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1984 Annual Status Report

Nuclear measurements and reference materials

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NUCLEAR MEASUREMENTS AND REFERENCE MATERIALS 1984

Research Staff: 117
Budget : 17.2 MECU
Projects :

- Nuclear Measurements
  - Nuclear Data
  - Nuclear Metrology
- Reference Materials
  - Nuclear Reference Materials
  - Non-Nuclear Reference Materials

PROGRAMME MANAGER: W. MÜLLER
COMMISSION OF THE EUROPEAN COMMUNITIES
JOINT RESEARCH CENTRE
Geel Establishment
B-2440 GEEL, Belgium

1. INTRODUCTION

This annual report represents the first of a series pertaining to the 1984-1987 JRC Programme "Nuclear Measurements and Reference Materials". This programme is carried out exclusively in the Geel Establishment (the Central Bureau for Nuclear Measurements, CBNM).
The work is divided in two projects Nuclear Measurements and Reference Materials.

The aim of the programme Nuclear Measurements and Reference Materials is to develop nuclear measurement techniques with special orientation towards satisfying specific EC demands for basic nuclear data and for materials and methods of reference.

In Nuclear Measurements the JRC-Geel-CBNM project forms part of the world-wide sets of actions to establish reliable data (e.g. neutron interaction cross-sections, radionuclide half lives) needed for the development and exploitation of nuclear energy for peaceful purposes. JRC-Geel-CBNM pays particular attention to complement similar actions of laboratories belonging to the Member States.

The project Reference Materials provides materials to which analytical and other measurements carried out predominantly in the nuclear community can be referred. One or more of the properties of the materials must therefore be well characterized and eventually certified. The task requires continuous monitoring and improvement of the techniques used for characterization.

2. RESULTS

Nuclear Measurements

This project is subdivided into two sub-projects "Nuclear Data" and "Nuclear Metrology".

Nuclear Data

This sub-project is concerned with nuclear data for standards, for fission and for fusion.

- Nuclear Data for Standards.

  Detectors for neutron flux spectra were developed and tested in an intercomparison. Neutron induced reactions, cross sections used as standard reference were determined accurately (e.g. the $^{6}Li/^{10}B$ (n,α) ratio, the fission cross-section of ^{235}U between 0.025 eV and 30 keV). An extensive evaluation of the thermal neutron constants of ^{233}U, ^{235}U, ^{239}Pu and ^{241}Pu and the fission yield of ^{252}Cf were published. This evaluation will be a valuable tool for future reactor calculations.

  During an IAEA Advisory Group Meeting (November 1984) it was proven that the standards area for neutron data, covered by JRC-Geel-CBNM activities, is a well selected one, but our effort on evaluation may have to be increased in the future.

  In the field of non-neutron data for standards selected decay data for some actinides were critically reviewed. This activity was part of an IAEA coordinated research programme.

  Experimental efforts were directed towards the absolute determination of the half life of ^{241}Pu; evaluations were made for emission probabilities of gamma and X-rays for a number of radionuclides.

- Nuclear Data for Fission Technology.

  Effort was concentrated on items which have been identified by EC countries as having high priority (within the context of the Nuclear Energy Agency's Nuclear Data Committee). Of special interest were measurements of:

- the capture cross-sections of nuclides present in the construction materials of reactors (iron, chromium, nickel);
- the shapes of some cross-sections in the thermal energy region, in particular the capture cross-section of ^{238}U and of ^{235}U and the fission cross-section of ^{235}U.

These measurements received considerable attention to accuracy and detail.

. Measurement of Nuclear Data for Fusion Technology.

In line with the Commission's overall rôle in the development of fusion energy, JRC-Geel-CBNM accepted to coordinate the nuclear data needs and measurements for fusion to be used in reactor designs. These measurements are intended to help the development of the Next European Torus (NET).

Nuclear Metrology

This sub-project covers the subjects radionuclide metrology, metrology of flux and dose, and nuclear metrology for trace analysis.

. Radionuclide Metrology.

Measurement techniques for the characterization and standardization of radioactive sources were improved; methods were developed to provide more accurate calibration of photon detectors, especially at low energies.

. Metrology for Neutron Flux and Dose.

The 6 MV Van de Graaff accelerator provided well defined neutron beams e.g. for international intercomparisons. Methods were developed to measure flux and dose.

. Nuclear Metrology for Trace Analysis.

The Proton Induced X-ray method of analysis of traces using the 3.7 MV Van de Graaff was further developed, in particular for environmental samples.

Reference Materials

The project is subdivided in two subprojects: Nuclear Reference Materials and Non- Nuclear Reference Materials.

Nuclear Reference Materials

This sub-project contains the items actinide reference materials, reference materials for dosimetry and samples and targets for nuclear measurements.

- Actinide Reference Materials.

  The main objective is to make available generally accepted European reference materials based on EC-certification. The actinide reference materials now available at JRC-Geel-CBNM, are given in the table below.
  During the reporting period, special emphasis was put on the finalization of a set of reference materials for the non-destructive assay of $^{235}U/U$ abundances by gamma-spectrometry. This technique was developed during the past years, and the achievable high precision now demands the availability of accurately defined reference materials, i.e. EC-NRM 171.
  European efforts in this project found a counterpart in the US: NBS will issue its share of the same material as SRM-969, together with an NBS certificate, the scientific content of which is equal to the EC-Certificate, issued by JRC-Geel-CBNM.

- Reference Materials for Dosimetry.

  Recognizing the importance of an assured supply of reference materials of high purity for use as neutron dosimeters, the Monitor Materials Sub-Group of the European Working Group on Reactor Dosimetry, in collaboration with JRC-Geel-CBNM established a list of requirements.
  JRC-Geel-CBNM organized the availability and characterization of these materials in collaboration with specialist laboratories within the European Community. At present 11 activation and 5 fission dosimetry materials have been examined prior to certification and issue.

- Samples and Targets for Nuclear Measurements.

  In the frame of this activity well characterized samples and targets were prepared in order to fulfil special requirements of JRC-Geel-CBNM and of other laboratories in the Communities. During 1984 a total of 463 samples, covering 72 applications, were delivered.

- Reference Materials for Environmental Radioactivy Measurements.

  The experimental work on measurements of radioactive trace impurities was delayed. Some of the equipment has to be adapted and a study of candidate reference materials is being made.

Non-Nuclear Reference Materials

This part of the programme aims at reference materials for biological applications and for the analyses of surfaces. Connected to this part is also the support to BCR (the cost shared action of the Community Reference Bureau).

- Reference Materials for Biological Applications.

  Isotope dilution mass spectrometry is being developed as a reference methodology for accurate determination of low-level concentrations of toxic elements in biological systems.

- Reference Materials for Analyses of Surfaces.

  For an intercomparison of surface analyses known quantities of arsenic atoms were implanted into silicon wafers. In connection with the electronic industry (more specifically for gold plated contacts) series of well defined and homogeneous thin layers of gold were evaporated in ultra-high vacuum and weighed in situ using a special microbalance.
  The layers will be used as working standards for coating thickness measurements. Techniques to analyse surfaces were further developed (Proton Induced X-ray Emission, Rutherford Backscattering, Particle Induced Gamma Emission).

- Support to BCR.

  JRC-Geel-CBNM is the Commission support laboratory for the BCR activities particularly with regard to preparation and conditioning of special materials and their storage and distribution. All materials previously dealt with at the Ispra and Petten Establishments have been transferred to Geel. A new building, to be dedicated for this activity has been designed. JRC-Geel-CBNM also continues to assist BCR in the development and preparation of non-nuclear reference materials in fields where scientific competence is available at JRC-Geel-CBNM.

3. CONCLUSIONS

High resolution data have been collected for neutron induced reactions, and it has been proven that the earlier investments made to compress neutron pulses at Linac and Van de Graaff were well founded.

The selected experimental measurements and the extensive evaluation of the thermal neutron constants of ^{233}U, ^{235}U, ^{239}Pu and ^{241}Pu, and of the fission neutron yield of ^{252}Cf have found wide appreciation.

In the field of non-neutron nuclear data the decay of ^{241}Pu was determined accurately hereby solving a contraversial point in this scientific field.

In the frame of international collaboration a series of existing non-neutron nuclear data was re-evaluated and the newly published tables are generally accepted. Steady progress was made for the preparation and characterization of basic reference materials for nuclear energy. One of the most important achievements here is the certification of a uranium oxide material to be used as reference for the determination of the ^{235}U content by gamma spectrometry. This work has been made in collaboration with the National Bureau of Standards (NBS, US), which offers identical samples and certificates as the EC ones.

In the new fields tackled, progress was made in neutron dosimetry (production of detectors for dosimetry in reactors and for medical applications).

The ties with the Community Bureau for References (BCR; cost shared action) were tightened and JRC-Geel-CBNM is now centralizing conditioning and distribution of BCR samples.

In comparison with the activities of the previous years the 1984 programme is marked by an increase of the ratios fusion data/fission data and non- nuclear reference materials/nuclear reference materials.

Code	Material	Application	Certified Quantities and Uncertainties (95% confidence level)	Certificate	Single Unit Size
EC-NRM 101	Uranium metal	element analyses	999.85 ± 0.05 g U · kg 1	EC	0.5 - 1 g
EC-NRM 110	Uranium dioxide pellets (1 g)		881.34 ± 0.13 g U · kg 1	EC	25 g
CBNM-106	Uranium dioxide pellets (10g)		881.43 ± 0.24 g U · kg^{-1}	CBNM	150 g
EC-NRM 171	Set of 5 Al cans with U_3O_8 of different $^{235}U/U$ abundances	$^{235}U/U$ abundance assay by gamma-spectrometry	0.3206 ± 0.0002 atom % ^{235}U	EC	200 g
			0.7209 ± 0.0005 atom % ^{235}U	EC	"
			1.9664 ± 0.0014 atom % ^{235}U	EC	"
			2.9857 ± 0.0021 atom % ^{235}U	EC	"
			4.5168 ± 0.0032 atom % ^{235}U	EC	"
CBNM-21	Uranium hexafluoride	isotope analyses (certified are all U isotope abundances)	0.4383 ± 0.0007 atom % ^{235}U	CBNM	20 g
CBNM-22	Uranium hexafluoride		0.7201 ± 0.0011 atom % ^{235}U	CBNM	20 g
CBNM-23	Uranium hexafluoride		3.2739 ± 0.0048 atom % ^{235}U	CBNM	20 g
CBNM-24	Uranium hexafluoride		5.0515 ± 0.0072 atom % ^{235}U	CBNM	20 g
CBNM-040-1	Spike solution; 0.997 $^{233}U/U$	element analyses by isotope dilution mass-spectrometry	1.1296 ± 0.0017 mg $^{233}U \cdot g^{-1}$	CBNM	10 ml
CBNM-041-1	Spike solution; 0.88 $^{242}Pu/Pu$		9.281 ± 0.028 µg $^{242}Pu \cdot g^{-1}$	CBNM	10 ml
CBNM-041-2	Spike solution; 0.88 $^{242}Pu/Pu$		66.11 ± 0.20 µg $^{242}Pu \cdot g^{-1}$	CBNM	10 ml
CBNM-042	Spike solution; 0.98 $^{244}Pu/Pu$		0.9359 ± 0.0028 µg $^{244}Pu \cdot g^{-1}$	CBNM	10 ml
CBNM-046-2	Spike solution; 0.997 $^{233}U/U$		1.211 ± 0.0017 mg $^{233}U \cdot g^{-1}$	CBNM	10 ml
	Spike solution; 0.88 $^{242}Pu/Pu$		5.690 ± 0.014 µg $^{242}Pu \cdot g^{-1}$	CBNM	10 ml
CBNM-60	Spike solution; 0.9985 $^{230}Th/Th$		40.38 ± 0.30 µg $^{230}Th \cdot g^{-1}$	CBNM	10 ml

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