QUALITY ASSURANCE AND QUALITY CONTROL IN YUGOSLAV ENVIRONMENTAL RADIATION PROTECTION METROLOGICAL AND LEGISTATION SYSTEM

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INTRODUCTION

Quality Assurance and Quality Control in Ionizing Radiation Metrology is performed through legal metrology, international and national intercomparation procedures and routine control of instrumentations and standards. Legal metrology defines methods, units, standards and instrumentations according to the technical and legal demands in all the aspects of Quality Assurance and Quality Control. According to international standards, legal metrology is performed by the national metrological organizations obliged to assure primary standards for physical quantities and their transfer to the user. In Yugoslavia the national metrological organization is the Federal Bureau for Measures and Precious Metals in charge to introduce primary and secondary standards and necessary legistations.(1) International intercomparations are within the domain of the Bureau International des Poids et Mesures, BIPM, in Sevre, France. Yugoslavia participated in international intercomparations in December,1991 in Sevre and in Budapest, in 1995. In the last ten years, several national intercomparations took place ( ).Routine control of instrumentations and standards is regulated by the National Law On Units And Instrumentation ( Sl list SRJ”, br.80/94, 28/96 i 12/98).

Still, according to Organization International de Métrologie Légale OIML only a few of the 54 states-members (in 1996) developed the consistent legal system in the area of ionizing radiation concerning general public application, as it is the case for medical applications. Only 18 of them, mostly technically developed countries had legally regulated the control of instrumentations, units and quantities of ionizing radiation, including Yugoslavia (5)

LEGAL METROLOGY OF IONIZING RADIATION IN YUGOSLAVIA

Federal Bureau of Measures and Precious Metals formally introduced Ionizing Radiation Metrology in its program in 1981, when Commission for Ionizing Radiation has been formed. The Commission formed several working groups: Working Group For Unification Of Units And Standards In Radiotherapy (now as Working Group For Medical Dosimetry); Working Group For Nuclear Instrumentation (now Working Group For Activity Of Radionuclides), Working Group For Non-Ionizing Radiation, dismissed in 1991, and
Working Group For Neutron Metrology. The first Yugoslav Protocol In Radiotherapy was one of the outstanding results of the working groups activities in.. ( ). In 1989, the Laboratory For Ionizing Radiation was formed.

The Bureau is now in possession of 3 primary standards in dosimetry of gamma radiation and high energy and mid-energy X ray radiation, and secondary standards in dosimetry of low energy and mid-energy X ray radiation and in dosimetry of radionuclides activity – α and γ emitters.

Primary standard of kerma in air is a gamma radiation $^{60}$Co graphite ionizing chamber, 1,0142 cm$^3$, type ND1005/A with electric current integrator ( National Office of Measures (OMH), Budapest. It was the standard the Bureau participated with in two international intercomparations (18*, 19*, 20*, 21*, 22*) and the standard was categorized the third on the global level, as announced in the BIMP Report 1990-1996 by the director of BIMP, Dr T.J.Quinn (23*). Standard has total uncertainty of 0,18%, 1σ. (Table 1).

Table 1. International intercomparations of kerma in air ($^{60}$Co), BIPM 1990-96.

<table>
<thead>
<tr>
<th>Laboratory</th>
<th>Country</th>
<th>Year</th>
<th>$K_{lab}/K_{BIPM}$</th>
<th>$\sigma$</th>
</tr>
</thead>
<tbody>
<tr>
<td>NMI</td>
<td>Holland</td>
<td>1991</td>
<td>1.0022</td>
<td>0.0046</td>
</tr>
<tr>
<td><strong>SZMMD</strong></td>
<td>Yugoslavia</td>
<td><strong>1991</strong></td>
<td><strong>0.9982</strong></td>
<td><strong>0.0019</strong></td>
</tr>
<tr>
<td>UDZ</td>
<td>Czech R.</td>
<td>1992</td>
<td>0.9992</td>
<td>0.0023</td>
</tr>
<tr>
<td>LPRI</td>
<td>France</td>
<td>1993</td>
<td>1.0025</td>
<td>0.0026</td>
</tr>
<tr>
<td>BEV</td>
<td>Austria</td>
<td>1994</td>
<td>1.0040</td>
<td>0.0022</td>
</tr>
<tr>
<td>OMH</td>
<td>Hungary</td>
<td>1994</td>
<td>1.0025</td>
<td>0.0024</td>
</tr>
<tr>
<td>BEV</td>
<td>Austria</td>
<td>1995</td>
<td>1.0038</td>
<td>0.0025</td>
</tr>
<tr>
<td>BEV</td>
<td>Austria</td>
<td>1995</td>
<td>1.0020</td>
<td>0.0025</td>
</tr>
<tr>
<td>LNMRI</td>
<td>Brazil</td>
<td>1995</td>
<td>1.0004</td>
<td>0.0023</td>
</tr>
</tbody>
</table>

Primary standard for absorbed dose in tissue is performed by ionometric method with a ionizing chamber with hole for tissue equivalent materials, type ND 1006, volume 0,27 cm$^3$ with current integrator, OMH, Budapest and tissue equivalent phantom (water and PMMA); uncertainty 0,6%, 1σ. There is a primary standard for exposure only for gamma radiation $^{60}$Co in graphite ionizing chamber with hole, type ND 1005/A., uncertainty 0,18%, 1σ.

Secondary standards for exposures of low and mid-energy X ray radiation are a plan-parallel ionizing chamber, type NE 2532/3C, volume 0,03 cm$^3$ and an ionizing chamber with hole, type NE 2530, volume 35 cm$^3$, both products of NE Technology Limited, UK, with electrometer Farmer, by Keithley, UK. For radionuclides activities, there are secondary standards for α and γ radiation: a semiconductor detector - spectrometer ORTEC, and a secondary reference materials for activity of the radionuclides $^{137}$Cs; $^{55}$Fe; $^{241}$Am, $^{60}$Co and $^{226}$Ra. The Bureau has a 4πγ ionizing chamber under pressure (CENTRONIC), but there is not complete electronic equipment to be included in SIR.
NATIONAL INTERCALIBRATIONS IN YUGOSLAVIA

The Bureau organized several intercalibrations concerning methods and standards. First one concerning the methods was the intercalibration of semiconductor detectors - HPGe gamma spectrometers in 1991 and 1992, in which 15 national laboratories took part. The reference materials for the intercomparation were prepared in the Laboratory for Radiochemistry, in the Institute of Nuclear Sciences Vinca, Belgrade, while the reference intercalibration materials were: milk powder, soil and water, contaminated by $^{22}\text{Na}$, $^{57}\text{Co}$, $^{60}\text{Co}$, $^{88}\text{Y}$, $^{133}\text{Ba}$ and $^{137}\text{Cs}$, produced by OMH, Budapest.

The first intercomparation of the personnel dosimeters was performed in 1991, and 10 institution involved in the area of personnel dosimetry took part. Two other intercomparations in dosimetry in collaboration with Institute Vinca and Military Academy Clinics were performed from 1991 up to now.

First Yugoslav intercomparison of dosimeters in radiotherapy with ionizing chamber took place in 1993. The intercomparation was performed in collaboration with the Institute of Oncology and Radiology of Serbia, Belgrade and included 5 radiotherapy centers. The results pointed to some corrective measures that were undertaken afterwards.

Until 1996, several intercomparations of absorbed dose were performed on the national level. As the result, in 1997, Yugoslavia joined the IAEA and WHO intercomparation of TL dosimeters: three radiotherapy center took part and best results were obtained for the Institute of Oncology and Radiotherapy of Serbia, whose secondary standard is closely correlated metrologically with the primary standard of the Federal Bureau.

LEGAL IONIZING RADIATION METROLOGY SYSTEM IN YUGOSLAVIA

Yugoslav Federal Bureau presented 63 legal metrological instructions for standards and instrumentation in the area of ionizing radiation metrology, including necessary classifications for activity unit standards for $\alpha$, $\beta$ and $\gamma$ emitters, exposures, doses in radiotherapy and radiation protection, absorbed doses including proton and neutron radiation.

Another important activity of the Federal Bureau is in the field of continuous staff education. Education of stuff includes not only stuff within the working groups for ionizing radiation but also the stuff outside the Bureau, all those working with the sources of ionized radiation in hospitals, industry and institutes. Workshops and seminars are regularly held and attended.
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