Scientific Production Company “Doza”

# GAMMA RAY IRRADIATION UNIT UPG-P FOR CALIBRATION SERVICES

## User Manual
## FVKM.412133.031RE

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This User Manual contains information on design, principle of operation, characteristics of the product and instructions essential for correct and safe use of this product (intended use, maintenance, servicing, storage and transportation), as well as information regarding the utilization of the product.

## 1 DESCRIPTION AND OPERATION OF THE PRODUCT

### 1.1 Product functionality

The gamma ray irradiation units UPG-P for calibration services FVKM.412133.031 (hereinafter – irradiation units or units) are intended for reproduction of the ambient dose equivalent rate (ADER), the exposure dose rate (EDR) and the absorbed dose rate (ADR) of gamma radiation.

The units are used in mobile laboratories, portable and stationary calibration stations at facilities for prompt calibration of dosimetric measuring instruments (hereinafter – instruments being calibrated) of gamma radiation in the collimated beam source $^{137}$Cs.

The units are available in three modifications, which differ by the bench length and the manner of changing the distance between the source and the instrument being calibrated:

- basic modification FVKM.412133.031 – changing the distance between the source and instrument being calibrated is carried out by moving the bench on rollers, with platform fixed on it, relative to the source container, the bench length is 1000 mm;
- modification 01 FVKM.412133.031-01 – changing the distance between the source and instrument being calibrated is carried out by moving the platform along the bench relative to the source container, the bench length is 1000 mm;
- modification 02 FVKM.412133.031-02 – similar to the modification 01, but the bench length is 2000 mm.

### 1.2 Technical characteristics

1.2.1 Range of reproduced values of dose rate:

- ADER of gamma radiation …….…….…….…….. $1 \cdot 10^{-6}$ to $1 \cdot 10^{-3}$ Sv·h$^{-1}$;
- EDR of gamma radiation ……..... $7.17 \cdot 10^{-12}$ to $7.17 \cdot 10^{-9}$ A·kg$^{-1}$ ($1 \cdot 10^{-4}$ to 0.1 R·h$^{-1}$);
- ADR of gamma radiation ……..……..…….. $5 \cdot 10^{-7}$ to $1 \cdot 10^{-3}$ Gy·h$^{-1}$.

1.2.2 Confidence limits of the relative error of reproduced values of dose rate at a confidence level 0.95:

- ADER of gamma radiation ……..…… ±7 %;
- EDR of gamma radiation ……..…… ±6 %;
- ADR of gamma radiation ……..…… ±7 %.

1.2.3 Limits of permissible relative error associated with the deviation from the inverse square law ……..……..…… ±4 %.

For this requirement to be met the room in which the calibration bench with irradiator is used should have dimensions not less than:

- length ……..……...…….. 4 m;
- width ……..……..…… 3 m;
- height ……..……...……...…… 2.5 m.

1.2.4 Dimensions of the uniform field in a plane perpendicular to the beam axis and distant 1 m from the source, within which the ADER varies by no more than ±6 %, …… 15 cm from beam axis.

1.2.5 The irradiator comprises two sealed radionuclide sources $^{137}$Cs: IGI-C-3-1 and IGI-C-3-8.

1.2.6 Operating conditions:

- temperature range ……..…… +(20 ±5) °C;
- relative humidity ……..…… 30 to 80 %;
- atmospheric pressure …… 86.0 to 106.7 kPa.

1.2.7 Level of ADER of background radiation in the room from external sources of gamma radiation ……...…..…… not more than 0.25 μSv·h$^{-1}$.

1.2.8 The irradiation units withstand the exposure to decontaminating solutions:

1) boric acid ($H_3BO_3$) – 16 g, sodium triosulfat ($Na_2S_2O_3 \cdot 5H_2O$) – 10 g, distilled water to 1 L;

2) trisodium phosphate or sodium hexametaphosphate (any synthetic detergent) – 10 - 20 g/L in water.

1.2.9 Overall dimensions and weights of modifications are presented in Table 1.1.

Table 1.1 – Overall dimensions and weight

| Modification | Overall dimensions, mm | | | Weight, kg |
|---|---|---|---|---|
| | Length | Width | Height | |
| Basic modification | 1218 | 244 | 410 | 52.0 |
| Modification 01 | 1261 | 180 | 325 | 45.2 |
| Modification 02 | 2261 | 180 | 325 | 47.2 |

1.2.10 Overall dimensions of source container …… (270×200×255) mm.

1.2.11 Weight of source container …… 37.0 kg.

1.2.12 Mean time before failure ……..…… not less than 25000 h.

1.2.13 Mean life time ……..…… not less than 10 years.

**1.3 Configuration**

1.3.1 The unit is a portable assembly composed of:

- lead container with collimator to accommodate radionuclide sources of gamma radiation and a rotator;
- two sources providing conditions for calibration of dosimetric measuring instruments in the range of ADER of gamma radiation from $1 \cdot 10^{-6}$ to $1 \cdot 10^{-3}$ Sv·h$^{-1}$;
- mechanism for opening the collimator and for fixing the sources;
- bench having two guides with source-to-detector distance meter graduated with 1 mm divisions;
- platform for positioning the instrument being calibrated in the beam, equipped with a mechanism for moving and locking the platform relative to the axis of the gamma radiation beam;
- module for fixing the instrument being calibrated on the platform;
- pointer to control the alignment of the radiation beam with the axis or the detector center;
- boxes for container and support for transportation.

**1.4 Design and operation**

1.4.1 The **basic modification** of the unit features a movable bench on which the platform is placed with fixing device for the instrument being calibrated and the container with radiation sources inside.

The platform together with the bench can be moved relative to the stationary container using handle; in this way the instrument being calibrated is positioned and fixed both in horizontal and vertical directions.

Movement of the bench with platform fixed on it to the required distance is carried out:

- in horizontal direction – using the handle of the bench (the position is then fixed using a screw);
- in vertical direction – using the up/down adjustment device.

Alignment of the radiation beam with the center of the detector or with a point for placement of the detector of the instrument being calibrated is controlled by the pointer.

The inverse square law (dose rate reduction in inverse proportion to the squared distance) is correct starting from the distance from the source 150 mm. For distances less than 150 mm the units are certified by method of comparison using a group of measuring instruments.

1.4.2 The units **of modifications 01, 02** feature a stationary bench, along which the platform is moved with fixing device for the instrument being calibrated and the container with sources inside.

The platform consists of a stand with support, detector center pointer and a clamping frame, which altogether allow placement and fixation of the instruments being calibrated both in horizontal and vertical directions.

The support allows moving the instrument in the longitudinal and transverse directions relative to the center of the radiation beam.

Dimensions of units are listed in Appendix A.

1.4.3 Design of the units allows the placement of the detector center relative to the source at a distance in the following ranges:

- basic modification - 150 to 1000 mm in horizontal direction and 110 to 280 mm in vertical direction relative to the unit's base with uncertainty not more than ±1 mm;
- modification 01 – 150 to 1000 mm in horizontal direction and 119 to 191 mm in vertical direction relative to the unit's base with uncertainty not more than ±1 mm;
- modification 02 – 150 to 2000 mm in horizontal direction and 119 to 191 mm in vertical direction relative to the unit's base with uncertainty not more than ±1 mm.

1.4.4 The sources remain in the container all the time; the radiation beam is open or shut using shutter. When the unit is not in use, the shutter must always be closed. The container walls provide the necessary degree of operator protection from gamma radiation and allow performing all preparatory operations prior to calibration.

1.4.5 The dose rate at the detector location can be changed by selecting one of the two sources and/or by changing the source-to-detector distance.

Typical values of ADER, EDR and ADR at the distance 1 m from the source (exact values are determined during certification of the unit) are listed in Table 1.1.

Table 1.1 – Typical values of ADER, EDR and ADR at the distance 1 m from the source

| Source | ADER, $Sv \cdot h^{-1}$ | EDR, $R \cdot h^{-1}$ | ADR, $Gy\ h^{-1}$ |
|---|---|---|---|
| IGI-C-3-1 | $4.1 \cdot 10^{-7}$ | $4.1 \cdot 10^{-5}$ | $4.1 \cdot 10^{-7}$ |
| IGI-C-3-8 | $4.1 \cdot 10^{-5}$ | $4.1 \cdot 10^{-3}$ | $4.1 \cdot 10^{-5}$ |

1.4.6 The principle of operation ensures the creation of required values of ADER, EDR or ADR at the detector location of the instrument being calibrated.

Metrological characteristics of units are identical. When switching from the source with lower activity to the source with higher activity, the units with the bench length of 1 m have a gap in the range of ADER from 10 to 40 $\mu Sv \cdot h^{-1}$. The unit with the bench length of 2 m provides overlapping of ADER ranges created by the sources.

1.4.7 Prior to irradiation of the instrument being calibrated the operator takes place behind the container and moves necessary source to the working position using the handle. To do this, the handle on the back side of the container has to be moved to the end position (left or right) and fixed by rotating clockwise. In this position, the source inside the container will be located in front of the collimator.

**1.5 Marking and sealing**

1.5.1 The unit has a nameplate with the following information:

- trademark and name of the manufacturer;
- reference designation of the unit;
- works number according to the manufacturer's system of numeration;
- made in Russia.

1.5.2 The container is marked with radiation warning sign.

1.5.3 Method of marking and place where it is made shall comply with the design documentation.

1.5.4 The units are sealed in accordance with the design documentation.

**1.6 Packing**

1.6.1 Packing of the units complies with the design documentation and provides protection against ingress of atmospheric precipitations and aerosols, splashes of water, dust, sand, solar ultra-violet radiation and limits the ingress of water vapour and gases.

**2 INTENDED USE**

**2.1 Operational limitations**

2.1.1 The units maintain metrological characteristics under the conditions specified in 1.2.6.

2.1.2 The units should be protected from adverse ambient conditions: high humidity, sharp temperature changes, direct sunlight.

2.1.3 The units must be used only with sources of gamma radiation of types IGI-C-3-1 and IGI-C-3-8 as specified in the certificate for the unit.

**2.2 Safety measures in the preparation of the product for use**

2.2.1 Before starting to use the unit, read the User Manual FVKM.412133.031RE.

2.2.2 During all operations with the unit follow all corporate radiation safety regulations.

2.2.3 Persons authorized to perform calibration operations must be admitted to work with sources of ionizing radiation in accordance with the established procedure. Individual radiation exposures of the staff must be monitored.

2.2.4 Facilities using the UPG-P units must organize and implements a radiation monitoring program. Radiation monitoring may be carried out by a person responsible for radiation safety or by dedicated radiation safety department.

2.2.5 The radiation beam must be oriented in the direction which ensures the safe conditions for the staff. An area of the primary beam field must be marked on the floor with red paint or fenced with shields. Entering this area when the shutter is open is **strictly forbidden**.

2.2.6 In the storage state of the unit the collimator must be closed; the source with higher activity must be in the lower slot; the source with lower activity - in the working slot of the container-collimator.

2.2.7 When the collimator is closed, the level of ADR of gamma radiation from the source in the container shell be below 20 $\mu Gy \cdot h^{-1}$ at the distance 1000 mm from the container.

2.2.8 ADR of gamma radiation from the source placed in the reloading container shall not exceed 25 $\mu Gy \cdot h^{-1}$ at the distance 1000 mm from the container.

2.2.9 In the ready for operation state the unit should be placed no closer than 1500 mm from walls of the room; along the axis of the radiation beam from collimator the distance from walls should be at least 4000 mm.

No special requirements for the room are set out provided that the above conditions are met.

**2.3 Preparation of the product for use**

2.3.1 Perform external inspection of the unit and make sure that mechanical parts are in good order.

2.3.2 Place the unit on a horizontal surface following the requirements in 2.2.11.

**2.4 Use of the product**

2.4.1 Place and fix the instrument being calibrated on the platform; the detector center shall be on the radiation beam axis and in the vertical direction shall coincide with the mark on the platform.

2.4.2 Depending on the required dose rate, select one of the two sources using handle at the unit and fix the selected source in working position.

2.4.3 Position the platform at the necessary distance from the source and fix it using screw.

**CAUTION!** CHANGING THE SOURCE-TO-DETECTOR DISTANCE SHOULD BE CARRIED OUT WITH THE SHUTTER CLOSES. BEFORE OPENING THE SHUTTER AND STARTING THE IRRADIATION OPERATOR MUST TAKE PLACE BEHIND THE CONTAINER.

2.4.4 Open the shutter of the container.

2.4.5 Take readings of the instrument being calibrated.

2.4.6 Close the shutter using the handle.

2.4.7 Calibration procedures are contained in manuals for the instruments being calibrated.

**3 MAINTENANCE**

**3.1 General notes**

3.1.1 The purpose of maintenance is to ensure safety and operability of UPG-P unit throughout its service life.

We recommend the following types and timing of maintenance:

- external inspection ……..…… once a month;
- external cleaning ……..…… once a month;
- check of main parameters ……..…… once a year.

3.1.2 External inspection shall include:

- check for mechanical damage of parts;
- presence of gamma radiation sources;
- check of the pointer indicating the distance on the bench;
- operability of mechanisms for moving and fixing of the platform.

3.1.3 External cleaning shall be conducted to avoid contamination of the unit.

3.1.3.1 To remove dust from external surfaces use a wet cloth or a brush.

3.1.3.2 To decontaminate the external surfaces use solutions 1) and 2) of the 1.2.8; after cleaning the surfaces using cloth moisten with decontaminating solution it is necessary to wipe surfaces using cloth moisten with distilled water and then dry using filter paper.

**3.2 Safety precautions**

During maintenance operations follow safety requirements specified in 2.2.

## 4 ROUTINE REPAIRS

4.1 In case of failure of any part of the unit the repair should be performed by the manufacturer.

## 5 STORAGE

5.1 Prior to putting into operation, the units with radioactive sources shall be stored in a heated warehouse with natural ventilation

- in manufacturer's package – at ambient temperatures from +5 to +40 ºC and relative humidity up to 80 % at +25 ºC;
- unpacked – at ambient temperatures from +10 ºC to +35 ºC and relative humidity up to 80 % at +25 ºC.

5.2 The storage location should be free of dust, chemical vapours, aggressive gases and other substances that may cause corrosion.

The storage location shall exclude exposure of the units to the direct rays of sunlight.

## 6 TRANSPORTATION

6.1 Transportation of the units should be carried out by personnel admitted to it in accordance with the established procedure.

During transportation, the level of ADER of radiation associated with the units (above natural background) at the places where accompanying personnel is present (including the driver's seat) is not more than 2.5 $\mu Sv \cdot h^{-1}$.

6.2 The units in the original manufacturer's package can be transported by all means of transport at any distance:

- transportation by railway shall be carried out in clean boxcars;
- when transported by air the boxes shall be placed in air-tight heated compartment;
- when transported by water and sea transport the boxes shall be placed in the hold.

6.3 Arrangement and fastening of the boxes on transport means shall provide their steady position en route, absence of displacement and striking each other.

6.4 The requirements of the inscriptions on the transport packing shall be observed during loading and unloading.

During loading and unloading operations the units should not be exposed to atmospheric precipitations.

6.5 Transportation conditions:

- temperature ……..…….….. from minus 50 to +50 °C;
- humidity ……..…….……...…..… up to 95 % at +35 °C;
- sinusoidal vibrations ……..…….. within frequency range from 10 to 55 Hz with displacement amplitude 0.35 mm.

## 8 DISPOSAL

8.1 After specified lifetime, radiation sources should be sent for disposal in accordance with the mandatory requirements of national legislation.

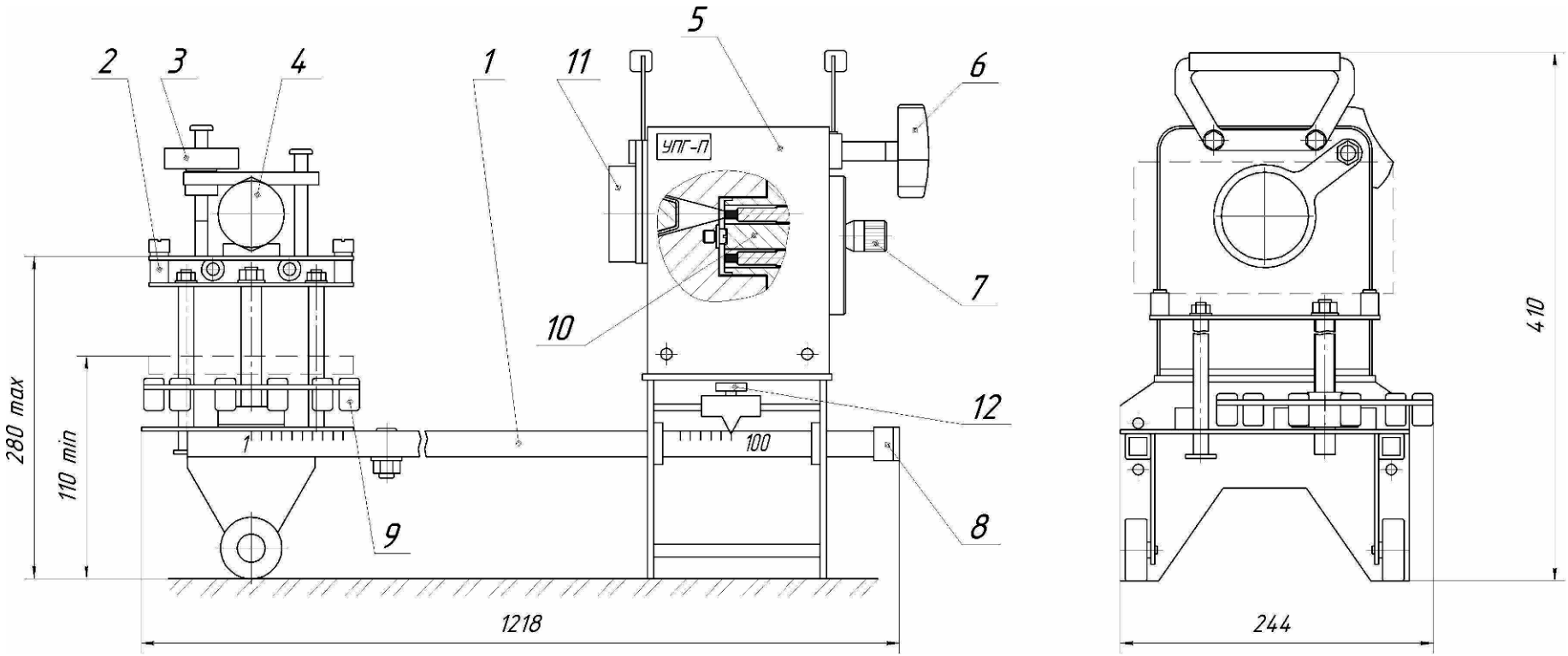
8.2 At the time of disposal of radiation sources the units after removal of sources should be examined for possible radioactive contamination.

If after decontamination the residual radioactive contamination of individual parts of the unit exceeds the values set out in the national standards, than these parts should be disposed.

If the radioactive contamination of the unit is below the limits set out in the national standards, or if it was decreased below the above limits as a result of decontamination, than the unit can be disposed without any radiation safety restrictions.

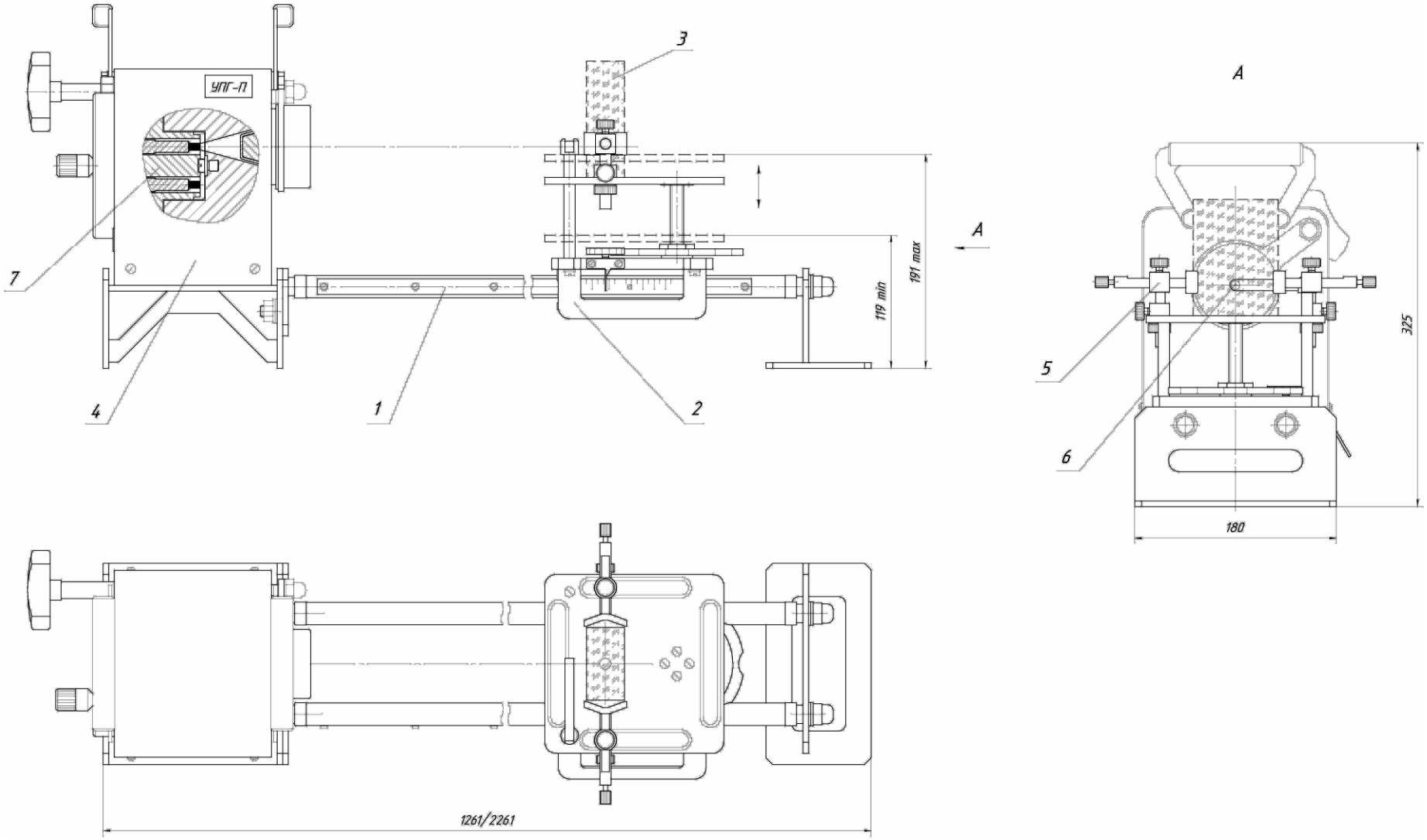
Appendix A
(obligatory)

## APPEARANCE AND OVERALL DIMENSIONS




| | | | |
|---|---|---|---|
| 1 – Movable bench | 4 – Instrument to be calibrated | 7 – Handle to fix the source | 10 – Rotator |
| 2 – Platform | 5 – Container | 8 – Handle to move the bench | 11 – Shutter |
| 3 – Holder | 6 – Handle to open/close shutter | 9 – Up/down adjustment device | 12 – Screw |

Figure A.1 – Appearance and overall dimensions of the unit (basic modification)




1 – Stationary bench
2 – Platform
3 – Instrument to be calibrated
4 – Container
5 – Support
6 – Pointer
7 – Rotator

Note – For modification 01 the bench length is 1261 mm; for modification 02 the length is 2261 mm.

Figure A.2 – Appearance and overall dimensions of the unit (modifications 01 or 02)