UDC 006.915.1ISO:544.584.2

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Improved accuracy of radiological measurements in test laboratories

In the "Norms of Radiation Safety of Ukraine" NRBU-97 there is the notion of monitoring the dosimetry (radiation-dosimetric) - a system of measurements and calculations, aimed at assessing exposure doses of individuals or groups of people, as well as the radiation environment of production and environment. Radiation control is a measurement control that, according to the definition, is performed to ensure the health of the population.

Purpose and setting of research. Consider the important issues of metrological support for radiation control of food products with given reliability. With the use of measuring equipment and for the purpose of radiation control, the requirements for their metrological characteristics are determined by the permissible value of the controlled quantity and the range of its change, and the accuracy of the control is determined by the errors of the measuring equipment and variations of the radiation parameters of the controlled samples of food products. Conducting radiation monitoring of specific activities of radionuclides in food and drinking water, taking into account mistakes of measuring devices and the reliability of control.

The main text of the article. In the "Norms of Radiation Safety of Ukraine" NRBU-97 there is the notion of monitoring the dosimetry (radiation-dosimetric) - a system of measurements and calculations, aimed at assessing exposure doses of individuals or groups of people, as well as the radiation environment of production and environment. Sometimes this type of control is called "radiation control" (RK). RK, by its very nature, is a measuring control, which, according to the definition, is carried out in order to ensure the health of the population. It includes the following steps:

- measurement of radiation parameters of objects (environment);
- estimation of errors of measurement results;
- comparison of the obtained results of measurements, taking into account the characteristics of their errors, with given control levels; assessment of the reliability of the performed control.

As can be seen from the list of stages of the LCD, the measurement is the basis on which all control is based.

In accordance with the Law of Ukraine "On metrology and metrological activity", the scope of state metrological control and supervision extends to such types of work as monitoring and radiation control, based on the measurement of

radiation parameters. According to Art. 20 of this Law, the objects of state metrological control and supervision are:

- measuring instruments (FVT);
- measurement methods (MVB).

That is why, in protecting people from the influence of ionizing radiation, not only the hygienic regulation of radiation factors plays a special role, but also the metrological maintenance of measurements of regulated parameters.

One of the most important measures to reduce the doses of internal exposure of the population is the establishment of hygienic regulations for the content of radionuclides in food and drinking water.

Today, the content of 137Cs and 90Sr in food and drinking water is regulated by GN 6.6.1.1-130-2006 "Permissible levels of radionuclide content 137Cs and 90Sr in food and drinking water".

The maintenance of these levels is achieved:

- Excluding those products that do not meet the standards;
- use of additional methods of processing of food raw materials;
- Restriction of the use of wild mushrooms and berries;
- application of various methods of reduction of individual doses (including control of the addition of potassium fertilizers and ferrocyanide supplements to animal feed).

The introduction of these measures, in turn, requires a significant increase in the level of radiation control of food products.

By its very nature, in the process of researching a sample of a food product, the control of its quality is carried out, that is, according to DSTU 3021-95, control of quantitative and (or) qualitative characteristics (properties).

Food control is carried out according to parameters such as the specific activity of man-made radionuclides contained in them, namely 137Cs and 90Sr. The basis of regulation of permissible levels of their content is laid not exceeding their annual effective dose of radiation 1mZv.

Limit of permissible error (means of measurements) - the maximum value, without taking into account the sign, the error of the measuring instrument (measuring instrument), under which this tool can still be considered suitable for use (DSTU 2681-94, p. 7.22). According to DSTU 3743-98 "State Valuation Scheme for Means of Measurement of Activity, Specific Activity and Volume Activity of Radionuclides" the limits of the permissible relative error of working means of measuring equipment dA shall not exceed 40%. Relative error is the ratio of the absolute measurement error to the conventionally true value of the measured value (DSTU-2681-94, p. 5.3) or the relative error of the measuring instrument - the ratio of the absolute error of the measuring instrument to the true value of the measured value (DSTU-2681-94, p. 7.18).

Given that 90Sr activity is, in most cases, determined not by direct measurements, but by the total b-activity of the sample and the activity of 137Cs and 40K in it, then to ensure an error of Sr = 40%, the determination of the 137Cs activity (40K) should not be more than 30%.

Absolute error (measurement) - the difference between the measurement result and the conventionally true value of the measured value (DSTU-2681-94,

clause 5.2) or the absolute error of the measuring instrument is the difference between the display of the measuring instrument and the true value of the measured value in the absence of methodological errors and errors from the interaction of measuring instruments with the object of measurement (DSTU-2681-94, p. 7.17).

According to the current normative documents in the field of metrology (for example, MI 1317-86, the results of control should be evaluated by the parameters that characterize its reliability.These parameters, according to the existing normative documents, there are errors of the first kind, that is, the level of significance a, or errors of the second kind , which in their content is a confidence probability.

The second stage is to calculate the uncertainty.

The ISO / IEC 17025: 2005 standard confirmed the need for procedures to assess the uncertainty of measurements carried out in accredited laboratories:

- when choosing, developing and evaluating the suitability of the methods and procedures used in the laboratory (p. 5.4.1 of ISO / IEC 17025: 2005);
- using standardized and non-standardized and laboratory-designed calibration or test procedures and procedures (p. 5.4.3, 5.4.4 of ISO / 1EC 17025: 2005 standard);
- when issuing calibration certificates and test protocols (clauses 5.6.2.1.1, 5.10.4.1 of ISO / IEC 17025: 2005 standard);
- when creating programs and procedures for calibrating their own source standards, sample substances and equipment, to ensure the traceability of calibrated and measured by the Laboratory to the International System of Units (SI) (p. 5.6 of the ISO | IEC 17025: 2005 standard).

The implementation of the listed requirements of the standard is based on the use of the "Guidance on the submission of measurement uncertainty" (GUM: 1993) developed by leading international organizations under the influence of international standardization processes for measuring the quality of the measurements and presenting their results. GUM contains unified rules in international practice for uncertainties of measurements and their summation during testing, calibration of measuring equipment, accreditation of metrological services, measuring laboratories, etc. In 1999, the European Accreditation Association published recommendations based on GUM based on "Indication of measurement calibrations" (EA-4/02). In 2001, the Recommendation RMG 43-001 on the application of GUM was established. Since October 2003 Ukraine has also signed the MRA. In July the CMG 43-2001 document was put into effect in Ukraine by the CMOM order.

The basic algorithm for calculating uncertainty of measurements when performing metrological works includes the following operations:

- drawing up a model equation;
- evaluation of input quantities, making corrections to
- known systematic effects in measurement results;
- calculation of the measurement result measurement;
- determination of standard uncertainties of input values;
- determination of sensitivity coefficients;
- calculating the contribution of the uncertainty of each input to the uncertainty of the measured value;

- determination of pairwise correlation of input values;
- calculation of the total standard uncertainty of the measured value;
- calculation of coverage factor;
- calculation of the expanded uncertainty of the magnitude.

As input values in the model equation, in addition to the quantities that are directly measured, the variables are their values and their uncertainties, known from external sources, as well as the correction to the measurement result on the known systematic effects, the main and additional absolute errors of the MESs that are used.

The third stage, which may affect the results of the RK and its reliability, is the sampling of products for radiological research, ie, the RR.

In accordance with GOST 15895-77, a controlled batch of products is a set of units of products of the same name, type or nominal size and size, and executed within a specified time interval under the same conditions and simultaneously submitted for control.

According to the Law of Ukraine "On metrology and metrological activity", all means of measuring equipment used for measuring in the field of state metrological control and supervision (quality control and safety of food products ...) must: first, pass state admission tests and be entered in the State Register of Measuring Instruments (p. 26) or pass state metrological certification and have a certificate about it (p. 27); second, to pass the verification and to have an active certificate about it (p. 28) of the Law of Ukraine "On Metrology and Metrological Activity" dated June 15, 2004 No. 11656-IV.

Thus, measuring instruments (MESs) used to measure the specific activity of radionuclides 137Cs and 90Sr in food and drinking water, in order to provide the Republic of Kazakhstan with compliance with the requirements of the Regulations (GN 6.6.1.1-130-2006 "Permissible levels of radionuclide content 137Cs and 90Sr in food and drinking water ") must meet the following requirements:

- the devices used should be entered in the State register of the MES of Ukraine or a specific model of the device must have a certificate of State metrological certification issued by Derzhspozhyvstandart of Ukraine;
- the limits of permissible relative errors of the MES during the measurement of specific activities of 137Cs and 90Sr radionuclides in samples of food and drinking water should not exceed 40%;
- the devices must have a valid certificate of verification;
- the activity of the radionuclide in the sample should be correlated with the PL for a product that is exposed to RC or investigated as MAM = <kc.cc.PL (kc - concentration coefficient, cc - coefficient calculated for the given reliability of control, which is characterized by the confidence probability p, at p = 0.95, the coefficient cc = 0.66);
- laboratory tests for the content of radionuclides 137Cs and 90Sr in food and drinking water should be metrologically certified methods of measuring the measurements that meet the requirements of ensuring the unity of measurements in force in Ukraine GOST and DSTU and provide the reliability of control of radiation parameters, characterized by a confidence probability not lower 0.95 (significance level ($\alpha = 0.05$).

Conclusions

In the case of using measuring instruments for the purpose of radiation control, the requirements for their metrological characteristics are mainly determined by the permissible value (regulation) of the controlled quantity and the range of its change.

The reliability of the control is determined by the errors (uncertainty) of the measuring equipment and variations of the radiation parameters of controlled samples of food products that are related to their sampling.

Normative document (GN 6.6.1.1-130-2006) establishes the reliability of food and drinking water control at the confidence level of 0.95 (significance level no higher than 0.05).

According to the normative document (GN 6.6.1.1-130-2006), the food product's suitability for use is carried out at the value of the coefficient of correspondence B, taking into account the errors of measuring devices during the control of the specific activities of radionuclides 137Cs and 90Sr in this product.

References

1. Норми радіаційної безпеки України (НРБУ-97). —К., —1998 р. —125 с.
2. ГОСТ 16504-81 Испытания и контроль качества продукции. Основные термины и определения. —М.: Изд стандартов, 1991. —28 с.
3. Закон України "Про метрологію та метрологічну діяльність" від 15.06.2004 №11765-IV.
4. ГН 6.6.1.1-130-2006. Допустимі рівні вмісту радіонуклідів ^{137}Cs і ^{90}Sr у продуктах харчування та питній воді (Затв. Наказом МОЗ України від 03.05.2006, №256, та зареєстр. в Мін'юсті України 17.07.2006 р., №845/12719).
5. ДСТУ 3021-95. Випробування і контроль якості продукції. Терміни та визначення. —К.: Держстандарт України, 1999. —53 с.
6. Закон України "Про статус і соціальний захист громадян, які постраждали внаслідок Чорнобильської катастрофи" №2400-III від 26.04.01, зі змінами та доповненнями.
7. Радіаційно-дозиметрична паспортизація населених пунктів території України, що зазнали радіоактивного забруднення внаслідок аварії на ЧАЕС, включаючи тиреодозиметричну паспортизацію: Інструктивно-методичні вказівки. —К., 1996.
8. ДСТУ 2681-94. Державна система забезпечення єдності вимірювань. Метрологія. Терміни та визначення, К.: Держстандарт України, 1999. —67 с.
9. ГОСТ 15484-81. Излучения ионизирующие и их измерение. Термины и определения. М.: Изд. стандартов, 1984. —22 с.
10. ДСТУ 3743-98. Державна повірочна схема для засобів вимірювань активності, питомої активності та об'ємної активності радіонуклідів. —К.:, Держстандарт України, 1996. —27 с.
11. МИ1317-86. Методические указания. Государственная система обеспечения единства измерений. Результаты и характеристики погрешности измерений. Формы представления. Способы использования при испытаниях

образцов продукции и контроле их параметров. —М.: Изд. стандартов, 1987. —64 с.

12. Бейли Н. Статистические методы в биологии. —М.: Изд.Иностранной литературы, 1962. —260 с.

13. Урбах В.Ю. Статистический анализ в биологических и медицинских исследованиях. —М.: Медицина, 1995. —295 с.

14. ГОСТ 15895-77. Статистические методы управления качеством продукции. Термины и определения. —М.: Изд стандартов, 1989. —45с.

15. ДСТУ 2681-94. Державна система забезпечення єдності вимірювань. Метрологія. Терміни та визначення. —К.:, Держстандарт України, 1999. — 41 с.

16. ДСТУ 3021-95. Випробування і контроль якості продукції. Терміни та визначення. —К.:, Держстандарт України, 1998. —57 с.

17. ДСТУ 3215-95. Метрологічна атестація засобів вимірювальної техніки. Організація та порядок проведення. —К.:, Держстандарт України, 1999.—48 с.

18. ДСТУ 3240-95. Вимірювання іонізуючих випромінювань. Метрологічне забезпечення. —К.:, Держстандарт України, 1997. —38 с.

19. ГОСТ 18321-73. (СТ СЭВ 1934-79.) Статистический контроль качества. Методы случайного отбора выборок штучной продукции. —М.: Изд. стандартов, 1987. —44 с.

20. ГОСТ 15895-77. Статистические методы управления качеством продукции. Термины и определения. —М.: Изд. стандартов, 1983. —39 с.

21. ГОСТ 15484-81. Излучения ионизирующие и их измерение. Термины и определения. —М.: Изд. стандартов, 1984. —32 с.

22. ГОСТ 12997-84. Изделия государственной системы промышленных приборов и средств автоматизации (с изменениями и дополнениями). —М.: Изд. стандартов, 1985. —41 с.

23. ГОСТ 8.207-76. Прямые измерения с многократными наблюдениями. Методы обработки результатов наблюдений. Основные положения. —М.: Изд. стандартов, 1981. —48 с.

24. ГОСТ 8.010-89. Методики выполнения измерений. Основные положення. —М.: Изд. стандартов, 1991. —28 с.

25. 20 років Чорнобильської катастрофи. Погляд у майбутнє. Національна доповідь. —Київ: Атіка, 2006. —323 с.

26. Закон України "Про захист людини від впливу іонізуючого випромінювання" №2397-III від 26.04.2001.

27. СТУ-РУкрАО913.15:2007. Стандарт асоціації «Українські акредитовані органи з оцінки відповідності» (УкрАО). Рекомендації з метрологічного забезпечення випробувальних і калібрувальних лабораторій. –К.: Виконавчий орган УкрАО, 2007.- 101с.