

ORGANIZATION OF THE IONIZING RADIATION METROLOGY IN BRAZIL

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Abstract: In this work it is presented the historical of the implementation and evolution of the metrology of the ionizing radiations in the Instituto de Radioproteção e Dosimetria, the formation of its technical staff, its participations in the Key-comparisons and in the metrological traceability programs developed by its metrology laboratory. It is also presented the main commitments assumed, as the adhesion to the Mutual Recognition Arrangement, MRA, the implementation and improvement of a quality system based on the ISO/IEC 17025, and the results of some quality indicators as the participations in scientific events and publications.

Keywords: Metrology, Ionizing radiation, Organization.

1. INTRODUCTION

In 1989 the National Institute of Metrology, Standardization and Industrial Quality, INMETRO, delegated to the Instituto de Radioproteção e Dosimetria, IRD, the right to act in the national level as designated laboratory in the area of ionizing radiation, with the mission to establish measurement methods and to disseminate the units related to the quantities in the field.

With the signature of the Mutual Recognition Arrangement, MRA, the thirty-eight signatories countries gave an important step for the recognition of their measurements and they created a strong tool for the basis of wide commercial agreements.

The meter convention, which is an agreement of diplomatic basis, gave to the BIPM the authority to establish the metrological equivalence of the standards that support the MRA.

2. HISTORICAL

In the beginning of the 70th-decade, the IRD already possessed laboratories that developed activities in the area of ionizing radiations metrology, i.e., the neutrons laboratories, radionuclide calibration and radiation dosimetry. These laboratories would later on compose the

National Laboratory of Ionizing Radiations Metrology, LNMRI.

In 1976, IRD started to integrate the Secondary Standard Dosimetry Laboratories, SSDL, network, coordinated by the International Atomic Energy Agency, AIEA, with support of the World Health Organization, WHO. The network was established to guarantee the quality of the measurements made in the field of the ionizing radiations worldwide.

As a consequence of the development of research activities and academic improvement accomplished in IRD/CNEN, in 1986 a researcher of LNMRI started to integrate the International Committee of Radionuclide Metrology, ICRM; participating in the first key-comparison organized by BIPM, using a primary calibration method for the quantity activity.

In 1989 the INMETRO designated LNMRI/IRD as a national laboratory for metrology of ionizing radiation. After the radiological accident of Goiânia, happened in 1987, the demand for calibration of radiation protection instruments at IRD was rapidly growing, and IRD decided to create a network of calibration laboratories to supply this demand. By this time there were only two laboratories available in the country, IRD and IPEN, in São Paulo. Later on, in 1991, the IRD submitted a cooperation project to the IAEA to improve the calibration network, create new laboratories for radiation protection in other regions of Brazil, and guarantee the traceability of the measurements in the field of worker's safety.

In 1996, BIPM donated to Brazil a steel sphere to be used in the manganese sulfate bath method, used as the primary standardization method of neutron sources. This method is used in research and development and in comparisons organized by BIPM.

In October 14th, 1999, the president of INMETRO and the coordinator of LNMRI, together with 38 countries signatories of the Meter Convention, they signed the Mutual Recognition Arrangement, MRA. Now, 45 countries have already jointed to the agreement. The main objective is to establish the degree of metrological equivalence of the standards maintained by the National Metrology Institutes,

NMI, to provide the mutual recognition of the calibration certificates and to supply technical and sound basis, for wide scientific and technological agreements, as well as agreements related to the international trade. The technical basis for the recognition of the certificates is the equivalence of the national standards established by means of the key-comparisons organized by BIPM and for the Regional Metrology Organizations.

In 2003, two LNMRI researchers' curricula were submitted to BIPM to compose its Consultative Ionizing Radiation Committee, CCRI. Now Brazil possesses representatives in three sections of the advisory committee (Dosimetry, Neutrons and Radioactivity).

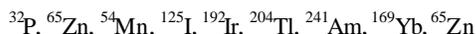
In 2004 it was implemented in LNMRI-IRD the requirements of the ISO/IEC 17025 standard for calibration laboratories. In this phase LNMRI was submitted to a Peer Review in order to validate the ISO standard requirements implementation. The quality system of LNMRI went soon after evaluated a in meeting of the Interamerican System of Metrology, SIM, being considered approved.

3. METROLOGICAL TRACEABILITY PROGRAMS

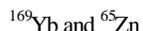
3.1. Quantity Activity

In the last five years, LNMRI has participated in several key-comparisons organized by BIPM as well as for Regional Metrology Organizations, seeking to establish the metrological equivalence of standards. To illustrate this work period, the main comparisons that LNMRI has participated are shown in items (a), (b) and (c):

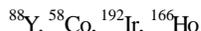
(a)- key-comparisons in radionuclide metrology organized by BIPM:



(b)- key-comparisons organized by EUROMET:



(c)- Key-comparisons organized by APMP:



3.2. Quantity Air-kerma and water Absorbed Dose

In terms of the quantity Air-kerma, the standard of LNMRI was compared with the standard of BIPM in 1986, 1996 and 2003. The agreement among the values measured by the standards of BIPM and LNMRI has been on the average of 0.1%.

In 2001 LNMRI participated in the key-comparison organized by the SIM for the quantity Air-kerma and Absorbed Dose to water, obtaining excellent results.

3.3. Comparison for neutron

The comparison accomplished by BIPM for neutron fluency was identified as CCRI(III)-K9.AmBe - organized in the period 1999/2005.

4. TRACEABILITY PROGRAMS ORGANIZED BY LNMRI

4.1. Chain of Traceability

The traceability in the radiation dosimetry area is established by means of the LNMRI standards, which are traceable to BIPM and PTB, and disseminated to the laboratories that participate in the Ionizing Radiation Metrology Network (IRMN), Figures 1 and 2 show the traceability chain between LNMRI, BIPM, and the IRMN.

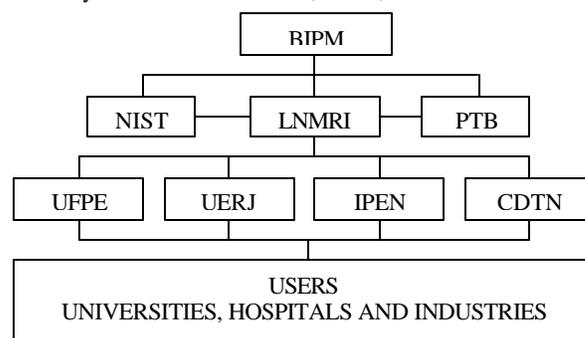


Fig. 1. Metrological traceability of the equipment of the user to the National Laboratory and this to BIPM for the quantity air-kerma

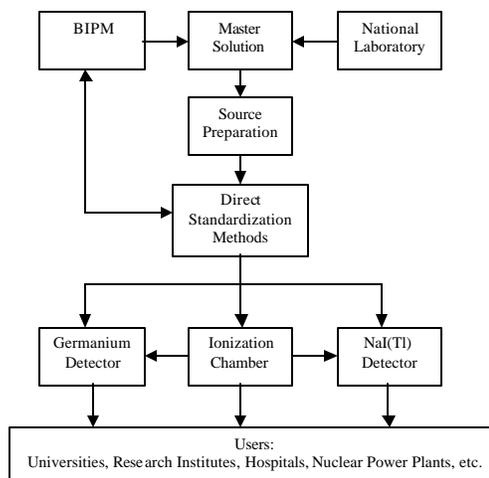


Fig. 2. Traceability to BIPM of the solutions and radioactive sources distributed to the users by the LNMRI

4.1.1. Air-kerma and Absorbed dose to water

The calibrations of the standards of the participant laboratories from the metrology network are executed periodically by LNMRI, and cover the radiation protection radiotherapy and applications.

4.1.2. Quantity Activity

The quantity activity has been worked arduously by LNMRI, in the last 20 years, because the calibration methods and measurements vary for each radionuclide and the maintenance of the standard is more complex, due to the radioactive decay with time.

For this reason, the metrological traceability is established for each radionuclide using the key-comparisons of BIPM and the submission of the measured values to the International Reference System SIRD of the BIPM.

In Brazil, the standard sources are disseminated in general for the research laboratories and users.

A National Program of Intercomparison, PNI, has been running for 15 years to guarantee the quality of the activity measurements for the environmental samples analysis laboratories. Every year there are three comparisons runs within PNI, with distribution of samples of several types of matrices and radionuclides, with posterior evaluation of the results of the determinations for the laboratories and emission of confidential report. From 1991 to 2004, 5767 assays were performed, for 22 participant laboratories with determination of 30 radionuclides.

Another program for quality control of the activity measurements is associated with the National Program of Comparison for radiopharmaceutical radionuclides, used by the Services of Nuclear Medicine. After accomplishing several comparison runs in the state of Rio de Janeiro, the program was extended in a metrological network to the whole country, covering the center-west and south region and it is beginning prepared to include the Northeast, North and Southeast regions. All the measurements are traceable to LNMRI and also to BIPM.

5. RESEARCH PROGRAMS

5.1. Description

The main research program of LNMRI is addressed to the implementation and optimization of measurement methods of the basic quantities of ionizing radiations metrology, involving the dosimetry, neutrons and radioactivity fields.

Radionuclides with short half-life, used in radiopharmaceutical products used in Nuclear Medicine, need an absolute calibration and metrological traceability to BIPM and it has also been treated with special attention in the determination of its nuclear parameters, as values of the half-life and gamma transition probability.

To perform these activities, new calibration methods were introduced, for instance, the CIEMAT-NIST method, coupled to liquid scintillation counters, and the double and triple coincidence (TDCR) methods.

In the dosimetry field, LNMRI introduced a new quantity, recommended by international organizations, for the measurement of doses of individuals occupationally exposed to the ionizing radiations within the country. LNMRI has participated in comparisons, coordinated by the IAEA, for this area and has presented a good performance.

5.2. Reduction of the measurements uncertainties

The quality of a measurement can be perfectly assessed by its uncertainty value, together with a detailed description of the type A and B components, exhibited in a worksheet.

A quality improvement of LNMRI can be observed in the key-comparisons results, as informed in the reports of BIPM, where LNMRI has reached results very close to the reference values, and presented measurement uncertainty

values among the smallest ones presented by the participants.

In the nuclear field, a quality improvement of the measurements is directly linked to the increase of the exposed worker's safety.

Additionally, the calibration and measurement systems are being gradually automated. This project will favor the reduction of human mistakes during information transfers and in the positioning of instruments.

5.3. Participation in scientific meetings and publications

The activities performance and the researches results of LNMRI can be observed by the frequency of participation in scientific meetings and specialized Committees of BIPM and of the Interamerican System of Metrology, SIM. The Figure 3 shows the participation in these events and the Figure 4, the number of publications in international and national journals, besides books, apostils and technical reports.

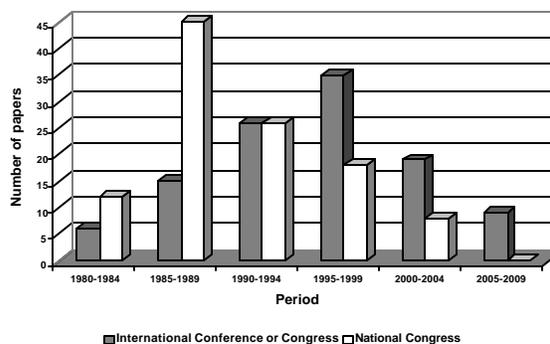


Fig. 3. Participation of LNMRI staff in scientific meetings in the period from 1980 to 2005

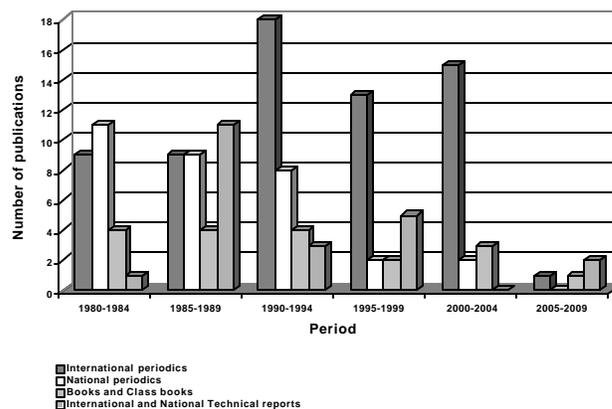


Fig. 4. Technical publications of the LNMRI staff in the period from 1980 to 2005

6. TECHNICAL STAFF AND HUMAN RESOURCES FORMATION

The current technical staff is constituted by 31 servers, being 12 with doctorate, 12 with master, 1 with high school level and 6 technicians of medium level.

A lot of master and doctorate thesis were developed in the laboratories of LNMRI, with internal and external

advising to IRD, and most of the courses were accomplished in a research institute, IME, and some universities, COPPE/UF RJ, UERJ and PUC. During the period from 1980 to 2005, 45 thesis were ended, being 33 of master and 12 of doctorate, most under advising of the IRD's technical staff.

Besides the academic titles, many technicians have been trained in the laboratories of PTB and GSF in Germany; NIST and EML in United States; NPL and NRPB in England; LNHB in France; CIEMAT in Spain and OFZS-IAEA in Austria.

Many metrology and radiation protection courses are ministered by the LNMRI staff, besides the advising of trainees for formation of human resources.

7. TECHNICAL COOPERATION

The technical cooperation has been a priority resource for the personal specialization. Besides the training in foreign laboratories that were already mentioned, the visits of experts were also used in the development of the measurement methods.

In the Tables 1 and 2, the experts that visited LNMRI are shown.

Table 1. Experts visitors in the dosimetry field.

Expert	Year	Laboratory
Juergen Boehm	1995	PTB
Juergen Boehm	1997	PTB
Hans M.Kramer	1997	PTB
J.M.Los Arcos	1999	CIEMAT
David Arnold	2000	RPC
J.Thurston	2000	KCARE
J.Dolo	2004	LNNB
N.Coursol	2004	LNHB

Table 2. Experts visitors in the radionuclide metrology field.

Expert	Year	Laboratory
A.Spemol	1982	IRMN
J.M.Hutchinson	1985	NIST
P.Simoen	1989	LNHB
K.F.Walz	1990	PTB
J.Morel	1997	LNHB
M.Echeeverry	1997	LNHB
N.Coursol	1997	LNHB
B.Chuvenet	1997	LNHB
J.M.Los Arcos	1999	LNHB
B.Coursey	2000	NIST
B.Zimmermann	2001	NIST
L.B.Barchero	2002	CIEMAT
N.Coursol	2002	LNHB
P.Cassette	2003	LNHB
N.Coursol	2004	LNHB
C.Papin	2005	LNHB

For the implementation of the measurement and calibration methods, resources were used from projects granted by the International Atomic Energy Agency, IAEA, and from the Brazilian government, as the PADCT (program

for support of scientific and technological development) and TIB (Basic Industrial Technology).

LNMRI/IRD has strengthen its position in the Inter-American Metrology System (SIM), by providing services and expertise to countries of the neighboring region, like: Bolivia, Costa Rica, Cuba, El Salvador, Equador, Nicaragua, Paraguay, and Uruguay.

8. CONCLUSION

The quality assurance programs for measurement and the implementation of metrological networks are helpful to disseminate the quantities and units, and serves to improve the integration of the measuring system, and produce credibility and capillarity. This is an important issue to a country like Brazil, which has continental dimensions

The good performances obtained by LNMRI/IRD in the last keys-comparisons are excellent examples of how the continuous work, in a given area, always reverts into good results.

The comparison programs developed in the national ambit and the applications of the standards for ionizing radiations contribute to the quality of the measurements in radiotherapy, radiation protection, and radiodiagnostics, and are an important support to basic researches in these fields.

The international recognition of the calibration certificates emitted by LNMRI-IRD, will open work opportunities at national level, besides the international cooperation.

REFERENCES

- [1] <http://www.bipm.org/> - Mutual Recognition Arrangement (MRA).
- [2] <http://www.bipm.org/appendixB/> - RI(I), RI(II) and RI(III).
- [3] Publications of LNMRI - 1980-2005.