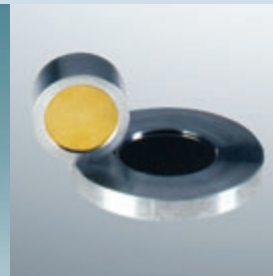


Eckert & Ziegler Reference & Calibration Sources

Product Information



www.meteorx.com

 Eckert & Ziegler
Isotope Products

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Eckert & Ziegler Reference & Calibration Sources Product Information



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General Information



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Licensing Requirements

It is Company policy to require written verification of the customer's Agreement State or NRC radioactive materials license for all items. No orders will be processed without a copy of the customer's license on file at Eckert & Ziegler Isotope Products (EZIP). This may be either a copy of the applicable portion of the license or a signed document on company letterhead stating that the customer's license (include license number) authorizes possession of the desired items in the form and quantity described on the purchase order. Compliance with applicable local, state and federal regulations concerning procurement and possession of radioactive materials is the responsibility of the customer.

Exempt Quantities

Small amounts of some byproduct material may be purchased without a specific license per Nuclear Regulatory Commission (NRC) regulations 10CFR30.18 and 10CFR30.71 Schedule B or the equivalent Agreement State regulations. Sources purchased as exempt quantities must be catalog items. Up to ten license exempt radioactive standards or sources may be shipped at one time. NRC regulations prohibit the further incorporation or use of license exempt sources in a manufactured device intended for further distribution. Contact the NRC or appropriate state agency for information on the use or possession of license exempt sources.

Returns Policy

Due to the nature of our products, all sales are final and no items can be returned for credit unless the customer has demonstrated that the product does not meet specifications. Such a claim must be made, and the source returned to EZIP, within 60 days after receipt of the shipment. NOTE: Before any return is made, EZIP must be notified so that a return authorization number can be assigned and proper shipping arrangements can be made. Shipments returned without a proper authorization number may be refused upon delivery.

Full credit will be given for sources that are found not to meet specifications as long as the source is returned to EZIP within the 60-day period mentioned above. EZIP will pay the return freight for the source, and the freight on the replacement. Sources reported and returned after the 60-day period will not be given credit, nor will EZIP pay for the return freight.

In the case that the customer ordered the incorrect part the following will apply:

- The customer will have 30 days to request a replacement source. There will be a restocking fee charged for the original source. If the customer calls between 30 and 60 days, only 50% credit will be given for the original source.
- After a 60-day period, no credit will be given.
- In all instances freight charges are the responsibility of the customer. In the event that the sources are being returned from an overseas location, the shipment must be sent with DDP (Delivery Duty Paid) terms so that the customer is billed for all fees.



General Information

Quality Assurance

EZIP maintains a comprehensive Quality Assurance program based on a number of industry recognized standards and regulations ensuring the production of consistently high value quality products.

EZIP's quality system is registered to ISO 9001/EN46001 and follows the regulations set forth in NRC Regulatory Guide 4.1.5 and 10CFR Appendix B, the required directive for the Nuclear Power Utilities and their suppliers.

For the quality-control testing of custom-geometry gamma-ray standards, Eckert & Ziegler Isotope Products maintains a current database including efficiencies from more than 40,000 individual standards in over 600 geometries. This data collection also allows Eckert & Ziegler Isotope Products to assist its customers in making informed decisions when choosing geometries and optimum activities for calibrating detectors.

These services are included as part of the package when purchasing standards from EZIP. All of our resources are available to assist you with your purchase. These are the reasons we say "Our Universe is Calibration" and why we believe it makes a difference to our customers. We invite you to visit our universe and investigate how we can meet your calibration needs.

EZIP manufactures a wide range of nuclear medicine devices that bear the CE Mark. Please note that these items are not offered in this catalog. Please request a Nuclear Medicine catalog from our customer service department for a full listing of our CE Marked products. This indicates their conformity to the provisions of Council Directive 93/42/EEC Annex II and enables them to be distributed freely within the European Community. All issues regarding any EZIP CE Marked sources in Europe are handled and reported by EZIP's European representative which can be contacted as follows:

BEBIG Isotopen- und
Medizintechnik GmbH
Robert-Rössle-Straße 10
D-13125 Berlin
www.bebig.de
Phone: + 49 (0) 30 94 10 84 - 0
Fax: + 49 (0) 30 94 10 84 - 240

Product Changes

New product and method development is a continuing process at EZIP. Catalog specifications notwithstanding, we reserve the right to change production methods or fabrication techniques which do not diminish the performance of the product.

Please contact customer support for product options or configurations that you may want that are not explicitly stated in this catalog. EZIP also offers engineering support to design or develop custom sources for your specific radiological needs.

Availability

Since EZIP manufactures a large variety of products with many options, only a small inventory of certain finished products is maintained. Most items can be shipped within thirty to forty-five days after receipt of the order. Please contact the sales order department for more information regarding the availability of a certain product or nuclide.

Terms, Conditions and Warranty

Our payment terms are net 30 days from date of shipment, delays in mailing of invoice notwithstanding.

All payments are to be made in U.S. Dollars. A \$700 documentary collection handling charge will be assessed to all orders involving a documentary letter of credit or draft for collection. A \$50 handling fee will be charged for all orders involving prepayment via wire transfer of funds. All new accounts must submit banking information and three references for credit review. Please allow three days to verify your credit status.

See page 81 for complete terms and conditions.



Methods of Calibration

EZIP participates in the Radioactivity Measurements Assurance Program (MAP) conducted by the National Institute of Standards and Technology (NIST) in cooperation with the Nuclear Energy Institute (NEI).

In this program NIST provides blind samples which are assayed by EZIP, with the results sent to NIST. NIST then reports back to EZIP the difference between the NIST calibrated value and the EZIP calibrated value. In addition, EZIP routinely sends finished products to NIST for product verification and calibration. Over the years, EZIP has maintained a high degree of precision and accuracy with NIST. Traceability is established and maintained through this cross-calibration process.

EZIP is also accredited through DKD (a globally recognized calibration accreditation agency) with the German National Laboratory (PTB) to offer DKD accredited calibrations for a large number of nuclides that EZIP regularly handles in its manufacturing facilities. Please contact customer service for availability of DKD accredited certification for your sources.

A certificate of calibration is provided for each traceable source as either NIST or DKD. The certificate provides a statement of traceability, a complete description of the physical and nuclear characteristics of the source, a description of the calibration method and quantitative identification of detected impurities. Activities are given in the Curie and SI systems. Sources are manufactured with contained activity values of +/-15% of the requested activity value unless otherwise noted in the catalog. All electroplated sources have a tolerance of +/-30% of the total contained activity.

The uncertainty value of the measured activity for a NIST traceable calibration can be as low as +/-3% at the 99% confidence level ($k=2.58$), and is no greater than +/-5% unless otherwise noted in the catalog. The uncertainty value of the measured activity for a DKD accredited calibration is typically 3 – 3.5% at the 95% confidence level ($k=2$) for those nuclides in EZIP's DKD Scope of Accreditation. Please contact customer service regarding the specific measurement uncertainty limit for each nuclide.

EZIP maintains a variety of state-of-the-art detector systems to calibrate sources and to check for impurities. The calibration equipment is checked daily using NIST traceable standards and stability is further ensured by maintaining the instrumentation in a carefully controlled environment. All assay equipment and techniques are verified through MAP on an on-going basis.

Sources are either calibrated directly against NIST standards or by using NIST traceable assay equipment and techniques.

Traceability

Eckert & Ziegler Isotope Products is committed to ensuring the traceability of its radionuclide calibration standards. For more than twenty-five years Eckert & Ziegler Isotope Products has participated in Measurements Assurance Programs (MAPs) with the National Institute of Standards and Technology (NIST) and has successfully completed over 1800 individual measurements on 40 different radionuclides. EZIP's participation in the NIST/ Nuclear Energy Institute (NIST/NEI) Measurements Assurance Program for the Nuclear Power Industry satisfies the requirements of the United States'

Nuclear Regulatory Commission's Regulatory Guide 4.15, Revision 1, 1979, and ANSI N42.22-1995 American National Standard – Traceability of Radioactive Sources to the National Institute of Standards and Technology (NIST) and Associated Instrument Quality Control.

Eckert & Ziegler Isotope Products is an active participant with the American National Standards Institute (ANSI) subcommittee on radioactivity measurements. EZIP's personnel have assisted in the writing of the standard on traceability (ANSI N42.22) and are assisting in the development of an accreditation program for standards suppliers.

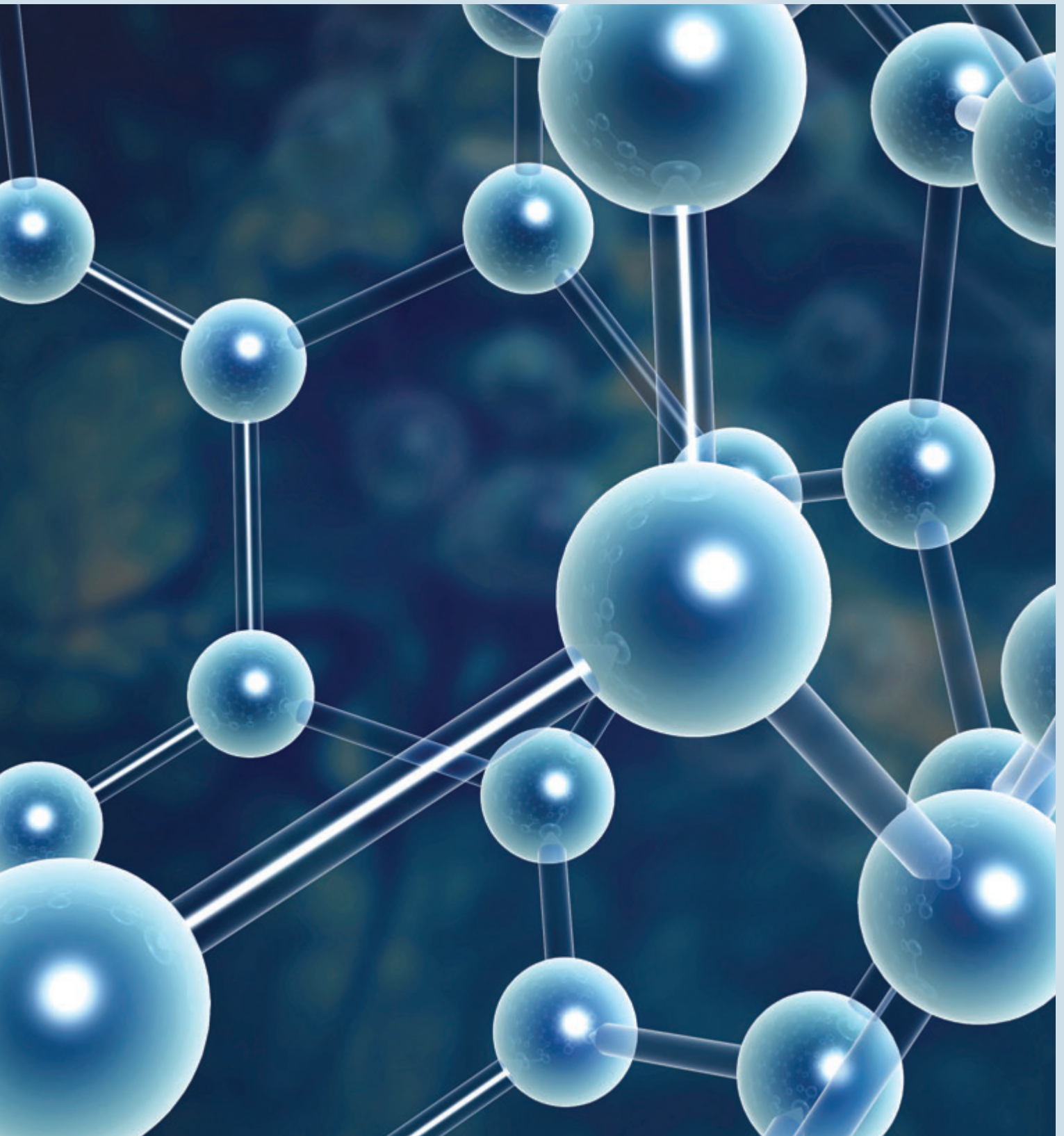
Half-Life Uncertainties

The half-lives for each nuclide mentioned in the EZIP Standards Catalog are listed along with their uncertainties and the reference from which these values were taken on pages 76–79 of the catalog. In all other sections of the catalog where half-lives are stated, the uncertainties have been omitted.

Photon Emissions Used in Source Calibration

A listing of the principal emissions are listed for every nuclide in all the individual sections of this product catalog. The specific values used in the calibration of the sources are listed for each nuclide on pages 76–79.

Special Isotopes



Reference and Calibration Sources

The following isotopes may require consultation with Technical Support before ordering. The information in this table is meant to alert the end user of these isotopes to certain features and issues associated with them.

| Special Isotopes | |
|------------------|---|
| Si-32 | P-32 daughter is in equilibrium. Glass containers are not suitable for long-term storage of Si-32 solutions and solutions sold by EZIP are packaged in polypropylene v-vials. |
| Ni-63 | Beta sources have no cover, and due to self-absorption within sources, they are certified for contained activity, and separately for surface emission rate. |
| Ge-68 | Ga-68 daughter (half-life: 68 minutes) is in equilibrium; both the positrons and 1077 keV gamma rays come from Ga-68. |
| Sr-90 | Y-90 daughter (half-life: 2.67 days) is in equilibrium. Users are urged to distinguish between orders for Sr-90 only and Sr-90/Y-90 taking into account activity of Y-90 present. The certified activity is generally for Sr-90 only. The surface emission rate for beta sources is for Sr-90, plus Y-90. |
| Zr-95 | Nb-95 daughter is generally not in equilibrium. Glass containers are not suitable for long-term storage of Zr-95 solutions, and EZIP packages Zr-95 in polypropylene v-vials. |
| Ru-106 | Rh-106 daughter (half-life: 29.8 seconds) is in equilibrium. All gamma rays come from the daughter Rh-106. |
| I-131Sim | Simulated I-131 is made from Ba-133 and Cs-137 to simulate I-131 in terms of gamma emissions. I-131 has gamma rays at 364 keV (81.2%) and at 636, 642, and 723 keV with branching ratios of 7.27, 0.220 and 1.80%, respectively. Ba-133 has gamma rays at 356 (61.94%) and 384 keV (8.905%). The gamma rays at 356 and 384 keV from Ba-133 are used to simulate the 364 keV gamma ray of I-131. The 662 keV gamma rays from Cs-137 are used to simulate the 636, 642, and 723 keV gamma rays of I-131. To produce the same number of gamma rays as 1 uCi of I-131 (at 364 keV), the amount of Ba-133 required will be $(81.2/61.94+8.90) = 1.146 \mu\text{Ci}$ and the amount of Cs-137 needed will be $(7.27+0.220+1.80)/85.1 = 0.1092 \mu\text{Ci}$. |
| Pb-210 | Bi-210 daughter is in equilibrium. |
| Ra-226 | Daughters (Rn-222, Po-218, Pb-214, Bi-214, Po-214 Pb-210, Bi-210, Po-210) may not be in equilibrium. Radon is a noble gas and will diffuse from the surface of its source and contaminate exposed surfaces. Open sources must be handled with caution. |
| Th-228 | Daughters (Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Po-212, Tl-208) may not be in equilibrium. Radon is a noble gas and will diffuse from the surface of its source and contaminate exposed surfaces. Open sources must be handled with caution. |
| Th-232 | Daughters (Ra-228, Ac-228, Th-228, Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Po-212, Tl-208) may not be in equilibrium. Due to its extremely low specific activity, only very small quantities of activity may be available. |
| Am-241 | Type M source has a backing of 0.0254 mm platinum plus 9.23 mg/cm ² kapton and a cover of 0.0254 mm aluminum. |
| Am-243 | Np-239 (beta active, half-life: 2.35 days) daughter is in equilibrium. Gamma rays (from Np-239): 106.1 keV (27.2%), 228.2 keV (11.27%), 277.6 keV (14.38%). |
| Cf-252 | Will have californium impurities and is supplied with a Technical Data Sheet. It is sold as a neutron source, fission source or alpha source, and calibrated accordingly. |

Special Isotopes

Uranium

Uranium consists of a mixture of isotopes. All uranium sources, in general, are certified on the basis of specific activity and mass. EZIP calculates the activity percentages of the isotopes present using technical data provided by the vendor of the material, and writes a Technical Data Sheet. The Technical Data Sheet is a part of the Certificate of Calibration.

It is very difficult to separate U-234 from U-235. Since the specific activity of U-234 is 2867 times that of U-235, a 1% amount by mass of U-234 in U-235 will create an activity of U-234 28 times higher than that of U-235.

Since the amount of uranium mass itself in a solution could be substantial, the solution densities could be much higher than the diluent (as high as 1.5 g/cc). Uranium sources are generally electroplated on an aluminum surface.

Natural uranium has the following atom % composition:

U-234 = 0.0055 atom %

U-235 = 0.720 atom %

U-238 = 99.2745 atom %

Enriched means higher atom % of U-235 than natural uranium.

Depleted means lower atom % of U-235 than natural uranium.

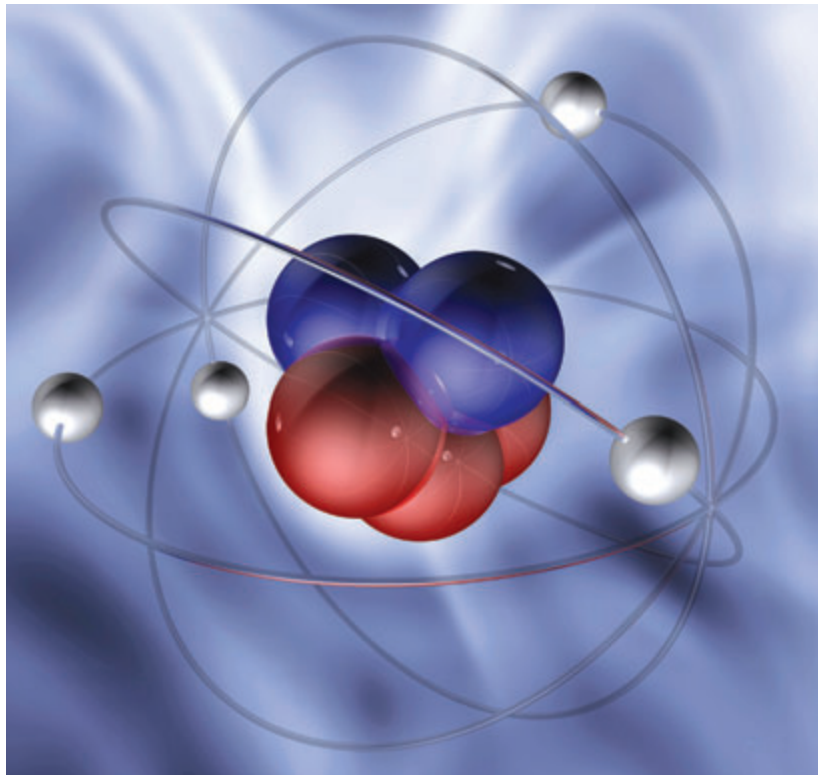
Uranium Isotopes

| | |
|-------|---|
| U-232 | Due to relatively short half-life, this isotope is generally free from other uranium isotopes. Daughters (Th-228, Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Po-212, Tl-208) may not be in equilibrium. When this isotope is available, sources and solutions are sold as: <ol style="list-style-type: none">1. <i>Purified with no daughters</i>: If this kind is ordered, the daughters have to be separated, the solution calibrated (using LSC) and the solution shipped within 72 hours.2. <i>As is</i>: (amount of daughters to be calculated).3. <i>Daughters in equilibrium</i>: In this case the right amount of Th-228 (in equilibrium with its daughters) is added. Please contact customer service for availability of this isotope. |
| U-233 | Technical Data Sheet, and EZIP will specify the activity for the primary isotope or the total activity. |
| U-235 | Technical Data Sheet, and EZIP will specify the activity for the total uranium activity. Please contact customer service for specific requirements. |
| U-236 | Technical Data Sheet, and EZIP will specify the activity for the primary isotope or the total uranium activity. |
| U-238 | Technical Data Sheet, and EZIP will specify the activity for the total uranium activity. Please specify natural or depleted. U-238 will be in equilibrium with Th-234 and Pa-234m (both beta active). Please contact customer service for specific requirements. |

Plutonium

Plutonium consists of a mixture of isotopes. EZIP calculates the activity percentages of the isotopes present using technical data provided by the vendor of the material, and writes a Technical Data Sheet. The Technical Data Sheet is a part of the Certificate of Calibration.

Plutonium isotopes are complicated by the presence of Pu-241, which is beta active, and has a relatively short half-life of 14.4 years. Its daughter is Am-241, which is alpha active with significant gamma rays.



Plutonium Isotopes

| | |
|--------|---|
| Pu-238 | Technical Data Sheet, and EZIP will specify the activity for the primary isotope or the total activity. |
| Pu-239 | Technical Data Sheet, and EZIP will specify the activity for the primary isotope or the total activity. |
| Pu-240 | Technical Data Sheet, and EZIP will specify the activity for the primary isotope or the total activity. |
| Pu-241 | Beta active. Technical Data Sheet, and EZIP will specify the activity for the Pu-241 isotope. |
| Pu-242 | Technical Data Sheet, and EZIP will specify the activity for the primary isotope or the total activity. |

Standard & Radionuclide Solutions



Standards Solutions 7000 Series

Accuracy: Each nuclide is NIST traceable, and many are DKD traceable. Please inquire with an Eckert & Ziegler Isotope Products customer service representative regarding specific nuclides. Contained activity values have a $\pm 15\%$ relative to the requested activity value. The uncertainty value of the measured activity value for a NIST-traceable calibration can theoretically be as low as $\pm 3\%$ at the 99% confidence level ($k=2.58$) but will be no greater than $\pm 5\%$ unless otherwise noted elsewhere in this publication. For DKD-accredited calibrations, the uncertainty value of the measured activity value is typically 3.0-3.5% at the 95% confidence limit ($k=2$) for certain nuclides in Eckert & Ziegler Isotope Products DKD Scope of Accreditation. Please inquire with an Eckert & Ziegler Isotope Products customer service representative regarding the specific measurement uncertainty limit for each nuclide.

Radionuclidic Solutions 6000 Series

Accuracy: Each isotope has a nominal contained activity of $\pm 15\%$.

Activity: Solutions are available in a variety of activities. Activity ranges for each nuclide are listed in the tables on pages 13–17.

Molarity: Different molarities are available upon request.

Carrier: Carrier materials will be added when considered appropriate or on request.

Purity: Radionuclidic impurities are specified on the Nominal Data Sheet. For applications that require specific

Activity: Solutions are available in a variety of activities. Activity ranges for each nuclide are listed in the tables on pages 13–17.

Molarity: Different molarities are available upon request.

Carrier: Carrier materials will be added when considered appropriate or upon request.

Purity: Radionuclidic impurities are specified on the Certificate of Calibration. For applications that require specific radionuclidic purity requirements, please contact customer service. For many alpha emitting nuclides and transuranics, radionuclidic purity is not always possible due to short lived daughters, and it is typical for isotopic ratios to vary greatly from batch to batch.

Chemical purity is not determined by EZIP, and is not reported on the Certificate of Calibration. Please contact customer service for special requirements.

radionuclidic purity, please contact customer service. For many alpha emitting nuclides and transuranics, radionuclidic purity is not always possible due to short lived daughters, and it is typical for isotopic ratios to vary greatly from batch to batch.

Chemical purity is not determined by EZIP, and is not reported on the Certificate of Calibration. Please contact customer service for special requirements.

Packaging: Radionuclide solutions packaging is offered in a variety of vials and ampoules listed on page 12 of this catalog. Please specify activity, and fill volume. Fill volumes must be at least 50% of the capacity of the chosen vial. There may be an extra

Packaging: Radionuclide solutions packaging is offered in a variety of vials and ampoules listed on page 12 of this catalog. Please specify activity, and fill volume. Fill volumes must be at least 50% of the capacity of the chosen vial. There may be an extra charge for some options. Customer supplied vials on all solution orders are not guaranteed by EZIP to be leak proof during shipment, and EZIP will not honor return or credit requests for leaking solutions in customer supplied vials. An extra charge for shielding high activity beta and gamma emitter solutions may apply. Please contact customer service for details.

Delivery: Most solutions are delivered within 10-14 days ARO. Expedited orders may be available upon request.

charge for some options. Customer supplied vials on all solution orders are not guaranteed by EZIP to be leak proof during shipment, and EZIP will not honor return or credit requests for leaking solutions in customer supplied vials. An extra charge for shielding high activity beta and gamma emitter solutions may apply. Please contact customer service for details.

Delivery: Most solutions are delivered in 7 days ARO. Expedited orders may be available upon request.

Standard & Radionuclide Solutions

Ordering and Quotations

To place an order or receive a quotation for any standard or radionuclide solution please provide the following information:

- Catalog Number
- Activity
- Configuration (include vial type and volume)
- Fill Volume

| Container Configuration | Material | Volume | Dimensions Outer Diameter x Length |
|----------------------------|---------------|---------|---------------------------------------|
| V-Vial | Glass | 1 mL | 0.55" x 1.93" (14 mm x 49 mm) |
| V-Vial | Glass | 5 mL | 0.83" x 1.93" (21 mm x 62 mm) |
| V-Vial | Glass | 10 mL | 1.0" x 2.9" (25 mm x 74 mm) |
| Serum Vial | Glass | 10 mL | 0.98" x 2.13" (25 mm x 54 mm) |
| Serum Vial | Glass | 20 mL | 1.18" x 2.24" (30 mm x 57 mm) |
| Flame Sealed Ampoule (FSA) | Glass | 1 mL | 0.41" x 2.64" (10.4 mm x 67 mm) |
| Flame Sealed Ampoule (FSA) | Glass | 5 mL | 0.65" x 3.31" (16.5 mm x 84 mm) |
| Flame Sealed Ampoule (FSA) | Glass | 10 mL | 0.75" x 4.21" (19 mm x 107 mm) |
| Flame Sealed Ampoule (FSA) | Glass | 20 mL | 0.89" x 5.12" (22.6 mm x 130 mm) |
| Flame Sealed Ampoule (FSA) | Glass | 50 mL | 1.12" x 7.0" (28.5 mm x 178 mm) |
| V-Vial | Polypropylene | 2 mL | 0.51" x 1.83" (12.7 mm x 46.5 mm) |
| V-Vial | Polypropylene | 5 mL | 0.80" x 2.34" (20.3 mm x 59.4 mm) |
| Plastic Bottle | Polypropylene | 125 mL | 2.0" x 4.0" (50.8 mm x 101.6 mm) |
| Plastic Bottle | Polypropylene | 1000 mL | 3.5" x 8.0" (88.9 mm x 203.2 mm) |



All solutions are prepared to a tolerance of +/-15% of the requested activity. NIST traceable calibrated solution uncertainties are stated in the table.

| Nuclide & Chemical Form | Catalog Number | Uncertainty (NIST) (99% Confidence Level) | Minimum Activity | | Maximum Activity | |
|---|----------------|---|------------------|----------|------------------|----------|
| Aluminum-26 | On Request | | | | | |
| Americium-241 | 6241 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Americium chloride in 1 M HCL | 7241 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Americium-243 | 6243 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Americium chloride in 1 M HCL | 7243 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Antimony-124 | 6124 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Antimony chloride in 6 M HCL | 7124 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Antimony-125 | 6225 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Antimony chloride in 6 M HCL | 7225 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Barium-133 | 6133 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Barium chloride in 0.1M HCL | 7133 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Beryllium-7 | On Request | | | | | |
| Beryllium chloride in 0.5 M HCL | On Request | | | | | |
| Bismuth-207 | 6207 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Bismuth chloride in 1M HCL | 7207 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Cadmium-109 | 6109 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Cadmium chloride in 0.1 M HCL | 7109 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 500 µCi | 18.5 MBq |
| Calcium-45 | 6045 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Calcium chloride in H ₂ O | 7045 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Californium-252 | 6252 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Californium nitrate in 0.1 M HNO ₃ | 7252 | Calibrated Solution uncertainty +/-3-5% | 10 nCi | 370 kBq | 100 µCi | 3.7 MBq |
| Carbon-14 (1) | 6014 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Benzoic Acid-Carboxyl-C-14 in 0.1 M NaOH | 7014 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Cerium-139 | 6139 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Cerium chloride in 0.5M HCL | 7139 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Cerium-141 | On Request | | | | | |
| Cesium-134(2) | 6134 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Cesium chloride in 0.1 M HCL | 7134 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Cesium-137 | 6137 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Cesium chloride in 0.1 M HCL | 7137 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Chlorine-36 | 6036 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Sodium chloride in H ₂ O | 7036 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Chromium-51 | 6051 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Chromium chloride in 0.5 M HCL | 7051 | Calibrated Solution uncertainty +/-3-5% | 500 nCi | 18.5 kBq | 500 µCi | 18.5 MBq |
| Cobalt-56 (3) | 6056 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Cobalt chloride in 0.1 M HCL | 7056 | Calibrated Solution uncertainty +/-3-5% | 200 nCi | 7.4 kBq | 100 µCi | 3.7 MBq |
| Cobalt-57 | 6057 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Cobalt chloride in 0.1 M HCL | 7057 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Co-56 and Co-58 < 0.2% | | | | | | |

1) Cannot offer Na₂CO₃ or any other carbonic acid form.

2) May contain Ba-133 impurity.

3) Impurities may exceed 10%. This isotope is sold as-is. Please contact customer service if you have specific requirements.

Standard & Radionuclide Solutions

All solutions are prepared to a tolerance of +/-15% of the requested activity. NIST traceable calibrated solution uncertainties are stated in the table.

| Nuclide & Chemical Form | Catalog Number | Uncertainty (NIST) (99% Confidence Level) | Minimum Activity | | Maximum Activity | |
|---|----------------|---|------------------|----------|------------------|---------|
| Cobalt-58 | On Request | | | | | |
| Cobalt-60 | 6060 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Cobalt chloride in 0.1 M HCl | 7060 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Curium-244 | 6244 | Nominal Solution | 1 nCi | 37 Bq | 100 µCi | 3.7 MBq |
| Curium nitrate in 1 M HNO ₃ | 7244 | Calibrated Solution uncertainty +/-3-5% | 10 nCi | 370 Bq | 100 µCi | 3.7 MBq |
| Europium-152 | 6152 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Europium chloride in 0.5 M HCl | 7152 | Calibrated Solution uncertainty +/-3-5% | 500 nCi | 18.5 kBq | 100 µCi | 3.7 MBq |
| Eu-154 <2% | | | | | | |
| Gd-153 impurity as high as 13%. Call customer service for specific information. | | | | | | |
| Europium-154 ⁽¹⁾ | 6154 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Europium chloride in 0.5 M HCl | 7154 | Calibrated Solution uncertainty +/-3-5% | 500 nCi | 18.5 kBq | 100 µCi | 3.7 MBq |
| Europium-155 ⁽¹⁾ | 6155 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Europium chloride in 0.5M HCl | 7155 | Calibrated Solution uncertainty +/-3-5% | 200 nCi | 7.4 kBq | 100 µCi | 3.7 MBq |
| Gadolinium-148 | On Request | | | | | |
| Gadolinium-153 | 6153 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Gadolinium chloride in 1 M HCl | 7153 | Calibrated Solution uncertainty +/-3-5% | 200 nCi | 7.4 kBq | 100 µCi | 3.7 MBq |
| Eu-154 < 2% | | | | | | |
| Germanium-68 ⁽²⁾ | 6068 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 85 MBq |
| Germanium chloride in 0.5 M HCl | 7068 | Calibrated Solution uncertainty +/-3-5% | 1 µCi | 37 kBq | 100 µCi | 3.7 MBq |
| Gold-195 | On Request | | | | | |
| Gold-198 | On Request | | | | | |
| Holmium-166m ⁽¹⁾ | 6166 | Nominal Solution | 1 nCi | 37 Bq | 100 µCi | 3.7 MBq |
| Holmium chloride in 0.1 M HCl | 7166 | Calibrated Solution uncertainty +/-3-5% | 200 nCi | 7.4 kBq | 100 µCi | 3.7 MBq |
| Hydrogen-3 | 6003 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Hydrogen-3 as H ₂ O | 7003 | Calibrated Solution uncertainty +/-3-5% | 500 nCi | 18.5 kBq | 100 µCi | 3.7 MBq |
| Iodine-125 | 6125 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Sodium iodide in 0.1M NaOH | 7125 | Calibrated Solution uncertainty +/-3-5% | 200 nCi | 7.4 kBq | 100 µCi | 3.7 MBq |
| Iodine-129 | 6129 | Nominal Solution | 1 nCi | 37 Bq | 10 µCi | 370 kBq |
| Sodium iodide in 0.1 M NaOH | 7129 | Calibrated Solution uncertainty +/-3-5% | 1 µCi | 37 kBq | 10 µCi | 370 kBq |
| Iodine-131 | 6131 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Sodium iodide in 0.1 M NaOH | 7131 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Iridium-192 | 6192 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Iridium chloride in 0.1 M HCl or Hexachloroiridate in H ₂ O | 7192 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Iron-55 | 6055 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Ferric chloride in 1 M HCl | 7055 | Calibrated Solution uncertainty +/-6.0% | 20 µCi | 740 kBq | 100 µCi | 3.7 MBq |

1) This isotope is sold as-is. Please contact customer service if you have specific impurity requirements.

2) In equilibrium with daughter Ga-68.

All solutions are prepared to a tolerance of +/-15% of the requested activity. NIST traceable calibrated solution uncertainties are stated in the table.

| Nuclide & Chemical Form | Catalog Number | Uncertainty (NIST) (99% Confidence Level) | Minimum Activity | | Maximum Activity | |
|--|----------------|---|------------------|---------|------------------|---------|
| Iron-59 | 6059 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Ferric chloride in 0.5 M HCl | 7059 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Lead-210 | 6210 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Lead nitrate in 1M HNO ₃ (1) | 7210 | Calibrated Solution uncertainty +/-7.1% | 200 nCi | 7.4 kBq | 100 µCi | 3.7 MBq |
| Manganese-54 | 6054 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Manganese chloride in 0.5 M HCl | 7054 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Mercury-203 | 6203 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Mercury chloride in 1 M HCl | 7203 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Neptunium-237 | 6237 | Nominal Solution | 1 nCi | 37 Bq | 100 µCi | 3.7 MBq |
| Neptunium nitrate in 4 M HNO ₃ | 7237 | Calibrated Solution uncertainty +/-3-5% | 10 nCi | 370 Bq | 100 µCi | 3.7 MBq |
| Nickel-63 | 6063 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Nickel chloride in 0.1 M HCl | 7063 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Niobium-95 | 6195 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Niobium chloride in 6 M HCl | 7195 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Phosphorus-32 | 6032 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Phosphoric acid in 0.02 M HCl | 7032 | Calibrated Solution uncertainty +/-3-5% | 1 µCi | 37 kBq | 100 µCi | 3.7 MBq |
| Plutonium-238 | 6238 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Plutonium nitrate in 4 M HNO ₃ | 7238 | Calibrated Solution uncertainty +/-3-5% | 10 nCi | 370 Bq | 100 µCi | 3.7 MBq |
| Plutonium-239 | 6239 | Nominal Solution | 1 nCi | 37 Bq | 100 µCi | 3.7 MBq |
| Plutonium nitrate in 4 M HNO ₃ | 7239 | Calibrated Solution uncertainty +/-3-5% | 10 nCi | 370 Bq | 100 µCi | 3.7 MBq |
| Plutonium-240 | 6240 | Nominal Solution | 1 nCi | 37 Bq | 100 µCi | 3.7 MBq |
| Plutonium nitrate in 4 M HNO ₃ | 7240 | Calibrated Solution uncertainty +/-3-5% | 10 nCi | 370 Bq | 100 µCi | 3.7 MBq |
| Plutonium-241 | 6341 | Nominal Solution | 1 nCi | 37 Bq | 100 µCi | 3.7 MBq |
| Plutonium nitrate in 4 M HNO ₃ | 7341 | Calibrated Solution uncertainty +/-3.5-5% | 10 nCi | 370 Bq | 100 µCi | 3.7 MBq |
| Plutonium-242 | 6242 | Nominal Solution | 1 nCi | 37 Bq | 100 µCi | 3.7 MBq |
| Plutonium nitrate in 4 M HNO ₃ | 7242 | Calibrated Solution uncertainty +/-3-5% | 10 nCi | 370 Bq | 100 µCi | 3.7 MBq |
| Purity specifications available upon request | | | | | | |
| Polonium-208 | On Request | | | | | |
| Polonium-209 | 6209 | Nominal Solution uncertainty +/-3.0% | 1 nCi | 37 Bq | 100 nCi | 3.7 kBq |
| Polonium nitrate in 1M HNO ₃ | 7209 | Calibrated Solution uncertainty +/-3-5% | 10 nCi | 370 Bq | 100 nCi | 3.7 kBq |
| Polonium-210 | 6310 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Polonium chloride in 2 M HCl | 7310 | Calibrated Solution uncertainty +/-3-5% | 10 nCi | 370 Bq | 100 µCi | 3.7 MBq |
| Promethium-147 | 6147 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Promethium chloride in 0.5 M HCl | 7147 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Radium-226 | 6226 | Nominal Solution | 1 nCi | 37 Bq | 100 µCi | 370 kBq |
| Radium nitrate in 1 M HNO ₃ | 7226 | Calibrated Solution uncertainty +/-3-5% | 10 nCi | 370 Bq | 100 µCi | 370 kBq |
| Radium-228 | On Request | | | | | |

To place an order or receive a quotation for any standard or radionuclide solution please provide the following information: **Catalog Number, Activity, Configuration** (include vial type and volume), and **Fill Volume**.

Customer Service—Orders and quotations may be faxed, phoned, or e-mailed:
 Phone: (661) 309-1010 Fax: (661) 257-8303
 Email: sales@ezag.com

1) In equilibrium with daughter Bi-210.

Standard & Radionuclide Solutions

All solutions are prepared to a tolerance of +/-15% of the requested activity. NIST traceable calibrated solution uncertainties are stated in the table.

| Nuclide & Chemical Form | Catalog Number | Uncertainty (NIST) (99% Confidence Level) | Minimum Activity | | Maximum Activity | |
|--|----------------|---|------------------|---------|------------------|---------|
| Rhenium-186 | On Request | | | | | |
| Rhenium-188 | On Request | | | | | |
| Ruthenium-103 | 6103 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Ruthenium chloride in 4 M HCl | 7103 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Ruthenium-106 | 6106 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Ruthenium chloride in 6 M HCl | 7106 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Samarium-151 | On Request | | | | | |
| Scandium-46 | 6046 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Scandium chloride in 0.5M HCl | 7046 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Selenium-75 | 6075 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Selenious acid in 0.1 M HCl | 7075 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Silicon-32 ⁽¹⁾ | 6132 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Sodium silicate in 0.1M NaOH | 7132 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Silver-110m | 6110 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Silver nitrate in 0.1 M HNO ₃ | 7110 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Sodium-22 | 6022 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Sodium chloride in H ₂ O | 7022 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Strontium-85 | 6085 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Strontium chloride in 0.5 M HCl | 7085 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Strontium-89 | On Request | | | | | |
| Strontium-90 ⁽²⁾ | 6090 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Strontium chloride in 0.1 M HCl | 7090 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Sulfur-35 | 6035 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Sodium Sulfate in H ₂ O | 7035 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Tantalum-182 ⁽³⁾ | 6182 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Tantalum nitrate in 4 M HNO ₃ + 0.2M HF | 7182 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Technetium-95m | On Request | | | | | |
| Technetium-99 ⁽⁴⁾ | 6099 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Ammonium pertechnetate in H ₂ O | 7099 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Tellurium-123m | 6123 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Tellurous acid in 4 M HCl | 7123 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Thallium-204 | 6204 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Thallium chloride in 1 M HCl | 7204 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Thorium-228 | 6228 | Nominal Solution | 1 nCi | 37 Bq | 100 µCi | 3.7 MBq |
| Thorium nitrate in ThCl ₄ in 1M HCl | 7228 | Calibrated Solution uncertainty +/-3-5% | 10 nCi | 370 Bq | 100 µCi | 3.7 MBq |

1) In equilibrium with daughter P-32. Packaged in polypropylene vial.

2) In equilibrium with Y-90.

3) Packaged in polypropylene vial.

4) 0.65 mCi/mL solubility limit.

All solutions are prepared to a tolerance of +/-15% of the requested activity. NIST traceable calibrated solution uncertainties are stated in the table.

| Nuclide & Chemical Form | Catalog Number | Uncertainty (NIST) (99% Confidence Level) | Minimum Activity | | Maximum Activity | |
|---|-----------------------|--|-------------------------|----------|-------------------------|----------|
| Thorium-229 | 6229 | Nominal Solution | 1 nCi | 37 Bq | 100 µCi | 3.7 MBq |
| Thorium nitrate in 0.1 M HNO ₃ | 7229 | Calibrated Solution uncertainty +/-3-5% | 10 nCi | 370 Bq | 100 µCi | 3.7 MBq |
| Thorium-230 | 6230 | Nominal Solution | 10 nCi | 37 Bq | 10 µCi | 3.7 MBq |
| Thorium nitrate in 0.1 M HNO ₃ | 7230 | Calibrated Solution uncertainty +/-3-5% | 10 nCi | 370 Bq | 10 µCi | 3.7 MBq |
| Thorium-232 | 6232 | Nominal Solution | 1 nCi | 37 Bq | 90 nCi | 3.3 kBq |
| Thorium nitrate in H ₂ O | 7232 | Calibrated Solution uncertainty +/-3-5% | 10 nCi | 370 Bq | 90 µCi | 3.3 kBq |
| Tin-113 | 6113 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Hexachlorostannate (IV) in 4 M HCl | 7113 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Uranium-232 | On Request | | | | | |
| Uranium-233 | 6233 | Nominal Solution | 1 nCi | 37 Bq | 10 µCi | 370 kBq |
| Uranyl nitrate in dilute Nitric Acid | 7233 | Calibrated Solution uncertainty +/-3-5% | 10 nCi | 370 Bq | 10 µCi | 370 kBq |
| Uranium-235 | 6235 | Nominal Solution | 1 nCi | 37 Bq | 100 nCi | 3.7 kBq |
| Uranyl nitrate in dilute Nitric Acid | 7235 | Calibrated Solution uncertainty +/-3-5% | 10 nCi | 370 Bq | 100 nCi | 3.7 kBq |
| Uranium-236 | 6336 | Nominal Solution | 1 nCi | 37 Bq | 100 µCi | 3.7 MBq |
| Uranyl nitrate in dilute Nitric Acid | 7336 | Calibrated Solution uncertainty +/-3-5% | 10 nCi | 370 Bq | 100 µCi | 3.7 MBq |
| Uranium-238 | 6338 | Nominal Solution | 1 nCi | 37 Bq | 100 nCi | 3.7 kBq |
| Uranyl nitrate in dilute Nitric Acid | 7338 | Calibrated Solution uncertainty +/-3-5% | 10 nCi | 370 Bq | 100 µCi | 3.7 MBq |
| Yttrium-88 | 6088 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Yttrium chloride in 0.1 M HCl | 7088 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Zinc-65 | 6065 | Nominal Solution | 1 nCi | 37 Bq | 5 mCi | 185 MBq |
| Zinc chloride in 0.5 M HCl | 7065 | Calibrated Solution uncertainty +/-3-5% | 100 nCi | 3.7 kBq | 100 µCi | 3.7 MBq |
| Zirconium-95 (1) | 6095 | Nominal Solution | 1 nCi* | 37 Bq* | 5 mCi* | 185 MBq* |
| Zirconium oxalate in 0.5M Oxalic Acid | 7095 | Calibrated Solution uncertainty +/-3-5% | 200 nCi* | 7.4 kBq* | 100 µCi* | 3.7 MBq* |

1) Packaged in polypropylene vial. *Assuming low % Nb-95 daughter. Call customer service for information.

To place an order or receive a quotation for any standard or radionuclide solution please provide the following information: **Catalog Number, Activity, Configuration** (include vial type and volume), and **Fill Volume**.

Customer Service—Orders and quotations may be faxed, phoned, or e-mailed:
 Phone: (661) 309-1010 Fax: (661) 257-8303
 Email: sales@ezag.com

Multinuclide Standards



The nine-nuclide gamma standard, routinely used to establish efficiency curves for gamma spectrometers, covers an energy range from 88 keV to 1836 keV. As options, Am-241 and/or Pb-210 can be added to extend the calibration curve down to 60 keV and 46 keV respectively. IPL offers two nine-nuclide gamma standards. Series 7500 contains Te-123m and Cr-51 for those customers who require a non-mercury containing standard.

Series 7600 contains Hg-203 and Ce-139. Please note that Hg-203 may leach out from polyethylene containers and may contaminate the entire container. Proper handling techniques must be observed. The component nuclides of each series have been chosen to minimize peak interference, and the activity ratios have been selected to yield similar count rates in all major peaks on typical coaxial germanium detectors.

The multinuclide standards are NIST traceable with each component certified with an uncertainty less than $\pm 5\%$ at the 99% confidence level except for Pb-210 when added. The multinuclide standards are prepared gravimetrically from calibrated solutions and then confirmed using a high purity germanium detector to ensure the highest possible quality.

Multinuclide standards are made to order and are available on a year-round basis in a variety of configurations described on pages 22–24. Standards can be supplied for special applications with nuclides, activities, containers and matrices manufactured to customer specifications.

Figure 19-A: Typical Efficiency vs. Energy Plot for 7500 ML

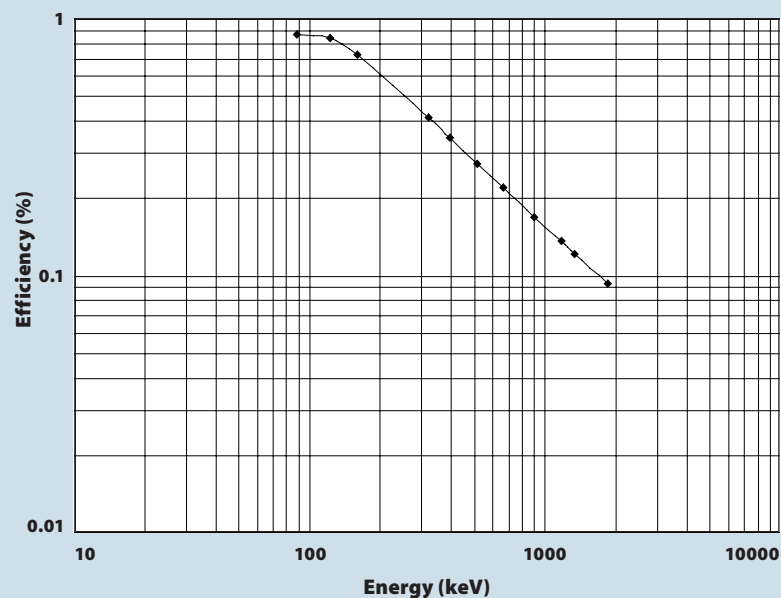
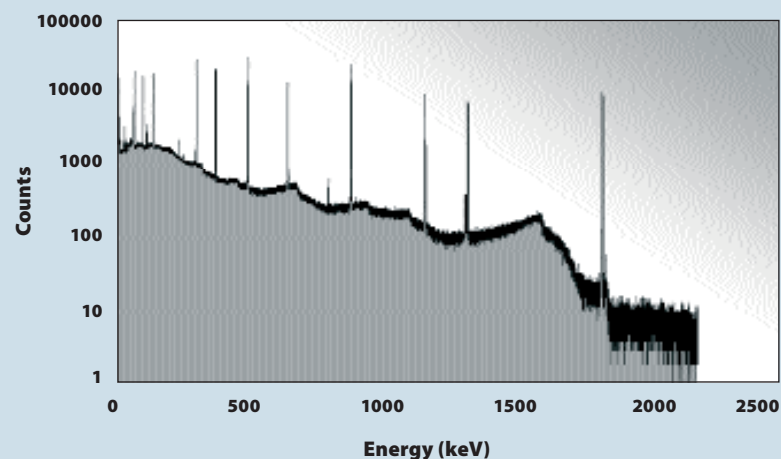


Figure 19-B: Multinuclide Spectrum of a 5 μ Ci Solution Containing Te-123m and Cr-51, Series 7500



Multinuclide Standards

| Model 7500—7500 ML | | | | | | | |
|--------------------|----------------------------|--------------------|-------------------|--------------|--------------------|---------------------------------------|---------------------------------|
| Isotope | Half-Life Years or Days | Gamma Ray (MeV) | Photons/ Decay | % Activity | (μCi) | Activity in 1 μCi , kBq | Photons/s per μCi |
| Cd-109 | 462.6 d | 0.088 | 0.0363 | 28.7 | 0.287 | 10.6 | 385 |
| Co-57 | 271.79 d | 0.122 | 0.856 | 1.1 | 0.011 | 0.407 | 348 |
| | | 0.137 | 0.107 | | | | 44 |
| Te-123m | 119.7 d | 0.159 | 0.840 | 1.4 | 0.014 | 0.518 | 435 |
| Cr-51 | 27.706 d | 0.320 | 0.0986 | 35.7 | 0.357 | 13.2 | 1302 |
| Sn-113 | 115.09 d | 0.392 | 0.649 | 5.2 | 0.052 | 1.92 | 1249 |
| Sr-85 | 64.849 d | 0.514 | 0.984 | 6.6 | 0.066 | 2.44 | 2403 |
| Cs-137 | 30.17 y | 0.662 | 0.851 | 4.8 | 0.048 | 1.78 | 1511 |
| Co-60 | 5.272 y | 1.173 | 0.999 | 5.6 | 0.056 | 2.07 | 2070 |
| | | 1.333 | 0.999 | | | | 2070 |
| Y-88 | 106.63 d | 0.898 | 0.940 | 10.9 | 0.109 | 4.03 | 3791 |
| | | 1.836 | 0.994 | | | | 4009 |
| Total | | | | 100.0 | 1.00 | 37.00 | |

| Model 7501—7500 ML + Am-241 | | | | | | | |
|-----------------------------|----------------------------|--------------------|-------------------|--------------|--------------------|---------------------------------------|---------------------------------|
| Isotope | Half-Life Years or Days | Gamma Ray (MeV) | Photons/ Decay | % Activity | (μCi) | Activity in 1 μCi , kBq | Photons/s per μCi |
| Am-241 | 432.17 y | 0.060 | 0.360 | 3.0 | 0.030 | 1.11 | 400 |
| Cd-109 | 462.6 d | 0.088 | 0.0363 | 28.7 | 0.287 | 10.6 | 385 |
| Co-57 | 271.79 d | 0.122 | 0.856 | 1.1 | 0.011 | 0.407 | 348 |
| | | 0.137 | 0.107 | | | | 44 |
| Te-123m | 119.7 d | 0.159 | 0.840 | 1.4 | 0.014 | 0.518 | 435 |
| Cr-51 | 27.706 d | 0.320 | 0.0986 | 35.7 | 0.357 | 13.2 | 1302 |
| Sn-113 | 115.09 d | 0.392 | 0.649 | 5.2 | 0.052 | 1.92 | 1249 |
| Sr-85 | 64.849 d | 0.514 | 0.984 | 6.6 | 0.066 | 2.44 | 2403 |
| Cs-137 | 30.17 y | 0.662 | 0.851 | 4.8 | 0.048 | 1.78 | 1511 |
| Co-60 | 5.272 y | 1.173 | 0.999 | 5.6 | 0.056 | 2.07 | 2070 |
| | | 1.333 | 0.999 | | | | 2070 |
| Y-88 | 106.63 d | 0.898 | 0.940 | 10.9 | 0.109 | 4.03 | 3791 |
| | | 1.836 | 0.994 | | | | 4009 |
| Total | | | | 103.0 | 1.03 | 38.1 | |

| Model 7503—7500 ML + Am-241 + Pb-210 | | | | | | | |
|--------------------------------------|----------------------------|--------------------|-------------------|--------------|--------------------|---------------------------------------|---------------------------------|
| Isotope | Half-Life Years or Days | Gamma Ray (MeV) | Photons/ Decay | % Activity | (μCi) | Activity in 1 μCi , kBq | Photons/s per μCi |
| Pb-210 | 22.3 y | 0.046 | 0.0418 | 30.0 | 0.300 | 11.10 | 464 |
| Am-241 | 432.17 y | 0.060 | 0.360 | 3.0 | 0.030 | 1.11 | 400 |
| Cd-109 | 462.6 d | 0.088 | 0.0363 | 28.7 | 0.287 | 10.6 | 385 |
| Co-57 | 271.79 d | 0.122 | 0.856 | 1.1 | 0.011 | 0.407 | 348 |
| | | 0.137 | 0.107 | | | | 44 |
| Te-123m | 119.7 d | 0.159 | 0.840 | 1.4 | 0.014 | 0.518 | 435 |
| Cr-51 | 27.706 d | 0.320 | 0.0986 | 35.7 | 0.357 | 13.2 | 1302 |
| Sn-113 | 115.09 d | 0.392 | 0.649 | 5.2 | 0.052 | 1.92 | 1249 |
| Sr-85 | 64.849 d | 0.514 | 0.984 | 6.6 | 0.066 | 2.44 | 2403 |
| Cs-137 | 30.17 y | 0.662 | 0.851 | 4.8 | 0.048 | 1.78 | 1511 |
| Co-60 | 5.272 y | 1.173 | 0.999 | 5.6 | 0.056 | 2.07 | 2070 |
| | | 1.333 | 0.999 | | | | 2070 |
| Y-88 | 106.63 d | 0.898 | 0.940 | 10.9 | 0.109 | 4.03 | 3791 |
| | | 1.836 | 0.994 | | | | 4009 |
| Total | | | | 133.0 | 1.33 | 49.2 | |

| Model 7600—7600 ML | | | | | | | |
|---------------------------|------------------------------------|----------------------------|---------------------------|-------------------|-----------------------------|--|---|
| Isotope | Half-Life Years or Days | Gamma Ray (MeV) | Photons/ Decay | % Activity | (μCI) | Activity in 1 μCI, kBq | Photons/s per μCI |
| Cd-109 | 462.6 d | 0.088 | 0.0363 | 42.0 | 0.420 | 15.5 | 564 |
| Co-57 | 271.79 d | 0.122 | 0.856 | 1.6 | 0.016 | 0.592 | 507 |
| | | 0.137 | 0.107 | | | | 63 |
| Ce-139 | 137.64 d | 0.166 | 0.799 | 2.0 | 0.020 | 0.740 | 591 |
| Hg-203 | 46.595 d | 0.279 | 0.815 | 6.0 | 0.060 | 2.22 | 1809 |
| Sn-113 | 115.09 d | 0.392 | 0.649 | 7.6 | 0.076 | 2.81 | 1825 |
| Sr-85 | 64.849 d | 0.514 | 0.984 | 9.6 | 0.096 | 3.55 | 3495 |
| Cs-137 | 30.17 y | 0.662 | 0.851 | 7.0 | 0.070 | 2.59 | 2204 |
| Co-60 | 5.272 y | 1.173 | 0.999 | 8.2 | 0.082 | 3.03 | 3031 |
| | | 1.333 | 0.999 | | | | 3031 |
| Y-88 | 106.63 d | 0.898 | 0.940 | 16.0 | 0.160 | 5.92 | 5565 |
| | | 1.836 | 0.994 | | | | 5884 |
| Total | | | | 100.0 | 1.00 | 37.00 | |

| Model 7601—7600 ML + Am-241 | | | | | | | |
|------------------------------------|----------|-------|--------|--------------|-------------|-------------|------|
| Am-241 | 432.17 y | 0.060 | 0.360 | 3.0 | 0.030 | 1.11 | 400 |
| Cd-109 | 462.6 d | 0.088 | 0.0363 | 42.0 | 0.420 | 15.5 | 564 |
| Co-57 | 271.79 d | 0.122 | 0.856 | 1.6 | 0.016 | 0.592 | 507 |
| | | 0.137 | 0.107 | | | | 63 |
| Ce-139 | 137.64 d | 0.166 | 0.799 | 2.0 | 0.020 | 0.740 | 591 |
| Hg-203 | 46.595 d | 0.279 | 0.815 | 6.0 | 0.060 | 2.22 | 1809 |
| Sn-113 | 115.09 d | 0.392 | 0.649 | 7.6 | 0.076 | 2.81 | 1825 |
| Sr-85 | 64.849 d | 0.514 | 0.984 | 9.6 | 0.096 | 3.55 | 3495 |
| Cs-137 | 30.17 y | 0.662 | 0.851 | 7.0 | 0.070 | 2.59 | 2204 |
| Co-60 | 5.272 y | 1.173 | 0.999 | 8.2 | 0.082 | 3.03 | 3031 |
| | | 1.333 | 0.999 | | | | 3031 |
| Y-88 | 106.63 d | 0.898 | 0.940 | 16.0 | 0.160 | 5.92 | 5565 |
| | | 1.836 | 0.994 | | | | 5884 |
| Total | | | | 103.0 | 1.03 | 38.1 | |

| Model 7603—7600 ML + Am-241 + Pb-210 | | | | | | | |
|---|----------|-------|--------|--------------|-------------|-------------|------|
| Pb-210 | 22.3 y | 0.046 | 0.0418 | 30.0 | 0.300 | 11.10 | 464 |
| Am-241 | 432.17 y | 0.060 | 0.360 | 3.0 | 0.030 | 1.11 | 400 |
| Cd-109 | 462.6 d | 0.088 | 0.0363 | 42.0 | 0.420 | 15.5 | 564 |
| Co-57 | 271.79 d | 0.122 | 0.856 | 1.6 | 0.016 | 0.592 | 507 |
| | | 0.137 | 0.107 | | | | 63 |
| Ce-139 | 137.64 d | 0.166 | 0.799 | 2.0 | 0.020 | 0.740 | 591 |
| Hg-203 | 46.595 d | 0.279 | 0.815 | 6.0 | 0.060 | 2.22 | 1809 |
| Sn-113 | 115.09 d | 0.392 | 0.649 | 7.6 | 0.076 | 2.81 | 1825 |
| Sr-85 | 64.849 d | 0.514 | 0.984 | 9.6 | 0.096 | 3.55 | 3495 |
| Cs-137 | 30.17 y | 0.662 | 0.851 | 7.0 | 0.070 | 2.59 | 2204 |
| Co-60 | 5.272 y | 1.173 | 0.999 | 8.2 | 0.082 | 3.03 | 3031 |
| | | 1.333 | 0.999 | | | | 3031 |
| Y-88 | 106.63 d | 0.898 | 0.940 | 16.0 | 0.160 | 5.92 | 5565 |
| | | 1.836 | 0.994 | | | | 5884 |
| Total | | | | 133.0 | 1.33 | 49.2 | |

Multinuclide Standards

| Multinuclide Gamma Standard | Catalog Number | Uncertainty (99% Confidence Level) | Minimum Activity | | Maximum Activity | |
|---|----------------|---|------------------|--------|------------------|---------|
| Mixed Gamma 7500 Nine Nuclide Mixed Gamma Solution in 2 M HCl with Cr-51 and Te-123m | 7500 | Calibrated Solution uncertainty +/-3-5% | 1 µCi | 37 kBq | 100 µCi | 3.7 MBq |
| 7501 with 3% Am-241 | 7501 | Calibrated Solution uncertainty +/-3-5% | 1 µCi | 37 kBq | 100 µCi | 3.7 MBq |
| 7502 with 30% Pb-210 (1) | 7502 | Calibrated Solution uncertainty +/-3-5% | 1 µCi | 37 kBq | 100 µCi | 3.7 MBq |
| 7503 with 3% Am-241 and 30% Pb-210 (1) | 7503 | Calibrated Solution uncertainty +/-3-5% | 1 µCi | 37 kBq | 100 µCi | 3.7 MBq |
| Mixed Gamma 7600 Nine Nuclide Mixed Gamma Solution in 2 M HCl with Hg-203 and Ce-139 | 7600 | Calibrated Solution uncertainty +/-3-5% | 1 µCi | 37 kBq | 100 µCi | 3.7 MBq |
| 7601 with 3% Am-241 | 7601 | Calibrated Solution uncertainty +/-3-5% | 1 µCi | 37 kBq | 100 µCi | 3.7 MBq |
| 7602 with 30% Pb-210 (1) | 7602 | Calibrated Solution uncertainty +/-3-5% | 1 µCi | 37 kBq | 100 µCi | 3.7 MBq |
| 7603 with 3% Am-241 and 30% Pb-210 (1) | 7603 | Calibrated Solution uncertainty +/-3-5% | 1 µCi | 37 kBq | 100 µCi | 3.7 MBq |
| Mixed Tri-Nuclide (2) In 4 M HCl | 7700 | Calibrated Solution uncertainty +/-3-5% | 1 µCi | 37 kBq | 100 µCi | 3.7 MBq |

Multinuclide Solutions— 7500 and 7600

Multinuclide solutions are available in 5 mL flame sealed glass ampoules. The nuclide mixture is supplied in 2 M HCl containing the appropriate amount of each carrier to prevent precipitation or adsorption on the glass walls. Additional ampoule sizes can be quoted on request.



Multinuclide Point Standards (GF-ML)

The GF-ML is available in the Type D or Type M configurations. See pages 46 and 48 for technical drawings. Both have a 1" (25.4 mm) outside diameter with nuclide deposited in the center of each disk.

10 µCi maximum activity for GF-ML-D, and 2 µCi maximum activity for GF-ML-M. Please contact customer service if greater activities are required.



Multinuclide Simulated Charcoal or Zeolite Cartridge (EG-CH-ML)

The activity is uniformly distributed between two polyimide films and placed under the screen of a 1" x 2.25" (25.4 mm x 57.2 mm) separable plastic charcoal cartridge (surface loaded). This configuration simulates a surface loaded charcoal cartridge. See page 33 for technical drawing.



1) Pb-210 uncertainty is +/- 7.1%

2) See page 29 for specifications of this mixture.

Simulated Gas Standards (SGS-ML)

This configuration is available in the 7500 series only. EZIP's' Simulated Gas Standard is used for the calibration of gamma-ray detectors for the counting of radioactive noble gases. EZIP supplies a uniform, low density foam standard in many configurations. These standards are available on a continual basis.

The nuclide combination employed in the Simulated Gas Standard is a nine-nuclide multinuclide gamma standard. Americium-241 and/or Lead-210 can be added to allow efficiency determinations down to 60 keV or 46 keV respectively. See page 20 for more information on our 7500 series nine-nuclide gamma standard.

Standard activity is 1-5 μCi (37 kBq-185 kBq) with higher activities on request. Single nuclide standards are also available on request. The foam matrix density range is 0.04-0.4 g/cc. The Simulated Gas Standards are NIST traceable $\pm 5\%$ at the 99% confidence level. Please refer to page 24 for a listing of available beaker sizes.



Planar Multinuclide Calibration Standards

Three large area multinuclide configurations are available. In all cases the active elements are prepared by evaporative deposition.

Ring and Disk (EAB-LB-ML)

EAB-LB disk standards are designed to check the performance and efficiency of low level counting systems such as proportional counters. The stainless steel disk containing the active element is surrounded by an aluminum ring which holds the window assembly in place. Please see page 57 for technical drawing.



Planchet (EAB-PL-ML)

These sources simulate cupped planchet samples and can be used as calibration or performance check standards. Please see page 56 for technical drawing.



Filter Paper (EAB-FP-ML)

Filter paper standards are designed to simulate surface smears and thus develop efficiencies for smear samples of similar construction. Please see page 58 and 59 for technical drawing.



Multinuclide Standards

Large Volume Multinuclide Standards (EG-LV-ML) and Multinuclide Marinelli Beaker Standards (EG-LVM-ML)

These configurations provide a convenient method to calibrate HPGe and NaI(Tl) detectors, Large Volume Multinuclide Standards (EG-LV-ML) and Multinuclide Marinelli Beaker Standards (EG-LVM-ML). In both series the radioactivity is uniformly dispersed in the matrix. Specify the series, matrix and container type and size. For the Marinelli beakers, specify the detector type. The following are examples of customer-supplied materials that may also be used:

- Soil
- Vegetation/Food Products
- Pulverized Concrete

The LV-ML wide mouth polyethylene sample bottles are available in 250 mL, 500 mL, and 1000 mL. Additional sizes are quoted upon request. Customer supplied containers will be filled upon request. See page 31 for technical drawings.

Series LVM-ML Marinelli beakers, for both HPGe and NaI(Tl) detectors, are available in 500 mL, 1000 mL, 2000 mL and 4000 mL sizes. This configuration is useful where maximum efficiency is needed such as environmental samples. See below for a complete listing of available sizes.



GA-MA Catalog Numbers for Marinelli Beakers

| Catalog Number | Detector Types | Detector "Endcap" Diameter Inches | cm |
|----------------------|----------------------|-----------------------------------|------|
| 200 ml Models | | | |
| 443016 | Germanium or Ge-Li | 3.00 | 7.6 |
| 463316 | Germanium, 3 x 3 NaI | 3.25 | 8.3 |
| 500 ml Models | | | |
| 523N-E | 2 x 2 NaI | 2.25 | 5.7 |
| 527G-E | Germanium | 2.75 | 7.0 |
| 530G-E | Germanium or Ge-Li | 3.00 | 7.6 |
| 533N | Germanium, 3 x 3 NaI | 3.25 | 8.3 |
| 538G | Germanium | 3.75 | 9.5 |
| 541G | Germanium | 4.00 | 10.2 |
| 580G | Germanium | 3.15 | 8.0 |
| 590G | Germanium | 3.54 | 9.0 |

1 Liter Models

| | | | |
|--------|----------------------|------|------|
| 125G | Germanium, 2 x 2 NaI | 2.50 | 6.4 |
| 127G | Germanium | 2.75 | 7.0 |
| 130G | Germanium or Ge-Li | 3.00 | 7.6 |
| LA130G | Germanium or Ge-Li | 3.00 | 7.6 |
| 132G | Germanium | 3.25 | 8.3 |
| 133N | 3 x 3 NaI | 3.25 | 8.3 |
| 138G | Germanium | 3.75 | 9.5 |
| 141G | Germanium | 4.00 | 10.2 |
| 190G | Germanium | 3.54 | 9.0 |

GA-MA Catalog Numbers for Marinelli Beakers

| Catalog Number | Detector Types | Detector "Endcap" Diameter Inches | cm |
|-----------------------|----------------------|-----------------------------------|------|
| 2 Liter Models | | | |
| 227G | Germanium | 2.75 | 7.0 |
| 230G | Germanium or Ge-Li | 3.00 | 7.6 |
| 233N | 3 x 3 NaI | 3.25 | 8.3 |
| 4 Liter Models | | | |
| 430G | Germanium or Ge-Li | 3.00 | 7.6 |
| 433N | 3 x 3 NaI | 3.25 | 8.3 |
| 438G | Germanium | 3.75 | 9.5 |
| 441G | Germanium | 4.00 | 10.2 |
| 445N | Germanium, 4 x 4 NaI | 4.25 | 10.8 |
| 448G | Germanium | 4.75 | 12.1 |

Standard Matrices

| Matrix | Density | Description | Density Tolerance |
|--------|--------------------------------|--|-------------------|
| Epoxy | 1.0 g/cc | Standard IPL Epoxy Mixture | +/- 10% |
| Sand | 1.7 g/cc | 50-70 Mesh Sand | |
| Epoxy | 1.1 to 2.0 g/cc | Standard IPL Proprietary Filler | +/- 10% |
| Epoxy | 2.1 to 3.5 g/cc ⁽¹⁾ | Upon Request | +/- 10% |
| Epoxy | 0.4 to 0.9 g/cc | Standard Epoxy Using Proprietary LD Filler | +/- 10% |
| Foam | 0.04-0.4 g/cc ⁽²⁾ | Low Density Styrofoam | 0.04 - 0.4 g/cc |

1) Not available with Am-241 or Pb-210 due to attenuation of the gamma emissions from the epoxy and interference of coincidental x-ray emissions from the epoxy matrix with the gamma rays from Am-241.

2) Volumes of 100 mL and above only. Below 100 mL, density cannot be guaranteed.

Planar Multinuclide Calibration Standards (EAB)

| EAB-7500 Series Multinuclide | | | | | |
|------------------------------|------------------------------------|-----------------|--------------------------------------|--|--------------------------------|
| Catalog Number | Overall Dimensions (OD x Height) | Active Diameter | Nature of Active Material | Window | Available Activities |
| EAB-7500-PL | Planchet | | | | |
| | 2.0" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 1 µCi-25 µCi 37 kBq-925 kBq |
| EAB-7500-47LB | LB Disk | | | | |
| | 1.85" x 0.125" 47 mm x 3.18 mm | 1.61" 41 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 1 µCi-25 µCi 37 kBq-925 kBq |
| EAB-7500-50LB | Planchet | | | | |
| | 2.0" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 1 µCi-25 µCi 37 kBq-925 kBq |

| EAB-7501 Series Multinuclide with 3% Am-241 | | | | | |
|---|-------------------------------------|-----------------|--------------------------------------|--|--------------------------------|
| Catalog Number | Overall Dimensions (OD x Height) | Active Diameter | Nature of Active Material | Window | Available Activities |
| EAB-7501-PL | Planchet | | | | |
| | 2.0" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 1 µCi-25 µCi 37 kBq-925 kBq |
| EAB-7501-47LB | LB Disk | | | | |
| | 1.85" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 1 µCi-25 µCi 37 kBq-925 kBq |
| EAB-7501-50LB | Planchet | | | | |
| | 2.0" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 1 µCi-25 µCi 37 kBq-925 kBq |

| EAB-7502 Series Multinuclide with 30% Pb-210 | | | | | |
|--|-------------------------------------|-----------------|--------------------------------------|--|--------------------------------|
| Catalog Number | Overall Dimensions (OD x Height) | Active Diameter | Nature of Active Material | Window | Available Activities |
| EAB-7502-PL | Planchet | | | | |
| | 2.0" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 1 µCi-25 µCi 37 kBq-925 kBq |
| EAB-7502-47LB | LB Disk | | | | |
| | 1.85" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 1 µCi-25 µCi 37 kBq-925 kBq |
| EAB-7502-50LB | Planchet | | | | |
| | 2.0" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 1 µCi-25 µCi 37 kBq-925 kBq |

| EAB-7503 Series Multinuclide with 3% Am-241 and 30% Pb-210 | | | | | |
|--|-------------------------------------|-----------------|--------------------------------------|--|--------------------------------|
| Catalog Number | Overall Dimensions (OD x Height) | Active Diameter | Nature of Active Material | Window | Available Activities |
| EAB-7503-PL | Planchet | | | | |
| | 2.0" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 1 µCi-25 µCi 37 kBq-925 kBq |
| EAB-7503-47LB | LB Disk | | | | |
| | 1.85" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 1 µCi-25 µCi 37 kBq-925 kBq |
| EAB-7503-50LB | Planchet | | | | |
| | 2.0" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 1 µCi-25 µCi 37 kBq-925 kBq |

Multinuclide Standards

Planar Multinuclide Calibration Standards (EAB)

| EAB-7600 Series Multinuclide | | | | | |
|------------------------------|------------------------------------|-----------------|--------------------------------------|--|--------------------------------|
| Catalog Number | Overall Dimensions (OD x Height) | Active Diameter | Nature of Active Material | Window | Available Activities |
| EAB-7600-PL | Planchet | | | | |
| | 2.0" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 1 µCi-25 µCi 37 kBq-925 kBq |
| EAB-7600-47LB | LB Disk | | | | |
| | 1.85" x 0.125" 47 mm x 3.18 mm | 1.61" 41 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 1 µCi-25 µCi 37 kBq-925 kBq |
| EAB-7600-50LB | Planchet | | | | |
| | 2.0" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 1 µCi-25 µCi 37 kBq-925 kBq |

| EAB-7601 Series Multinuclide with 3% Am-241 | | | | | |
|---|-------------------------------------|-----------------|--------------------------------------|--|--------------------------------|
| Catalog Number | Overall Dimensions (OD x Height) | Active Diameter | Nature of Active Material | Window | Available Activities |
| EAB-7601-PL | Planchet | | | | |
| | 2.0" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 1 µCi-25 µCi 37 kBq-925 kBq |
| EAB-7601-47LB | LB Disk | | | | |
| | 1.85" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 1 µCi-25 µCi 37 kBq-925 kBq |
| EAB-7601-50LB | Planchet | | | | |
| | 2.0" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 1 µCi-25 µCi 37 kBq-925 kBq |

| EAB-7602 Series Multinuclide with 30% Pb-210 | | | | | |
|--|-------------------------------------|-----------------|--------------------------------------|--|--------------------------------|
| Catalog Number | Overall Dimensions (OD x Height) | Active Diameter | Nature of Active Material | Window | Available Activities |
| EAB-7602-PL | Planchet | | | | |
| | 2.0" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 1 µCi-25 µCi 37 kBq-925 kBq |
| EAB-7602-47LB | LB Disk | | | | |
| | 1.85" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 1 µCi-25 µCi 37 kBq-925 kBq |
| EAB-7602-50LB | Planchet | | | | |
| | 2.0" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 1 µCi-25 µCi 37 kBq-925 kBq |

| EAB-7603 Series Multinuclide with 3% Am-241 and 30% Pb-210 | | | | | |
|--|-------------------------------------|-----------------|--------------------------------------|--|--------------------------------|
| Catalog Number | Overall Dimensions (OD x Height) | Active Diameter | Nature of Active Material | Window | Available Activities |
| EAB-7603-PL | Planchet | | | | |
| | 2.0" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 1 µCi-25 µCi 37 kBq-925 kBq |
| EAB-7603-47LB | LB Disk | | | | |
| | 1.85" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 1 µCi-25 µCi 37 kBq-925 kBq |
| EAB-7603-50LB | Planchet | | | | |
| | 2.0" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 1 µCi-25 µCi 37 kBq-925 kBq |

Filter Paper (EAB-FP-ML)

Filter paper standards are designed to simulate surface smears and thus develop efficiencies for smear samples of similar construction. The standard mounts for the filter paper source are detailed below.

| EAB-FP-7500 Series Multinuclide | | | | | |
|--|---|-----------------|--------------------------------|--|--------------------------------|
| Catalog Number | Overall Dimensions (OD x Height) | Active Diameter | Nature of Active Material | Window | Available Activities |
| EAB-7500-PL-FP | Planchet 2.0" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar | 1 μCi-25 μCi 37 kBq-925 kBq |
| | LB Disk 1.85" x 0.125" 47 mm x 3.18 mm | 1.61" 41 mm | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar | 1 μCi-25 μCi 37 kBq-925 kBq |
| EAB-7500-50LB-FP | 2.0" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar | 1 μCi-25 μCi 37 kBq-925 kBq |
| EAB-FP-7501 Series Multinuclide with 3% Am-241 | | | | | |
| Catalog Number | Overall Dimensions (OD x Height) | Active Diameter | Nature of Active Material | Window | Available Activities |
| EAB-7501-PL-FP | Planchet 2.0" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar | 1 μCi-25 μCi 37 kBq-925 kBq |
| | LB Disk 1.85" x 0.125" 47 mm x 3.18 mm | 1.61" 41 mm | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar | 1 μCi-25 μCi 37 kBq-925 kBq |
| EAB-7501-50LB-FP | 2.0" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar | 1 μCi-25 μCi 37 kBq-925 kBq |
| EAB-FP-7502 Series Multinuclide with 30% Pb-210 | | | | | |
| Catalog Number | Overall Dimensions (OD x Height) | Active Diameter | Nature of Active Material | Window | Available Activities |
| EAB-7502-PL-FP | Planchet 2.0" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar | 1 μCi-25 μCi 37 kBq-925 kBq |
| | LB Disk 1.85" x 0.125" 47 mm x 3.18 mm | 1.61" 41 mm | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar | 1 μCi-25 μCi 37 kBq-925 kBq |
| EAB-7502-50LB-FP | 2.0" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar | 1 μCi-25 μCi 37 kBq-925 kBq |
| EAB-FP-7503 Series Multinuclide with 3% Am-241 and 30% Pb-210 | | | | | |
| Catalog Number | Overall Dimensions (OD x Height) | Active Diameter | Nature of Active Material | Window | Available Activities |
| EAB-7503-PL-FP | Planchet 2.0" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar | 1 μCi-25 μCi 37 kBq-925 kBq |
| | LB Disk 1.85" x 0.125" 47 mm x 3.18 mm | 1.61" 41 mm | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar | 1 μCi-25 μCi 37 kBq-925 kBq |
| EAB-7503-50LB-FP | 2.0" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar | 1 μCi-25 μCi 37 kBq-925 kBq |

Multinuclide Standards

Filter Paper (EAB-FP-ML)

Filter paper standards are designed to simulate surface smears and thus develop efficiencies for smear samples of similar construction. The standard mounts for the filter paper source are detailed below.

| EAB-FP-7600 Series Multinuclide | | | | | |
|---|---|-----------------|--------------------------------|--|--------------------------------|
| Catalog Number | Overall Dimensions (OD x Height) | Active Diameter | Nature of Active Material | Window | Available Activities |
| EAB-7600-PL-FP | Planchet 2.0" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar | 1 μCi-25 μCi 37 kBq-925 kBq |
| | LB Disk 1.85" x 0.125" 47 mm x 3.18 mm | 1.61" 41 mm | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar | 1 μCi-25 μCi 37 kBq-925 kBq |
| EAB-7600-50LB-FP | 2.0" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar | 1 μCi-25 μCi 37 kBq-925 kBq |
| EAB-FP-7601 Series Multinuclide with 3% Am-241 | | | | | |
| Catalog Number | Overall Dimensions (OD x Height) | Active Diameter | Nature of Active Material | Window | Available Activities |
| EAB-7601-PL-FP | Planchet 2.0" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar | 1 μCi-25 μCi 37 kBq-925 kBq |
| | LB Disk 1.85" x 0.125" 47 mm x 3.18 mm | 1.61" 41 mm | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar | 1 μCi-25 μCi 37 kBq-925 kBq |
| EAB-7601-50LB-FP | 2.0" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar | 1 μCi-25 μCi 37 kBq-925 kBq |
| EAB-FP-7602 Series Multinuclide with 30% Pb-210 | | | | | |
| Catalog Number | Overall Dimensions (OD x Height) | Active Diameter | Nature of Active Material | Window | Available Activities |
| EAB-7602-PL-FP | Planchet 2.0" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar | 1 μCi-25 μCi 37 kBq-925 kBq |
| | LB Disk 1.85" x 0.125" 47 mm x 3.18 mm | 1.61" 41 mm | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar | 1 μCi-25 μCi 37 kBq-925 kBq |
| EAB-7602-50LB-FP | 2.0" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar | 1 μCi-25 μCi 37 kBq-925 kBq |
| EAB-FP-7603 Series Multinuclide with 3% Am-241 and 30% Pb-210 | | | | | |
| Catalog Number | Overall Dimensions (OD x Height) | Active Diameter | Nature of Active Material | Window | Available Activities |
| EAB-7603-PL-FP | Planchet 2.0" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar | 1 μCi-25 μCi 37 kBq-925 kBq |
| | LB Disk 1.85" x 0.125" 47 mm x 3.18 mm | 1.61" 41 mm | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar | 1 μCi-25 μCi 37 kBq-925 kBq |
| EAB-7603-50LB-FP | 2.0" x 0.125" 50.8 mm x 3.18 mm | 1.77" 45 mm | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar | 1 μCi-25 μCi 37 kBq-925 kBq |

Tri-Nuclide Calibration Standards—TN Series

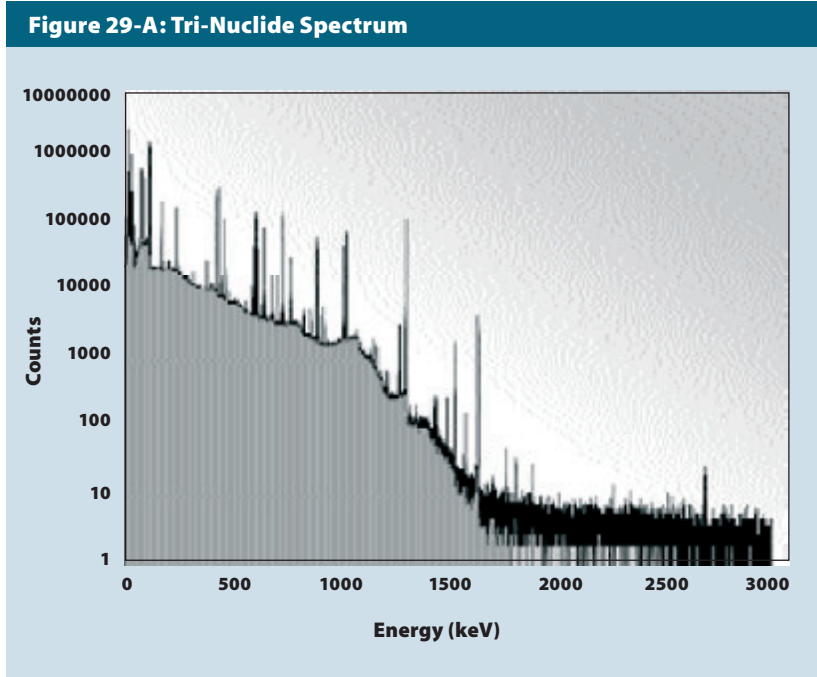
This standard is a multiple energy gamma emitting standard consisting of Sb-125 (T1/2=2.76y), Eu-154 (T1/2=8.59y), and Eu-155 (T1/2=4.85y). It is a relatively long lived gamma standard with many useful calibration points between 56 keV and 1597 keV.

While this standard does have the advantage of a longer useful life span when compared to the nine-nuclide mixed gamma standard, there are some disadvantages including cascade summing and spectral conflicts in photopeak emission rates.

The Tri-Nuclide Source is available as a nominal activity check source for various gamma energies, or as a NIST traceable gamma efficiency calibration standard in which the activity of each nuclide is certified to within $\pm 5\%$ at the 99% confidence level. The Tri-Nuclide is available in the same configurations as the nine nuclide multiline standard described on page 20.

| Tri-Nuclide Calibration | | | | | | |
|-------------------------|----------------|--------------------|---------------------|------------------|--|----------------------------|
| Nuclide | Half-Life Days | Gamma Energy (MeV) | Photons/Decay (MeV) | Percent of Total | Total Activity in 2 μCi (74 kBq) Activity | Approx. Photons/s Standard |
| Sb-125 | 1007.7 | 0.4279 | 0.297 | 40 | 0.800 (29.6) | 2300 |
| | | 0.6006 | 0.1773 | | | 1580 |
| Eu-154 ⁽¹⁾ | 3136.8 | 0.1231 | 0.412 | 40 | 0.800 (29.6) | 6090 |
| | | 0.7233 | 0.202 | | | 2990 |
| | | 1.0047 | 0.182 | | | 2694 |
| | | 1.274 | 0.350 | | | 5180 |
| Eu-155 | 1770 | 1.5965 | 0.0181 | 20 | 0.400 (14.8) | 268 |
| | | 0.087 | 0.311 | | | 2300 |
| | | 0.105 | 0.214 | | | 1580 |

1) Eu-154 will have Eu-152 impurities. Call customer service at time of order for specific information.



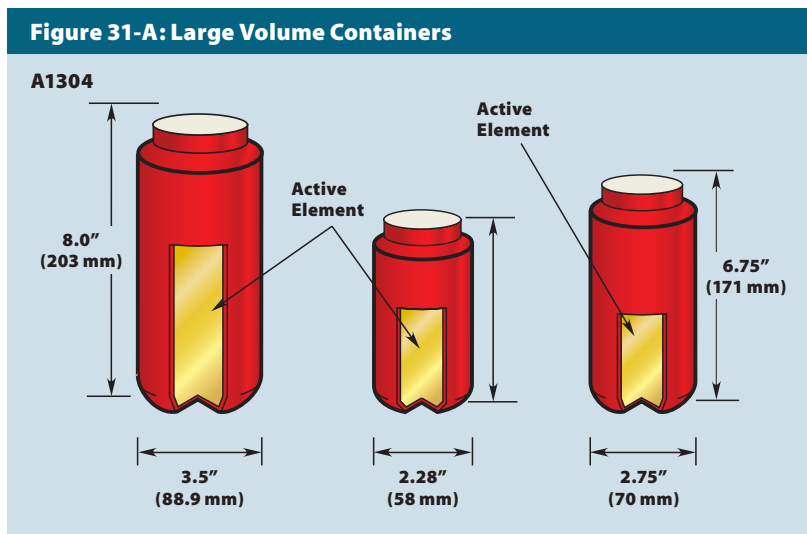
Large Volume Calibration Standards



The model EG Series standards offer a convenient method to calibrate HPGe and NaI(Tl) detectors for the analysis of soil and water samples, reactor coolants, air samples, and other environmental materials. Standard activity is 0.1 μCi (3.7 kBq) - 5 μCi (185 kBq). Customer supplied containers will be filled upon request.

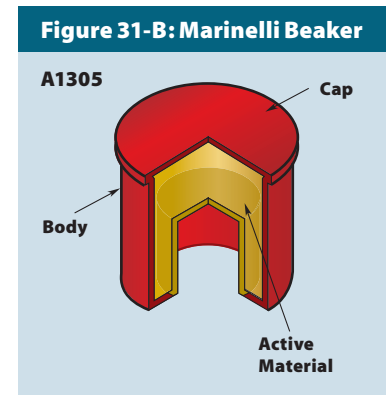
Large Volume Bottle Gamma Standards—EG-LVB

Series LVB wide mouth polyethylene sample bottles are available in 250 mL, 500 mL, and 1000 mL. Additional sizes are available upon request.



Marinelli Gamma Standards—EG-LVM

Series LVM Marinelli beakers, for both HPGe and NaI(Tl) detectors, are available in 500 mL, 1000 mL, 2000 mL and 4000 mL sizes. This configuration is useful where maximum efficiency is needed such as environmental samples. See table on page 32 for complete details on beakers.



See table on page 32 for model numbers and dimensions.

| Standard Matrices for Large Volume Bottle Containers and Marinelli Beakers | | | | |
|--|--------------------------------|--|----------------------------------|--|
| Matrix | Density | Materials | Density Tolerance ⁽¹⁾ | Details |
| Epoxy | 1.0 g/cc | Standard EZIP Epoxy Mixture | +/- 10% | Customer supplied materials may be used upon request. In both series the radioactivity is uniformly dispersed in the matrix. Specify the series, matrix and container type and size. For the Marinelli beakers, specify the model number as listed on page 32. |
| Sand | 1.7 g/cc | 50-70 Mesh Sand | | |
| Epoxy | 1.1 to 2.0 g/cc | Standard EZIP Proprietary Filler | +/- 10% | |
| Epoxy | 2.1 to 3.5 g/cc | Upon Request | +/- 10% | |
| Epoxy | 0.4 to 0.9 g/cc | Standard Epoxy Using Proprietary LD Filler | +/- 10% | |
| Foam | 0.04 to 0.4g/cc ⁽²⁾ | Low Density Styrofoam | 0.04 - 0.4 g/cc | |

1) Epoxy matrices will cure over time. Shrinkage may occur and cause density to increase slightly. There may also be separation of epoxy away from the wall of its container which will not affect the function of the source.

2) Volumes of 100 mL and above only. Below 100 mL density can not be guaranteed.

Large Volume Calibration Standards

GA-MA Catalog Numbers for Marinelli Beakers

| Catalog Number | Detector Types | Detector "Endcap" Diameter Inches | Diameter cm |
|-----------------------|----------------------|-----------------------------------|-------------|
| 200 ml Models | | | |
| 443016 | Germanium or Ge-Li | 3.00 | 7.6 |
| 463316 | Germanium, 3 x 3 Nal | 3.25 | 8.3 |
| 500 ml Models | | | |
| 523N-E | 2 x 2 Nal | 2.25 | 5.7 |
| 527G-E | Germanium | 2.75 | 7.0 |
| 530G-E | Germanium or Ge-Li | 3.00 | 7.6 |
| 533N | Germanium, 3 x 3 Nal | 3.25 | 8.3 |
| 538G | Germanium | 3.75 | 9.5 |
| 541G | Germanium | 4.00 | 10.2 |
| 580G | Germanium | 3.15 | 8.0 |
| 590G | Germanium | 3.54 | 9.0 |
| 1 Liter Models | | | |
| 125G | Germanium, 2 x 2 Nal | 2.50 | 6.4 |
| 127G | Germanium | 2.75 | 7.0 |
| 130G | Germanium or Ge-Li | 3.00 | 7.6 |
| LA130G | Germanium or Ge-Li | 3.00 | 7.6 |
| 132G | Germanium | 3.25 | 8.3 |
| 133N | 3 x 3 Nal | 3.25 | 8.3 |
| 138G | Germanium | 3.75 | 9.5 |
| 141G | Germanium | 4.00 | 10.2 |
| 190G | Germanium | 3.54 | 9.0 |

GA-MA Catalog Numbers for Marinelli Beakers

| Catalog Number | Detector Types | Detector "Endcap" Diameter Inches | Diameter cm |
|-----------------------|----------------------|-----------------------------------|-------------|
| 2 Liter Models | | | |
| 227G | Germanium | 2.75 | 7.0 |
| 230G | Germanium or Ge-Li | 3.00 | 7.6 |
| 233N | 3 x 3 Nal | 3.25 | 8.3 |
| 4 Liter Models | | | |
| 430G | Germanium or Ge-Li | 3.00 | 7.6 |
| 433N | 3 x 3 Nal | 3.25 | 8.3 |
| 438G | Germanium | 3.75 | 9.5 |
| 441G | Germanium | 4.00 | 10.2 |
| 445N | Germanium, 4 x 4 Nal | 4.25 | 10.8 |
| 448G | Germanium | 4.75 | 12.1 |



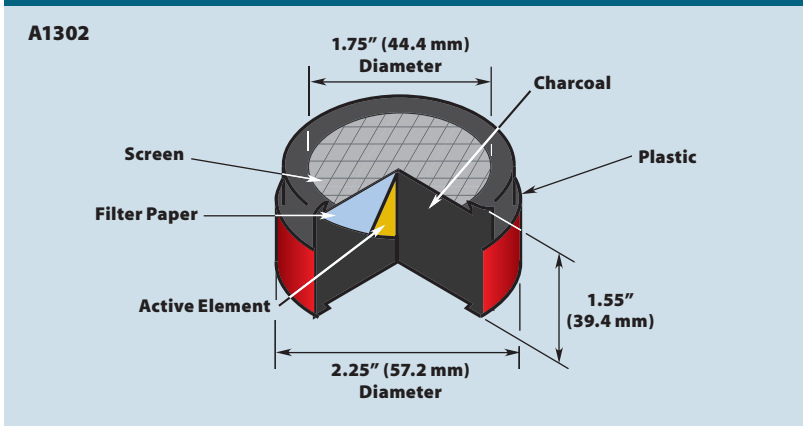
Simulated Charcoal or Zeolite Gamma Cartridge Standards—EG-CH

Face Loaded: The activity is uniformly distributed between two polyimide films and placed under the screen of a 1" x 2.25" (25.4 mm x 57.2 mm) plastic charcoal cartridge (surface loaded).

Uniform Distribution: The activity is uniformly distributed within the charcoal or zeolite filling of the cartridge.

An aluminum metal cartridge is also available upon request. The standard activity for all configurations is 0.1 μCi (3.7 kBq). Sources are NIST traceable for contained activity.

Figure 33-A : Charcoal Cartridge



NOTE: I-125 and I-129 are available as surface loaded sources only. See "Simulated I-125" standards on page 45.

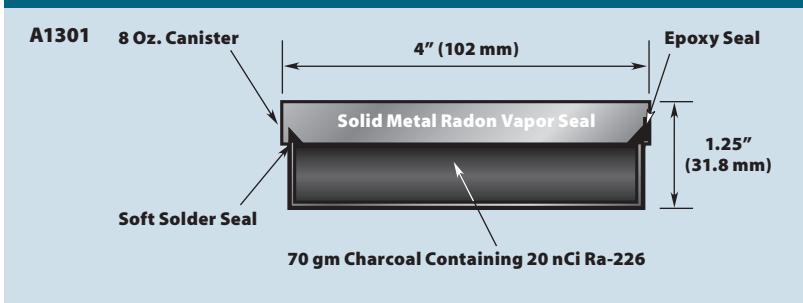
Radon-226 Canister Standard—EG-226C

These standards are used to calibrate radioassay systems for measuring nanocurie levels of environmental radon in standard EPA charcoal canisters. The gamma spectrum above the Ra-226 gamma at 186 keV (4%) is identical with that of Rn-222 and its daughters.

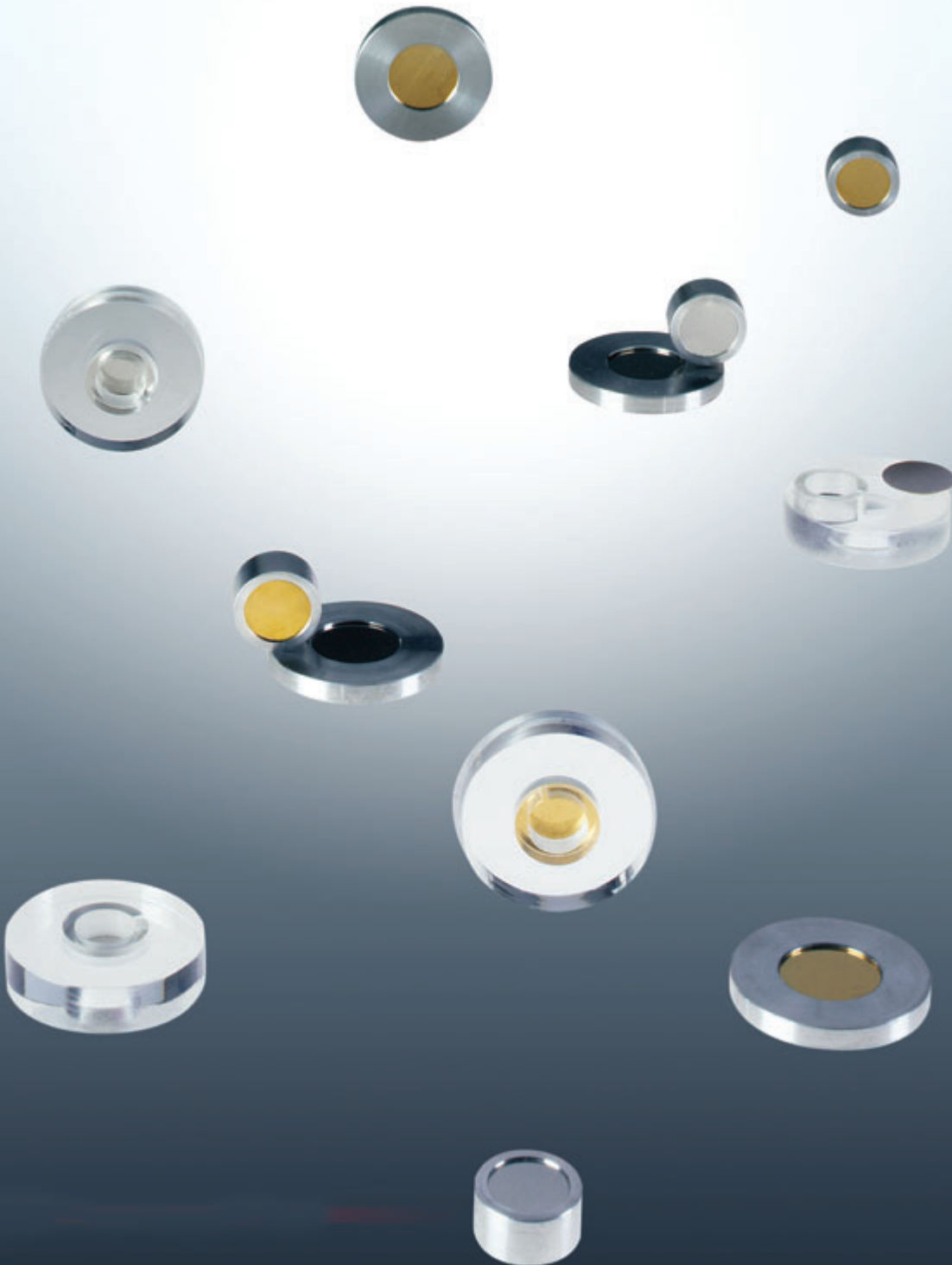
The standard is prepared by uniform dispersion of a calibrated Ra-226 solution into the charcoal fill of a standard 1.25" x 4" (31.8 mm x 102 mm) canister, which is then sealed over the charcoal to define the charcoal volume and to prevent the escape of Rn-222 and its daughter products.

The EG-226C is supplied with 20 nCi (740 Bq) Ra-226 and is NIST traceable. Calibration accuracy is within $\pm 5\%$ of the stated value at the 99% confidence level. Other activities and canister sizes are available on request.

Figure 33-B : Radon Canister



Alpha Particle Standards



The majority of alpha standards listed on pages 36–39 are spectroscopy grade and are suitable for the most exacting research requirements as well as for routine counting room applications. Standards that emit radon gas, most notably Th-228 and Ra-226, should not be used in gross alpha applications. Most sources are prepared by electrodeposition of the desired nuclide on a mirror finish platinum surface foil and are fixed to the surface by diffusion-bonding. These sources exhibit narrow line widths, generally less than 20 keV FWHM for high specific activity nuclides such as Po-210 and Am-241. Calibration methods are described on page 5.

Even the lowest intensity uncovered alpha source may deteriorate with time, showing signs of removable activity as well as decreased spectral resolution. This is caused by the migration of the active material into the substrate and by the accumulation of dust and grime.

For these reasons the source should be stored in a closed container when not in use. The inside of the container should be checked periodically for free activity. EZIP considers the useful life of alpha sources with long half-lives to be two years. We recommend a program of scheduled replacement for these sources.

Cf-252 sources are all supplied with a 100 µg/cm² gold cover. Please note that the gold will not prevent the loss of fission fragments and EZIP suggests the following procedures be followed when handling any Cf-252 source:

- The container should be opened and handled in a hood, glove box, or other well-ventilated enclosure and only by qualified personnel.
- If possible, when not in use, the source should be stored under vacuum or in inert atmosphere to prevent corrosion. These sources are not warranted as suitable for any specific application nor is EZIP liable for any damage or contamination to facilities or equipment resulting from their use.

All activities of Ra-226 and Th-228 standards are supplied with a 100 µg/cm² gold cover which is sufficient to prevent loss of radioactive recoil daughter products.

The general warranty does not apply to any open source of Cf-252, Th-228, or Ra-226. Additional gold covering up to 200 µg/cm² is available upon request.

All electroplated sources are prepared +/- 30% of nominal activity.

| Activities for U-235, U-238 and Th-232 | | | | | | | | | |
|---|-----------------|-----------|-----------|---------------------|---------------------|----------------------|----------------------|------------|------------|
| Capsule Type | Active Diameter | U-235 dpm | U-235 nCi | U-238 (Natural) dpm | U-238 (Natural) nCi | U-238 (Depleted) dpm | U-238 (Depleted) nCi | Th-232 dpm | Th-232 nCi |
| A-1 | 5 mm | 1000 | 0.45 | 140 | 0.063 | 70 | 0.032 | 15 | 0.007 |
| A-2 | 5 mm | 1000 | 0.45 | 140 | 0.063 | 70 | 0.032 | 15 | 0.007 |
| PM | 5 mm | 1000 | 0.45 | 140 | 0.063 | 70 | 0.032 | 15 | 0.007 |

- 1) Activities are for total alpha activity.
- 2) Individual uranium isotopes specified on Technical Data Sheets supplied with source certificates.
- 3) Due to low specific activity of these isotopes, these AF sources are not spectral grade sources.
- 4) Multiply nCi*37 to convert to Bq.

| | Weight % | | | | Activity % | | | |
|---------------------------|-----------------|--------|--------|--------|-------------------|-------|--------|---------|
| | U-234 | U-235 | U-236 | U-238 | U-234 | U-235 | U-236 | U-238 |
| Natural Uranium (0.72%) | 0.0055 | 0.720 | — | 99.274 | 49.501 | 2.250 | — | 48.249 |
| Depleted Uranium (0.017%) | 0.0002 | 0.0173 | 0.0000 | 99.982 | 2.875 | 0.108 | 0.0019 | 97.015 |
| Enriched Uranium (97.66%) | 1.658 | 97.663 | 0.1497 | 0.5296 | 97.904 | 2.003 | 0.0918 | 0.00169 |

Alpha Particle Standards

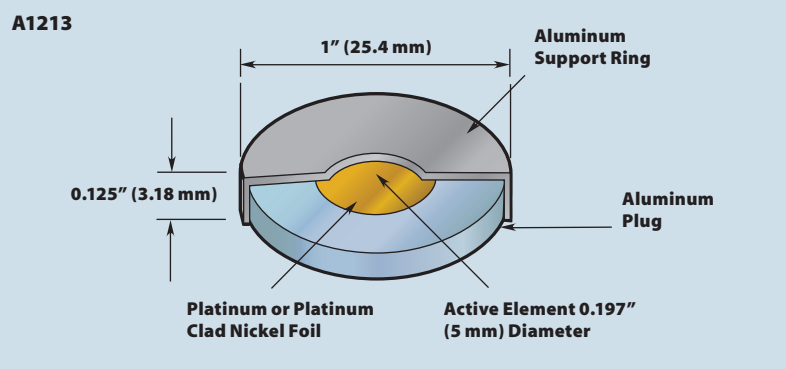
Alpha Particle Standards—Type A-1

The type A-1 source is permanently fixed in an aluminum holder 1" diameter x 0.125" high (25.4 mm x 3.18 mm). The active diameter is 0.197" (5.0 mm).

All alpha standards are offered as spectral grade sources up to the activity and active diameters listed unless otherwise noted. All electroplated alpha standards are manufactured to a tolerance of +/-30% of the nominal activity. All AF type sources are delicate surface sources; the active surface of the source must not be wipe tested or touched.



Figure 36-A: Type A-1 Disk, DWG A1213



Overall Dimensions

| Overall Diameter | Active Diameter | Height |
|------------------|-----------------|---------|
| 1" | 0.197" | 0.125" |
| 25.4 mm | 5 mm | 3.18 mm |

Window & Exceptions

| Window | Exceptions |
|--------|---|
| None | Cf-252, Ra-226, and Th-228: 100 µg/cm ² gold Po-210: 100 µg acrylic/cm ² only |

Alpha Particle Standards—Type A-1

| Catalog Number | Nuclide | Half-Life | Significant Alpha Energies (keV) | Nature of Active Material | Available Activities |
|----------------|-----------------------------------|----------------------------|-------------------------------------|--|----------------------------------|
| AF-241-A1 | Americium-241 | 432.2 y | 5388, 5443, 5486 | Electroplated onto Platinum Surface | 1 nCi-100 nCi (37 Bq-3.7 kBq) |
| AF-252-A1 | Californium-252 | 2.645 y | 6076, 6118 | Electroplated onto Platinum Surface | 1 nCi-100 nCi (37 Bq-3.7 kBq) |
| AF-244-A1 | Curium-244 | 18.11 y | 5763, 5805 | Electroplated onto Platinum Surface | 1 nCi-100 nCi (37 Bq-3.7 kBq) |
| AF-148-A1 | Gadolinium-148 | 75 y | 3184 | On Request | — |
| AF-237-A1 | Neptunium-237 ⁽¹⁾ | 2.140 x 10 ⁶ y | 4640-4873 | Electroplated onto Platinum Surface | 1 nCi-10 nCi (37 Bq-370 Bq) |
| AF-210-A1 | Polonium-210 | 138.376 d | 5304 | Electroless Deposition onto Silver Substrate | 1 nCi-100 nCi (37 Bq-3.7 kBq) |
| AF-238P-A1 | Plutonium-238 | 87.74 y | 5456, 5499 | Electroplated onto Platinum Surface | 1 nCi-100 nCi (37 Bq-3.7 kBq) |
| AF-239-A1 | Plutonium-239 | 2.411 x 10 ⁴ y | 5105, 5143, 5156 | Electroplated onto Platinum Surface | 1 nCi-10 nCi (37 Bq-370 Bq) |
| AF-226-A1 | Radium-226 ^(2,3) | 1,600 y | 4601, 4784 Daughters 5489 thru 7687 | Electroplated onto Platinum Surface | 1 nCi-100 nCi (37 Bq-3.7 kBq) |
| AF-228-A1 | Thorium-228 ^(2,4) | 698.2 d | 5341, 5423 Daughters 5449 thru 8784 | Electroplated onto Platinum Surface | 1 nCi-100 nCi (37 Bq-3.7 kBq) |
| AF-230-A1 | Thorium-230 | 7.54 x 10 ⁴ y | 4621, 4688 | Electroplated onto Platinum Surface | 1 nCi-10 nCi (37 Bq-370 Bq) |
| AF-232-A1 | Thorium-232 ^(1,2) | 1.405 x 10 ¹⁰ y | 3952, 4010 | Electroplated onto Platinum Surface | 0.007 nCi (0.26 Bq) |
| AF-235-A1 | Uranium-235 ^(1,2) | 7.037 x 10 ⁸ y | 4215-4597 | Electroplated onto Aluminum Foil | Max. Activity 0.4 nCi (14.8 Bq) |
| AF-238(Nat)-A1 | Uranium-238(Nat) ^(1,2) | 4.468 x 10 ⁹ y | 4147, 4196 | Electroplated onto Aluminum Foil | Max. Activity 0.05 nCi (1.85 Bq) |
| AF-238D-A1 | Uranium-238D ^(1,2) | 4.468 x 10 ⁹ y | 4147, 4196 | Electroplated onto Aluminum Foil | Max. Activity 0.032 nCi |

1) Not supplied as spectroscopy grade sources.

2) Not necessarily in equilibrium with daughters at time of shipment.

3) Radium-226 will leak Rn-222 gas.

4) Thorium-228 will leak Rn-220 gas.

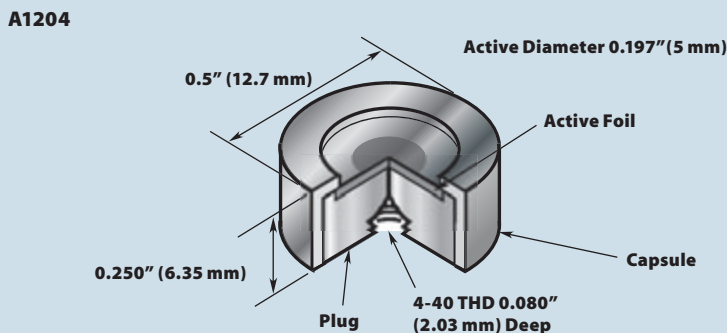
Alpha Particle Standards—Type A-2

The type A-2 source is permanently fixed in an aluminum holder 0.5" diameter x 0.250" high (12.7 mm x 6.35 mm). The active diameter is 0.197" (5.0 mm).

All alpha standards are offered as spectral grade sources up to the activity and active diameters listed unless otherwise noted. All electroplated alpha standards are manufactured to a tolerance of +/-30% of the nominal activity.



Figure 37-A: Type A-2 Disk



Overall Dimensions

| Overall Diameter | Active Diameter | Height |
|------------------|-----------------|---------|
| 0.5" | 0.197" | 0.250" |
| 12.7 mm | 5 mm | 6.35 mm |

Window & Exceptions

| Window | Exceptions |
|--------|---|
| None | Cf-252, Ra-226, and Th-228: 100 µg/cm ² gold Po-210: 100 µg acrylic/cm ² only |

Alpha Particle Standards—Type A-2

| Catalog Number | Nuclide | Half-Life | Significant Alpha Energies (keV) | Nature of Active Material | Available Activities |
|----------------|-----------------------------------|----------------------------|-------------------------------------|--|----------------------------------|
| AF-241-A2 | Americium-241 | 432.2 y | 5388, 5443, 5486 | Electroplated onto Platinum Surface | 1 nCi-100 nCi (37 Bq-3.7 kBq) |
| AF-252-A2 | Californium-252 | 2.645 y | 6076, 6118 | Electroplated onto Platinum Surface | 1 nCi-100 nCi (37 Bq-3.7 kBq) |
| AF-244-A2 | Curium-244 | 18.11 y | 5763, 5805 | Electroplated onto Platinum Surface | 1 nCi-100 nCi (37 Bq-3.7 kBq) |
| AF-148-A2 | Gadolinium-148 | 75 y | 3184 | On Request | — |
| AF-237-A2 | Neptunium-237 ⁽¹⁾ | 2.140 x 10 ⁶ y | 4640-4873 | Electroplated onto Platinum Surface | 1 nCi-10 nCi (37 Bq-370 Bq) |
| AF-210-A2 | Polonium-210 | 138.376 d | 5304 | Electroless Deposition onto Silver Substrate | 1 nCi-100 nCi (37 Bq-3.7 kBq) |
| AF-238P-A2 | Plutonium-238 | 87.74 y | 5456, 5499 | Electroplated onto Platinum Surface | 1 nCi-100 nCi (37 Bq-3.7 kBq) |
| AF-239-A2 | Plutonium-239 | 2.411 x 10 ⁴ y | 5105, 5143, 5156 | Electroplated onto Platinum Surface | 1 nCi-10 nCi (37 Bq-370 Bq) |
| AF-226-A2 | Radium-226 ^(2,3) | 1,600 y | 4601, 4784 Daughters 5489 thru 7687 | Electroplated onto Platinum Surface | 1 nCi-100 nCi (37 Bq-3.7 kBq) |
| AF-228-A2 | Thorium-228 ^(2,4) | 698.2 d | 5341, 5423 Daughters 5449 thru 8784 | Electroplated onto Platinum Surface | 1 nCi-100 nCi (37 Bq-3.7 kBq) |
| AF-230-A2 | Thorium-230 | 7.54 x 10 ⁴ y | 4621, 4688 | Electroplated onto Platinum Surface | 1 nCi-10 nCi (37 Bq-370 Bq) |
| AF-232-A2 | Thorium-232 ^(1,2) | 1.405 x 10 ¹⁰ y | 3952, 4010 | Electroplated onto Platinum Surface | 0.007 nCi (0.26 Bq) |
| AF-235-A2 | Uranium-235 ^(1,2) | 7.037 x 10 ⁸ y | 4215-4597 | Electroplated onto Aluminum Foil | Max. Activity 0.4 nCi (14.8 Bq) |
| AF-238(Nat)-A2 | Uranium-238(Nat) ^(1,2) | 4.468 x 10 ⁹ y | 4147, 4196 | Electroplated onto Aluminum Foil | Max. Activity 0.05 nCi (1.85 Bq) |
| AF-238D-A2 | Uranium-238D ^(1,2) | 4.468 x 10 ⁹ y | 4147, 4196 | Electroplated onto Aluminum Foil | Max. Activity 0.032 nCi |

1) Not supplied as spectroscopy grade sources.

2) Not necessarily in equilibrium with daughters at time of shipment.

3) Radium-226 will leak Rn-222 gas.

4) Thorium-228 will leak Rn-220 gas.

Alpha Particle Standards

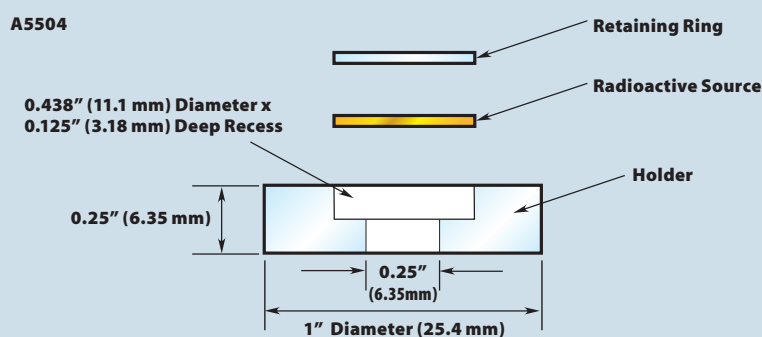
Alpha Particle Standards—Type PM

The PM source is mounted in a plastic holder from which it can be separated for installation in a counting chamber or device. The holder is 1" diameter x 0.125" high (25.4 mm x 3.18 mm). The removable active foil is 0.438" (11.1 mm) in diameter with the active diameter 0.197" (5.0 mm). The foils are platinum or platinum clad nickel between 0.005" and 0.010" (0.127 mm and 0.254 mm) thick.

All alpha standards are offered as spectral grade sources up to the activity and active diameters listed unless otherwise noted. All electroplated alpha standards are manufactured to an accuracy of +/-30% of the nominal activity.



Figure 38-A: Type PM Disk



Overall Dimensions

| Overall Diameter | Active Diameter | Height |
|------------------|-----------------|---------|
| 1" | 0.197" | 0.25" |
| 25.4 mm | 5 mm | 6.35 mm |

Window & Exceptions

| Window | Exceptions |
|--------|---|
| None | Cf-252, Ra-226, and Th-228: 100 µg/cm ² gold Po-210: 100 µg acrylic/cm ² only |

Alpha Particle Standards—Type A-1

| Catalog Number | Nuclide | Half-Life | Significant Alpha Energies (keV) | Nature of Active Material | Available Activities |
|----------------|-----------------------------------|----------------------------|-------------------------------------|--|----------------------------------|
| AF-241-PM | Americium-241 | 432.2 y | 5388, 5443, 5486 | Electroplated onto Platinum Surface | 1 nCi-100 nCi (37 Bq-3.7 kBq) |
| AF-252-PM | Californium-252 | 2.645 y | 6076, 6118 | Electroplated onto Platinum Surface | 1 nCi-100 nCi (37 Bq-3.7 kBq) |
| AF-244-PM | Curium-244 | 18.11 y | 5763, 5805 | Electroplated onto Platinum Surface | 1 nCi-100 nCi (37 Bq-3.7 kBq) |
| AF-148-PM | Gadolinium-148 | 75 y | 3184 | On Request | — |
| AF-237-PM | Neptunium-237 ⁽¹⁾ | 2.140 x 10 ⁶ y | 4640-4873 | Electroplated onto Platinum Surface | 1 nCi-10 nCi (37 Bq-370 Bq) |
| AF-210-PM | Polonium-210 | 138.376 d | 5304 | Electroless Deposition onto Silver Substrate | 1 nCi-100 nCi (37 Bq-3.7 kBq) |
| AF-238P-PM | Plutonium-238 | 87.74 y | 5456, 5499 | Electroplated onto Platinum Surface | 1 nCi-100 nCi (37 Bq-3.7 kBq) |
| AF-239-PM | Plutonium-239 | 2.411 x 10 ⁴ y | 5105, 5143, 5156 | Electroplated onto Platinum Surface | 1 nCi-10 nCi (37 Bq-370 Bq) |
| AF-226-PM | Radium-226 ^(2,3) | 1,600 y | 4601, 4784 Daughters 5489 thru 7687 | Electroplated onto Platinum Surface | 1 nCi-100 nCi (37 Bq-3.7 kBq) |
| AF-228-PM | Thorium-228 ^(2,4) | 698.2 d | 5341, 5423 Daughters 5449 thru 8784 | Electroplated onto Platinum Surface | 1 nCi-100 nCi (37 Bq-3.7 kBq) |
| AF-230-PM | Thorium-230 | 7.54 x 10 ⁴ y | 4621, 4688 | Electroplated onto Platinum Surface | 1 nCi-10 nCi (37 Bq-370 Bq) |
| AF-232-PM | Thorium-232 ^(1,2) | 1.405 x 10 ¹⁰ y | 3952, 4010 | Electroplated onto Platinum Surface | 0.007 nCi (0.26 Bq) |
| AF-235-PM | Uranium-235 ^(1,2) | 7.037 x 10 ⁸ y | 4215-4597 | Electroplated onto Aluminum Foil | Max. Activity 0.4 nCi (14.8 Bq) |
| AF-238(Nat)-PM | Uranium-238(Nat) ^(1,2) | 4.468 x 10 ⁹ y | 4147, 4196 | Electroplated onto Aluminum Foil | Max. Activity 0.05 nCi (1.85 Bq) |
| AF-238D-PM | Uranium-238D ^(1,2) | 4.468 x 10 ⁹ y | 4147, 4196 | Electroplated onto Aluminum Foil | Max. Activity 0.032 nCi |

1) Not supplied as spectroscopy grade sources.

2) Not necessarily in equilibrium with daughters at time of shipment.

3) Radium-226 will leak Rn-222 gas.

4) Thorium-228 will leak Rn-220 gas.

Alpha Source Set

| Catalog Number | Overall Dimensions (OD x Height) | Active Diameter | Nature of Active Material | Window | Set Consists Of |
|----------------|----------------------------------|-----------------|-------------------------------------|-----------|---|
| AF-0200 | 1" X 0.125" 25.4 mm X 3.18 mm | 0.197" 5 mm | Electroplated onto Platinum Surface | No Window | Am-241 (0.1 μ Ci/3.7 kBq), Th-228 and Th-230 (0.01 μ Ci/370 Bq) |

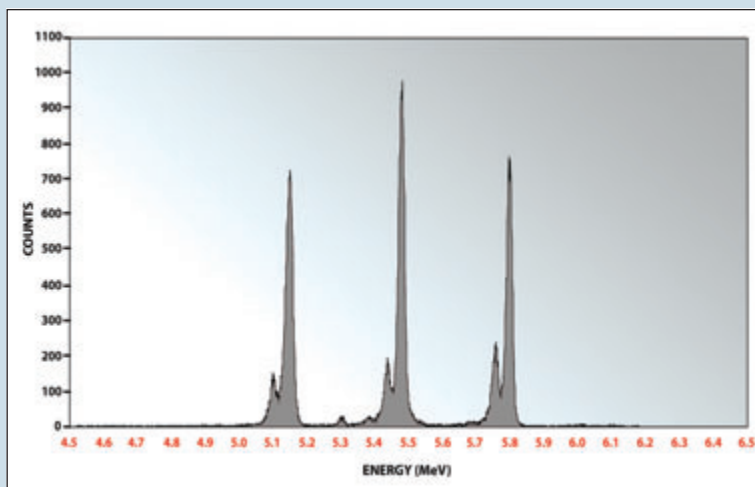
Composite Alpha Source—AF Comp

The composite alpha source is designed to be used as an energy marker for alpha spectroscopy systems. Pu-239, Am-241 and Cm-244, 0.01 μ Ci (370 Bq) each, are electroplated onto a polished platinum or platinum clad nickel foil. The active area is 0.197" (5.0 mm). The source is supplied uncovered. These nuclides provide alpha particles from approximately 5100 to 5800 keV and exhibit line widths typically less than 20 keV FWHM. This energy range is wide enough to provide a valid energy calibration for most alpha emitting nuclides.

The source, when purchased as a NIST traceable standard, can also be used to determine detector efficiencies for alpha particles. Total activity and individual activities are provided on the Certificate of Calibration.

The composite alpha source is available in the type A-2, A-1, and PM configurations as described on pages 36–38.

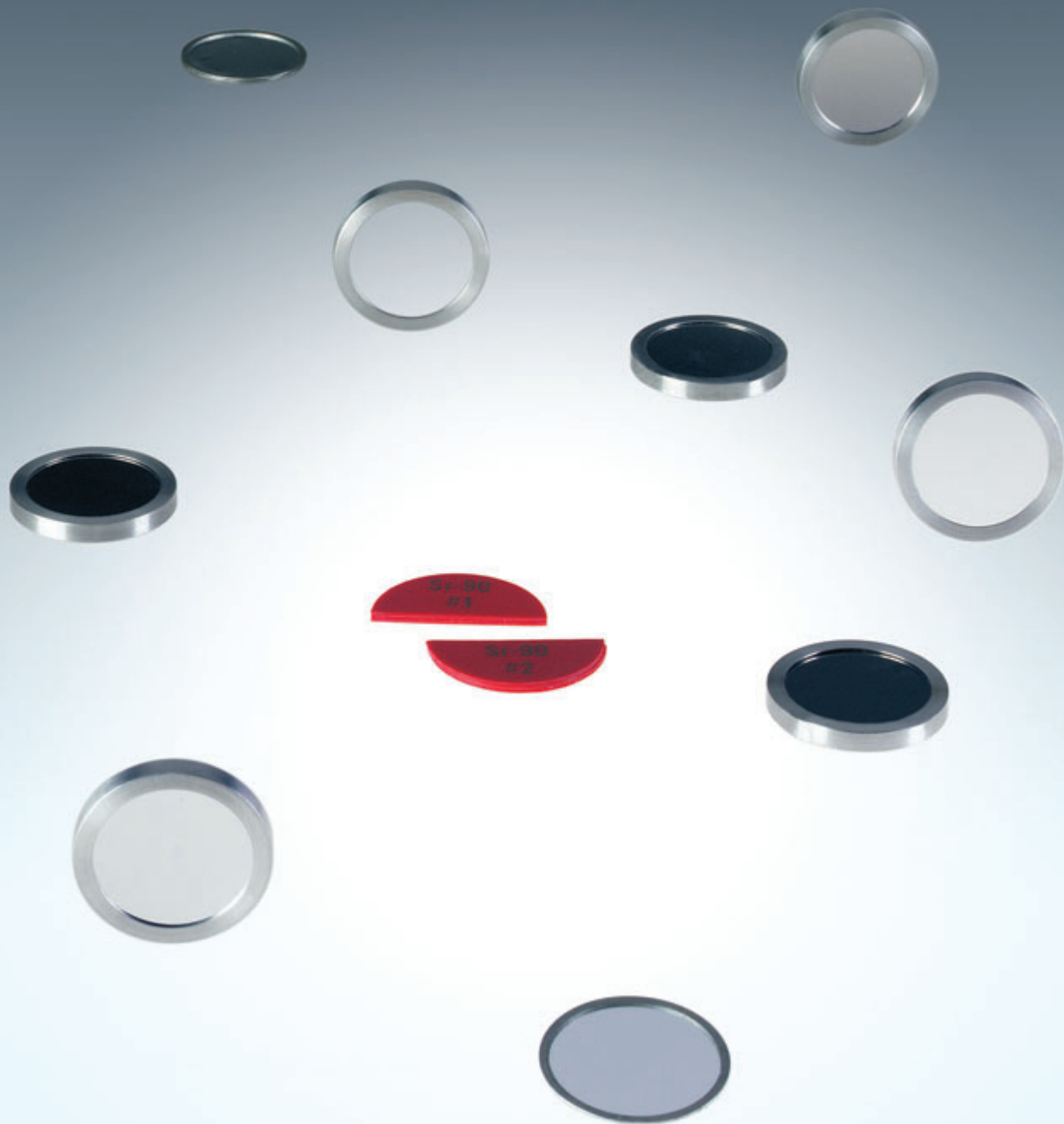
Figure 39-A:
Composite Alpha Source Spectrum Using Silicon Barrier Detector



Standard Windows

| Window Material | FWHM Increase | Energy Decrease |
|----------------------------------|---------------|-----------------|
| 100 μ g/cm ² Gold | 15 keV | 15 keV |

Beta Particle Standards



A wide range of beta emitting nuclides are offered for counting and educational uses. Certification of all BF Series sources includes both contained activity and 2π emission rate. Sources are traceable to NIST with ±2% to ±5% accuracy at the 99% confidence level. Source configurations are surface conductive on all surfaces to enable their use in windowless proportional counters.

Beta Particle Standards— Type A and Type MF2

See the following pages 42 and 43 for descriptions.

Split Source Set— BF-090SPLIT

This source is for use in determining coincidence corrections for G.M. counters. It consists of two plastic half disks with a total overall diameter of 1" (25.4 mm). Each half-source contains a nominal 0.1 μCi (3.7 kBq) of Sr-90/Y-90.

Beta Standards Set— BF-200

This set consists of six nuclides covering the energy range 156-2282 keV (maximum): C-14, Tc-99, Cl-36, Pb-210/Bi-210, Pm-147 and Sr-90/Y-90. This set can be ordered without Lead-210. The C-14 source contains 0.1 μCi (3.7 kBq). The other nuclides contain 0.01 μCi (370 Bq). The sources are Type A or Type MF2, 1" (25.4 mm) overall diameter and 0.125" (3.18 mm) thick. Customer will specify source type. Please note that Pb-210 is not offered in the MF2 configuration. Included in each set is an empty mount, one 0.9 mg/cm² aluminized Mylar window, one stainless steel disk, aluminum plug, aluminum support ring, and a Model BF-090SPLIT split source.

Sr-90 Sources

Sr-90 sources produced by EZIP are certified as to the contained activity of the Sr-90 only. Sr-90, a beta emitter, is in equilibrium with the Y-90 daughter. Thus, a 1 μCi (37 kBq) Sr-90 source also contains 1 μCi (37 kBq) of Y-90. When comparing sources in similar geometries (i.e., similar backing, cover and source detector distance) good results should be obtained. Sr-90 has an average beta energy of 196 keV and Y-90 has an average beta energy of 934 keV, thus care must be taken when comparing sources of substantially different geometries since effects such as backscatter and window absorption must be considered.

| Beta Source Sets | | | | | |
|------------------|----------------------------------|-------------------|----------------------------|------------------------------|---|
| Catalog Number | Overall Dimensions (OD x Height) | Active Diameter | Nature of Active Material | Window | Set Consists Of |
| BF-200 | 1" x 0.125" 25.4 mm x 3.18 mm | 0.805" 20.4 mm | Evaporative Salts on Mylar | 0.9 mg/cm ² Mylar | C-14 (0.1 μCi/3.7 kBq), Tc-99, Cl-36, Pb-210/Bi-210, Sr-90/Y-90, Pm-147 (0.01 μCi/370 Bq each), Type A or MF2 Disc, NIST Traceable, Nominal Split Source |
| BF-0200E | 1" x 0.125" 25.4 mm x 3.18 mm | 0.805" 20.4 mm | Evaporative Salts on Mylar | 0.9 mg/cm ² Mylar | C-14 (0.1 μCi/3.7 kBq), Tc-99, Cl-36, Pb-210/Bi-210, Sr-90/Y-90, Pm-147 (0.01 μCi/370 Bq each), Type A or MF2 Disc, Exempt Source, NIST Traceable, Nominal split source |
| BF-0200CK | 1" x 0.125" 25.4 mm x 3.18 mm | 0.805" 20.4 mm | Evaporative Salts on Mylar | 0.9 mg/cm ² Mylar | C-14 (0.1 μCi/3.7 kBq), Tc-99, Cl-36, Pb-210/Bi-210, Sr-90/Y-90, Pm-147 (0.01 μCi/370 Bq each), Type A or MF2 Disc, Non-Exempt Source, Nominal, Nominal Split Source |
| BF-0200CKE | 1" x 0.125" 25.4 mm x 3.18 mm | 0.805" 20.4 mm | Evaporative Salts on Mylar | 0.9 mg/cm ² Mylar | C-14 (0.1 μCi/3.7 kBq), Tc-99, Cl-36, Pb-210/Bi-210, Sr-90/Y-90, Pm-147 (0.01 μCi/370 Bq each), Type A or MF2 Disc, Exempt Source, Nominal, Nominal Split Source |

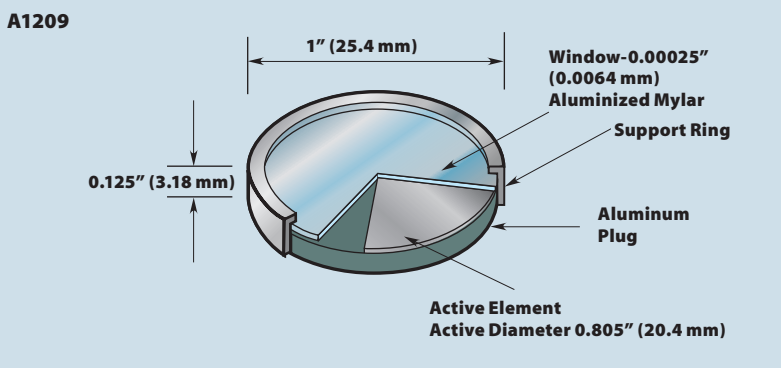
Beta Particle Standards

Beta Particle Standards—Type A

The active material is uniformly distributed over the surface of a 0.937" (23.8 mm) diameter foil and sealed in an aluminum mounting ring under a 0.9 mg/cm² aluminized Mylar window for most nuclides. The active diameter of the source is 0.805" (20.4 mm). Special absorbers may be included under the window to filter undesirable low energy radiation. This configuration is most useful for determining efficiencies of G.M. and windowless counters used for beta assaying evaporated liquid samples. The overall source diameter is 1" (25.4 mm) and 0.125" (3.18 mm) thick.



Figure 42-A: Type A-1 Disk



Overall Dimensions

| Overall Diameter | Active Diameter | Height |
|------------------|-----------------|---------|
| 1" | 0.805" | 0.125" |
| 25.4 mm | 20.4 mm | 3.18 mm |

| Nature of Active Deposit | Available Activities |
|--|-----------------------------------|
| Evaporated Salts on 0.010" Stainless Steel | 5 nCi -100 nCi (185 Bq - 3.7 kBq) |

| Exceptions |
|---|
| Bi-210 : 10 nCi - 100 nCi (370 Bq - 3.7 kBq) |
| Sr-90 : 2.5 nCi - 100 nCi (92.5 Bq - 3.7 kBq) |

Beta Particle Standards—Type A

| Catalog Number | Nuclide | Half-Life | Substrate | Significant Beta Energies (E _{max} keV) | Window |
|----------------|------------------------------|--------------------------|-----------------------------|--|---|
| BF-210-A | Bismuth-210 (Pb-210 parent) | 22.3 y | Stainless Steel | 1160 | 6.9 mg/cm ² Aluminum |
| BF-014-A | Carbon-14 | 5730 y | Polymeric Membrane | 156 | 0.9 mg/cm ² Aluminized Mylar |
| BF-137-A | Cesium-137 | 30.17 y | Stainless Steel | 1175 | 0.9 mg/cm ² Aluminized Mylar |
| BF-036-A | Chlorine-36 | 3.01 x 10 ⁵ y | Stainless Steel | 1142 | 0.9 mg/cm ² Aluminized Mylar |
| BF-060-A | Cobalt-60 | 5.272 y | Stainless Steel | 1491 | 0.9 mg/cm ² Aluminized Mylar |
| BF-068-A | Germanium-68 (1) | 270.8 d | Stainless Steel | 2921 (β ⁺) | 0.9 mg/cm ² Aluminized Mylar |
| BF-147-A | Promethium-147 | 2.6234 y | Stainless Steel | 225 | 0.9 mg/cm ² Aluminized Mylar |
| BF-106-A | Ruthenium-106/Rhodium-106 | 1.020 y | Stainless Steel | 39, 3540 | 0.9 mg/cm ² Aluminized Mylar |
| BF-032-A | Silicon-32/Phosphorus-32 (2) | 104 y | Stainless Steel | 225, 1710 | 13.7 mg/cm ² Aluminum |
| BF-022-A | Sodium-22 | 950.8 d | Stainless Steel | 2842 (β ⁺) | 0.9 mg/cm ² Aluminized Mylar |
| BF-090-A | Strontium-90/Yttrium-90 (3) | 28.5 y | Stainless Steel | 546, 2282 | 0.9 mg/cm ² Aluminized Mylar |
| BF-099-A | Technetium-99 | 2.13 x 10 ⁵ y | Stainless Steel | 294 | 0.9 mg/cm ² Aluminized Mylar |
| BF-204-A | Thallium-204 | 3.78 y | Stainless Steel | 763 | 0.9 mg/cm ² Aluminized Mylar |
| BF-113-A | Tin-113 | 115.1 d | Platinum Foil or Pt/Clad Ni | 392 | 0.9 mg/cm ² Aluminized Mylar |

1) Positron emission from Ga-68.

2) This long-lived P-32 standard is the beta emitting P-32 daughter of the long-lived Si-32 parent. The standard mounting for this source is the A capsule with a 0.002" (0.051 mm) Al window. This window will absorb more than 60% of the Si-32 225 keV betas and less than 5% of the P-32 betas. Standards are prepared with the P-32 in equilibrium with the parent Si-32.

3) See page 41 regarding Sr-90 sources.

Beta Particle Standards—Type MF2

This is a “scatterless” configuration in which the activity is applied as a 0.12” (3 mm) spot centered between two laminated 0.9 mg/cm² aluminized Mylar foils. The source is supplied in a removable aluminum holder. In the holder the source has an overall diameter of 1” (25.4 mm) and a thickness of 0.125” (3.18 mm). Out of the holder the source is 0.937” (23.8 mm) in diameter with a thickness of approximately 0.030” (0.76 mm).

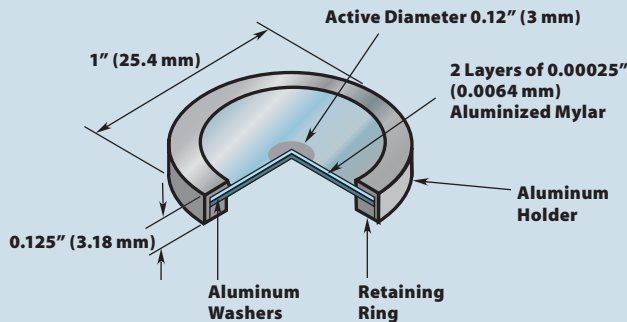
This configuration is most useful for the precise determination of G.M. and proportional counter efficiencies, and as an educational tool for the verification of the inverse square law, as well as demonstrating back-scatter phenomena.

Additional beta sources can be found on pages 55–65 including disk standards suitable for use with low background counting systems and 3.94” x 3.94” (100 mm x 100 mm) distributed beta sources for instrument calibration and dose assessments.



Figure 43-A: Type MF-2 Disk

A1207



Overall Dimensions

| Overall Diameter | Active Diameter | Height |
|------------------|-----------------|---------|
| 1” | 0.12” | 0.125” |
| 25.4 mm | 3 mm | 3.18 mm |

| Nature of Active Deposit | Available Activities |
|---------------------------|-----------------------------------|
| Evaporated Salts on Mylar | 5 nCi -100 nCi (185 Bq - 3.7 kBq) |

| Exceptions |
|--|
| Bi-210: 10 nCi - 100 nCi (370 Bq - 3.7 kBq) |
| Sr-90: 2.5 nCi - 100 nCi (92.5 Bq - 3.7 kBq) |

Beta Particle Standards—Type MF2

| Catalog Number | Nuclide | Half-Life | Substrate | Significant Beta Energies (E _{max} keV) | Window |
|----------------|--|--------------------------|--------------------|--|---|
| BF-014-MF2 | Carbon-14 | 5730 y | Polymeric Membrane | 156 | 0.9 mg/cm ² Aluminized Mylar |
| BF-137-MF2 | Cesium-137 | 30.17 y | Stainless Steel | 1175 | 0.9 mg/cm ² Aluminized Mylar |
| BF-036-MF2 | Chlorine-36 | 3.01 x 10 ⁵ y | Stainless Steel | 1142 | 0.9 mg/cm ² Aluminized Mylar |
| BF-060-MF2 | Cobalt-60 | 5.272 y | Stainless Steel | 1491 | 0.9 mg/cm ² Aluminized Mylar |
| BF-068-MF2 | Germanium-68 ⁽¹⁾ | 270.8 d | Stainless Steel | 2921 (β ⁺) | 0.9 mg/cm ² Aluminized Mylar |
| BF-147-MF2 | Promethium-147 | 2.6234 y | Stainless Steel | 225 | 0.9 mg/cm ² Aluminized Mylar |
| BF-106-MF2 | Ruthenium-106/Rhodium-106 | 1.020 y | Stainless Steel | 39, 3540 | 0.9 mg/cm ² Aluminized Mylar |
| BF-022-MF2 | Sodium-22 | 950.8 d | Stainless Steel | 2842 (β ⁺) | 0.9 mg/cm ² Aluminized Mylar |
| BF-090-MF2 | Strontium-90/Yttrium-90 ⁽²⁾ | 28.5 y | Stainless Steel | 546, 2282 | 0.9 mg/cm ² Aluminized Mylar |
| BF-099-MF2 | Technetium-99 | 2.13 x 10 ⁵ y | Stainless Steel | 294 | 0.9 mg/cm ² Aluminized Mylar |
| BF-204-MF2 | Thallium-204 | 3.78 y | Stainless Steel | 763 | 0.9 mg/cm ² Aluminized Mylar |

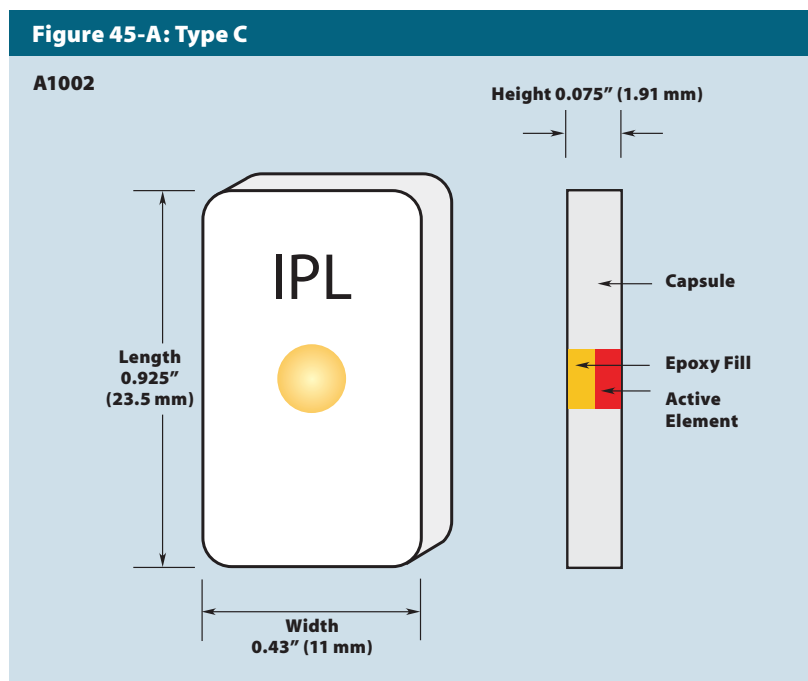
Gamma and X-Ray Standards



A wide range of gamma and x-ray standards for research and educational use are available in the energy range of 5.9 to 2614 keV. Many nuclides are available up to 100 μCi (3.7 MBq) to allow for the lower efficiencies of detection inherent in many instruments. Available activity ranges are listed for each nuclide in the tables on pages 46 to 53. Please contact customer service for other activity requirements.

Gamma Standards—Type C

The type C configuration can be used to check the performance of G.M. and NaI (TI) detectors. The maximum activity of this source type is 10 μCi (370 kBq). Please call customer service for a quotation.



| Overall Dimensions | | | |
|--------------------|-------|---------|-----------------|
| Height | Width | Length | Active Diameter |
| 0.075" | 0.43" | 0.925" | 0.118" |
| 1.91 mm | 11 mm | 23.5 mm | 3 mm |

| Window & Active Deposit | |
|-------------------------|---------------------------|
| Window | Nature of Active Deposit |
| Plastic | Evaporated Metallic Salts |

| Simulated I-125 Sources | | |
|--|--|---------------------|
| I-129 sources are frequently referred to as "simulated I-125 sources." I-129 does not in fact simulate I-125 well enough to use it to calibrate an I-125 counter. The equivalence of I-129 to I-125 will vary from one counter to another due to the differing photon energies and counting geometries. EZIP recommends the purchase of an I-125 standard for the initial instrument calibration. An I-129 source may then be used for a daily check of instrument response. | The energies and abundances of I-125 and I-129 x-rays and photons are: | |
| | | |
| | K x-rays (keV) | Gammas (keV) |
| I-125 | (Te) 27-32 (141%) | 35.5 (6.66%) |
| I-129 | (Xe) 29-35 (70.8%) | 39.6 (7.5%) |

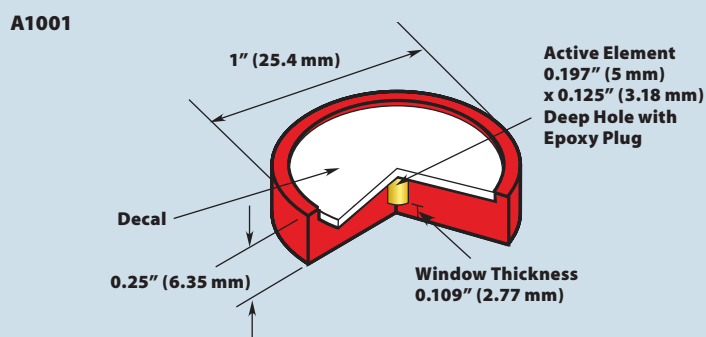
Gamma and X-Ray Standards

Gamma Standards—Type D

The type D configuration is mainly used for checking the performance of G.M. and NaI(Tl) detectors. The type D disk is a 1" (25.4 mm) diameter by 0.250" (6.35 mm) thick disk constructed of high strength plastic. The active diameter is 0.197" (5 mm).



Figure 46-A: Type D Disk



| Overall Dimensions | | |
|--------------------|-----------------|---------|
| Overall Diameter | Active Diameter | Height |
| 1" | 0.197" | 0.25" |
| 25.4 mm | 5 mm | 6.35 mm |

| Window & Active Deposit | |
|-------------------------|---------------------------|
| Window | Nature of Active Deposit |
| Plastic | Evaporated Metallic Salts |

Gamma Standards—Type D

| Catalog Number | Nuclide | Half-Life | Major Photon Emissions (keV) | Available Activities |
|----------------|---------------|--------------------------|---|-----------------------------------|
| GF-241-D | Americium-241 | 432.17 y | 59.5 (36%), 11-20 (39.5%) Np L x-rays | 5 nCi-100 µCi 185 Bq-3.7 MBq |
| GF-124-D | Antimony-124 | 60.20 d | 602.7 (97.9%), 722.8 (10.9%), 1690.9 (47.6%) | 5 nCi-100 µCi 185 Bq-3.7 MBq |
| GF-125A-D | Antimony-125 | 1007.7 d | 428 (29.7%), 464 (10.5%), 601 (17.7%), 607 (5%), 636 (11.2%), 27-32 (75.1%) Te K x-rays | 5 nCi-100 µCi 185 Bq-3.7 MBq |
| GF-133-D | Barium-133 | 3862 d | 80 (34.1%), 303 (18.3%), 356 (61.9%), 32-37 (53.2%) Cs K x-rays | 5 nCi-100 µCi 185 Bq-3.7 MBq |
| GF-007-D | Beryllium-7 | 53.284 d | 478 (10.3%) | 25 nCi-500 µCi 925 Bq-18.5 MBq |
| GF-207-D | Bismuth-207 | 1.16 x 10 ⁴ d | 570 (97.7%), 1064 (74.5%), 9-15 (32.5%), Pb L x-rays, 72-88 (77.7%) Pb K x-rays | 5 nCi-100 µCi 185 Bq-3.7 MBq |
| GF-109-D | Cadmium-109 | 462.6 d | 88 (3.6% from Ag-109m), 22-26 (99.4%) Ag K x-rays | 50 nCi-1 mCi 1.85 kBq-37 MBq |
| GF-139-D | Cerium-139 | 137.640 d | 33.03 (22.8%), 33.4 (41.9%), 165.9 (79.9%), 33-39 (80%) La x-rays | 5 nCi-10 µCi 185 Bq-370 kBq |
| GF-141-D | Cerium-141 | On Request | — | — |
| GF-134-D | Cesium-134 | 754.28 d | 563 (8.4%), 569 (15.4%), 605 (97.6%), 796 (85.4%) | 5 nCi-100 µCi 185 Bq-3.7 MBq |
| GF-137-D | Cesium-137 | 30.17 y | 662 (85.1% from Ba-137), 32-37 (7.2%) Ba K x-rays | 5 nCi-1 mCi 185 Bq-3.7 MBq |
| GF-051-D | Chromium-51 | 27.706 d | 320 (9.86%), 4.9-5.4 (22.8%) V K x-rays | 25 nCi-500 µCi 185 Bq-37 MBq |

Gamma Standards—Type D

| Catalog Number | Nuclide | Half-Life | Major Photon Emissions (keV) | Available Activities |
|----------------|----------------------------------|---------------------------|--|------------------------------------|
| GF-056-D | Cobalt-56 | 77.31 d | 846.8 (99.9%), 1238 (66.1%), 1771 (15.5%), 2035 (7.8%), 2598 (17%), 3253 (7.6%), others up to 3452 | 10 nCi-100 µCi 370 Bq-3.7 MBq |
| GF-057-D | Cobalt-57 | 271.79 d | 14 (9.2%), 122 (85.6%), 136.5 (10.7%), 6.4-7.1 (57.9%) Fe K x-rays | 5 nCi-1 mCi 185 Bq-37 MBq |
| GF-058-D | Cobalt-58 | 70.86 d | 810 (99.5%), 6.4-7.1 (26.7%) Fe K x-rays | 5 nCi-100 µCi 185 Bq-3.7 MBq |
| GF-060-D | Cobalt-60 | 5.272 y | 1173 (100%), 1333 (100%) | 5 nCi-1 mCi 185 Bq-37 MBq |
| GF-152-D | Europium-152 | 4933 d | 122-1408, 40-47 (74%) Sm + Gd x-rays | 25 nCi-100 µCi 925 Bq-3.7 MBq |
| GF-154-D | Europium-154 | 3136.8 d | 123-1597, 42-50 (25.6%) Gd x-rays | 25 nCi-100 µCi 925 Bq-3.7 MBq |
| GF-155-D | Europium-155 | 1770 d | 87 (34%), 105 (20.6%), 42-50 (24.0%), Gd K x-rays | 10 nCi-100 µCi 370 Bq-3.7 MBq |
| GF-153-D | Gadolinium-153 | 242 d | 97 (29.5%), 103 (21.1%), 40-49 (122%) Eu K x-rays | 5 nCi-1 mCi 185 Bq-37 MBq |
| GF-068-D | Germanium-68 | 270.8 d | 511 (178%), 1077 (3.2%) from Ga-68, 9.2-10.4 (44.1%) Ga K x-rays, 8.6-9.6 (4.7%) Zn K x-rays | 100 nCi-100 µCi 3.7 kBq-3.7 MBq |
| GF-166-D | Holmium-166m ⁽¹⁾ | 1200 y | 81-1427, 48-58 (37.6%) Er K x-rays | 10 nCi-10 µCi 370 Bq-370 kBq |
| GF-125-D | Iodine-125 | 59.43 d | 35 (6.58%), 27-32 (139%) Te K x-rays | 10 nCi-100 µCi 370 Bq-3.7 MBq |
| GF-129-D | Iodine-129 | 1.57 x 10 ⁷ y | 40 (7.5%), 29-35 (70.4%) Xe K x-rays | 50 nCi-1 µCi 1.85 kBq-37 kBq |
| GF-059-D | Iron-59 | 44.51 d | 1099 (56.3%), 1292 (43.7%) | 5 nCi-100 µCi 185 Bq-3.7 MBq |
| GF-054-D | Manganese-54 | 312.3 d | 835 (100%), 5.4-5.9 (25.6%) Cr K x-rays | 5 nCi-100 µCi 185 Bq-3.7 MBq |
| GF-203-D | Mercury-203 | 46.595 d | 279.2 (81.5%) | 10 nCi-50 µCi 370 Bq-1.85 MBq |
| GF-226-D | Radium-226 | 1600 y | 47-2448 (includes daughters) | 50 nCi-10 µCi 1.85 kBq-370 kBq |
| GF-106-D | Ruthenium-106 | 1.020 y | 512 (20.7%), 622 (9.8%) from Rh-106 | 25 nCi-100 µCi 925 Bq-3.7 MBq |
| GF-046-D | Scandium-46 | 83.79 d | 889 (99.9%), 1121 (99.9%) | 5 nCi-100 µCi 185 Bq-3.7 MBq |
| GF-075-D | Selenium-75 | 119.64 d | 121 (17.1%), 136 (58.8%), 265 (59%), 280 (25%), 10.5-12.0 (56.8%) As K x-rays | 5 nCi-100 µCi 185 Bq-3.7 MBq |
| GF-110-D | Silver-110m | 249.8 d | 657.8 (94.4%), 884.6 (72.6%) | 5 nCi-50 µCi 185 Bq-1.85 MBq |
| GF-131-D | Simulated I-131 | ~5 y | 356 (from Ba-133), 662 (from Cs-137/Ba-137) | 50 nCi-100 µCi 1.85 kBq-3.7 MBq |
| GF-022-D | Sodium-22 | 950.8 d | 511 (178%), 1275 (100%) | 5 nCi-100 µCi 185 Bq-3.7 MBq |
| GF-085-D | Strontium-85 | 64.849 d | 514 (98.4%), 13.3-15.3 (58.7%) Rb K x-rays | 5 nCi-100 µCi 185 Bq-3.7 MBq |
| GF-228-D | Thorium-228 | 698.2 d | 84-2614 (includes daughters) | 10 nCi-10 µCi 370 Bq-370 kBq |
| GF-113-D | Tin-113 | 115.09 d | 392 (64% from In-113 m), 24-28 (96.8%) In K x-rays | 5 nCi-100 µCi 185 Bq-3.7 MBq |
| GF-235-D | Uranium-235 ⁽¹⁾ | 7.037 x 10 ⁸ y | 143 (10.5%), 186 (53%), 90-105 (10.8%) Th K x-rays | 10 nCi-100 nCi 370 Bq-3.7 kBq |
| GF-238U-D | Uranium (Natural) ⁽¹⁾ | 4.468 x 10 ⁹ y | 26-2448 (includes daughters) | 10 nCi-100 nCi 370 Bq-3.7 kBq |
| GF-088-D | Yttrium-88 | 106.630 d | 898 (94%), 1836 (99.4%), 14.1-16.2 (61.6%) Sr K x-rays | 5 nCi-100 µCi 185 Bq-3.7 MBq |
| GF-065-D | Zinc-65 | 244.26 d | 1116 (50.6%), 8.0-8.9 (38.7%) Cu K x-rays | 5 nCi-100 µCi 185 Bq-3.7 MBq |
| GF-095-D | Zirconium-95/Nb-95 | 64.02 d | 724 (44.1%), 757 (54.5%) | 10 nCi-50 µCi 370 Bq-1.85 MBq |

1) 9 mm active diameter.

Gamma Sets—Type D

| Catalog Number | Available Activities | Sets Consist Of |
|----------------|----------------------|---|
| GF-290-0.1D | 0.1 µCi 3.7 kBq | Ba-133, Cd-109, Co-57, Co-60, Cs-137, Mn-54 and Na-22 |
| GF-290-1D | 1 µCi 37 kBq | Ba-133, Cd-109, Co-57, Co-60, Cs-137, Mn-54 and Na-22 |
| GF-290-10D | 10 µCi 370 kBq | Ba-133, Cd-109, Co-57, Co-60, Cs-137, Mn-54 and Na-22 |

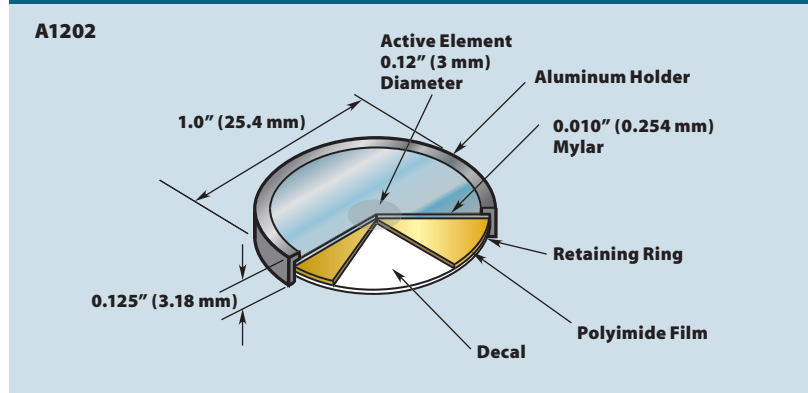
Gamma and X-Ray Standards

Gamma Standards—Type M

The type M thin “scatterless” disk is used in applications involving high resolution solid state detectors. The activity is deposited on 9 mg/cm² aluminumized Mylar (polyester) disk, and covered with 0.9 mg/cm² Kapton (polyimide). The source is supplied in a removable aluminum holder. In the holder the source has an overall diameter of 1” (25.4 mm) and a thickness of 0.125” (3.18 mm). Out of the holder the source is 0.937” (23.8 mm) in diameter with a thickness of approximately 0.030” (0.76 mm). The active diameter is 0.12” (3 mm).



Figure 48-A: Type M Disk



Overall Dimensions

| Overall Diameter | Active Diameter | Height |
|------------------|-----------------|---------|
| 1" | 0.12" | 0.125" |
| 25.4 mm | 3 mm | 3.18 mm |

Window

0.010" (0.254 mm)
Aluminized Mylar

Nature of Active Deposit

Evaporated
Metallic Salts

Exceptions

Fe-55: 0.00025" (0.0064 mm) Aluminized Mylar
Am-241: 0.001" (0.0254 mm) Aluminum and Platinum Foils

Gamma Standards—Type M

| Catalog Number | Nuclide | Half-Life | Major Photon Emissions (keV) | Available Activities |
|----------------|---------------|--------------------------|---|------------------------------------|
| GF-241-M | Americium-241 | 432.17 y | 59.5(36%), 11-20(39.5%) Np L x-rays | 5 nCi-10 µCi 185 Bq-370 kBq |
| GF-124-M | Antimony-124 | 60.20 d | 602.7(97.9%), 722.8(10.9%), 1690.9(47.6%) | 5 nCi-100 µCi 185 Bq-3.7 MBq |
| GF-125A-M | Antimony-125A | 1007.7 d | 428(29.7%), 464(10.5%), 601(17.7%), 607(5%), 636(11.2%), 27-32(75.1%) Te K x-rays | 5 nCi-100 µCi 185 Bq-3.7 MBq |
| GF-133-M | Barium-133 | 3862 d | 80(34.1%), 303(18.3%), 356(61.9%), 32-37(53.2%) Cs K x-rays | 5 nCi-100 µCi 185 Bq-3.7 MBq |
| GF-007-M | Beryllium-7 | 53.28 d | 478(10.3%) | 25 nCi-500 µCi 925 Bq-18.5 MBq |
| GF-207-M | Bismuth-207 | 1.16 x 10 ⁴ d | 570(97.7%), 1064(74.5%), 9-15(32.5%), Pb L x-rays, 72-88(77.7%) Pb K x-rays | 5 nCi-100 µCi 185 Bq-3.7 MBq |
| GF-109-M | Cadmium-109 | 462.6 d | 88(3.6% from Ag-109 m), 22-26(99.4%) Ag K x-rays | 50 nCi-100 µCi 1.85 kBq-3.7 MBq |
| GF-139-M | Cerium-139 | 137.640 d | 33.03(22.8%), 33.4(41.9%), 165.9(79.9%), 33-39(80%) La x-rays | 50 nCi-1 µCi 1.85 kBq-37 kBq |
| GF-141-M | Cerium-141 | 32.5 d | 36.0(9.1%), 35.6(5%), 145.4(48.4%), 352.42(17%), Pr x-rays | On Request — |
| GF-134-M | Cesium-134 | 754.28 d | 563(8.4%), 569(15.4%), 605(97.6%), 796(85.4%) | 5 nCi-100 µCi 185 Bq-3.7 MBq |
| GF-137-M | Cesium-137 | 30.17 y | 662(85.1% from Ba-137), 32-37(7.2%) Ba K x-rays | 5 nCi-100 µCi 185 Bq-3.7 MBq |
| GF-051-M | Chromium-51 | 27.706 d | 320(9.86%), 4.9-5.4(22.8%) V K x-rays | 25 nCi-100 µCi 925 Bq-3.7 MBq |

| Gamma Standards—Type M | | | | | |
|------------------------|--------------------|-----------|--|----------------------|------------------|
| Catalog Number | Nuclide | Half-Life | Major Photon Emissions (keV) | Available Activities | |
| GF-056-M | Cobalt-56 | 77.31 d | 846.8(99.9%), 1238(66.1%), 1771(15.5%), 2035(7.8%), 2598(17%), 3253(7.6%), others up to 3452 | 10 nCi-100 µCi | 370 Bq-3.7 MBq |
| GF-057-M | Cobalt-57 | 271.79 d | 14(9.2%), 122(85.6%), 136.5(10.7%), 6.4-7.1(57.9%) Fe K x-rays | 5 nCi-100 µCi | 185 Bq-3.7 MBq |
| GF-058-M | Cobalt-58 | 70.86 d | 810(99.5%), 6.4-7.1(26.7%) Fe K x-rays | 5 nCi-100 µCi | 185 Bq-3.7 MBq |
| GF-060-M | Cobalt-60 | 5.272 y | 1173(100%), 1333(100%) | 5 nCi-100 µCi | 185 Bq-3.7 MBq |
| GF-152-M | Europium-152 | 4933 d | 122-1408, 40-47(74%) Sm +Gd x-rays | 25 nCi-100 µCi | 925 Bq-3.7 MBq |
| GF-154-M | Europium-154 | 3136.8 d | 123-1597, 42-50(25.6%) Gd x-rays | 25 nCi-100 µCi | 925 Bq-3.7 MBq |
| GF-155-M | Europium-155 | 1770 d | 87(34%), 105(20.6%), 42-50(24.0%), Gd K x-rays | 10 nCi-100 µCi | 370 Bq-3.7 MBq |
| GF-153-M | Gadolinium-153 | 242 d | 97(29.5%), 103(21.1%), 40-49(122%) Eu K x-rays | 10 nCi-100 µCi | 370 Bq-3.7 MBq |
| GF-068-M | Germanium-68 | 270.8 d | 511(178%), 1077(3.2%) from Ga-68, 9.2-10.4(44.1%) Ga K x-rays, 8.6-9.6(4.7%) Zn K x-rays | 100 nCi-100 µCi | 3.7 kBq-3.7 MBq |
| GF-166-M | Holmium-166m | 1200 y | 81-1427, 48-58(37.6%) Er K x-rays | 10 nCi-1 µCi | 370 Bq-37 kBq |
| GF-055-M | Iron-55 | 999 d | 5.8-6.5(27.3%) Mn K x-rays | 1 µCi-100 µCi | 37 kBq-3.7 MBq |
| GF-059-M | Iron-59 | 44.51 d | 1099(56.3%), 1292(43.7%) | 5 nCi-100 µCi | 185 Bq-3.7 MBq |
| GF-054-M | Manganese-54 | 312.3 d | 835(100%), 5.4-5.9(25.6%) Cr K x-rays | 5 nCi-100 µCi | 185 Bq-3.7 MBq |
| GF-203-M | Mercury-203 | 46.595 d | 279.2(81.5%) | 10 nCi-10 µCi | 370 Bq-370 kBq |
| GF-046-M | Scandium-46 | 83.79 d | 889(99.9%), 1121(99.9%) | 5 nCi-100 µCi | 185 Bq-3.7 MBq |
| GF-075-M | Selenium-75 | 119.64 d | 121(17.1%), 136(58.8%), 265(59%), 280(25%), 10.5-12.0(56.8%) As K x-rays | 5 nCi-100 µCi | 185 Bq-3.7 MBq |
| GF-110-M | Silver-110m | 249.8 d | 657.8(94.4%), 884.6(72.6%) | 5 nCi-50 µCi | 185 Bq-1.85 MBq |
| GF-131-M | Simulated I-131 | ~5 y | 356(from Ba-133), 662(from Cs-137/Ba-137) | 50 nCi-100 µCi | 1.85 kBq-3.7 MBq |
| GF-022-M | Sodium-22 | 950.8 d | 511(178%), 1275(100%) | 5 nCi-100 µCi | 185 Bq-3.7 MBq |
| GF-085-M | Strontium-85 | 64.849 d | 514(98.4%), 13.3-15.3(58.7%) Rb K x-rays | 5 nCi-100 µCi | 185 Bq-3.7 MBq |
| GF-113-M | Tin-113 | 115.09 d | 392(64% from In-113 m), 24-28(96.8%) In K x-rays | 5 nCi-10 µCi | 185 Bq-370 kBq |
| GF-088-M | Yttrium-88 | 106.630 d | 898(94%), 1836(99.4%), 14.1-16.2(61.6%) Sr K x-rays | 5 nCi-100 µCi | 185 Bq-3.7 MBq |
| GF-065-M | Zinc-65 | 244.26 d | 1116(50.6%), 8.0-8.9(38.7%) Cu K x-rays | 5 nCi-100 µCi | 185 Bq-3.7 MBq |
| GF-095-M | Zirconium-95/Nb-95 | 64.02 d | 724(44.1%), 757(54.5%) | 10 nCi-50 µCi | 370 Bq-1.85 MBq |

| Gamma Sets—Type M | | | |
|-------------------|----------------------|-----------------|---|
| Catalog Number | Available Activities | Sets Consist Of | |
| GF-290-0.1M | 0.1 µCi | 3.7 kBq | Ba-133, Cd-109, Co-57, Co-60, Cs-137, Mn-54 and Na-22 |
| GF-290-1M | 1 µCi | 37 kBq | Ba-133, Cd-109, Co-57, Co-60, Cs-137, Mn-54 and Na-22 |
| GF-290-10M | 10 µCi | 370 kBq | Ba-133, Cd-109, Co-57, Co-60, Cs-137, Mn-54 and Na-22 |

Gamma and X-Ray Standards

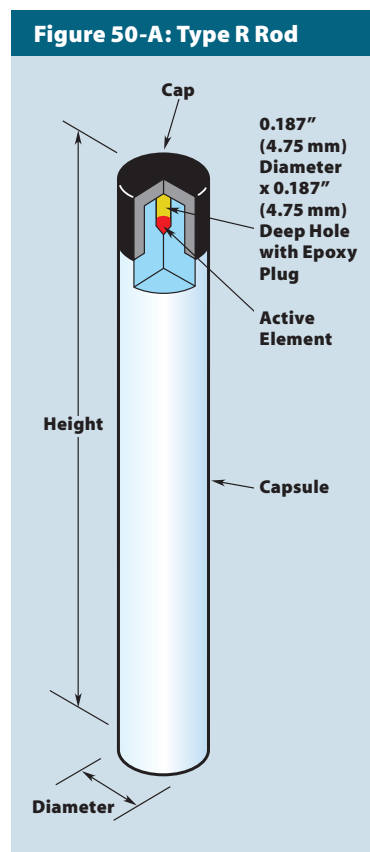
Gamma Standards—Type R

The type R rod is used for calibrating well type NaI(Tl) detectors. It is constructed of high strength plastic and is offered in three sizes: 5" high x 0.625" diameter (127 mm x 15.9 mm), 5" high x 0.5" diameter (127 mm x 12.7 mm) and 2.95" x 0.5" diameter (74.9 mm x 12.7 mm). The active diameter of the rod standard is 0.187" (4.75 mm).



| Window & Active Materials | |
|---------------------------|----------------------------|
| Window | Nature of Active Materials |
| Plastic | Evaporated Metallic Salts |

| Overall Dimensions | | | | |
|--------------------|----|-----------------|------------------|------------------|
| Assembly | X | Height | Diameter | Active Diameter |
| A1100 | R1 | 5" (127 mm) | 0.625" (15.9 mm) | 0.187" (4.75 mm) |
| A1102 | R2 | 5" (127 mm) | 0.5" (12.7 mm) | 0.187" (4.75 mm) |
| A1103 | R3 | 2.95" (74.9 mm) | 0.5" (12.7 mm) | 0.187" (4.75 mm) |



| Gamma Standards—Type R | | | | | |
|------------------------|---------------|--------------------------|---|----------------------|-----------------|
| Catalog Number | Nuclide | Half-Life | Major Photon Emissions (keV) | Available Activities | |
| GF-241-x | Americium-241 | 432.17 y | 59.5 (36%), 11-20 (39.5%) Np L x-rays | 5 nCi-100 µCi | 185 Bq-3.7 MBq |
| GF-124-x | Antimony-124 | 60.20 d | 602.7(97.9%), 722.8(10.9%), 1690.9(47.6%) | 5 nCi-100 µCi | 185 Bq-3.7 MBq |
| GF-125A-x | Antimony-125A | 1007.7 d | 428(29.7%), 464(10.5%), 601(17.7%), 607(5%), 636(11.2%), 27-32(75.1%) Te K x-rays | 5 nCi-100 µCi | 185 Bq-3.7 MBq |
| GF-133-x | Barium-133 | 3862 d | 80(34.1%), 303(18.3%), 356(61.9%), 32-37(53.2%) Cs K x-rays | 5 nCi-100 µCi | 185 Bq-3.7 MBq |
| GF-007-x | Beryllium-7 | On Request | | | |
| GF-207-x | Bismuth-207 | 1.16 x 10 ⁴ d | 570(97.7%), 1064(74.5%), 9-15(32.5%), Pb L x-rays, 72-88(77.7%) Pb K x-rays | 5 nCi-100 µCi | 185 Bq-3.7 MBq |
| GF-109-x | Cadmium-109 | 462.6 d | 88(3.6% from Ag-109 m), 22-26(99.4%) Ag K x-rays | 50 nCi-1 mCi | 1.85 kBq-37 MBq |
| GF-139-x | Cerium-139 | 137.640 d | 33.03(22.8%), 33.4(41.9%), 165.9(79.9%), 33-39(80%) La x-rays | 5 nCi-10 µCi | 185 Bq-370 kBq |
| GF-141-x | Cerium-141 | 32.5 d | 36.0 (9.1%), 35.6 (5%), 145.4 (48.4%), 352.42 (17%), Pr x-rays | On Request | — |
| GF-134-x | Cesium-134 | 754.28 d | 563(8.4%), 569(15.4%), 605(97.6%), 796(85.4%) | 5 nCi-100 µCi | 185 Bq-3.7 MBq |
| GF-137-x | Cesium-137 | 30.17 y | 662(85.1% from Ba-137), 32-37(7.2%) Ba K x-rays | 5 nCi-1 mCi | 185 Bq-37 MBq |
| GF-051-x | Chromium-51 | 27.706 d | 320(9.86%), 4.9-5.4(22.8%) V K x-rays | 25 nCi-500 µCi | 925 Bq-18.5 MBq |

| Gamma Standards—Type R | | | | | |
|------------------------|--------------------|---------------------------|--|----------------------|------------------|
| Catalog Number | Nuclide | Half-Life | Major Photon Emissions (keV) | Available Activities | |
| GF-056-x | Cobalt-56 | 77.31 d | 846.8(99.9%), 1238(66.1%), 1771(15.5%), 2035(7.8%), 2598(17%), 3253(7.6%), others up to 3452 | 10 nCi-100 µCi | 370 Bq-3.7 MBq |
| GF-057-x | Cobalt-57 | 271.79 d | 14(9.2%), 122(85.6%), 136.5(10.7%), 6.4-7.1(57.9%) Fe K x-rays | 5 nCi-100 µCi | 185 Bq-3.7 MBq |
| GF-058-x | Cobalt-58 | 70.86 d | 810(99.5%), 6.4-7.1(26.7%) Fe K x-rays | 5 nCi-100 µCi | 185 Bq-3.7 MBq |
| GF-060-x | Cobalt-60 | 5.272 y | 1173(100%), 1333(100%) | 5 nCi-100 µCi | 185 Bq-3.7 MBq |
| GF-152-x | Europium-152 | 4933 d | 122-1408, 40-47(74%) Sm +Gd x-rays | 25 nCi-100 µCi | 925 Bq-3.7 MBq |
| GF-154-x | Europium-154 | 3136.8 d | 123-1597, 42-50(25.6%) Gd x-rays | 25 nCi-100 µCi | 925 Bq-3.7 MBq |
| GF-155-x | Europium-155 | 1770 d | 87(34%), 105(20.6%), 42-50(24.0%), Gd K x-rays | 10 nCi-100 µCi | 370 Bq-3.7 MBq |
| GF-153-x | Gadolinium-153 | 242 d | 97(29.5%), 103(21.1%), 40-49(122%) Eu K x-rays | 10 nCi-100 µCi | 370 Bq-3.7 MBq |
| GF-068-x | Germanium-68 | 270.8 d | 511(178%), 1077(3.2%) from Ga-68, 9.2-10.4(44.1%) Ga K x-rays, 8.6-9.6(4.7%) Zn K x-rays | 100 nCi-100 µCi | 3.7 kBq-3.7 MBq |
| GF-166-x | Holmium-166m | 1200 y | 81-1427, 48-58(37.6%) Er K x-rays | 10 nCi-10 µCi | 370 Bq-370 kBq |
| GF-125-x | Iodine-125 | 59.43 d | 35(6.58%), 27-32(139%) Te K x-rays | 10 nCi-10 µCi | 370 Bq-370 kBq |
| GF-129-x | Iodine-129 | 1.57 x 10 ⁷ y | 40(7.5%), 29-35(70.4%) Xe K x-rays | 50 nCi-1 µCi | 1.85 kBq-37 kBq |
| GF-059-x | Iron-59 | 44.51 d | 1099(56.3%), 1292(43.7%) | 5 nCi-100 µCi | 185 Bq-3.7 MBq |
| GF-054-x | Manganese-54 | 312.3 d | 835(100%), 5.4-5.9(25.6%) Cr K x-rays | 5 nCi-100 µCi | 185 Bq-3.7 MBq |
| GF-203-x | Mercury-203 | 46.595 d | 279.2(81.5%) | 10 nCi-50 µCi | 370 Bq-1.85 MBq |
| GF-226-x | Radium-226 | 1600 y | 47-2448 (includes daughters) | 50 nCi-10 µCi | 1.85 kBq-370 kBq |
| GF-106-x | Ruthenium-106 | 1.020 y | 512(20.7%), 622(9.8%) from Rh-106 | 25 nCi-100 µCi | 925 Bq-3.7 MBq |
| GF-046-x | Scandium-46 | 83.79 d | 889(99.9%), 1121(99.9%) | 5 nCi-100 µCi | 185 Bq-3.7 MBq |
| GF-075-x | Selenium-75 | 119.64 d | 121(17.1%), 136(58.8%), 265(59%), 280(25%), 10.5-12.0(56.8%) As K x-rays | 5 nCi-100 µCi | 185 Bq-3.7 MBq |
| GF-110-x | Silver-110m | 249.8 d | 657.8(94.4%), 884.6(72.6%) | 5 nCi-50 µCi | 185 Bq-1.85 MBq |
| GF-131-x | Simulated I-131 | ~5 y | 356(from Ba-133), 662(from Cs-137/Ba-137) | 50 nCi-100 µCi | 1.85 kBq-3.7 MBq |
| GF-022-x | Sodium-22 | 950.8 d | 511(178%), 1275(100%) | 5 nCi-100 µCi | 185 Bq-3.7 MBq |
| GF-085-x | Strontium-85 | 64.849 d | 514(98.4%), 13.3-15.3(58.7%) Rb K x-rays | 5 nCi-100 µCi | 185 Bq-3.7 MBq |
| GF-228-x | Thorium-228 | 698.2 d | 84-2614 (includes daughters) | 50 nCi-10 µCi | 1.85 kBq-370 kBq |
| GF-113-x | Tin-113 | 115.09 d | 392(64% from In-113 m), 24-28(96.8%) In K x-rays | 5 nCi-100 µCi | 185 Bq-3.7 MBq |
| GF-235-x | Uranium-235 | 7.037 x 10 ⁸ y | 143(10.5%), 186(53%), 90-105(10.8%) Th K x-rays | 10 nCi-100 nCi | 370 Bq-3.7 kBq |
| GF-238U-x | Uranium (Natural) | 4.468 x 10 ⁹ y | 26-2448 (includes daughters) | 10 nCi-35 nCi | 370 Bq-1.29 kBq |
| GF-088-x | Yttrium-88 | 106.630 d | 898(94%), 1836(99.4%), 14.1-16.2(61.6%) Sr K x-rays | 5 nCi-100 µCi | 185 Bq-3.7 MBq |
| GF-065-x | Zinc-65 | 244.26 d | 1116(50.6%), 8.0-8.9(38.7%) Cu K x-rays | 5 nCi-100 µCi | 185 Bq-3.7 MBq |
| GF-095-x | Zirconium-95/Nb-95 | 64.02 d | 724(44.1%), 757(54.5%) | 10 nCi-50 µCi | 370 Bq-1.85 MBq |

| Gamma Sets—Type R | | | |
|-------------------|----------------------|-----------------|---|
| Catalog Number | Available Activities | Sets Consist Of | |
| GF-290-0.1x | 0.1 µCi | 3.7 kBq | Ba-133, Cd-109, Co-57, Co-60, Cs-137, Mn-54 and Na-22 |
| GF-290-1x | 1 µCi | 37 kBq | Ba-133, Cd-109, Co-57, Co-60, Cs-137, Mn-54 and Na-22 |
| GF-290-10x | 10 µCi | 370 kBq | Ba-133, Cd-109, Co-57, Co-60, Cs-137, Mn-54 and Na-22 |

Gamma and X-Ray Standards

Gamma Standards—Type T

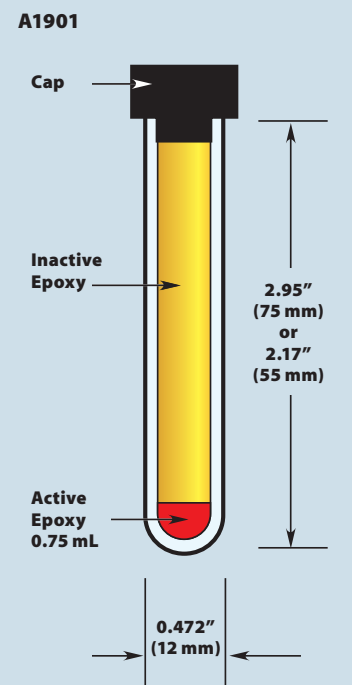
The type T plastic test tube is used in clinical instrument calibrations. Each polypropylene tube contains 0.75 mL of active epoxy with the balance of the tube filled with cold epoxy. Tube sizes are 2.95" high x 0.472" diameter (75 mm x 12 mm) or 2.17" high x 0.472" diameter (55 mm x 12 mm).



| Window & Active Materials | |
|---------------------------|-------------------------------------|
| Window | Nature of Active Materials |
| Not Applicable | Metallic Salts Distributed in Epoxy |

| Overall Dimensions | | | |
|--------------------|---------------|----------------|---------------|
| X | Height | Diameter | Active Volume |
| T1 | 2.17" (55 mm) | 0.472" (12 mm) | 0.75 mL |
| T2 | 2.95" (75 mm) | 0.472" (12 mm) | 0.75 mL |

Figure 52-A: Type T



| Gamma Standards—Type T | | | | |
|------------------------|---------------|--------------------------|---|--------------------------------|
| Catalog Number | Nuclide | Half-Life | Major Photon Emissions (keV) | Available Activities |
| GF-241-x | Americium-241 | 432.17 y | 59.5 (36%), 11-20 (39.5%) Np L x-rays | 5 nCi-10 µCi 185 Bq-370 kBq |
| GF-124-x | Antimony-124 | 60.20 d | 602.7(97.9%), 722.8(10.9%), 1690.9(47.6%) | 5 nCi-10 µCi 185 Bq-370 kBq |
| GF-125A-x | Antimony-125A | 1007.7 d | 428(29.7%), 464(10.5%), 601(17.7%), 607(5%), 636(11.2%), 27-32(75.1%) Te K x-rays | 5 nCi-10 µCi 185 Bq-370 kBq |
| GF-133-x | Barium-133 | 3862 d | 80(34.1%), 303(18.3%), 356(61.9%), 32-37(53.2%) Cs K x-rays | 5 nCi-10 µCi 185 Bq-370 kBq |
| GF-007-x | Beryllium-7 | On Request | | |
| GF-207-x | Bismuth-207 | 1.16 x 10 ⁴ d | 570(97.7%), 1064(74.5%), 9-15(32.5%), Pb L x-rays, 72-88(77.7%) Pb K x-rays | 5 nCi-10 µCi 185 Bq-370 kBq |
| GF-109-x | Cadmium-109 | 462.6 d | 88(3.6% from Ag-109 m), 22-26(99.4%) Ag K x-rays | 50 nCi-10 µCi 1.85 kBq-370 kBq |
| GF-139-x | Cerium-139 | 137.640 d | 33.03(22.8%), 33.4(41.9%), 165.9(79.9%), 33-39(80%) La x-rays | 5 nCi-10 µCi 185 Bq-370 kBq |
| GF-141-x | Cerium-141 | 32.5 d | 36.0(9.1%), 35.6(5%), 145.4(48.4%), 352.42(17%), Pr x-rays | — — |
| GF-134-x | Cesium-134 | 754.28 d | 563(8.4%), 569(15.4%), 605(97.6%), 796(85.4%) | 5 nCi-10 µCi 185 Bq-370 kBq |
| GF-137-x | Cesium-137 | 30.17 y | 662(85.1% from Ba-137), 32-37(7.2%) Ba K x-rays | 5 nCi-10 µCi 185 Bq-370 kBq |
| GF-051-x | Chromium-51 | 27.706 d | 320(9.86%), 4.9-5.4(22.8%) V K x-rays | 25 nCi-10 µCi 925 Bq-370 kBq |

Gamma Standards—Type T

| Catalog Number | Nuclide | Half-Life | Major Photon Emissions (keV) | Available Activities |
|----------------|--------------------|-------------------------|--|-----------------------------------|
| GF-056-x | Cobalt-56 | 77.31 d | 846.8(99.9%), 1238(66.1%), 1771(15.5%), 2035(7.8%), 2598(17%), 3253(7.6%), others up to 3452 | 10 nCi-10 µCi 370 Bq-370 kBq |
| GF-057-x | Cobalt-57 | 271.79 d | 14(9.2%), 122(85.6%), 136.5(10.7%), 6.4-7.1(57.9%) Fe K x-rays | 5 nCi-10 µCi 185 Bq-370 kBq |
| GF-058-x | Cobalt-58 | 70.86 d | 810(99.5%), 6.4-7.1(26.7%) Fe K x-rays | 5 nCi-10 µCi 185 Bq-370 kBq |
| GF-060-x | Cobalt-60 | 5.272 y | 1173(100%), 1333(100%) | 5 nCi-10 µCi 185 Bq-370 kBq |
| GGF-152-x | Europium-152 | 4933 d | 122-1408, 40-47(74%) Sm +Gd x-rays | 25 nCi-10 µCi 925 Bq-370 kBq |
| GF-154-x | Europium-154 | 3136.8 d | 123-1597, 42-50(25.6%) Gd x-rays | 25 nCi-10 µCi 925 Bq-370 kBq |
| GF-155-x | Europium-155 | 1770 d | 87(34%), 105(20.6%), 42-50(24.0%), Gd K x-rays | 10 nCi-10 µCi 370 Bq-370 kBq |
| GF-153-x | Gadolinium-153 | 242 d | 97(29.5%), 103(21.1%), 40-49(122%) Eu K x-rays | 10 nCi-10 µCi 370 Bq-370 kBq |
| F-068-x | Germanium-68 | 270.8 d | 511(178%), 1077(3.2%) from Ga-68, 9.2-10.4(44.1%) Ga K x-rays, 8.6-9.6(4.7%) Zn K x-rays | 100 nCi-10 µCi 3.7 kBq-370 kBq |
| GF-166-x | Holmium-166m | 1200 y | 81-1427, 48-58(37.6%) Er K x-rays | 10 nCi-1 µCi 370 Bq-37 kBq |
| GF-125-x | Iodine-125 | 59.43 d | 35(6.58%), 27-32(139%) Te K x-rays | 10 nCi-10 µCi 370 Bq-370 kBq |
| GF-129-x | Iodine-129 | 1.5 x 10 ⁷ y | 40(7.5%), 29-35(70.4%) Xe K x-rays | 50 nCi-1 µCi 1.85 kBq-37 kBq |
| GF-059-x | Iron-59 | 44.51 d | 1099(56.3%), 1292(43.7%) | 5 nCi-10 µCi 185 Bq-370 kBq |
| GF-054-x | Manganese-54 | 312.3 d | 835(100%), 5.4-5.9(25.6%) Cr K x-rays | 5 nCi-10 µCi 185 Bq-370 kBq |
| GF-203-x | Mercury-203 | 46.595 d | 279.2(81.5%) | 10 nCi-10 µCi 370 Bq-370 kBq |
| GF-046-x | Scandium-46 | 83.79 d | 889(99.9%), 1121(99.9%) | 5 nCi-10 µCi 185 Bq-370 kBq |
| GF-075-x | Selenium-75 | 119.64 d | 121(17.1%), 136(58.8%), 265(59%), 280(25%), 10.5-12.0(56.8%) As K x-rays | 5 nCi-10 µCi 185 Bq-370 kBq |
| GF-110-x | Silver-110m | 249.8 d | 657.8(94.4%), 884.6(72.6%) | 5 nCi-10 µCi 185 Bq-370 kBq |
| GF-131-x | Simulated I-131 | ~5 y | 356 (from Ba-133), 662 (from Cs-137/Ba-137) | 50 nCi-10 µCi 1.85 kBq-370 kBq |
| GF-022-x | Sodium-22 | 950.8 d | 511(178%), 1275(100%) | 5 nCi-10 µCi 185 Bq-370 kBq |
| GF-085-x | Strontium-85 | 64.849 d | 514(98.4%), 13.3-15.3(58.7%) Rb K x-rays | 5 nCi-10 µCi 185 Bq-370 kBq |
| GF-113-x | Tin-113 | 115.09 d | 392(64% from In-113 m), 24-28(96.8%) In K x-rays | 5 nCi-10 µCi 185 Bq-370 kBq |
| GF-088-x | Yttrium-88 | 106.630 d | 898(94%), 1836(99.4%), 14.1-16.2(61.6%) Sr K x-rays | 5 nCi-10 µCi 185 Bq-370 kBq |
| GF-065-x | Zinc-65 | 244.26 d | 1116(50.6%), 8.0-8.9(38.7%) Cu K x-rays | 5 nCi-10 µCi 185 Bq-370 kBq |
| GF-095-x | Zirconium-95/Nb-95 | 64.02 d | 724(44.1%), 757(54.5%) | 10 nCi-10 µCi 370 Bq-370 kBq |

Gamma Sets—Type T

| Catalog Number | Available Activities | Sets Consist Of |
|----------------|----------------------|---|
| GF-290-0.1x | 0.1 µCi 3.7 kBq | Ba-133, Cd-109, Co-57, Co-60, Cs-137, Mn-54 and Na-22 |
| GF-290-1x | 1 µCi 37 kBq | Ba-133, Cd-109, Co-57, Co-60, Cs-137, Mn-54 and Na-22 |
| GF-290-10x | 10 µCi 370 kBq | Ba-133, Cd-109, Co-57, Co-60, Cs-137, Mn-54 and Na-22 |

Planar Calibration Standards



This series includes the Extended Alpha or Beta Standards (EAB) and the Large Decade Standards (LDS). These standards are used for the calibration of alpha, beta and wide area counters. EAB standards are typically disks and LDS standards are either large square or large rectangular standards. All sources are NIST traceable based on output or contained activity. NIST certification on contained activity is not available on some alpha and beta sources. The surface emission rate in 2π is given on the certificate and is NIST traceable for most nuclides. Note that the emission rate for a given energy spectrum is a function of detector geometry, gas composition, pressure and material of construction, so that virtually every detector may have a different response. All electroplated sources are prepared +/- 30% of nominal activity.

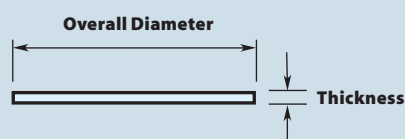
EAB—Unmounted Foil

These are rugged sources designed primarily for the calibration of portable survey instruments in the plant or field.

These sources are annealed, so that the active surface of the source may be gently wiped or touched without removing activity from the surface.

Figure 55-A: Unmounted Configuration

A14-6



Overall Dimensions

| X | Overall Diameter | Active Diameter | Thickness | Minimum | Maximum |
|-----|------------------|-----------------|------------------|----------------|--------------------|
| 25U | 0.984" (25 mm) | 0.787" (20 mm) | 0.03" (0.762 mm) | 5 nCi (185 Bq) | 31 nCi (1.14 kBq) |
| 32U | 1.26" (32 mm) | 0.984" (25 mm) | 0.03" (0.762 mm) | 5 nCi (185 Bq) | 49 nCi (1.81 kBq) |
| 47U | 1.85" (47 mm) | 1.73" (45 mm) | 0.03" (0.762 mm) | 5 nCi (185 Bq) | 159 nCi (58.8 kBq) |
| 50U | 2.0" (50.8 mm) | 1.85" (47 mm) | 0.03" (0.762 mm) | 5 nCi (185 Bq) | 173 nCi (64.0 kBq) |

Planar Calibration Standards—Unmounted Foil

| Catalog Number | Nuclide | Half-Life | Principle Emissions (keV) | Nature of Active Material | Window |
|----------------|---------------|-----------------------|---------------------------|------------------------------------|--------|
| EAB-241-x | Americium-241 | 432.17 y | 5388, 5443, 5486 α | Electroplated onto Stainless Steel | None |
| EAB-239-x | Plutonium-239 | 2.411×10^4 y | 5105, 5143, 5156 α | Electroplated onto Stainless Steel | None |
| EAB-099-x | Technetium-99 | 2.13×10^5 y | 294 β_{max} | Electroplated onto Stainless Steel | None |
| EAB-230-x | Thorium-230 | 7.54×10^4 y | 4621, 4688 α | Electroplated onto Stainless Steel | None |



Planar Calibration Standards

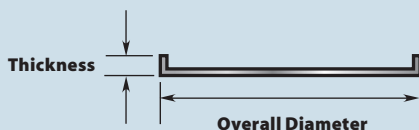
Planchet—EAB-PL

These standards simulate cupped planchet samples and can be used as calibration or performance check standards.



Figure 56-A: PL Style

A1410



Overall Dimensions

| Overall Diameter | Active Diameter | Height |
|------------------|-----------------|---------|
| 2.0" | 1.77" | 0.125" |
| 50.8 mm | 45 mm | 3.18 mm |

Activities & Exceptions

Available Activities

5 nCi–100 nCi (185 Bq–3.7 kBq)

Exceptions

| | |
|--------|-------------------------------------|
| Cl-36 | 1 nCi–1.6 μ Ci (37 Bq–59.2 kBq) |
| U-235 | 1 nCi–25 nCi (37 Bq–925 Bq) |
| U-238 | 1 nCi–4 nCi (37 Bq–148 Bq) |
| U-238D | 1 nCi–2 nCi (37 Bq–74 Bq) |

Planar Calibration Standards—PL Style

| Catalog Number | Nuclide | Half-Life | Principle Emissions (keV) | Nature of Active Material | Window |
|----------------|---|---------------------------|--|---|---|
| EAB-241-PL | Americium-241 ⁽⁴⁾ | 432.17 y | 5388, 5443, 5486 α | Electroplated onto Stainless Steel | None |
| EAB-014-PL | Carbon-14 | 5730 y | 156 β_{\max} | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar |
| EAB-137-PL | Cesium-137 | 30.17 y | 662, 1175 β_{\max} | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar |
| EAB-036-PL | Chlorine-36 | 3.01 x 10 ⁵ y | 1142 β_{\max} | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar |
| EAB-060-PL | Cobalt-60 | 5.272 y | 1173, 1332 ~300 β_{\max} | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar |
| EAB-125-PL | Iodine-125 ⁽¹⁾ | 59.43 d | 35.5, 27–32 K x-rays γ | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar |
| EAB-129-PL | Iodine-129 | 1.57 x 10 ⁷ y | 40, 29–35 K x-rays γ | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar |
| EAB-239-PL | Plutonium-239 ⁽⁴⁾ | 2.411 x 10 ⁴ y | 5105, 5143, 5156 α | Electroplated onto Stainless Steel | None |
| EAB-210-PL | Polonium-210 ⁽²⁾ | 138.376 d | 5304 α | Electroless Deposit onto Silver Substrate | None |
| EAB-147-PL | Promethium-147 | 2.6234 y | 225 β | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar |
| EAB-131-PL | Simulated Iodine-131 | ~5 y | 356, 662 γ | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar |
| EAB-090-PL | Strontium 90/Yttrium-90 ⁽³⁾ | 28.5 y | Sr-90:546 β , Y-90:2282 | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar |
| EAB-099-PL | Technetium-99 ⁽⁴⁾ | 2.13 x 10 ⁵ y | 294 β | Electroplated onto Stainless Steel | None |
| EAB-204-PL | Thallium-204 | 3.78 y | 763 β | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar |
| EAB-230-PL | Thorium-230 ⁽⁴⁾ | 7.54 x 10 ⁴ y | 4621, 4688 α | Electroplated onto Stainless Steel | None |
| EAB-235-PL | Uranium-235 (beta from Pa-231) ⁽²⁾ | 7.037 x 10 ⁸ y | 4215–4597 α | Electroplated onto Aluminum Substrate | 100 μ g/cm ² Acrylic |
| EAB-238-PL | Uranium-238 (Natural) ⁽²⁾ | 4.468 x 10 ⁹ y | 4147, 4196 (beta from Pa-234) α | Electroplated onto Aluminum Substrate | 100 μ g/cm ² Acrylic |

1) See note on page 45 regarding I-125 sources.

2) 100 μ g/cm² acrylic cover available upon request.

3) See note on page 41 regarding Sr-90/Y-90 sources.

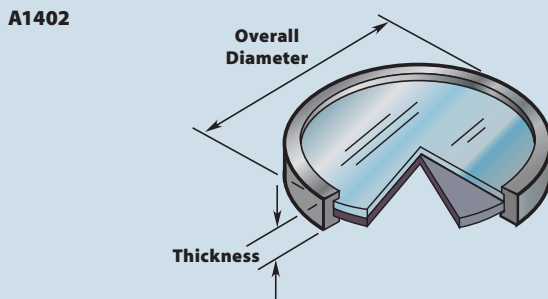
4) 100 μ g/cm² gold cover available upon request.

Ring and Disk—EAB-LB

EAB-LB disk standards are designed to check the performance and to determine the efficiency of low level counting systems such as proportional counters. The stainless steel disk containing the active element is surrounded by an aluminum ring which holds the window assembly in place.



Figure 57-A: LB Configuration



Overall Dimensions

| X | Overall Diameter | Active Diameter | Height |
|------|------------------|-----------------|------------------|
| 47LB | 1.85" (47 mm) | 1.61" (41 mm) | 0.125" (3.18 mm) |
| 50LB | 2.0" (50.8 mm) | 1.77" (45 mm) | 0.125" (3.18 mm) |

Activities & Exceptions

Available Activities

5 nCi-100 nCi (185 Bq-3.7 kBq)

Exceptions

| | |
|--------|-------------------------------------|
| Cl-36 | 1 nCi-1.6 μ Ci (37 Bq-59.2 kBq) |
| U-235 | 1 nCi-25 nCi (37 Bq-92.5 Bq) |
| U-238 | 1 nCi-4 nCi (37 Bq-148 Bq) |
| U-238D | 1 nCi-2 nCi (37 Bq-74 Bq) |

Planar Calibration Standards—LB Configuration

| Catalog Number | Nuclide | Half-Life | Principle Emissions (keV) | Nature of Active Material | Window |
|----------------|---|---------------------------|--|---|---|
| EAB-241-x | Americium-241 ⁽⁴⁾ | 432.17 y | 5388, 5443, 5486 α | Electroplated onto Stainless Steel | None |
| EAB-014-x | Carbon-14 | 5730 y | 156 β_{\max} | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar |
| EAB-137-x | Cesium-137 | 30.17 y | 662, 1175 β_{\max} | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar |
| EAB-036-x | Chlorine-36 | 3.01 x 10 ⁵ y | 1142 β_{\max} | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar |
| EAB-060-x | Cobalt-60 | 5.272 y | 1173, 1332 ~300 β_{\max} | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar |
| EAB-125-x | Iodine-125 ⁽¹⁾ | 59.43 d | 35.5, 27-32 K x-rays γ | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar |
| EAB-129-x | Iodine-129 | 1.57 x 10 ⁷ y | 40, 29-35 K x-rays γ | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar |
| EAB-239-x | Plutonium-239 ⁽⁴⁾ | 2.411 x 10 ⁴ y | 5105, 5143, 5156 α | Electroplated onto Stainless Steel | None |
| EAB-210-x | Polonium-210 ⁽²⁾ | 138.376 d | 5304 α | Electroless Deposit onto Silver Substrate | None |
| EAB-147-x | Promethium-147 | 2.6234 y | 225 β | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar |
| EAB-131-x | Simulated Iodine-131 | ~5 y | 356, 662 γ | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar |
| EAB-090-x | Strontium 90/Yttrium-90 ⁽³⁾ | 28.5 y | Sr-90:546 β , Y-90:2282 | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar |
| EAB-099-x | Technetium-99 ⁽⁴⁾ | 2.13 x 10 ⁵ y | 294 β | Electroplated onto Stainless Steel | None |
| EAB-204-x | Thallium-204 | 3.78 y | 763 β | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar |
| EAB-230-x | Thorium-230 ⁽⁴⁾ | 7.54 x 10 ⁴ y | 4621, 4688 α | Electroplated onto Stainless Steel | None |
| EAB-235-x | Uranium-235 (beta from Pa-231) ⁽²⁾ | 7.037 x 10 ⁸ y | 4215-4597 α | Electroplated onto Aluminum Substrate | 100 μ g/cm ² Acrylic |
| EAB-238-x | Uranium-238 (Natural) ⁽²⁾ | 4.468 x 10 ⁹ y | 4147, 4196 (beta from Pa-234) α | Electroplated onto Aluminum Substrate | 100 μ g/cm ² Acrylic |

1) See note on page 45 regarding I-125 sources.

2) 100 μ g/cm² acrylic cover available upon request.

3) See note on page 41 regarding Sr-90/Y-90 sources.

4) 100 μ g/cm² gold cover available upon request.

Planar Calibration Standards

Planchet—EAB-PL-FP

Filter paper standards are designed to simulate surface smears and thus establish efficiencies for smear samples of similar construction. Since alpha and beta particles are easily attenuated by the filter paper, the actual surface emission may not appear to relate to the contained activity. Therefore, efficiencies derived with such standards have a large uncertainty caused by the inherent absorption. Filter paper standards are most useful in establishing action levels for smear samples. The calibration certificate provides both the contained activity and the surface emission rate of the standard.

Beta standards are covered with 0.9 mg/cm² aluminized Mylar. Alpha standards are covered with 100 - 200 µg/cm² of acrylic. In addition to the mounts described above, the active filter paper can be mounted in any of the EAB-LB or EAB-PL configurations.

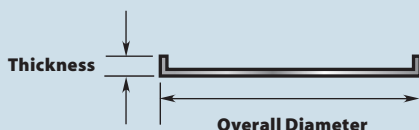


| Overall Dimensions | | |
|--------------------|-----------------|---------|
| Overall Diameter | Active Diameter | Height |
| 2.0" | 1.77" | 0.125" |
| 50.8 mm | 45 mm | 3.18 mm |

| Activities & Exceptions | |
|--------------------------------|--------------------------------|
| Available Activities | |
| 5 nCi-100 nCi (185 Bq-3.7 kBq) | |
| Exceptions | |
| Cl-36 | 1 nCi-1.6 µCi (37 Bq-59.2 kBq) |
| U-235 | 1 nCi-25 nCi (37 Bq-925 Bq) |
| U-238 | 1 nCi-5 nCi (37.5 Bq-185 Bq) |
| U-238D | 1 nCi-2 nCi (37 Bq-74 Bq) |

Figure 58-A: PL-FP Style

A1410



Planar Calibration Standards—PL-FP Style

| Catalog Number | Nuclide | Half-Life | Principle Emissions (keV) | Nature of Active Material | Window |
|----------------|---|---------------------------|----------------------------------|-----------------------------|---|
| EAB-241-PL-FP | Americium-241 | 432.17 y | 5388, 5443, 5486 α | Deposited onto Filter Paper | 100 µg/cm ² Acrylic |
| EAB-014-PL-FP | Carbon-14 | 5730 y | 156 β _{max} | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar |
| EAB-137-PL-FP | Cesium-137 | 30.17 y | 662, 1175 β _{max} | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar |
| EAB-036-PL-FP | Chlorine-36 | 3.01 x 10 ⁵ y | 1142 β _{max} | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar |
| EAB-060-PL-FP | Cobalt-60 | 5.272 y | 1173, 1332 ~300 β _{max} | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar |
| EAB-125-PL-FP | Iodine-125 ⁽¹⁾ | 59.43 d | 35.5, 27-32 K x-rays γ | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar |
| EAB-129-PL-FP | Iodine-129 | 1.57 x 10 ⁷ y | 40, 29-35 K x-rays γ | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar |
| EAB-239-PL-FP | Plutonium-239 | 2.411 x 10 ⁴ y | 5105, 5143, 5156 α | Deposited onto Filter Paper | 100 µg/cm ² Acrylic |
| EAB-210-PL-FP | Polonium-210 (NIST, contained activity only) | 138.376 d | 5304 α | Deposited onto Filter Paper | 100 µg/cm ² Acrylic |
| EAB-147-PL-FP | Promethium-147 | 2.6234 y | 225 β | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar |
| EAB-131-PL-FP | Simulated Iodine-131 | ~5 y | 356, 662 γ | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar |
| EAB-090-PL-FP | Strontium 90/Yttrium-90 ⁽²⁾ | 28.5 y | Sr-90:546 β, Y-90:2282 | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar |
| EAB-099-PL-FP | Technetium-99 | 2.13 x 10 ⁵ y | 294 β | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar |
| EAB-204-PL-FP | Thallium-204 | 3.78 y | 763 β | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar |
| EAB-230-PL-FP | Thorium-230 | 7.54 x 10 ⁴ y | 4621, 4688 α | Deposited onto Filter Paper | 100 µg/cm ² Acrylic |
| EAB-235-PL-FP | Uranium-235 (beta from Pa-231) | 7.037 x 10 ⁸ y | 4215-4597 α | Deposited onto Filter Paper | 100 µg/cm ² Acrylic |
| EAB-238-PL-FP | Uranium-238 (Natural) | 4.468 x 10 ⁹ y | 4147, 4196 (beta from Pa-234) α | Deposited onto Filter Paper | 100 µg/cm ² Acrylic |

1) See note on page 45 regarding I-125 sources.
2) See note on page 41 regarding Sr-90/Y-90 sources.

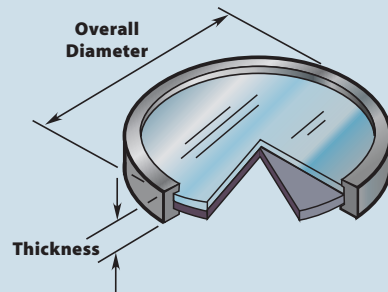
Ring and Disk—EAB-LB-FP

The stainless steel disk containing the active element is surrounded by an aluminum ring which holds the window assembly in place.



Figure 59-A: LB-FP Configuration

A1402



Overall Dimensions

| X | Overall Diameter | Active Diameter | Height |
|---------|------------------|-----------------|------------------|
| 47LB-FP | 1.85" (47 mm) | 1.61" (41 mm) | 0.125" (3.18 mm) |
| 50LB-FP | 2.0" (50.8 mm) | 1.77" (45 mm) | 0.125" (3.18 mm) |

Activities & Exceptions

Available Activities

5 nCi-100 nCi (185 Bq-3.7 kBq)

Exceptions

| | |
|-------------|-------------------------------------|
| Cl-36 | 1 nCi-1.6 μ Ci (37 Bq-59.2 kBq) |
| U-235 | 1 nCi-25 nCi (37 Bq-925 Bq) |
| U-238: 47LB | 1 nCi-4 nCi (37 Bq-148 Bq) |
| U-238: 50LB | 1 nCi-4 nCi (37 Bq-148 Bq) |
| U-238D | 1 nCi-2 nCi (37 Bq-74 Bq) |

Planar Calibration Standards—LB-FP Configuration

| Catalog Number | Nuclide | Half-Life | Principle Emissions (keV) | Nature of Active Material | Window |
|----------------|---|---------------------------|--|-----------------------------|---|
| EAB-241-x-FP | Americium-241 | 432.17 y | 5388, 5443, 5486 α | Deposited onto Filter Paper | 100 μ g/cm ² Acrylic |
| EAB-014-x-FP | Carbon-14 | 5730 y | 156 β_{\max} | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar |
| EAB-137-x-FP | Cesium-137 | 30.17 y | 662, 1175 β_{\max} | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar |
| EAB-036-x-FP | Chlorine-36 | 3.01 x 10 ⁵ y | 1142 β_{\max} | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar |
| EAB-060-x-FP | Cobalt-60 | 5.272 y | 1173, 1332 \sim 300 β_{\max} | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar |
| EAB-125-PL-FP | Iodine-125 ⁽¹⁾ | 59.43 d | 35.5, 27-32 K x-rays γ | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar |
| EAB-129-x-FP | Iodine-129 | 1.57 x 10 ⁷ y | 40, 29-35 K x-rays γ | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar |
| EAB-239-x-FP | Plutonium-239 | 2.411 x 10 ⁴ y | 5105, 5143, 5156 α | Deposited onto Filter Paper | 100 μ g/cm ² Acrylic |
| EAB-210-x-FP | Polonium-210 (NIST, contained activity only) | 138.376 d | 5304 α | Deposited onto Filter Paper | 100 μ g/cm ² Acrylic |
| EAB-147-x-FP | Promethium-147 | 2.6234 y | 225 β | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar |
| EAB-131-x-FP | Simulated Iodine-131 | \sim 5 y | 356, 662 γ | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar |
| EAB-090-x-FP | Strontium 90/Yttrium-90 ⁽²⁾ | 28.5 y | Sr-90:546 β , Y-90:2282 | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar |
| EAB-099-x-FP | Technetium-99 | 2.13 x 10 ⁵ y | 294 β | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar |
| EAB-204-x-FP | Thallium-204 | 3.78 y | 763 β | Deposited onto Filter Paper | 0.9 mg/cm ² Aluminized Mylar |
| EAB-230-x-FP | Thorium-230 | 7.54 x 10 ⁴ y | 4621, 4688 α | Deposited onto Filter Paper | 100 μ g/cm ² Acrylic |
| EAB-235-x-FP | Uranium-235 (beta from Pa-231) | 7.037 x 10 ⁸ y | 4215-4597 α | Deposited onto Filter Paper | 100 μ g/cm ² Acrylic |
| EAB-238-x-FP | Uranium-238 (Natural) | 4.468 x 10 ⁹ y | 4147, 4196 (beta from Pa-234) α | Deposited onto Filter Paper | 100 μ g/cm ² Acrylic |

Planar Calibration Standards

Large Area Standards—LDS Sources

The Large Area Standards (LDS Series) are intended for the calibration of large area survey probes currently used for area and personnel monitoring.

A comprehensive range of alpha and beta energies is listed in the tables on pages 76–77. Requirements for other nuclides, activity levels and larger geometries can be accommodated upon request.

Active elements are prepared by electroplating or by evaporative deposition. Available activity levels for each nuclide are listed in the tables on pages 61–65.

Sources may be supplied with aluminum or Mylar windows or as uncovered sources depending on the nature of the active deposit and the emitted energy.

Electroplated standards are supplied on an aluminum or stainless steel backing plate. Deposited standards employing Mylar covers are supplied with a plastic backing plate. All standards are supplied in plastic storage boxes.

Two Standard Sizes are Available

Model 1620: 3.94" x 3.94"
(100 mm x 100 mm) active area

Model 1621: 3.94" x 5.91"
(100 mm x 150 mm) active area

Calibration

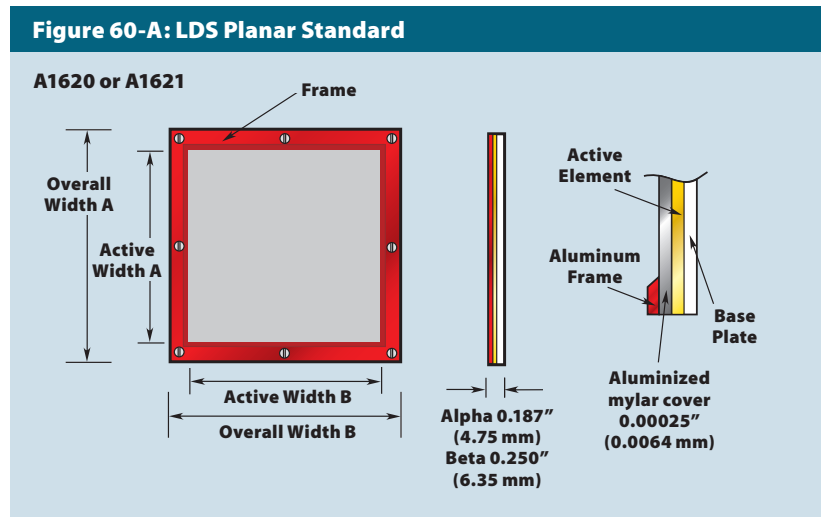
The contained activity is certified in nanocuries or microcuries and becquerels or kilobecquerels and is NIST traceable $\pm 5\%$.

The surface emission rate in 2π is given on the certificate and is NIST traceable for most nuclides.

Standard Sets for Specialized Applications

Decade Standard Sets (LDS-300) are designed to routinely check the tracking of G.M. and proportional counters from scale to scale. They may be supplied as an alpha, low energy beta, or high energy beta/gamma set. Each set is supplied as 3 standards with activities at 1,000 dpm, 10,000 dpm and 100,000 dpm (16.7 Bq, 166.7 Bq and 1.67 kBq). Each source is NIST traceable $\pm 5\%$ on contained activity.

Figure 60-A: LDS Planar Standard



Overall Dimensions

| Model | Overall Width "A" | Active Width "A" | Overall Width "B" | Active Width "B" |
|----------------|-------------------|------------------|-------------------|------------------|
| LDS-XXX-100 mm | 4.75" (121 mm) | 3.94" (100 mm) | 4.75" (121 mm) | 3.94" (100 mm) |
| LDS-XXX-150 mm | 4.75" (121 mm) | 3.94" (100 mm) | 6.73" (171 mm) | 5.91" (150 mm) |

| Americium-241 | | | | | | |
|----------------------------|-----------------------------------|---|---------------------------------------|--------|--|--------------------------------|
| Half-Life: 432.17 y | | E_{MAX} β (keV) or E_a (keV): 5388, 5443, 5486 | | | Other Significant Radiations: Gamma | |
| Catalog Number | Overall Dimensions | Active Dimensions | Nature of Active Material | Window | Available Activities | Additional Information |
| LDS-241-100 mm | 4.75" x 4.75" 121 mm x 121 mm | 3.94" X 3.94" 100 mm x 100 mm | Electroplated onto Stainless Steel | None | 5 nCi-100 nCi 185 Bq-3.7 kBq | +/-30% of Nominal Activity. |
| LDS-241-150 mm | 4.75" x 6.725" 121 mm x 171 mm | 3.94" x 5.91" 100 mm x 150 mm | Electroplated onto Stainless Steel | None | 5 nCi-100 nCi 185 Bq-3.7 kBq | |

| Carbon-14 | | | | | | |
|--------------------------|-----------------------------------|--|--------------------------------------|--|---|--------------------------------|
| Half-Life: 5730 y | | E_{MAX} β (keV) or E_a (keV): 156 | | | Other Significant Radiations: None | |
| Catalog Number | Overall Dimensions | Active Dimensions | Nature of Active Material | Window | Available Activities | Additional Information |
| LDS-014-100 mm | 4.75" x 4.75" 121 mm x 121 mm | 3.94" X 3.94" 100 mm x 100 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 5 nCi-100 nCi 185 Bq-3.7 kBq | +/-15% of Nominal Activity. |
| LDS-014-150 mm | 4.75" x 6.725" 121 mm x 171 mm | 3.94" x 5.91" 100 mm x 150 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 5 nCi-100 nCi 185 Bq-3.7 kBq | |

| Cesium-137 | | | | | | |
|----------------------------|-----------------------------------|---|--------------------------------------|--|--|--------------------------------|
| Half-Life: 432.17 y | | E_{MAX} β (keV) or E_a (keV): 5388, 5443, 5486 | | | Other Significant Radiations: Gamma | |
| Catalog Number | Overall Dimensions | Active Dimensions | Nature of Active Material | Window | Available Activities | Additional Information |
| LDS-137-100 mm | 4.75" x 4.75" 121 mm x 121 mm | 3.94" X 3.94" 100 mm x 100 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 5 nCi-100 nCi 185 Bq-3.7 kBq | +/-15% of Nominal Activity. |
| LDS-137-150 mm | 4.75" x 6.725" 121 mm x 171 mm | 3.94" x 5.91" 100 mm x 150 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 5 nCi-100 nCi 185 Bq-3.7 kBq | |

| Chlorine-36 | | | | | | |
|---|-----------------------------------|---|--------------------------------------|--|---|--------------------------------|
| Half-Life: 3.01 x 10⁵ y | | E_{MAX} β (keV) or E_a (keV): 1142 | | | Other Significant Radiations: None | |
| Catalog Number | Overall Dimensions | Active Dimensions | Nature of Active Material | Window | Available Activities | Additional Information |
| LDS-036-100 mm | 4.75" x 4.75" 121 mm x 121 mm | 3.94" X 3.94" 100 mm x 100 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 5 nCi-100 nCi 185 Bq-3.7 kBq | +/-15% of Nominal Activity. |
| LDS-036-150 mm | 4.75" x 6.725" 121 mm x 171 mm | 3.94" x 5.91" 100 mm x 150 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 5 nCi-100 nCi 185 Bq-3.7 kBq | |

| Cobalt-60 | | | | | | |
|---------------------------|-----------------------------------|---|--------------------------------------|--|--|--------------------------------|
| Half-Life: 5.272 y | | E_{MAX} β (keV) or E_a (keV): ~300 keV | | | Other Significant Radiations: Gamma | |
| Catalog Number | Overall Dimensions | Active Dimensions | Nature of Active Material | Window | Available Activities | Additional Information |
| LDS-060-100 mm | 4.75" x 4.75" 121 mm x 121 mm | 3.94" X 3.94" 100 mm x 100 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 5 nCi-100 nCi 185 Bq-3.7 kBq | +/-15% of Nominal Activity. |
| LDS-060-150 mm | 4.75" x 6.725" 121 mm x 171 mm | 3.94" x 5.91" 100 mm x 150 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 5 nCi-100 nCi 185 Bq-3.7 kBq | |

Planar Calibration Standards

Iodine-129

Half-Life: **1.57 x 10⁷ y**

E_{MAX} b (keV) or E_a (keV): **154**

Other Significant Radiations: **None**

| Catalog Number | Overall Dimensions | Active Dimensions | Nature of Active Material | Window | Available Activities | Additional Information |
|----------------|-----------------------------------|----------------------------------|--------------------------------------|--|---------------------------------|--|
| LDS-129-100 mm | 4.75" x 4.75" 121 mm x 121 mm | 3.94" X 3.94" 100 mm x 100 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 5 nCi-100 nCi 185 Bq-3.7 kBq | Simulates I-125. Refer to note on page 45 regarding "Simulated I-125" standards. |
| LDS-129-150 mm | 4.75" x 6.725" 121 mm x 171 mm | 3.94" x 5.91" 100 mm x 150 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 5 nCi-100 nCi 185 Bq-3.7 kBq | |

+/-15% of Nominal Activity.

Plutonium-238

Half-Life: **87.74 y**

E_{MAX} b (keV) or E_a (keV): **5456, 5499**

Other Significant Radiations: **None**

| Catalog Number | Overall Dimensions | Active Dimensions | Nature of Active Material | Window | Available Activities | Additional Information |
|----------------|-----------------------------------|----------------------------------|---------------------------------------|--------|---------------------------------|--------------------------------|
| LDS-238-100 mm | 4.75" x 4.75" 121 mm x 121 mm | 3.94" X 3.94" 100 mm x 100 mm | Electroplated onto Stainless Steel | None | 5 nCi-100 nCi 185 Bq-3.7 kBq | +/-30% of Nominal Activity. |
| LDS-238-150 mm | 4.75" x 6.725" 121 mm x 171 mm | 3.94" x 5.91" 100 mm x 150 mm | Electroplated onto Stainless Steel | None | 5 nCi-100 nCi 185 Bq-3.7 kBq | |

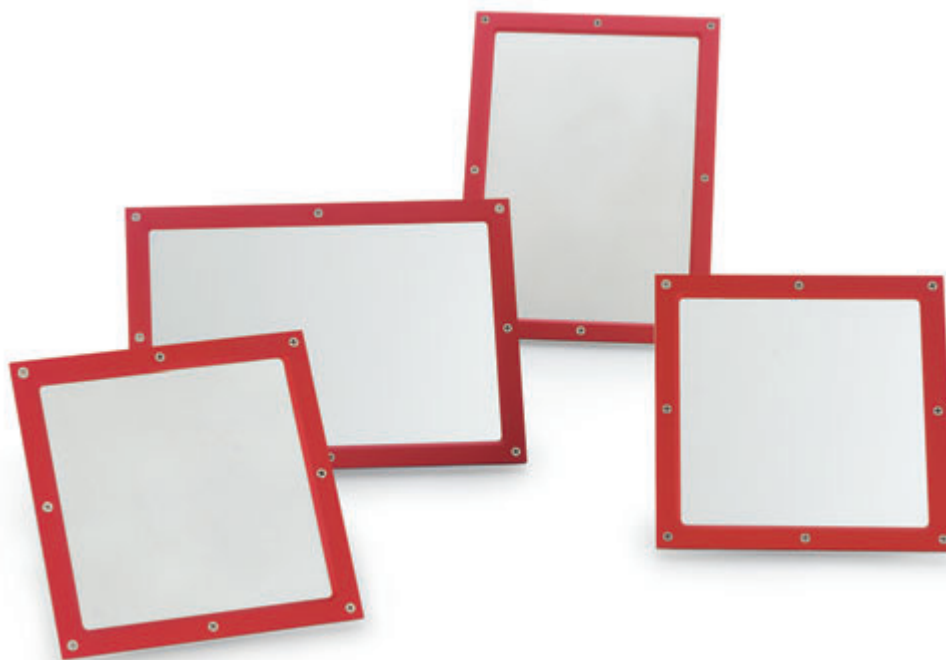
Plutonium-239

Half-Life: **2.411 x 10⁴ y**

E_{MAX} b (keV) or E_a (keV): **5105, 5143, 5156**

Other Significant Radiations: **None**

| Catalog Number | Overall Dimensions | Active Dimensions | Nature of Active Material | Window | Available Activities | Additional Information |
|----------------|-----------------------------------|----------------------------------|---------------------------------------|--------|---------------------------------|--------------------------------|
| LDS-239-100 mm | 4.75" x 4.75" 121 mm x 121 mm | 3.94" X 3.94" 100 mm x 100 mm | Electroplated onto Stainless Steel | None | 5 nCi-100 nCi 185 Bq-3.7 kBq | +/-30% of Nominal Activity. |
| LDS-239-150 mm | 4.75" x 6.725" 121 mm x 171 mm | 3.94" x 5.91" 100 mm x 150 mm | Electroplated onto Stainless Steel | None | 5 nCi-100 nCi 185 Bq-3.7 kBq | |



| Promethium-147 | | | | | | |
|----------------------------|-----------------------------------|--|--------------------------------------|--|---|--------------------------------|
| Half-Life: 2.6234 y | | E_{MAX} β (keV) or E_a (keV): 225 | | | Other Significant Radiations: None | |
| Catalog Number | Overall Dimensions | Active Dimensions | Nature of Active Material | Window | Available Activities | Additional Information |
| LDS-147-100 mm | 4.75" x 4.75" 121 mm x 121 mm | 3.94" X 3.94" 100 mm x 100 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 5 nCi-100 nCi 185 Bq-3.7 kBq | +/-15% of Nominal Activity. |
| LDS-147-150 mm | 4.75" x 6.725" 121 mm x 171 mm | 3.94" x 5.91" 100 mm x 150 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 5 nCi-100 nCi 185 Bq-3.7 kBq | |

| Silicon-32 / Phosphorus-32 | | | | | | |
|-----------------------------------|-----------------------------------|--|--------------------------------------|---------------------------|---|---|
| Half-Life: 104 y | | E_{MAX} β (keV) or E_a (keV): 225, 1710 | | | Other Significant Radiations: None | |
| Catalog Number | Overall Dimensions | Active Dimensions | Nature of Active Material | Window | Available Activities | Additional Information |
| LDS-032-100 mm | 4.75" x 4.75" 121 mm x 121 mm | 3.94" X 3.94" 100 mm x 100 mm | Deposited onto Polymeric Membrane | 0.002" Aluminum Window | 5 nCi-100 nCi 185 Bq-3.7 kBq | This long-lived P-32 standard is the beta emitting P-32 daughter of the long-lived Si-32 parent. The standard mounting for this source includes a 0.002" (0.051 mm) Al window. This window will absorb more than 60% of the Si-32 225 keV betas and less than 5% of the P-32 betas. Standards are prepared with the P-32 in equilibrium with the parent Si-32. +/-15% of Nominal Activity. |
| LDS-032-150 mm | 4.75" x 6.725" 121 mm x 171 mm | 3.94" x 5.91" 100 mm x 150 mm | Deposited onto Polymeric Membrane | 0.002" Aluminum Window | 5 nCi-100 nCi 185 Bq-3.7 kBq | |

| Strontium-90 / Yttrium-90 | | | | | | |
|----------------------------------|-----------------------------------|--|--------------------------------------|--|---|---|
| Half-Life: 28.5 y | | E_{MAX} β (keV) or E_a (keV): 546, 2282 | | | Other Significant Radiations: None | |
| Catalog Number | Overall Dimensions | Active Dimensions | Nature of Active Material | Window | Available Activities | Additional Information |
| LDS-090-100 mm | 4.75" x 4.75" 121 mm x 121 mm | 3.94" X 3.94" 100 mm x 100 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 5 nCi-100 nCi 185 Bq-3.7 kBq | Refer to note on page 41 regarding Sr-90 sources. |
| LDS-090-150 mm | 4.75" x 6.725" 121 mm x 171 mm | 3.94" x 5.91" 100 mm x 150 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 5 nCi-100 nCi 185 Bq-3.7 kBq | +/-15% of Nominal Activity. |

| Technetium -99 | | | | | | |
|---|-----------------------------------|--|---------------------------------------|--------|---|--------------------------------|
| Half-Life: 2.13 x 10⁵ y | | E_{MAX} β (keV) or E_a (keV): 294 | | | Other Significant Radiations: None | |
| Catalog Number | Overall Dimensions | Active Dimensions | Nature of Active Material | Window | Available Activities | Additional Information |
| LDS-099-100 mm | 4.75" x 4.75" 121 mm x 121 mm | 3.94" X 3.94" 100 mm x 100 mm | Electroplated onto Stainless Steel | None | 5 nCi-100 nCi 185 Bq-3.7 kBq | +/-30% of Nominal Activity. |
| LDS-099-150 mm | 4.75" x 6.725" 121 mm x 171 mm | 3.94" x 5.91" 100 mm x 150 mm | Electroplated onto Stainless Steel | None | 5 nCi-100 nCi 185 Bq-3.7 kBq | |

Planar Calibration Standards

Thallium -204

Half-Life: **3.78 y**

E_{MAX} β (keV) or E_{α} (keV): **763**

Other Significant Radiations: **None**

| Catalog Number | Overall Dimensions | Active Dimensions | Nature of Active Material | Window | Available Activities | Additional Information |
|----------------|-----------------------------------|----------------------------------|--------------------------------------|--|---------------------------------|--------------------------------|
| LDS-204-100 mm | 4.75" x 4.75" 121 mm x 121 mm | 3.94" X 3.94" 100 mm x 100 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 5 nCi-100 nCi 185 Bq-3.7 kBq | +/-15% of Nominal Activity. |
| LDS-204-150 mm | 4.75" x 6.725" 121 mm x 171 mm | 3.94" x 5.91" 100 mm x 150 mm | Deposited onto Polymeric Membrane | 0.9 mg/cm ² Aluminized Mylar | 5 nCi-100 nCi 185 Bq-3.7 kBq | |

Thorium-230

Half-Life: **7.54 x 10⁴ y**

E_{MAX} β (keV) or E_{α} (keV): **4621, 4688**

Other Significant Radiations: **None**

| Catalog Number | Overall Dimensions | Active Dimensions | Nature of Active Material | Window | Available Activities | Additional Information |
|----------------|-----------------------------------|----------------------------------|---------------------------------------|--------|---------------------------------|--------------------------------|
| LDS-230-100 mm | 4.75" x 4.75" 121 mm x 121 mm | 3.94" X 3.94" 100 mm x 100 mm | Electroplated onto Stainless Steel | None | 5 nCi-100 nCi 185 Bq-3.7 kBq | +/-30% of Nominal Activity. |
| LDS-230-150 mm | 4.75" x 6.725" 121 mm x 171 mm | 3.94" x 5.91" 100 mm x 150 mm | Electroplated onto Stainless Steel | None | 5 nCi-100 nCi 185 Bq-3.7 kBq | |



Uranium-235Half-Life: **7.037 x 10⁸ y** E_{MAX} b (keV) or Ea(keV): **4215-4597**Other Significant Radiations: **Gamma**

| Catalog Number | Overall Dimensions | Active Dimensions | Nature of Active Material | Window | Available Activities | Additional Information |
|----------------|-----------------------------------|----------------------------------|--------------------------------|--------|---------------------------------|--------------------------------|
| LDS-235-100 mm | 4.75" x 4.75" 121 mm x 121 mm | 3.94" X 3.94" 100 mm x 100 mm | Electroplated onto Aluminum | None | 5 nCi-200 nCi 185 Bq-7.4 kBq | +/-30% of Nominal Activity. |
| LDS-235-150 mm | 4.75" x 6.725" 121 mm x 171 mm | 3.94" x 5.91" 100 mm x 150 mm | Electroplated onto Aluminum | None | 5 nCi-200 nCi 185 Bq-7.4 kBq | Nominal Activity. |

Uranium-238Half-Life: **4.468 x 10⁹ y** E_{MAX} b (keV) or Ea(keV): **4147, 4196**Other Significant Radiations: **Gamma**

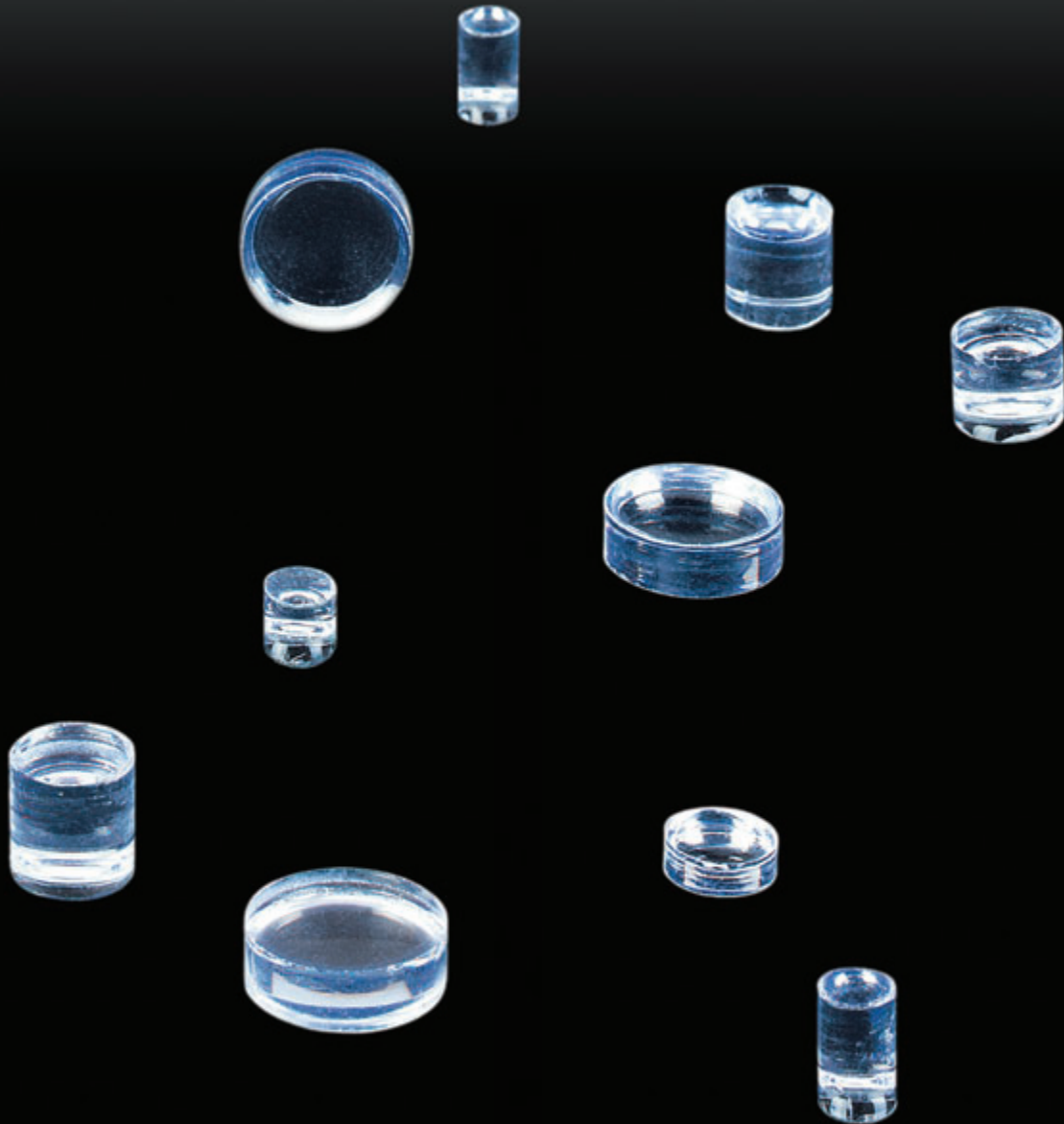
| Catalog Number | Overall Dimensions | Active Dimensions | Nature of Active Material | Window | Available Activities | Additional Information |
|-----------------|-----------------------------------|----------------------------------|--------------------------------|--------|---------------------------------|--------------------------------|
| LDS-238U-100 mm | 4.75" x 4.75" 121 mm x 121 mm | 3.94" X 3.94" 100 mm x 100 mm | Electroplated onto Aluminum | None | 5 nCi-30 nCi 185 Bq-1.11 kBq | +/-30% of Nominal Activity. |
| LDS-238U-150 mm | 4.75" x 6.725" 121 mm x 171 mm | 3.94" x 5.91" 100 mm x 150 mm | Electroplated onto Aluminum | None | 5 nCi-30 nCi 185 Bq-1.11 kBq | Nominal Activity. |

Uranium-238DHalf-Life: **4.468 x 10⁹ y** E_{MAX} b (keV) or Ea(keV): **4147, 4196**Other Significant Radiations: **Gamma**

| Catalog Number | Overall Dimensions | Active Dimensions | Nature of Active Material | Window | Available Activities | Additional Information |
|-----------------|-----------------------------------|----------------------------------|--------------------------------|--------|-------------------------------|--------------------------------|
| LDS-238D-100 mm | 4.75" x 4.75" 121 mm x 121 mm | 3.94" X 3.94" 100 mm x 100 mm | Electroplated onto Aluminum | None | 5 nCi-15 nCi 185 Bq-555 Bq | +/-30% of Nominal Activity. |
| LDS-238D-150 mm | 4.75" x 6.725" 121 mm x 171 mm | 3.94" x 5.91" 100 mm x 150 mm | Electroplated onto Aluminum | None | 5 nCi-15 nCi 185 Bq-555 Bq | Nominal Activity. |



Sources for Research Applications



Alpha Sources—AFR Sources

The AFR sources with rolled foils are available for Am-241 and Po-210. The standard mounting is in a type A-2 capsule (Fig 68-A) with a 9.5 mm (0.375") active diameter.

The active element for Am-241 consists of a rolled monolithic foil in which the activity is incorporated into a thin gold layer and bonded to a 0.001 mm (0.00004") gold cover. (Fig 67-A). The active element for Po-210 consists of a rolled monolithic foil in which the activity is incorporated into a thin gold layer and bonded to a 0.001 mm (0.00004") silver cover. (Fig 67-B). The active foils are sealed into the A-2 capsule with a vacuum compatible epoxy resin. The resulting unit is suitable for space and other high vacuum and low temperature applications. The foil construction is extremely resistant to leakage from puncture since there is no separate window or air space. The self absorption of the gold matrix plus the integral window absorption reduces the alpha-max energy to approximately 4.7 MeV for Am-241 and approximately 4.2 MeV for Po-210. Inquiries for more accurate calibration will be quoted upon request. These sources are not sold as spectral grade sources.

The standard active area is approximately 0.71 cm² corresponding to the 9.5 mm (0.374") window diameter. Contained activity is certified to ±30% of the nominal value. NIST traceability is available for contained activity of Am-241 sources up to 100 µCi (3.7 MBq). NIST traceability is not available for Po-210 sources.

Standard activities are listed below. Higher activities for both nuclides are available on request.

Figure 67-A : Am-241 Rolled Foil Cross-Section

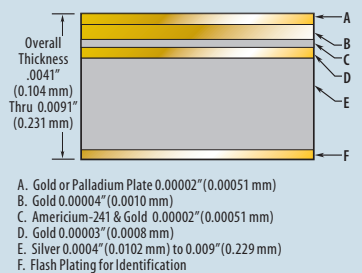
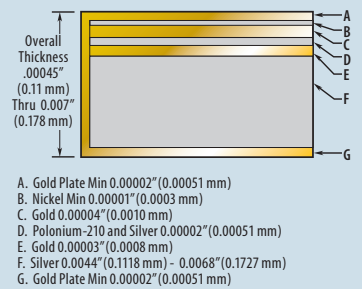


Figure 67-B : Po-210 Rolled Foil Cross-Section



AFR Sources^(1,2)

| Catalog Number | Nuclide | Half-Life | Max Alpha Energy (keV) | Active Diameter | Maximum Activity |
|----------------|---------|-----------------|------------------------|-----------------|------------------|
| AFR-210 | Po-210 | 138.376 days | 5304 | 5 mm | 1 µCi |
| AFR-228 | Th-228 | 698.2 days | 5341, 5423 | 5 mm | 1 µCi |
| AFR-238 | Pu-238 | 87.74 years | 5456, 5499 | 5 - 8 mm | 1 µCi |
| AFR-239 | Pu-239 | 2.411E+04 years | 5143, 5156 | 5 - 8 mm | 1 µCi |
| AFR-241 | Am-241 | 432.14 years | 5443, 5486 | 5 mm | 1 µCi |
| AFR-244 | Cm-244 | 18.11 years | 5763, 5805 | 5 mm | 1 µCi |

The following group of model numbers is sold as is. Activity and active diameters are not variable, and rolled foils all come with gold cover.

| | | | | | |
|------------|--------|--------------|------------|--------|----------|
| PO2A210U | Po-210 | 138.376 days | 5304 | 9.5 mm | 10 µCi |
| PO2A2100U | Po-210 | 138.376 days | 5304 | 9.5 mm | 100 µCi |
| PO2A21000U | Po-210 | 138.376 days | 5304 | 9.5 mm | 1000 µCi |
| AM1A210U | Am-241 | 432.14 years | 5443, 5486 | 9.5 mm | 10 µCi |
| AM1A250U | Am-241 | 432.14 years | 5443, 5486 | 9.5 mm | 50 µCi |
| AM1A2100U | Am-241 | 432.14 years | 5443, 5486 | 9.5 mm | 100 µCi |

1) All sources listed are not sold as spectral grade sources.

2) 100 µg/cm² gold covers are available upon request for AFR prefixed models.

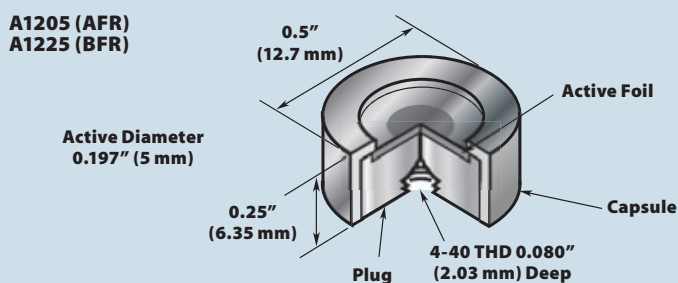
Sources for Research Applications

BFR Sources

These sources provide a safe and convenient package for prototype studies, attenuation, and general laboratory use. The standard mount is in an A-2 capsule. Contained activity is supplied as a nominal value $\pm 15\%$. A NIST traceable calibration of the contained activity is available for Ru-106/Rh-106 only.



Figure 68-A: Type A-2 Capsule



BFR Sources

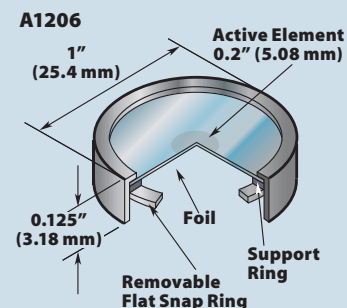
| Catalog Number | Nuclide | Half-Life | Principle Beta Emissions (E_{\max} keV) | Substrate | Window | Maximum Activity |
|------------------------|-----------------|-----------|--|-------------------------|----------------------------|-------------------------|
| BFR-106 ⁽¹⁾ | Ru-106 / Rh-106 | 1.020 y | 39 / 3540 | 0.210" x 0.040" Ceramic | 13.7 mg/cm ² Al | 10 μ Ci 370 kBq |
| BFR-090 ⁽¹⁾ | Sr-90 / Y-90 | 28.5 y | 546 / 2282 | 0.210" x 0.040" Ceramic | 40 mg/cm ² SS | 10 μ Ci 370 kBq |
| BFR-204 ⁽¹⁾ | Tl-204 | 3.78 y | 763 | 0.210" x 0.040" Ceramic | 13.7 mg/cm ² Al | 100 μ Ci 3.7 MBq |

1) Source has a ceramic active element which will reduce beta output.

Mono-Energetic (Conversion) Electron Sources—ME Series

These sources are used as energy markers for the calibration of solid-state detectors and beta spectrometers. Sources are prepared by electrodeposition or evaporation of the radionuclide as a 0.2" (5.08 mm) diameter spot on very thin Mylar, nickel, or platinum surface foil, and protected by a 100-200 µg/cm² acrylic cover. This assembly is mounted in an aluminum ring from which it can easily be removed (MF-1 mount). Contained activity is supplied as a nominal value ±15%. A NIST traceable calibration of the contained value will be provided on request. Sources are sold as "open sources". The source surface can not be wiped. Please refer to page 72 for complete wipe test information.

Figure 69-A: MF-1 Disk



| ME Series | | | | | | | | |
|----------------|---------|-----------|-------------------------------------|-----------|-----------------------|------------------------------------|------------------|---------|
| Catalog Number | Nuclide | Half-Life | Significant Electron Energies (keV) | Substrate | Method of Preparation | Window | Maximum Activity | |
| ME-133 | Ba-133 | 3862 d | 5, 45, 75, 267, 320 | Mylar | Evaporation | 100-200 µg/cm ² acrylic | 10 µCi | 370 kBq |
| ME-207 | Bi-207 | 32.2 y | 481, 975, 1047 | Platinum | Evaporation | 100-200 µg/cm ² acrylic | 10 µCi | 370 kBq |
| ME-109 | Cd-109 | 462.6 d | 63, 85 | Nickel | Evaporation | 100-200 µg/cm ² acrylic | 10 µCi | 370 kBq |
| ME-137 | Cs-137 | 30.17 y | 624, 656 | Mylar | Evaporation | 100-200 µg/cm ² acrylic | 10 µCi | 370 kBq |
| ME-057 | Co-57 | 271.79 d | 7, 14, 115, 129 | Nickel | Evaporation | 100-200 µg/cm ² acrylic | 10 µCi | 370 kBq |
| ME-113 | Sn-113 | 115.09 d | 20, 23, 364, 388 | Platinum | Evaporation | 100-200 µg/cm ² acrylic | 10 µCi | 370 kBq |

Sources for Research Applications

Positron Sources—POSK and POSN Series

Ge-68 and Na-22 positron sources are available in titanium and polyimide film configurations. Although designed primarily for use in studies of solid state vacancy phenomena, the titanium configuration may be used in any application requiring conditions of high vacuum or elevated temperature.

The titanium source is 0.750" (19.1 mm) in diameter and has an active diameter of 0.375" (9.53 mm). The activity is placed between two layers of 0.0002" (0.0051 mm) titanium foil, supported by two 0.010" (0.25 mm) titanium disks. This assembly is sealed by electron beam welding.

The polyimide source is 0.5" (12.7 mm) in diameter and has an active diameter of 0.2" (5.08 mm). Other sizes are available upon request. The activity is deposited between two layers of 7.2 mg/cm² polyimide and sealed with epoxy. This source is NOT designed for vacuum applications or for temperatures above approximately 200°C. Contained activity is supplied as a nominal value $\pm 15\%$. A NIST traceable calibration of the contained value will be quoted upon request.

Positron Series

| Nuclide | Half-Life | B+ Probability % | Positron (E_{max} keV) | Major Photons (keV) |
|---------------|-----------|------------------|---------------------------|--|
| Na-22 | 950.8 d | 89.4 | 2842 | 511 ⁽¹⁾ , 1275 (100%) |
| Ge-68 / Ga-68 | 270.8 d | 89 | 2921 (Ga-68) | 511 ⁽¹⁾ , 1077 (3.0%) (Ga-68) |

1) From positron annihilation.

POSK Series

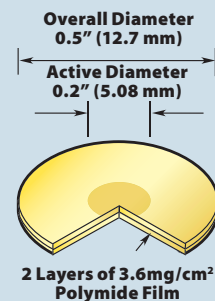
| Catalog Number | Nuclide | Support Material | Activity Range | |
|----------------|---------|------------------|--------------------------|-----------------|
| POSK-22 | Na-22 | Polyimide | 10 μ Ci-100 μ Ci | 370 kBq-3.7 MBq |
| POSK-68 | Ge-68 | Polyimide | 10 μ Ci-100 μ Ci | 370 kBq-3.7 MBq |

POSN Series

| Catalog Number | Nuclide | Support Material | Activity Range | |
|----------------|---------|------------------|-------------------------|------------------|
| POSN-22 | Na-22 | Titanium | 10 μ Ci-50 μ Ci | 370 kBq-1.85 MBq |
| POSN-68 | Ge-68 | Titanium | 10 μ Ci-50 μ Ci | 370 kBq-1.85 MBq |

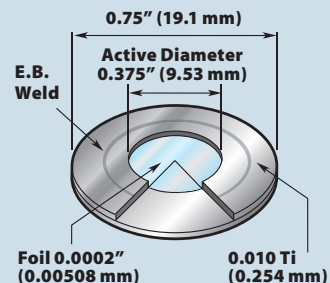
**Figure 70-A:
POSK Configuration**

A2306



**Figure 70-B:
POSN Configuration**

A2305



Leak Test Information

The following are descriptions of the leak tests performed by EZIP on the various products in this catalog. The applicable wipe test for the product ordered will be marked off on the back of the calibration certificates and/or nominal data sheets supplied with each source. More than one leak test type may be applicable per source. For example a calibrated solution supplied in a flame sealed ampoule will require both the standard wipe test and the ampoule leak test.

Standard Wipe Test

The source was wiped over its entire surface with a moistened filter paper disk. After drying, the disk was checked for activity using a windowless proportional counter, end-window G.M. tube or plastic scintillation detector. There was < 0.001 μCi beta-gamma and < 0.0001 μCi alpha of removable activity.

Special Wipe Test

The source was wiped over its entire surface with moistened polystyrene. The polystyrene was then dissolved in a liquid scintillation cocktail and counted in a liquid scintillation counter. There was < 0.001 μCi beta-gamma and < 0.0001 μCi alpha of removable activity.

Ampoule Leak Test

The ampoule was kept in an inverted position on a filter paper disk or polystyrene wipe for a minimum of 16 hours. The wipe was then checked for activity using a windowless proportional counter, end-window G.M. tube, plastic scintillation detector or liquid scintillation counter. There was < 0.001 μCi beta-gamma and < 0.0001 μCi alpha of removable activity.

Leak Test Not Applicable

The active area of the source is uncovered or is protected by a very thin coating. Although the deposit is adherent, it is neither designed nor certified to pass a standard leak test. The inactive portions of the source have been checked using the standard wipe test or special wipe test depending on the nuclide. There was < 0.001 μCi beta-gamma and < 0.0001 μCi alpha of removable activity.

Other Leak Test

In some instances, such as the production of a custom source, the use of a non-standard leak test may be necessary. In such instances the test will be fully described in this section of the Leak Test Certificate located on the back of the Calibration Certificate or Nominal Source Data Sheet.

Curie/SI Conversion Tables

| Conversion Tables for Radioactivity | |
|--|---|
| Curie Units $\mu\text{Ci} / \text{mCi} / \text{Ci}$ | Becquerel Units $\text{kBq} / \text{MBq} / \text{GBq}$ |
| 0.1 | 3.7 |
| 0.25 | 9.25 |
| 0.5 | 18.5 |
| 0.75 | 27.75 |
| 1 | 37 |
| 2 | 74 |
| 3 | 111 |
| 5 | 185 |
| 7 | 259 |
| 10 | 370 |
| 20 | 740 |
| 25 | 925 |

| Curie Units $\mu\text{Ci} / \text{mCi} / \text{Ci}$ | Becquerel Units $\text{MBq} / \text{GBq} / \text{TBq}$ |
|--|---|
| 50 | 1.85 |
| 60 | 2.22 |
| 100 | 3.7 |
| 200 | 7.4 |
| 250 | 9.25 |
| 500 | 18.5 |
| 800 | 29.6 |
| 1000 | 37 |

To convert from one unit to another, read across from one column to the other ensuring the units are in the same line of the column headings. For example:

From the first table:
 $0.1 \text{ mCi} = 3.7 \text{ MBq}$
 $0.1 \text{ Ci} = 3.7 \text{ GBq}$

From the second table:
 $50 \text{ mCi} = 1.85 \text{ GBq}$
 $3.7 \text{ MBq} = 100 \mu\text{Ci}$

| Densities of Common Window and Absorber Materials | | | | |
|---|--------|----|--------------|--|
| Metal or Material | Symbol | Z | Density g/cc | Density $\text{mg}/\text{cm}^2/\text{mil}$ |
| Aluminized Mylar | — | — | 1.42 | 3.60 |
| Kapton | — | — | 1.42 | 3.60 |
| Stainless Steel | — | — | 7.86 | 20.0 |
| Beryllium | Be | 4 | 1.85 | 4.70 |
| Aluminum | Al | 13 | 2.70 | 6.86 |
| Titanium | Ti | 22 | 4.50 | 11.43 |
| Iron | Fe | 26 | 7.86 | 20.0 |
| Nickel | Ni | 28 | 8.90 | 22.6 |
| Copper | Cu | 29 | 8.92 | 22.7 |
| Silver | Ag | 47 | 10.5 | 26.7 |
| Platinum | Pt | 78 | 21.45 | 54.5 |
| Gold | Au | 79 | 19.3 | 49.0 |
| Lead | Pb | 82 | 11.34 | 28.8 |

| dps | dpm | Bq | Ci |
|---------------|----------------|-------|-------------------|
| 1 | 60 | 1 Bq | 27 pCi |
| 1,000 | 60,000 | 1 kBq | 27 nCi |
| 1,000,000 | 60,000,000 | 1 MBq | 27 μCi |
| 1,000,000,000 | 60,000,000,000 | 1 GBq | 27 mCi |

| Ci | Bq | dpm |
|------------------|----------|-----------------------|
| 1 pCi | 0.037 Bq | 2.2 |
| 1 nCi | 37 Bq | 2.22×10^3 |
| 1 μCi | 37 kBq | 2.22×10^6 |
| 1 mCi | 37 MBq | 2.22×10^9 |
| 1 Ci | 37 GBq | 2.22×10^{12} |

| Absorbed Dose |
|-----------------------|
| 1 gray (Gy) = 100 rad |
| 1 rad = 0.01 Gy |

| Dose Equivalent |
|--------------------------|
| 1 Sievert (Sv) = 100 rem |
| 1 rem = 0.01 Sv |

ANSI/ISO Classifications

The development of these standards began in 1962 and they were published in 1968. The standards were written so that both the regulatory agencies and the users would have specifications which would characterize radioactive sources and establish performance standards.

The tables on the following page are from ANSI.N542 and ISO.2919, Classifications of sealed radioactive sources.

The concept of both ANSI.N542 and ISO.2919 is that design standards are not mandated but a series of tests are specified for which prototypes of new designs are subjected. In this manner innovation is encouraged without sacrificing safety standards. Minimum performance must be met to demonstrate suitability for certain applications.

Current copies of these standards are available from:

American National Standards Institute

1430 Broadway
New York, NY 10018
(212) 642-4900

Global Engineering

15 Inverness Way East
Englewood CO 80112
(800) 854-7179

International Organization for Standardization

1, Rue De Varendel
Case Postale 56
CH-1211 Geneva 20
Switzerland
41-22-734-0150

| Test | Class | | | | | | |
|--------------------------|---------|--|--|---|--|--|-----------------|
| | 1 | 2 | 3 | 4 | 5 | 6 | X |
| Temperature | No Test | -40°C (20 min) +80°C (1 h) | -40°C (20 min) +80°C (1 h) | -40°C (20 min) +400°C (1 h) and thermal shock +400°C to 20°C | -40°C (20 min) +600°C (1 h) and thermal shock +600°C to 20°C | -40°C (20 min) +800°C (1 h) and thermal shock +800°C to 20°C | Special Test |
| External Pressure | No Test | 25 kN/m ² abs. (3.6 lbf/in ²) to atmosphere | 25 kN/m ² abs. (3.6 lbf/ in ²) to atmosphere | 25 kN/m ² abs. (3.6 lbf/in ²) to 7 MN/m ² (1,015 lbf/in ²) abs. | 25 kN/m ² abs. (3.6 lbf/in ²) to 7 MN/m ² (10,153 lbf/in ²) abs. | 25 kN/m ² abs. (3.6 lbf/in ²) to 7 MN/m ² (24,656 lbf/in ²) abs. | Special Test |
| Impact | No Test | 50 g (1.8 oz) from 1 m (3.28 ft) and free drop ten times to a steel surface from 1.5 m (4.92 ft) | 200 g (7 oz) from 1 m | 2 kg (4.4 lb) from 1 m | 5 kg (11 lb) from 1 m | 20 kg (44 lb) from 1 m | Special Test |
| Vibration | No Test | 30 min 25 to 500 Hz at 5 g peak amp | 30 min 25 to 50 Hz at 5 g peak amp and 50 to 90 Hz at 0.635 mm amp peak to peak and 90 to 500 Hz at 10 g | 90 min 25 to 80 Hz at 1.5 mm peak amp peak to peak and 80 to 2000 Hz at 20 g | Not Used | Not Used | Special Test |
| Puncture | No Test | 1 g (15.4 gr) from 1 m | 10 g (154 gr) from 1 m | 50 g (1.76 oz) from 1 m | 300 g (10.6 oz) from 1 m | 1 kg (2.2 lb) from 1 m | Special Test |

The tests are performed on two sources. Different specimens of the same source design are allowed for each test in the above table. To pass a test the sealed source must retain its activity after each test and pass the prescribed leak tests. Source performance is generally described as C12345, a letter and five digits. The letter will be either C or E. C indicates the activity does not exceed limits established by nuclide dependent upon its toxicity and the solubility of its physical form. E indicates the activity exceeds those limits. The five digits indicate, respectively, the highest test passed for temperature, pressure, impact, vibration, and puncture.

| Sealed Source Usage | | Sealed Source Test and Class | | | | |
|---|---------------------------------------|------------------------------|----------|--------|-----------|----------|
| | | Temperature | Pressure | Impact | Vibration | Puncture |
| Radiography—Industrial | Unprotected Source | 4 | 3 | 5 | 1 | 5 |
| | Source in Device | 3 | 3 | 3 | 1 | 3 |
| Medical | Radiography | 3 | 2 | 3 | 1 | 2 |
| | Gamma Teletherapy | 5 | 3 | 5 | 2 | 4 |
| Gamma Gauges | Unprotected Source | 4 | 3 | 3 | 3 | 3 |
| | Source in Device | 4 | 3 | 2 | 3 | 2 |
| Beta Gauges and Sources for Low Energy Gamma Gauges or X-ray Fluorescence Analysis (excluding gas filled sources) | | 3 | 3 | 2 | 2 | 2 |
| Oil Well Logging | | 5 | 6 | 5 | 2 | 2 |
| Portable Moisture and Density Gauge (including hand held or dolly transported) | | 4 | 3 | 3 | 3 | 3 |
| General Neutron Source Application (excluding reactor start-up) | | 4 | 3 | 3 | 2 | 3 |
| Calibration Sources—Activity Greater Than 30μCi | | 2 | 2 | 2 | 1 | 2 |
| Gamma Irradiators ⁽¹⁾ | Categories II, III, IV ⁽³⁾ | 4 | 3 | 4 | 2 | 4 |
| | Category I | 4 | 3 | 3 | 2 | 3 |
| Ion Generators ⁽²⁾ | Chromatography | 3 | 2 | 2 | 1 | 1 |
| | Static Eliminators | 2 | 2 | 2 | 2 | 2 |
| | Smoke Detectors | 3 | 2 | 2 | 2 | 2 |

1) For the purposes of this standard, gamma irradiators have been divided into four distinct categories.

2) Source-device combination may be tested.

3) Category I = Self-Contained-Dry Source Storage, Category II = Panoramic-Dry Source Storage, Category III = Self-Contained-Wet Source Storage, and Category IV = Panoramic-Wet Source Storage.

Alpha Decay Nuclide Data

| Alpha Decay Nuclide Data | | | | | | |
|--------------------------|------------|----------------------|----------------------|-----------|------------------------------|-----------------|
| Nuclide | Decay Mode | Alpha Energies (keV) | Branching Ratios (%) | Reference | Half-Life | Half-Life, Days |
| Am-241 | a | 5443, 5486 | 12.8, 85.2 | IAEA | 432.17 ± 0.66 years | 157850 |
| Am-243 | a | 5234, 5277 | 11, 88 | IAEA | (2.690 ± 0.008) E + 06 days | 2690000 |
| Cf-242 | a | 6076, 6118 | 15.2, 81.6 | TRI | 2.645 ± 0.008 years | 966.1 |
| Cf-249 | a | 5812 | 84.4 | TRI | 350.6 ± 2.1 years | 128057 |
| Cf-250 | a | 5989, 6031 | 15.1, 84.5 | TRI | 13.08 ± 0.09 years | 4777.5 |
| Cf-251 | a | 5677, 5851 | 35, 27 | TRI | 898 ± 44 years | 327995 |
| Cm-242 | a | 6070, 6113 | 25.0, 74.0 | NCRP | 162.8 ± 0.4 days | 162.8 |
| Cm-243 | a | 5742, 5786 | 10.57, 73.3 | TRI | 28.5 ± 0.2 years | 10409.6 |
| Cm-244 | a | 5763, 5805 | 23.6, 76.4 | TRI | 18.11 ± 0.02 years | 6614.7 |
| Gd-148 | a | 3183 | 100 | TRI | 75 ± 3 years | 27393 |
| Np-237 | a | 4772, 4788 | 25, 47 | TRI | (2.140 ± 0.010) E + 06 years | 7.816 E+08 |
| Po-208 | a | 5116 | 100 | TRI | 2.898 ± 0.002 years | 1058 |
| Po-209 | a | 4880 | 99.17 | TRI | 102 ± 5 years | 37256 |
| Po-210 | a | 5304 | 100 | NCRP | 138.376 ± 0.002 days | 138.376 |
| Pu-236 | a | 5721, 5768 | 31.7, 68.1 | TRI | 2.851 ± 0.008 years | 1041.3 |
| Pu-238 | a | 5456, 5499 | 28.3, 71.6 | NCRP | 87.74 ± 0.04 years | 32047 |
| Pu-239 | a | 5143, 5156 | 15.1, 73.2 | TRI | (2.411 ± 0.003) E + 04 years | 8.806 E+06 |
| Pu-240 | a | 5134, 5168 | 26.39, 73.5 | NCRP | 6564 ± 11 years | 2397501 |
| Pu-242 | a | 4856, 4901 | 22.4, 78 | NCRP | (3.763 ± 0.020) E + 05 years | 1.373 E+08 |
| Ra-226 | a | 4601, 4784 | 5.55, 94.45 | NCRP | 1600 ± 7 years | 584400 |
| Th-228 | a | 5341, 5423 | 26.7, 72.7 | IAEA | 698.2 ± 0.6 days | 698.2 |
| Th-229 | a | 4845, 4901 | 56.2, 10.20 | Tec261 | 7340 ± 160 years | 2.68 E+06 |
| Th-230 | a | 4621, 4688 | 23.4, 76.3 | TRI | (7.54 ± 0.03) E + 04 years | 2.75 E+07 |
| Th-232 | a | 3952, 4010 | 23, 77 | NCRP | (1.405 ± 0.006) E + 10 years | 5.132 E+12 |
| U-232 | a | 5264, 5320 | 31.2, 68.6 | TRI | 68.9 ± 1.0 years | 25166 |
| U-233 | a | 4783, 4825 | 13.2, 84.4 | TRI | (1.592 ± 0.020) E + 05 years | 5.815 E+07 |
| U-234 | a | 4724, 4776 | 27.5, 72.5 | TRI | (2.454 ± 0.006) E + 05 years | 8.963 E+07 |
| U-235 | a | 4364, 4395 | 11, 55 | TRI | (7.037 ± 0.011) E + 08 years | 2.570 E+11 |
| U-236 | a | 4445, 4494 | 26, 74 | TRI | (2.342 ± 0.003) E + 07 years | 8.554 E+09 |
| U-238 | a | 4147, 4196 | 23, 77 | TRI | (4.468 ± 0.005) E + 09 years | 1.632 E+12 |

All alpha energies and branching ratios are taken from [The Table of Radioactive Isotopes](#), Shirley, Virginia S., Editor, John Wiley & Sons, NY, 1986. Half-lives are taken from quoted reference.

Beta Decay Nuclide Data

| Beta Decay Nuclide Data | | | | | | |
|-------------------------|----------------|-----------------------------|----------------------|------------|----------------------------|-----------------|
| Nuclide | Decay Mode | Beta Maximum Energies (keV) | Branching Ratios (%) | Reference | Half-Life | Half-Life, Days |
| Bi-210 | b ⁻ | 1162 | 100 | NCRP | 5.013 ± 0.005 days | 5.013 |
| C-14 | b ⁻ | 156.5 | 100 | NCRP | 5730 ± 40 years | 2.093 E+06 |
| Ca-41 | EC | — | — | TRI | (1.03 ± 0.04) E + 05 years | 3.762 E+07 |
| Ca-45 | b ⁻ | 256.7 | 100 | NCRP | 163 ± 1 days | 163 |
| Cd-109 | EC | — | — | IAEA | 462.6 ± 0.7 days | 462.6 |
| Cl-36 | b ⁻ | 709.3 | 98.1 | NCRP | (3.01 ± 0.02) E + 05 years | 1.099 E+08 |
| Co-57 | EC | — | — | IAEA | 271.79 ± 0.09 days | 271.79 |
| Co-60 | b ⁻ | 317.9* | 100 | IAEA | 5.272 ± 0.001 years | 1925.5 |
| Cs-137 | b ⁻ | 511.5, 1173.2* | 94.43, 5.53 | IAEA | 30.17 ± 0.16 years | 11020 |
| Ge-68/Ga-68 | b ⁺ | — | — | NCRP | 270.8 ± 0.3 days | 270.8 |
| H-3 | b ⁻ | 18.6 | 100 | NCRP | 12.35 ± 0.01 years | 4511 |
| I-125 | EC | — | — | IAEA | 59.43 ± 0.06 days | 59.43 |
| I-129 | b ⁻ | 153 | 100 | NCRP | (1.57 ± 0.04) E + 07 years | 5.734 E+09 |
| Na-22 | b ⁺ | 545.5* | 89.84 | IAEA | 950.8 ± 0.9 days | 950.8 |
| Ni-63 | b ⁻ | 65.88 | 100 | NCRP | 96 ± 4 years | 35064 |
| Np-238 | b ⁻ | 1248 | 100 | TRI | 2.117 ± 0.002 days | 2.117 |
| P-32 | b ⁻ | 1710 | 100 | NCRP | 14.29 ± 0.02 days | 14.29 |
| Pb-210 | b ⁻ | 16.5, 63.0 | 82, 18 | NCRP | 22.3 ± 0.2 years | 8145.1 |
| Pm-147 | b ⁻ | 224.7 | 99.99 | NCRP | 2.6234 ± 0.0002 years | 958.2 |
| Pu-241 | b ⁻ | 20.82 | 100 | NCRP | 14.4 ± 0.2 years | 5259.6 |
| Ra-228 | b ⁻ | — | — | TRI | 5.75 ± 0.03 years | 2100 |
| S-35 | b ⁻ | 166.7 | 100 | NCRP | 87.44 ± 0.07 days | 87.44 |
| Si-32 | b ⁻ | 226.8 | 100 | NCRP | 104 ± 13 years | 37986 |
| Sm-145 | EC | — | — | TRI | 340 ± 3 days | 340 |
| Sm-151 | b ⁻ | 421 | 100 | TRI | 90 ± 6 years | 32872 |
| Sn-119m | IT | — | — | NCRP | 293.0 ± 1.3 days | 293 |
| Sr-89 | b ⁻ | 1492* | 100 | ARI vol 49 | 50.5 ± 0.1 days | 50.5 |
| Sr-90 | b ⁻ | 546.2 | 100 | NCRP | 28.5 ± 0.2 years | 10410 |
| Tc-99 | b ⁻ | 294 | 100 | TRI | (2.13 ± 0.05) E + 05 years | 7.780 E+07 |
| Te-125m | IT | — | — | NCRP | 57.40 ± 0.05 days | 57.4 |
| Tl-204 | b ⁻ | 763 | 97.45 | TRI | 3.78 ± 0.02 years | 1380.6 |
| U-237 | b ⁻ | 252 | 100 | TRI | 6.75 ± 1 days | 6.75 |
| Y-90 | b ⁻ | 2283 | 99.98 | NCRP | 64.0 ± 0.1 hours | 2.667 |

* From NCRP Report No. 58.

Gamma Ray Nuclide Data

| Gamma Ray Decay Nuclide Data | | | | | | |
|------------------------------|----------------|-----------------------|---------------------------------|-----------|----------------------------|-----------------|
| Nuclide | Decay Mode | Gamma Energies (keV) | Branching Ratios | Reference | Half-Life | Half-Life, Days |
| Al-26 | b ⁺ | 1809 | 0.9976 gammas per decay | NCRP | (7.2 ± 0.3) E + 05 years | 262980000 |
| Ag-108m | EC | 614.3, 722.9 | 0.898, 0.908 gammas per decay | NCRP | 127 ± 21 years | 46386.75 |
| Ag-110m | b ⁻ | 657.8, 884.7 | 0.9438, 0.726 gammas per decay | NCRP | 249.8 ± 0.1 days | 249.8 |
| Am-241 | a | 59.5 | 0.360 gammas per decay | IAEA | 432.17 ± 0.66 years | 157850 |
| Am-243 | a | 74.7 | 0.674 gammas per decay | I | — | — |
| Au-195 | EC | 98.9 | 0.109 gammas per decay | NCRP | 183 ± 2 days | 183 |
| Au-198 | b ⁻ | 411.8 | 0.9557 gammas per decay | IAEA | 2.6943 ± 0.0008 days | 2.6943 |
| Ba-133 | EC | 302.9, 356.0 | 0.1830, 0.6194 gammas per decay | IAEA | 3862 ± 15 days | 3862 |
| Be-7 | EC | 477.6 | 0.1032 gammas per decay | NCRP | 53.284 ± 0.004 days | 53.284 |
| Bi-207 | EC | 569.7, 1064 | 0.9774, 0.745 gammas per decay | IAEA | (1.16 ± 0.07) E + 04 days | 11600 |
| I-131 | b ⁻ | 364.5, 637.0 | 0.812, 0.0727 gammas per decay | NCRP | 8.021 ± 0.001 days | 8.021 |
| Cd-109 | EC | 88.0 | 0.0363 gammas per decay | IAEA | 462.6 ± 0.7 days | 462.6 |
| Ce-139 | EC | 165.9 | 0.7987 gammas per decay | IAEA | 137.640 ± 0.023 days | 137.64 |
| Ce-141 | b ⁻ | 145.4 | 0.4844 gammas per decay | NCRP | 32.50 ± 0.01 days | 32.5 |
| Ce-144 | b ⁻ | 133.5 | 0.1109 gammas per decay | NCRP | 285.0 ± 0.1 days | 285 |
| Co-56 | EC | 846.8, 1238 | 0.9993, 0.6607 gammas per decay | IAEA | 77.31 ± 0.19 days | 77.31 |
| Co-57 | EC | 122.1, 136.5 | 0.8560, 0.1068 gammas per decay | IAEA | 271.79 ± 0.09 days | 271.79 |
| Co-58 | b ⁺ | 810.8 | 0.9945 gammas per decay | IAEA | 70.86 ± 0.07 days | 70.86 |
| Co-60 | b ⁻ | 1173, 1333 | 0.9986, 0.9998 gammas per decay | IAEA | 5.272 ± 0.001 years | 1925.5 |
| Cr-51 | EC | 320.1 | 0.0986 gammas per decay | IAEA | 27.706 ± 0.007 days | 27.706 |
| Cs-134 | b ⁻ | 604.7 | 0.9763 gammas per decay | IAEA | 754.28 ± 0.22 days | 754.28 |
| Cs-137 | b ⁻ | 661.7 | 0.851 gammas per decay | IAEA | 30.17 ± 0.16 years | 11020 |
| Eu-152 | e | 344.3 | 0.2657 gammas per decay | IAEA | 4933 ± 11 days | 4933 |
| Eu-154 | b ⁻ | 723.3, 1274 | 0.202, 0.350 gammas per decay | IAEA | 3136.8 ± 2.9 days | 3136.8 |
| Eu-155 | b ⁻ | 86.5, 105.3 | 0.311, 0.214 gammas per decay | IAEA | 1770 ± 50 days | 1770 |
| Fe-55 | EC | 5.9 - 6.5 (Mn x-rays) | 0.283 photons per decay | IAEA | 999 ± 8 days | 999 |
| Fe-59 | b ⁻ | 1099, 1292 | 0.563, 0.437 gammas per decay | NCRP | 44.51 ± 0.02 days | 44.51 |
| Gd-153 | EC | 97.4, 103.2 | 0.295, 0.211 gammas per decay | NCRP | 242 ± 1 days | 242 |
| Ge-68/Ga-68 | EC | 1077 | 0.0324 gammas per decay | NCRP | 270.8 ± 0.3 days | 270.8 |
| Hf-172 | EC | 125.9 | 0.113 gammas per decay | TRI | 1.87 ± 0.03 years | 683.0175 |
| Hg-203 | b ⁻ | 279.2 | 0.8148 gammas per decay | IAEA | 46.595 ± 0.013 days | 46.595 |
| Ho-166m | b ⁻ | 184.4, 810.3 | 0.721, 0.577 gammas per decay | NCRP | 1200 ± 180 years | 438300 |
| I-125 | EC | 35.5 only | 0.0658 gammas per decay | IAEA | 59.43 ± 0.06 days | 59.43 |
| I-129 | b ⁻ | 39.6 only | 0.075 gammas per decay | NCRP | (1.57 ± 0.04) E + 07 years | 5734425000 |
| Ir-192 | b ⁻ | 316.5 | 0.8286 gammas per decay | NCRP | 73.83 ± 0.01 days | 73.83 |

| Gamma Ray Decay Nuclide Data | | | | | | |
|------------------------------|---------------------|----------------------------|---------------------------------|------------|---------------------------|-----------------|
| Nuclide | Decay Mode | Gamma Energies (keV) | Branching Ratios | Reference | Half-Life | Half-Life, Days |
| K-40 | b ⁻ , EC | 1461 | 0.1067 gammas per decay | TRI | (1.277 ± 0.008)E+09 years | 4.66424E+11 |
| Kr-85 | b ⁻ | 514.0 | 0.00434 gammas per decay | NCRP | 10.72 ± 0.01 years | 3915.48 |
| Mn-54 | EC | 834.8 | 0.9998 gammas per decay | IAEA | 312.3 ± 0.4 days | 312.3 |
| Na-22 | b ⁺ | 1275 | 0.9994 gammas per decay | IAEA | 950.8 ± 0.9 days | 950.8 |
| Nb-95 | b ⁻ | 765.8 | 0.9981 gammas per decay | IAEA | 34.975 ± 0.007 days | 34.975 |
| Np-237 | a | 312.0 (from Pa-233) | 0.386 gammas per decay | TRI | (2.14 ± 0.01)E+06 yrs | 781635000 |
| Np-238 | b ⁻ | 984.5, 1029 | 0.278, 0.203 gammas per decay | TRI | 2.117 ± 0.002 days | 2.117 |
| Np-239 | b ⁻ | 106.1, 277.6 | 0.267, 0.143 gammas per decay | IAEA | 2.350 ± 0.004 days | 2.35 |
| Pa-233 | b ⁻ | 312.0 | 0.386 gammas per decay | TRI | 27.0 ± 0.1 days | 27 |
| Pb-210 | b ⁻ | 46.5 | 0.0418 gammas per decay | NCRP | 22.3 ± 0.2 years | 8145.075 |
| Ra-226 | a | 186.0 | 0.0351 gammas per decay | NCRP | 1600 ± 7 years | 584400 |
| Ra-228 | b ⁻ | 338.4, 911.1 (from Ac-228) | 0.113, 0.266 gammas per decay | TRI | 5.75 ± 0.03 years | 2100 |
| Rh-101 | EC | 127.2, 198.0 | 0.73, 0.708 gammas per decay | TRI | 3.3 ± 0.3 years | 1205.325 |
| Ru-103 | b ⁻ | 497.1, 610.3 | 0.91, 0.0576 gammas per decay | NCRP | 39.26 ± 0.02 days | 39.26 |
| Ru-106/Rh-106 | b ⁻ | 511.9, 621.9 | 0.207, 0.098 gamma per decay | TRI | 1.020 ± 0.003 years | 372.555 |
| Sb-124 | b ⁻ | 602.7 | 0.9792 gammas per decay | NCRP | 60.20 ± 0.03 days | 60.2 |
| Sb-125 | b ⁻ | 427.9 | 0.297 gammas per decay | IAEA | 1007.7 ± 0.6 days | 1007.7 |
| Sc-46 | b ⁻ | 889.3, 11201 | 0.9998, 0.9999 gammas per decay | IAEA | 83.79 ± 0.04 days | 83.79 |
| Se-75 | EC | 136.0, 279.5 | 0.588, 0.250 gammas per decay | IAEA | 119.64 ± 0.24 days | 119.64 |
| Sn-113 | EC | 391.7 | 0.649 gammas per decay | IAEA | 115.09 ± 0.04 days | 115.09 |
| Sr-85 | EC | 514.0 | 0.984 gammas per decay | IAEA | 64.849 ± 0.004 days | 64.849 |
| Sr-89 | b ⁻ | 909.1 | 0.009555 gammas per decay | ARI vol 49 | 50.5 ± 0.1 days | 50.5 |
| Ta-182 | b ⁻ | 1121, 1221 | 0.350, 0.272 gammas per decay | NCRP | 114.43 ± 0.04 days | 114.43 |
| Tc-95m | EC | 582.1 | 0.314 gammas per decay | TRI | 61 ± 2 days | 61 |
| Te-123m | b ⁻ | 159.0 | 0.840 gammas per decay | TRI | 119.7 ± 0.1 days | 119.7 |
| Th-228 | a | 583.2 (from Th-208) | 0.306 gammas per decay | IAEA | 698.2 ± 0.6 days | 698.2 |
| Th-229 | a | 193.5 | 0.0441 gammas per decay | Tec261 | 7340 ± 160 years | 2.68E+06 |
| Th-232 | a | 59.0 | 0.0019 gammas per decay | NCRP | (1.405 ± 0.006)E+10 yrs | 5.13176E+12 |
| Ti-44 | EC | 78.4 | 0.947 gammas per decay | NCRP | 47.3 ± 1.2 years | 17276.325 |
| Tm-170 | b ⁻ | 84.3 | 0.0326 gammas per decay | NCRP | 128.6 ± 0.3 days | 128.6 |
| Xe-127 | EC | 202.9 | 0.683 gammas per decay | NCRP | 36.4 ± 0.1 days | 36.4 |
| Xe-133 | b ⁻ | 81 | 0.371 gammas per decay | NCRP | 5.243 ± 0.001 days | 5.243 |
| Y-88 | EC | 898.0, 1836 | 0.940, 0.9936 gammas per decay | IAEA | 106.630 ± 0.025 days | 106.63 |
| Yb-169 | EC | 63.1, 198.0 | 0.437, 0.3494 gammas per decay | NCRP | 32.03 ± 0.01 days | 32.03 |
| Zn-65 | EC | 1116 | 0.5060 gammas per decay | IAEA | 244.26 ± 0.26 days | 244.26 |
| Zr-95 | b ⁻ | 724.2, 756.7 | 0.441, 0.545 gammas per decay | TRI | 64.02 ± 0.04 days | 64.02 |

Packing and Shipping Containers

Packaging and shipment of radioactive materials at EZIP adhere to the regulations of the U.S. Department of Transportation (49 CFR), The International Civil Aviation Organization Technical Instructions on the Safe Transport of Dangerous Goods by Air (ICAO TI), and trade association guidelines such as the International Air Transport Association (IATA).

EZIP uses two types of packaging to ship radioactive materials: excepted packaging and type A packaging.

Type A packaging is used to carry normal form radioactive material as defined by the A2 values of 49 CFR 173.435 (1998) and IATA 10.4.2.3 (2001) and encapsulated radioactive material that has been issued an IAEA certificate of Competent Authority Special Form Radioactive Material Encapsulation Certificate by the U.S. Department of Transportation.

In the Standard Type A configuration, sources are sealed in an inner container and centered in a fiberboard box. Sources requiring heavy shielding are shipped in a lead shield centered in a fiberboard box.

Excepted Packaging (Limited Quantity) is used when the activity limits do not exceed those defined in 49 CFR 173.425 (1998) and IATA regulations table 10.5.A (2001) and the radiation level at any point on the package does not exceed 0.5 millirem per hour. All boxes shipped from EZIP as "excepted packages" meet the requirements of 49 CFR 173.421(1998) and IATA regulation 10.5.9.4(2001).

Radiation levels on the external surfaces of all packages and at a distance of one meter from all external surfaces (Transport Index), will not exceed the limits set in 49 CFR 173.441(1998) or IATA 10.5.16 (2001). All measurements are made with an Eberline RO2 or equivalent ion chamber survey instrument.

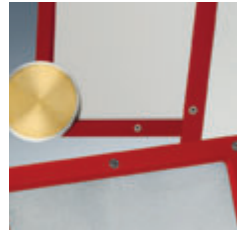
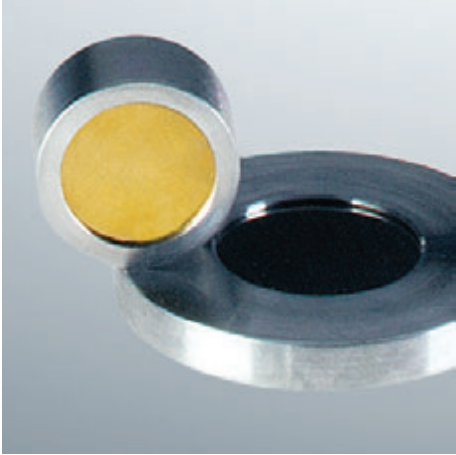
Unless special arrangements are made with the customer in advance, radiation levels at the surface of any shielded inner containers will not exceed 200 millirem per hour as measured with an Eberline RO2 or equivalent ion chamber survey instrument.

Terms and Conditions

- 1. DEFINITIONS.** A. The word “goods” as used herein means products offered or acknowledged in this catalog, ordered by Buyer and furnished by Seller. B. The word “services” means testing and other services offered or acknowledged in this catalog, ordered by Buyer and provided by Seller.
- 2. GENERAL.** The terms and conditions set forth herein shall exclusively govern the sale of goods by Seller to Buyer and the furnishing of services by Seller to Buyer. Acceptance of this offer or of the goods or services furnished under quotations or acknowledgements is expressly limited to the terms and conditions contained herein. Any terms and conditions stated by Buyer in any purchase order or other document accepting or ordering such goods or services containing statements, clauses, terms or conditions modifying, adding to, repugnant to, or inconsistent with the terms and conditions of Seller herein contained, may only be deemed accepted by Seller if so stated in writing by a duly authorized signatory of Seller. Buyer further expressly agrees that such terms accepted by Seller are accepted only upon the condition and with the express understanding that, notwithstanding any statements, clauses, terms or conditions contained on any forms of Buyer, the liabilities of Seller shall be determined solely by the terms and conditions stated herein. Acceptance by Buyer of any goods offered for sale or services performed by Seller is expressly limited to the terms and conditions contained herein, and acceptance of said terms shall be deemed to be acceptance of the Buyer’s performance inconsistent with any term or condition herein shall constitute a waiver as to said term or condition only.
- 3. PRICES.** All prices quoted are in U.S. dollars, F.O.B. Burbank, California and/or Valencia, California. Quoted prices do not include charges for shipping, handling, insurance and hazardous materials documentation. State, use, consumption, compensating and excise taxes and retailers occupations taxes payable or collectable by Seller in connection with its sales shall be in addition to invoice prices and are not listed on the invoice unless specifically noted. Buyer will reimburse Seller for same at the time of payment of the invoice, whether or not such taxes are separately stated on the invoice. If Buyer claims exemption from any of these taxes, Buyer shall promptly furnish satisfactory proof of such exemption and shall indemnify Seller for any loss or damage, including attorneys’ fees, Seller may incur in the event any taxing authority finds that Seller should have collected tax.
- 4. DELIVERY.** All delivery dates are estimated as accurately as possible; however, Seller shall not be liable for any loss, damage or delay caused or occasioned by acts of God, fire, strikes, insurrection, riot, accident, embargo, delay of carrier, act of civil or military authority, failure of a supplier to make timely delivery, the requirements of any statute, order or directive of any governmental authority, or, without limiting the generality of the foregoing, by any other cause which is unavoidable or beyond Seller’s reasonable control. If delays from any such cause occur, the delivery time is correspondingly extended.
- 5. TITLE AND RISK OF LOSS.** Title to and risk of loss of goods shall pass to the Buyer upon delivery to carrier even if transportation costs are prepaid by the Seller.
- 6. PAYMENT TERMS.** Payment shall be due 30 days from date of invoice. If Buyer requests Seller to hold goods for delivery later than scheduled, the invoice shall bear the scheduled delivery date and payment shall be due 30 days from the scheduled delivery date. Buyer bears all risk of loss or damage while such goods are in Seller’s possession and shall pay all reasonable charges for goods held for more than two months and shall reimburse Seller for all use or personal property taxes levied on held goods at any time while in Seller’s possession. Seller shall have the right to modify, change or withdraw credit at any time and without notice. If in the Seller’s judgment the financial responsibility of Buyer becomes impaired or unsatisfactory or if Buyer defaults under any contract with Seller, Seller may demand and Buyer shall give advance cash payment or satisfactory security and Seller may withhold shipments until such payment or security is received. Buyer expressly waives any right of set-off and shall make no deductions from payments due hereunder or for any damages of any type claimed by Buyer against Seller.
- 7. LIMITED WARRANTY.** Seller warrants that at the time of shipment the products sold by it are free from defects in material and workmanship and conform to specifications, which accompany the product. Seller makes no other warranty, expressed or implied, with respect to the products, including any warranty of merchantability or fitness for any particular purpose. Complaints of breach of warranty on radioactive products must be received in writing by Seller within two half-lives of the radioactive material or 30 days, whichever first occurs. The maximum liability for any breach of warranty shall be replacement of the product or refund of the invoice price of the product. Seller shall in no case be liable for special, incidental or consequential damages of any kind.
- 8. LIMITATION OF LIABILITY AND INDEMNIFICATION.** SELLER ASSUMES NO LIABILITY FOR SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES OF ANY KIND. Buyer by acceptance of the goods or services assumes all liability for, and shall indemnify and hold Seller harmless against, the consequence of use or misuse by Buyer, its employees or others. Further, Buyer agrees to defend any and all suits, claims and demands brought against Seller and agrees to and will indemnify Seller and save it harmless from and against any and all suits, claims and demands whatsoever for injuries to or death of any person, or damage to or loss of property alleged out of, in connection with or to be incidental to Seller’s furnishing of goods or services contemplated herein, whether or not such injury, death, loss or damage shall be caused or contributed to by the joint or concurring negligence of Seller. Buyer further agrees to and will pay, liquidate, discharge and satisfy any and all judgements, awards or expenses which may be rendered against or incurred by Seller on account of injuries to or death of any person or loss or damage to any property whatsoever, caused by, arising out of, in connection with or incidental to Seller’s furnishing of the goods or services contemplated herein, including but not limited to all costs of suit, attorneys’ fees and expenses in connection therewith, whether or not such judgement, award or expense is rendered against or incurred by Seller, in whole or in part, because of the joint or concurring negligence of the Seller. As used in this paragraph, the word “Seller” shall include Seller, its officers, directors, employees and agents. Buyer’s care, custody and control at any time of the goods contemplated herein shall give rise to a conclusive presumption between the parties that any negligence was joint or concurring. This paragraph, in its entirety, also applies to suits, claims and demands based on the rules of strict liability and product liability.
- 9. CHANGES AND GOODS MADE TO BUYER’S SPECIFICATIONS.** Seller reserves the right where possible to make any change in material or in its design which is an improvement but bears no obligation to do so. If goods are made to specifications of Buyer, it is upon the express condition that Buyer shall assume all responsibility and shall indemnify and hold the Seller harmless if the goods infringe or contribute to the infringement of, or are alleged to infringe or contribute to the infringement of any letters, patent, copyright or trademark where such infringement arose out of the designs, drawings or specifications supplied by Buyer alone or in combination with elements supplied by Seller.
- 10. SELLER INSPECTION AND TESTING.** The goods are inspected and, where practicable, submitted to Seller’s standard tests at Seller’s plant before delivery. Buyer agrees to pay Seller reasonable additional charges for any additional tests which Buyer requires Seller to perform.
- 11. BUYER INSPECTION AND ACCEPTANCE.** Within 30 days after tender of delivery to or receipt by Buyer of any shipment, Buyer shall inform Seller in writing if the goods are found defective or short in any respect. Failure to so inform Seller or any use by Buyer of the goods shall constitute conclusive evidence that Seller satisfactorily performed and Buyer waives any right to reject such goods thereafter.
- 12. COMPLIANCE WITH LAWS.** Buyer agrees that in the performance hereof it will comply with all applicable laws, statutes, rules, regulations or orders of the National government or political subdivision thereof and same shall be deemed incorporated by reference herein. A. In the United States: Federal and State regulations require a copy of a Buyer’s NRC license, Agreement State License, or Licensing State License together with all amendments, to be on file with Seller before any shipment of radioactive materials can be made. Buyer and Seller each warrant that it is an equal opportunity employer and that if this order is placed as a contract or subcontract under United States Government prime contract, those clauses required by federal law to be included are herein incorporated by reference. B. In Canada: A copy of the Buyer’s AECB license, together with all amendments must be on file with Seller prior to any shipment of radioactive materials.
- 13. LIMITATION PERIOD.** Causes of action for breach of contract relative to any order for goods or services shall not be asserted after one year from the date that said cause of action occurs, provided that this limitation shall not apply to actions by Seller to recover purchase price of the goods.
- 14. CANCELLATION.** The contract arising out of Buyer’s order cannot be canceled, transferred to others, or changed after receipt by Seller, except as may mutually be agreed in writing between the parties.
- 15. APPLICABLE LAW.** Seller reserves any and all rights and remedies provided by law. The contract arising out of Buyer’s order shall be interpreted and construed in accordance with the laws of the State of California.
- 16. WAIVERS.** No waiver by Seller of any breach of any provision hereof shall constitute a waiver of any other breach of such provision. Seller’s failure to object to provisions contained in any communications from Buyer shall not be deemed an acceptance of such provisions or as a waiver of the provisions hereof.
- 17. NO OTHER REPRESENTATIONS.** There are no understandings, agreements, representations or warranties, either written or oral, relative to the goods or services that are not fully expressed in this document. No statement, recommendation or assistance made or offered through its representatives or by any sales literature in connection with the use of any goods, shall be or constitute a waiver by Seller or any of the provisions hereof. The provisions of this document supersede and cancel any previous understanding or agreement between the parties with respect to the subject matter hereof and this document expresses the final and complete understanding of the parties.
- 18. ARBITRATION.** All disputes arising out of this contract shall be determined by binding arbitration in accordance with the rules of the American Arbitration Association. In such arbitration, the prevailing party shall be awarded attorneys’ fees and costs (including costs of experts) and the provisions of California Code of Civil Procedure Section 1283.05 shall apply.

Notes

A series of 20 horizontal gray bars, stacked vertically, intended for writing notes. The bars are evenly spaced and cover most of the page's width.





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