Review of the VNIIM Activity in the Field of radioactivity. 2001 – 2003

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I. Radionuclide Activity Measurement.

1.1. Activity measurements of ^{226}Ra primary standard mass.

1.2. Environmental samples measurement:

- measurements of photon flux of ^{235}U standard sources of tube and sphere geometry;
- calculation of virtual mass ^{235}U in the range 10-1000 g.

1.3. Development of a secondary standard of activity on the basis of semiconductor detectors - definition of factors of cascade summation correction for semiconductor detectors of a great volume.

1.4. Standardization of industrial and medical reference sources.

- measurement of KX and LX – ray fluxes in the range 10-350 keV from medical reference sources;
- restoration of a real photon spectrum of bremsstrahlung radiation from medical β-emitting radionuclides (^{147}Pm, ^{204}Tl) sources in a range 10-350 keV, from the apparatus spectrum using the method of a response function;
- definition of the coefficient of dependence between the photon flux of KX-ray, activity and air kerma radionuclides of medical KX-ray sources on the basis radionuclides: ^{147}Pm, ^{204}Tl, ^{153}Gd, ^{238}Pu, ^{241}Am etc;
- routine standardization of 25 radionuclides in point, volume and surface sources.

1.5. Improvement of measurement techniques.

- theoretical calculation of the counting efficiency for 4πγ NaI detector by VC3D Monte-Carlo Code for cascade radionuclides: ^{166}Ho, ^{152}Eu, ^{154}Eu, ^{134}Cs, ^{133}Ba etc;
- measurement of ^{134}Cs activity solution with 4πγ NaI well crystal at LNHB;
- designing a new large 4πγ NaI detector of the sandwich type (two crystals 200*100 mm, entrance window-0.5 mm Al) (in progress);
- development of the VC3D Monte-Carlo Code;
- using PENELOPE Monte-Carlo code for theoretical calculation of the counting efficiency of the 4πγ NaI detector

II. International Activities

2.1. Participation in the ICRM'2001 conference held at PTB, Braunschweig, Germany.

2.2. Participation in the BIPM full scale international comparisons of ^{238}Pu, ^{204}Tl and ^{65}Zn solutions.

2.2.1. The VNIIM received ampoule No. A1189/00 with ^{238}Pu solution.

The ^{238}Pu activity was measured by two methods: 4πa-LX-coincidence and the defined solid angle method (DSA). The 4pa-LX-coincidence method is realized on an installation with a proportional 4π-counter for registration of a-particles and scintillation counter with a 1 mm thick crystal NaI (Tl) with beryllium window. LX-photons were registered in the (10-30) keV energy window. The dead time in each channel was (1.2±0.1) μs, the coincidence resolving time was (0.916±0.003) μs. The maximal counting efficiency of a-particles in the 4π-counter was 99.8%.

Special attention was paid to stability of the resolving and dead time during measurements, as the sources were manufactured with activity from $5 \cdot 10^3$ Bq up to 10^4 Bq because of weak intensity of LX-radiation. The stability of operation was tested by measurement of ^{198}Au activity in gold foil during approximately two half-lives of ^{198}Au (7 days).

The greatest uncertainty component (0.15 %) was connected with measurement of background in the LX-channel. The combined uncertainty was 0.16%.

In the DSA method a-particles were counted with a ZnS(Ag) detector by thickness less than 100 μm and diameter of 80 mm. The combined uncertainty of this method was 0.14%.

The measurement results agreed within limits of the estimated uncertainty.

2.2.2. The VNIIM received ampoule No. 30 with ^{204}Tl solution.

The ^{204}Tl activity was measured by a 4πβ-counting method in a proportional 4π-counter. The dead time was (3.0±0.1) μs. The corrections for β-particle absorption in the film and source material were measured to be 1.1%.

The decay scheme correction (Auger electrons because of an electron capture branch) was taken from tabular data and is estimated to be 2.0%. The combined uncertainty was 0.4%.

2.2.3. The ^{65}Zn solution for international comparison was obtained in ampoule No. Zn0228. Two methods were used to measure its activity: the conventional 4π $(KX+e^-)$-γ-coincidence extrapolation method and the KX-γ-coincidence method in small solid angles on an installation with two scintillation crystals NaI (Tl) of different thickness.

In the 4π $(KX+e^-)$-γ-coincidence method the Auger electrons and X-rays were registered in a proportional 4π-counter filled with mixture of 90% Ar + 10% CH_4 at a pressure of 0.1 MPa. γ-rays were registered with a NaI(Tl) scintillation crystal 40 mm thick and 40 mm in diameter in the (453-1200) keV energy window. The maximum efficiency was obtained 41%. The efficiency was varied (down to 20%) by adding films and foils to sources, and also by changing the proportional counter voltage. It was noticed that because of peculiar properties of the ^{65}Zn decay scheme there is a considerable uncertainty in fitting the linear dependence of measurement result on the counting efficiency in the proportional counter and its extrapolation to 100 %, therefore uncertainty of the result in this method was estimated in 1.25%. In our opinion the KX-γ-coincidence method using two scintillation crystals NaI(Tl):

100 μm thick with beryllium window (KX-ray detector) and 40 mm thick (γ-ray detector) is more precise in ^{65}Zn activity measurement. The main uncertainty component in this method is due to counting statistics, and the complete combined uncertainty of this method is determined in 0.25%. The results of both measurement methods coincided within limits of the estimated uncertainty, but we consider the result obtained by the KX-γ-coincidence method as more reliable and our main result.

2.3. With the BNM-LNHB (France) standardization and determination of the γ-ray emission probabilities for ^{154}Eu and ^{226}Ra.

2.4. Participation in the project 236/BY/01 COOMET: "Interlaboratory comparisons of colza standard reference material of the Cs^{137} specific activity"

2.5. Participation in the intercomparisons of β-emitting rate of ^{36}Cl large area source with NIST, INER, KRISS, PTB, CSIR and NMIJ/AIST.