30 with a 7-meter long cable:

| | | | | |
|---|---|---|---|---|
| A | 30 | 4000 | 4000 | 7 |

Note – Frequency ranges 66.6 – 166.6 are used for ‘groove’ control surface and frequency ranges 400 – 9999 are used ‘pinion’ control surface. For ИП36Ex, variant of output signal of type B is available only.

H.11 Converter ИП37

| DC output signal | Measurement range | | Sensor cable length |
|---|---|---|---|
| | vibration displace-ment | displacement | |
| A – (1 – 5) mA<br>B – (4 – 20) mA<br>AI – (1 – 5) mA (bend.)<br>BI – (4 – 20) mA (bend.) | 0.25 – (0 – 0.25) mm<br>0.5 – (0 – 0.5) mm | 1 – (0 – 1) mm<br>2 – (0 – 2) mm | 0.5 - 0.5 m<br>etc. up to<br>12 - 12 m |

Note – Displacement (gap) of (0 – 1) mm is applied for turbines of not more than 25 MW in capacity.

Example of marking of the converter ИП37 for measuring shaft bending with unified output signal (1–5) mA, with the measurement range of vibration displacement of (0 – 0.5) mm with measurement range of displacement of (0 – 2) mm applied with the sensor that has a 5-meter long cable:

| | | | |
|---|---|---|---|
| ИП37 | AI | 0.5 / 2 | 5 |

H.12 Converter ИП42, ИП43

| DC output signal | Measurement range | Width of “band” | Sensor cable length |
|---|---|---|---|
| A – (1 – 5) mA<br>B – (4 – 20) mA | 08 – (0 – 8) mm<br>10 – (0 – 10) mm<br>etc. up to<br>50 – (0 – 50) mm | 10 - 10 mm<br>20 - 20 mm<br>etc. up to<br>80 - 80 mm | 3 - 3 m<br>etc. up to<br>12 - 12 m |

Example of marking of the converter ИП42, ИП43 with unified output signal (1 – 5) mA, measurement range of (0 – 30) mm, at band width of 20 mm applied with sensor ДВТ40.20, ДВТ43.20 supplied with a 5 m long cable:

| | | | |
|---|---|---|---|
| A | 30 | 20 | 5 |

H.13 Converter ИП44

| DC output signal | Measurement range | Sensor type | Sensor cable length |
|---|---|---|---|
| A – (1 – 5) mA<br>B – (4 – 20) mA | 1 – ± 1,0 mm/m<br>2 – ± 2,0 mm/m<br>5 – ± 5,0 mm/m | 70 - ДВТ70 | 3 - 3 m<br>etc. up to<br>10 - 10 m |

Example of marking of the converter ИП44 with unified output signal of (1 – 5) mA, measurement range of ± 2,0 mm/m applied with sensor ДВТ70 supplied with 5 m long cable:

| | | | | |
|---|---|---|---|---|
| ИП44 | A | 2 | 70 | 5 |

**Marking and serial number of the converters are applied onto the cover nameplate.**

**Serial numbers of the sensor and converter should match.**

H.14 Converter ИП24

| AC output signal | Measurement range |
|---|---|
| A – (1 – 5) mA | 15 – (0 – 15) mm/sec<br>30 – (0 – 30) mm/sec<br>50 – (0 – 50) mm/sec<br>100 – (0 – 100) mm/sec |

Example of marking of the converter ИП24 with output signal of (1 – 5) mA, measurement range of (0 – 50) mm/sec:

| | | |
|---|---|---|
| ИП24 | A | 50* |

**Marking and the serial number of the sensors are applied onto the amplifier cover nameplate.**

*****For versions with frequency measurement range (2 – 1000) Hz letter “H” is added to the marking of the measurement range.*

H.15 Sensor ДВТ82

| DC output signal | Measurement range | The presence of a hinge (only for АС-3) |
|---|---|---|
| А – (1 – 5) mA<br>В – (4 – 20) mA | 10 – (0 – 10) mm<br>20 – (0 – 20) mm<br>etc. up to<br>360 – (0 – 360) mm | Ш – Hinge |

Example of marking of the sensor with unified output signal (4 – 20) mA and measurement range of (0 – 50) mm:

| ДВТ82 | В | 50 | Ш |
|---|---|---|---|

Note:

- For versions of ДВТ82 sensor with a hinge (used with МУ15, only according to АС-3), the designation “Ш” is applied on the sticker.

**Marking and serial number of the ДВТ82 are applied onto the sensor cover nameplate.**

**Serial number of the sensor and its type is applied onto the rod.**

**Serial numbers of the sensor and rod should match.**

H.16 Sensor ДПЭ22МВ, ДПЭ22МВТ, ДПЭ22П, ДПЭ22Ех

| AC output signal | Measurement range | Cable length | Cable type | Fasteners |
|---|---|---|---|---|
| А – (1 – 5) mA | 12 – (0 – 12) mm/sec<br>15 – (0 – 15) mm/sec<br>30 – (0 – 30) mm/sec<br>50 – (0 – 50) mm/sec<br>100 – (0 – 100) mm/sec | 3 – 3 m<br>etc. up to<br>12 – 12 m | И – insulated<br>р – detachable | API610 – as per standard API 610 |

Example of marking of the sensor with output signal of (1 – 5) mA, measurement range of (0 – 15) mm/sec, 7- m long cable, insulated and detachable cable, with fasteners as per API 610:

| А* | 15** | 7Ир*** | API610 |
|---|---|---|---|

** For versions with galvanic isolation in the power circuit, the letter "г" is added to the marking of the output signal.*

*** For versions with a frequency range (2 - 1000) Hz, the letter “Н” is added to the marking of the measuring range.*

**** If there is an insulated metal hose, detachable connection of the piezoelectric sensor and amplifier, the marking is added to the cable length.*

H.17 Sensor ДПЭ23МВ, ДПЭ23МВТ, ДПЭ23П, ДПЭ23Ех

| DC output signal | Measurement range | Cable length | Cable type | Fasteners |
|---|---|---|---|---|
| A – (1 – 5) mA<br>B – (4 – 20) mA | 12 – (0 – 12) mm/sec<br>15 – (0 – 15) mm/sec<br>30 – (0 – 30) mm/sec<br>50 – (0 – 50) mm/sec<br>100 – (0 – 100) mm/sec | 3 – 3 m<br>etc. up to<br>12 – 12 m | И – insulated<br>p – detachable | API610 –<br>as per stand-<br>ard AP I610 |

Example of marking of the sensor with unified signal of (4 – 20) mA, measurement range of (0 – 15) mm/sec and 5-m long cable and the detachable connector:

| | | |
|---|---|---|
| B* | 15 | 5p*** |

** For versions with galvanic isolation in the power circuit, the letter "г" is added to the marking of the output signal.*

*** For versions with a frequency range (2 - 1000) Hz, the letter “H” is added to the marking of the measuring range.*

**** If there is an insulated metal hose, detachable connection of the piezoelectric sensor and amplifier, the marking is added to the cable length.*

**Marking and serial number of the sensors are applied onto the amplifier cover nameplate.**

H.18 Comparator К21

| Relay disconnection delay time | Sensor cable length |
|---|---|
| 10 - 10 s<br>20 - 20 s<br>0.5 - 0.5 s | 0.5 - 0.5 m<br>etc. up to<br>12 - 12 m |

Example of marking of the comparator К21 with the relay disconnection delay time of 20 sec applied with the sensor and a 5-meter long cable:

| | | |
|---|---|---|
| К21 | 20 | 5 |

H.19 Comparator К22, К22Ex

| DC output signal | Sensor type | Sensor cable length | Control surface |
|---|---|---|---|
| A – (1 – 5) mA<br>B – (4 – 20) mA<br>V – (0 – 20) V | 10 – ДВТ10, ДВТ10Ex<br>30 – ДВТ30 | 0.5 – 0.5 m<br>etc. up to<br>12 – 12 m | П – groove<br>From 1 to 255* inclusive<br>Ш – pinion |
| C - (0 – 10) mA | | | П – groove |
| * - input signal frequency ratio | | | |

Example of marking of the comparator К22Ex with output signal of (4 – 20) mA applied with the sensor ДВТ10Ex that has a 7-m long cable, control surface – pinion:

| | | | |
|---|---|---|---|
| B | 10 | 7* | Ш |

** For К22 versions with РСГ7ТВ connector, the letters “рс” are added to the marking.*

**Marking and serial number of the comparators are applied onto the cover nameplate.**

H.20 Eddy current sensors ДВТ10, ДВТ10Ex, ДВТ20, ДВТ21, ДВТ20Ex, ДВТ23, ДВТ30, ДВТ40, ДВТ43, ДВТ50, ДВТ60, ДВТ70

ДВТ10, ДВТ10Ex

| Sensor length | | Sensor cable length |
|---|---|---|
| 30 – 30 mm | 110 – 110 mm | 0.5 – 0.5 m |
| 40 – 40 mm | 120 – 120 mm | etc. up to |
| 50 – 50 mm | 130 – 130 mm | 12 – 12 m |
| 70 – 70 mm | 150 – 150 mm | |
| 80 – 80 mm | 155 – 155 mm | |
| 85 – 85 mm | 160 – 160 mm | |
| 100 – 100 mm | 180 – 180 mm | |
| 105 – 105 mm | 200 – 200 mm | |

ДВТ20, ДВТ20Ex

| Sensor length | Sensor cable length |
|---|---|
| 27 – 27 mm | 0.5 – 0.5 m |
| 30 – 30 mm | etc. up to |
| 40 – 40 mm | 12 – 12 m |
| 50 – 50 mm | |
| 80 – 80 mm | |

Example of marking of the 50-mm long sensor ДВТ10 with 7-m long cable:

| | | |
|---|---|---|
| ДВТ10 | 50* | 7** |

ДВТ23, ДВТ30, ДВТ60

| Length of the sensor with the cable |
|---|
| 0.5 – 0.5 m<br>etc. up to<br>12 – 12 m |

ДВТ21, ДВТ40, ДВТ43, ДВТ50, ДВТ70

| Length of the sensor with the cable |
|---|
| 3 – 3 m<br>etc. up to<br>13 – 13 m |

Example of marking of the sensor ДВТ70 with 7-m long cable:

| | |
|---|---|
| ДВТ70 | 7 |

Example of marking of the sensor ДВТ50 with 7-m long cable (with МУ15):


** For sensor ДВТ10, ДВТ20, ДВТ10Ex, ДВТ20Ex using a pipe and a sleeve made of steel material 12Х18Н10Т ГОСТ 5632-2014, the letter "н" is added to the marking (default material is rod ДКРПП ЛС59-1 ГОСТ 2060-2006 with Н6 coating).*

*** When protecting the sensor cable with a metal hose, the letter "М" is added to the cable length marking. For the versions of sensor ДВТ10, ДВТ20, ДВТ21, ДВТ30, ДВТ50, ДВТ60.10 with РС7ТВ connector, the letters "рс" are added to the marking.*

Note:

- for versions of the sensor ДВТ50 with a hinge (used with МУ15, only according to АС-3), the designation “Ш” is applied on the sticker.

**Marking and serial number of the sensors are applied onto the cable tags.**

**Serial number and type is applied onto the ДВТ50sensor rod.**

**Serial numbers of sensor ДВТ50 and rod should match.**

H.21 Sensor ДПЭ23МВП

| DC output signal | Measurement range | Sensor cable length |
|---|---|---|
| A – (1 – 5) mA<br>B – (4 – 20) mA | 0.25 – (0 – 0.25) mm<br>0.5 – (0 – 0.5) mm | 3 – 3 m<br>etc. up to<br>12 – 12 m |

Example of marking of the sensor with output signal (1 – 5) mA, measurement range of (0 – 0.25) mm and a 7- m long cable:

| | | | |
|---|---|---|---|
| ДПЭ23МВП | A | 0.25 | 7 |

**Marking and serial number of the sensor are applied onto the amplifier cover nameplate.**

H.22 Hall effect sensor ДХМ

| Cable length |
|---|
| 3 – 3 m<br>etc. up to<br>12 – 12 m |

Example of marking of the sensor ДХМ with 5-m long cable:

| | |
|---|---|
| ДХМ | 5 |

**Marking and serial number of the sensor are applied onto the cable tag.**

H.23 Connecting cables КС10, КС11, КС24

| КС10, КС11 | КС24 | |
|---|---|---|
| Cable length | Cable length | |
| 3 – 3 m<br>5 – 5 m<br>7 – 7 m<br>9 – 9 m<br>12 – 12 m<br>13 – 13 m<br>15 – 15 m | 5 – 5 m<br>7 – 7 m<br>8 – 8 m<br>10 – 10 m<br>12 – 12 m<br>14 – 14 m | 16 – 16 m<br>17 – 17 m |

Example of marking a connecting cable with a length of 10 m:

| | |
|---|---|
| КС10 | 10* |

**Serial number of the cable is applied onto the cable tag.**

**Serial numbers of sensor, cable and converter should match.**

** For КС10 versions with connectors РС7ТВ (socket) РСГ7ТВ (plug), the letters "рс" are added to the marking.*

H.24 Transducer boxes КП13, КП15, КП23, КП25

| Type | Purpose |
|---|---|
| КП13 | For installation of one converter of type ИП |
| КП13Р | Ditto |
| КП13-Пр | " |
| КП13Х | For installation of one explosion-proof converter of type ИП34Ex, ИП36Ex, К22Ex |
| КП13Х-Пр1 | Ditto. For installation of one explosion-proof amplifier for ДПЭ sensors |
| КП13ХР | Ditto |
| КП13К | For connecting sensor ДХМ |
| КП13КР | Ditto |
| КП15В | For installation of one converter ИП24 and SPD |
| КП15М | For installation of one converter ИП34, ИП42, К22 and SPD |
| КП23В | For installation of three converters of type ИП |
| КП23ВР | Ditto |
| КП23-Пр | Ditto |
| КП23П | For installation of three amplifiers of ДПЭ sensors |
| КП23ПР | Ditto |
| КП23ВХ | For installation of three explosion-proof converters of type ИП34Ex, ИП36Ex, К22Ex |
| КП23Х-Пр | Ditto. For installation of three amplifiers of explosion-proof sensors ДПЭ |
| КП23ПХ | For installation of three amplifies of explosion-proof sensors ДПЭ |
| КП25В2 | For installation of two converters ИП24 and SPD |
| КП25В3 | For installation of 3 converters ИП24 and SPD |
| КП25М2 | For installation of 2 converters ИП34, ИП42, К22 and SPD |
| КП25М3 | For installation of 3 converters ИП34, ИП42, К22 and SPD |

**Type and serial number are applied onto the sticker located on the transducer box casing.**

H.25 Metal hose БШ24

| Metal hose length | Note |
|---|---|
| 5.5 - 5,5 m<br>5.5Б - 5,5 m<br>7 - 7 m<br>8 - 8 m | For ДВТ40, ДВТ43 |

**Marking and serial number are applied onto the metal hose tag.**

H.26 Rods

Marking determines the type of the applied rod.

1 – rod ВШПА.421412.060.01;

2 – rod ВШПА.421412.060.03;

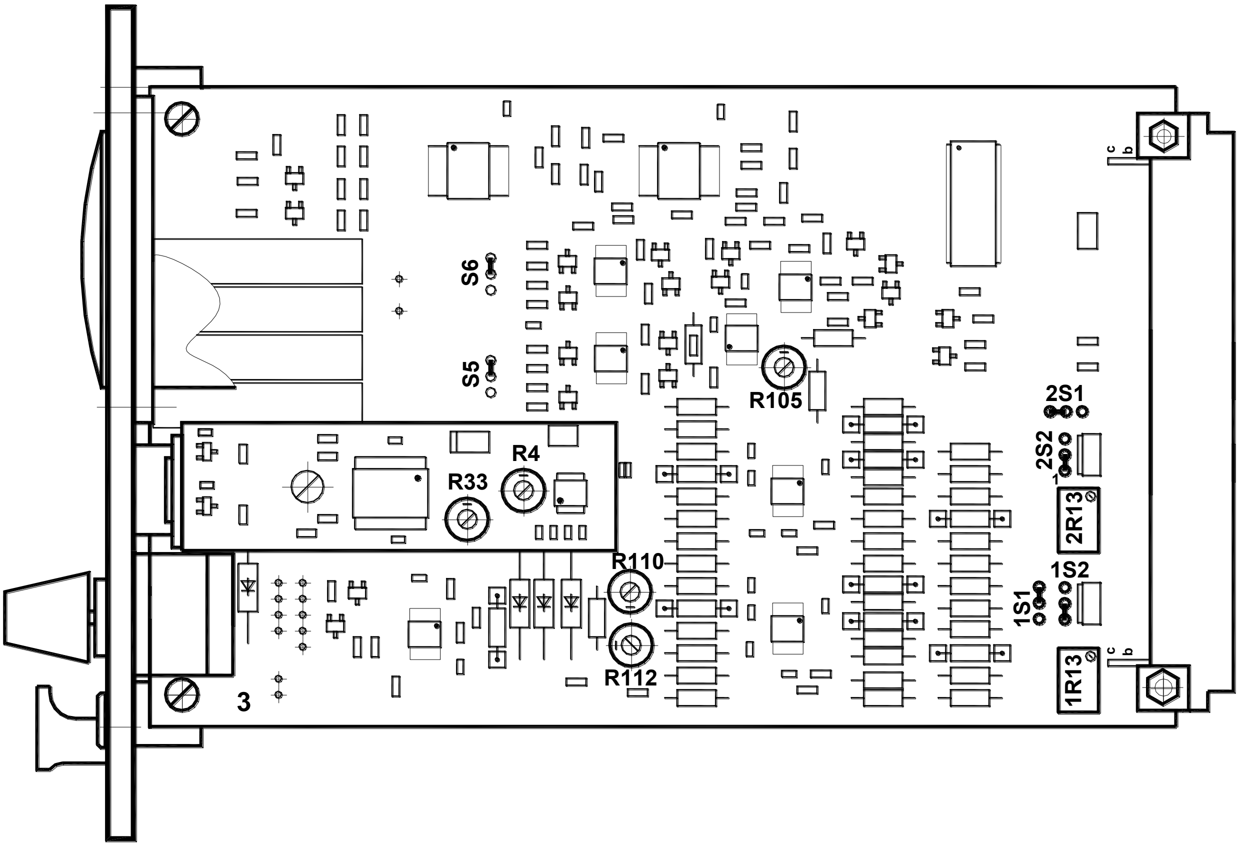
3 – rod ВШПА.421412.060.04;

5 – rod ВШПА.421412.060.10.

## Annex J
(Informative)

### Arrangement and purpose of controls

J.1 Control boards and units



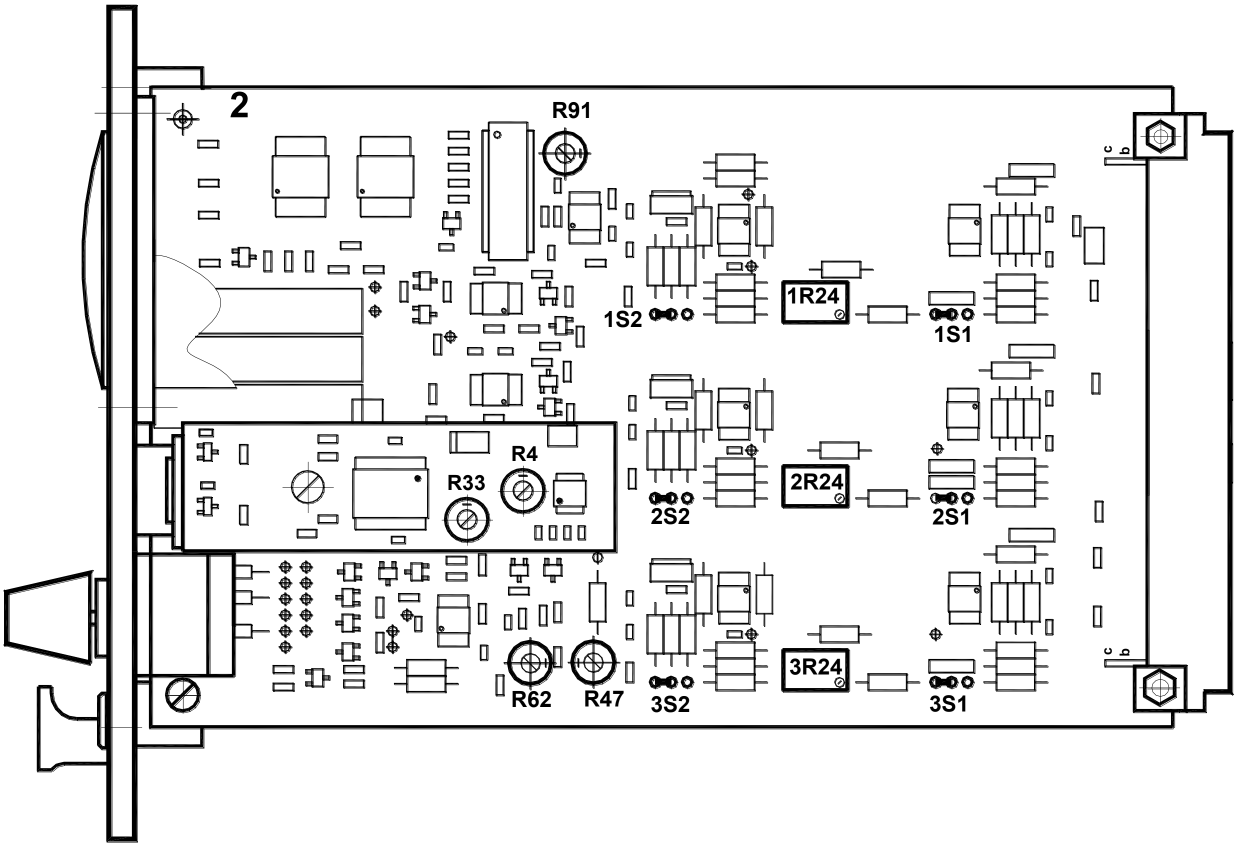

Variant B – shown.

Variant A – jumpers 1S1, 2S1, 1S2, and 2S2 should not be fitted.

| | | |
|---|---|---|
| 1 | – Adjustment of the unified signal initial current (0; 4 mA) | 1R13 (2R13) |
| 2 | – Adjustment of the pointer instrument readings | |
| | Origin (bottom) of the scale | R112 |
| | End (top) of the scale | R110 |
| 3 | – Adjustment of the digital indicator readings: | |
| | Origin (bottom) of the scale | R33 |
| | End (top) of the scale | R4 |
| 4 | – Adjustment of reference voltage + 10 V | R105 |

Note – Digit placed before the element designation denotes the measuring channel.

Figure J.1 – Control boards and units ПК10, ПК11, БК10, БК11




Variant B – shown.

Variant A – jumpers 1S1, 1S2, 2S1, 2S2, 3S1 and 2S2 should not be fitted.

1 – Adjustment of the unified signal initial current (0; 4 mA) 1R24 (2R24, 3R24).

2 – Adjustment of the pointer instrument readings

Origin (bottom) of the scale R62.

End (top) of the scale R47.

3 – Adjustment of the digital indicator readings:

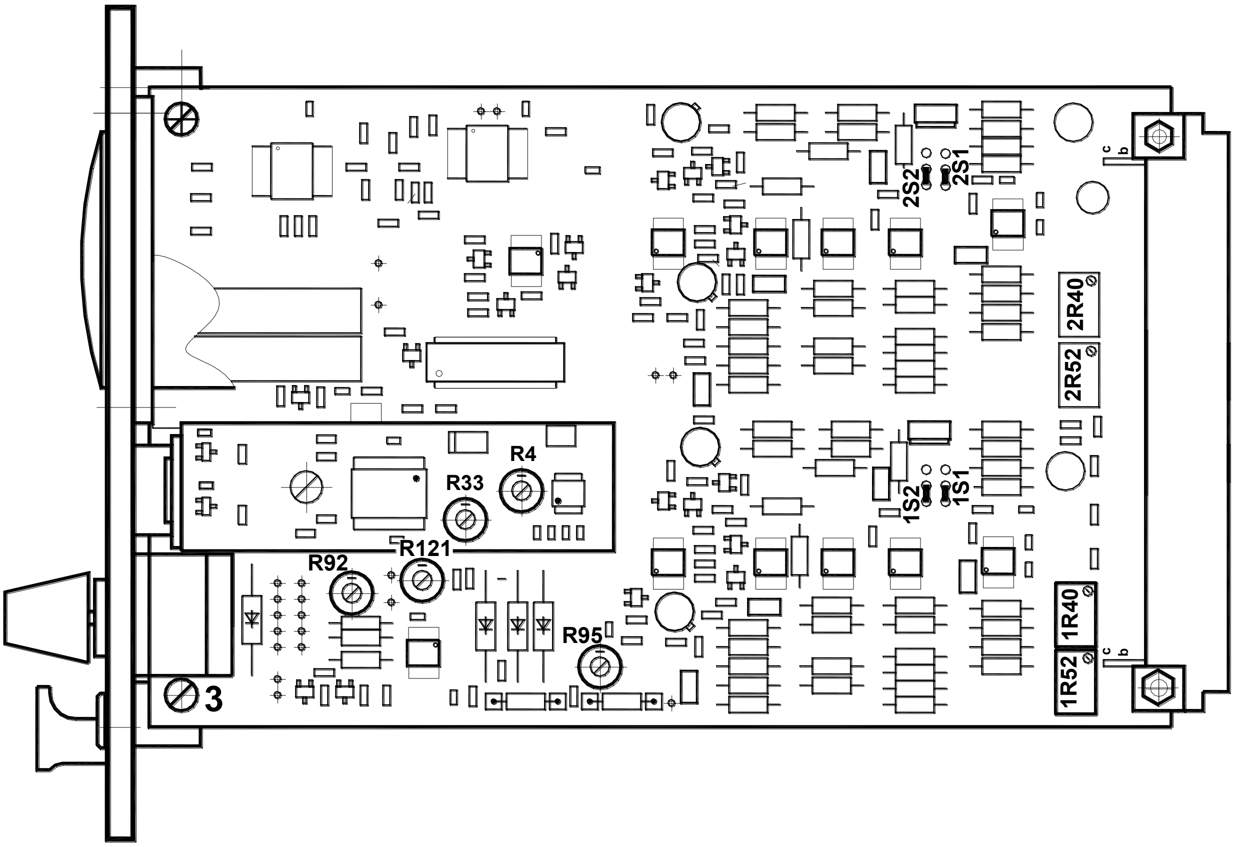
Origin (bottom) of the scale R33

End (top) of the scale R4.

4 – Adjustment of reference voltage + 10 V R91.

Note – Digit placed before the element designation denotes the measuring channel.

Figure J.2 – Control boards ПК12, ПК13



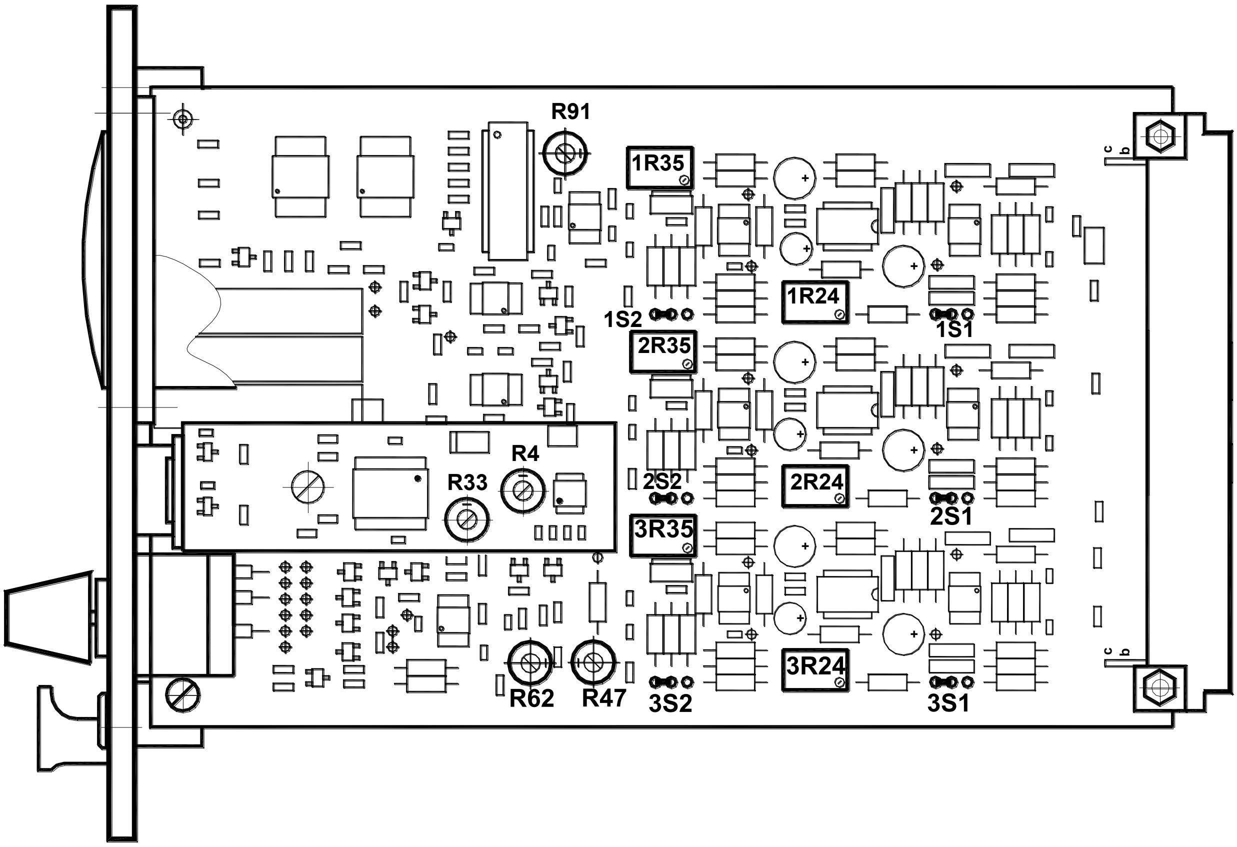

Variant B – shown.

Variant A – jumpers 1S1, 1S2, 2S1, 2S2 should not be fitted.

| | |
|---|---|
| 1 – Setting of unified output signal | 1R40 (2R40) |
| 2 - Adjustment of the unified signal initial current (0; 4 mA) | 1R52 (2R52) |
| 3 – Adjustment of the pointer instrument readings | |
| Origin (bottom) of the scale | R92. |
| End (top) of the scale | R95. |
| 4 – Adjustment of the digital indicator readings: | |
| Origin (bottom) of the scale | R33 |
| End (top) of the scale | R4. |
| 5 – Adjustment of reference voltage + 10 V | R121. |

Note – Digit placed before the element designation denotes the measuring channel.

Figure J.3 – Control boards and units ПК20, ПК21, БК20, БК21



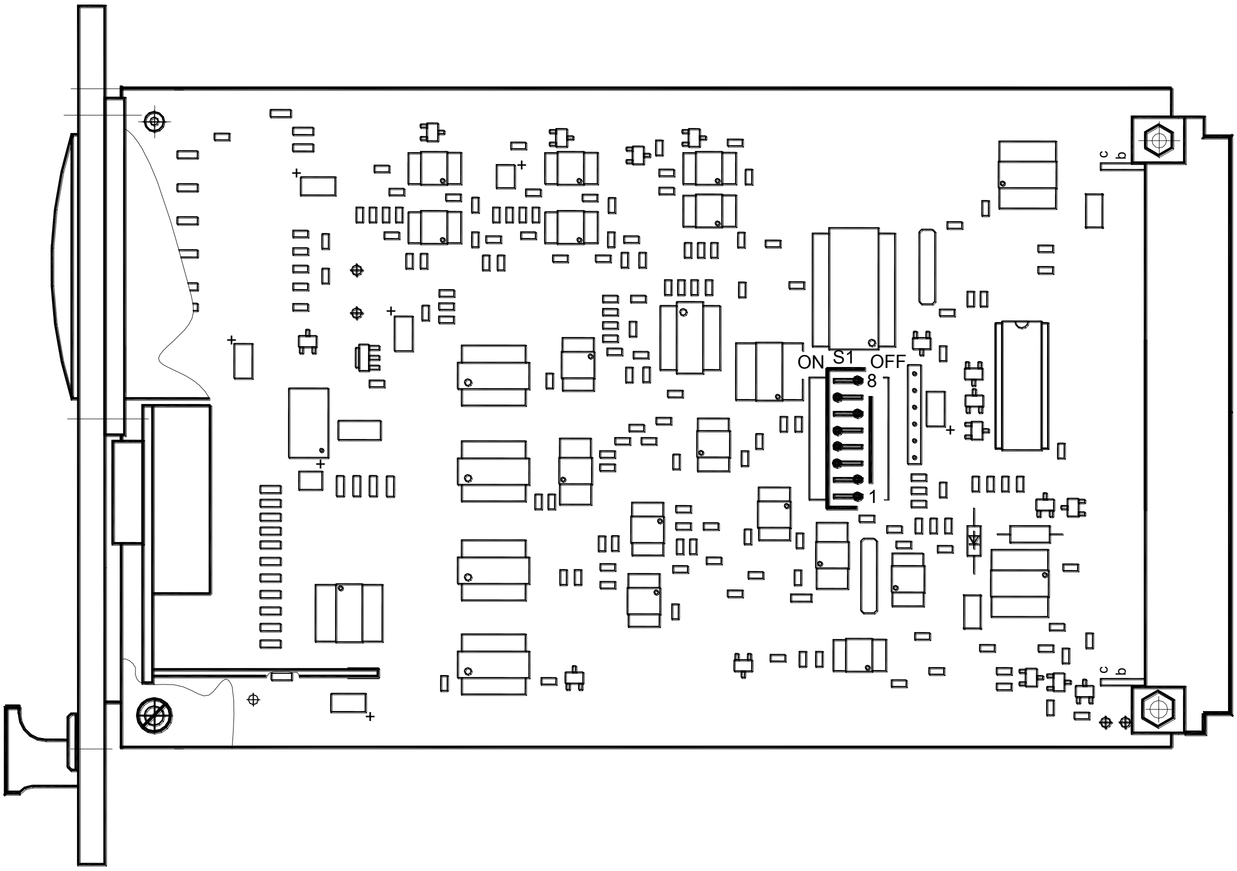

Variant B – shown.

Variant A – jumpers 1S1, 1S2, 2S1, 2S2, 3S1 and 3S2 should not be fitted.

| | |
|---|---|
| 1 – Setting of unified output signal | 1R35 (2R35, 3R35) |
| 2 - Adjustment of the unified signal initial current (0; 4 mA) | 1R24 (2R24, 3R24) |
| 3 – Adjustment of the pointer instrument readings | |
| Origin (bottom) of the scale | R62 |
| End (top) of the scale | R47 |
| 4 – Adjustment of the digital indicator readings: | |
| Origin (bottom) of the scale | R33 |
| End (top) of the scale | R4 |
| 5 – Adjustment of reference voltage + 10 V | R91 |

Note – Digit placed before the element designation denotes the measuring channel.

Figure J.4 – Control boards and units ПК30, ПК31, ПК32, БК30, БК31, БК32




| S1 switch position | ON | OFF |
|---|---|---|
| 1 | I input 20 mA | I input 5 mA |
| 2 | I output 20 mA | I output 5 mA |
| 3 | NORMAL | PROGR |
| 4 | NORMAL | PROGR |
| 5 | NORMAL | PROGR |
| 6 | STOP 2 SEC | STOP 22 SEC |
| 7 | NORMAL | PROGR |
| 8 | CALIBR | NORMAL |

1 – Setting of input current.

2 – Setting of output current.

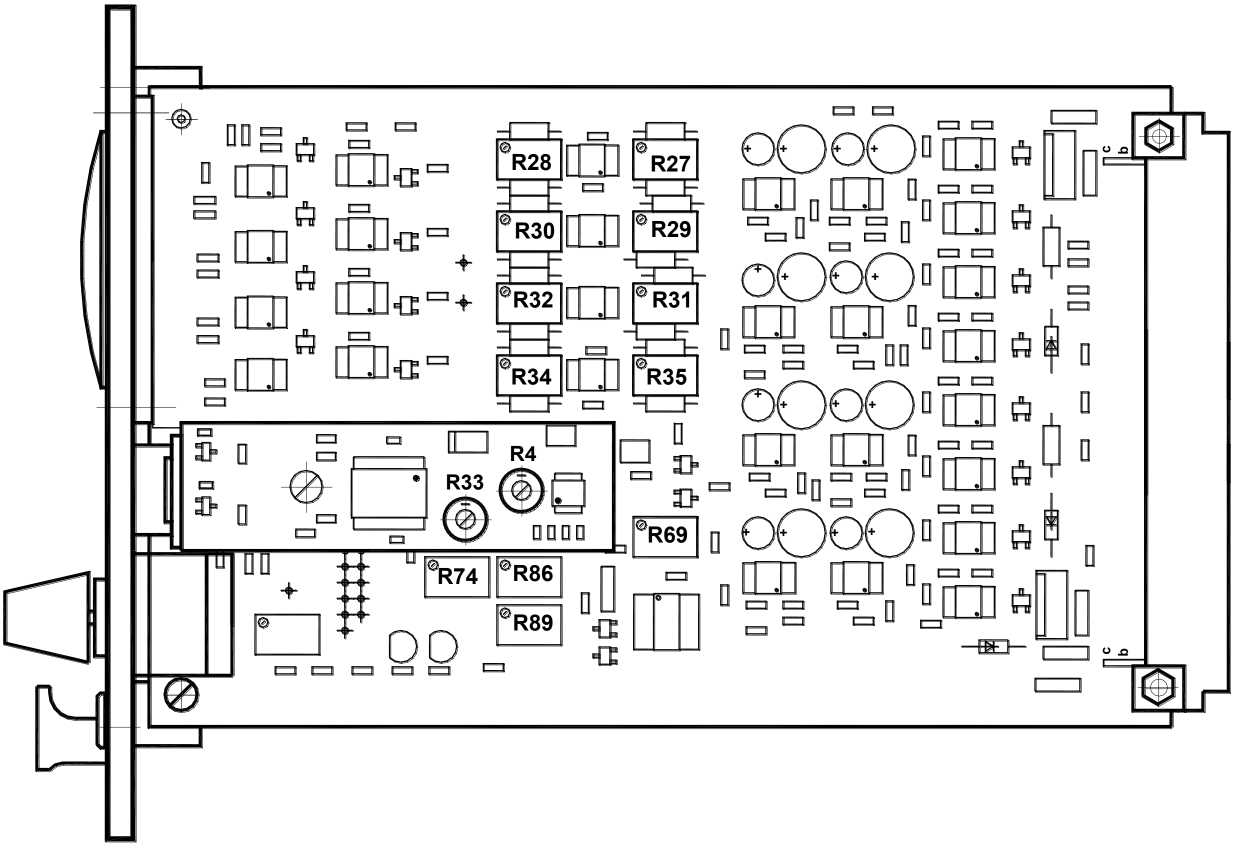
6 – Setting of output signal STOP occurrence time.

NORMAL standard operating procedure

PROGR programming mode (used in the process of manufacturing).

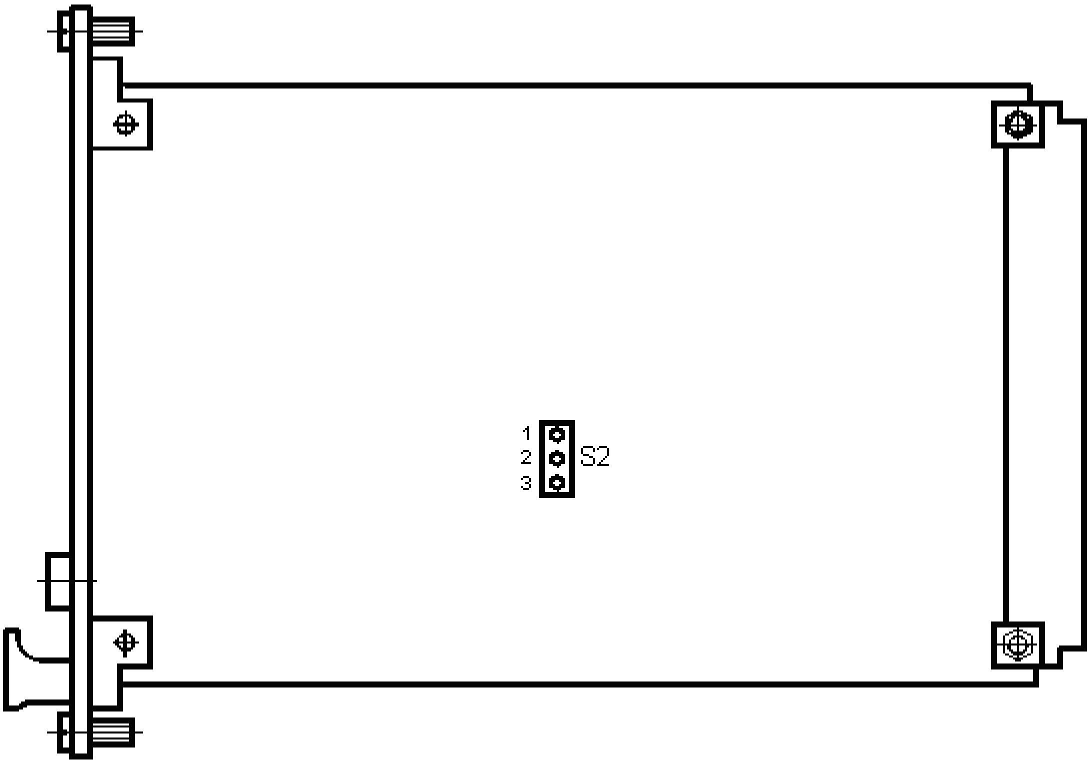
CALIBR calibration (used in the process of manufacturing).

Figure J.5 – Control board and unit ПК40, БК40



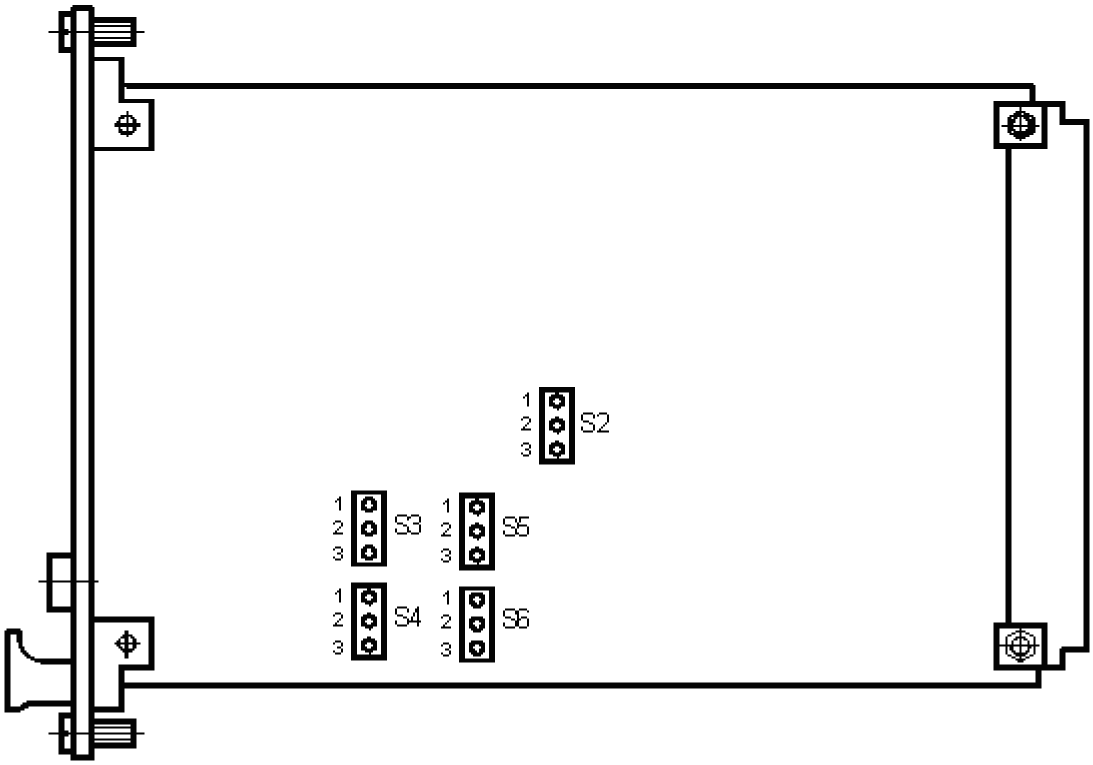

| | | |
|---|---|---|
| 1 | – Setting of cutoff frequency | R69 |
| 2 | – Setting of signaling level | R74 |
| 3 | – Adjustment of reference voltage +10 V | R84 |
| 4 | – Adjustment of pointer instrument readings: | |
| | Origin (bottom) of the scale | R89 |
| | End (top) of the scale | R86 |
| 5 | – Adjustment of digital indicator readings: | |
| | Origin (bottom) of the scale | R33 |
| | End (top) of the scale | R4 |
| 6 | – Adjustment of DC output signal (0-10 V): | |
| | Channel 1 | R27 |
| | Channel 2 | R28 |
| | Channel 3 | R29 |
| | Channel 4 | R30 |
| | Channel 5 | R31 |
| | Channel 6 | R32 |
| | Channel 7 | R35 |
| | Channel 8 | R34 |

Figure J.6 – Control board ПК51




| S2 switch position | Variant marking | Note |
|---|---|---|
| 1-2 | 1 | 2x8 channels |
| 2-3 | 2 | 16 channels |

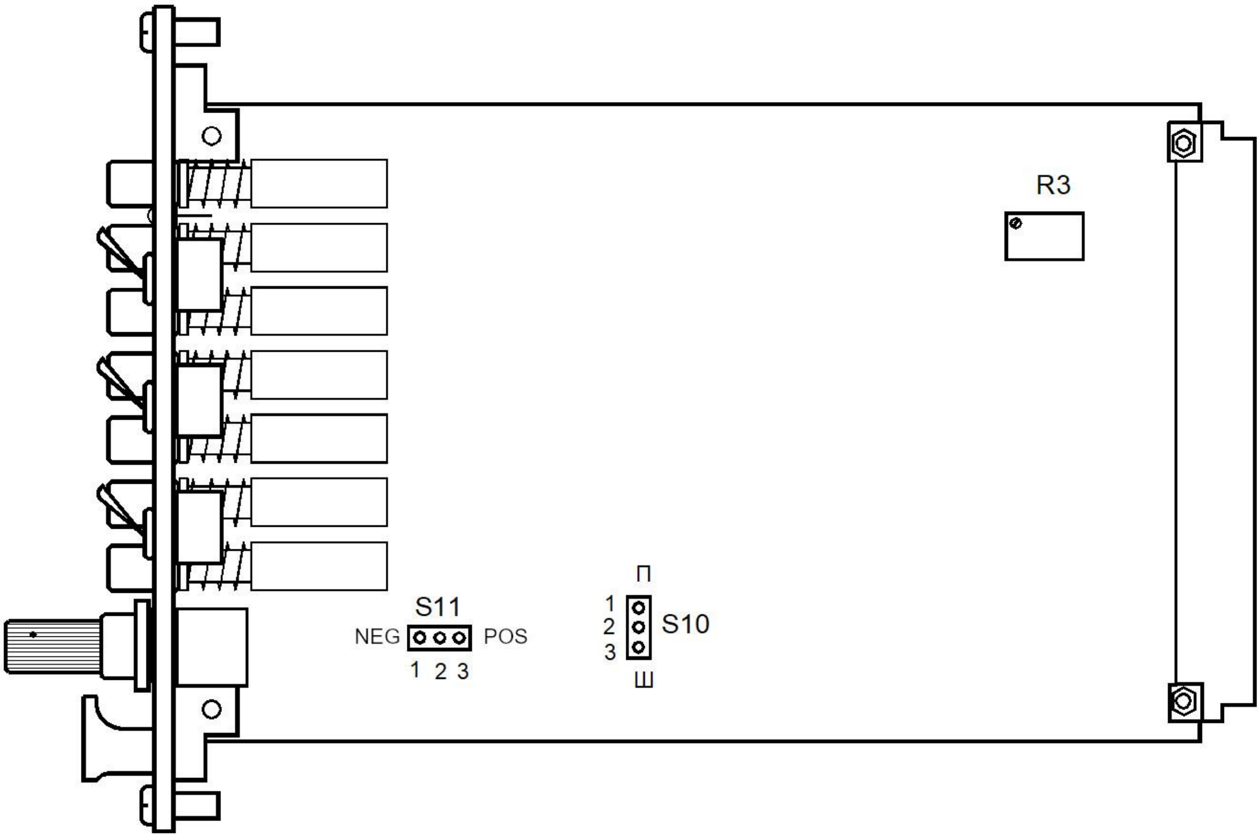
Figure J.7 – Control board ПК72




Position of jumpers determining eight inputs for ‘M’ and ‘M1’ memory registers

<table>
<tr><th>S3</th><th>S4</th><th>S5</th><th>S6</th><th>Input ПК73</th><th>Memory LED ‘M’</th></tr>
<tr><td>1 – 2</td><td></td><td></td><td></td><td>1</td><td rowspan="2">1</td></tr>
<tr><td>3 – 2</td><td></td><td></td><td></td><td>9</td></tr>
<tr><td></td><td></td><td></td><td></td><td>2</td><td>2</td></tr>
<tr><td></td><td>1 – 2</td><td></td><td></td><td>3</td><td rowspan="2">3</td></tr>
<tr><td></td><td>3 – 2</td><td></td><td></td><td>11</td></tr>
<tr><td></td><td></td><td></td><td></td><td>4</td><td>4</td></tr>
<tr><td></td><td></td><td>1 – 2</td><td></td><td>5</td><td rowspan="2">5</td></tr>
<tr><td></td><td></td><td>3 – 2</td><td></td><td>13</td></tr>
<tr><td></td><td></td><td></td><td></td><td>6</td><td>6</td></tr>
<tr><td></td><td></td><td></td><td>1 – 2</td><td>7</td><td rowspan="2">7</td></tr>
<tr><td></td><td></td><td></td><td>3 – 2</td><td>15</td></tr>
<tr><td></td><td></td><td></td><td></td><td>8</td><td>8</td></tr>
</table>

Figure J.8 – Control board ПК73

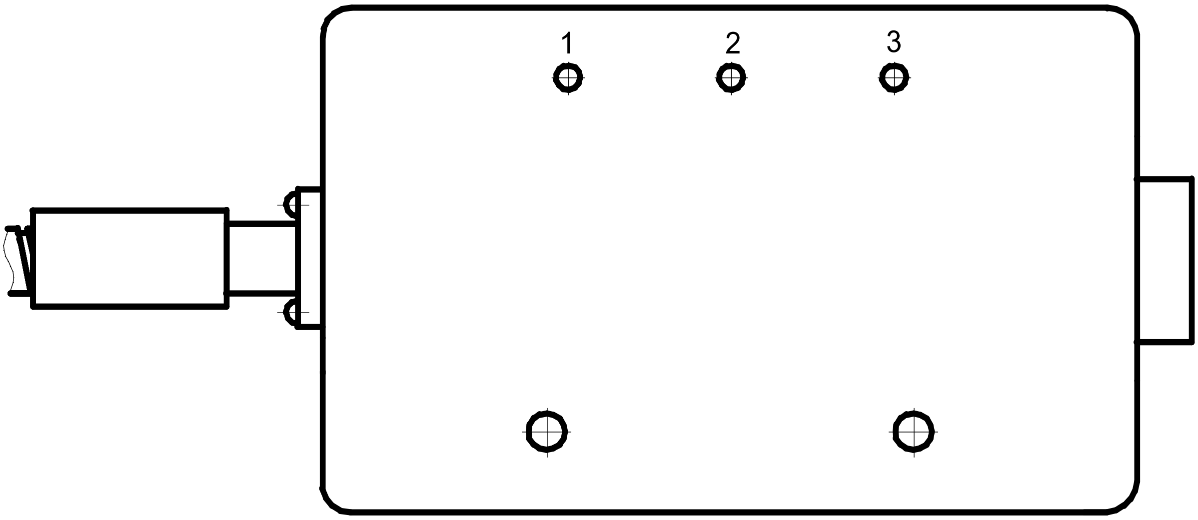



R3 – Sinusoidal voltage generator startup.

| Variant | S10 | S11 | Note |
|---|---|---|---|
| 1 | 1 – 2 | 1 – 2 | (1 – 170) Hz; ‘groove’; negative polarity |
| 2 | 1 – 2 | 3 – 2 | (1 – 170) Hz; ‘groove’; positive polarity |
| 3 | 3 – 2 | 1 – 2 | (60 – 10000) Hz; ‘pinion’; negative polarity |
| 4 | 3 – 2 | 3 – 2 | (60 – 10000) Hz; ‘pinion’; positive polarity |

Figure J.9 – Control board ПК90

J.2 Sensors, converters, comparators




Sensor ДПЭ22МВ, ДПЭ22МВТ, ДПЭ22П, ДПЭ22Ех

1 – Adjustment of conversion rate

Sensor ДПЭ23МВ, ДПЭ23МВТ, ДПЭ23П

1 – Adjustment of conversion rate by AC output (output 1)

2 – Adjustment of conversion rate by DC output (output 2)

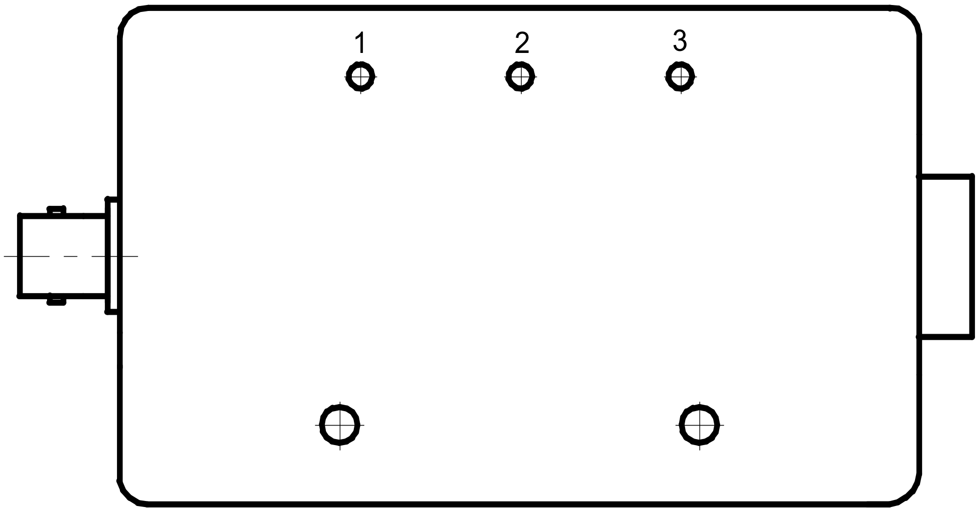
3 – Adjustment of initial current (4 mA) by DC output (output 2)

Sensor ДПЭ23Ех, ДПЭ23МВП

2 – Adjustment of conversion rate by DC output

3 – Adjustment of initial current by DC output

Figure J.10 – Amplifies of ДПЭ sensor




Converter ИП34, ИП34Ех, ИП37 (output 1)

1 – Adjustment of conversion rate at the beginning of the measurement range.

2 – Setting of the initial current for the sensor output signal of 1 mA or 4 mA.

3 – Setting of the limit value for the sensor output signal of 5 mA or 20 mA.

.

Converter ИП36, ИП36Ех

2 – Adjustment of conversion rate

3 – Setting of initial current of the converter output signal 1 mA or 4 mA

Converter ИП42, ИП43

2 – Setting of the converter output signal of 3 mA or 12 mA in zero position of the rotor band (ridge) relative to the ДВТ40, ДВТ43 sensor as per Annex D.

3 – Adjustment of the conversion rate.

Converter ИП44

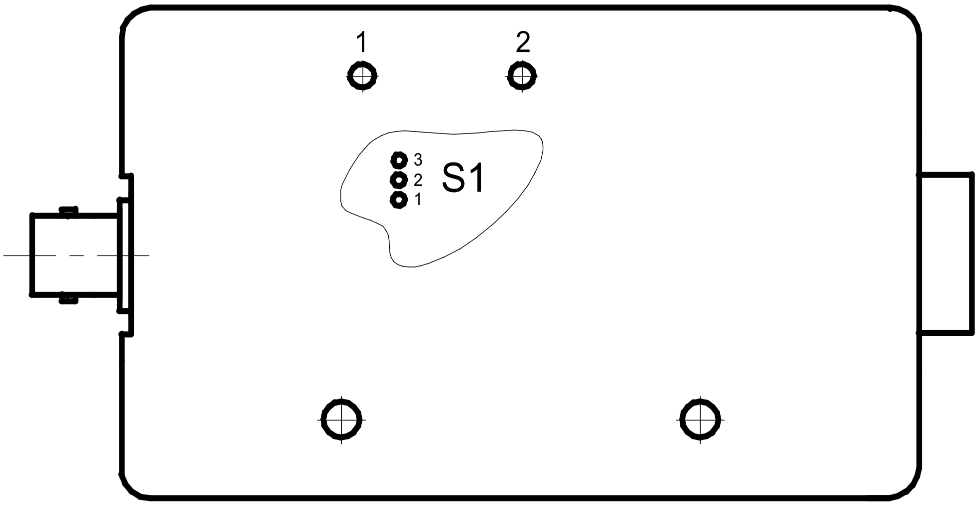
2 – Setting of the converter output signal value of 3 mA or 12 mA.

3 – Adjustment of conversion rate.

Converter ИП24

1 – Adjustment of conversion rate.

Figure J.11 – Converters ИП

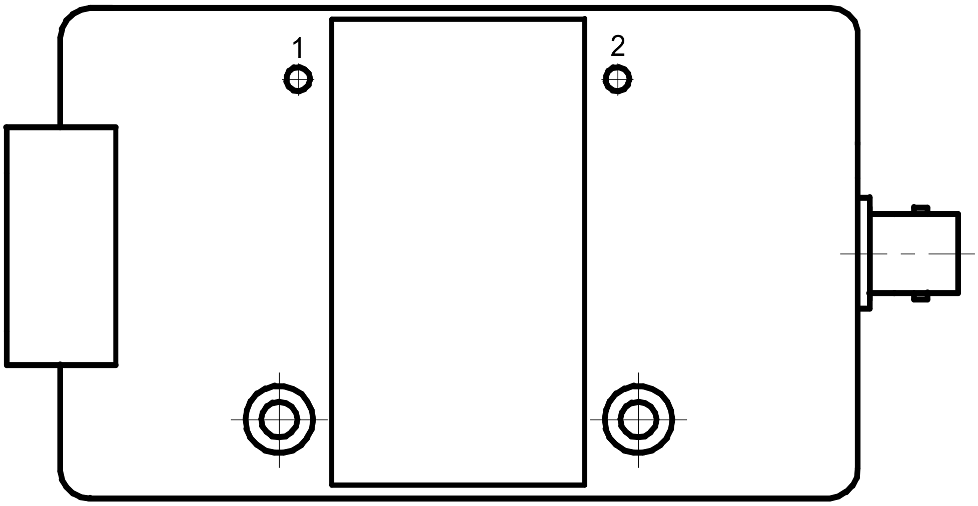



1 – Adjustment of the comparator output 2 characteristics (gap).

2 – Adjustment of (setting) distance for the comparator actuation.

| Variant | S1 jumper position |
|---|---|
| Groove | 2 – 3 |
| Pinion | 1 – 2 |

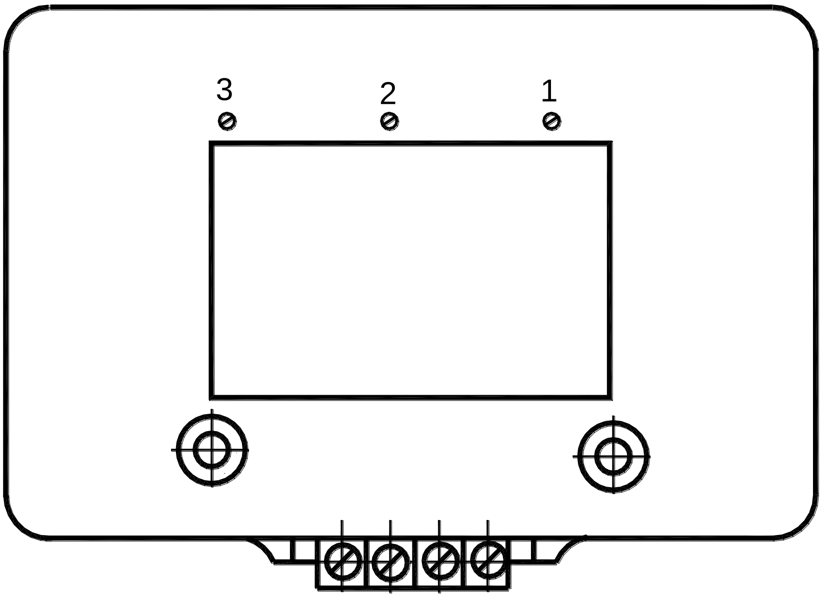
Figure J.12 – Comparators К22, К22Ex




1 – Adjustment of conversion rate.

2 – Setting of initial current of the sensor output signal 1 mA or 4 mA.

Figure J.13 – Converter ИП37 (output 2)




1 – Adjustment of conversion rate at the beginning of the measurement range.

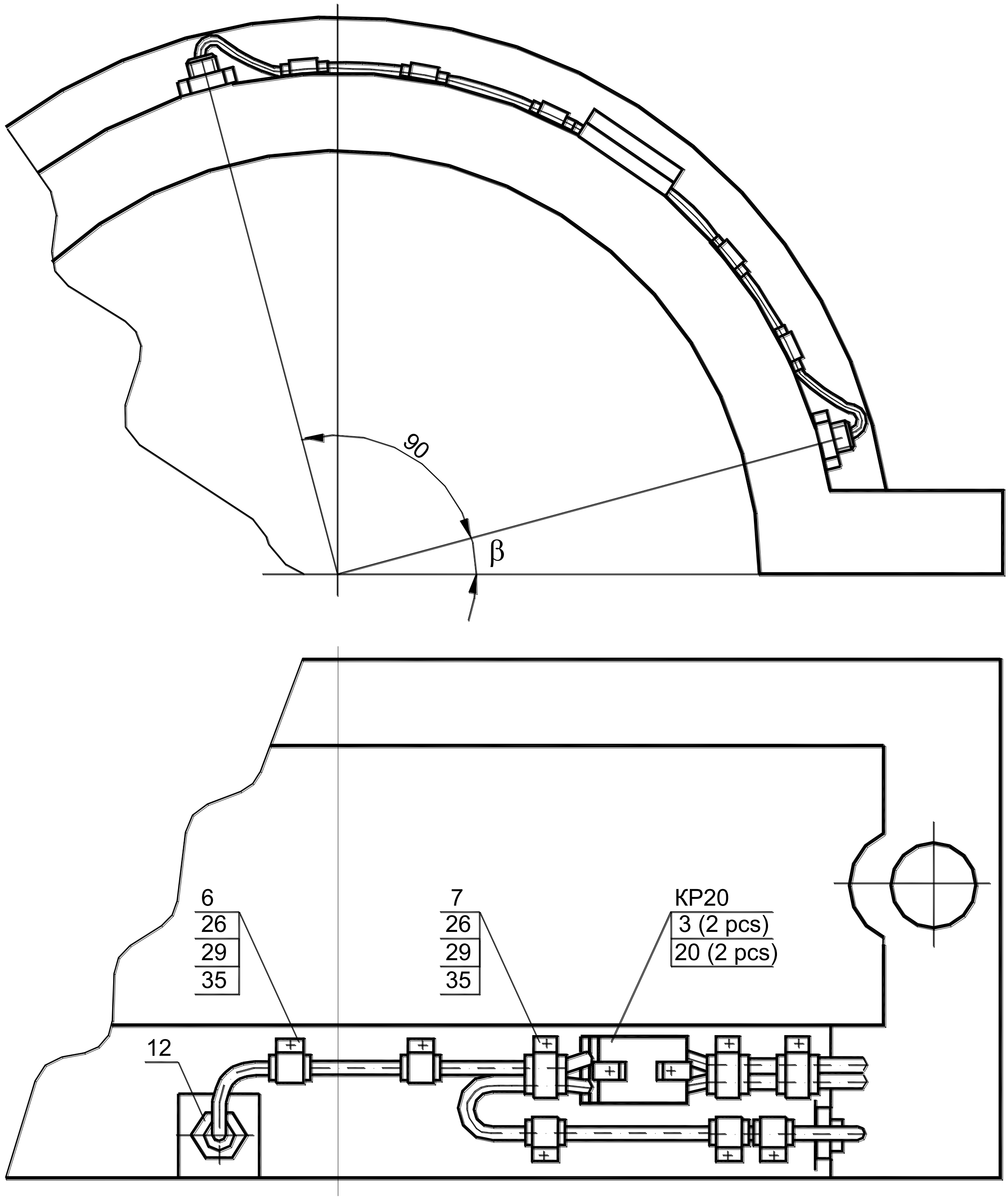
2 – Setting of initial current of the sensor output signal of 1 mA or 4 mA.

3 – Setting of the limit value for the sensor output signal of 5 mA or 20 mA.

Figure J.14 – Sensor ДВТ82

## Annex K
(Mandatory)

### Mounting drawings of assembly units



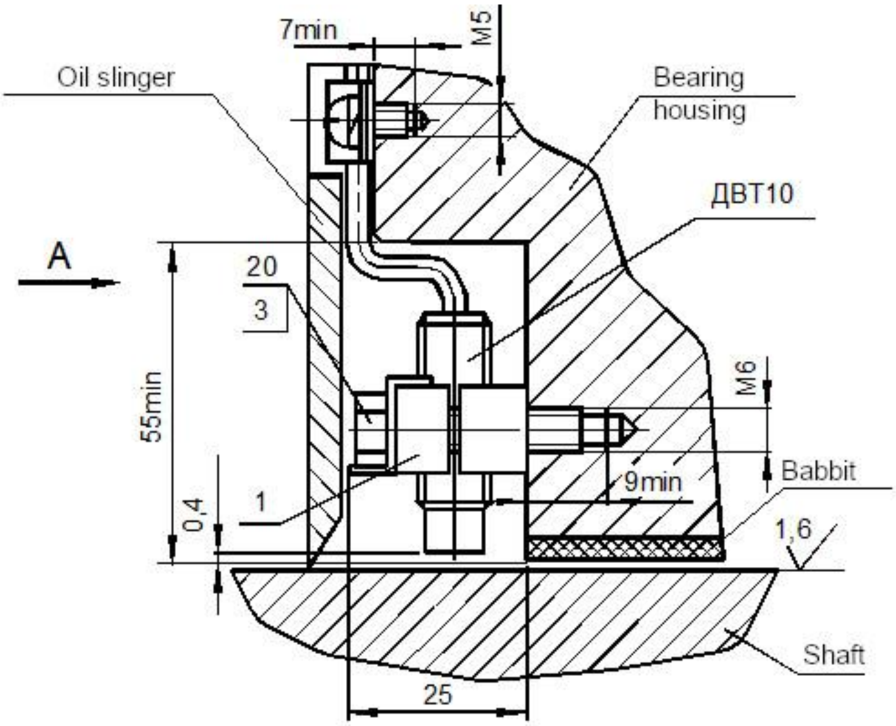

Cabling from the rotor side to the coupling side depends on the bearing design.

$\beta$ – Minimum possible sensor installation angle (depends on the bearing cover design).

Minimum cable bending radius – $R_{min}$ = 20 mm.

Figure K.1 - Example of sensors installation on the bearing housing for vibration displacement measurements in two planes

**Installation of the ДВТ10, ДВТ10Ex sensors under the oil slinger**



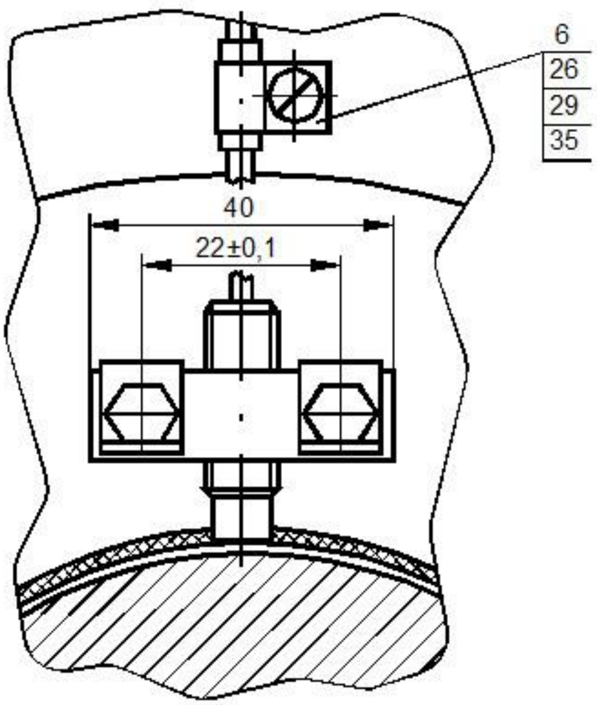




Figure K.2

Note: the gap is zero (So) - 0.4 mm

**Setting of sensor ДВТ10 in the bearing housing**

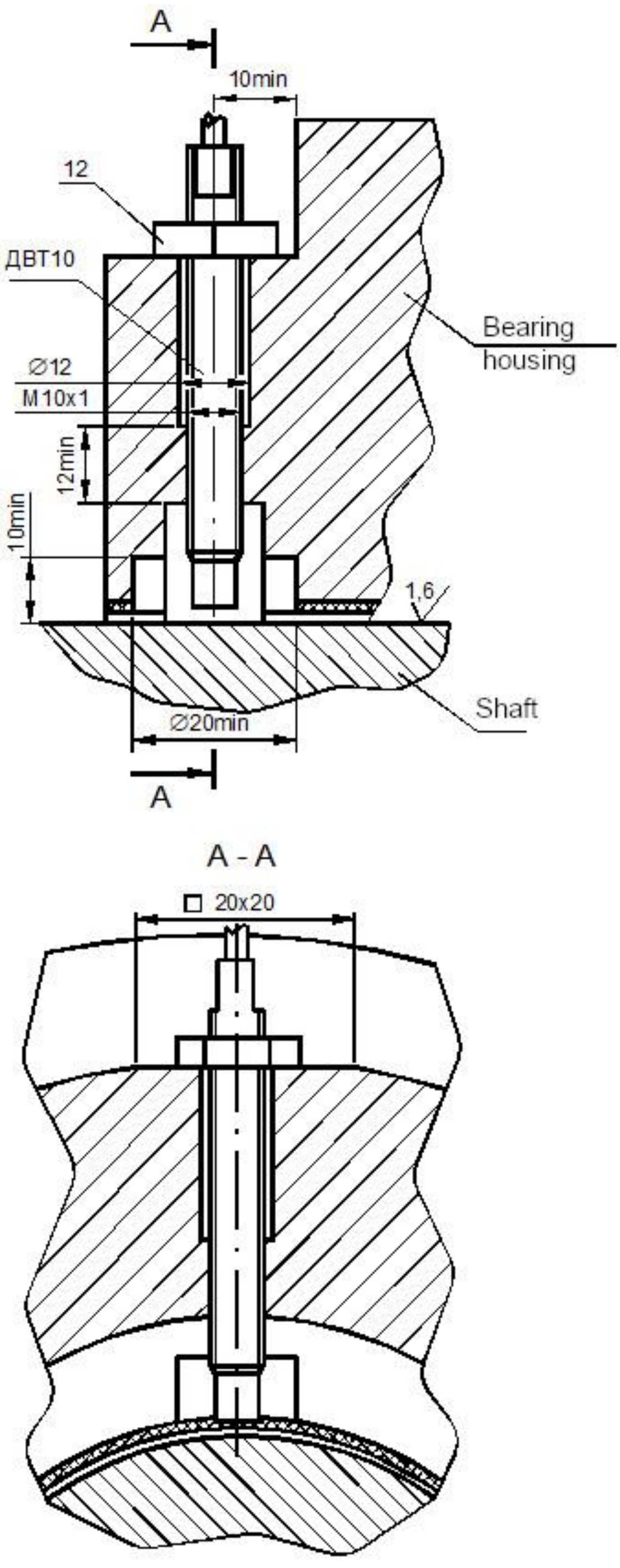



Figure K.3

**Installation of the ДВТ20, ДВТ20Ex sensors for axial offset measuring in one channel**

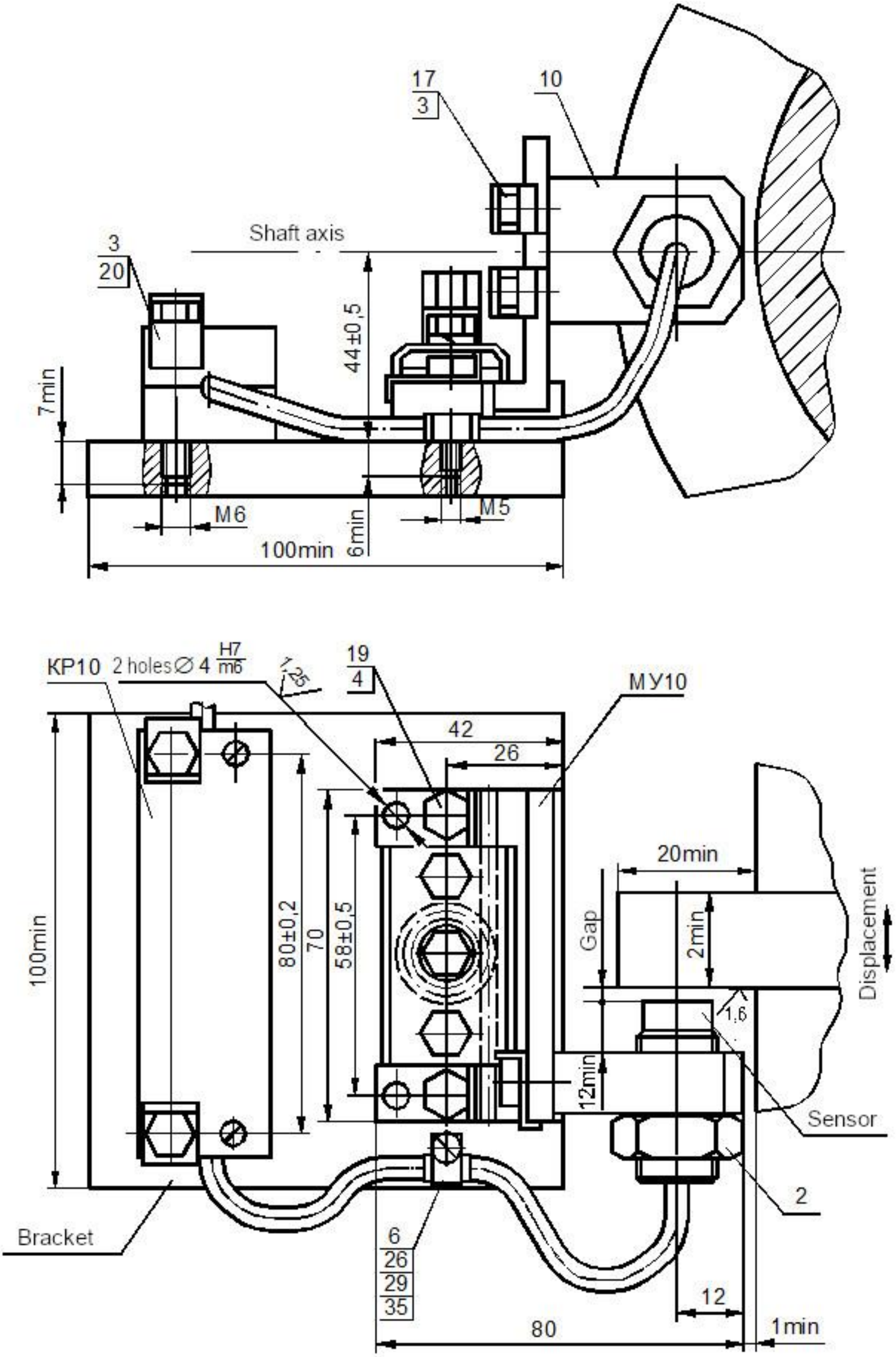



Figure K.4 – Installation of the sensor basing on ВШПА.421412.000.35.

Note: the gap is preset one (Sн).

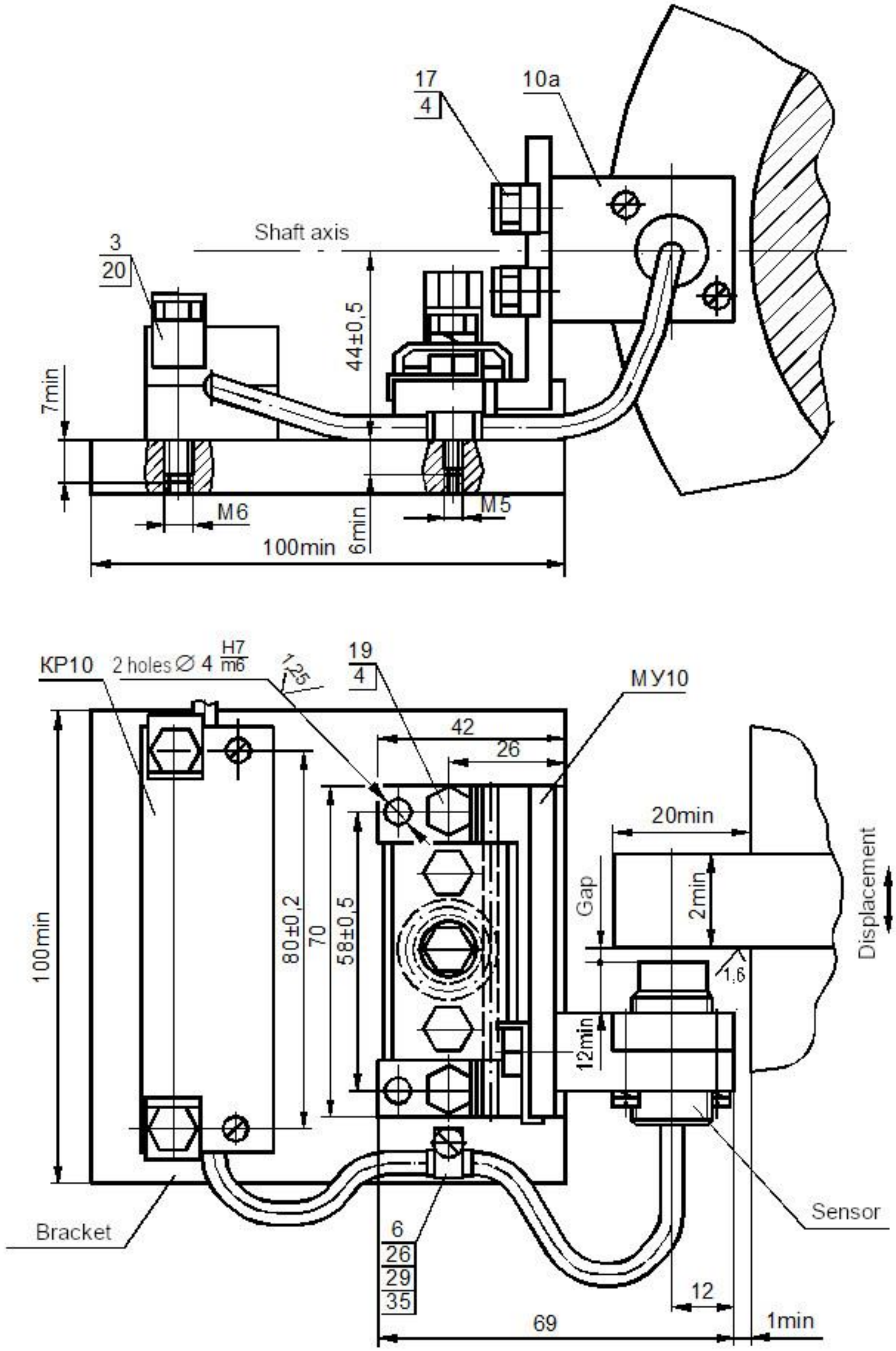



Figure K.5 - Installation of the sensor basing on ВШПА.421412.000.15.

Note: the gap is preset one (Sн).

**Installation of the ДВТ20, ДВТ20Ex sensors for axial offset measuring in two channels**

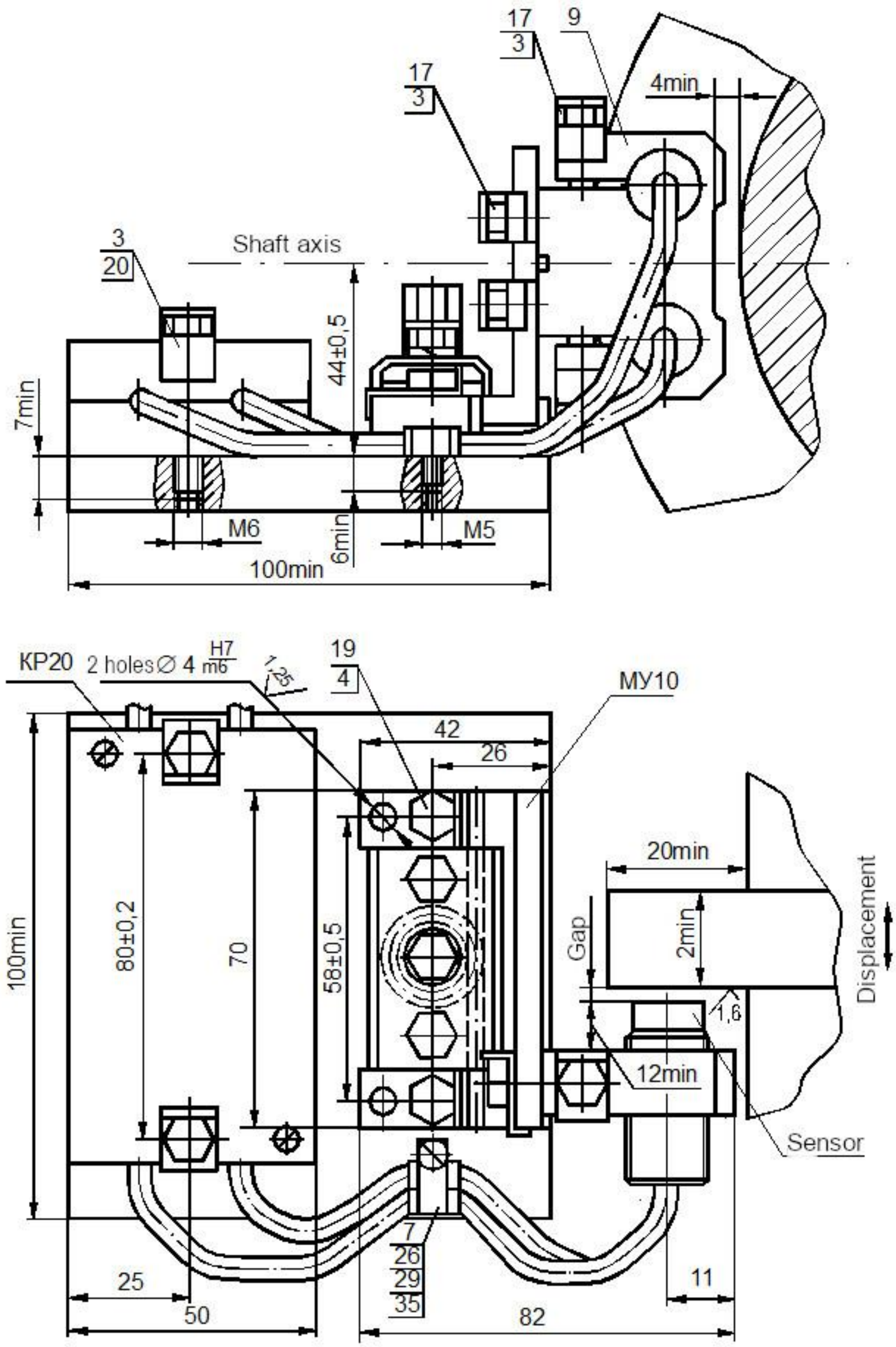



Figure K.6 - Installation of the sensor basing on ВШПА.421412.000.28.

Note: the gap is preset one (Sн).

**Installation of the ДВТ20, ДВТ20Ex sensors for axial offset measuring in three channels**

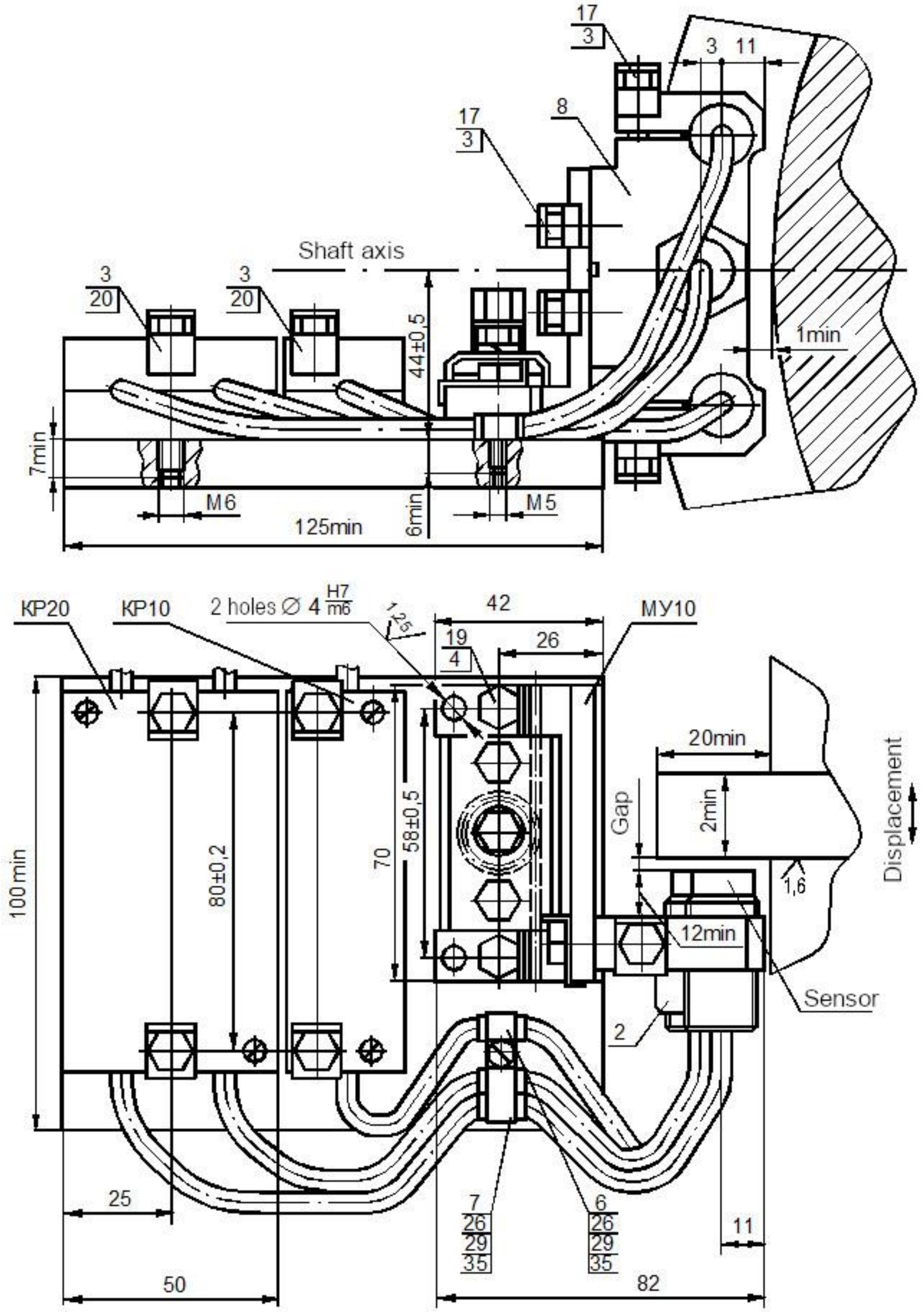
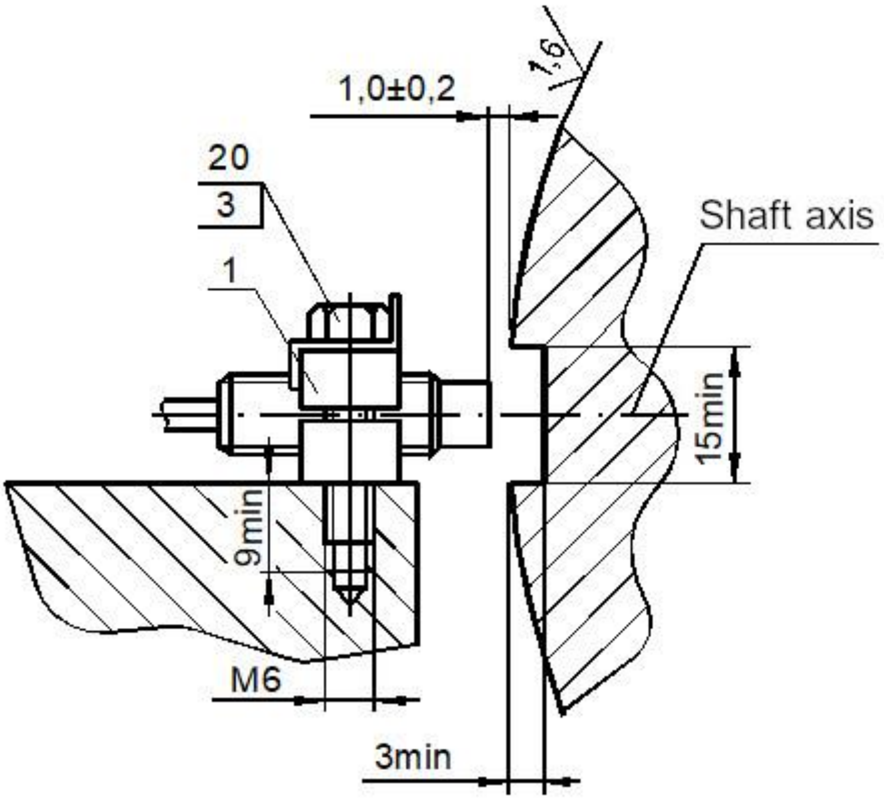



Figure K.7 - Installation of the sensor basing on ВШПА.421412.000.27.

Note: the gap is preset one (Sн).

**Installation of the ДВТ10, ДВТ10Ex sensors for the rotor RPM measuring**

Groove control surface




Pinion control surface

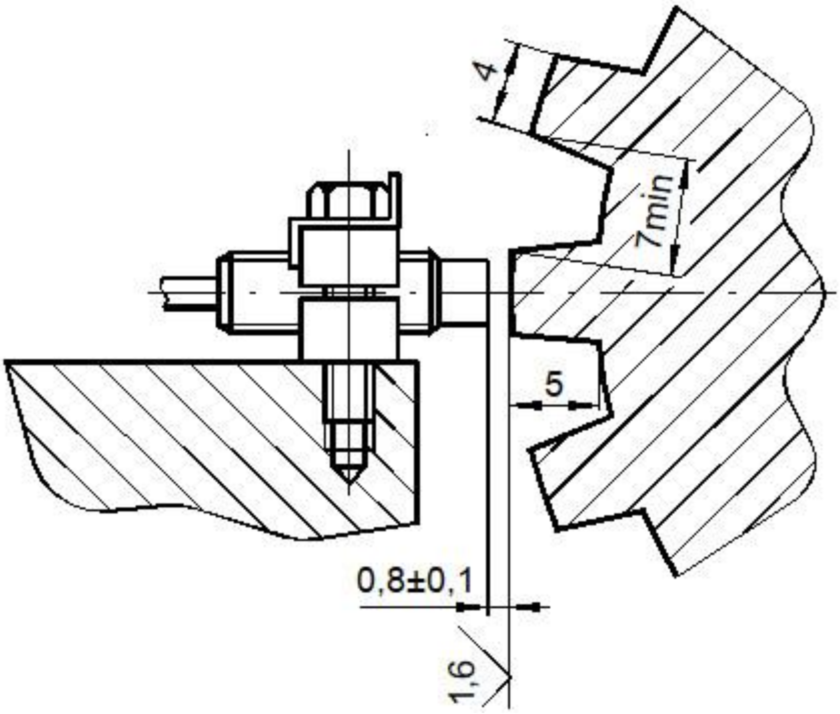
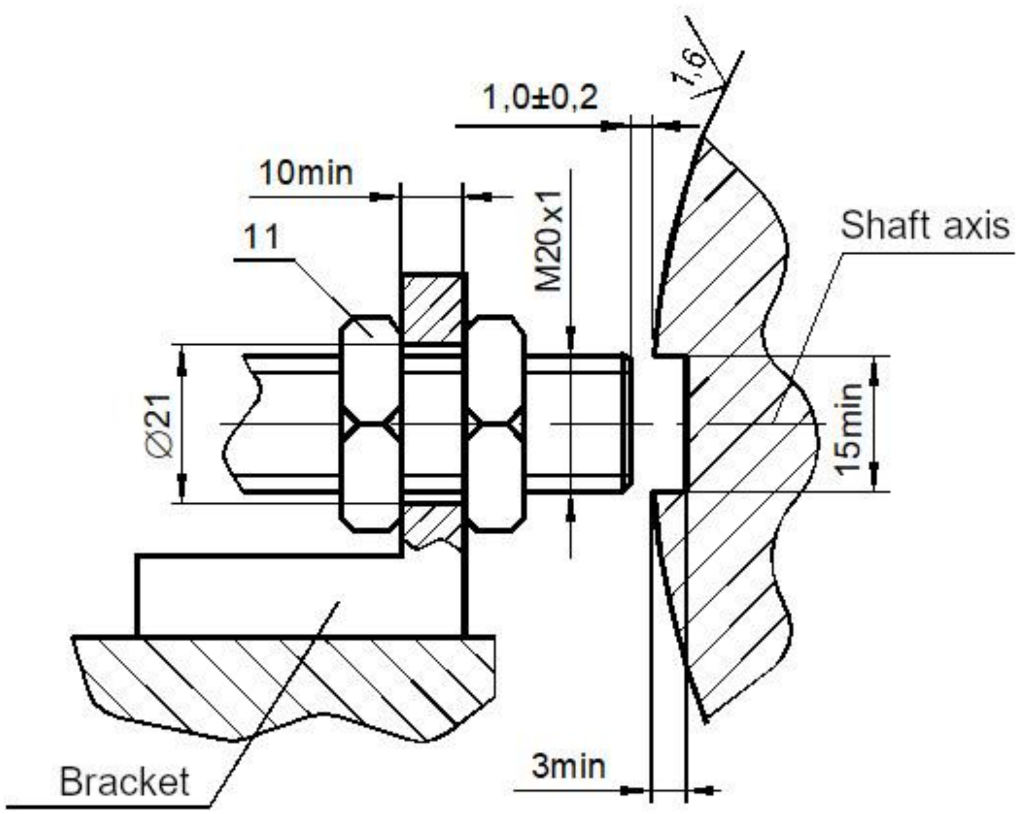


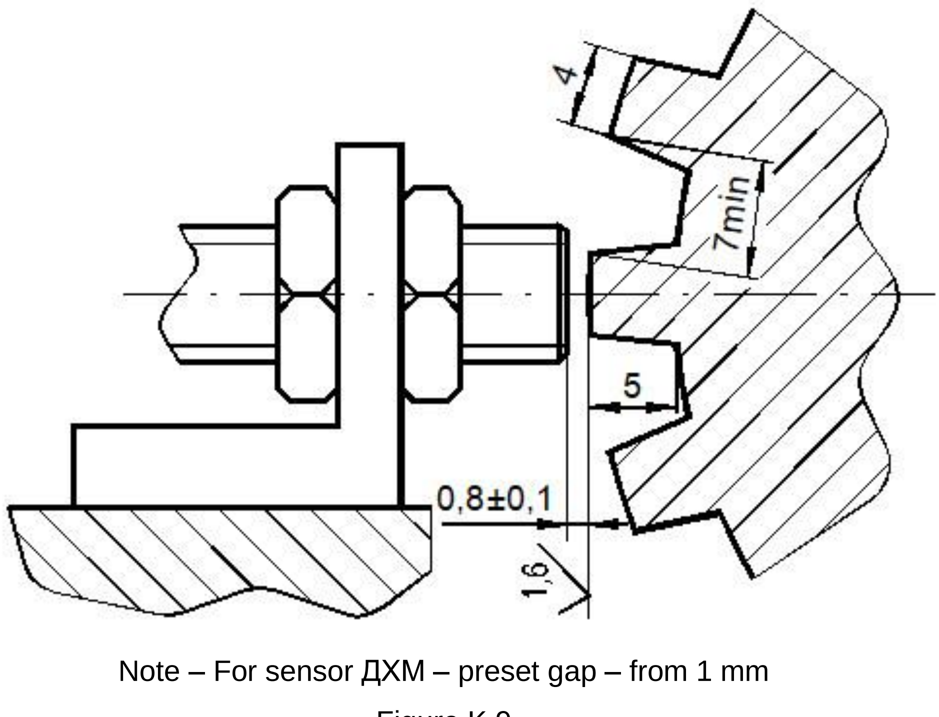

Figure K.8

**Installation of the ДВТ30, ДХМ sensor for the rotor RPM measuring**

Groove control surface



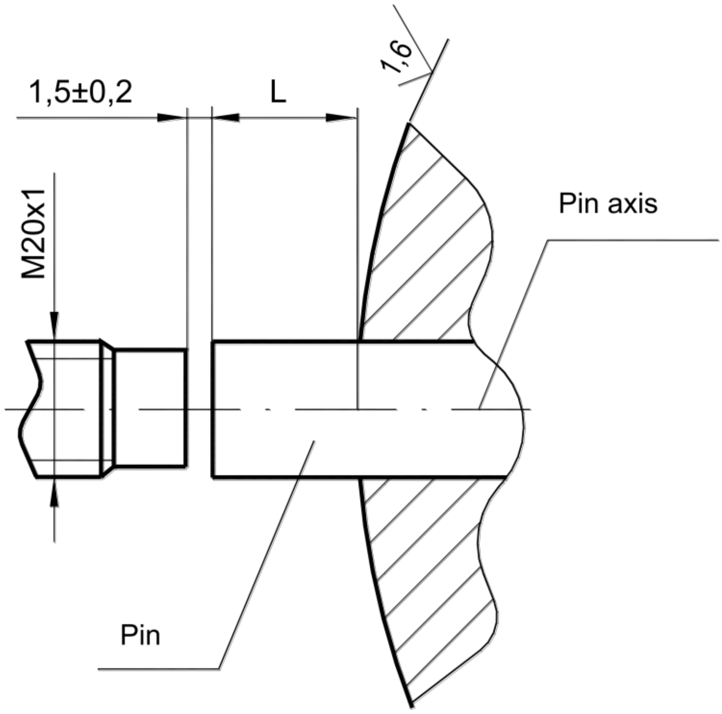

Pinion control surface




Note – For sensor ДХМ – preset gap – from 1 mm

Figure K.9

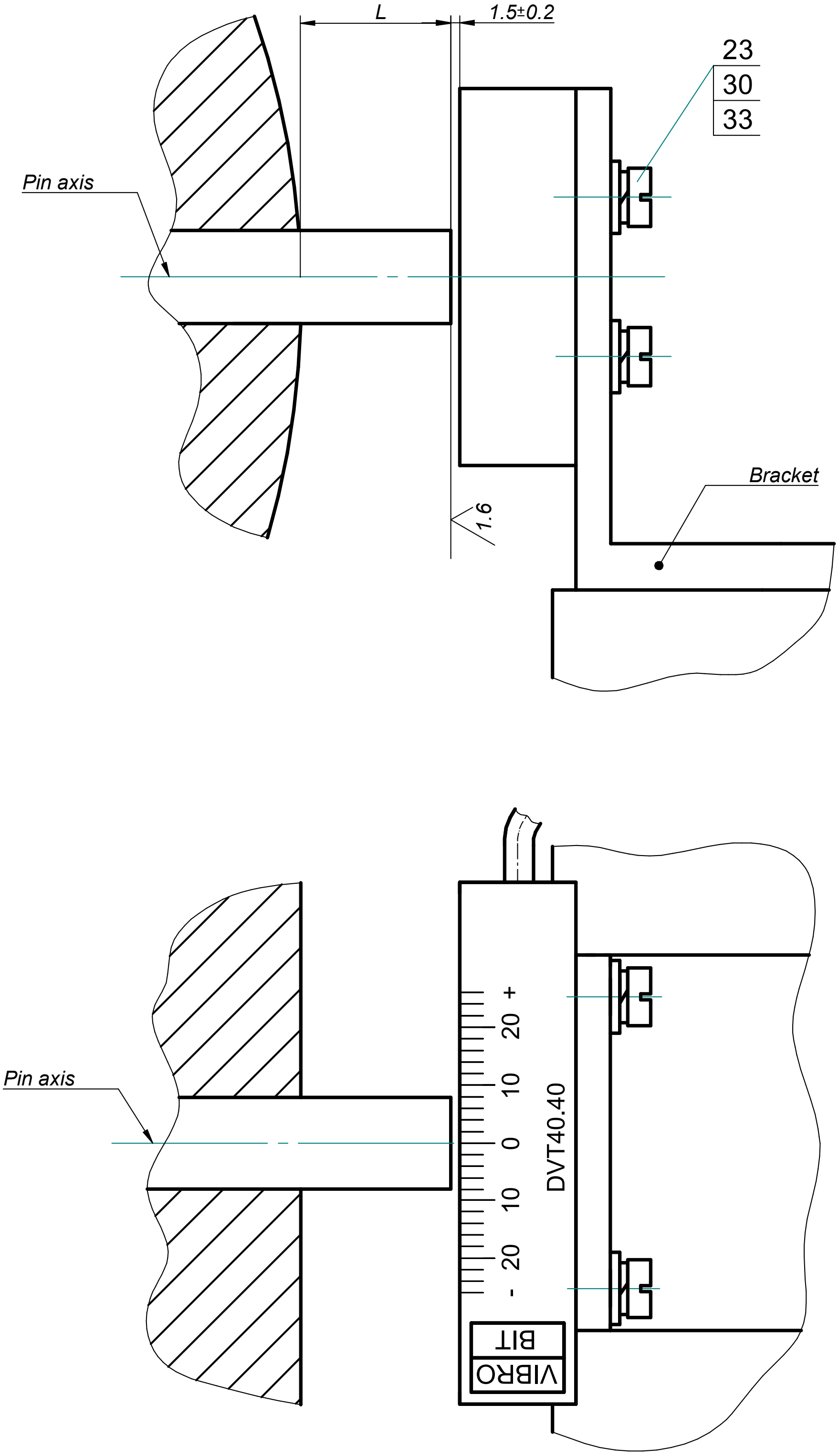
**Installation of sensor ДВТ23 for signaling pin actuation**




L – Pin protrusion distance

Figure K.10

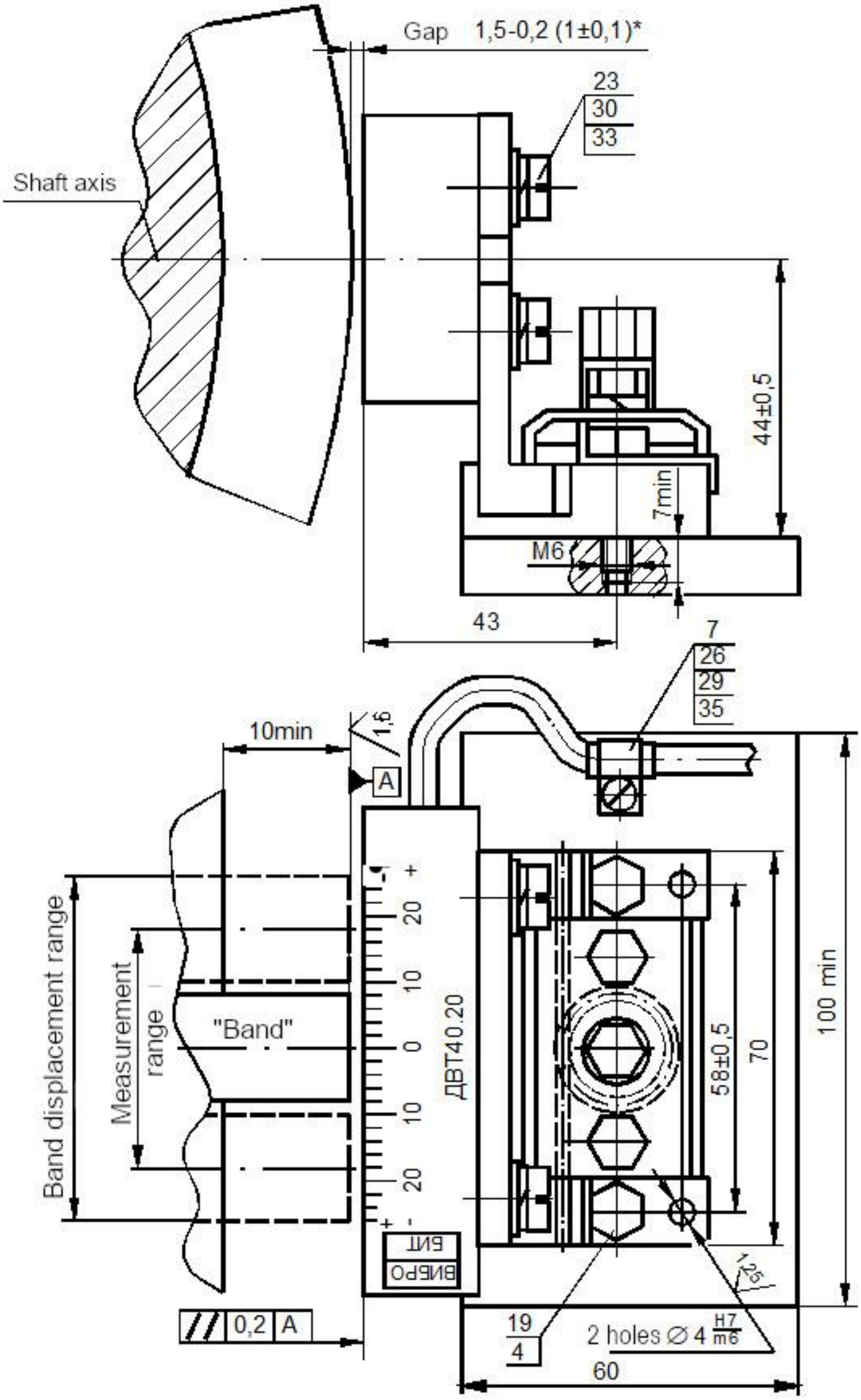
**Installation of sensor ДВТ40.40, ДВТ43.40 for signaling pin actuation**




L – Pin protrusion distance ($L_{min}$=3 mm)

Figure K.11

**Installation of the ДВТ40, ДВТ43 sensor for measuring rotor relative expansion**



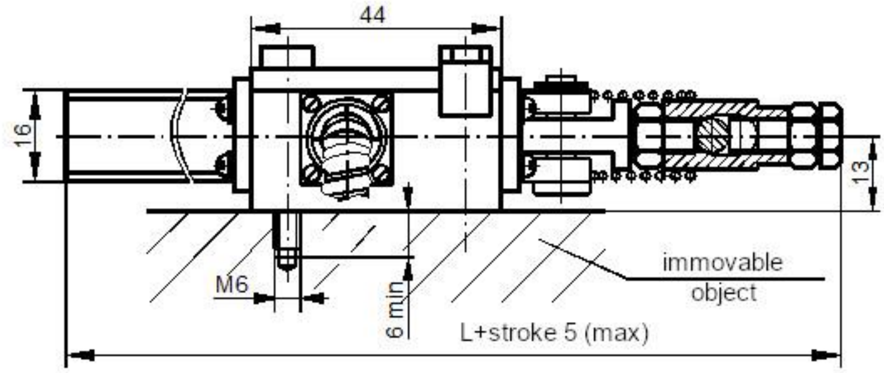

* - at band width – 10 mm

Figure K.12

Note: preset gap (Sн).

**Installation of the ДВТ50 sensor for measuring linear displacements.**

**Variant of installation with rod ВШПА.421412.060.01**




| Measurement range S, mm | L, mm |
|---|---|
| 0...10 | 198 |
| 0...20 | |
| 0...30 | |
| 0...50 | |
| 0...60 | |
| 0...80 | |
| 0...100 | 258 |
| 0...130(0...120) | |
| 0...160 | 358 |
| 0...200(0...180) | |
| 0...250 | 458 |
| 0...320 | |
| 0...360 | 488 |

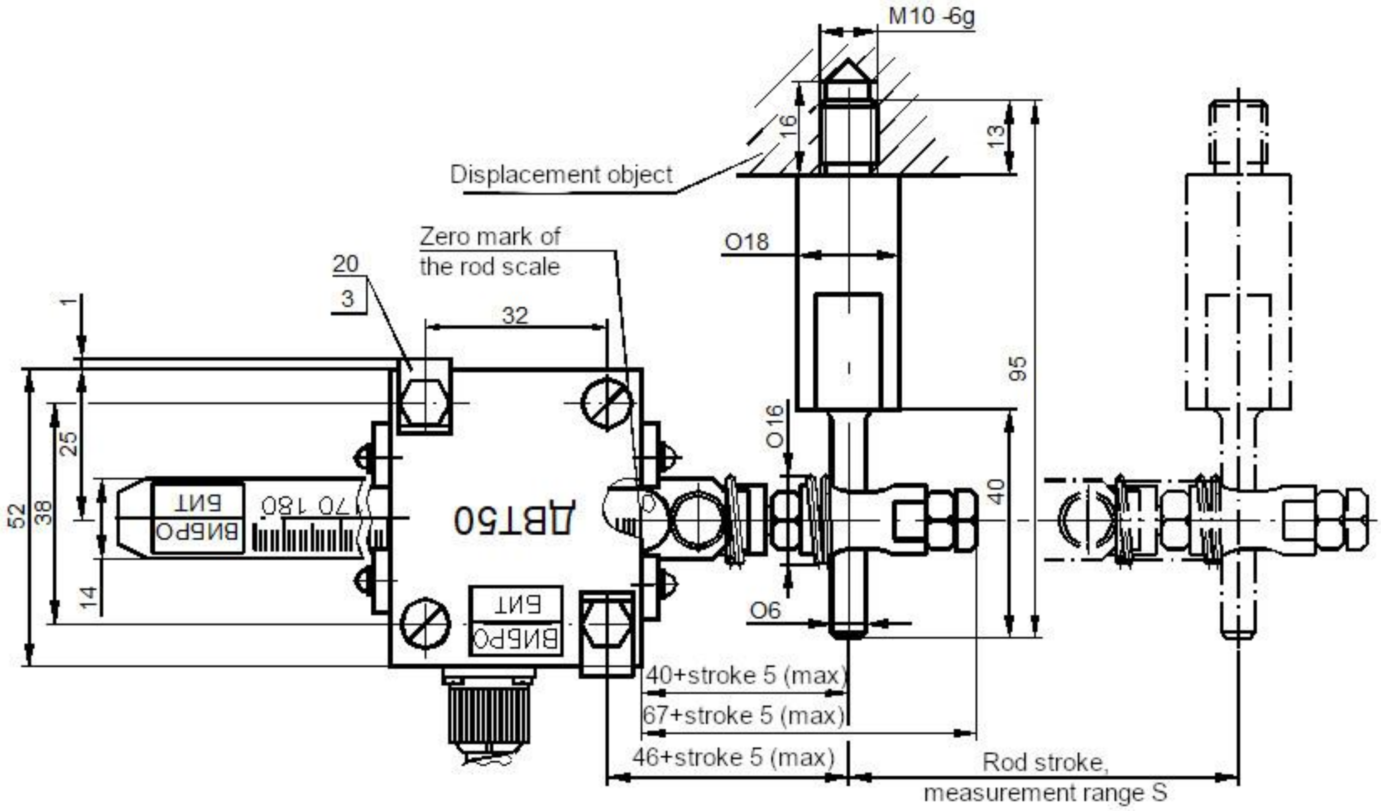
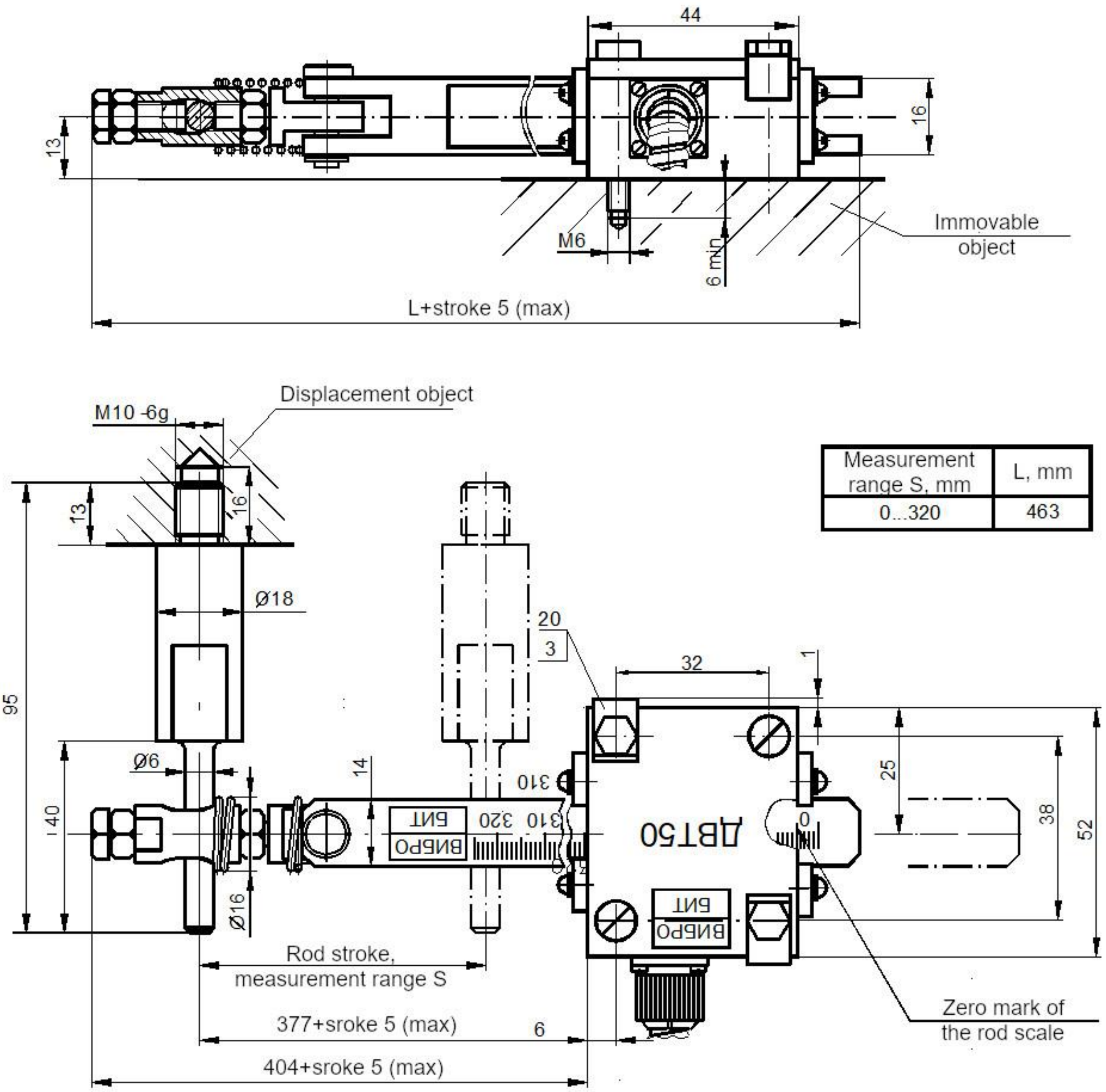



Figure K.13

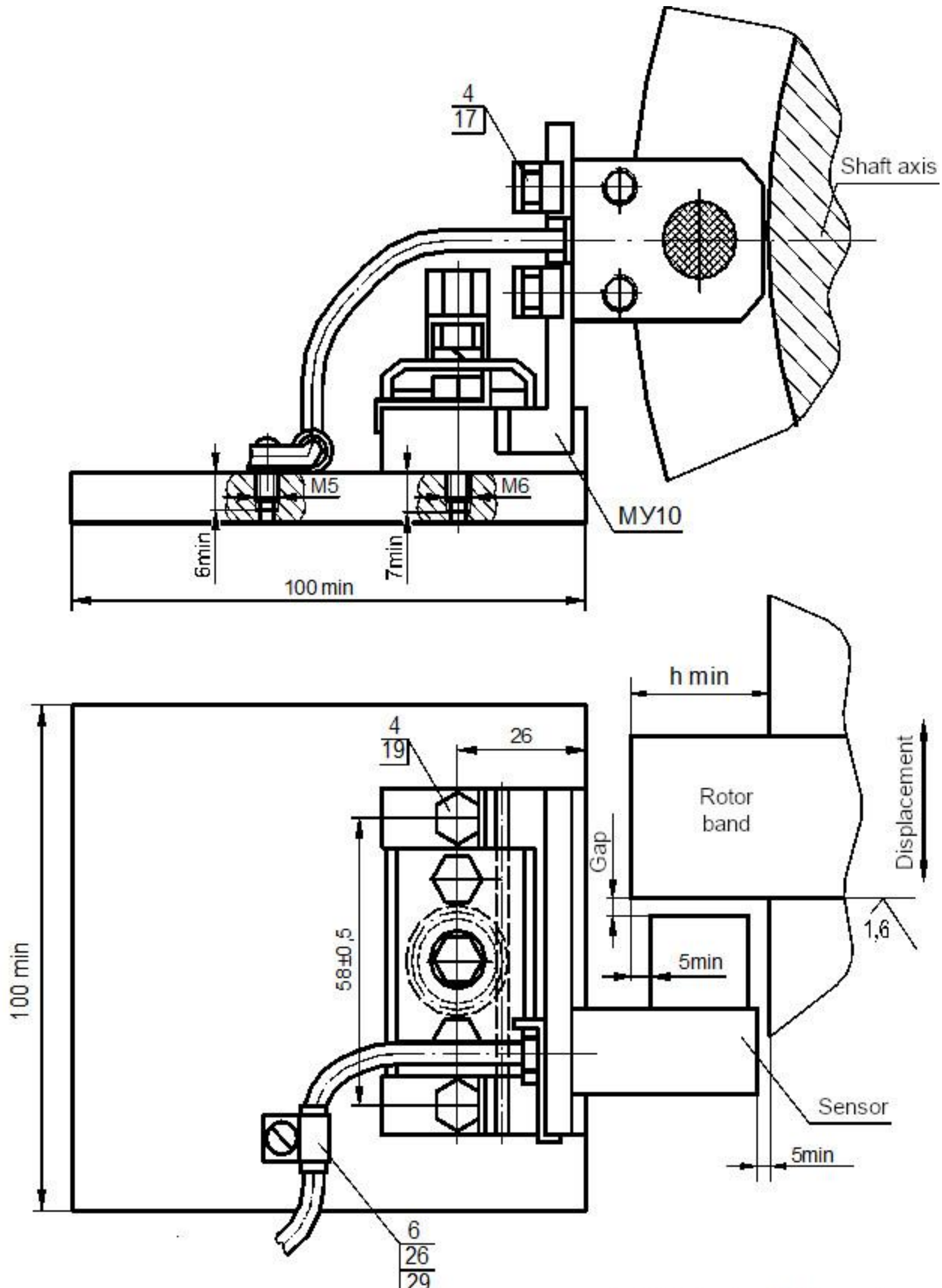
**Variant of installation with rod ВШПА.421412.060.03**




| Measurement range S, mm | L, mm |
|---|---|
| 0...320 | 463 |

Figure K.14

**Installation of the ДВТ60 sensor for measuring the rotor relative expansion**

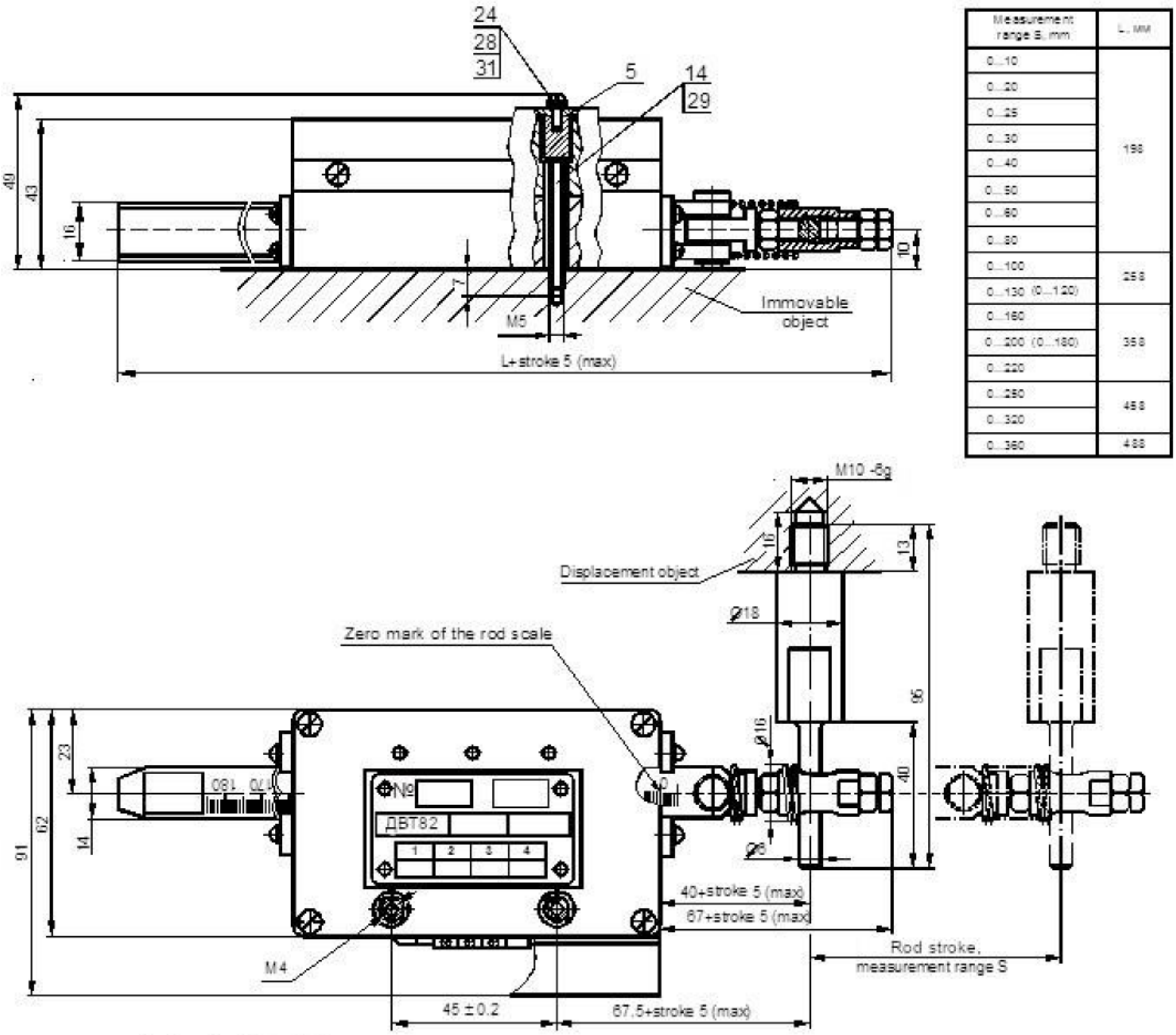



| Sensor | h min |
|---|---|
| ДВТ60.10 | 40 |
| ДВТ60.20 | 58 |
| ДВТ60.30 | 70 |

Figure K.15

Note: the gap preset one (Sн).

## Installation of the ДВТ82 sensor for linear displacement measuring

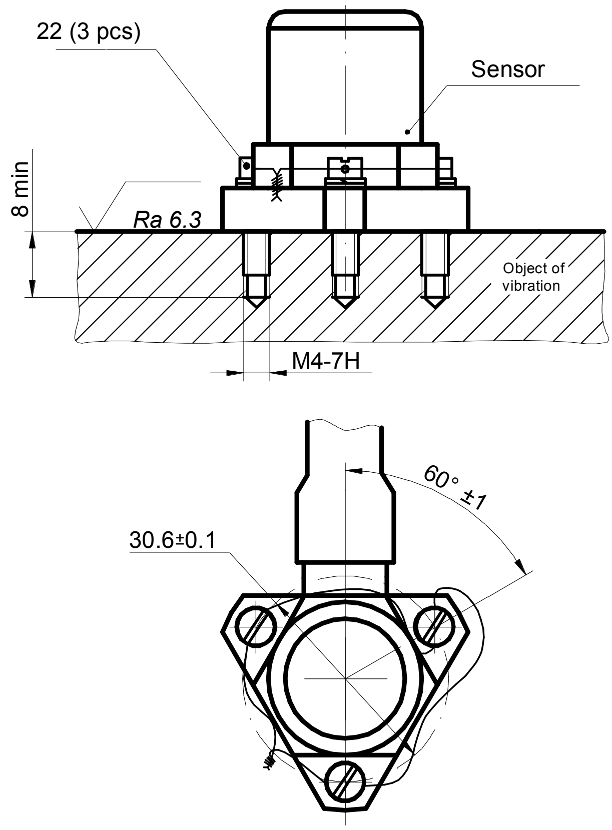



| Measurement range S, mm | L, мм |
|---|---|
| 0...10 | 198 |
| 0...20 | |
| 0...25 | |
| 0...30 | |
| 0...40 | |
| 0...50 | |
| 0...60 | |
| 0...80 | |
| 0...100 | 258 |
| 0...130 (0...120) | |
| 0...160 | 358 |
| 0...200 (0...180) | |
| 0...220 | |
| 0...250 | 458 |
| 0...320 | |
| 0...360 | 488 |

Part position 5 is not shown

Figure K.16

**Installation of sensors ДПЭ**




To be secured by the wire as per ГОСТ 792–67 or ГОСТ 17305–71.

Figure K.17 – Installation of sensors ДПЭ22МВ, ДПЭ22МВТ, ДПЭ22Ех, ДПЭ23МВ, ДПЭ23МВТ, ДПЭ23Ех

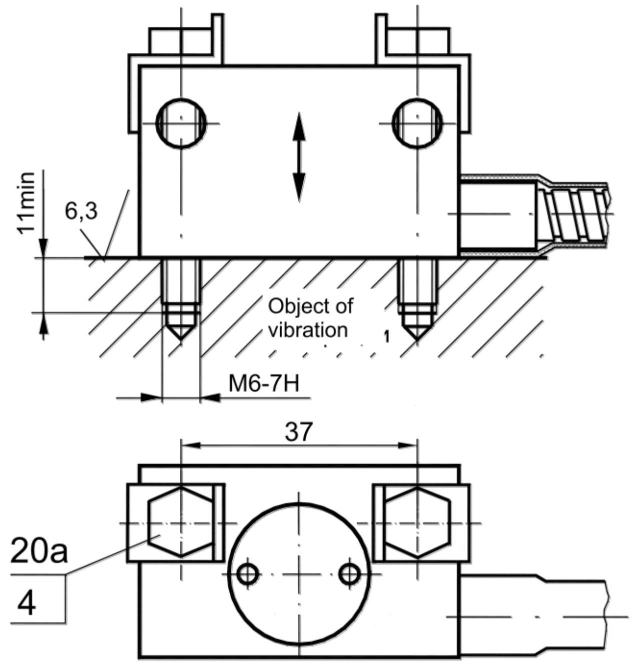



Figure K.18 – Setpoint of sensors ДПЭ22П, ДПЭ23П

**Installation of sensors ДПЭ on the cube**

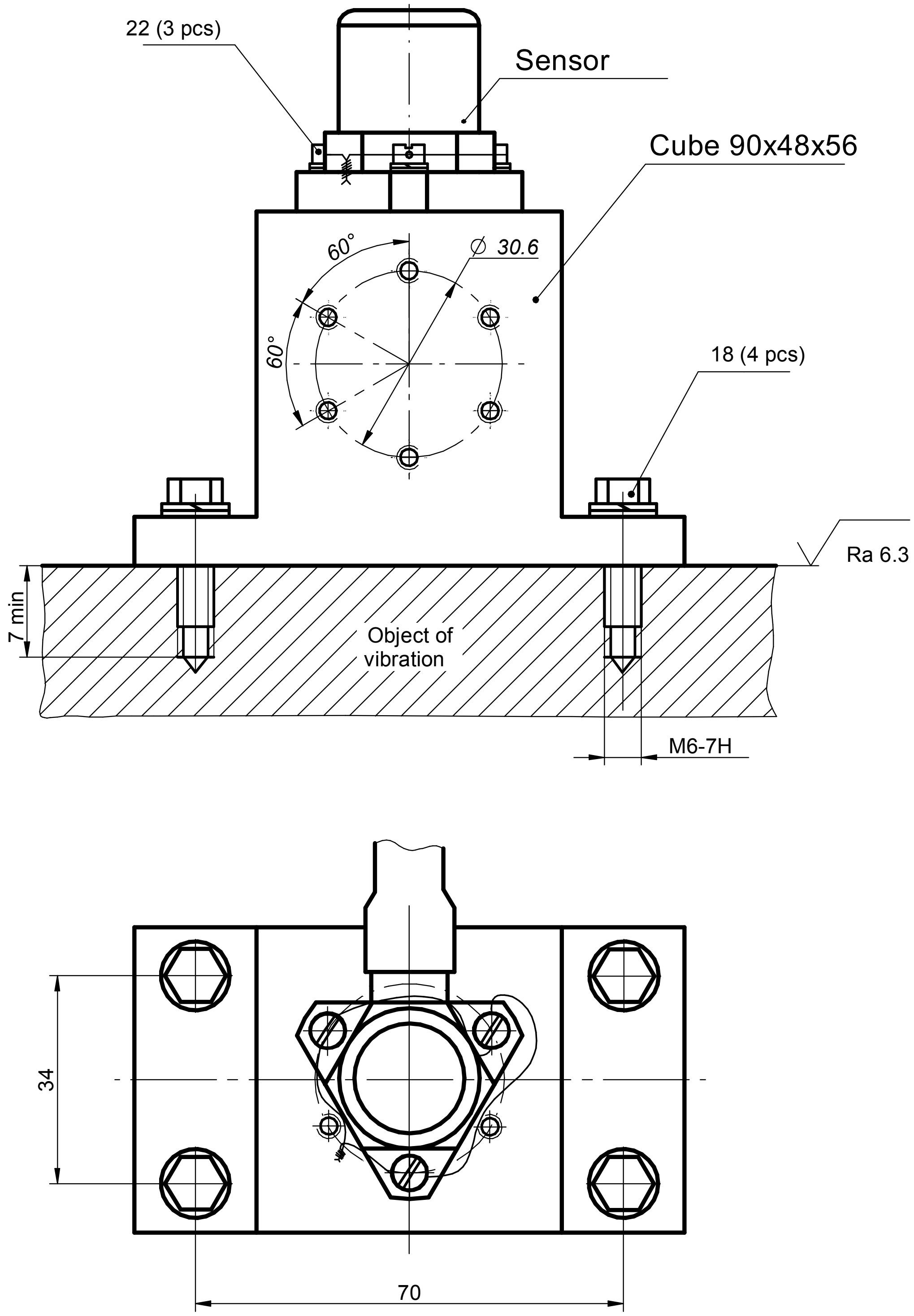



Figure K.19 – Installation of sensors ДПЭ22МВ, ДПЭ22МВТ, ДПЭ22Ех, ДПЭ23МВ, ДПЭ23МВТ, ДПЭ23Ех

**Installation of sensors 625B01 on the insulated cube**

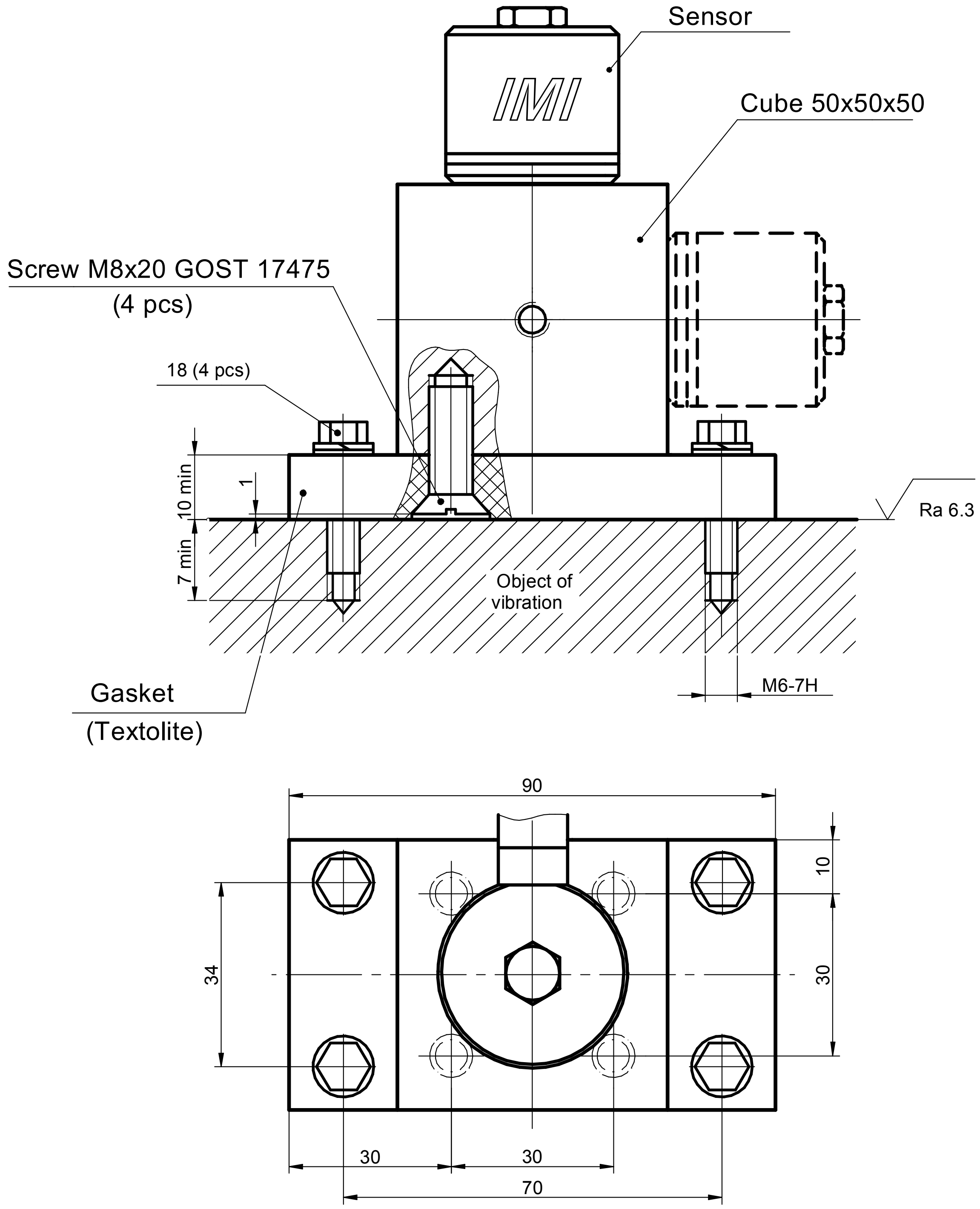
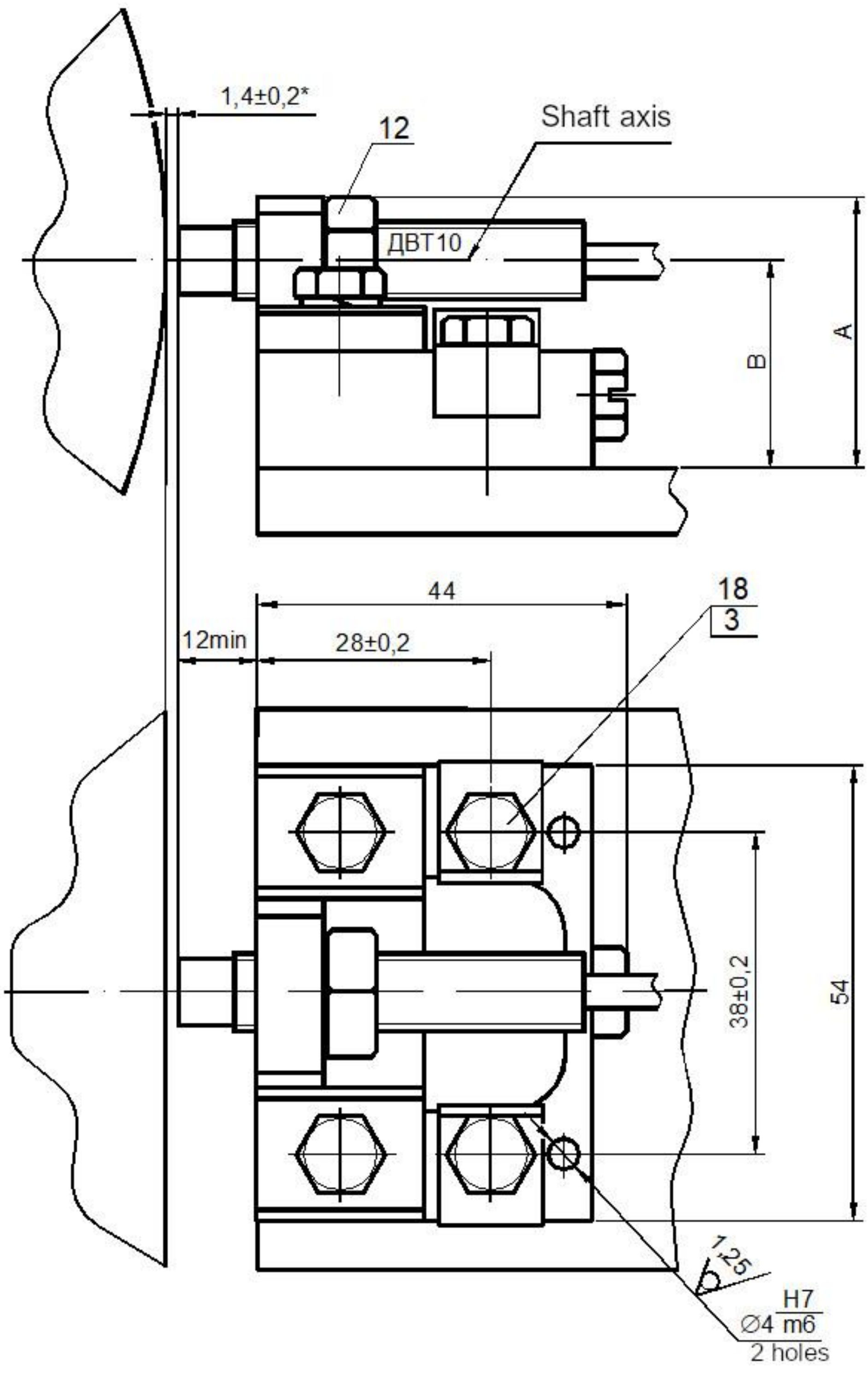



Figure K.20

**Installation of sensor ДВТ on the setter МУ11**




| Version | Dimensions, mm | | Note |
|---|---|---|---|
| | A | B | |
| For ДВТ10, ДВТ10Ex | 32 | 23 ± 0.2 | In bowing measuring |
| For ДВТ20, ДВТ20Ex | 43 | 32 ± 0.2 | – |

* - Dimension is given for reference only

Figure K.21

**Installation of sensors ДПЭ on the insulated generator bearing**

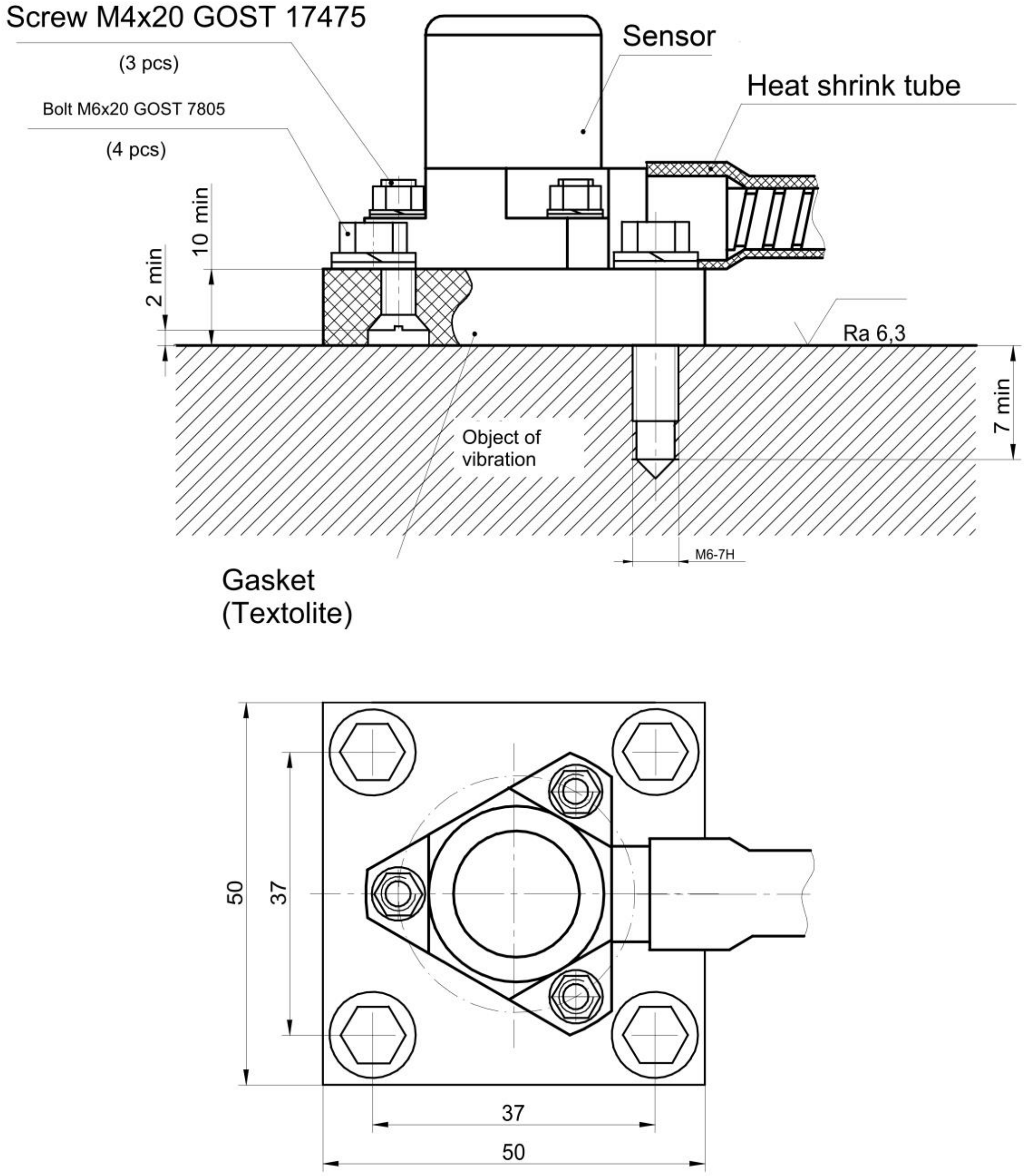
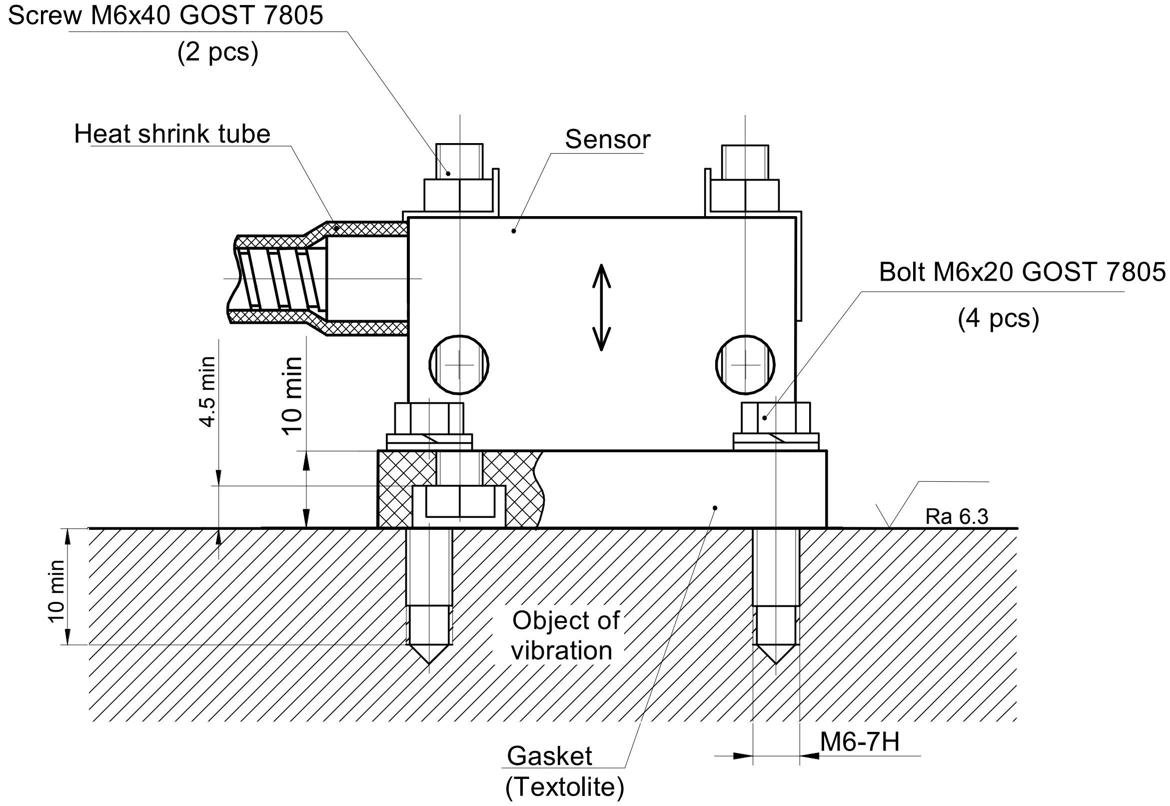



Figure K.22 – Installation of sensors ДПЭ22МВ, ДПЭ22МВТ, ДПЭ23МВ, ДПЭ23МВТ with insulated metal hose



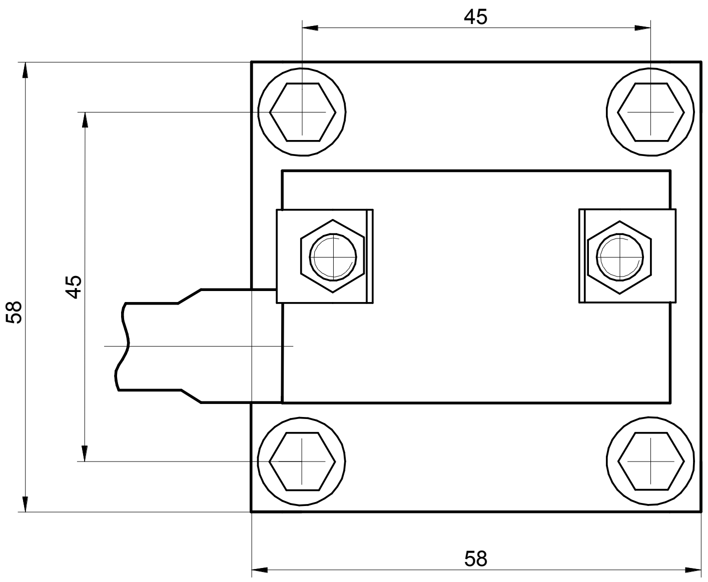




Figure K.23 – Installation of sensors ДПЭ22П, ДПЭ23П with insulated metal hose

**Installation of sensor ДВТ70**

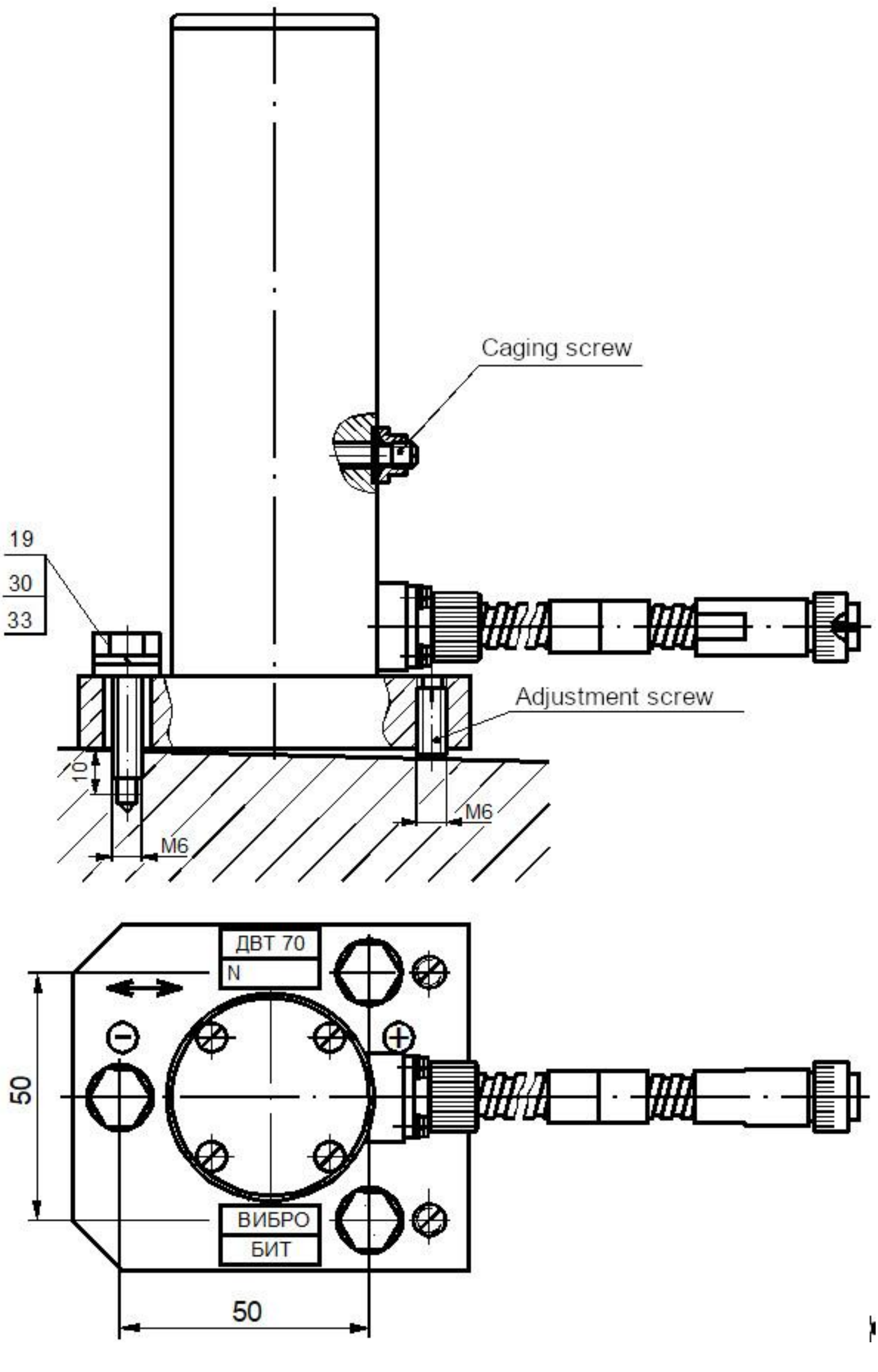
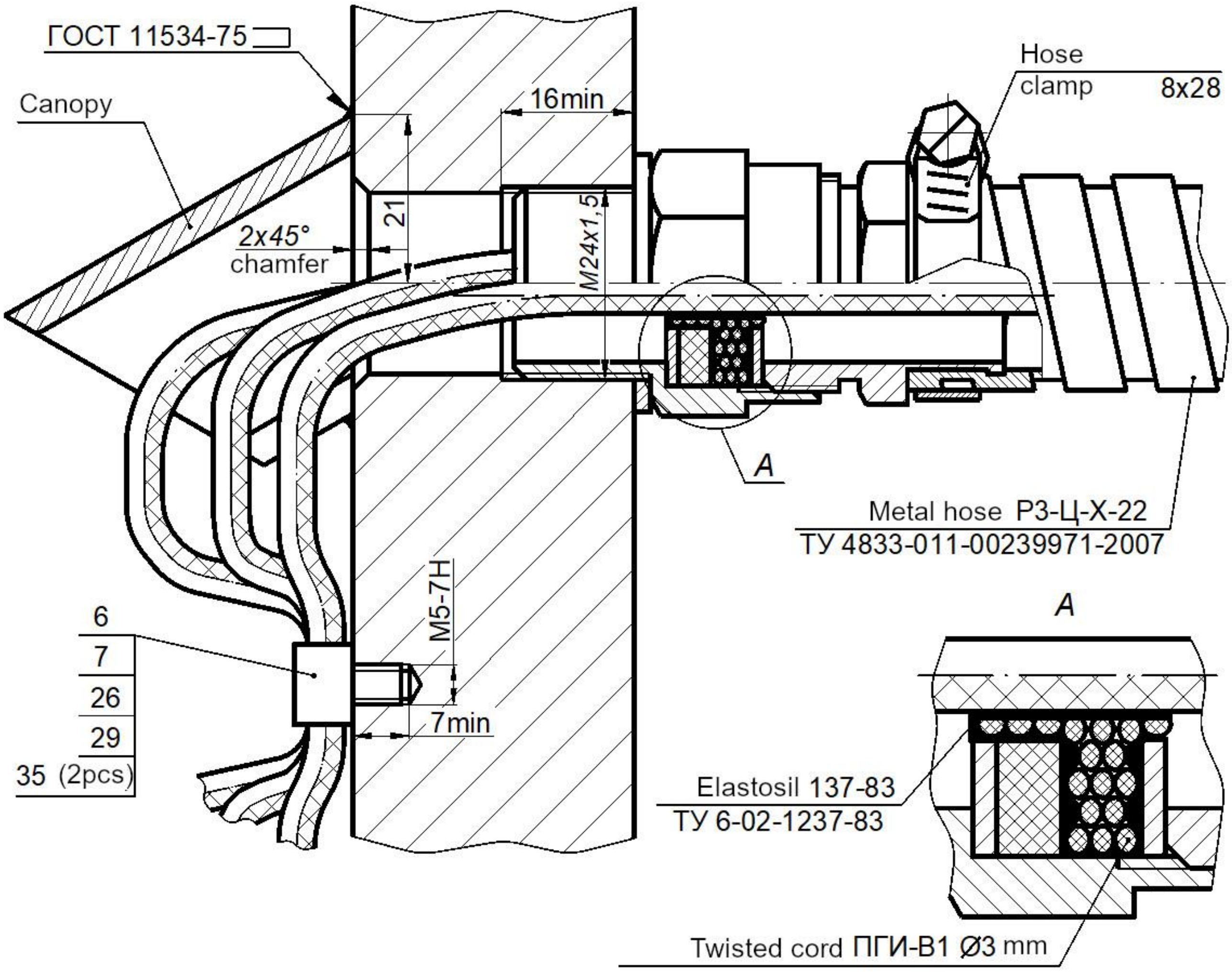



Figure K.24

**Installation of M24 feedthrough**




Notes:

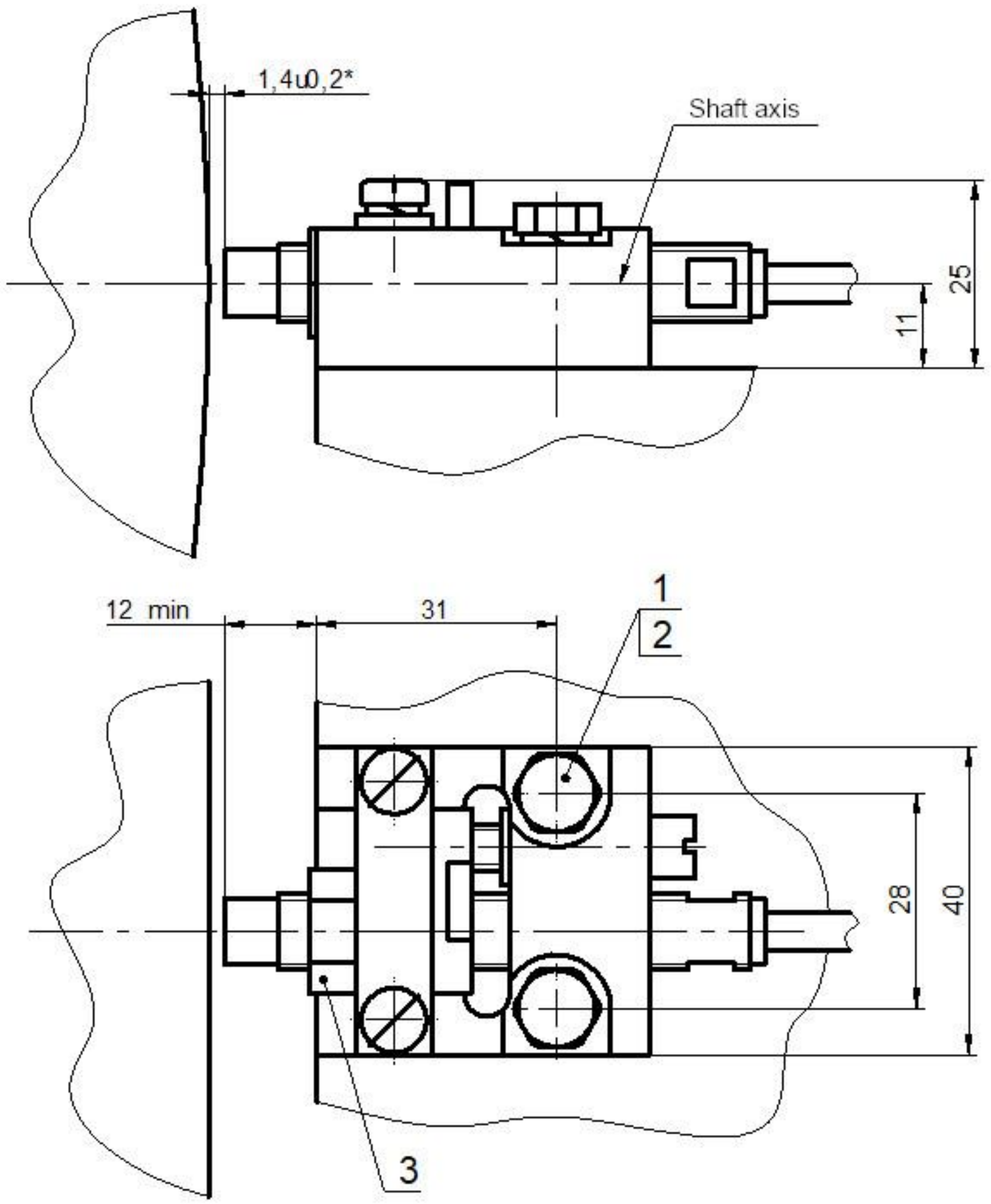
1 Canopy shall be installed when it is necessary to protect the feedthrough hole from massive oil flows. The drawing is even in Figure U.1.

2 Elastosil 137-83 and the twisted cord ПГИ-В1 are applied during installation and are not part of the delivered complete set.

3 Twisted cord ПГИ-В1 Ø3 mm is produced by NPP PromGrafit LLC (Moscow). It is permissible to replace it for the one equivalent in characteristics and application thwith operating temperature up to 400°C.

Figure K.25

**Installation of sensor ДВТ10 on the setter МУ14**

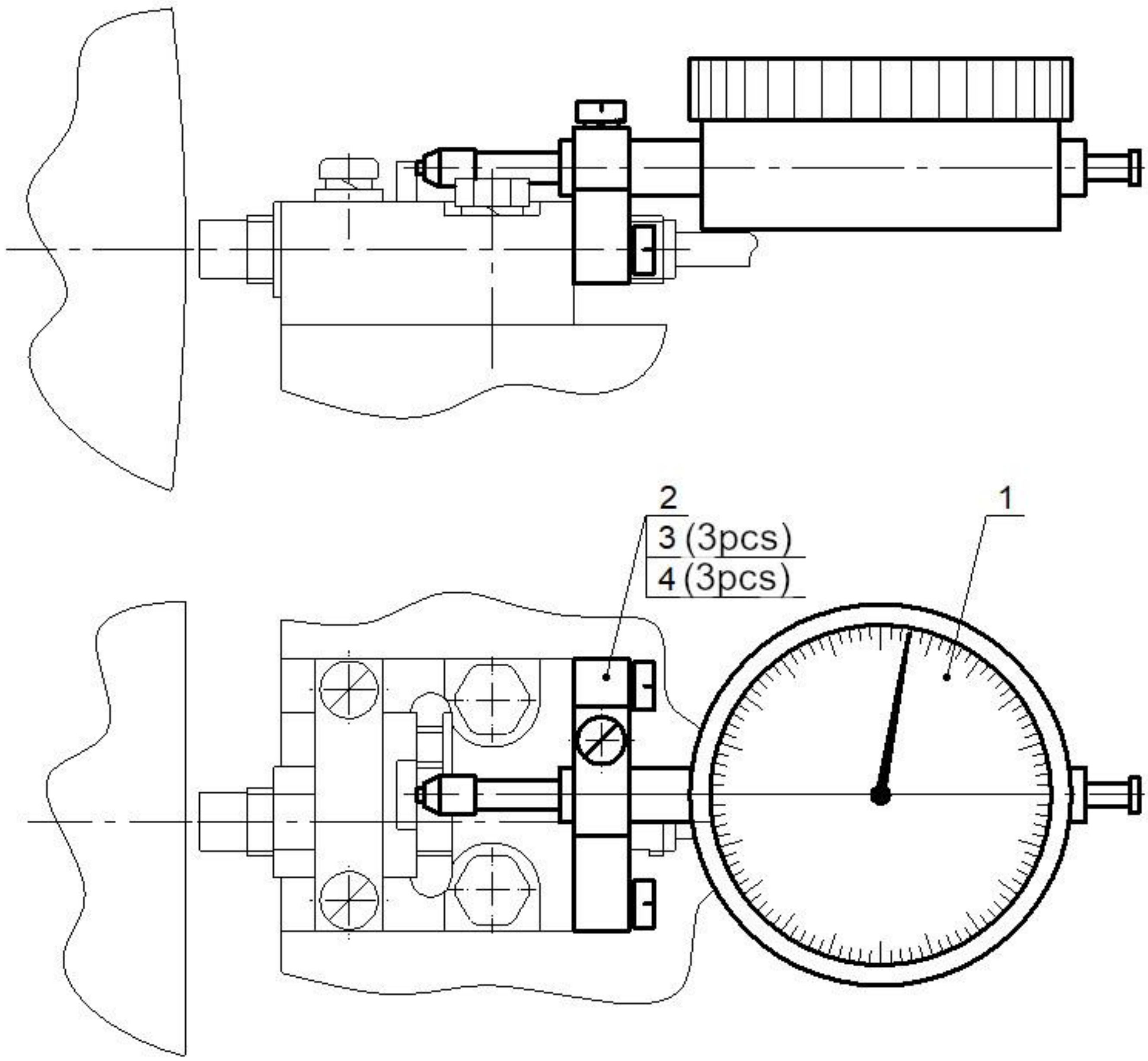



* - Dimension for reference only

1 - Bolt М6х25 ГОСТ 7805;
2 - Washer 6 65Г ГОСТ 6402;
3 - Nut ВШПА.421412.018.00.03.

Figure K.26

**Installation of the dial test indicator on the setter МУ14**

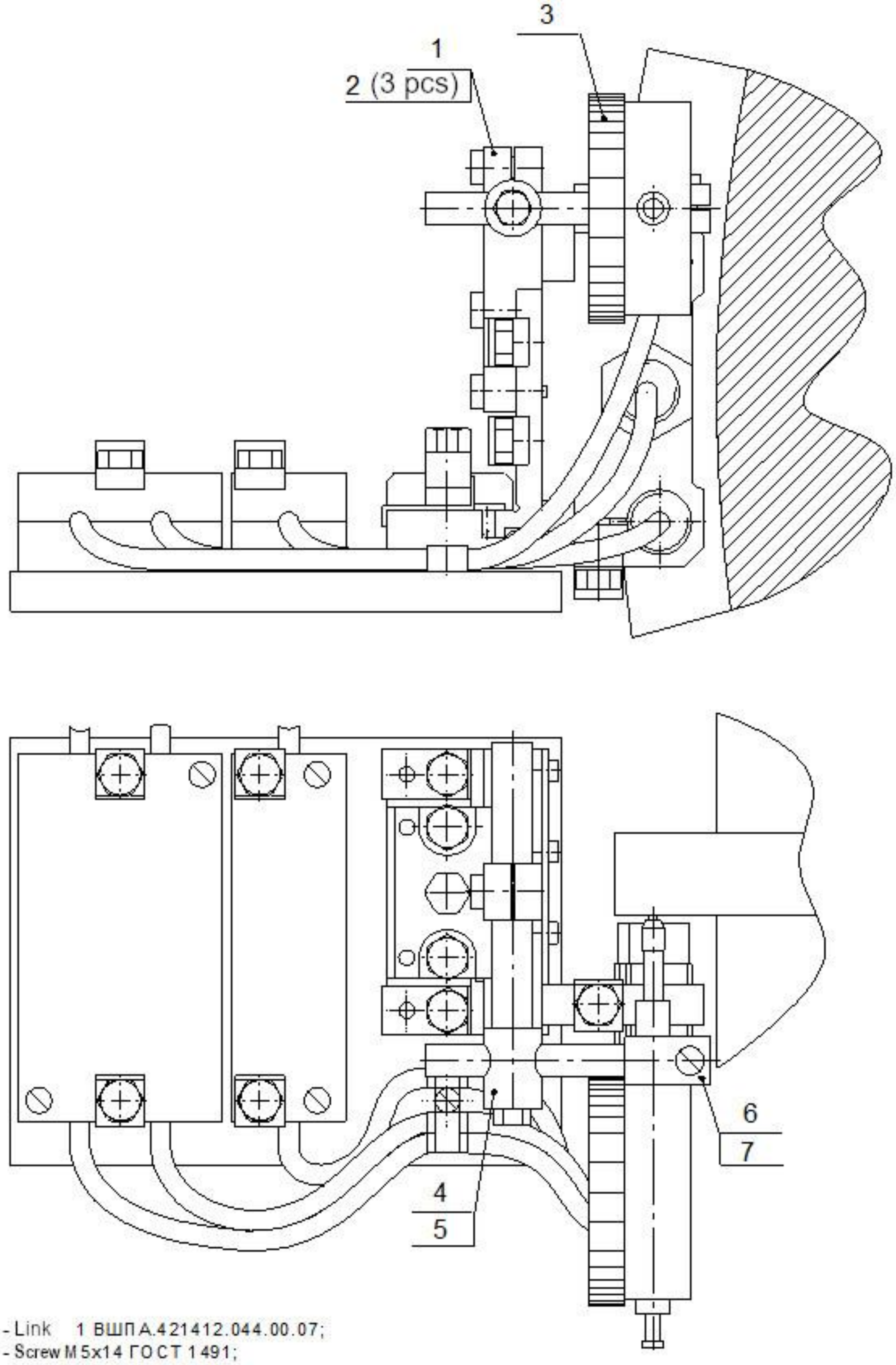



1 - Indicator ИЧ10 cl.1 ГОСТ 577-68;
2 - Holder ИЧ ВШПА.421412.1441.00.05;
3 - Screw M 4x14 ГОСТ 1491;
4 - Washer 4 65Г ГОСТ 6402.

Figure K.27

**Installation of all the dial test indicator on the setter МУ10**

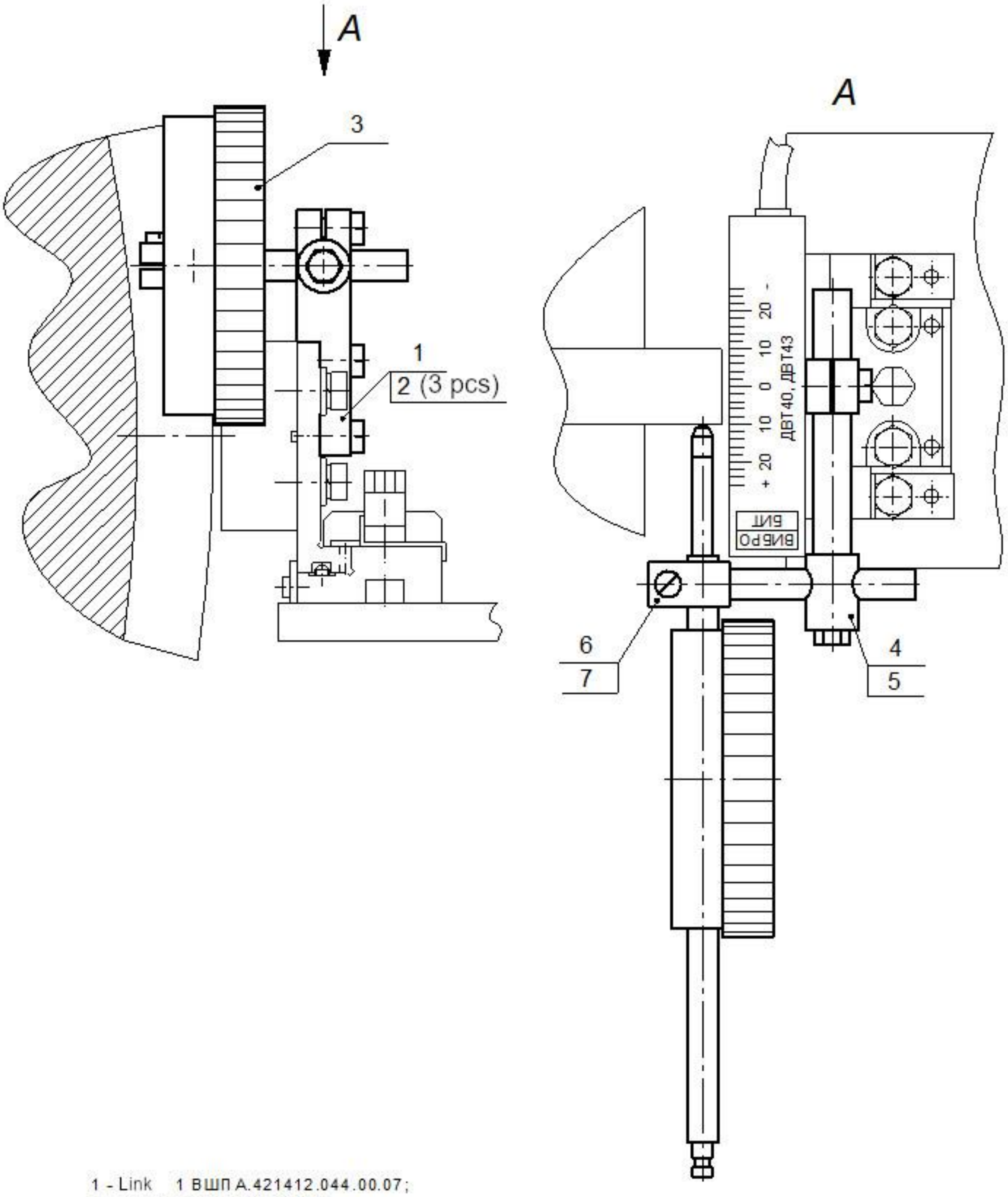
**in measuring axial offset by three channels**




1 - Link 1 ВШПА.421412.044.00.07;
2 - Screw М5х14 ГОСТ 1491;
3 - Indicator ИЧ 10 cl.1 ГОСТ 577-68;
4 - Link 2 ВШПА.421412.044.00.08;
5 - Bolt М5х10 ГОСТ 7805;
6 - Link 3 ВШПА.421412.044.00.09;
7 - Screw М 4х12 ГОСТ 1491.

Figure К.28

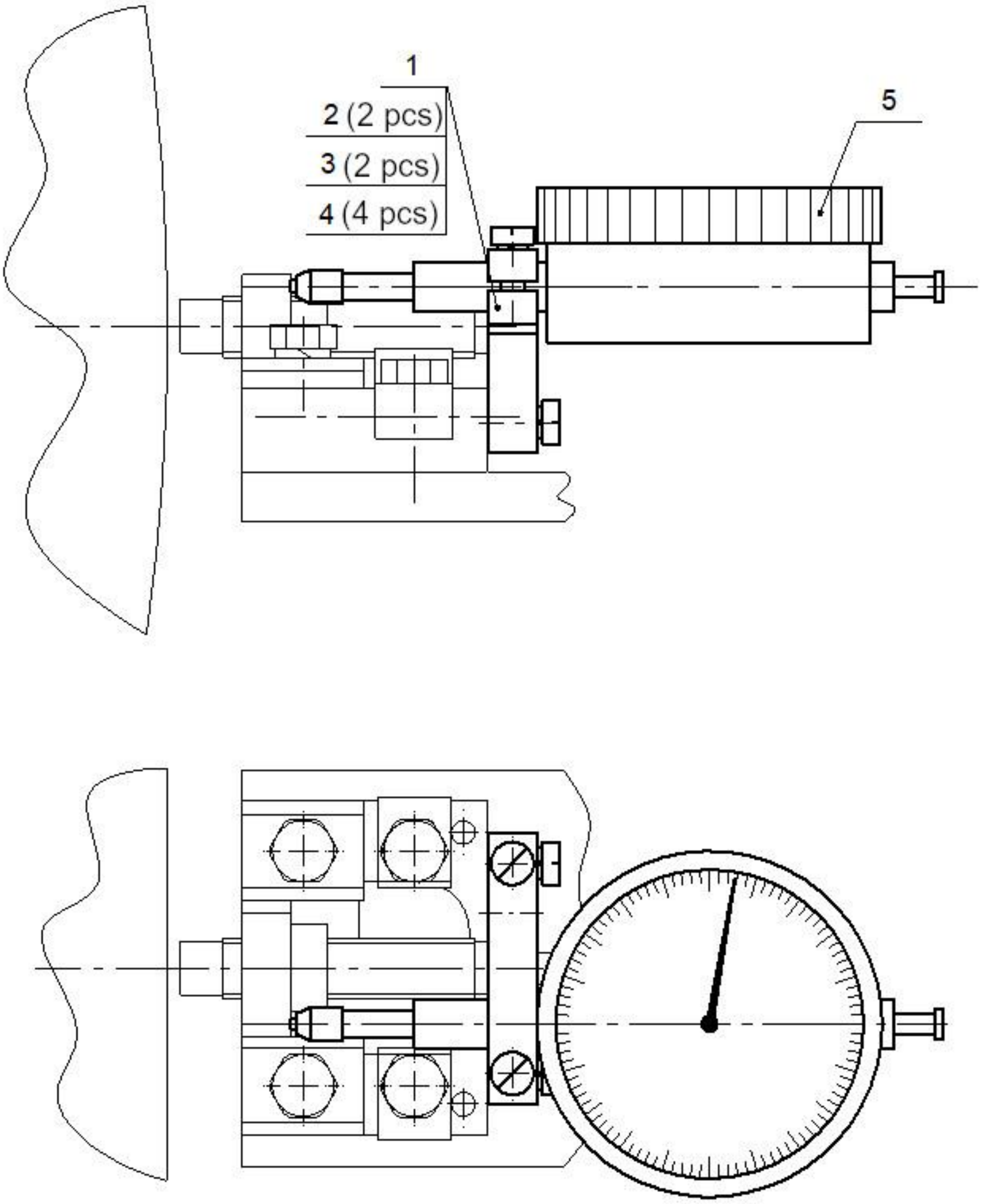
**Installation of the dial indicator on the МУ10 setter when measuring the rotor relative expansion**




1 - Link 1 ВШП А.421412.044.00.07;
2 - Screw М 5х14 ГОСТ 1491;
3 - Indicator ИЧ50 cl.1 (without lug);
4 - Link 2 ВШП А.421412.044.00.08;
5 - Bolt М 5х10 ГОСТ 7805;
6 - Screw М 4х12 ГОСТ 1491.

Figure K.29

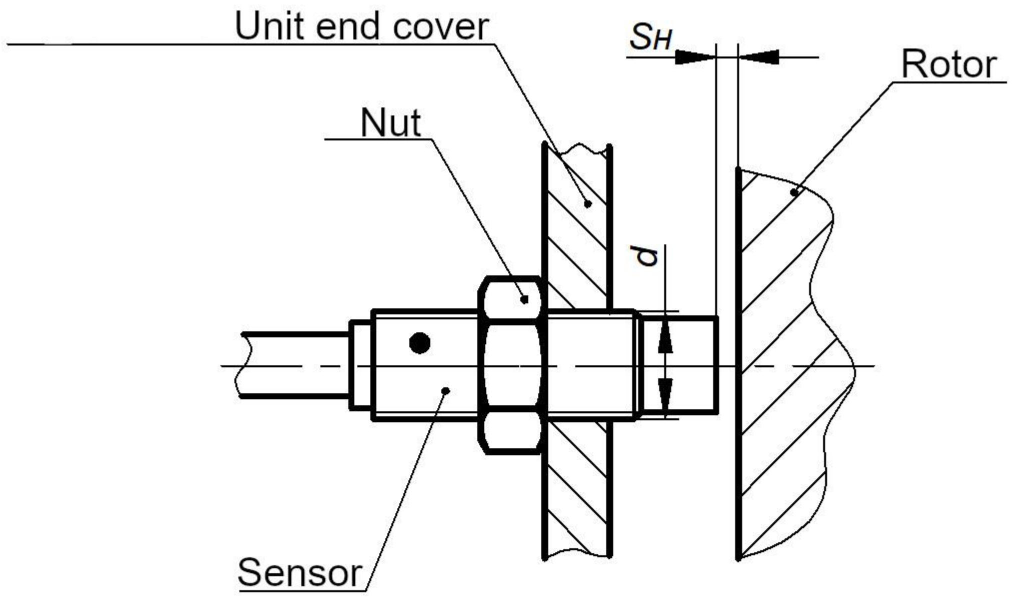
**Installation of the dial indicator on the setter МУ11**




1 - Holder ИЧ ВШПА.421412.144.00.05;
2 - Screw M 4x12 ГОСТ 1491;
3 - Screw M 4x16 ГОСТ 1491;
4 - Washer 4 65Г ГОСТ 6402;
5 - Indicator ИЧ10 cl.1 ГОСТ 577-68.

Figure K.30

**Installation of the axial offset sensor when installing on the end cover**

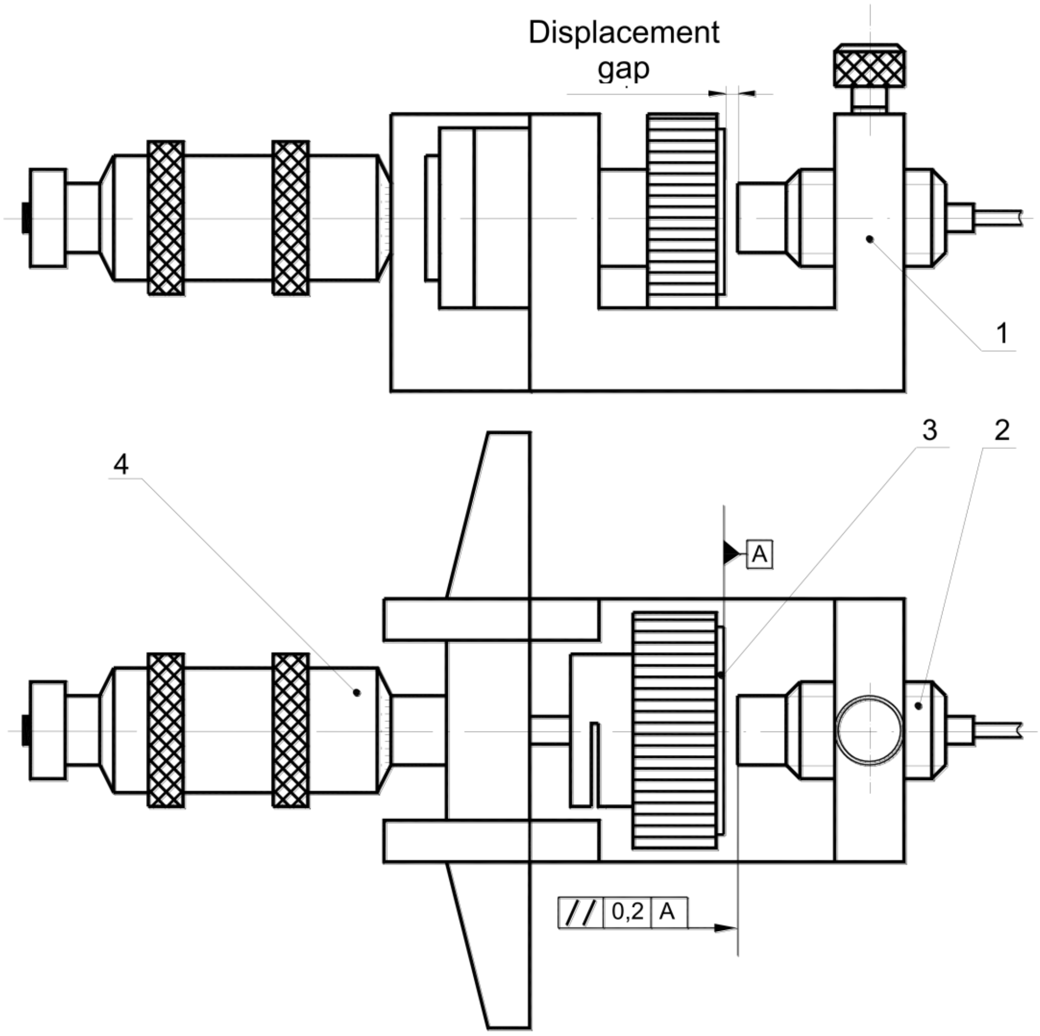



| Sensor | Nut | d, mm | Sн, mm |
|---|---|---|---|
| ДВТ10, ДВТ10Ex | pos.12 | M10x1 | 1,5 ± 0,1 |
| ДВТ20, ДВТ20Ex | pos.2 | M16x1 | 3,0 ± 0,1 |

Figure K.31

**Annex L**
(Mandatory)

**Installation of the sensors on stands, devices**



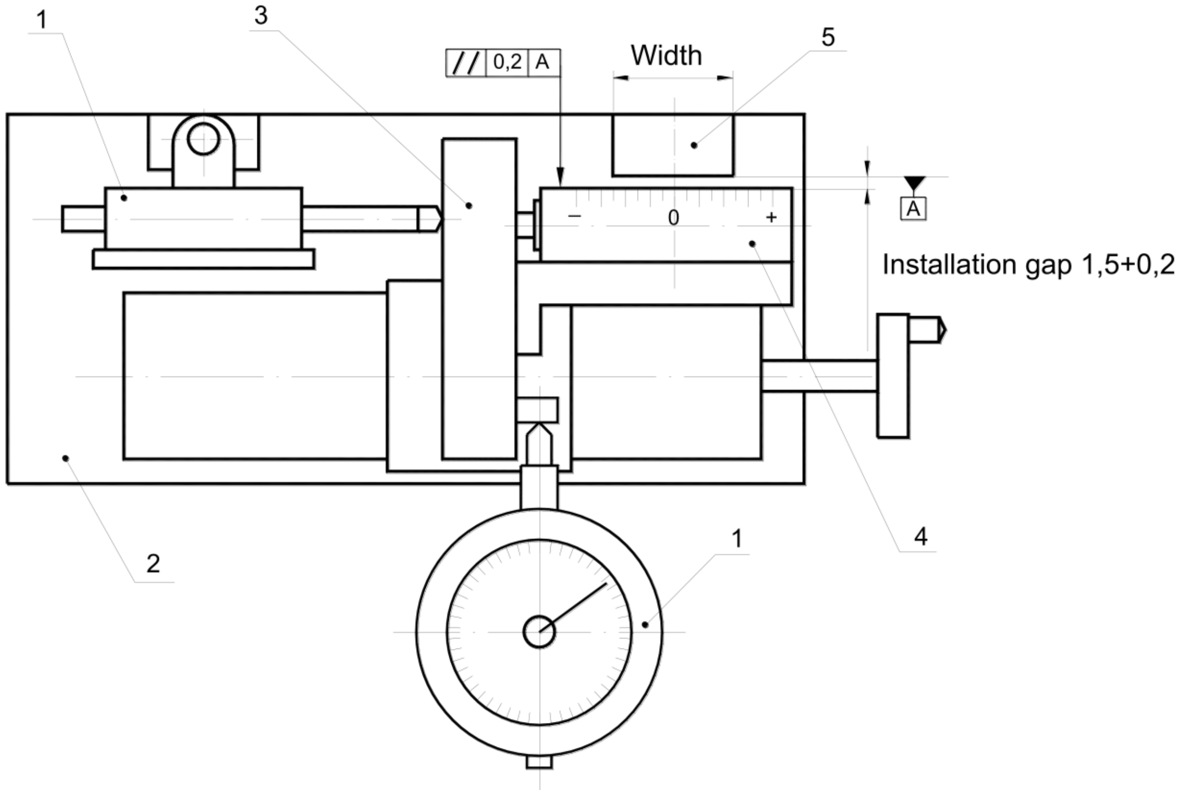

1 – Stand СП10;

2 – Sensor;

3 – Test specimen;

4 – Micrometric depth-gauge ГМ100.

Figure L.1 – Setpoint of sensors ДВТ10, ДВТ10Ex, ДВТ20, ДВТ20Ex, ДВТ23, ДВТ30 on the stand СП10




1 – Dial indicator ИЧ10 (ИЧ50);

2 – Stand СП20;

3 – Calibration plate;

4 – Sensor ДВТ40, ДВТ43;

5 – Test specimen (band) ВШПА.421412.061.00.24 or ВШПА.421412.061.00.27.

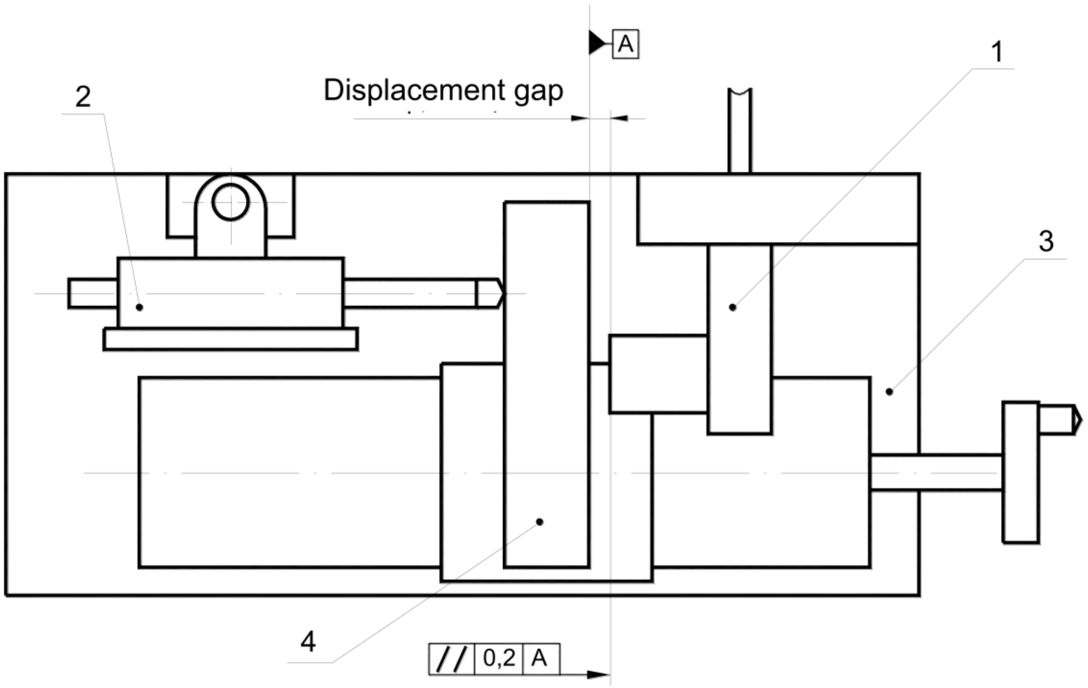
Notes:

‘0’ – Position of the sensor and the test specimen equaling to 0.5 of the measurement range, at the value of the converter output signal of (3 ± 0.1) mA (12 ± 0.4) mA);

‘+’ – Direction of the test specimen displacement relative to the position ‘0’, increading the output current to 5 mA (20 mA) (measurement range (50 – 100) %);

‘–’ – Direction of the test specimen displacement relative to the position ‘0’, decreasing the output current to 1 mA (4 mA) (measurement range (0 – 50) %).

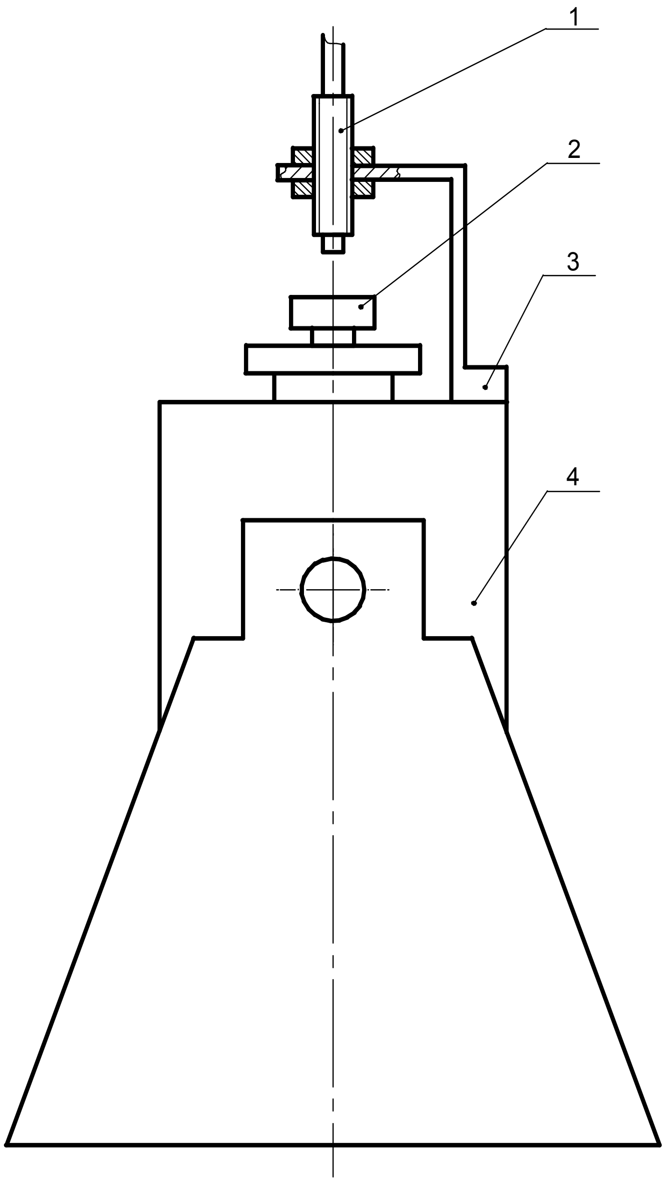
Figure L.2 – Installation of the ДВТ40, ДВТ43 sensor on the stand СП20




1 – Sensor ДВТ60;
2 – Dial indicator ИЧ10, ИЧ25;
3 – Stand СП20;
4 – Test specimen.

Figure L.3 – Installation of the ДВТ60 sensor on the stand СП20

**Installation of sensors on the vibration stand**



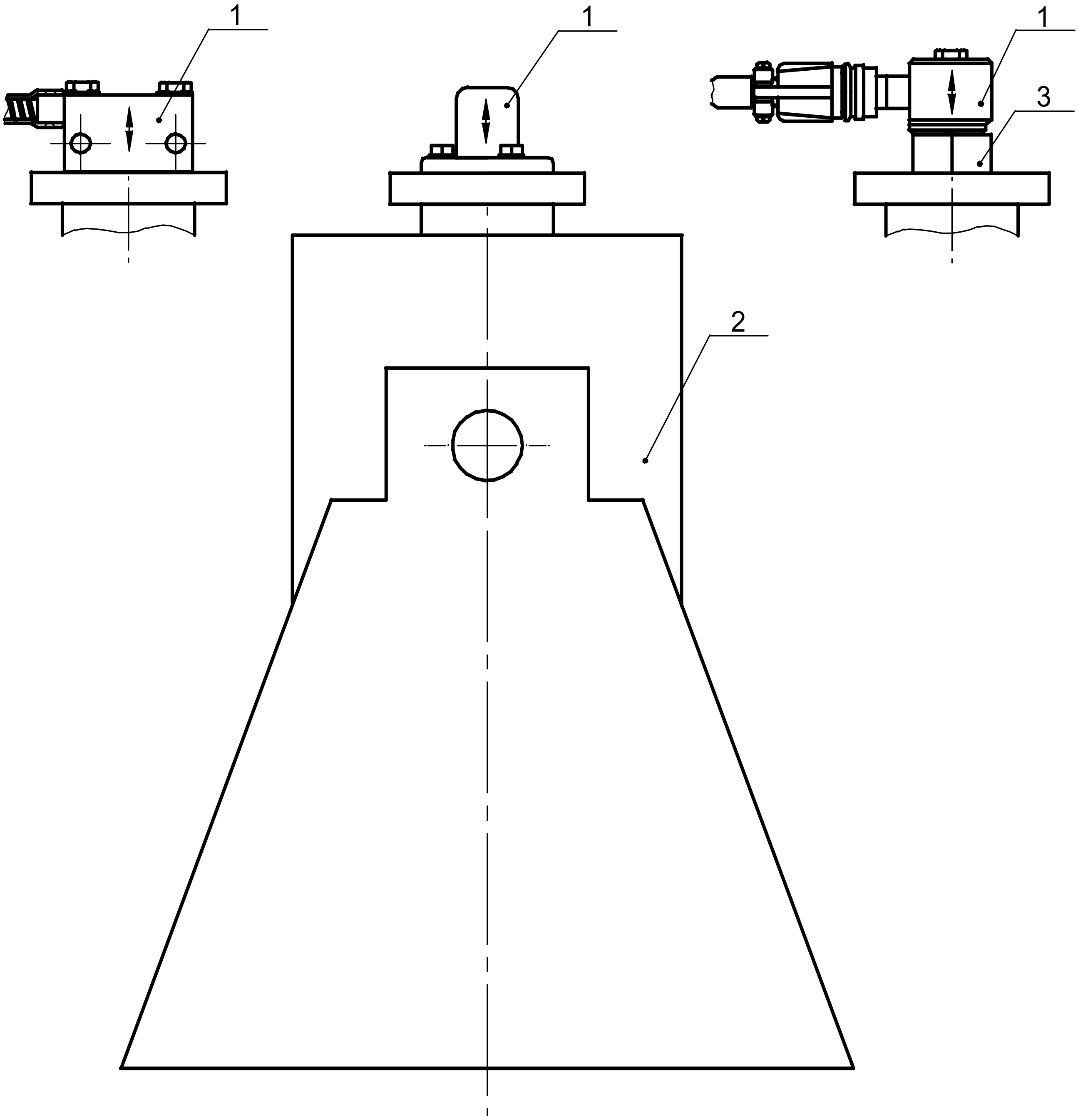

1 – Sensor ДВТ10, ДВТ10Ex;

2 – Test specimen;

3 – Bracket ВШПА.421412.197.00.06;

4 – Vibration stand.

Figure L.4– Installation of the ДВТ10, ДВТ10Ex sensors



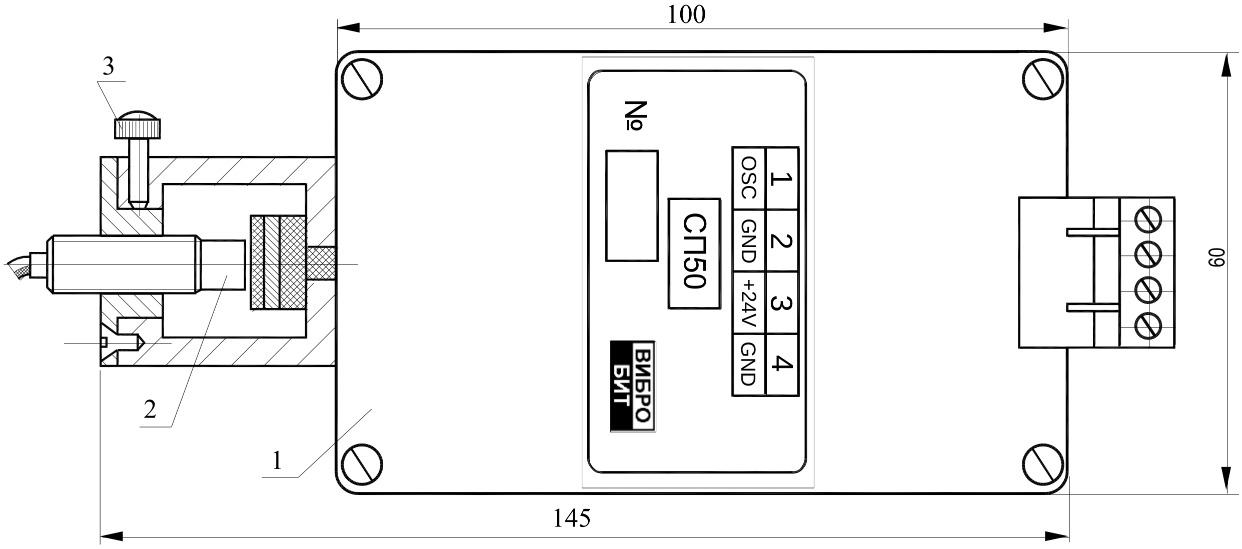

1 – Sensor ДПЭ22МВ, ДПЭ22МВТ, ДПЭ22П, ДПЭ22Ех, ДПЭ23МВ, ДПЭ23МВТ, ДПЭ23П, ДПЭ23Ех, 625В01, ДПЭ24;

2 – Vibration stand;

3 – Adapter sleeve ВШПА.421412.000.79.

Figure L.5 – Installation of piezoelectric sensors

**СП50 resistance loss device**

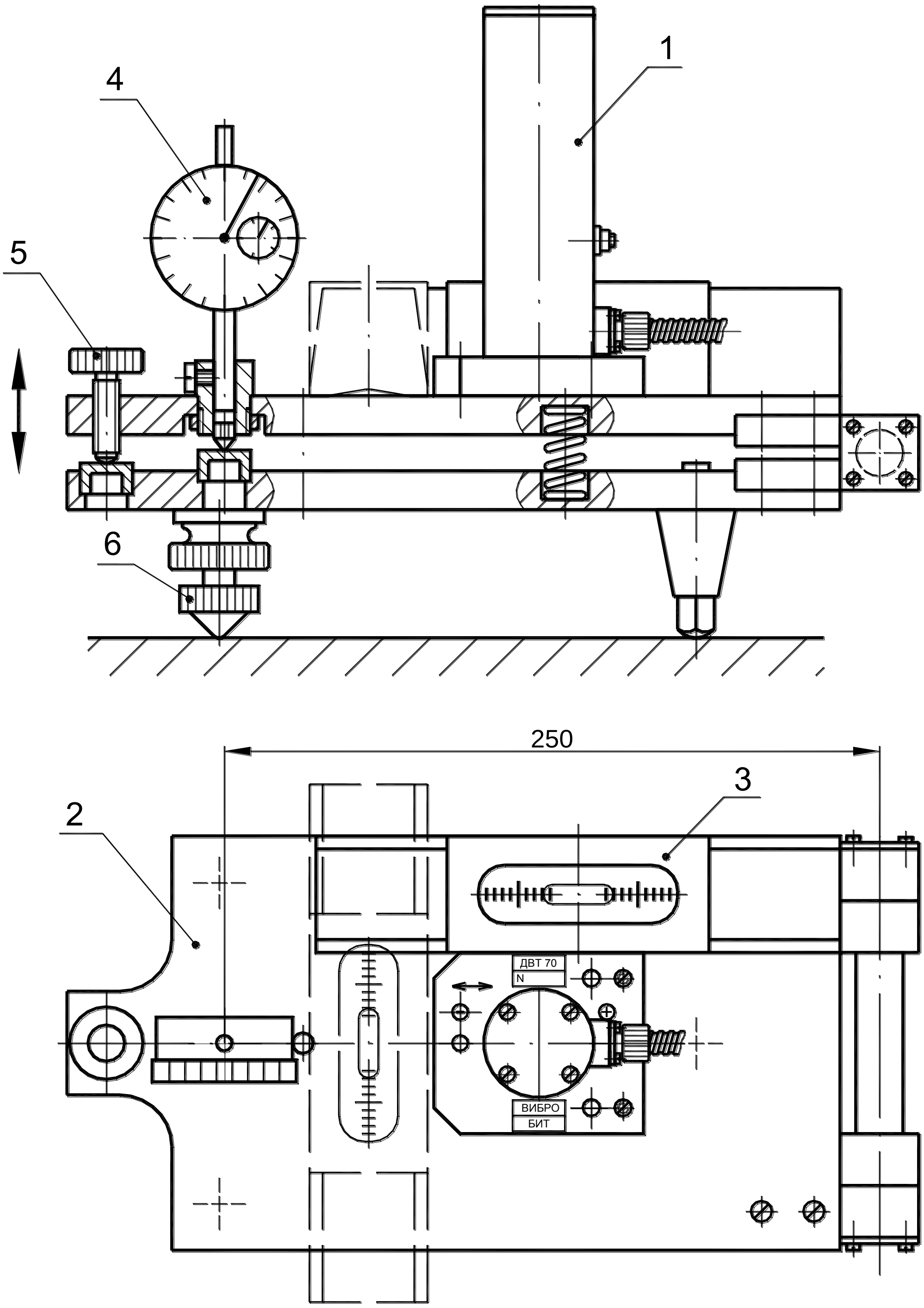



1– СП50 resistance loss device;

2– Sensor ДВТ10, ДВТ10Ex;

3– Locking screw.

Figure L.6 – Installation of the sensors ДВТ10, ДВТ10Ex




1 –Sensor ДВТ70;

2 – Device СП60;

3 – Block Level 200 – 0.02 ГОСТ 9392-89;

4 – Dial indicator IC 10 Class1 ГОСТ 577-68;

5 – Adjustment screw;

6 – Setting screw.

Figure L.7 – Installation of sensor ДВТ70 on the device СП60

# Annex M
(Mandatory)

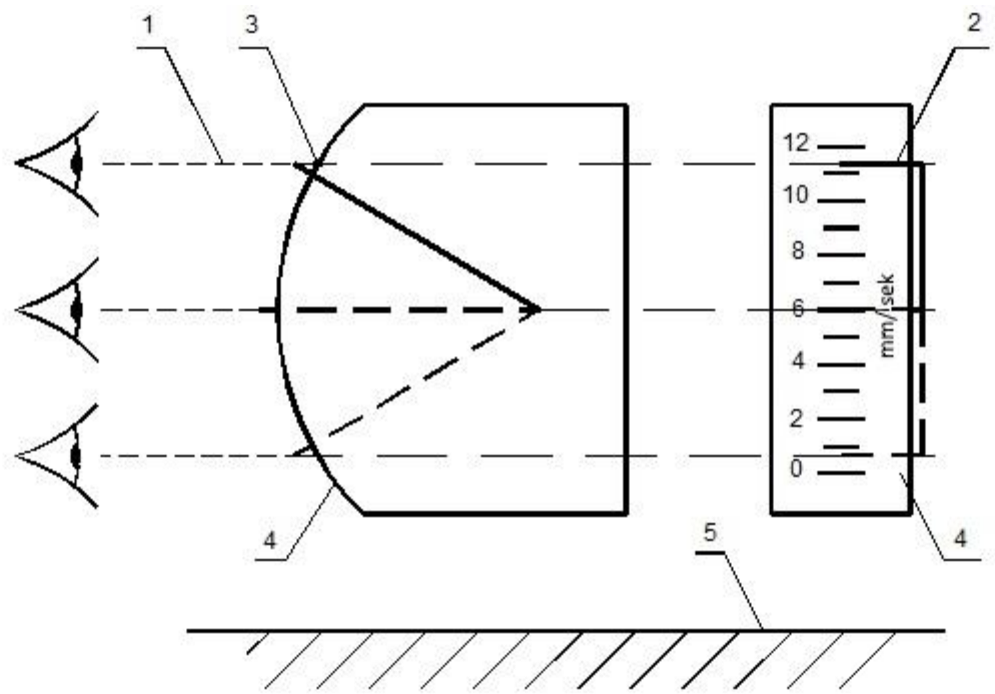
## Reading pointer instrument indications

Install the control board (unit) so that the pointer instrument was in the vertical position.

The line of sight must be horizontal.

Reading – projection of the pointer spear-shaped part onto the scale as per Figure M.1.

Note – should no supply voltage be available, reading may differ from the lower limit of the scale – should not be considered as a fault.




1 – Line of sight;

2 – Spear-shaped part of the pointer;

3 – Reading;

4 – Scale;

5 – Horizon.

Figure M.1

# Annex N
(Mandatory)

## Adjustment procedure

N.1 Arrangement of controls is presented in Annex J

N.2 ДВТ10, ДВТ20, ДВТ30, ДВТ50 and ДВТ60 with ИП34 converters, sensor ДВТ82, sensors ДВТ10Ех, ДВТ20Ех with converter ИП34Ех

– Set the zero gap for the sensor on the stand. Use resistor 2 to set the output current of the converter equaling to 1(4) mA.

– Set displacement on the stand equaling to 50 % of the measurement range, and use the resistor 1 to set the output current 3 (12) mA (set the conversion rate to the beginning of the measurement range). Where the conversion rate is changed, the converter initial current of 1 (4) mA is also changed, so it should be set at zero gap. Procedure for setting 1(4) and 3 (12) mA shall be performed several times by applying the approximation method.

– Set displacement on the stand equaling to 100 % of the measurement range, and by applying the resistor 3, set the output current of the converter equaling to 5 (20) mA.

– Check the converter output characteristic throughout the entire measurement range (0; 12.5; 25; 50; 75; 100 %). Determine measurement error in indicated points. If measurement error falls outside the tolerance limit, then, it is necessary to perform fine adjustment of the converter. Fine adjustment shall be reformed in compliance with the above procedure. Output characteristic of the converter must provide for measurement error conformity with technical requirements.

N.3 Sensor ДВТ40, ДВТ43 with converter ИП42, ИП43

– Install the sensor on the stand in place, when ‘0’ on the sensor scale coincides with the middle of the control surface – ‘band’. Use resistor 2 to set output signal equaling to 3 (12) mA.

– Move the sensor on the stand to the side of negative values by 50 % of the measurement range. Use Resistor 3 to set the converter output signal equaling to 1 (4) mA.

– Check the converter output characteristic throughout the entire measurement range (0; 12.5; 25; 50; 75; 100 %). Determine measurement error in indicated points. If measurement error falls outside the tolerance limit, then, it is necessary to perform fine adjustment of the converter. Output characteristic of the converter must provide for measurement error conformity with technical requirements.

N4 Change of control board variant by the DC output signal

– Install the jumpers as per Figures J.1 – J.4.

– Use potentiometer to set the unified signal initial current to (0; 4 mA) at zero input signal.

– Check correspondence between the output current limit falue and the maximum input signal.

N.5 Sensors ДВТ10, ДВТ10Ex, ДВТ30 with comparator К22, К22Ex

– Install the sensor on the equipment in compliance with Figures K8, K9.

– Voltage on the output 2 of the comparator К22 (К22Ex) relative to the casing or the common conduct with the 'Groove' control surface and the sensor positioned above the shaft surface must not exceed 5 V (U1) for К22 and 3 V (U1) for К22Ex, and when the sensor is located above the groove – not less than 11 V (U2) for К22 and 9 V (U2) for К22Ex.

– Voltage adjustment to be performed by resistor 1 (Figure K.12). Output current of the К22 (К22Ex) by the output 1 must be equal to 1 (4) mA when the sensor is located above the shaft, and above the groove – 5 (20) mA.

– The comparator is intended to compare voltage at output 2 with the voltage setpoint equaling to 8 V for К22, 6 V for К22Ex and is set by resistor 2 (Figure K.12). To ensure stable operation of the comparator, it is necessary to gain the guaranteed setpoint excess and guaranteed nonoperation in two informative rotor conditions relative to the sensor at the rotor vibration and displacement.

– If voltage U1 equals to 1-2 V (less than 1 V for К22Ex) or exceeds 7 V (5 V for К22Ex), then it is necessary to re-calibrate К22(К22Ex) by changing the value of the fixed-value resistor in the variable resistor 1 circuit so that voltage is within the range of (5±1) V ((3±1) V for К22Ex), or use the resistor 2 to change the setpoint voltage. The range of setpoint voltage change equals to (0-8,5) V for К22 ((0-9,5) V for К22Ex). Adjustment of U1 is possible through the change of the sensor gap.

N.6 Sensors ДПЭ, 625B01 with ИП24, ДПЭ24 with ИП24

N.6.1 Install the sensor on the vibration stand according to Figure L.6.

N.6.2 Set load resistance R equaling to (2 ± 0.005) kOhm for output 1.

N.6.3 Set direct current equaling to 1 (4) mA by applying the resistor 3 for output 2 (for ДПЭ23).

N.6.4 Set vibration velocity V, mm/sec, equaling to 100 % of the measurement range on the stand.

N.6.5 Use the resistor 1 to set the alternating RMS voltage U, V, for output 1 calculated by formula:

$$U=V*R*Kp, \qquad (N.1)$$

Where,

V – Vibration velocity value determined on the vibration stand, mm/s;

R – Load resistance, 2 kOhm ;

Kp - nominal value of conversion rate determined by Table 12. mA*s/mm.

N.6.6 Use resistor 2 to set direct current 5 (20) mA at output 2 (for ДПЭ23).

N.6.7 Switch off the vibration stand

N.6.8 Repeat steps N.6.3, N.6.4, N.6.5 and N.6.6.

# Annex P
(Informative)

## Order specification form for assembly units of Vibrobit 100 equipment

The example of the specification completion is given in Table P.1

Table P.1

| Description and type | Version (marking) | Quantity, pcs | Note |
|---|---|---|---|
| Eddy-current sensor ДВТ10 | 40 * 0.5 | 3 | 0.5 m |
| Converter ИП34 | A * 02 * 10 * 5 | 3 | |
| Control board ПК10 | B * 1 – 0 – 1 | 3 | |
| Cable КС10 | 5 | 3 | 5 m |
| Framework “Евромеханика 19” 3U 84HP (3НЕ – 84 – ТЕ) | – | 1 | |
| Cabinet PS 4000 RITTAL 1800x600x600 | – | 1 | |
| Connector box КР10 | – | 3 | |
| Transducer box КП13 | – | 2 | |
| Stand СП10 | – | 1 | |
| | | | |
| Set В10 | B * 3 – 0 – 5 | 2 | $L_{sen}$=50 mm, $L_{cab}$=5 m |
| Set В32 | A * 12 | 7 | $L_{cab}$=7 m |
| Set В40 | A * 4 * 1 | 1 | ДВТ10, БИ23-2pcs |

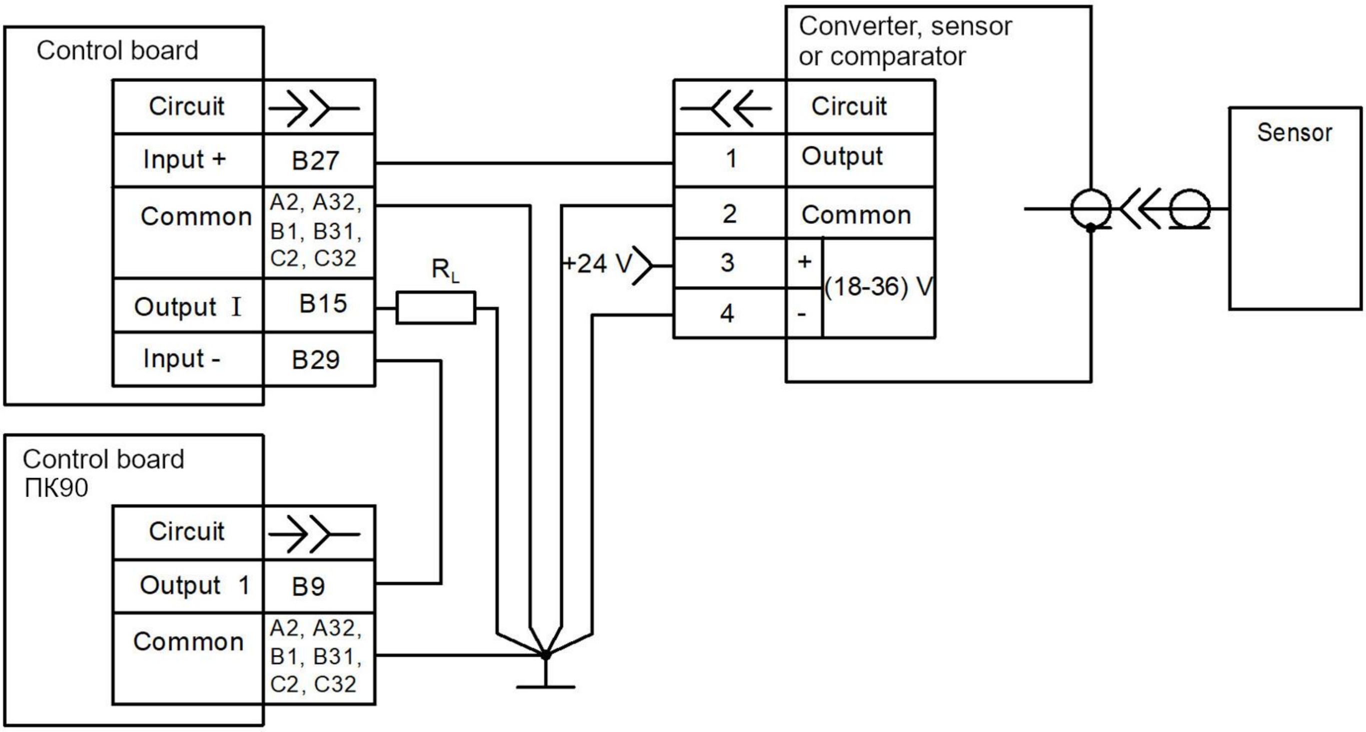
The columns ‘Description and type’ and ‘Note’ shall be completed in compliance with subclause 1.2 and Annexes F, G.

The column ‘Version (marking)’ shall be completed in compliance with subclause 1.3 and Annexes E, H.

## Annex S
(Informative)

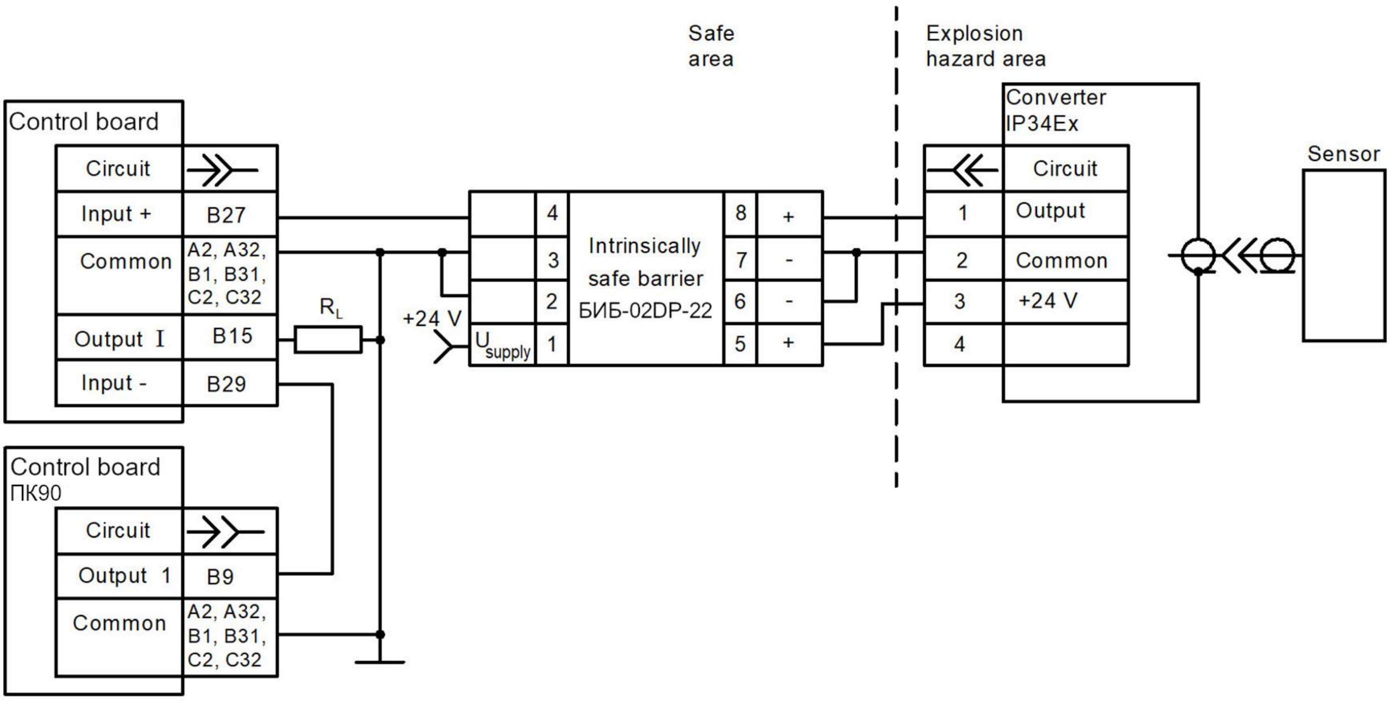
## Electric schematic diagrams of measuring channels

S.1 Measurement of displacement and vibration displacement parameter by control boards




$R_L$ – unified signal load resistance.

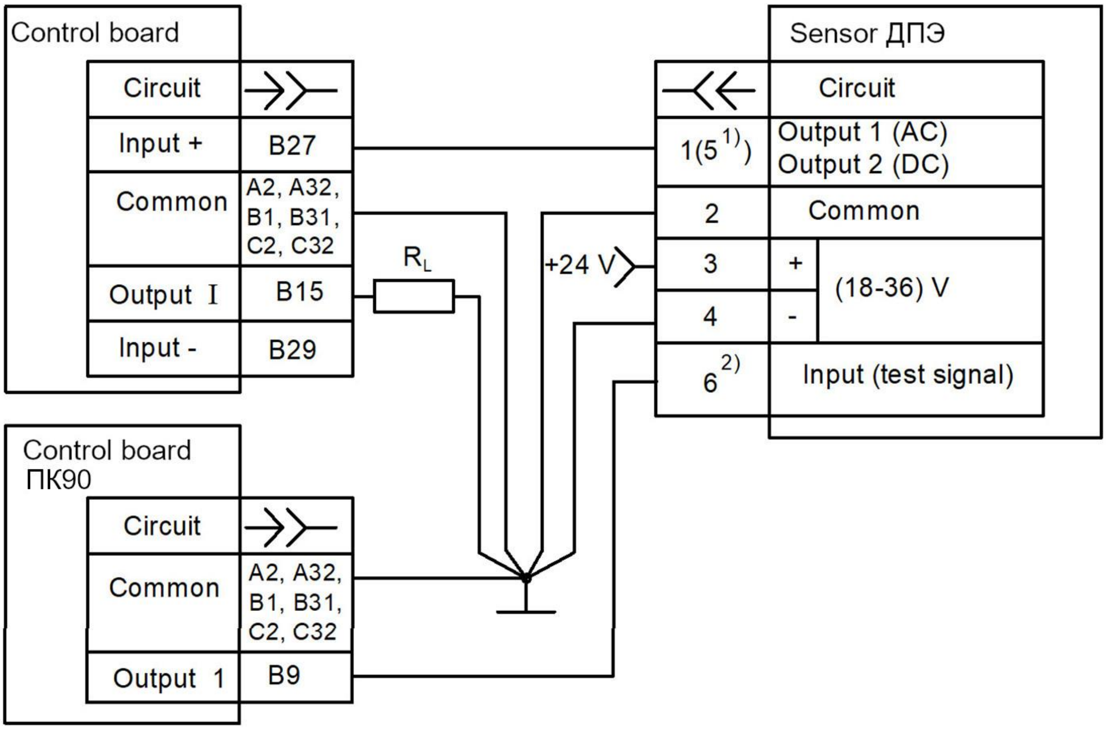
S.2 Measurement of displacement and vibration displacement parameter by control boards across the intrinsically safe barrier




$R_L$ – unified signal load resistance.

* Paragraphs T.1, T.2, T.5, T.6, T.9, T.11 depict sensors, converters, comparators with a coaxial connector.

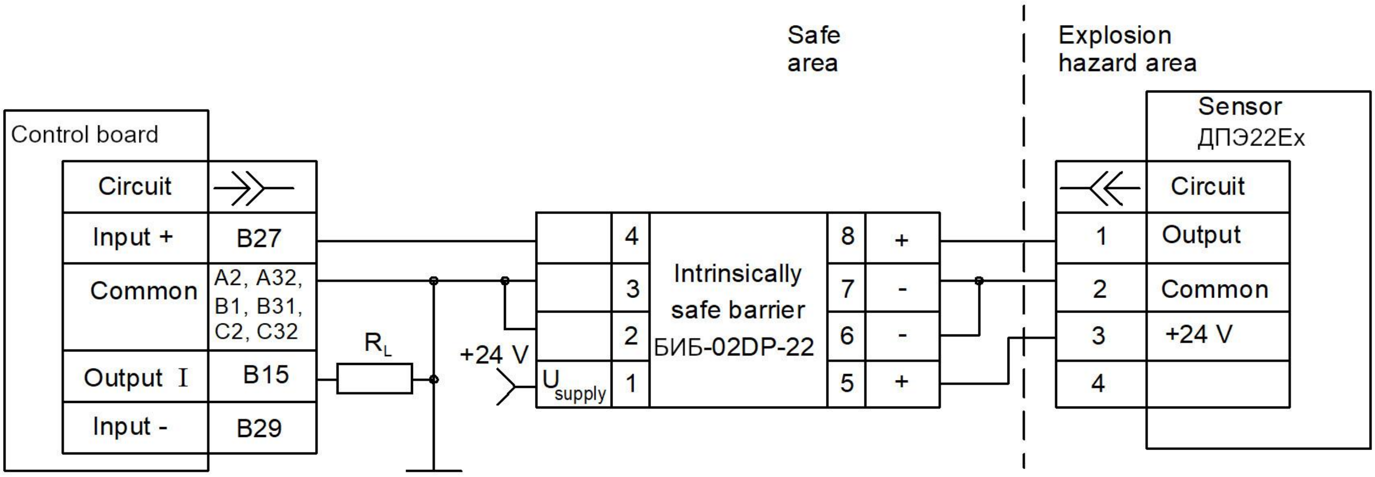
S.3 Vibration velocity parameter measurements by control boards




1) depends on the control board input signal
2) for sensors ДПЭ23МВ, ДПЭ23МВТ, ДПЭ23П

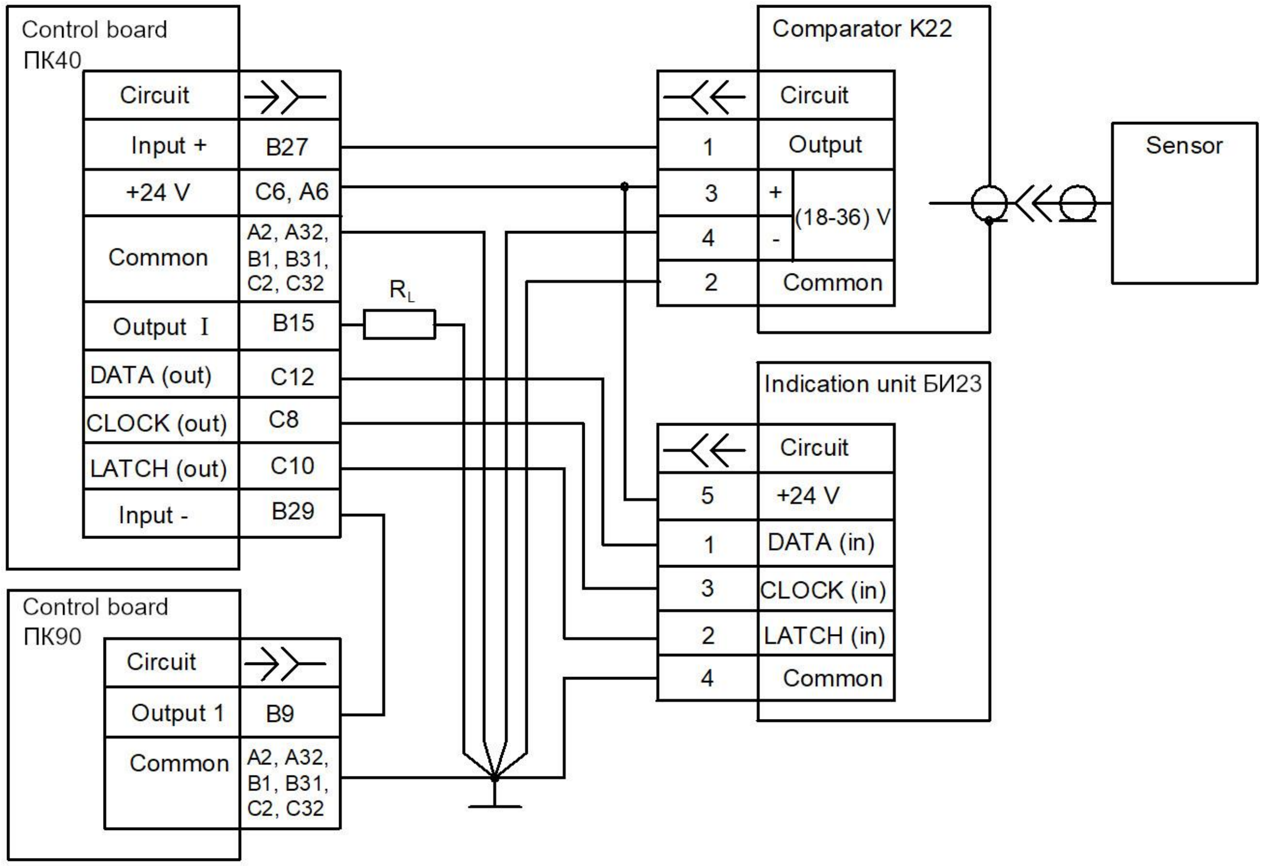
$R_L$ – unified signal load resistance.

S.4 Vibration velocity parameter measurements by control boards across the intrinsically safe barrier



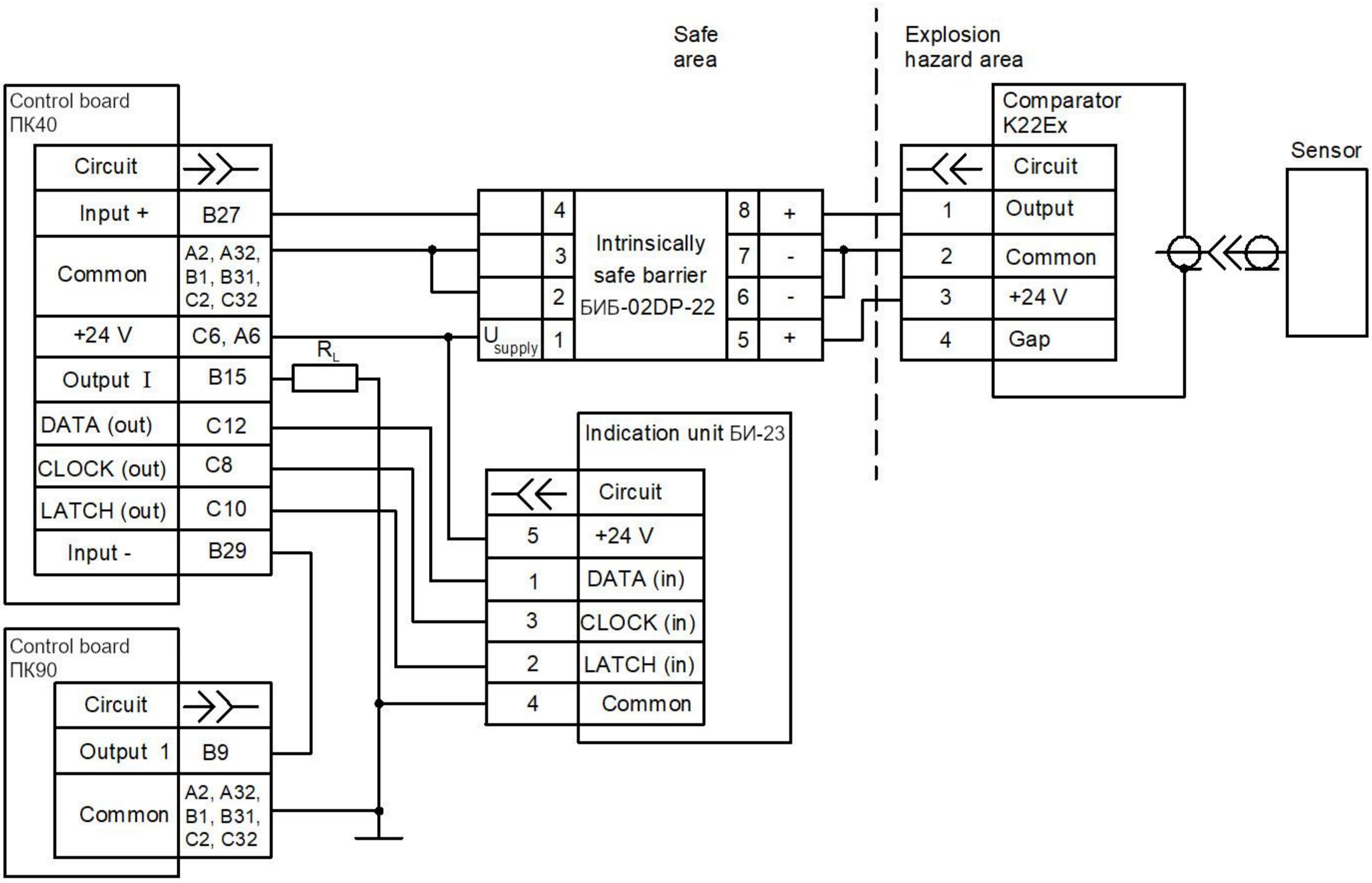

$R_L$ – unified signal load resistance.

S.5 RPM measurement



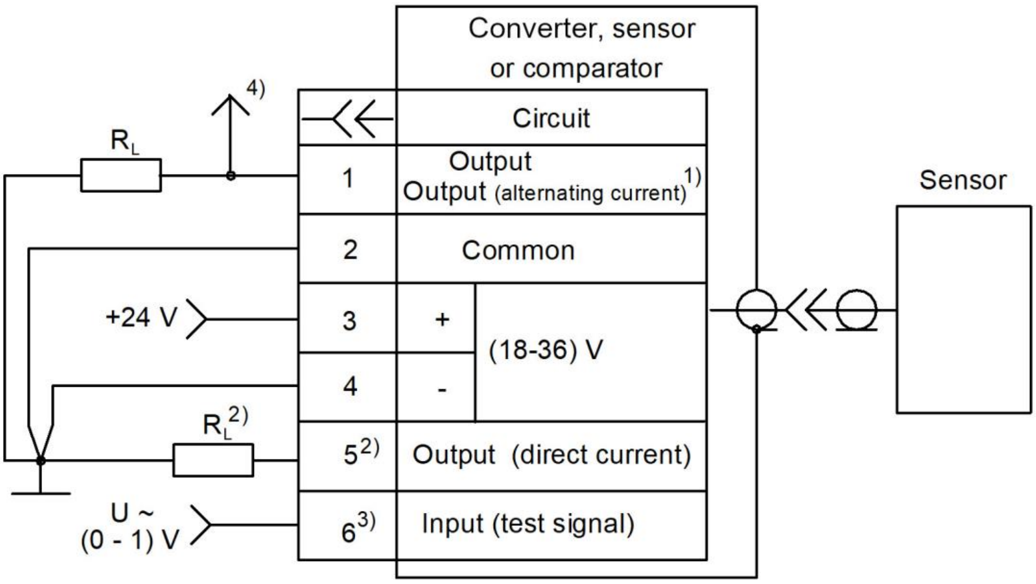

$R_L$ – unified signal load resistance.

S.6 RPM measurements across the intrinsically safe barrier




$R_L$ – unified signal load resistance

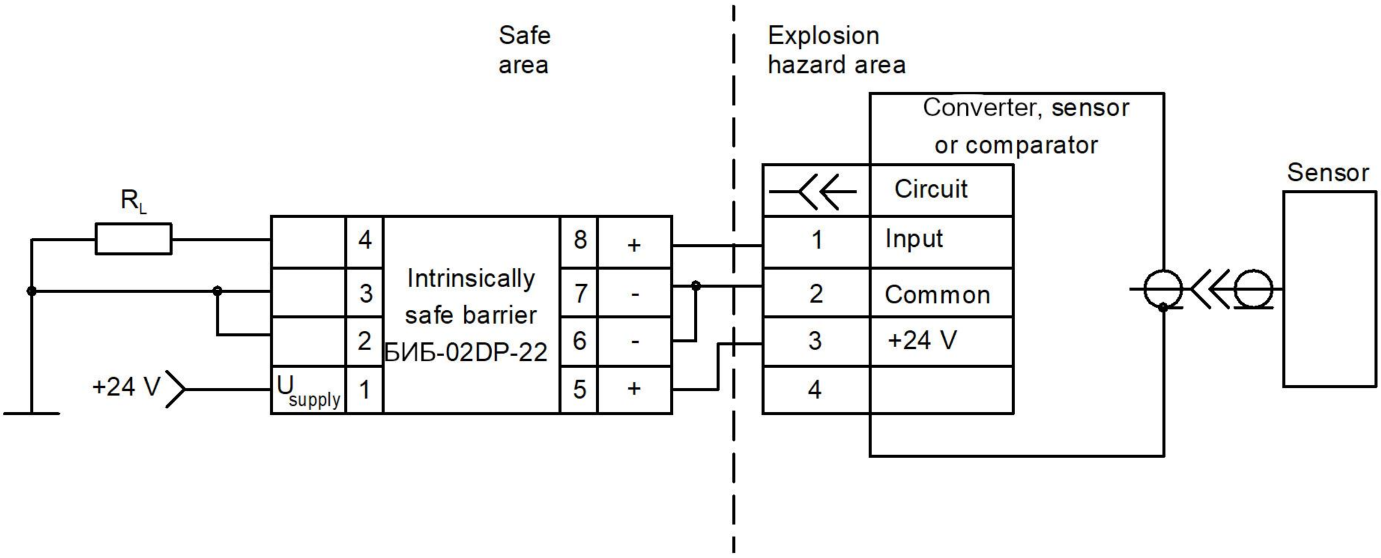
S.7 Independently applied sensors, converters and comparators




1) For sensors ДПЭ and converters ИП36, ИП37;
2) For sensors ДПЭ23МВ, ДПЭ23МВТ, ДПЭ23П and converters ИП36, ИП37;
3) For sensors ДПЭ;
4) Output signal – alternating voltage, input resistance not less than 1 Mohm.

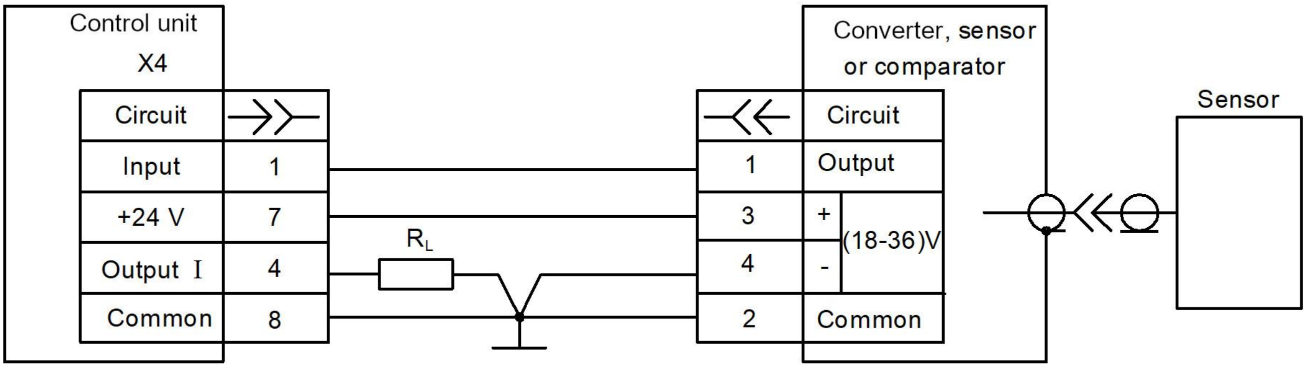
$R_L$ – unified signal load resistance

S.8 Independently applied sensors, converters, and comparators connected across the intrinsically safe barrier



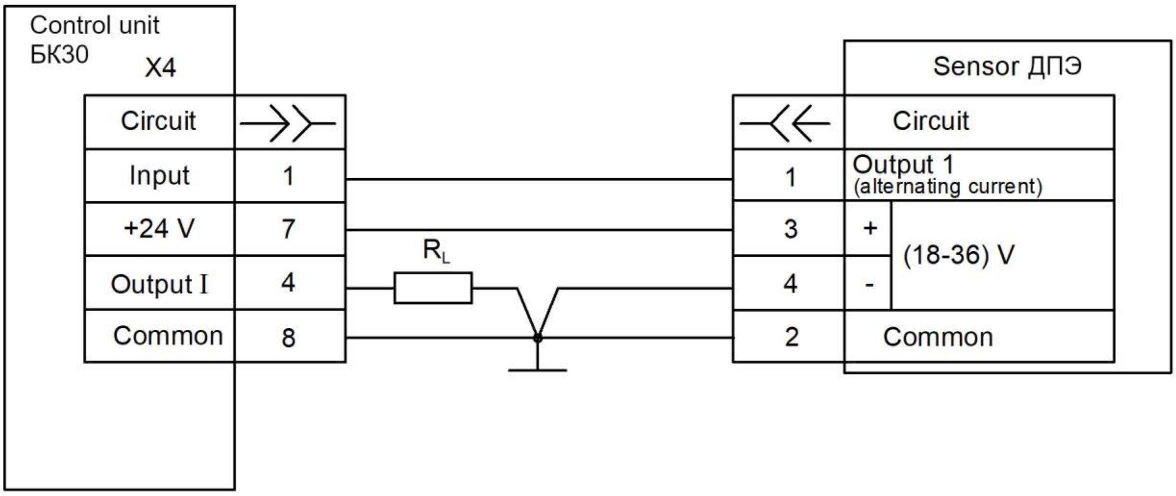

$R_L$ – load resistance.

S.9 Measurement of displacement and vibration displacement parameters by control units БК10, БК20



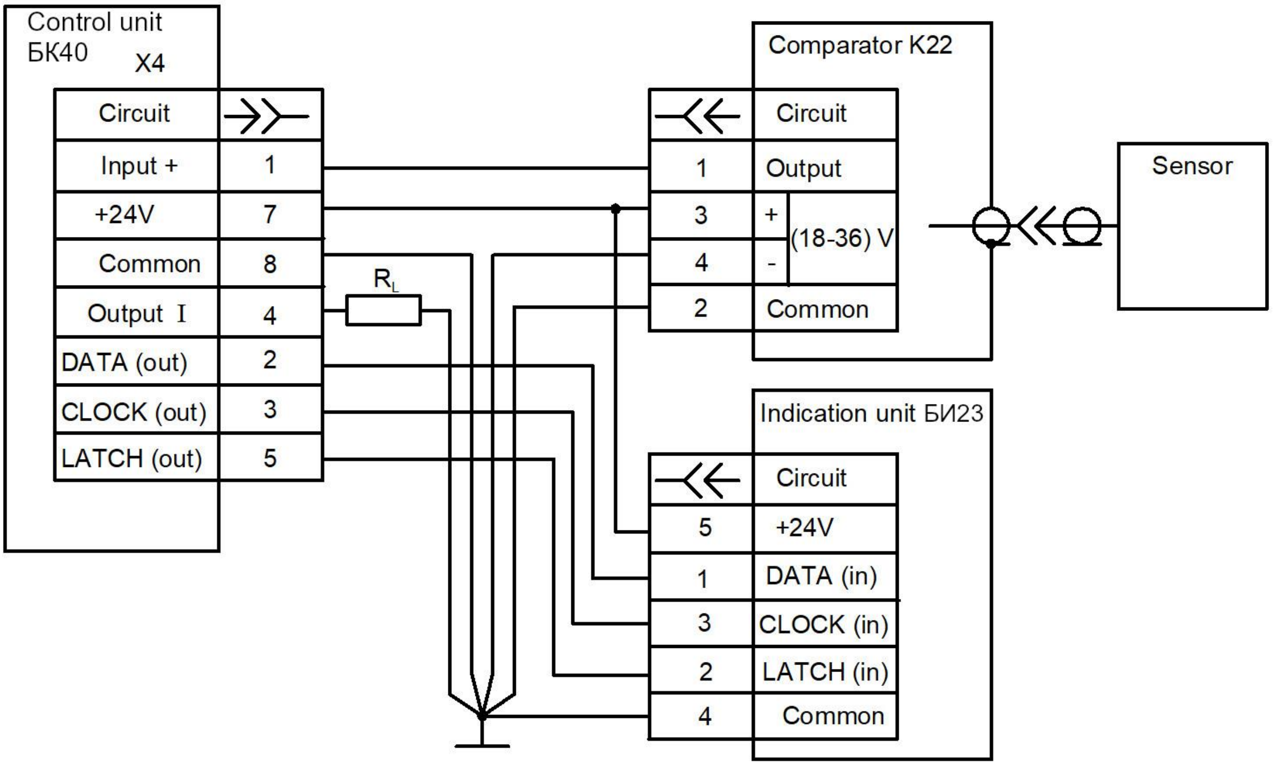

$R_L$ – unified signal load resistance.

S.10 Measurement of vibration velocity by control units БК30




$R_L$ – unified signal load resistance.

S.11 Parameter measurement by control units БК40




$R_L$ – unified signal load resistance

# Annex T

(Mandatory)

## Completeness of fasteners for installation of equipment

Table T.1

| Item | Designation, ГОСТ | Description | Quantity, pcs | | | | | | | | | Note |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ДВТ10 ДВТ10Ex (on stand) | ДВТ10 ДВТ10Ex (on МУ11), (in bearing) | ДВТ20 ДВТ20Ex (1ch on МУ10), (on МУ11) | ДВТ20 ДВТ20Ex (2ch on МУ 10) | ДВТ20 ДВТ20Ex (3ch on МУ10) | ДВТ30 | ДВТ40 | ДВТ50 | ДВТ60 | |
| 1 | ВШПА.421412.000.01 | Stand | 1 | – | – | – | – | – | – | – | – | |
| 2 | ВШПА.421412.000.04 | Nut | – | – | 1[6)] | 4[3)] | 1 (6[4)]) | – | – | – | – | M16x1 |
| 3 | ВШПА.421412.000.16 | Washer | 2 | – | 2[6)] | 4 (2[3)]) | 4 (2[4)]) | – | – | 2 | – | 22 mm |
| 4 | ВШПА.421412.000.16-01 | Washer | – | – | 2[5)] | – | – | – | – | – | 2 | 35 mm |
| 6 | ВШПА.421412.000.19 | Clamp | 3 | 3 | 3 | – | 3 | 3 | – | 3 | 3 | single. |
| 7 | ВШПА.421412.000.20 | Clamp | – | 3[1)] | – | 3 | 3 | – | 3 | – | – | double |
| 8 | ВШПА.421412.000.27 | Base | – | – | – | – | 1 | – | – | – | – | 3ch |
| 9 | ВШПА.421412.000.28 | Base | – | – | – | 1 | – | – | – | – | – | 2ch |
| 10 | ВШПА.421412.000.35 | Base | – | – | 1 | – | – | – | – | – | – | 1ch |
| 10a | ВШПА.421412.000.15 | | | | | | | | | | | |
| 11 | ВШПА.421412.014.00.03 | Nut | – | – | – | – | – | 2 | – | – | – | M20x1 |
| 12 | ВШПА.421412.018.00.03 | Nut | – | 1 | – | – | – | – | – | – | – | M10x1 |
| 17 | ГОСТ 7805 | Bolt M6x16 | – | – | 2 | 4 (2[3)]) | 4 (2[4)]) | – | – | – | 2 | |
| 20 | ГОСТ 7805 | Bolt M6x30 | 2 | – | – | – | – | – | – | 2 | – | |
| 23 | ГОСТ 1491 | Screw M6x16 | – | – | – | – | – | – | 4 | – | – | |
| 26 | ГОСТ 17473 | Screw M5x8 | 3 | 3 (6[1)]) | 3 | 3 | 6 | 3 | 3 | 3 | 3 | |
| 27 | ГОСТ 17473 | Screw M6x16 | – | – | – | – | – | – | – | – | – | |
| 28 | ГОСТ 6402 | Washer 4 65Г | – | – | – | – | – | – | – | – | – | |
| 29 | ГОСТ 6402 | Washer 5 65Г | 3 | 3 (6[1)]) | 3 | 3 | 6 | 3 | 3 | 3 | 3 | |
| 30 | ГОСТ 6402 | Washer 6 65Г | – | – | – | – | – | – | 4 | – | – | |
| 33 | ГОСТ 11371 | Washer 6 | – | – | – | – | – | – | 4 | – | – | |
| 35 | ГОСТ 19034 | Tube 305, ТВ-40А, 5. 20 mm | 3 | 3 (6[1)] | 3 | 3 | 6 | 3 | 3 | 3 | 3 | |

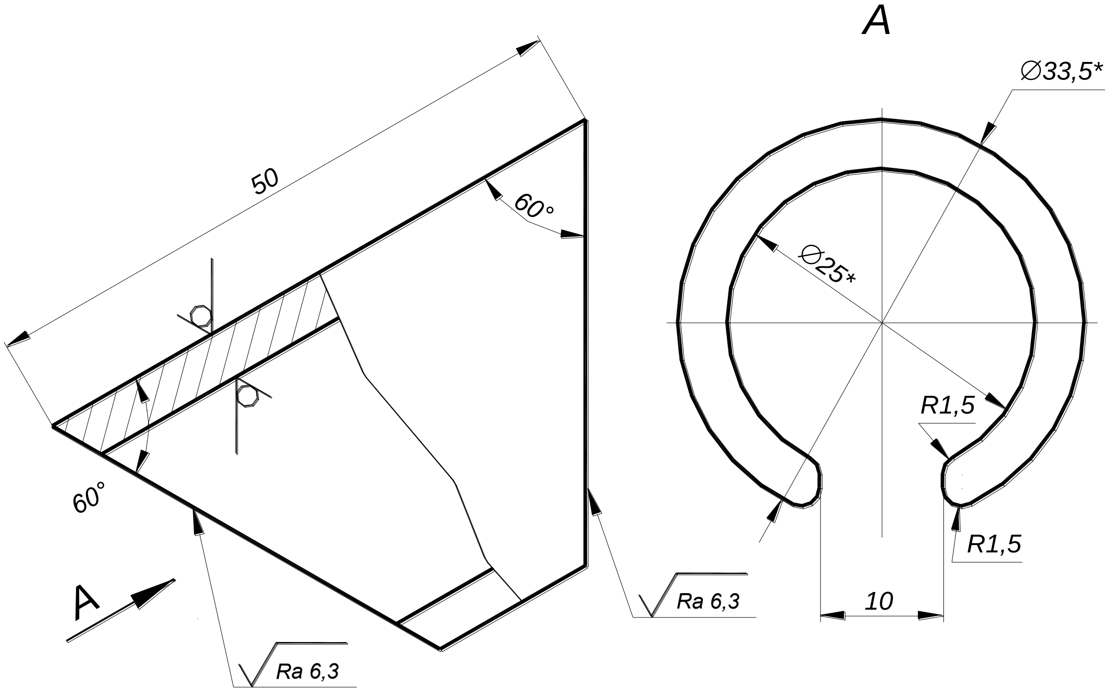
*Continuation of Table T.1*

| Item | Designation, ГОСТ | Description | Quantity, pcs | | | | | | | | | | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ДВТ21 | ДВТ70 | ДВТ82 | ИП | ДПЭ | | КР10, КР20 | КП13, КП23П, КП23В | МУ10 | МУ11 | |
| | | | | | | | МВ Ex | П | | | | | |
| 3 | ВШПА.421412.000.16 | Washer | – | – | – | – | – | – | 2 | – | – | 2 | 22 mm |
| 4 | ВШПА.421412.000.16-01 | Washer | – | – | – | – | – | 2 | – | – | 2 | – | 35 mm |
| 5 | ВШПА.421412.000.18 | Housing | – | – | 1 | – | – | – | – | – | – | – | As required |
| 14 | ВШПА.421412.060.00.12 | Screw | – | – | 2 | – | – | – | – | – | – | – | |
| 18 | ГОСТ 7805 | Bolt M6x20 | – | – | – | – | – | – | – | – | – | 2 | |
| 19 | ГОСТ 7805 | Bolt M6x25 | – | 3 | – | – | – | – | – | – | 2 | – | |
| 20 | ГОСТ 7805 | Bolt M6x30 | – | – | – | – | – | – | 2 | – | – | – | |
| 20a | ГОСТ 7805 | Bolt M6x40 | – | – | – | – | – | 2 | – | – | – | – | |
| 22 | ВШПА.421412.000.75-01 | Capstan screw | – | – | – | – | 3 | – | – | – | – | – | |
| 24 | ГОСТ 17473 | Screw M4x10 | – | – | 2[2)] | – | – | – | – | – | – | – | |
| 25 | ГОСТ 17473 | Screw M4x30 | – | – | – | 2 | 2 | – | – | – | – | – | |
| 27 | ГОСТ 17473 | Screw M6x16 | – | – | – | – | – | – | – | 2 | – | – | |
| 28 | ГОСТ 6402 | Washer 4 65Г | – | – | 2[2)] | 2 | 5 | – | – | – | – | – | |
| 29 | ГОСТ 6402 | Washer 5 65Г | – | – | 2 | – | – | – | – | – | – | – | |
| 30 | ГОСТ 6402 | Washer 6 65Г | – | 3 | – | – | – | – | – | 2 | – | – | |
| 31 | ГОСТ 10450 | Washer 4 | – | – | 2[2)] | 2 | 5 | – | – | – | – | – | |
| 33 | ГОСТ 11371 | Washer 6 | – | 3 | – | – | – | – | – | 2 | – | – | |
| 34 | ВШПА.421412.033.00.04 | Nut | 1 | – | – | – | – | – | – | – | – | – | M27x1 |

[1)] - When installing two sensors
[2)] – Housing fasteners;
[3)] - When installing basing on ВШПА.421412.000.28-01;
[4)] - When installing basing on ВШПА.421412.000.27-01;
[5)] - When installing basing on ВШПА.421412.000.15;
[6)] - When installing basing on ВШПА.421412.000.35.

**Annex U**
(recommended)

**Canopy**




1. Dimensions for reference only
2. Tube $\frac{\text{Ц - 25 x 3,2 ГОСТ 3262-75}}{\text{БСт3 ГОСТ 380 - 2005}}$.
3. Technical requirements according to ОСТ4 Г0.070.014-75

Figure U.1

**Annex V**
(Informative)

# Letter of the equipment acceptance for repair
# №______ dated «__»________ 20__.

| No. | Name of equipment | Serial No. | Year of manu-facture | Q-ty | Note |
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The equipment is under warranty (supplied) basing on:_____________________________

number of contract, account

**Customer representative**

position

/

signature full name

**stamp**

Date of the equipment transfer (shipment)

«___» _______________20__

**Executive Representative**

position

/

signature full name

**stamp**

Equipment Acceptance Date

«___» _______________20__

## Record of revisions

| Rev. | Sheet (page) number | | | | Total sheets (pages) in document | Document No. | Accompanying document reference number and date | Signature | Date |
|---|---|---|---|---|---|---|---|---|---|
| | changed | replaced | new | revoked | | | | | |
| 28 | | All | | | 243 | 2743-21 ИИ | — | | |
| 29 | | 36, 243 | | | – | 2800-21 ИИ | | | |
| 30 | | All | | | 244 | 2895-21 ИИ | | | |
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