Eckert & Ziegler Analytics

Product Information

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Analytics

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Introduction

The sole focus at Eckert & Ziegler Analytics is the preparation of quality radioactive calibration standards and calibration-related products. Our in-depth understanding of the intricacies of custom-standard preparation and the preparation of inter-laboratory cross-check samples makes us the premier supplier of custom-made radionuclide calibration standards and inter-laboratory cross-check products. Eckert & Ziegler Analytics' experienced, professional staff ensures that you are able to purchase the appropriate standards for your calibration needs. Our continuing technical support after the sale guarantees that you meet those calibration needs.

Traceability

Eckert & Ziegler Analytics is committed to ensuring the traceability of its radionuclide calibration standards. For more than twenty-five years Eckert & Ziegler Analytics 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. Eckert & Ziegler Analytics' 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 Analytics is an active participant with the American National Standards Institute (ANSI) subcommittee on radioactivity measurements. Eckert & Ziegler Analytics' 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.

Quality

Eckert & Ziegler Analytics has one of the best quality-assurance programs in the custom-standard preparation industry. From 1980 to the present Eckert & Ziegler Analytics has delivered quality standards whose calibrations are accurate and completely supported by quality-assurance documentation. Each of our standards must pass a rigorous quality-control testing process.

For the quality-control testing of custom-geometry gamma-ray standards, Eckert & Ziegler Analytics maintains a current database including efficiencies from more than 40,000 individual standards in over 600 geometries. This data collection also allows Eckert & Ziegler Analytics 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 Eckert & Ziegler Analytics standards. 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.

Gamma-Ray Standards

Analytics' Mixed-Gamma-Ray Standards provide efficiency calibrations for germanium gamma-ray-spectrometer systems over a wide energy range. These radionuclide mixtures provide the most accurate calibrations available for modern, high-efficiency germanium detectors.

All custom-made, gamma-ray calibration standards must pass Analytics' quality-control requirements as follows:

Calibrations utilizing Analytics' standards demonstrate traceability to NIST. Analytics' 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.

Each standard is prepared gravimetrically with a calibrated balance.

After preparation, each standard is counted with a calibrated, germanium spectrometer system.

The counting efficiencies at each primary energy are compared to the counting efficiency of at least one independent standard and agreement must be within Analytics' stated uncertainty. For the quality-control testing of custom-geometry gamma-ray standards, Analytics maintains a current database including efficiencies from more than 40,000 individual standards in over 600 geometries.

Mixed Gamma Standard (Basic 8-isotope mixture): Advantages

The Mixed Gamma Standard contains carefully selected radionuclides for minimum spectral interference.

The use of multiple gamma-ray-emitting radionuclides with simple spectra (single or at most twin gamma-ray emissions) allows the activities of each component to be adjusted to give approximately equal counting statistics across the entire energy range. The result is that all regions of the energy-versus-efficiency curve will have equal precision.

This mixture minimizes coincident summing effects, which is particularly important when counting close to large, high-efficiency, germanium detectors. For more information on problems with coincidence summing consult "The Counting Room: Special Edition," Radioact. Radiochem., McFarland, T., Ed; Caretaker Communications, 1994; pp 67-86.

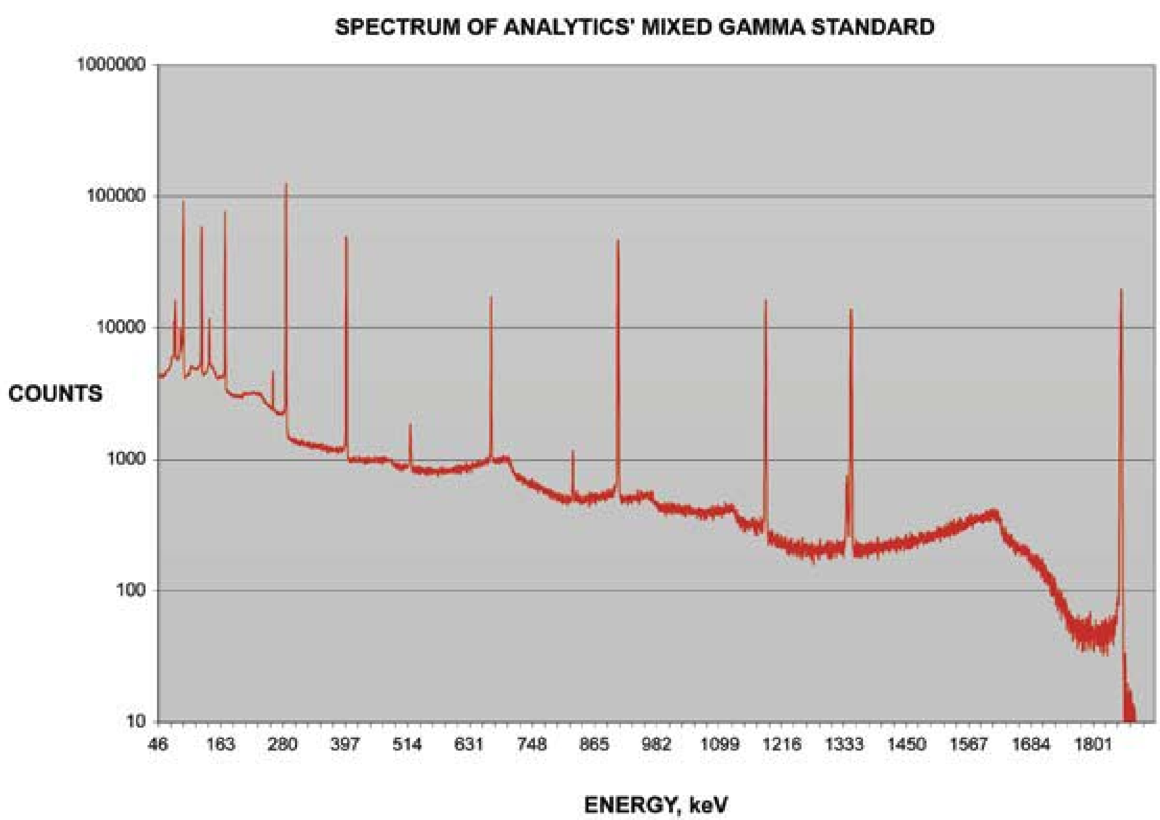
The calibration is performed by germanium spectrometry on the final mixture. This procedure provides verifiable final calibrations and uncertainty values for each component. Typical uncertainties are in the range of 3 - 4%, relative expanded uncertainty (k=2).

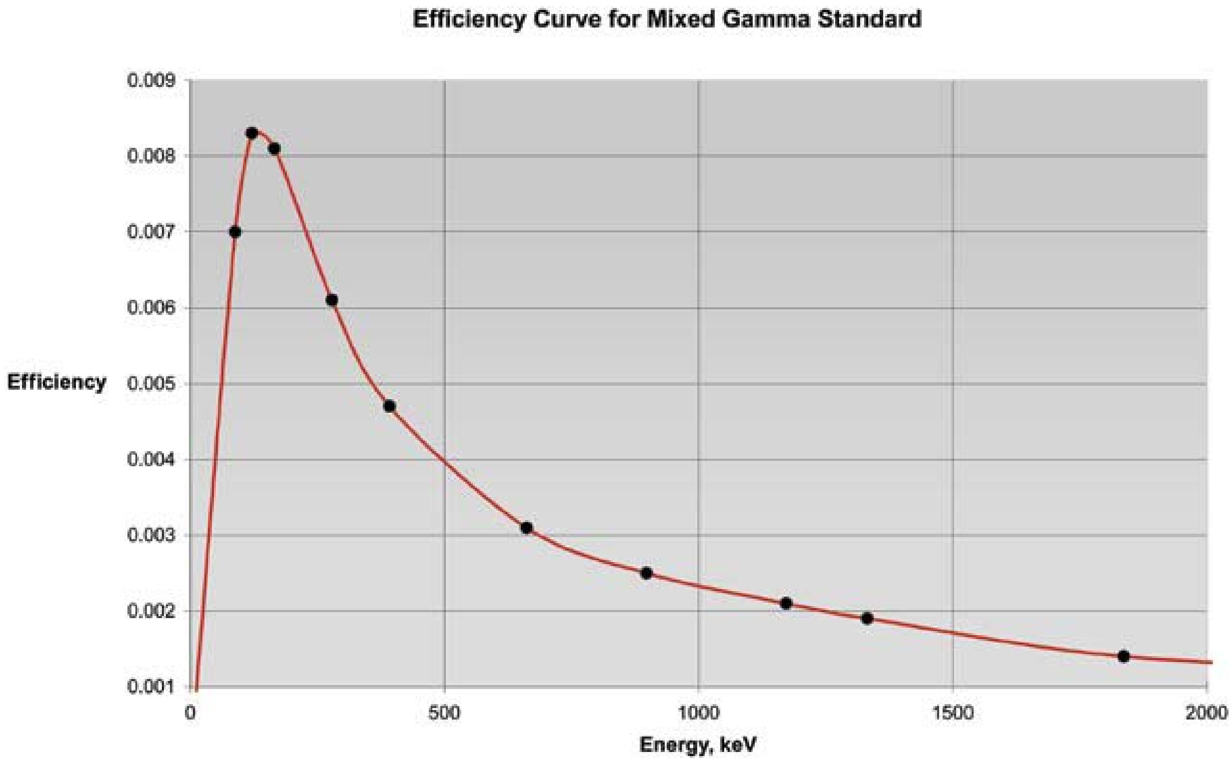
Gamma-Ray Standards

Matrices

Over the past twenty-five years Analytics has prepared custom-made standards in hundreds of different geometries utilizing many different matrices.

- Water-equivalent solid standards are prepared in hundreds of different geometries. These standards are individually traceable and much safer to handle in the counting room than liquid standards. There is no possibility of leakage, spillage or plate-out of the radioactive material. Matrix density is 1.15 g/cc.
- Air filter standards are uniformly deposited to your specifications and sealed in customer supplied counting configurations.
- Charcoal and silver zeolite cartridge standards are prepared in customer supplied cartridges loaded to your specifications.
- Soil or sand standards are prepared in customer supplied counting containers. Matrix density ranging from 1.5 g/cc to 1.7 g/cc.
- High density solids with density range from 1.5 to 2.0 g/cc.
- Vegetation or simulated vegetation standards are prepared in customer supplied counting containers with an approximate density of 0.6 g/cc.
- Simulated gas standards are prepared in customer supplied gas counting containers. These low-density (0.02 g/cc) standards have the same gamma-ray attenuation characteristics as actual gas standards and greatly extend the energy range and useful life of the calibration standard.
- Point sources are mounted in various geometries, again to your specifications.





Other Mixtures

Analytics' Mixed Gamma Standard utilizes the basic eight radionuclides listed as Option 1 in the Mixed Gamma-Ray Standards Table. The approximate gamma-ray emission rate for a 3 microCi (111 kBq) source is given as an example. Option 2 adds ^{241}Am to the mixture to extend the energy range down to 59.5 keV. Option 3 adds ^{85}Sr to give a gamma-ray emission at 514 keV, which is useful in some applications. Option 4 adds both ^{241}Am and ^{85}Sr. To further extend the low-energy range to 46.5 keV, ^{210}Pb can be added to the mixture. In order to measure coincidence-summing effects ^{65}Zn (1115 keV) and ^{54}Mn (835 keV) can be added. Option 5 replaces the ^{203}Hg in the mixture with ^{51}Cr, and adds ^{85}Sr. Option 6, True Coincidence Correction (TCC) mixture, is used with special software to correct for coincidence summing effects. Custom mixtures for other applications such as NaI(TI) spectrometry can also be prepared. See tables listed for all options.

For additional information consult our technical representatives.

Gamma-Ray Standards

Mixed Gamma-Ray Standards Table

Option 1 Basic Eight Radionuclide Mixture			
Radio-Nuclide	Energy (keV)	Half-Life	Approx Emission Rate*
^{109}Cd	88	462.6 d	2900
^{57}Co	122	271.79 d	1900
^{139}Ce	166	137.6 d	2400
^{203}Hg	279	46.61 d	4500
^{113}Sn	392	115.1 d	3300
^{137}Cs	662	30.07 y	2200
^{88}Y	898	106.6 d	8000
^{60}Co	1173	5.271 y	3800
^{60}Co	1332	5.271 y	3800
^{88}Y	1836	106.6 d	8400

Option 2 Basic Eight Radionuclide Mixture Plus			
Radio-Nuclide	Energy (keV)	Half-Life	Approx Emission Rate*
^{241}Am	59.5 keV	432 y	2200

Option 3 Basic Eight Radionuclide Mixture Plus			
Radio-Nuclide	Energy (keV)	Half-Life	Approx Emission Rate*
^{85}Sr	514 keV	64.84 d	3900

Option 4 Basic Eight Radionuclide Mixture Plus			
Radio-Nuclide	Energy (keV)	Half-Life	Approx Emission Rate*
^{241}Am	59.5 keV	432 y	2200
^{85}Sr	514 keV	64.84 d	3900

* Approximate gamma-ray emission rate (gps) from a 3 microCi (111 kBq) standard. Individual emission rates may vary from batch to batch.

Mixed Gamma-Ray Standards Table (cont.)

Option 5 Basic Eight Radionuclide Mixture Replaces ^{203}Hg with ^{51}Cr and adds ^{85}Sr			
Radio-Nuclide	Energy (keV)	Half-Life	Approx Emission Rate*
^{51}Cr	320.1 keV	27.7 d	4600
^{85}Sr	514 keV	64.84 d	3900

Option 6 True Coincidence Correction Mixture (TCC)			
Radio-Nuclide	Energy (keV)	Half-Life	Approx Emission Rate*
^{241}Am	59.5	432 y	2300
^{109}Cd	88	462.6 d	2100
^{57}Co	122	271.79 d	1300
^{139}Ce	166	137.6 d	1600
^{203}Hg	279	46.61 d	3900
^{113}Sn	392	115.1 d	2100
^{85}Sr	514	64.84 d	4400
^{134}Cs	604.7	754.2 d	7000
^{137}Cs	662	30.07 y	1500
^{134}Cs	795.9	754.2 d	6100
^{54}Mn	834.9	312.1 d	4000
^{88}Y	898	106.6 d	7000
^{65}Zn	1115.6	244.3 d	5400
^{88}Y	1836	106.6 d	7400

* Approximate gamma-ray emission rate (gps) from a 3 microCi (111 kBq) standard. Individual emission rates may vary from batch to batch.

Single-Radionuclide Standards

Calibrations utilizing Analytics' standards have demonstrated traceability to NIST. Analytics 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.

Analytics can prepare custom-geometry single-radionuclide standards utilizing a wide variety of radionuclides. Contact us with your specifications of radionuclide, activity and geometry. All custom-made, calibration standards must pass Analytics' documented quality-control requirements.

Matrices

Over the past twenty-five years Analytics has prepared custom-made standards in hundreds of different geometries utilizing many different matrices.

- Water-equivalent solid standards are prepared in hundreds of different geometries. These standards are individually traceable and much safer to handle in the counting room than liquid standards. There is no possibility of leakage, spillage or plate-out of the radioactive material. Matrix density is 1.15 g/cc.
- Air Filter standards are uniformly deposited to your specifications and sealed in customer supplied counting configurations.
- Charcoal and silver zeolite cartridge standards are prepared in your cartridges loaded to your specifications.
- Soil or sand standards are prepared in customer supplied counting containers. Matrix density range from 1.5 g/cc to 1.7 g/cc.
- High density solids with density range from 1.5 to 2.0 g/cc.
- Vegetation or simulated vegetation standards are prepared in customer supplied counting containers with an approximate density of 0.6 g/cc.
- Simulated gas standards are prepared in customer supplied gas counting containers. These low-density (0.02 g/cc) standards have the same gamma-ray attenuation characteristics as actual gas standards and greatly extend the energy range and useful life of the calibration standard.
- Point sources are mounted in various geometries, again to your specifications.

If you do not find your specific geometry give us a call. Let us put our experience in preparing custom standards to work for you.

Each standard is prepared gravimetrically with a calibrated balance. After preparation, each standard is counted with a calibrated detector system.

Gas Standards

Simulated-Gas Standards

Analytics' custom-made, simulated-gas standards provide calibration for gamma-ray spectrometers over a wide energy range. The standards are prepared using Analytics' mixed gamma-ray standard mixtures deposited on a low-density polystyrene matrix in your actual counting containers. The matrix has a density of 0.015 to 0.020 g/cc. These standards require no attenuation corrections over the energy range 59.5 to 1836 keV. The simulated-gas standards have several advantages over gas standards. The simulated standards provide a wider energy range, have longer useful life, require no transfers and are leak proof.

All custom-made, simulated-gas standards are prepared gravimetrically from NIST traceable solutions and are thoroughly QC tested against actual gas standards in the same geometry.

Unpressurized Gas Standards

Analytics supplies unpressurized transferable gas standards allowing customers to perform calibrations on virtually any counting container using an actual gas. These standards are supplied in a 33-mL glass sphere with two stopcocks and a septum port for transfer. A transfer kit, including a calibrated gas syringe and instructions, can be purchased to perform multiple accurate transfers and calibrations from the standard.

Radionuclides available as unpressurized gas standards are ^{133}Xe, ^{127}Xe, ^{85}Kr, and a mixed standard including all three radionuclides. The mixed standard provides the widest energy range calibration practical with real radioactive gasses. The mixed gas standard has gamma-ray emissions at 81, 145, 172, 202, 375, and 514 keV.

Pressurized Gas Standards

Analytics supplies pressurized gas standards for the calibration of effluent monitors. These standards are prepared volumetrically from calibrated NIST traceable gas standards. These standards are pressurized with nitrogen and are available as either approximately 20 liters of gas in a 500-mL steel cylinder (lecture bottle) or as approximately 130 liters of gas in a 2.3-L steel cylinder. Regulators are available for an additional charge. Radionuclides available as pressurized gas standards are ^{133}Xe and ^{85}Kr.

Liquid Standards

All liquid radionuclide standards are prepared gravimetrically from NIST traceable solutions. After preparation all standards are QC tested with our calibrated counting systems.

Analytics will provide relative expanded uncertainties (expressed in % of value) or expanded uncertainties (expressed in same units as the certified value) with a coverage factor of 2, which approximates a 95% confidence level for all standards. Uncertainties are estimated using the guidance in NIST Technical Note 1297, "Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results".

Custom

Custom liquid standards are available in a wide range of activities and volumes as single radionuclide standards, or as custom mixtures. Custom liquid standards are available in 5-, 10-, 20- or 50-mL flame-sealed glass vials.

Liquid standards are also available in larger volume flame-sealed reagent bottles of 100-, 250-, 500- and 1000-mL volumes. The storage bottles have a ground glass cap to prevent evaporation and to reseal the standard for storage between calibrations.

Stock

Certain longer-lived liquid radionuclide standards are available from stock providing rapid delivery. Stock liquids are available in 5-mL flame-sealed glass vials at activities specified in the Radioactive Liquid Standards—Stock table on page 18.

Low-Level Tracers

Low-level radioactive tracer solutions are available in flame-sealed reagent bottles with a ground glass cap to minimize evaporative losses. These samples are particularly useful for radiochemical measurements, which require a spike for yield determinations. These solutions may also be used as control samples for various analytes.

Liquid Standards

Radioactive Liquid Standards—Custom

Radio-nuclide	Chemical Form, Carrier	Volume, ml	Activity, kBq	Activity, microCi	Relative Expanded Uncertainty (k=2)%*
^{241}Am	Am(III) in 1M HCl, Carrier Free	5 - 50	1.85 to 740	0.05 to 20	2.0
^{243}Am	Am(III) in 1M HCl, Carrier Free	Call for availability			
^{133}Ba	Ba(II) in 0.1M HCl, 30 µg/g Ba	5 - 50	3.7 to 1850	0.1 to 50	1.7
^{207}Bi	Bi(III) in 1M HCl, 30 µg/g Bi	5 - 50	1.85 to 3.7	0.05 to 0.1	2.0
^{14}C	Labeled glucose (50 µg/g) + formaldehyde (1 µg/g) in water	5 - 50	1.85 to 370	0.05 to 10	3.5
^{14}C	Na_2CO_3 in 0.001M NaOH, 30 µg/g	5 - 50	1.85 to 370	0.05 to 10	3.5
^{45}Ca	Ca(II) in 0.1M HCl, 30 µg/g Ca	5 - 50	3.7 to 3700	0.1 to 100	2.5
^{109}Cd	Cd(II) in 0.1M HCl, 30 µg/g Cd	5 - 50	37 to 3700	1 to 100	3.5
^{139}Ce	Ce(III) in 0.1M HCl, 30 µg/g Ce	5 - 50	3.7 to 1850	0.1 to 50	2.0
^{141}Ce	Ce(III) in 0.1M HCl, 30 µg/g Ce	5 - 50	3.7 to 1850	0.1 to 50	2.5
^{36}Cl	Cl(-I) in 0.0005M NaOH, 30 µg/g Cl	5 - 50	1.85 to 37	0.05 to 1	1.7
244Cm	Cm(III) in 1M HCl, Carrier free	5 - 50	1.85 to 3.7	0.05 to 0.1	2.0
^{57}Co	Co(II) in 0.1M HCl, 30 µg/g Co	5 - 50	3.7 to 3700	0.1 to 100	1.7
^{58}Co	Co(II) in 0.1M HCl, 30 µg/g Co	Call for availability			
^{60}Co	Co(II) in 0.1M HCl, 30 µg/g Co	5 - 50	3.7 to 3700	0.1 to 100	1.2
^{51}Cr	Cr(III) in 0.1M HCl, 30 µg/g Cr	5 - 50	37 to 7400	1 to 200	1.7
^{134}Cs	Cs(I) in 0.1M HCl, 30 µg/g Cs	5 - 50	3.7 to 3700	0.1 to 100	1.7
^{137}Cs	Cs(I) in 0.1M HCl, 30 µg/g Cs	5 - 50	3.7 to 3700	0.1 to 100	1.7
^{152}Eu	Eu(III) in 0.1M HCl, 30 µg/g Eu	5 - 50	3.7 to 1850	0.1 to 50	1.7
Fe-55	Fe(III) in 0.1M HCl, 30 µg/g Fe	5 - 50	3.7 to 3700	0.1 to 100	4.5
^{59}Fe	Fe(III) in 0.1M HCl, 30 µg/g Fe	5 - 50	3.7 to 3700	0.1 to 100	1.7
^{148}Gd	Gd(III) in 1M HCl, Carrier free	Call for availability			
^{3}H	Tritiated water	5 - 50	3.7 to 3700	0.1 to 100	3.0
^{203}Hg	Hg(II) in 0.1M HCl, 30 µg/g Hg	5 - 50	3.7 to 185	0.1 to 5	1.7
^{125}I	I(-I) in 0.01M NaOH + 0.006M Na_2SO_3, 30 µg/g I	5 - 50	3.7 to 3700	0.1 to 100	3.5
^{129}I	I(-I) in 0.01M NaOH + 0.006M Na_2SO_3, 30 µg/g I	5 - 50	1.85 to 1850	0.05 to 0.1	3.0
^{131}I	I(-I) in 0.01M NaOH + 0.006M Na_2SO_3, 30 µg/g I	5 - 50	3.7 to 3700	0.1 to 100	1.7
^{54}Mn	Mn(II) in 0.1M HCl, 30 µg/g Mn	5 - 50	3.7 to 1850	0.1 to 50	1.7
Mixed Gamma	Cd(II)-109, Co(II)-57, Ce(III)-139 Hg(II)-203, Sn(IV)-113, Cs(I)-137, Y(III)-88 and Co(II)-60 in 4M HCl, 30 µg/g carrier for each nuclide	5 - 50	3.7 to 740	0.1 to 20	3.3
^{22}Na	Na(I) in 0.1M HCl 30 µg/g Na	5 - 50	3.7 to 1850	0.1 to 50	2.0

Radioactive Liquid Standards—Custom (cont.)

Radio-nuclide	Chemical Form, Carrier	Volume, ml	Activity, kBq	Activity, microCi	Relative Expanded Uncertainty (k=2)%*
^{59}Ni	Ni(II) in 0.1M HCl, 30 µg/g Ni	5 - 50	1.85 to 3.7	0.05 to 0.1	4.5
^{63}Ni	Ni(II) in 0.1M HCl, 10 µg/g Ni	5 - 50	1.85 to 37	0.05 to 1	3.0
^{237}Np	Np (V) in 2M HCl, Carrier free	Call for availability			
^{32}P	H_3PO_4 in 0.01M HCl, 30 µg/g P	5 - 50	18.5 to 29600	0.5 to 800	1.7
^{210}Pb	Pb(II) in 1M HNO_3, Carrier free	5 - 50	3.7 to 37	0.1 to 1	3.3
^{147}Pm	Pm(III) in 0.1M HCl, 30 µg/g Eu	5 - 50	3.7 to 185	0.1 to 5	1.7
^{209}Po	Po(IV) in 2M HCl, Carrier free	Call for availability			
^{236}Pu	Pu(VI) in 3M HNO_3, Carrier free	Call for availability			
^{238}Pu	Pu(VI) in 3M HNO_3, Carrier free	5 - 50	3.7 to 37	0.1 to 1	2.0
^{239}Pu	Pu(VI) in 3M HNO_3, Carrier free	5 - 50	0.37 to 37	0.01 to 1	2.0
^{241}Pu	Pu(VI) in 3M HNO_3, Carrier free	Call for availability			
^{226}Ra	Ra(II) in 0.1M HCl, 50 µg/g Ba	5 - 50	3.7 to 370	0.1 to 10	5.0
^{228}Ra	Ra(II) in 0.1M HCl, 50 µg/g Ba	5 - 50	1.85 to 185	0.05 to 5	4.0
^{106}Ru	Ru(III) in 0.1M HCl, 50 µg/g Ru	Call for availability			
^{35}S	Na_2SO_4 in water, 30 µg/g S	5 - 50	3.7 to 3700	0.1 to 100	1.7
^{125}Sb	Sb(III) in 6M HCl, 30 µg/g Sb	5 - 50	3.7 to 1850	0.1 to 50	3.4
^{113}Sn	Sn(IV) in 4M HCl, 30 µg/g Sn	5 - 50	3.7 to 1850	0.1 to 50	1.7
^{85}Sr	Sr(II) in 0.1M HCl, 30 µg/g Sr	5 - 50	3.7 to 1850	0.1 to 50	1.7
^{89}Sr	Sr(II) in 0.1M HCl, 30 µg/g Sr	5 - 50	3.7 to 1850	0.1 to 50	1.7
^{90}Sr	Sr(II) in 0.1M HCl, 30 µg/g Sr	5 - 50	1.85 to 1850	0.05 to 50	1.7
^{99}Tc	Tc(VII) in 0.001M KOH, Carrier free	5 - 50	3.7 to 1850	0.1 to 50	2.5
^{228}Th	Th(IV) in 0.5M HNO_3, Carrier free	5 - 50	3.7 to 37	0.1 to 1	3.5
^{229}Th	Th(IV) in 0.5M HNO_3, Carrier free	Call for availability			
^{230}Th	Th(IV) in 0.5M HNO_3, Carrier Free	5 - 50	0.37 to 37	0.01 to 1	2.0
Th-Natural	Th(IV) in 0.5M HNO_3 (^{228}Th in equilibrium with ^{232}Th)	Call for availability			
^{204}Tl	Tl(I) in 0.1M HCl, 30 µg/g Tl	5 - 50	3.7 to 185	0.1 to 5	1.7
^{232}U	U(VI) in 1M HNO_3, Carrier free	5 - 50	3.7	30.1	5.0
^{233}U	U(VI) in 1M HNO_3, Carrier free	5 - 50	0.37 to 18.5	0.01 to 0.5	2.0
U-Natural	U(VI) in 1M HNO_3 (includes $^{234}U + ^{235}U + ^{238}U$)	5 - 50	0.37 to 3.7	0.01 to 0.1	3.3
^{88}Y	Y(III) in 0.1M HCl, 30 µg/g Y	5 - 50	3.7 to 370	0.1 to 10	1.2
^{65}Zn	Zn(II) in 0.1M HCl, 30 µg/g Zn	5 - 50	3.7 to 1850	0.1 to 50	1.7

*Nominal values and may differ based on specific calibrations.

Liquid Standards

Radioactive Liquid Standards—Stock

Radio-nuclide	Chemical Form, Carrier	Volume, ml	Activity, kBq	Activity, microCi	Relative Expanded Uncertainty (k=2)%*
^{241}Am	Am (III) in 1M HCl, Carrier Free	5	18.5 and 37	0.5 and 1	2.0
^{14}C	Labeled glucose (50 µg/g) + formaldehyde (1 µg/g) in water	5	37	1	3.5
^{14}C	Na_2CO_3 in 0.001M NaOH, 30 µg/g	5	37	1	3.5
^{36}Cl	Cl (-I) in 0.0005M NaOH, 30 µg/g Cl	5	37	1	1.7
^{60}Co	Co (II) in 0.1M HCl, 30 µg/g Co	5	37 and 185	1 and 5	1.2
^{137}Cs	Cs (I) in 0.1M HCl, 30 µg/g Cs	5	37 and 185	1 and 5	1.7
^{152}Eu	Eu (III) in 0.1M HCl, 30 µg/g Eu	5	37 and 185	1 and 5	1.7
^{55}Fe	Fe (III) in 0.1M HCl, 30 µg/g Fe	5	37	1	4.5
^{3}H	Tritiated water	5	37 and 185	1 and 5	3.0
^{129}I	I (-I) in 0.01M NaOH + 0.006M Na_2SO_3, 30 µg/g I	5	3.7	0.1	3.0
Mixed Gamma plus addition of ^{241}Am	Cd (II) -109, Co (II) -57, Ce (III) -139, Hg (II) -203, Sn (IV) -113, Cs (I) -137, Y (III) -88 and Co (II) -60 in 4M HCl, 30 µg/g carrier for each nuclide; Am-241 carrier free	5	185	5	3.3
^{59}Ni	Ni (II) in 0.1M HCl, 30 µg/g Ni	5	3.7	0.1	4.5
^{236}Pu	Pu (VI) in 3M HNO_3, Carrier free	5	0.37 and 0.925	0.01 and 0.025	2.0
^{239}Pu	Pu (VI) in 3M HNO_3, Carrier free	5	37	1	2.0
^{226}Ra	Ra (II) in 0.1M HCl, 50 µg/g Ba	5	3.7, 18.5, 37	0.1, 0.5, 1	5.0
^{228}Ra	Ra (II) in 0.1M HCl, 50 µg/g Ba	5	3.7 and 18.5	0.1 and 0.5	4.0
^{90}Sr	Sr(II) in 0.1M HCl, 30 µg/g Sr	5	3.7 and 37	0.1 and 1	1.7
^{99}Tc	Tc(VII) in 0.001M KOH, Carrier free	5	3.7 and 37	0.1 and 1	2.5
^{229}Th	Th (IV) in 0.5M HNO_3, Carrier free	5	0.37	0.01	3.5
^{230}Th	Th (IV) in 0.5M HNO_3, Carrier Free	5	3.7 and 18.5	0.1 and 0.5	2.0
^{232}U	U (VI) in 1M HNO_3, Carrier free	5	3.7	0.1	5.0
^{233}U	U (VI) in 1M HNO_3, Carrier free	5	3.7 and 18.5	0.1 and 0.5	2.0
U-Natural	U (VI) in 1M HNO_3 (includes $^{234}U + ^{235}U + ^{238}U$)	5	1.85	0.05	3.3

*Nominal values and may differ based on specific calibrations.

Radioactive Liquid Standards—Low-Level Tracers

Radio-nuclide	Chemical Form, Carrier	Volume, ml	Activity, Bq/mL	Activity, pCi/mL	Relative Expanded Uncertainty (k=2)%*
^{243}Am	Am (III) in 1M HCl, Carrier Free	100 - 1000	0.1 to 1	2.7 to 27	4.0
^{236}Pu	Pu (VI) in 3M HNO_3, Carrier free	100 - 1000	0.1 to 1	2.7 to 27	2.0
^{238}Pu	Pu (VI) in 3M HNO_3, Carrier free	100 - 1000	0.1 to 1	2.7 to 27	2.0
^{239}Pu	Pu (VI) in 3M HNO_3, Carrier free	100 - 1000	0.1 to 1	2.7 to 27	2.0
^{242}Pu	Pu (VI) in 3M HNO_3, Carrier free	100 -1000	0.01 to 0.1	0.27 to 2.7	2.0
^{226}Ra	Ra (II) in 0.1M HCl, 50 µg/g Ba	100 - 1000	0.1 to 1	2.7 to 27	5.0
^{228}Ra	Ra (II) in 0.1M HCl, 50 µg/g Ba	100 - 1000	0.1 to 1	2.7 to 27	4.0
^{90}Sr	Sr(II) in 0.1M HCl, 30 µg/g Sr	100 - 1000	0.1 to 1	2.7 to 27	1.7
^{99}Tc	Tc(VII) in 0.001M KOH, Carrier free	100 - 1000	0.1 to 1	2.7 to 27	2.5
^{229}Th	Th (IV) in 0.5M HNO_3, Carrier free	100 - 1000	0.1 to 1	2.7 to 27	3.5
^{230}Th	Th (IV) in 0.5M HNO_3, Carrier Free	100 - 1000	0.1 to 1	2.7 to 27	2.0
Th-Natural	Th (IV) in 0.5M HNO_3 (^{228}Th in equilibrium with ^{232}Th)	100 - 1000	0.1 to 1	2.7 to 27	5.0
^{232}U	In 1M HNO_3, Carrier free	100 - 1000	0.1 to 1	2.7 to 27	5.0
^{233}U	In 1M HNO_3, Carrier free	100 - 1000	0.1 to 1	2.7 to 27	2.0
U-Natural	In 1M HNO_3 (Consist of $^{234}U + {}^{235}U + {}^{238}U$)	100 - 1000	0.1 to 1	2.7 to 27	3.3

*Nominal values and may differ based on specific calibrations.

Health Physics Standards

Analytics provides custom-made calibration standards for alpha-/beta-particle measurements using proportional counters, GM counters and scintillation counters as well as standards for gamma/x-ray measurements using scintillation detectors and solid-state detectors. Analytics' standards provide the most accurate calibrations for wipe test determinations, airborne particulate and gaseous measurements, wide-area contamination measurements, internal dosimetry (whole-body counting), waste-drum measurements, decontamination/decommissioning and environmental measurements.

All custom-made alpha, beta or gamma-ray calibration standards must pass Analytics' documented quality-control testing:

Analytics' standards have demonstrated traceability to NIST. Analytics 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.

Each standard is prepared gravimetrically with a calibrated balance. After preparation, each standard is counted with a calibrated counting system.

The counting efficiency is compared to the counting efficiency of at least one independent standard and agreement must be within Analytics' stated uncertainty. For quality-control testing of custom-geometry standards, Analytics maintains a current database including efficiencies from thousands of alpha, beta and gamma-ray standards.

Airborne Particulate and Wipe-Test Determinations

Analytics supplies custom-geometry filter-paper standards that provide accurate calibrations for air particulate and contamination (wipe test) measurements. Analytics' custom-made alpha and beta filter-paper standards are Mylar™ covered and calibrated in total activity contained in the standard. As shown in the published study (Reference 1), Mylar™ covered activity calibrated standards are vastly superior to electrodeposited, emission-rate calibrated standards for alpha/beta air filter and wipe-test determinations. Measurements performed using instruments calibrated with emission-rate sources or electrodeposited standards may under report the activity by as much as 100% for alpha emitters, 40% for low-energy beta emitters, and 25% for high-energy beta emitters. The Mylar™ covering gives realistic attenuation characteristics and the custom mounting using the customer's filter and planchet gives realistic backscattering characteristics. The Mylar™ covering can be 0.5, 0.85 or 1.7 mg/cm^2 depending on the application. Other coverings are available upon request.

Analytics' filter standards are prepared gravimetrically from calibrated solutions. A wide variety of alpha, beta or gamma-ray emitting radionuclides can be used. The preparation is performed using a computer- controlled applicator that applies a large number of microliter-sized drops in the specified active area on a Mylar™ covering for alpha/beta counting or on a more rugged polyester tape for gamma-ray counting. The advantages of this preparation technique are discussed in Reference 2. After the drops are evaporated the Mylar™/tape covering is fixed to the customer specified filter substrate with the activity between the covering and the filter. The covering and filter composite is then mounted in the customers' planchet or specified backing for counting. The calibration of the standard comes from the gravimetric preparation and is given in total activity contained in the standard. After preparation the standard is QC tested as described at the beginning of this section.

Analytics' filter standards can be prepared with a wide variety of active areas to accurately reproduce the actual counting geometry: circular, semi-circular, a quarter circle to simulate a folded filter, square, rectangular and many others. For special applications the activity can be made to vary across the active area.

References
1 McFarland, R.C., "Comparison of Alpha and Beta Calibration Standards for Air-filter and Wipe-Test Analyses: Does Your Analysis Seriously Under-Report the Activity?" Radioact. Radiochem., 9(3), 8, (1998).

2 McFarland, R.C., "Geometric Considerations in the Calibration of Germanium Detectors for Filter-Paper Counting." Radioact Radiochem., 2(1), 4, (1991).

Planchets (Simulated Evaporated Liquid)

Planchet standards simulating an evaporated liquid are prepared for use in gross alpha and gross beta determinations. As with the filter standards, the standard is prepared gravimetrically on Mylar™ using the computer controlled applicator. The Mylar™ is mounted directly in the customer's planchet without a filter or backing. The backscatter and attenuation characteristics simulate an evaporated liquid in a planchet with a solid residue of approximately 0.5 or 0.85 mg/cm^2.

Airborne Radio-Iodine Determinations

Analytics supplies mixed and single radionuclide gamma-ray standards for airborne radio-iodine determinations. The calibrated radionuclide solution is gravimetrically dispensed and evaporated on activated charcoal or silver zeolite then is sealed in the customer's canister or cartridge. The activity can be deposited on the first 3 to 5 mm of the charcoal or zeolite material to simulate the distribution found in actual samples (face-loaded) or homogenously loaded throughout the cartridge to calibrate for "flip" counting applications. A thorough discussion of the measurement of airborne radio-iodine can be found in D.M. Montgomery's paper, "Calibrating Germanium Detectors for Assaying Radio-iodine in Charcoal Cartridges", Radioact. Radiochem, 1(2),4, (1990).

Charcoal or silver zeolite canister or cartridge standards can be prepared using Analytics' mixed gamma-ray standard or using single radionuclides such as ^{125}I or ^{131}I. In applications where gamma-ray coincidence summing is not a problem ^{133}Ba can be used. For more information on coincidence summing see "The Counting Room: Special Edition" referenced previously.

Health Physics Standards

Surface-Contamination Monitors

Standards for alpha, beta and gamma-ray surface contamination monitors can be supplied in many different sizes. Alpha and beta standards are Mylar™ covered. As discussed in the section on air particulate and wipe test standards these Mylar™-covered activity calibrated standards are vastly superior to emission-rate electrodeposited standards for contamination determinations. The Mylar™ covering can be 0.5, 0.85 or 1.7 mg/cm^2 depending on the application. Gamma-ray contamination monitor standards are contained in a more durable plastic covering.

Analytics' surface contamination standards are prepared gravimetrically from calibrated solutions. A wide variety of alpha, beta or gamma-ray emitting radionuclides can be used. The preparation is performed using a computer-controlled applicator that applies a large number of microliter sized drops in the specified active area as described previously. Geometries prepared include the standard square 10 x 10 cm, 10 x 15 cm, and up to 1 x 1 m standards. Other configurations are available. As with all of Analytics' standards, after preparation each standard is QC tested on a calibrated detector and the efficiency data must agree with at least one independent standard in the same geometry. Analytics maintains extensive files on previously prepared contamination monitor standards for QC comparisons.

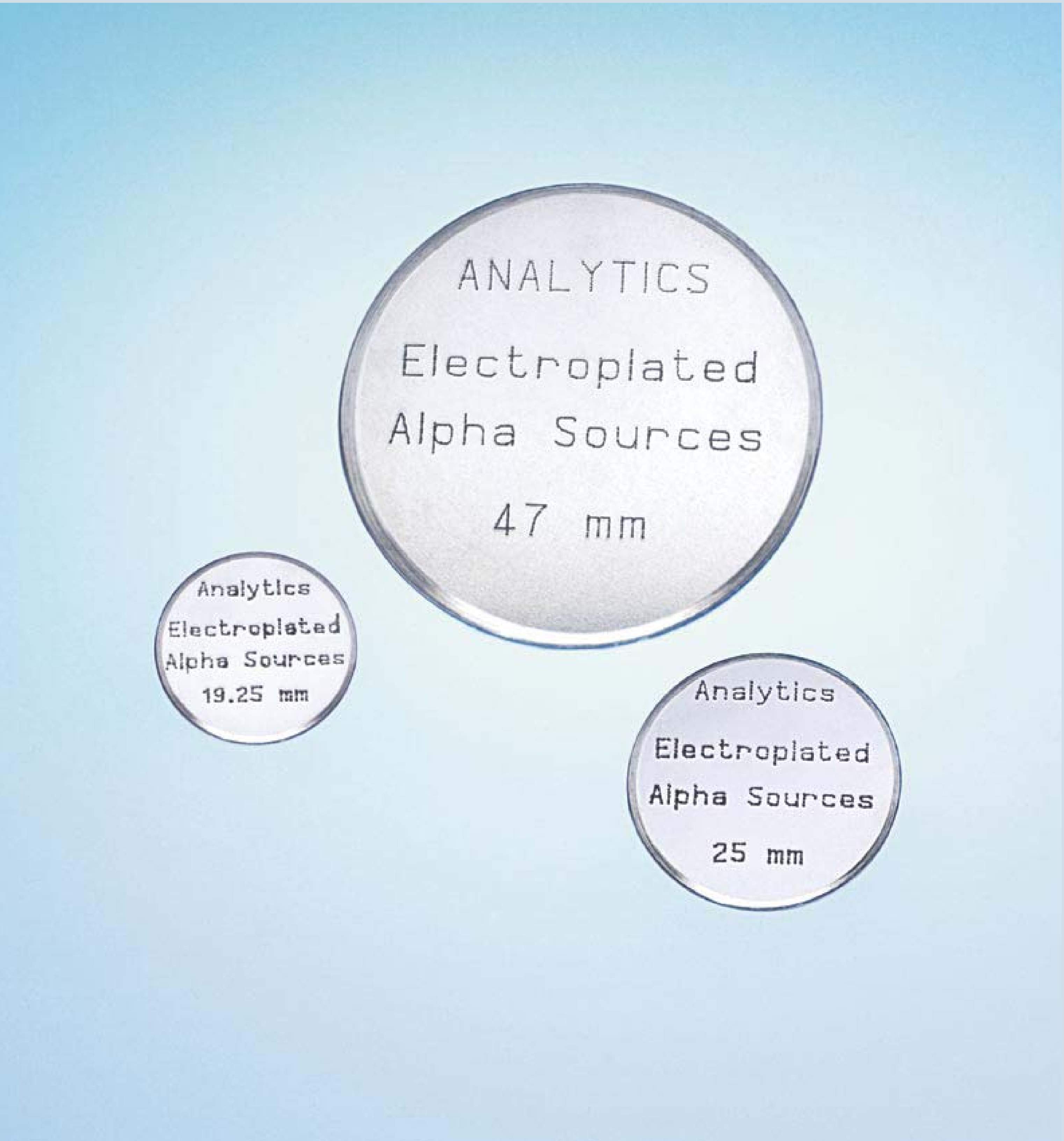
Internal Dosimetry (Whole Body Counting)

Analytics prepares whole body counting standards for a wide variety of systems and phantoms including the Fastscan™, BOMAB™, Humanoid and several types of bottle phantom systems. Standards are supplied as water-equivalent solid standards or in liquid form for transfer to various types of phantoms. The water-equivalent solid standards are prepared directly in some of the compartmentalized phantoms or in bottles to be placed in cavities in other phantoms or as sets of small cylinders to be placed in a phantom. If your dosimetry program is required to measure the contamination in wild animals found around your facility, Analytics has prepared large volume standards to simulate deer or smaller animals. A wide variety of radionuclides and mixtures of radionuclides can be used. Contact us with your requirements.

Large-Volume Gamma-Ray Standards for Waste Assay and Effluent Monitoring

Analytics has prepared a wide variety of large-volume, solid gamma-ray standards in drums, and in the large-volume counting chambers of effluent monitors. These solid standards provide safe long-lived standards for calibration and routine detector QC monitoring. Solid standards can be prepared in various matrices: water-equivalent solid or sand depending on the desired attenuation characteristics. These standards are prepared gravimetrically from calibrated solutions. Due to the large volume, low activity and unusual shape of these standards, QC testing is performed by taking a sample of the filling material and counting in a calibrated geometry. Many different radionuclides can be used. Contact us with your requirements.

Electrodeposited Standards



Analytics supplies custom geometry electrodeposited standards for alpha spectrometry. The standards can be prepared on 19.2 mm, 24.1 mm or 47.1 mm stainless steel disks with various active areas. The following mixtures of radionuclides are available:

- Natural Uranium, ^{239}Pu and ^{241}Am
- ^{230}Th, ^{239}Pu and ^{244}Cm
- ^{230}Th, ^{239}Pu, ^{244}Cm and ^{241}Am
- Mixed Alpha "Stock" disk—U-Natural, ^{239}Pu and ^{241}Am - 24.1 mm diameter x 0.6 mm thick stainless steel disk, 24.1 mm diameter active area, 1.7 Bq (100 dpm) per isotope (available to ship in 7 work days).

Single radionuclide standards can be prepared using any of the radionuclides in the mixtures as well as ^{238}Pu, and depleted or enriched uranium. All standards are calibrated in total alpha emission rate measured by gas-flow or scintillation counting. In addition, mixed standards are certified for individual radionuclides using alpha spectrometry.

^{99}Tc calibrated for only beta emission rate is available, and can be prepared on 24.1 mm or 47.1 mm stainless steel disks with various active areas.

Liquid Scintillation Counting Standards

Quenched

Custom quench standard sets (typically 5-10 vials) for liquid scintillation counting can be prepared using the customer's LS counting fluid (cocktail). Standards are prepared gravimetrically and flame sealed in glass LS vials. Radionuclides available include, but are not limited to the following:

^{3}H	^{63}Ni
^{14}C	^{99}Tc
^{36}Cl	^{89}Sr
^{55}Fe	^{90}Sr

After preparation, the quenched sets are counted on one of Analytics' calibrated liquid scintillation counting systems. Contact us with your specific requirements. Customers can supply their specific type of liquid scintillation vials.

Unquenched

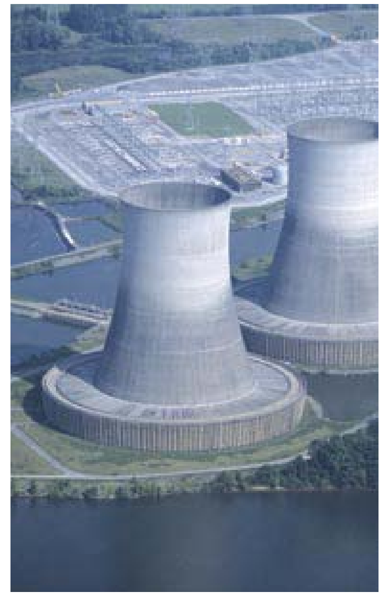
A set contains ^{3}H, ^{14}C, and a background sample. Activities are 5 kBq (300,000 dpm) for ^{3}H and 2.16 kBq (130,000 dpm) for ^{14}C.

Alpha/Beta

A set contains ^{241}Am, ^{36}Cl and a background sample. Typical activities are 1.6 kBq (100,000 dpm) for each isotope. Other radionuclides and activities are available upon request.

Inter-Laboratory Cross-Check Programs

The verification of analytical performance through a blind cross-check program is an integral part of an effective quality-assurance program; and is recommended by the United States Nuclear Regulatory Commission, the Institute of Nuclear Power Operations and ANSI N42.23 -1996 American National Standard Measurement and Associated Instrument Quality Assurance for Radioassay Laboratories.



Two distinct inter-laboratory cross-check programs are offered by Analytics. The Inter-Laboratory Cross-Check Program for nuclear power plant laboratories provides blind samples that simulate routine effluent samples. The Inter-Laboratory Cross-Check Program for environmental measurements laboratories provides blind samples at environmental levels in water, milk, soil, simulated vegetation, air filters and charcoal cartridges. Each program provides quarterly, blind samples at concentrations that permit an evaluation of your analytical accuracy. The concentration of radionuclides covers a range that allows for reasonable counting statistics.

Advantages

- Samples can be used for the training and testing of personnel and procedures.
- Interferences and activity levels can be varied to better test procedures and equipment.
- Analytics' samples are carefully prepared from calibrated standards and shipped in stable forms, therefore the samples' activities are more accurately known.
- Traceability is maintained through Analytics' participation in measurement assurance programs with NIST/NEI.

Training, procedure testing and measurements assurance are all areas that benefit from Analytics' Inter-Laboratory Cross-Check Programs.

Applications

- Performance and technique evaluation
- Technician qualification
- Internal quality-control samples
- Accuracy and precision evaluation
- Evaluating sample-preparation procedures
- Testing radiochemical procedures
- Exploring new laboratory techniques
- Qualifying computer software

Inter-Laboratory Cross-Check Programs

Nuclear Power Plant Laboratories

In 1982, Analytics developed a comprehensive, inter-laboratory cross-check program for radiochemistry analysis. The Inter-Laboratory Cross-Check Program for nuclear power plant laboratories is a quarterly program designed specifically for the nuclear power industry and commercial laboratories performing effluent and 10 CFR Part 61 analyses. This program provides blind samples whose composition and activity levels simulate plant effluent and health physics samples. The table listed below summarizes sample matrices and radionuclide combinations routinely available on a quarterly basis. Analytics can adjust sample types and activity levels to meet your particular needs. Typical radioactive and stable interfering species are present in each sample.

Sample	Form	Activity*	Activity*
^{55}Fe	20-mL Liquid	5E-3 microCi/g	111 Bq/g
Gross Alpha	20-mL Liquid	1E-4 microCi/g	148 Bq/g
Gross Beta	20-mL Liquid	5E-3 microCi/g	111 Bq/g
Gamma Isotopic	20-mL Liquid	1E-1 microCi/g	3.7 kBq/g
^{89}Sr / ^{90}Sr (89) (90)	20-mL Liquid 20-mL Liquid	5E-2 microCi/g 5E-3 microCi/g	1.85 kBq/g 111 Bq/g
Tritium	20-mL Liquid	5E-3 microCi/g	111 Bq/g
Gamma Isotopic	Solid	5E-1 microCi	18.5 kBq
Gross Alpha Planchet	Solid	5E-3 microCi	111 Bq
Gross Beta Planchet	Solid	5E-3 microCi	111 Bq
^{131}I on Charcoal	Solid	1.0 microCi	37 kBq
Whole Body Unknowns	Solid, 5+1 LSV or Fastscan™ LSV	4.5 microCi	166.5 kBq
^{85}Kr ^{133}Xe	Gas Ampoule	10 microCi 5 microCi	370 kBq 185 kBq
^{85}Kr ^{133}Xe	33-mL Gas-Sphere	80 microCi 10 microCi	2960 kBq 370 kBq

*Values are less than or equal to activity stated.
Special mixture for part 61 including transuranics, 129I and others upon request.

The gamma isotopic sample is a variable mixture of fission and activation products commonly found in nuclear power plants. These cross-check samples are available in air filter, liquid or water-equivalent solid forms in your specific geometry. Whole body unknowns price includes 5 quart bottles and 1 liquid scintillation vial or a Fastscan™ in liquid scintillation vial, containers supplied by Analytics. The ^{133}Xe / ^{85}Kr gas sample is available in a sealed gas-counting vial or a transferable glass sphere. A transfer kit is available for an additional charge. There is a minimum of four samples per shipment. An additional fee will apply for less than 4 items per shipment.

Reporting Procedures

Sample price includes comparison report with one result per sample. Comparison reports for multiple results (eg. detectors, shelves, etc.) are available at an additional cost. You will receive a report using the NRC Confirmatory Measurements criteria and format for comparing analytical measurements within 15 work days from our receipt of your results. If a disagreement can not be resolved by reanalysis of the data, we will ship follow-up samples at your request at standard published rates, subject to availability. Analytics compiles periodic summaries of data from all participants for comparison. These summaries do not provide individual results in order to maintain confidentiality.

Environmental Measurements Laboratories

This inter-laboratory cross-check program provides blind samples at environmental levels on a quarterly basis at concentrations that permit an evaluation of your analytical accuracy. The table below summarizes sample matrices and radionuclide combinations routinely available on a quarterly basis. Gamma-ray emitters include mixed-activation products with half-lives greater than seven days. Activity listed is per radionuclide. Contact Analytics for information on special orders and custom configurations.

Sample	Analysis	Radionuclides	Sample Size	Activity	Activity
Vegetation (simulated)	Gamma-ray emitters	Minimum of six	1.0 L(~550 g)	0.05-0.5 pCi/g	1.85 – 18.5 mBq/g
Water	Alpha/Beta	^{241}Am, ^{137}Cs	1.0 L	10-300 pCi/L	370 – 1.11 E4 mBq/L
Water	Tritium	^{3}H	0.5 L	2000-15000 pCi/L	7.4 E4 – 5.55E5 mBq/L
Water	Gamma-ray emitters*	Minimum of six	1.0 L	50-300 pCi/L	1850 – 1.11 E4 mBq/L
Water	Transuranics	^{241}Am, ^{238}Pu, ^{239}Pu, ^{237}Np, ^{244}Cm	1.0 L	1-10 pCi/L	37 – 370 mBq/L
Water	Natural radioactivity	^{238}U, ^{234}U, ^{232}Th, ^{226}Ra, ^{228}Ra	1.0 L	25-100 pCi/L	925 – 3700 mBq/L
Water	Beta emitters	^{89}Sr, ^{90}Sr, ^{99}Tc	1.0 L	10-100 pCi/L	370 – 3700 mBq/L
Soil	Gamma-ray emitters	Minimum of six	500 cc (750 g)	0.05-0.5 pCi/g	1.85 – 18.5 mBq/g
Soil	Transuranics	^{238}Pu, ^{239}Pu, ^{237}Np, ^{244}Cm	3 x 50 g	1-10 pCi/g	37 – 370 mBq/g
Soil	Natural radioactivity	^{238}U, ^{234}U, ^{232}Th, ^{226}Ra, ^{228}Ra	3 x 50 g	0.1-1.0 pCi/g	3.7 – 37 mBq/g
Soil	Beta emitters	^{89}Sr, ^{90}Sr, ^{99}Tc	3 x 50 g	1-10 pCi/g	37 – 370 mBq/g
Milk	Gamma-ray emitters*	Minimum of six	1.0 L	50-300 pCi/L	1850 – 1.11 E4 mBq/L
Milk	Radiochemical	^{90}Sr, ^{131}I	1.0 L	10-100 pCi/L	370 – 3700 mBq/L
Milk	Beta emitters	^{89}Sr, ^{90}Sr	1.0 L	10-100 pCi/L	370 – 3700 mBq/L
Air Filter	Alpha/Beta	^{241}Am, ^{137}Cs	1 filter	10-250 pCi	370 – 9250 mBq
Air Filter	Gamma-ray emitters	Minimum of six	1 filter	50-200 pCi	1850 – 7.4 E3 mBq
Air Filter	Transuranics	^{238}Pu, ^{239}Pu, ^{237}Np, ^{244}Cm	1 filter	1-10 pCi	37 – 370 mBq
Air Filter	Natural radioactivity	^{238}U, ^{234}U, ^{232}Th, ^{226}Ra, ^{228}Ra	1 filter	1-100 pCi	37 – 3700 mBq
Air Filter	Beta emitters	^{89}Sr, ^{90}Sr, ^{99}Tc	1 filter	10-100 pCi	370 – 3700 mBq
Charcoal cartridge	Gamma-ray emitters	^{131}I	1 cartridge	10-100 pCi	370 – 3700 mBq

*Includes 131 I between 10-100 pCi/L (370 – 3700 mBq/L)
mBq=millibecquerel

There is a minimum of four samples per shipment. An additional fee will apply for less than 4 items per shipment.

Reporting Procedures

Sample price includes comparison report with one result per sample. Comparison reports for multiple results (eg. detectors, shelves, etc.) are available at an additional cost. You will receive a report within 15 work days from our receipt of your results. The known values along with client values are tabulated with the ratios of the known to reported values. Since data quality objectives vary among laboratories, no pass/fail criteria are used.

Eckert & Ziegler Analytics
1380 Seaboard Industrial Blvd.
Atlanta, GA 30318 USA

Phone: (404) 352-8677
Fax: (404) 352-2837
Email: analytics@ezag.com

www.ezag.com

Eckert & Ziegler
Analytics