VNIIM activity in the Field of X-ray, Gamma- Beta- and Electron Radiation Dosimetry 2001 – 2003

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Introduction

The basic directions of the dosimetry group's activity were:

- research work bared on the State Primary Standards of:
  - air kerma and air kerma rate of X-ray and γ-radiation;
  - absorbed dose and absorbed dose rate of β-radiation;
  - electrons flux, electrons flux density and fluence, energy flux, energy electron and bremsstrahlung radiation flux density and fluence;
- international cooperation;
- calibration and verification of measuring means for consumer and manufacturers of dosimetric equipment;
- testing of dosimetric measuring means applied for control of radiation safety and in medical radiology;
- certified testing of production based on use of generating and radionuclide sources;
- preparation and development of normative documentation in the field of dosimetry.

1 Research Work

Research work, which was carried out on the State Primary Standards, was directed to decrease of the uncertainty of transfer of the size of dosimetric units to the Secondary Standards and to the working measuring means.

1.1 The X-ray spectra measurements were carried out for modes with photon energies in the range 10-50 keV and 50-300 keV including modes of the series H, N, L (ISO 4037) and modes RQR and RQA (IEC 61267). The measurements were made on the basis of HPGe-semiconductor detector.

1.2 The modernization of the standard extrapolation parallel plate ionization chamber EK-2M was carried out. The tissue-equivalent entrance window was changed to thinner one (1,3 mg/cm^2). It allows to measure of beta-radiation absorption and attenuation in the range of beta-particles mean energy from 17 keV to 930 keV.

1.3 The Complex Standard of electrons flux, electrons flux density and fluence, energy flux, energy electron flux density and fluence, bremsstrahlung

radiation with energy from 0,1 to 50 MeV flux density and fluence was confirmed as` State Primary Standard (SS 72-01).

1.4 The preliminary experimental investigations for determination of the connection's coefficients between the bremsstrahlung radiation energy flux density with energy from 0,1 to 50 MeV and air kerma were carried out.

2 International cooperation

The international cooperation was directed on completion of bi-lateral comparison between VNIIM and PTB in beta dosimetry, actualization of VNIIM calibration services, participation in the International Conferences and Symposiums.

2.1 The final stage of bilateral comparisons of the Russian and German National Standards in the field of beta-radiation was carried out by using VNIIM's fixed volume parallel plate ionization chamber PK2-1-type № 02. As a result of this comparison the calibration factors for chamber PK2-1 were obtained from standard beta radiation fields of $^{90}Sr+^{90}Y$, ^{85}Kr, ^{147}Pm radionuclide sources on the 7 mg/cm^2 of soft tissue depth. So we have calibration coefficients for PK2-1 chamber obtained in the standard fields of beta-radiation BNM-LNHB(France), PTB(Germany) and VNIIM(Russia). Project of joint publication was prepared on the basis of comparison of Russian and German Standards.

The possibility of including this bilateral intercomparison in the EUROMET program was discussed and the decision about introducing on the CCRI Meeting of the proposal for the beta intercomparison should be organized by CCRI and/or EUROMET.

The draft of joint paper was prepared on the basis of summarized results of two stages of intercomparison

2.2 The modern base of the VNIIM calibration services in the field of dosimetry was introduced to COOMET. In frames of realization of mutual inspections RMO calibration services the audit calibration services of was carried out for the IAEA, CSIR, PTB, VNIIFTRI and BelGIM.

2.3 The Report concerning the questions of traceability of the units of kerma in air and kerma rate in air from the VNIIM National Standard to the medical measuring means was introduced to the International Symposium on Standards and Codes of Practice in the Medical Radiation Dosimetry (November 25-28, Vienna, Austria).

3 Calibration and verification of measuring means

In accordance with the Law of the Russian Federation “About the Ensuring of the Unity of Measurements” all measuring means used in radiation safety, labor protection, medicine, customs and bank operations are examined by the State Verification before their putting on the market (delivery on import) and in a process of operation.

3.1. During 1999-2000 the calibrations and verification more than 320 dosimetric measuring means including UNIDOS dosemeters with a set of ionizing chambers of the types 77335, 77334, 30001, 31002, 23342, 23343 (for the Belarus NMI and the Belarus NII of Oncology and Medical Radiology) and radionuclide sources including ^{55}Fe, ^{57}Co, ^{60}Co and ^{226}Ra were carried out.

3.2. The comparisons of six Secondary Standards of kerma in air and kerma rate in air for gamma-radiation of ^{137}Cs and ^{60}Co were carried out. These Standards belong to the metrological services of the enterprises-manufacturers of the dosimetric equipment, to the Regional Center of Metrology and Standardization, Base Dosimetric Laboratory of Health Ministry of Russia and Metrological Service of Military Ministry of Russia. Comparison with State Primary Standard was made using the comparator – a set of ionizing chambers of M 30001, TM 23361 and TM 32002 types. The total comparison uncertainty $S_{\Sigma} = 0,8–0,9$ %.

4. Trials of measuring instruments types and certification tests for radiation safety

All types of measuring means produced in Russia or being imported to our country are tested to confirm all metrological and technical characteristics declared by manufacturer and to establish conformity to the Russian and International Standard's requirements. The types of measuring means with good testing results are included in the State Register of Measuring Instruments that allows to use them on the Russian Federation territory.

According to Russian laws production including the generating and radionuclide sources is tested for the radiation safety.

VNIIM is authorized by Gosstandart of Russia for carrying out these tests to confirm the type of measuring means and do certification tests for radiation safety.

4.1 21 tests of dosimetric measuring means of Russian and foreign enterprises were carried out for this period of time. The following devices are among them:

- individual dosemeters RAD-62 and DIS-1 (“Rados Tecnology Oy”, Finland);
- devices for radiation monitoring: dosemeters-radiometers MKC-AT1125 (NPP “ATOMTEX”, Belarus), dosemeters SmartION (St.Gobain Crystals & Detectors UK LTD, GB);
- for medical radiology: x-ray dosemeters DEP-01M (“Gelpic”, Russia), dosemeters Keithley Model 35040 (Keithley Instruments Inc, USA) etc.

4.2 For this period six certification tests of the measuring means were carried out for radiation safety of the products generating x-ray or including radionuclide sources. Among them there are customs examination units “Shmel-90/K” and x-ray portable scanner for inner cavities “Watson” (“FLESH ELECTRONIC’, Russia), a set for clearing and cementation of liquid radioactive waste products MMCY GRO (A.P.Aleksandrov NITI, Russia) etc.

4.3 The energy dependences of sensitivity were investigated for new types of dosimetric devices with detectors on the basis of ionizing chambers, organic and inorganic scintillators, Si-diodes and Geiger-Muller counters of various modifications.

5 Elaboration of the basic standard documents in dosimetry

The laboratory activity in this field implies the elaboration of the International and State Standards (GOST and GOST-R), supervising documents (RD) and methodical instructions (MI) in the field of ionizing radiation. Besides the methodical instructions on primary and periodic verification of measuring means are also developed by the laboratory.

5.1 More than 14 techniques of carrying out of verification and calibration of the dosimetric measuring means were prepared during 2001-2003, among them there is one technique for x-ray dosemeters in the RQR and RQA modes and the other one is for verification of the radiation control systems using the portable control complexes.

5.2 Eight techniques of measurements applying dosimetric measuring means in working conditions were prepared. Among them there is “Technique of carrying out measurement of absorbed dose rate in air in the primary beams of long-term and short-term (duration is not higher then 30 ms) of x-ray equipment and behind the shielding applying portable dosemeters”, “Technique of carrying out measurement of equivalent dose rate for gamma-ray on the surface individual protection of the radiation-technology sets with electrons accelerator (till 1 MeV)”.

5.3 The first dedition of International Standard for CIS countries “Ionizing radiations and their measurements. Terms and definitions” was written. It standardizes the terminology in the field of ionizing radiation.

PUBLICATION

1. N.D.Villevalde, A.V.Oborin, E.N.Yurjatin, I.A.Kharitonov **"To the Question about Condition of Metrological Ensuring for Dosimetric Measurements X-ray and Gamma Radiation".** *Proceedings of the International Symposium "Actual Problems of Dosimetry", Minsk, 24-26 October, 2001.*

2. I.A.Kharitonov, N.D.Villevalde, A.V.Oborin **"Calibration of the Dosemeters for Radiation Protection in Accordance with Demands of Modern Native and Foreign Standards"**. *Proceedings of International Conference "Radiation Safety: Ecology – Atomic Energy ", St.Petersburg, 24-28 September, 2001.*

3. I.A.Kharitonov, N.D.Villevalde, A.V.Oborin **"To the Question about Determination of Fixing Characteristics of Monitors at Release it from Manufacture and Exploitation"**. *Proceedings of International Conference "Radiation Safety: Ecology – Atomic Energy ", St.Petersburg, 24-28 September, 2001.*

4. D.T.Burns (BIPM), N.D.Villevalde, A.V.Oborin, E.N.Yurjatin (VNIIM) **"Comparison of the air kerma standards of the VNIIM and the BIPM in the medium-energy X-ray range".** *Rapport BIPM-2001/07, 11pp.*

5. D.T.Burns (BIPM), N.D.Villevalde, A.V.Oborin, E.N.Yurjatin (VNIIM) **"Comparison of the air kerma standards of the VNIIM and the BIPM in the low-energy X-ray range".** *Rapport BIPM-2002/06, 12pp.*

6. I.A.Kharitonov, N.D.Villevalde, A.V.Oborin, V.I.Fominykh "**Air Kerma National Standard of Russian Federation for X-ray and Gamma Radiation. Activity SSDL/VNIIM in Medical Radiation Dosimetry Field**". *International Symposium on Standards and Codes of Practice in Medical Radiation Dosimetry, Vienna, Austria, 25-28 November, 2002, IAEA-CN-96, pp.33-34.*

7. I.A.Kharitonov, I.I.Tsvetkov "**The New State Primary Standard of Russia for Metrological Ensuring of Release from Manufacture and Exploitation the Medical and Indastrial Accelerators "**.*Proceedings of X International Meeting on Application of the Charged Particles Accelerators in Industry and Medicine, St.Petersburg, 1-4 October, 2001.*

8. I.A.Kharitonov, I.I.Tsvetkov "**Research of Metrological Characteristics of the Measuring Cannel with Ionization Chamber IC-70-0,6 sm^3 and Electrometer Keithley for Medical Accelerators SL75-5MT"**.*Proceedings of X International Meeting on Application of the Charged Particles Accelerators in Industry and Medicine, St.Petersburg, 1-4 October, 2001.*

9. V.L.Uvarov, I.I.Tsvetkov "**Development of Methods and Instruments for Invasive Diagnostic of the Scanning Electrons Beam "**.*Proceedings of X International Meeting on Application of the Charged Particles Accelerators in Industry and Medicine, St.Petersburg, 1-4 October, 2001.*

10. I.A.Kharitonov, I.I.Tsvetkov "**The State Primary Standard of Units of Flux, Flux Density and Fluence of Electrons, Flux energy, Flux Density Energy and Fluence of Energy Electrons and Bremsstrahlung Radiation – GET 72-01"**, *Izmeritelnaya Technica*, № 9, 2002.