Special measures of radionuclides activity to metrological support of measurements in radiation control

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Abstract. The possibilities of FSUE VNIIFTRI for production and calibrating special measures of activity (imitants of radioactive contamination of environmental objects) are presented. A description of the measures of activity with different geometries and materials for the calibration of spectrometric, radiometric and aerosol equipment is given. The importance and practical importance of the production of these imitants is determined by the fact that they are widely used for metrological support of radiometric and spectrometric measuring instruments because it make it possible to calibrate the measuring instruments for conditions that are closest to the real ones, thereby reducing the error of the measurement results.

1. Introduction

Currently, radiation and environmental safety is one of the priority areas. Therefore, there is a vast task to ensure the unity and reliability of measurements of radionuclide activity of environmental objects in industry.

One of the main activities of the Research Department of Metrology of Ionizing Radiation (NIO-4) of VNIIFTRI is to develop and produce various imitants (measures of activity) of radioactive contamination of environmental objects, nuclear and building materials, agricultural products and food. The imitants are both monolithic and granular bulk samples with variable parameters.

The imitants are widely used for metrological support of radiometric and spectrometric measuring instruments since it possible to use them for calibration the measuring instruments in actual-use environment, thereby reducing the error of the measurement results [1].

The special measures of activity of radionuclides are produced both like an approved type of the measures and for the specific needs of the Customers [2].

The measures of activity are radioactive substance with a specific measurement geometry (a specific design and relative position of the object of study and the detector of the measuring instrument). The form of the measures of activity excludes pollution of environmental and equipment when used them in actual-use environment. They can be divided into four groups which are described following.
2. Description and possibilities of production of the special measures of activity

The first group is point measures of activity. In this case, the active part is made of an aliquot of nuclide solution localized application with known specific activity on a substrate with following sealing. The point measures of activity are shown in figure 1.

![Figure 1. The point measures of activity](image1)

The second group is surface measures of activity. In this case, the active part is made of a nuclide solution uniform distribution with known specific activity on the surface of a substrate with following sealing. The surface measures of activity are shown in figure 2.

![Figure 2. Surface measures of activity](image2)

The third group is solid-state volumetric measures of activity, the active part of which is made of a nuclide uniform distribution with known activity in the volume of sources, followed by sealing. If necessary, the volume of the source can be made in metal or organic forms. The source can also be made in a temporary form followed removal. The solid-state volumetric measures of activity are shown in figure 3.
The fourth group is bulk granular volumetric measures of activity consisted of sealed granules with radionuclide or mixture of uniformly distributed radionuclides. The bulk granular volumetric measures of activity are shown in figure 4.

Almost any material characterized various natural environment objects (plant material, sand, soil, water, gas) can be used in the production of the radioactive contamination imitants. In the most cases, basis is an epoxy resin with known activity, and density of the source determines the degree of equivalence to real samples. For the bulk and the solid-state imitants (imitants of soil, sand and food samples), the density can vary between 0.5 – 2.4 g/cm3, for imitants of water, air and gas 0.05 – 1.0 g/cm3. The list of radionuclides, which can be used as a basis of the measures of activity, are presented in table 1 [3]. The list is not full.
Table 1. The list of radionuclides, which can be used as a basis of the measures of activity

| Radionuclide | Half Life, yrs | Radionuclide | Half Life, yrs |
|--------------|----------------|--------------|----------------|
| $^{207}$Bi   | 32.9           | $^{232}$Th   | 1.4·$10^{10}$  |
| $^{131}$Ba   | 10.51          | $^{40}$K     | 1.248·$10^{9}$ |
| $^{137}$Cs   | 30.17          | $^{90}$Sr    | 28.79          |
| $^{44}$Ti    | 60.0           | $^{36}$Cl    | 3.1·$10^{5}$   |
| $^{22}$Na    | 2.6            | $^{239}$Pu   | 2.411·$10^{4}$ |
| $^{241}$Am   | 432.6          | $^{60}$Co    | 5.2713         |
| $^{226}$Ra   | 1600           | $^{152}$Eu   | 13,537         |

The main characteristics of the sources are given in the table 2 [2].

Table 2. The main characteristics of the sources

| Name of characteristic                          | Characteristic value |
|-------------------------------------------------|----------------------|
| Energy range, keV                               | 4 – 6130             |
| Activity (specific activity) range, Bq (Bq/kg, Bq/l) | от 10 до $1\cdot10^6$ |
| Expanded uncertainty at coverage factor $k = 2$ (corresponding to a confidence interval of approximately 95% assuming a normal distribution), % | ± (5 – 20)          |
| Unevenness distribution of activity on the surface (by volume), %, no more | 5                   |
| Average technical life time from commissioning, years | from 5 to 20       |
| Operating conditions:                           |                      |
| - the temperature range, °C                     | from -50 to +50      |
| - the relative humidity range at the temperature 30 °C, % | to 95               |
| - atmospheric pressure, kPa                     | from 25 to 105       |

There are the necessary radiochemical and technological equipment for the production of measures of activity at VNIIFTRI.

Metrology supporting of spectrometric measuring instruments with the special activity measures imitated real environmental samples radionuclides pollution allows decrease the error of the measurement results in field of radiation technologies: radiation safety at emergency situations, control of agricultural products, environmental objects (soil, yes, air), medicine (for example, radiation therapy in oncology), etc.

3. References.

[1] Sarkisov E R 2005 Standards of the unit of activity of radionuclides of VNIIFTRI and metrological support of radiation ecology *Collection of scientific works of VNIIFTRI* 52 (144) 74

[2] Radionuclide sources of photon radiation of metrological purpose, closed, IMN-G (Electronic resource) https://fgis.gost.ru/fundmetrology/registry/4/items/355459

[3] MGFK.412128.001TU 2010 Radionuclide sources of photon radiation of metrological purpose, closed, IMN-G Technical conditions (Moscow: Russian Metrological Institute of Technical Physics and Radio Ingineering).