

Report to the CCRI Section II on the activity carried out at the ENEA-INMRI on radionuclide measurements in the period 2003-2005

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1. INTRODUCTION

The present report summarizes the 2003-2005 activities carried out at the National Institute for Ionising Radiation Metrology (ENEA-INMRI) in the field of interest of CCRI Section II, i.e. radionuclide measurements. The main characteristics of the national standards maintained in Italy at the ENEA-INMRI in the field of radionuclide measurement are reported in the following table.

National standards maintained at the ENEA-INMRI (Italy) in the field of radionuclide measurements

Quantity	Standard	Radionuclide	Uncertainty Range (^) (%)	Measurement Range
Activity (+)	-n. 2 $4\pi\beta\text{-}\gamma$ coincidence counting systems	β and $\beta\text{-}\gamma$ emitters	0.1 - 3	(1 - 20) kBq
	-n. 1 NaI(Tl) well-type sum-peak coincidence counting system	$\gamma\text{-}\gamma$ emitters	0.5 - 3	(1 - 20) kBq
	-n. 1 NaI(Tl) well-type $4\pi\gamma$ counting system	γ emitters	0.5 - 3	(1 - 20) kBq
	-n. 1 LS (CIEMAT/NIST) counting system	β and x-ray emitters	0.6 - 3	(1 - 20) kBq
	-n. 1 Rn-in-water generator	^{222}Rn -in-water	2	$(200 - 10^4)$ Bq/dm ³
	-n. 1 Electrostatic cell	^{222}Rn -in-air	1	(1 - 15) kBq
	-n. 1 Well-type ionisation chamber*	γ emitters	0.2 - 3	$(10 - 2 \cdot 10^4)$ kBq
Activity concentration	-n. 3 HPGe γ -ray spectrometers*	x and γ emitters	1 - 5	$(1 - 10^5)$ Bq
	-n. 1 0.1 m ³ radon chamber*	^{222}Rn -in-air	2 - 10	$(10^2 - 10^4)$ Bq/m ³
Surface emission rate	-n. 1 2π windowless gas flow proportional counter	α and β emitters	0.5 - 3	$(1 - 20)$ s ⁻¹

(^) Rounded values for standard combined uncertainties (1σ).

(*) High precision secondary standards.

(+) Issue of radioactivity standards: Standard radioactive sources are supplied in different geometries in the activity concentration range from 10^{-2} Bq g⁻¹ to 2 MBq g⁻¹ (aqueous solutions in standard ampoule or in flask of different size) and in the activity range from 1 Bq to 20 MBq (sources in Marinelli beaker, in ampoule, on paper filter and point sources).

The ENEA-INMRI programmes in the field of radionuclide metrology in the last two years (2003-2005) were focused, as in the past, on maintaining and developing the national standards for activity measurements and on the more general activities in the field of standardisation and quality-assurance in radioactivity measurements. The main specific activities carried out at ENEA-INMRI in this field are summarised below.

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2. DEVELOPMENT OF NATIONAL STANDARDS AND COMPARISONS

Standardisation of ^{99m}Tc

A new measurement standard, based on the $4\pi\gamma$ high efficiency counting method, was developed in 2001 for absolute standardisation of radionuclides with complex decay scheme. A NaI(Tl) well-type crystal (125 cm x 125 cm) with accurately known geometrical parameters (uncertainty of 0.1 mm) was used. The new standardisation method was firstly applied at ENEA-INMRI during the ^{152}Eu BIPM comparison. In this case the single-photon detection efficiency curve, generated by Geant 3.21 Monte Carlo code, was used for calculating the specific nuclide counting efficiency by Winkler's NaJ5EF Fortran program. In 2004 the Monte Carlo code has been implemented in Linux environment. A new subroutine developed by Jean-Pascal Laedermann at the Institut de Radiophysique Appliquée and Office Federal de Metrologie (IRA-OFMET) in Switzerland, for simulation of radionuclide decay process was incorporated. The new code was used for calculation of the ^{99m}Tc counting efficiency and for standardization of this nuclide particularly used in Nuclear Medicine.

Standardisation of ^{18}F

[^{18}F]Fluorodeoxyglucose(FDG) is the most successful and widely used radiopharmaceutical for Positron Emission Tomography (PET). In Italy, an extensive commercial production and distribution of FDG by Amersham Health Srl started 1 years ago. The radionuclide is produced by the Scanditronix MC40 Cyclotron of the EU Joint Research Centre in Ispra. To fulfil the growing request for ^{18}F measuring instruments calibrations, a research collaboration was started between the ENEA-INMRI, the JRC-Ispra and the Hamersham Healt Srl to develop the ^{18}F national primary standard. Because of its relatively short half-life (109.7 min), the ^{18}F standardisation was carried out on the production site by using the CIEMAT/NIST method. The analysis of measurement results indicated a ^{48}V impurity, produced in the Titanium target.

Participation in the BIPM intercomparison on ^{125}I

The sum-peak coincidence counting method was applied for absolute activity measurement of a ^{125}I solution in the frame of a BIPM international key comparison. The mother solution was initially checked for radionuclide purity. A number of sources for absolute measurements were then prepared in flame sealed glass ampoules containing 1 cm³ of inactive diluent and increasing masses of ^{125}I mother solution (from 3.5 to 38 mg). These sources were counted in two experimental systems based on different high efficiency NaI(Tl) well-type detector (respectively 550 cm³ and 1600 cm³). Usual corrections for background and decay were applied. Single- (full-energy) and sum-peak superimposition was corrected by a linear extrapolation of the peak tails. Random summing and dead time effects were corrected by linear extrapolation to zero count rate (zero mass). This correction was drastically reduced thanks to the use of high performance digital multiparametric acquisition system (Fast Comtec PMA3), recently installed at ENEA-INMRI. The relative combined standard uncertainty of the ENEA-INMRI results was 0.3%. The results of the intercomparison are under evaluation by the BIPM.

Standardisation of Radon in air

The ENEA-INMRI primary standard for radon-in-air measurements, in operation since 1995, was renewed. An additional radon reference monitor, based on a Genitron AlphaGuard, was

installed in the system gas circuit. To this purpose, the monitor cell was modified with the addition of a gas flow adapter. The AlphaGuard monitor, thank to its notable stability of response and low humidity dependence, allowed recalibration of the radon reference atmosphere with lower uncertainty.

3. QA NATIONAL PROGRAMME AND CALIBRATION ACTIVITY

Development of a ^{18}F transfer standard

The number of ^{18}F calibration requests is growing in Italy, due to the increasing ^{18}F [FDG] use. A new portable well-type ionisation chamber was then acquired and calibrated by the ENEA-INMRI, using the newly developed ^{18}F primary standard. This new chamber will be used as a transfer secondary standard measurement system. It can be transported in Hospitals or in ^{18}F [FDG] production centres where local instrumentation can be calibrated by comparison.

Calibration of radioactive sources

Radioactive standards (liquid solutions, point sources, gas sources, paper filters and spiked reference materials for a total of about 100 sources per year) were provided for calibration of radioactivity measurement instruments in the country and for organisation of bilateral comparisons for QA.

Calibration of radionuclide activity measurement instruments

The measurement instrument calibration service has been active as in past years. Among these:

1. Extended calibrations were made for the $^{99\text{m}}\text{Tc}$ measurement instruments of the children's Hospital "Bambin Gesù" in Rome
2. Calibration facilities were implemented in 2004 for the growing demand arising from a number of laboratories in the Country in the field of radon measurements. The ENEA-INMRI radon chamber and the radon-in-water standard were used for this purpose.
3. Calibration of surface contamination monitors were performed according to ISO standards. In the 2004-2005 period about 50 instruments were calibrated mainly with ^{241}Am , ^{90}Sr and ^{14}C sources.

A new intercomparison campaign for the radioactivity surveillance network

The main Quality Assurance program conducted by ENEA-INMRI in the field of radioactivity measurements regarded the national network for environmental radioactivity surveillance. The program is based on periodical calibration and intercomparison campaigns carried out by ENEA-INMRI under request of the National Agency for Environmental Protection. This program started more than 15 years ago. Beta counting and γ -ray spectrometry in environmental samples are the main objects of the program. This QA program was effective in reducing to about 10% the maximum deviation of the results among the network laboratories. A new national intercomparison campaign was carried out for γ -ray spectrometry measurements on spiked simulated filters. To this purpose about 60 sources were prepared and distributed to the participating laboratories. Results of the intercomparison are under evaluation by the ENEA-INMRI.

4. PARTICIPATION IN METROLOGICAL AND STANDARDISATION ORGANISATIONS

Part of the time was devoted to activity in metrological and standardisation organisations: ICRM, BIPM/CCRI-II, IEC/TC45, ISO/TC85/SC2, UNI (National Standardisation Organisation). P. De Felice has continued his office as Secretary of the International Committee of Radionuclide Metrology.

5. STAFF

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Mr. A. Manzotti (50%) ⁽¹⁾	manzotti	4563

- (1) Due to the shortage of personnel some technicians share their work (e.g., mechanical workshop) among the different sections of the Institute.
- (2) Administrative service and technical assistance for maintaining and repair are supplied by the CR Casaccia central service. Some activities at the ENEA-INMRI in the period 2003-2005 have been carried out with the collaboration of some students.

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