International Atomic Energy Agency
Department of Nuclear Sciences and Applications
IAEA Environment Laboratories

Vienna International Centre, P.O. Box 100, 1400 Vienna, Austria

REFERENCE SHEET

CERTIFIED REFERENCE MATERIAL

IAEA-473

SHORT-LIVED RADIONUCLIDES IN MILK POWDER

TABLE 1. CERTIFIED VALUES FOR MASSIC ACTIVITIES

(based on dry mass)

Radionuclide	Certified value [Bq kg^{-1}]	Uncertainty* [Bq kg^{-1}]	Half-life [1]
^{89}Sr	2405	77	50.57 (3) days
^{90}Sr	209	5	28.80 (7) years
^{134}Cs	357	7	2.0644 (14) years
^{137}Cs	224	5	30.05 (8) years

*The uncertainty is expressed as a combined standard uncertainty with a coverage factor k = 1 estimated in accordance with the JCGM 100:2008 Evaluation of measurement data – Guide to the expression of uncertainty in measurement [2].

Reference date for decay correction: 1 November 2014

Origin and preparation of the material

The material was prepared using a batch of ordinary milk powder from Czech Republic with non-detectable radiostrontium and radiocaesium content by spiking technique, using radioactive reference solutions with low uncertainty from four providers (see Table 2).

TABLE 2. CERTIFICATES FOR THE TRACEABILITY

Item	Serial number of the certificate	Commercial provider
^{89}Sr solution	SR89ELSB45 79241/1	LEA
^{90}Sr solution	NIST SRM 4234 A	NIST
^{134}Cs solution	Cs134ELSR50	CERCA
^{137}Cs solution	CDZ64/S4/14/70	Amersham

All dilution steps and (technological) material balance of the entire preparation process were tracked by weight measurement.

The spike solution was prepared using calibrated high precision analytical balances. The dry mass determination of the raw material (during the preparation steps) was carried out by a thermo balance.

The spiking process was carried out in two steps: at first, 1 kg of the material was spiked, then dried in the open air and homogenized in a TURBULA 10 power blender using a special Teflon-lined container. To force the blending process and to destroy potential conglomerates 15 ceramic balls were added. In a second step this concentrate was diluted to 20 kg and homogenized in the TURBULA 51 power blender for 60 hours.

The bottling was finished within one working day. Altogether 197 bottles were prepared, each containing 100 g of milk powder.

The bottles were labeled, arranged into plastic boxes and sterilized using gamma-ray irradiation with a total dose of 25 kGy using a ^{60}Co source.

Homogeneity of the material

The homogeneity of the material was tested for 1 g sample size using gross beta measurement by LSC technique. For the homogeneity test 7 samples (out of 197) were taken and each divided into three parts. Afterwards a 1 g aliquot was taken from each part and mixed with 15 mL Instagel scintillator and 5mL high purity water. The milk powder was completely dissolved and the produced scintillator-water gel was stable enough for the period of measurement (2-3 days). Each sample was measured 3 times for 40 minutes. The decay correction during the homogeneity study due to the short lived Sr-89 has been considered proportionally according to its activity ratio. The measurement results have been evaluated by the determination of basic statistical parameters and ANOVA. The results are summarized in the following table.

TABLE 3. RELATIVE RESULTS OF THE HOMOGENEITY TEST

No. of considered data	21
Relative minimum	-2.4 %
Relative maximum	2.93 %
Arithmetical mean	100 %
Median	100.06 %
RSD	1.3 %
Theoretical limit*	0.8 %
F-value	2.21
F (critical)	2.85
r(within bottle)	1.11 %
r(between bottles)	1.65 %

* From the square root of the detected count numbers
(due to the uncertainty of the radioactive decay)

Both the basic statistical and ANOVA parameters demonstrate sufficient homogeneity at the level of 1 g.

Particle size distribution

The particle size distribution was determined by a laser scattering particle size analyzer (Horiba LA 950) using dry conditions. The results of three independent measurements are shown in *FIG. 1.*

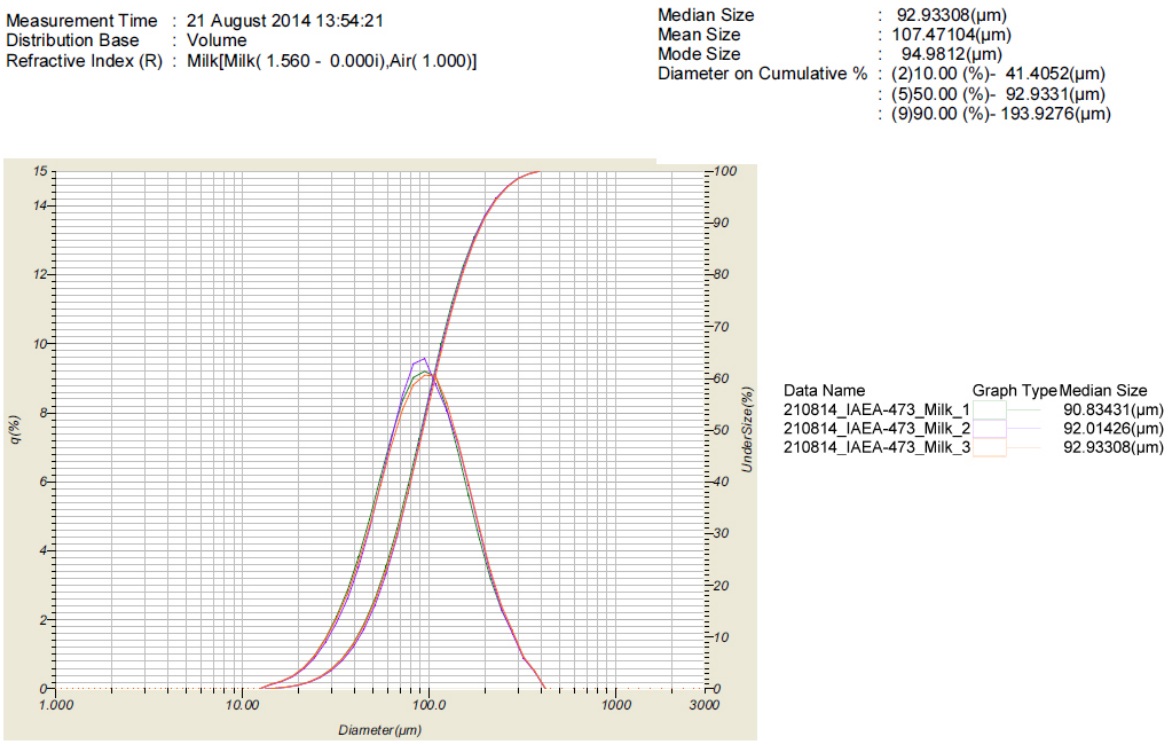

FIG. 1. The result of the particle size analysis

Assignment of values - Certification procedure

The assigned values given in Table 1 were derived by formulation (calculation) based on the certified values of the radioactive reference solutions and from the dilution factors applied during the preparation steps.

The IAEA Reference Materials Certification Committee decided to accept the assigned values as presented in the Table 1 above.

Statement on metrological traceability and uncertainty of assigned values

The property values were derived from the certified values specified in the certificates of the radioactive solutions by calculation considering the dilution factors controlled by an unbroken chain of weighings. Thus they are traceable to the derived SI unit Bq kg^{-1} through the certificates of the reference solutions as issued by the providers (see Table 2).

The measurement uncertainty associated with the assigned value is expressed as a combined standard uncertainty with a coverage factor k = 1 estimated in accordance with the JCGM 100:2008 Evaluation of measurement data – Guide to the expression of uncertainty in measurement [2].

The specified combined standard uncertainty was calculated from the following contributors:

- Uncertainty of the radioactive reference solutions
- Uncertainty of the dilution steps including each individual mass determination
- Discrepancy of the technological material balance (accounting for the loss of material during processing)
- Contribution resulting from the between bottles heterogeneity.

Intended use

This Certified Reference Material is intended to be used for verification of performance indicators (precision, repeatability, reproducibility) of the simultaneous measurement of ^{89}Sr and ^{90}Sr in presence of radiocaesium isotopes. These radiocaesium isotopes are simulating the case of the real nuclear emergency situation. The relatively low uncertainty of the property values minimize the contribution of the CRM to the combined standard uncertainty derived from the measurement.

The quick decaying of the ^{89}Sr isotope gives an opportunity to study the behavior of the radioanalytical method at different $^{89}Sr/^{90}Sr$ ratios.

The CRM is not intended for any calibration purpose.

Instructions for use

The IAEA-473 Certified Reference Material is supplied in 100 g units. The material homogeneity is guaranteed if a minimum test portion of 10 g is used.
The particle size distribution of the material is in a narrow range 41 - 194 microns (at 10 % and 90 % cumulative percentage), which minimizes any chance for segregation. However to overcome segregation effects due to storage or transportation, the material should be mixed before opening the bottle. All necessary precautions should be taken when opening the bottle to prevent any spread of the powder in the laboratory.

Since the moisture content can vary with ambient humidity and temperature, it is recommended to check it prior to analysis and to calculate all results on a dry mass basis.

Dry mass determination

The dry content of the material was measured in two steps. At first the optimum temperature was determined by the Mettler HR-83 Halogen thermo balance in the range of 50-100°C, from this range the 90 °C was identified as optimum temperature. Further, the average moisture content of the material was determined by drying several test portions of 2 g in an oven at 90 (± 2) °C for 8 hours, and was found to be 3.8 (± 0.1)% with a coverage factor *k*=1.

Handling and storage

The original unopened bottle should be stored securely at ambient temperature in a dark and dry place. It is recommended to avoid direct exposure to sunlight or to a source of heat.

Issue and expiry date

The issue date of this Certified Reference Material is **1 November 2014**. Based on experience with similar materials, the reference values for the respective radionuclides with appropriate decay correction are valid until

- for ^{89}Sr **31 January 2015**
- for ^{90}Sr, ^{134}Cs and ^{137}Cs **31 January 2019**

The IAEA is monitoring the long-term stability of the material for ^{90}Sr, ^{134}Cs and ^{137}Cs and customers will be informed in case of any observed change.

Legal disclaimer

The IAEA makes no warranties, expressed or implied, with respect to the data contained in this reference sheet and shall not be liable for any damage that may result from the use of such data.

Compliance with ISO Guide 31:2000

The content of this IAEA Reference Sheet is in compliance with the ISO Guide 31:2000: Reference materials — Content of certificates and labels [3].

Citation of this reference sheet

It is suggested to cite this reference sheet according to the following example, as appropriate to the citation format used: INTERNATIONAL ATOMIC ENERGY AGENCY, Reference Sheet for CRM IAEA-473, 'Short-lived radionuclides in milk powder', IAEA, Vienna, 6 pp. (The latest version published applies; see "Note" below).

Note

Certified values as stated in this reference sheet may be updated if more information becomes available. Users of this material should ensure that the reference sheet in their possession is current. The current version may be found in the IAEA's Reference Materials online catalogue:

http://nucleus.iaea.org/rpst/ReferenceProducts/ReferenceMaterials

Further information:

For further information regarding this material, please contact:

Terrestrial Environment Laboratory
International Atomic Energy Agency
Vienna International Centre
P.O. Box 100, A-1400 Vienna, Austria
Tel.: +43 1 2600 28237
E-mail: NAEL-TEL.Contact-Point@iaea.org

REFERENCES

[1] BNM – CEA/LABORATOIRE NATIONAL HENRI BECQUEREL , Table de Radionucleides, $^{89}Sr_{51}$ http://www.nucleide.org/DDEP_WG/DDEPdata.htm

[2] JOINT COMMITTEE FOR GUIDES IN METROLOGY (JGCM), Evaluation of measurement data – Guide to the expression of uncertainty in measurement, JGCM 100:2008 (GUM with minor corrections), (2008). http://www.bipm.org/utils/common/documents/jcgm/JCGM_100_2008_E.pdf

[3] INTERNATIONAL ORGANIZATION FOR STANDARDIZATION, Reference materials – Content of certificates and labels, ISO Guide 31: 2000, ISO, Geneva (2000).

Ales Fajgelj
Chair,
RM Certification Committee

Sandor Tarjan
Project Officer,
Terrestrial Environment Laboratory