# RADIONUCLIDE CALIBRATION STANDARDS 2017

**Czech Metrology Institute**
**Inspectorate for Ionizing Radiation**

**EUROSTANDARD CZ**

Czech Metrology Institute (CMI) is the highest technical authority in the Czech Republic for the field of metrology in general, which puts it into the role of the National Metrology Institute (NMI). The **Inspectorate for Ionizing Radiation (IIR)** (established in 1992) is its branch aimed at metrology of all kinds of ionizing radiations. Besides the tasks connected to measuring, calibrating and certifying of all kinds of equipment and sources of radiation, it also produces **its own range of radioactive standards** for multiple purposes. The scale of products was designed specifically to suit the needs of subjects utilizing radioactivity for a wide variety of goals, e.g. laboratories for radioactivity measurement, laboratories of nuclear medicine, hygienic labs, legal metrology, etc.

CMI-IIR possesses the **national standard of unit of radioactivity – Becquerel (Bq)** and one of its primary tasks is to maintain the primary standard of radioactivity in compliance with the International System of Units (SI) and to provide services required by the Czech and international legislation in order to ensure accuracy and safety of equipment used in scientific and industrial radiometry. Performance of the laboratory of absolute measurements is verified by a **system of international comparisons**, which guarantees the highest level of quality control, (please see the section of Traceability below).

CMI-IIR is a holder of the following certifications:

**Accredited testing laboratory No. 1341** **Certificate No. 68/2011 (CIA)**
**Determination of classification of sealed sources according to ČSN 40 4302 (ISO 2919)**
**License for handling ionizing radiation sources issued by SÚJB (State Office for Nuclear Safety)**

ISO 9001 REGISTERED
DNV
MGMT. SYS.
RvA C 024
DNV Certification B.V., The Netherlands

Certified laboratory in accordance with ISO 9001:2008
Certificate No. 51254-2009-AQ-CZS-RvA
(DNV – Det Norske Veritas)

Private limited liability company EUROSTANDARD CZ was established in 1994 in order to provide CMI-IIZ with distribution and promotion services, so that it could focus strictly on research, development and production. EUROSTANDARD CZ also provides services in the area of consulting, transportation and distribution of radioactive material (RM) from a wide variety of international suppliers.

During the years, the cooperation of the two subjects grew stronger and now, EUROSTANDARD CZ not only distributes the standards of radioactivity from the CMI-IIR's production, but due to its knowledge of the market and know-how in the area of handling the RM is now also charged with obtaining RM from abroad, various tasks connected to logistics of the sources and appliances and disposal of depleted radioactive sources.

EUROSTANDARD CZ, spol. s r.o. is a holder of the **9001:2008 quality assurance certificate** No. 37810/A/0001/UK/En issued by the URS as well as, of course, all the necessary licenses and **authorizations of the State Office for Nuclear Safety (SONS) for handling ionizing radiation sources** and a license for transportation of dangerous goods including radioactive materials (**ADR + Class 7**).


CERTIFICATE NO. 37810

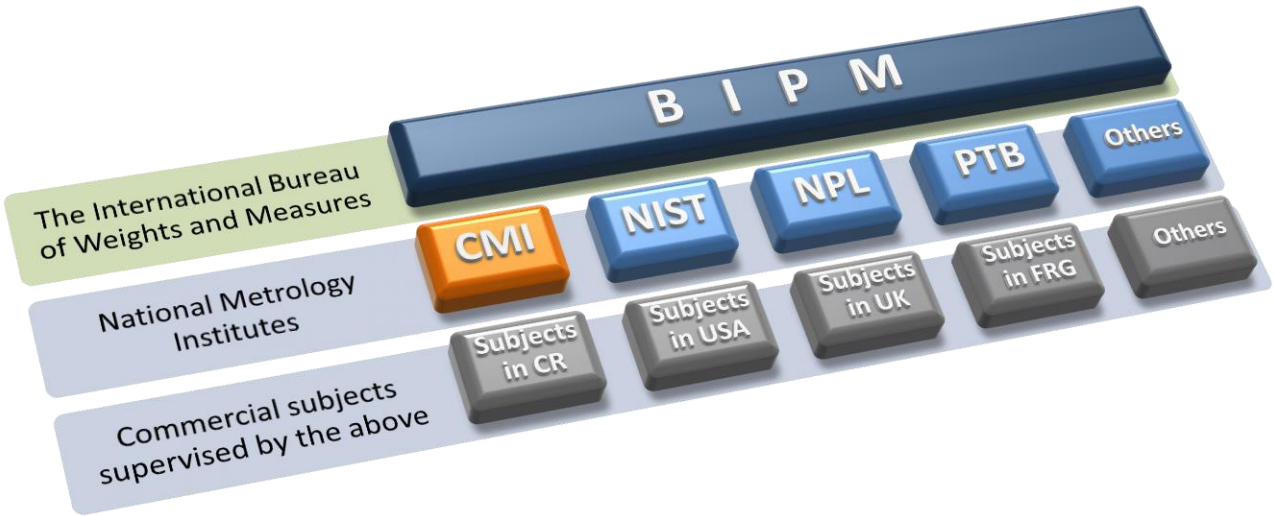
9001:2008 quality assurance certificate No. 37810/A/0001/UK/En (URS)

**TRACEABILITY AND UNCERTAINTY**

To maintain the worldwide coherence of measures, the CMI-IIR cooperates with other National Metrology Institutes on a regular basis. Probably the most important goal of such cooperation between NMIs is to maintain and possibly improve the level of their performance, reliability and accuracy of measurement. The key initiatives in this regard are the comparisons of performance of separate NMIs. These international comparisons are mainly organized by the **International Bureau of Weights and Measures** (Le Bureau international des poids et mesures - **BIPM**), for more information, please see **http://www.bipm.org** . Another organization helping the cooperation between NMI within the European region is **European Association of National Metrology Institutes (EURAMET)**, who (beside other activities) also organizes comparative measurements.

CMI-IIR gives the highest importance to the quality of its products and **all the sources produced by CMI-IIR are secondary standards** (derived from the primary national standard) and are therefore considered to be of the highest level of quality (lowest uncertainty) available on the commercial market. **Key Comparisons** (please see the section dedicated to on-line resources) as well as additional comparisons are organized and supervised by the **Consultative Committee for Ionizing Radiation (CCIR/CCRI – in French).**

**This puts CMI-IIR on the same hierarchy level as NIST (USA), NPL (UK), PTB (Germany) and other NMI**. Calibration certificates issued by CMI-IIR (which accompany every source distributed) state and ensure that the source measured or equipment calibrated is traceable to the national standard which is therefore equivalent to other national standards of BIPM members.



*Such comparisons are organized usually once a year. Every NMI receives identical source of ionizing radiation and performs appropriate measurement methods. The results are then submitted to BIPM and discussed thoroughly. The outcome of such comparisons is a table of equivalency showing the results and setting the equivalency between individual results.*

The shorter the chain of traceability the lower is the uncertainty level, which is preferable to be the lowest possible. For some tasks such as calibrations and medical use**, the lowest possible uncertainty level is essential for successful and reliable operations.**

**PRICING SYSTEM**

Being a state institution doesn't mean that CMI-IIR is a non-profit organization but it is not strictly profit-oriented. Therefore it can offer very competitive prices on the global market. This is especially significant when it comes to individual wishes of our customers. Whether it is a custom-made mixture of nuclides or a special kind of measurement or determination, we are confident enough that it would be a hard task to find a cheaper supplier while maintaining precision, quality and low level of uncertainty.

We also provide the service of disposal of used and/or depleted sources from our production free of charge.

For information about specific prices, please do not hesitate to contact the Eurostandard CZ company, who will promptly give you a quotation including estimated price of distribution. Unless specified otherwise, prices are usually valid until the end of the current year. For a new year to come, prices are usually corrected by inflation, exchange rates and evaluation of the market of radionuclides, which influences the final price greatly.

**Q: Are sources (standards) produced by CMI-IIR traceable to NIST (NPL, etc.)?**

**A**: No, because CMI-IIR is at the same level of traceability hierarchy as NIST and is therefore equal to it in the matters of traceability. The connection to NIST is established however through a system of international comparative measurements organized by BIPM (please see the Traceability and uncertainty section, page 3)

**Q: Do I need any special license to order your standards?**

**A**: This depends on the specific source and mainly its (specific) activity. When it exceeds the level for "radioactive source" we are then legally obliged to require a permission for handling RM granted to you or your company by an appropriate state authority. Some limits of total activity are in the table at the back cover of this catalog.

**Q: Can CMI-IIR provide me with custom made sources?**

**A**: Yes, products in this catalog are the most commonly used standards and some of them are in stock, but it is quite often to produce standards according to client's specifications, whether it is an unusual mixture of nuclides, activities or geometry. Such sources are then marked with a suffix "X" (e.g. ER X)

**Q: Can Eurostandard CZ provide me with products of other producers?**

**A**: Yes, Eurostandard CZ can use its database of producers and suppliers to give you a quotation on most of possible demands from materials to special kinds of sources, e.g. Mossbauer sources, etc. Eurostandard CZ also provides services connected to importing, exporting, customs clearance and transportation of radioactive materials.

**ORDERING**
Please note that all the orders of CMI-IIR's production (this catalogue) should be placed through the EUROSTANDARD CZ company, all the orders and enquiries placed directly to the CMI-IIR will be forwarded to this distributor.

Enquiries or questions can be placed by mail, fax, e-mail, telephone or Skype. But please note that in case of orders, there has to be a written form (at least an e-mail message). All the orders discussed by phone or Skype will be then required to be summarized by the buyer and submitted in a written form, by e-mail preferably.

Please remember to provide us with enough information in your orders:

**Product type** (Optionally the catalogue reference code)
**Geometry** of the standard (Specifications of customer's own container/carrier - if applicable)
**Nuclide and activity** (or photon flux)
**Other requirements or notes**
**Billing address** (please include your VAT registration number)
**Consignee address** (if differs from the Billing address)
Preferred date of delivery (optional)

**Contacts for ordering:**
**Address**:
EUROSTANDARD CZ, spol. s r.o.
Radiová 1
Prague 10
100 00
Czech Republic

**Email**: info@eurostandard.cz
dutkova@eurostandard.cz (optional)
dutka@eurostandard.cz (optional)

**Telephone**: +420 266 020 499
**Fax**: +420 266 020 499

**Skype**: Eurostandard-cz

**DELIVERY TIME AND DISTRIBUTION**

The period between acceptance of the purchase order and delivery of the goods varies and depends on various aspects. The standard period (unless specified otherwise) is set to five to six weeks, but with the exception of time-demanding production procedures and high season, we usually deliver the purchased goods earlier.

If the product is not classified as dangerous goods, we can send it by a courier company directly to the customer's address. In case it is considered dangerous goods, the most common practice while sending the goods abroad is to use air freight with Incoterms CPT delivery condition to the nearest international airport. Especially with dangerous goods, this is usually the least expensive way of transportation. The client then arranges a transportation company with ADR (Class 7) license to deliver the goods to their address, or transports it by their own means. We can however arrange any kind of transportation preferred by the client. In such cases, we always try to find the most suitable solutions, then inform our client about the stipulated price of transportation and wait for their confirmation.

**Every quoted price of distribution issued by EUROSTANDARD CZ always includes all the relevant fees. These are (in general): handling, packing and packaging, transportation to the airport (or forwarder), basic insurance and customs clearance charges (if applicable). In case of CPT condition, the distribution cost also includes the price of freight.**

**PAYMENT CONDITIONS**

Standard period in which we kindly ask our foreign customers to execute payments is net 30 days after reception of the goods (and invoice). We believe that thirty days are enough for international settlements and it is a common practice globally. In case of delayed payments, we would send a reminder within few days after the due date. In case of no response or no progress in the settlement after three reminders, we would have to proceed to take legal actions.

EUROSTANDARD CZ accepts payments via bank transfer in CZK, EUR and USD, every invoice includes the particular bank details for the currency in question.

**DESCRIPTION**

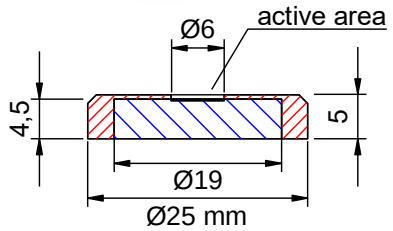
The radioactive substance in thin layer on the Pt foil is squeezed to the duraluminium casing with dimensions 25 x 5 mm (diameter x height). The casing has front window with diameter of 6 mm. The active area must be carefully protected against moisture, dust and abrasion.

**APPLICATION**

They are widely used as control sources in comparative measurements, for energy and efficiency calibration of alpha-spectrometers, determination of efficiency of window and windowless counters of α particles.

**MEASUREMENT**

Flux of α particles to spatial angle 2**π** sr is determined by 2π proportional counter. Activity is calculated from flux using correction on back scattering, spatial angle and self-absorption.




| Nuclide | Half life (days) | Particle energy (keV) | Type | Particle flux (2 p sr, $s^{-1}$) | Uncertainty of flux (%) | Activity ( kBq) | Code (for ordering) |
|---|---|---|---|---|---|---|---|
| $^{239}$Pu | 8,811 x $10^{6}$ | 5 147 | EA 13 | 57 | 0,3 | 0,1 | **PUA 13** |
| | | | EA 14 | 570 | 0,3 | 1,0 | **PUA 14** |
| $^{241}$Am | 1,578 x $10^{5}$ | 5 480 | EA 13 | 57 | 0,3 | 0,1 | **AMA 13** |
| | | | EA 14 | 570 | 0,3 | 1,0 | **AMA 14** |
| | | | EA 15 | 5700 | 0,3 | 10 | **AMA 15** |
| $^{241}$Am + $^{239}$Pu | - | - | EA 14 | 570 | 0,3 | 1,0 | **AMPU 14** |

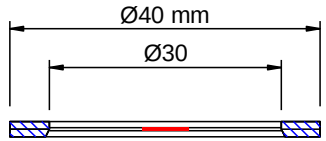
Uncertainty is an abbreviation for combined standard uncertainty ( P = 68,3 %).

**DESCRIPTION**

Standards of X and g photon flux type EFF and EFX are the point sources with minimum self-absorption emitting homogeneously to angle near 4π sr. The activity is deposited between two welded polyethylene foils with square weight 3,6 ± 0,3 mg.cm $^{-2}$ . The foils are located in the metal ring with outer diameter 40 mm. The active material is located in the centre of the foil.

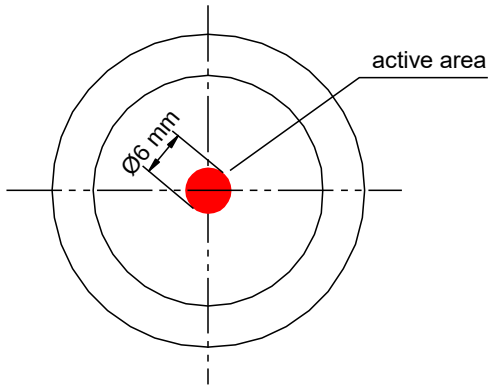
**APPLICATION**

Standards EFF and EFX are designed for energy and efficiency calibration of counters and spectrometers of X and γ photons. The activity of the standard gives the source strength approximately ~10 $^{4}$ s $^{-1}$ .




**MEASUREMENT**

The source strength of the EFX standard is determined by means of a suitable 4π counter. For the standards EFF (emitting photons γ ) source emission is calculated from the activity and the known photon yields.




| Nuclide | Half life (days) | Photon energy (keV) | | Photon flux in 4 π sr | | Uncertainty (%) | Code |
|---|---|---|---|---|---|---|---|
| | | X - K | γ | keV | s $^{-1}$ | | |
| $^{55}$ Fe | 986 | 5,888 | | 5,888 | 10 $^{4}$ | 1,5 | FMFX |
| $^{57}$ Co | 271,26 | 6,4 | 122,06<br>136,46 | 122,06<br>136,46 | 10 $^{4}$ | 1,5 | CTFF |
| $^{65}$ Zn | 243,9 | 8,03 | 1115,52 | 8,03 | 10 $^{4}$ | 1,7 | ZNFX |
| $^{85}$ Sr | 64,78 | 13,4 | 514 | 13,4 | 10 $^{4}$ | 2,2 | SAFX |
| $^{109}$ Cd | 462,6 | 22 | 88,035 | 22 | 10 $^{4}$ | 1,5 | CDFX |
| $^{241}$ Am | 157800 | 13,93<br>17,61 $X_L$ | 26,34<br>59,54 | 59,54 | 10 $^{4}$ | 1,9 | AMFF |

Uncertainty is an abbreviation for combined standard uncertainty ( P = 68,3 %).

## DESCRIPTION

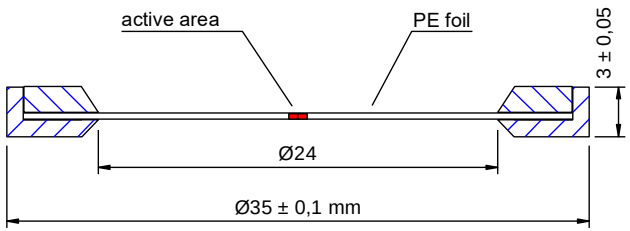
Standards of γ photon flux EFS are the point sources with minimum self-absorption emitting homogeneously to angle near 4π sr. The activity is deposited between two welded polyethylene foils with thickness less than 0,2 mm. Foils are mounted in the metal ring with outer diameter 35 mm. The active material is located in the centre of the foil.

## APPLICATION

The standards EFS are designed for energy and efficiency calibration of gamma spectrometers with Ge(Li) and HPGe detectors. Used radionuclides cover energy range 100 keV - 2 MeV.

## MEASUREMENT

The activity of the standard is calculated from the mass and specific activity of the standard solution. The specific activity is determined by absolute measurement.


| Nuclide | Half life (days) | Energy (keV) | Photon – yield (%) | Uncertainty of activity (%) | Uncertainty of photon flux, (%) | Activity (kBq) | Code |
|---|---|---|---|---|---|---|---|
| $^{57}$Co | 271,26 | 122,06 | 85,45 | 1,2 | 1,2 | 50 | CTS 01 |
| | | 136,46 | 10,77 | | 2,2 | | |
| $^{139}$Ce | 137,50 | 165,853 | 80,1 | 1,2 | 1,3 | 80 | CCS 01 |
| $^{203}$Hg | 46,72 | 279,19 | 81,49 | 1,3 | 1,4 | 150 | HGS 01 |
| $^{85}$Sr | 64,78 | 514,0 | 99,278 | 1,2 | 1,2 | 250 | SAS 01 |
| $^{137}$Cs | 11019 | 661,649 | 85,10 | 1,2 | 1,2 | 400 | CSS 01 |
| $^{54}$Mn | 312,22 | 834,83 | 99,978 | 1,0 | 1,0 | 450 | MNS 01 |
| $^{60}$Co | 1925,4 | 1173,21 | 99,865 | 0,8 | 0,8 | 700 | COS 01 |
| | | 1332,47 | 99,981 | | | | |
| $^{88}$Y | 106,60 | 898,021 | 93,52 | 1,5 | 1,5 | 700 | YWS 01 |
| | | 1836,03 | 99,36 | | | | |
| $^{133}$Ba | 3897 | 53,170 | 2,2 | 1,0 | - | 250 | BAS 01 |
| | | 79,612 | 3,18 | | 4,3 | | |
| | | 80,989 | 34,2 | | 5,3 | | |
| | | 160,613 | 0,62 | | 5,2 | | |
| | | 223,234 | 0,447 | | - | | |
| | | 276,402 | 7,17 | | 2,0 | | |
| | | 302,795 | 18,46 | | 1,8 | | |
| | | 355,95 | 62,22 | | 1,4 | | |
| | | 383,78 | 8,93 | | 1,8 | | |
| $^{152}$Eu | 4858 | 121,782 | 28,40 | 1,0 | 1,2 | 600 | EUS 01 |
| | | 244,700 | 7,54 | | | | |
| | | 344,281 | 26,52 | | | | |
| | | 411,11 | 2,246 | | | | |
| | | 444,0 | 2,78 | | | | |
| | | 778,91 | 12,94 | | | | |
| | | 964,01 | 14,60 | | | | |
| | | 1086,50 | 10,09 | | | | |
| | | 1112,06 | 13,56 | | | | |
| | | 1408,04 | 20,80 | | | | |

Uncertainty is an abbreviation for combined standard uncertainty ( P = 68,3 %).

**DESCRIPTION**

A weighed amount of the standard solution is dropped on the disc of filter paper in the polymethylmetacrylate capsule. The capsule is sealed up, when dried. The capsule and the reflector layer of common NaI(Tl) scintillators provide a sufficient filtering of β radiation of relevant radionuclide. For $^{144}Ce$ this filtration is not sufficient and for the types EG 1 and EG 3 layer of minimum 3,2 mm Al between the standard and the detector is necessary.

**APPLICATION**

Energy and efficiency calibration of scintillation spectrometers and counters of γ and X radiation. They can serve as reference sources for relative measurements. Their activity is chosen so that:

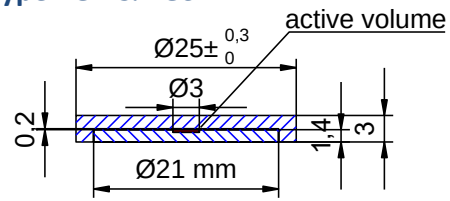
- **standard EG 1** in closed geometry with the NaI(Tl) 38 x 25 mm
- **standard EG 2** inserted to the well of NaI(Tl) 45 x 50 mm
- **standard EG 3** located 10 cm from the forehead of NaI(Tl) 38 x 25 mm

gives approx. 1700 counts per second for energy higher than 30 keV.

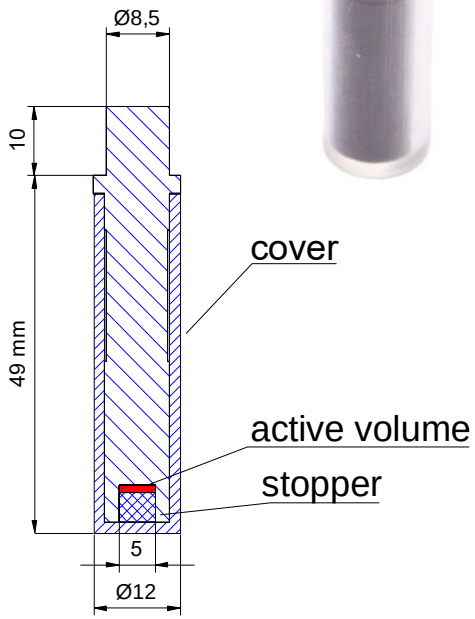
**MEASUREMENT**

The activity of individual standards is calculated from the mass of the standard solution and is checked by relative measurements of γ photon flux. The specific activity is determined by absolute measurement using 4π β-γ , 4π α-γ or 4π X-γ coincidence method or 4π proportional counter.


**Type EG1 & EG3**




**Type EG2**



| Nuclide | Half life (days) | Type | Activity (kBq) | Energy of photons γ (keV) | Yield of photons (%) | Uncertainty (%) | Code |
|---|---|---|---|---|---|---|---|
| $^{22}$Na | 950 | EG 1 | 5 | 511,0<br>1275,55 | 18,66<br>99,94 | 1,0 | NAG - 1 |
| | | EG 2 | 3 | | | | NAG - 2 |
| | | EG 3 | 100 | | | | NAG - 3 |
| $^{54}$Mn | 312,22 | EG 1 | 13 | 846,76 | 99,92 | 0,7 | MNG - 1 |
| | | EG 2 | 6 | | | | MNG - 2 |
| | | EG 3 | 300 | | | | MNG - 3 |
| $^{57}$Co | 271,26 | EG 1 | 6 | 122,06<br>136,46 | 85,45<br>10,77 | 1,0 | CTG - 1 |
| | | EG 2 | 2 | | | | CTG - 2 |
| | | EG 3 | 150 | | | | CTG - 3 |
| $^{60}$Co | 1925,4 | EG 1 | 10 | 1173,21<br>1332,47 | 99,865<br>99,981 | 0,7 | COG - 1 |
| | | EG 2 | 4 | | | | COG - 2 |
| | | EG 3 | 200 | | | | COG - 3 |
| $^{65}$Zn | 243,9 | EG 1 | 40 | 1115,52 | 50,75 | 1,6 | ZNG - 1 |
| | | EG 2 | 18 | | | | ZNG - 2 |
| | | EG 3 | 800 | | | | ZNG - 3 |
| $^{88}$Y | 106,6 | EG 1 | 8 | 898,021<br>1836,030 | 93,52<br>99,36 | 1,2 | YWG - 1 |
| | | EG 2 | 4 | | | | YWG - 2 |
| | | EG 3 | 200 | | | | YWG - 3 |
| $^{129}$I | 5,734.10 $^{9}$ | EG 1 | 15 | 39,58<br>29 - 33 $X_K$ | 7,46<br>> 70 | 0,7 | IZG - 1 |
| | | EG 2 | 5 | | | | IZG - 2 |
| $^{133}$Ba | 3897 | EG 1 | 3 | 80,989<br>302,795<br>355,95 | 34,2<br>18,46<br>62,22 | 0,8 | BAG - 1 |
| | | EG 2 | 2 | | | | BAG - 2 |
| | | EG 3 | 80 | | | | BAG - 3 |

| Nuclide | Half life (days) | Type | Activity (kBq) | Energy of photons γ (keV) | Yield of photons (%) | Uncertainty (%) | Code |
|---|---|---|---|---|---|---|---|
| $^{137}$Cs | 11019 | EG 1 | 16 | 661,649 | 85,10 | 0,9 | CSG - 1 |
| | | EG 2 | 7 | | | | CSG - 2 |
| | | EG 3 | 300 | | | | CSG - 3 |
| $^{141}$Ce | 32,50 | EG 1 | 10 | 145,444 | 48,43 | 0,9 | CKG - 1 |
| | | EG 2 | 3 | | | | CKG - 2 |
| | | EG 3 | 250 | | | | CKG - 3 |
| $^{144}$Ce | 284,4 | EG 1 | 30 | 133,531 | 11,09 | 1,1 | CEG - 1 |
| | | EG 2 | 8 | | | | CEG - 2 |
| | | EG 3 | 600 | | | | CEG - 3 |
| $^{152}$Eu | 4858 | EG 1 | 30 | from 121 to 1538 keV | depends on energy | 0,8 | EUG - 1 |
| | | EG 2 | 15 | | | | EUG - 2 |
| | | EG 3 | 450 | | | | EUG - 3 |
| $^{203}$Hg | 46,72 | EG 1 | 8 | 279,19 | 81,49 | 1,1 | HGG - 1 |
| | | EG 2 | 3 | | | | HGG - 2 |
| | | EG 3 | 200 | | | | HGG - 3 |
| $^{241}$Am | 157800 | EG 1 | 15 | 59,5364 | 35,67 | 0,6 | AMG - 1 |
| | | EG 2 | 5 | | | | AMG - 2 |
| | | EG 3 | 450 | | | | AMG - 3 |

Uncertainty is an abbreviation for combined standard uncertainty ( P = 68,3 %).

## DESCRIPTION

Marinelli beakers are filled with silicone rubber containing uniformly distributed radionuclide or mixture of radionuclides. Default density of the active volume is 0,98 $g.cm^{-3}$ and mean atomic number approaches water. The standards are available in 3 types of polypropylene beakers with default volumes 450, 500 and 1000 ml. Other volumes, nuclides, activities or beakers are available on request. Custom geometry can be filled with no extra charge.

## APPLICATION

Energy and efficiency calibration of gamma spectrometers.

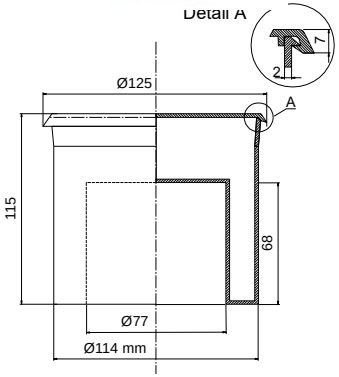
## MEASUREMENTS

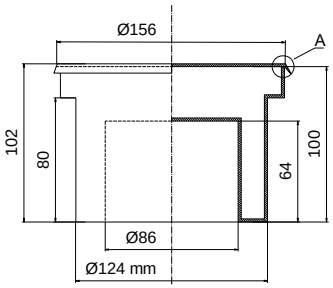
The standards are prepared from the standard solutions ER(EB) whose activity is determined by absolute method. The final sources are checked by measurement on gamma spectrometer with HPGe detector. Combined standard uncertainty of activity is approx. 2 %.

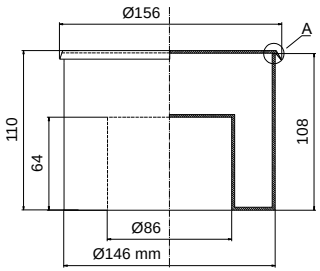
**0530G –** 450 ml

**0540G** – 500 ml

**1040G** – 1 l




| Type | Nuclide | Half life (days) | Activity (kBq) |
|---|---|---|---|
| MBSS 1 | $^{152}$Eu | 4858 | 3 |
| MBSS 2 | Mixture: $^{241}$Am, $^{109}$Cd, $^{139}$Ce, $^{57}$Co, $^{60}$Co, $^{137}$Cs, $^{113}$Sn, $^{85}$Sr, $^{88}$Y, $^{51}$Cr | - | 40 |
| MBSS 3 | $^{134}$Cs | 753 | * |
| MBSS 4 | $^{137}$Cs | 11019 | 3 |
| MBSS 5 | $^{226}$Ra | 584300 | 3 |
| MBSS 6 | $^{57}$Co | 271,26 | * |
| MBSS 7 | $^{60}$Co | 1925,4 | 3 |
| MBSS 8 | $^{241}$Am | 157800 | 10 |
| MBSS 9 | $^{232}$Th | $5{,}15 \cdot 10^{12}$ | 1,5 |
| MBSS 10 | $^{153}$Gd | 241,6 | * |
| MBSS 12 | $^{133}$Ba | 3897 | * |
| MBSS 13 | $^{109}$Cd | 462,6 | 20 |
| MBSS 14 | $^{210}$Pb | 8108 | * |
| MBSS 15 | $^{192}$Ir | 74,12 | * |
| MBSS 16 | $^{85}$Sr | 64,78 | * |
| MBSS 17 | $^{54}$Mn | 312,22 | * |
| MBSS 18 | $^{88}$Y | 106,60 | * |
| MBSS 19 | $^{139}$Ce | 137,50 | * |
| MBSS 20 | $^{40}$K | $4{,}602 \cdot 10^{11}$ | 1,5 |

**DESCRIPTION**

Mixture of 10 isotopes ($^{241}$Am, $^{109}$Cd, $^{139}$Ce, $^{57}$Co, $^{60}$Co, $^{137}$Cs, $^{113}$Sn, $^{85}$Sr, $^{88}$Y, $^{51}$Cr) developed especially for calibration of gamma measuring equipment. It covers the gamma energy range of **59,540– 1836,03 keV with 12 energy peaks**. Combined standard uncertainty of activity is below approximately 3 %.

**APPLICATION**

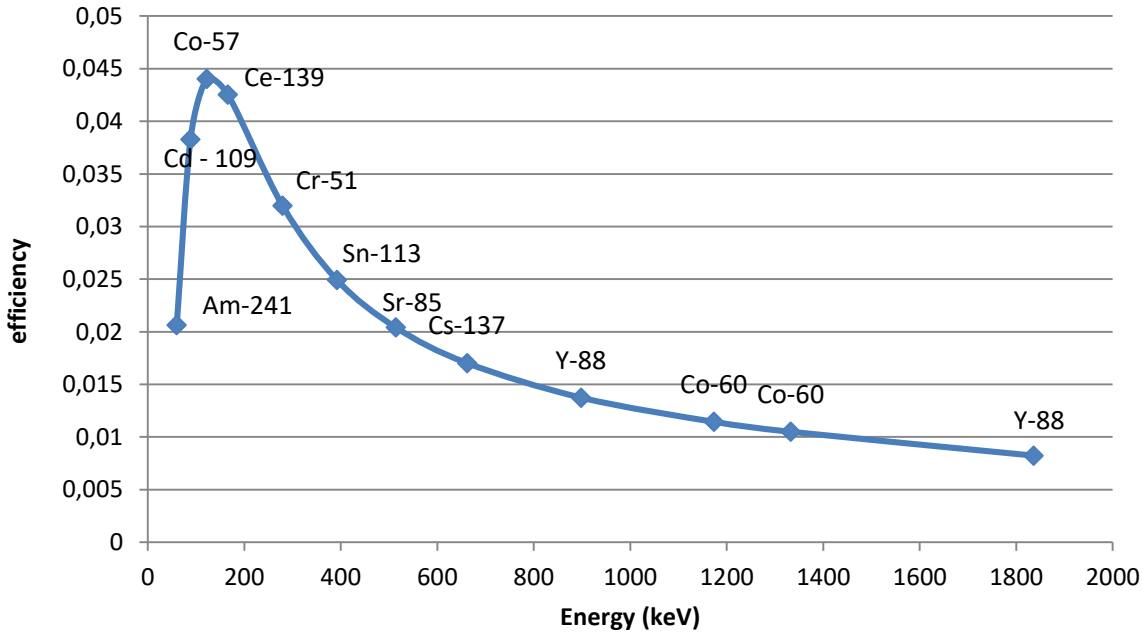
Energy and efficiency calibration of gamma spectrometers

**PRODUCT TYPES**

Our multi-gamma mixture can be used in a wide range of forms including the most popular: liquid solutions (**ER-mix**), and a silicon resin (**CBSS2**). Without Hg-203, it can also be produced as a planar source (**EM/EZ**), **filter**, or a sample of contaminated steel (**ES).**

| Nuclide | γ Energy (keV) |
|---|---|
| **Am-241** | 59,540 |
| **Cd-109** | 88,034 |
| **Co-57** | 122,060 |
| **Ce-139** | 165,853 |
| **Cr-51** (replacing Hg-203) | 320 |
| **Sn-113** | 391,702 |
| **Sr-85** | 514,008 |
| **Cs-137** | 661,649 |
| **Y-88** | 898,042 |
| **Co-60** | 1173,238 |
| **Co-60** | 1332,502 |
| **Y-88** | 1836,030 |

**Efficiency calibration curve of a HPGe spectrometer**



**DESCRIPTION**

Standard radionuclide solution is deposited on a disc metal base in approx. 50 dots/cm$^2$. Evaporated solution is overlayed with thermally cured layer of protective laquer and aluminium layer with square weight approx. 20 µg/cm$^2$ deposited in vacuum. Square weight of protective layer is less than 0,1 mg/cm$^2$. The active layer must be protected against dust, touch and corrosive atmosphere.

**APPLICATION**

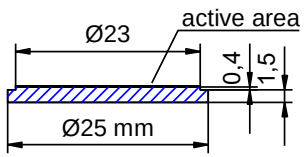
Efficiency calibration in measurements of various radionuclides in thin layer particularly for checking of relative measurements in surface, water, air and personnel contamination with α and β emitting radionuclides. Likewise for checking of stability of contamination monitors. For measurements of contamination can be used also standards EZ with larger active area.

**MEASUREMENT**

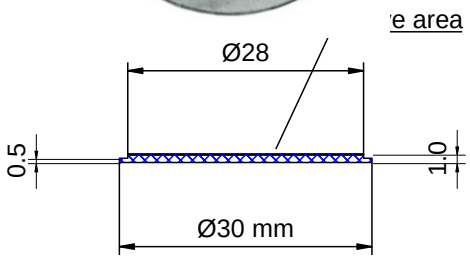
The activity is calculated from mass and specific activity of standard solution, traceable to primary activity standard. Surface emission is measured with windowless proportional counter with uncertainty < 1 %. Both values are specified in associated documentation.

**DIMENSIONS:** **(**Other dimensions on request)

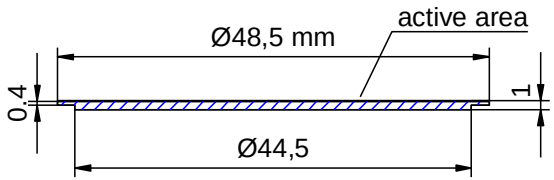
**Types EM 1, EM 2, EM 3, EM 4**
diameter of the active area 23 mm
overall diameter 25 mm
thickness 1,5 mm




**Types EM 12, EM 22, EM 32, EM 42**
diameter of the active area 28 mm
overall diameter 30 mm
thickness 1 mm




**EM 145 and EM 445**
diameter of the active area 48,5 mm
overall diameter 48,5 mm
thickness 1 mm



| Nuclide | Half life (days) | Particle energy (keV) α | Particle energy (keV) β | Particle energy (keV) γ | Type | Square activity (Bq.cm$^{-2}$) | Uncertainty of activity (%) | Code |
|---|---|---|---|---|---|---|---|---|
| $^{14}$C | 2,089.10$^{6}$ | | 155 | | EM 1 | 10 | < 1,1 | CWM 1 |
| | | | | | EM 12 | | | CWM 12 |
| | | | | | EM 3 | 100 | | CWM 3 |
| | | | | | EM 32 | | | CWM 32 |
| $^{60}$Co | 1925,4 | | 310 | 1173 | EM 1 | 10 | < 1,1 | COM 1 |
| | | | | | EM 12 | | | COM 12 |
| | | | | 1332 | EM 3 | 100 | | COM 3 |
| | | | | | EM 32 | | | COM 32 |
| $^{90}$Sr | 10281 | | 540 | | EM 1 | 10 | < 1,1 | STM 1 |
| | | | | | EM 12 | | | STM 12 |
| | | | 2260 | | EM 145 | | | STM 145 |
| | | | | | EM 3 | 100 | | STM 3 |
| | | | | | EM 32 | | | STM 32 |
| $^{137}$Cs | 11019 | | 520 | 661 | EM 1 | 10 | < 1,1 | CSM 1 |
| | | | | | EM 12 | | | CSM 12 |
| | | | 1170 | | EM 3 | 100 | | CSM 3 |
| | | | | | EM 32 | | | CSM 32 |
| $^{147}$Pm | 958 | | 220 | | EM 1 | 10 | < 1,1 | PMM 1 |
| | | | | | EM 12 | | | PMM 12 |
| | | | | | EM 3 | 100 | | PMM 3 |
| | | | | | EM 32 | | | PMM 32 |
| $^{204}$Tl | 1384 | | 770 | | EM 1 | 10 | < 1,2 | TLM 1 |
| | | | | | EM 12 | | | TLM 12 |
| | | | | | EM 3 | 100 | | TLM 3 |
| | | | | | EM 32 | | | TLM 32 |
| U_nat | $^{238}$U - 1,647.10$^{12}$<br>$^{235}$U - 2,593 . 10$^{11}$<br>$^{234}$U - 9,02 . 10$^{7}$ | 4150<br>4750 | 2310<br>190 | | EM 2 | 1 | < 1,1 | UWM 2 |
| | | | | | EM 22 | | | UWM 22 |
| $^{239}$Pu | 8,806.10$^{6}$ | 5147 | | | EM 2 | 1 | < 1,1 | PUM 2 |
| | | | | | EM 22 | | | PUM 22 |
| | | | | | EM 4 | 10 | | PUM 4 |
| | | | | | EM 42 | | | PUM 42 |
| $^{241}$Am | 157800 | 5437<br>5480 | | 60 | EM 2 | 1 | < 1,1 | AMM 2 |
| | | | | | EM 22 | | | AMM 22 |
| | | | | | EM 445 | | | AMM 445 |
| | | | | | EM 4 | 10 | | AMM 4 |
| | | | | | EM 42 | | | AMM 42 |

Uncertainty is an abbreviation for combined standard uncertainty ( P = 68,3 %).

**DESCRIPTION**

Standard radionuclide solution is deposited on a metal base with standard dimensions 200 x 140 x 1,5 mm (or dimensions on request) in approx. 50 dots/cm$^2$. Evaporated solution is overlayed with thermally cured layer of protective laquer and aluminium layer with square weight approx. 20 µg/cm$^2$ deposited in vacuum. Square weight of protective layer is less than 0,1 mg/cm$^2$. The active layer must be protected against dust, touch and corrosive atmosphere.

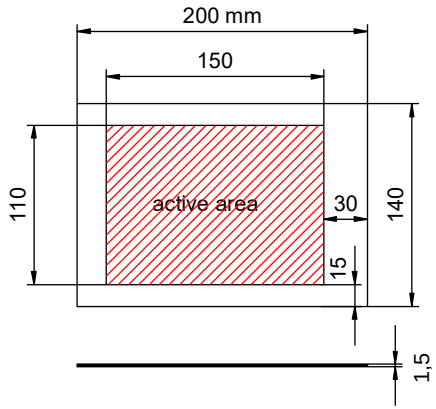
**APPLICATION**

Efficiency calibration of instruments for monitoring the surface and personal contamination by α and β emitting radionuclides. Likewise they can be used for checking of contamination monitor stability.

**MEASUREMENT**

The activity is calculated from mass and specific activity of standard solution, traceable to primary activity standard. Surface emission is measured with windowless proportional counter with uncertainty < 1 %. Both values are specified in associated documentation.

| Nuclide | Half life (days) | Particle energy (keV) α | β | γ | Type | Square activity (Bq.cm$^{-2}$) | Uncertainty of activity (%) | Code |
|---|---|---|---|---|---|---|---|---|
| $^{14}$C | 2,089. 10$^6$ | | 155 | | EZ 1 | 10 | < 1,1 | CWZ-1 |
| $^{60}$Co | 1925,4 | | 310 | 1173<br>1332 | EZ 1 | 10 | < 1,1 | COZ-1 |
| $^{90}$Sr | 10281 | | 540<br>2260 | | EZ 1 | 10 | < 1,1 | STZ-1 |
| $^{137}$Cs | 11019 | | 520<br>1170 | 661 | EZ 1 | 10 | < 1,1 | CSZ-1 |
| $^{147}$Pm | 958 | | 220 | | EZ 1 | 10 | < 1,1 | PMZ-1 |
| $^{204}$Tl | 1384 | | 770 | | EZ 1 | 10 | < 1,2 | TLZ-1 |
| U $_{nat}$ | $^{238}$U - 1,647.10$^{12}$<br>$^{235}$U - 2,593. 10$^{11}$<br>$^{234}$U - 9,02.10$^7$ | 4150<br>4750 | 190<br>2310 | | EZ 2 | 1 | < 1,1 | UWZ-2 |
| $^{239}$Pu | 8,806 . 10$^6$ | 5147 | | | EZ 2 | 1 | < 1,1 | PUZ-2 |
| $^{241}$Am | 157800 | 5437 | | 60 | EZ 2 | 1 | < 1,1 | AMZ-2 |




Uncertainty is an abbreviation for combined standard uncertainty ( P = 68,3 %).

# EB - $^{226}$ Ra STANDARD - SOLUTION

## DESCRIPTION

Aqueous solution of the appropriate quantity of $^{226}$ Ra. Chemical composition of the solution: 1 g $BaCl_2$ /l and 10g HCl/l. EB 00 is the aqueous solution of 1 g $BaCl_2$ /l and 10 g HCl/l with very low and determined mass fraction of $^{226}$ Ra.

## APPLICATION

The standards are designed for efficiency calibration of activity (mass) determination of $^{226}$ Ra or $^{222}$ Rn. Standard solutions are used either in the form of sealed ampoules for calibration or weighed part of the solution can be added to the analyzed sample as so called internal standard. After dilution by EB 00 solution is possible to prepare working standards with activities similar to measured samples. For emanometric determination of $^{226}$ Ra or $^{222}$ Rn in water, air and so on it is possible to transfer them to a washing bottle from which radon is expelled by a stream of gas.

## MEASUREMENT

Standard solutions are prepared by dissolving of $^{226}$ Ra content of standard ES activity of which was determined by comparison of gamma photon flux of the standard with the flux of IIR primary radium standards. Comparison is carried out by means of the 4π -γ ionization chamber of IIR.

| Nuclide | Half life (days) | Type | Mass of the solution (g) | Concentration of $^{226}$Ra (ng/g) | Mass of $^{226}$ Ra (ng) | Uncertainty (%) | Packing | Code |
|---|---|---|---|---|---|---|---|---|
| $^{226}$ Ra | 584300 | EB 6 | 1 | 1000 | 1000 | 0,5 | Glass ampoule 1 ml | **RAB 6** |
| | | EB 7 | 1 | 100 | 100 | 0,5 | | **RAB 7** |
| | | EB 8 | 1 | 10 | 10 | 0,5 | | **RAB 8** |
| | | EB 9 | 1 | 1 | 1 | 0,6 | | **RAB 9** |
| | | EB 10 | 1 | 0,1 | 0,1 | 0,7 | | **RAB 10** |
| | | EB 65 | 5 | 1000 | 5000 | 0,5 | Glass ampoule 5 ml | **RAB 65** |
| | | EB 75 | 5 | 100 | 500 | 0,5 | | **RAB 75** |
| | | EB 85 | 5 | 10 | 50 | 0,5 | | **RAB 85** |
| | | EB 95 | 5 | 1 | 5 | 0,6 | | **RAB 95** |
| | | EB 105 | 5 | 0,1 | 0,5 | 0,7 | | **RAB 105** |

$^{226}$ Ra is in the radioactive equilibrium with its short life daughter products.
Activity of 1 g $^{226}$ Ra is 3,658.10 $^{10}$ Bq
Uncertainty is an abbreviation for combined standard uncertainty ( P = 68,3 %).

# EP - $^{226}$ Ra STANDARD - SOLID

## DESCRIPTION

A mixture of $RaSO_4$ and $BaSO_4$ is encapsulated in a cylindrical cell which is soldered, put in a tube or needle with length 13,5 - 25,5 mm and diameter 1,65 - 2,65 mm and soldered again. Both the cell and the outer capsule are made of alloy of 90 % Pt and 10 % Ir. The total wall thickness is 0.5 $\pm$ 0.05 mm which is sufficient to absorb all alpha and beta radiation.

## APPLICATION

The standards are designed for calibration of dosimetric instruments, efficiency calibration in activity measurements of $^{226}$ Ra and other radionuclides. The calibration of dosimetric instruments is based on the knowledge that 1 g of $^{226}$ Ra with a 0,5 mm Pt filter has an exposure rate of 59,12 x $10^{-9}$ A .$kg^{-1}$ .

## MEASUREMENT

Mass of $^{226}$ Ra is determined by comparison with IIR primary radium standards by means of 4$\pi$ -γ ionization chamber. Radiation of primary standards is filtered with 0,5 mm Pt.

| Nuclide | Half life (days) | Type [1] | Mass of $^{226}$ Ra [2] (mg) | Uncertainty (%) | Code |
|---|---|---|---|---|---|
| $^{226}$ Ra | 584300 | EP 10 | 20 | 0,5 | **RAP-22** |
| | | EP 9 | 10 | 0,5 | **RAP-12** |
| | | EP 8 | 5 | 0,5 | **RAP-53** |
| | | EP 1 | 1 | 0,5 | **RAP-13** |
| | | EP 14 | 0,1 | 0,5 | **RAP-14** |
| | | EP 15 | 0,01 | 0,6 | **RAP-15** |
| | | EP 16 | 0,001 | 0,7 | **RAP-16** |

[1] These standards are sealed sources and are tested for leakage
[2] Activity of 1 g $^{226}$ Ra is 3,658.$10^{10}$ Bq
Uncertainty is an abbreviation for combined standard uncertainty ( P = 68,3 %).

**DESCRIPTION**
Approximately 1 or 5 g of the radioactive solution is sealed in a glass ampoule. Review of types and their parameters is in the table 1.

**APPLICATION**
The standards are designed for efficiency calibration of all kinds of detectors, type ER 2 is especially suitable for the calibration of proportional, scintillation and GM counters, types ER 3 and ER X for ionization chambers. Standard solutions are used either directly or after dilution for preparation of working standards. Application for internal standards is also possible.

**MEASUREMENT**
The ER 2 and ER 25 standards are directly prepared from a standard solution, the specific activity of which was determined by absolute measurement using the 4**π** ( α , β , X, e) - γ coincidence method or by a 4**π** proportional counter. The specific activity of the ER 3 and ER X standards is calculated from the dilution ratio and the specific activity of ER 2 standard solution.

**AVAILABILITY OF NUCLIDES**
Nuclides are divided into three categories. No Availability class means they are usually in stock. Class D represents nuclides available on request, the delivery time is usually 8+ weeks. Nuclides in class F will be ordered and produced twice a year, usually in April and October, so please make sure to plan their use ahead.

| Type | Mass (g) | Specific activity (MBq/g) | Activity (MBq) | Packing | Code |
|---|---|---|---|---|---|
| **ER 1*** | 1 | 0,005 | 0,005 | glass ampoule 1 ml | **IZR 1( $^{129}$ I)** |
| **ER 2** | 1 | 0,100 | 0,100 | glass ampoule 1 ml | **...R 2** |
| **ER 25** | 5 | 0,100 | 0,500 | glass ampoule 5 ml | **...R 25** |
| **ER 3** | 1 | 5 | 5 | glass ampoule 1 ml | **...R 3** |
| **ER X** | **Tailor-made solutions based on customer's request** | | | | |

* refers only to $^{129}$ I standards

| Nuclide | Availability | Half life (days) | Chemical composition of aqueous solution | Uncertainty (%) | Code |
|---|---|---|---|---|---|
| $^{3}$H | | 4510 | $H_2O$ | 1,7 | HWR |
| $^{7}$Be | F | 53,23 | 30 mg $BeSO_4$ /l + 3 g HCl /l | 1,0 | BER |
| $^{14}$C | | $2{,}089 \cdot 10^{6}$ | 5 g $Na_2CO_3$ /l | 1,5 | CWR |
| $^{22}$Na | | 950 | 50 mg NaCl /l + 36 g HCl /l | 0,8 | NAR |
| $^{24}$Na | F | 0,62571 | 50 mg NaCl /l + 36 g HCl /l | 0,6 | NKR |
| $^{32}$P | F | 14,30 | 50 mg $H_3PO_4$ /l | 0,6 | PWR |
| $^{35}$S | D | 87,46 | 50 mg $Na_2SO_4$ /l | 1,3 | SWR |
| $^{45}$Ca | D | 162,8 | 20 mg $CaCl_2$ /l + 3 g HCl/l | 1,2 | CAR |
| $^{51}$Cr | D | 27,701 | 30 mg $CrCl_3$ /l + 3 g HCl /l | 0,8 | CRR |
| $^{54}$Mn | | 312,22 | 50 mg $MnCl_2$ /l + 3 g HCl/l | 0,6 | MNR |
| $^{55}$Fe | | 986 | 50 mg $FeCl_3$ /l + 3 g HCl/l | 2,7 | FMR |
| $^{56}$Co | F | 77,7 | 20 mg $CoCl_2$ /l + 3 g HCl/l | 1,9 | CBR |
| $^{57}$Co | | 271,26 | 20 mg $CoCl_2$ /l + 3 g HCl/l | 0,8 | CTR |
| $^{58}$Co | D | 70,78 | 20 mg $CoCl_2$ /l + 3 g HCl/l | 1,0 | CYR |
| $^{59}$Fe | F | 44,54 | 50 mg $FeCl_3$ /l + 3 g HCl/l | 0,8 | FER |
| $^{60}$Co | | 1925,4 | 20 mg $CoCl_2$ /l + 3 g HCl/l | 0,4 | COR |
| $^{63}$Ni | | 36560 | 20 mg $NiCl_2$ /l + 3 g HCl/l | 1,5 | NIR |
| $^{65}$Zn | | 243,9 | 50 mg $ZnCl_2$ /l + 3 g HCl/l | 1,5 | ZNR |
| $^{67}$Ga | D | 3,261 | 12,6 mg $GaCl_3$ /l + 7 g HCl/l | 1,2 | GAR |
| $^{75}$Se | D | 119,6 | 20 mg $Na_2SeO_3$ /l + 4 g NaOH/l | 1,0 | SER |
| $^{85}$Sr | | 64,78 | 20 mg $SrCl_2$ /l + 3 g HCl/l | 0,8 | SAR |
| $^{86}$Rb | D | 18,696 | 20 mg RbCl/l + 3 g HCl/l | 0,8 | RBR |
| $^{88}$Y | | 106,60 | 20 mg $YCl_3$ /l + 3 g HCl/l | 1,2 | YWR |
| $^{89}$Sr | | 50,6 | 20 mg $SrCl_2$ /l + 3 g HCl/l | 0,6 | SRR |
| $^{90}$Sr | | 10281 | 20 mg $Sr(NO_3)_2$ /l + 20 mg $Y(NO_3)_3$ /l + 3 g $HNO_3$ /l | 0,6 | STR |
| $^{90}$Y | F | 2,671 | 50 mg $YCl_3$ /l + 3 g HCl/l | 0,6 | YKR |
| $^{95}$Zr | F | 64 | 12 mg $(NH_4)_4Zr(C_2O_4)_4$ /l + 12 mg $(NH_4)_3NbO(C_2O_4)_3$ /l+ 0,5 g $H_2C_2O_4$ /l | 1,0 | ZRR |
| $^{95}$Nb | F | 35,04 | 12 mg $(NH_4)_3NbO(C_2O_4)_3$ /l + 0,5 g $H_2C_2O_4$ /l | 0,6 | NBR |

Availability:
D – On request, longer delivery time
F – Planned orders of material twice a year (April and October)

Uncertainty is an abbreviation for combined standard uncertainty ( P = 68,3 %).

| Nuclide | Availability | Half life (days) | Chemical composition of aqueous solution | Uncertainty (%) | Code |
|---|---|---|---|---|---|
| $^{99}$Mo | F | 2,750 | 25 mg $(NH_4)_2MoO_4$ /l + 0,3 g $NH_4OH$/l | 1,0 | MOR |
| $^{99m}$Tc | F | 0,25096 | 3 g $NH_4OH$/l | 1,5 | TCR |
| $^{106}$Ru | F | 368,3 | 50 mg $RuCl_3$ /l + 50 mg $RhCl_3$ /l + 30 g HCl/l | 1,2 | RUR |
| $^{109}$Cd | | 462,6 | 50 mg $CdCl_2$ /l + 3 g HCl/l | 1,3 | CDR |
| $^{113}$Sn | | 115,10 | 50 mg $H_2SnCl_6$ /l + 216 g HCl/l | 1,2 | SNR |
| $^{124}$Sb | D | 60,20 | 50 mg $SbCl_3$ /l + 70 g HCl/l | 1,2 | SBR |
| $^{125}$I | | 59,89 | 50 mg KI/l + 50 mg $Na_2S_2O_3$ /l | 0,6 | ITR |
| $^{129}$I | | $5{,}734 \cdot 10^9$ | 4 g KI/l + 10 g $Na_2S_2O_3$ /l | 0,6 | IZR |
| $^{131}$I | | 8,051 | 50 mg KI/l + 50 mg $Na_2S_2O_3$ /l | 0,6 | IWR |
| $^{131}$I | | 8,051 | 2 μg $I_2$/ml $CCl_4$ | 1,0 | IER |
| $^{133}$Ba | | 3897 | 30 mg $BaCl_2$ /l + 3 g HCl/l | 0,6 | BAR |
| $^{134}$Cs | | 753,0 | 20 mg CsCl/l + 3 g HCl/l | 0,8 | CGR |
| $^{137}$Cs | | 11019 | 20 mg CsCl/l + 3 g HCl/l | 0,8 | CSR |
| $^{139}$Ce | | 137,50 | 20 mg $CeCl_3$ /l + 3 g HCl/l | 0,8 | CCR |
| $^{141}$Ce | D | 32,50 | 30 mg $CeCl_3$ /l + 3 g HCl/l | 0,8 | CKR |
| $^{144}$Ce | D | 284,4 | 20 mg $CeCl_3$ /l + 20 mg $PrCl_3$ + 3 g HCl/l | 1,0 | CER |
| $^{147}$Pm | | 958,0 | 20 mg $PrCl_3$ /l + 20 mg $NdCl_3$ + 3 g HCl/l | 1,5 | PMR |
| $^{152}$Eu | | 4858 | 30 mg $EuCl_3$ /l + 3 g HCl/l | 0,6 | EUR |
| $^{192}$Ir | D | 74,12 | 50 mg $Na_2IrCl_6$ /l + 3 g HCl/l | 0,8 | IRR |
| $^{203}$Hg | | 46,72 | 50 mg $Hg(NO_3)_2$ /l + 4 g $HNO_3$ /l + 50 mg $H_2SO_4$ /l | 1,0 | HGR |
| $^{204}$Tl | | 1384 | 30 mg $Tl_2SO_4$ /l + 3 g $HNO_3$ /l | 1,3 | TLR |
| $^{210}$Po | F | 138,4 | 25 mg $TeO_2$ /l + 63 g $HNO_3$ /l | 1,3 | POR |
| $^{210}$Pb | | 8108 | 20 mg $Pb(NO_3)_2$ /l + 20 mg $Bi(NO_3)_3$ /l + 25 mg $TeO_2$ /l + 63 g $HNO_3$ /l | 1,3 | PBR |
| $^{239}$Pu | | $8{,}806 \cdot 10^6$ | 63 g $HNO_3$ /l | 1,2 | PUR |
| $^{241}$Am | | 157800 | 20 mg $Sm(NO_3)_3$ /l + 6,3 g $HNO_3$ /l | 0,4 | AMR |
| $^{243}$Am | D | $2{,}69 \cdot 10^6$ | 20 mg $Sm(NO_3)_3$ /l + 6,3 g $HNO_3$ /l | 0,4 | AWR |
| Unat | | $1{,}63 \cdot 10^{12}$ | 1,66 g $UO_2(NO_3)_2$ /l + 6,3 g $HNO_3$ /l | 1,0 | UER |

Availability:
D – On request, longer delivery time
F – Planned orders of material twice a year (April and October)

Uncertainty is an abbreviation for combined standard uncertainty ( P = 68,3 %).

**DESCRIPTION**

1 ml of polymerised mixture of epoxy resin containing $^{241}$Am and $^{129}$I in the plastic test tube with dimensions 12 x 73 mm (diameter x length). Activities of $^{241}$Am and $^{129}$I are in such a ratio that resulting spectrum γ on a well type NaI(Tl) detector corresponds as much as possible with $^{125}$I γ spectrum. Test tube is closed by plastic stopper.

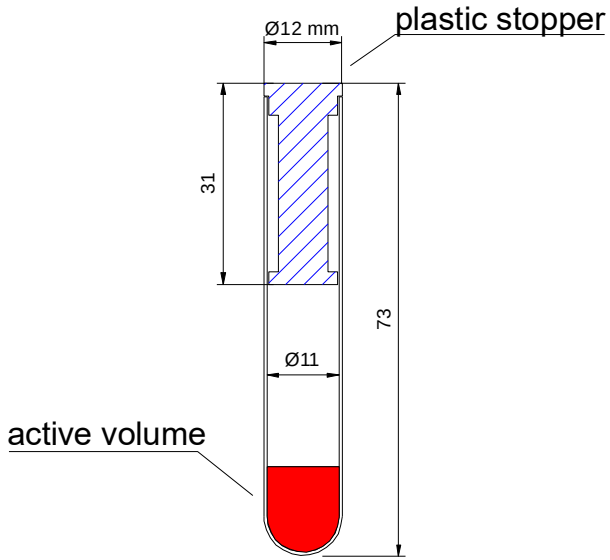
**APPLICATION**

The standards are designed for the calibration and checking of RIA gamma counters, especially for the measuring of kits with $^{125}$I.

**MEASUREMENT**

The effective activity is determined by the comparison measurement with $^{125}$I working standards using the gamma spectrometer with a well type NaI(Tl) detector 50 x 50. Nominal activity is 1500 Bq of $^{125}$I.

## CODE: ESIT



**DESCRIPTION**

Set of 10 pieces of 5 ml glass ampoules containing 30 kBq $CH_3$ $^{131}$ I each, absorbed in 0,1 g sorbent for gas chromatography. After opening ampoule, methyl iodide can be released by heating on 200 - 250 $^{o}$ C in stream of carrier gas (air, Nitrogen). Content of $CH_3$ I in ampoule is 2 mg (nominal values).

**APPLICATION**

For checking of gas monitors in nuclear facilities, especially in nuclear power plants.

**MEASUREMENTS**

Activity is determined by gamma spectrometry with HPGe detector.

**NOTE**

Combined standard uncertainty is ( P = 68,3 %) nominally 1,5 %.

**DESCRIPTION**

Standards in 10 ml penicillin vials in form of polyacrylamide gel, active volume is 5 ml. In case of breaking the vial , polyacrylamide gel prevents larger contamination, which the radioactive solution would not.


**APPLICATION**

The standards are used for calibration and checking of measuring devices in nuclear medicine, e.g. activity calibrators.

**MEASUREMENT**

The activity is determined by measurement in 4π ionization chamber, which is the part of national standard of activity.

| Nuclide | Half life (days) | Photon energy (keV) | Yield of photons (%) | Activity (MBq) | Uncertainty (%) | Code |
|---|---|---|---|---|---|---|
| $^{57}$Co | 271,26 | 122,06 | 85,45 | 5 | 1,5 | CTNM |
| | | 136,46 | 10,77 | | | |
| $^{60}$Co | 1925,4 | 1173,21 | 99,87 | 5 | 0,8 | CONM |
| | | 1332,47 | 99,98 | | | |
| $^{133}$Ba | 3897 | 30,63 | 32,00 | 5 | 1,2 | BANM |
| | | 30,97 | 61,51 | | | |
| | | 35,00 | 17,00 | | | |
| | | 35,80 | 3,70 | | | |
| | | 80,989 | 34,2 | | | |
| | | 276,402 | 7,17 | | | |
| | | 302,795 | 18,46 | | | |
| | | 355,95 | 62,22 | | | |
| | | 383,78 | 8,93 | | | |
| $^{137}$Cs | 11019 | 661,649 | 85,10 | 5 | 1,2 | CSNM |
| $^{241}$Am | 157800 | 59,54 | 35,67 | 5 | 2,3 | AMNM |

Uncertainty is an abbreviation for combined standard uncertainty ( P = 68,3 %).

**DESCRIPTION**

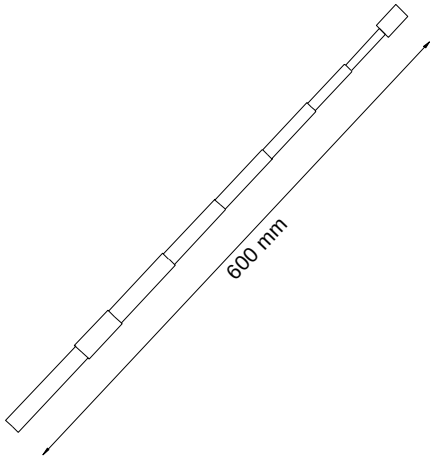
Dried weighed part of standard solution of $^{57}$Co is closed in a cylindrical plastic capsule with dimensions 11 x 9 mm (diameter x length). The source is installed on the top of the telescopic holder. Nominal activity is 5 MBq.

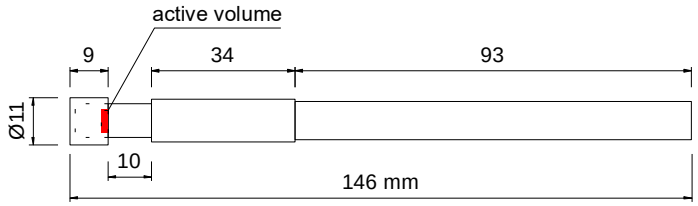
**APPLICATION**

The source is used mainly as a marker in nuclear medicine.

**MEASUREMENT**

The activity is calculated from the mass of the standard solution.



**DESCRIPTION**

Standards of radioactive rare gases $^{41}$Ar, $^{85}$Kr, $^{133}$Xe are designed for calibration and checking of monitors of nuclear facilities outlets, especially those of nuclear power plants. Known activity of radioactive gas is closed in the steel pressure bottle in mixture with air under pressure up to 100 bar. Declared quantity is volume activity at normal conditions. Technology of production is described in documents 911-MP-C001-07, 911-MP-C002-07 and 911-MP-C003-07.

**APPLICATION**

Radioactive gas is blown off to the monitor systems of nuclear facilities.

**MEASUREMENT**

Activity of $^{41}$Ar is determined by gamma spectrometry with HPGe detector, activities of $^{85}$Kr and $^{133}$Xe by measurement with calibrated ionization chamber.

**NOTE:**

Normal conditions are p = 101,3 kPa and t= 0 $^{o}$ C

**DESCRIPTION**

The Bottle Manequin Absorber Phantom (BOMAB) is the model of the human body 170 cm tall, separated into ten discrete parts, which can be independently filled. It is made from high density polyethylene, 4.8 - 5 mm thick, internal volume is approximately 55 $dm^3$ . It is supplied either empty or filled with non active silicone resin with specific density near 1 $g.cm^{-3}$ or filled with the same material containing activity, usually $^{152}$Eu. The overall dimensions comply with requirements of Reference Man described in ICRP 23.

**APPLICATION**

BOMAB provides a functional simulation for the scattering of radiation in an adult human figure, to calibrate and check of whole body counters used for *in vivo* determination of deposited γ emitting radionuclides.

**MEASUREMENT**

The activity is calculated from the specific activity and the mass of used standard solutions and from mass of filler.

| Description | Pieces | Shape | Profile (cm) | Height (cm) | Volume ($dm^3$) |
|---|---|---|---|---|---|
| **head** | 1 | ellipse | 19 x 14 | 20 | 3,50 |
| **neck** | 1 | circle | 13 diameter | 10 | 1,00 |
| **thorax** | 1 | ellipse | 30 x 20 | 40 | 15,00 |
| **lumbar** | 1 | ellipse | 36 x 20 | 20 | 9,00 |
| **thigh** | 2 | circle | 15 diameter | 40 | 5,90 |
| **leg** | 2 | circle | 12 diameter | 40 | 3,60 |
| **arm** | 2 | circle | 10 diameter | 60 | 3,60 |

## DESCRIPTION

Accurate and long term stable sources of defined activity of $^{222}$ Rn in gas phase. Radon is released from thin layer of a plastic foil with emanation power approaching 1. The source is constructed as a stainless steel cylindrical case supplied on the ends with the two ball valves and the two aerosol filters connected on the output aperture of the valves. All parts are made from stainless steel or Teflon. The sources are produced in activity range 20, 100, 200, 500, 1000 a 2000 kBq of $^{226}$ Ra with commercial label RF 20, RF 100, .... RF 2000.

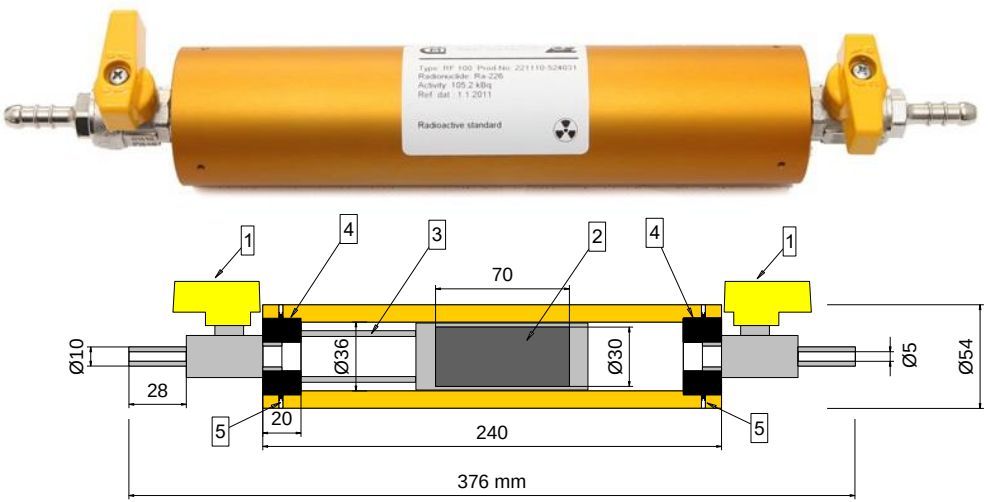
## APPLICATION

The sources are designed for laboratory and field conditions. The main application is calibration of devices and detectors for activity measurements of $^{222}$ Rn and $^{226}$ Ra in environmental research. The user can apply the source in batch or flow through mode.

## MEASUREMENT

The activity of $^{226}$ Ra is determined by comparison with IIR standards, the emanation power by gamma spectrometry on a HPGe detector.

| SPECIFICATION | |
|---|---|
| **Combined standard uncertainty of $^{226}$ Ra activity** | 1,6 % |
| **Emanation power** | near 1 |
| **Internal volume** | 260 cm $^{3}$ |
| **Maximum flow of carrier gas** | 10 l/min. |
| **Working temperature and relative moisture** | 0 - 40 $^{o}$ C, 0 - 100 % |
| **Dimensions** | 566 x 72 mm |
| **Weight** | 3,2 kg |




1 – ball valve
2 – emanator
3 – holder
4 – flange
5 – retaining screw
Material: Dural, brass, stainless steel, Teflon, epoxy resin

**DESCRIPTION**

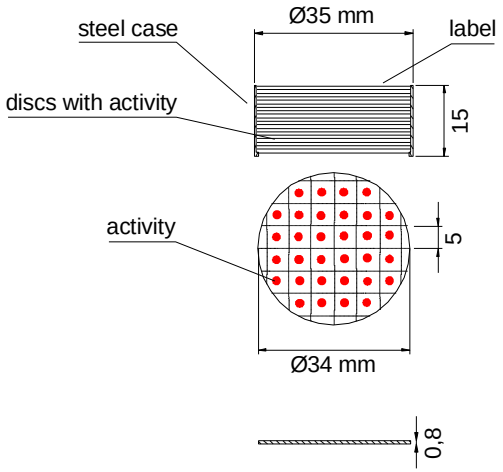
Cylinder shape standards type ESCO and ESCS consist of outer case with inserted discs with activity of $^{60}$Co or $^{137}$Cs. Activity is deposited in points in the net 5 x 5 mm. Discs putting together originate a cylinder with approximately homogeneously deposited activity. Disc and case are made from polished stainless steel. Standard dimension of cylinder is 35 x 15 mm, standard dimension of one disc is 34 x 0,8 mm (diameter x thickness). Other dimensions are made according to requirements of customer.

**APPLICATION**

Standards are designed for efficiency calibration of gamma spectrometers used for checking $^{137}$Cs and $^{60}$Co activity in steel. These radionuclides can occur in scrap iron as a result of liquidation of medical or industrial sources. According to customer requirements is possible to prepare standards with other radionuclides or with mixture of radionuclides.

**MEASUREMENT**

Activity of the standard is calculated from the mass and specific activity of the standard solution. The specific activity is determined by suitable absolute method. Produced sources are checked by comparison with IIR by standards gamma spectrometry with HPGe detector.



The table below shows some of the nuclides and their activity limits. Activity below this value (together with a specific activity limit) is a necessary condition for the source not to be classified as **a source of ionizing radiation** - according to the Czech legislation (307/2002 Col.) which is based on the Euratom agreement. Therefore our client is not obliged to present any form of license or authorisation, plus the transportation gets easier and cheaper.

| Nuclide | Limit | Nuclide | Limit | Nuclide | Limit |
|---|---|---|---|---|---|
| H-3 | 1 GBq | Sr-89 | 1 MBq | Ce-141 | 10 MBq |
| Be-7 | 10 MBq | Sr-90 | 10 kBq | Ce-144 | 100 kBq |
| C-14 | 10 MBq | Y-90 | 100 kBq | Pm-147 | 10 MBq |
| Na-22 | 1 MBq | Mo-99 | 1 MBq | Eu-152 | 1 MBq |
| P-32 | 100 kBq | Ru-103 | 1 MBq | Ir-192 | 10 kBq |
| S-35 | 100 MBq | Ru-106 | 100 kBq | Ta-182 | 10 kBq |
| Cr-51 | 10 MBq | Cd-109 | 1 Mbq | Hg-203 | 100 kBq |
| Mn-54 | 1 MBq | Ag-110m | 1 Mbq | Tl-204 | 10 kBq |
| Fe-55 | 1 MBq | Sn-113 | 10 MBq | Bi-207 | 1 MBq |
| Co-56 | 100 kBq | Te-123m | 10 MBq | Pb-210 | 10 kBq |
| Co-57 | 1 MBq | Sb-124 | 1 MBq | Rn-222 | 100 MBq |
| Co-58 | 1 MBq | Sb-125 | 1 MBq | Ra-226 | 10 kBq |
| Fe-59 | 1 MBq | I-125 | 1 MBq | Th-230 | 10 kBq |
| Co-60 | 100 kBq | I-131 | 1 MBq | Th-234 | 10 kBq |
| Zn-65 | 1 MBq | Ba-133 | 100 kBq | Am-241 | 10 kBq |
| Se-75 | 1 MBq | Xe-133 | 10 kBq | | |
| Kr-85 | 10 kBq | Cs-134 | 10 kBq | | |
| Sr-85 | 1 MBq | Cs-137 | 10 kBq | | |
| Y-88 | 1 MBq | Ce-139 | 1 Mbq | | |


Producer:

**CMI-IIZ**

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