Purpose

The purpose of these procedures is to describe the setup, measurement, and reporting procedures for alpha- and beta-particle radioactivity-measurements. Included, are descriptions of measurements using the primary standards the NIST $2\pi\alpha$ proportional counter (small-area) and the NIST $2\pi\alpha/\beta$ proportional counter (large-area). Also included, are measurements using the primary standards in conjunction with a passive implanted planar silicon detector (PIPS), or the NIST table (external counter).

Scope

These procedures describe the alpha- and beta-particle-emission-rate measurements for “thin” conductive solid alpha- and beta-particle emitting sources by means of the small- and large-area proportional counters, mixed source spectroscopy using the PIPS, and the emission-rate measurements of higher activity sources using the external counter. Test number 43030C corresponds to emission rate calibrations of alpha- and beta-particle-emitting radionuclides and activity calibrations of alpha particle-emitting radionuclides. Test number 43040C is for activity calibrations of beta-particle-emitting radionuclides. Test number 43050C refers to calibrations of mixed-alpha-particle-emitting sources. Circular sources with a diameter of up to 10 cm can be measured in the small-area $2\pi\alpha$ counter. Sources with dimensions of 18 cm by 30 cm or smaller can be measured in the large-area $2\pi\alpha/\beta$. Small-circular sources with a diameter of up to 5 cm can be measured in the PIPS. Sources with dimensions of 18 cm by 30 cm can be measured on the NIST table. The measurement procedures for test number 43031S are the same as the other services, but allow for proficiency testing and for the calibration of sources that are outside the parameters set in the other services. Additional tasks are involved in proficiency tests, see Appendix C for details. All sources measured in the counters must have an electrically conducting surface layer so that no accumulated charge is developed that can cause field distortion.

Definitions

Alpha-particle-emission-rate: the number of alpha particles emitted into 2π-geometry per unit time. The measurement unit is s^{-1} (counts per second or cps).

Activity: the number of nuclei that disintegrate per unit time. The measurement unit is the becquerel (Bq).

Equipment

- Small-area 2πα proportional counter
- Large-area 2πα/β proportional counter
- PIPS counter
- NIST table external counter
- Computers and MCA with data collection and reduction capabilities
- Compressed air gas tank, attachments, and controls
- P-10 counting gas tanks, attachments, and controls
- Associated electronic equipment including mini bins, voltage supply, pre-amplifiers and amplifiers

Equipment Quality Control

The functioning of the instrumentation is checked by comparing the measurement results for a standard reference source, corrected for decay and background, with previous results for the same standard. The measurements on the standards are recorded in the small-area Excel spreadsheet file “CheckSA”, for the large-area spreadsheet file “CheckLA”, external counter spreadsheet “CheckNT”, and PIPS spreadsheet “CheckSB” found in the “Excel Files” folder in the “Documents” folder accessed on the investigator’s computer, and backed-up on an external drive and the division shared drive, 682 (\\elwood.nist.gov)(L:) >internal>PL846_04.

Validation of Software

Validation of manual calculation of experimental results is performed by comparing values found using data processing software. This is performed on the initial version and subsequent to any changes in the program. Results of validations are recorded in the current alpha- and beta-test binder. This software is stored on computers used for these procedures, by authorized personnel, in building 245 room H220.

Health and Safety Precautions

Radiation Safety

Radiation safety training and assessment services are provided by the NIST Radiation Safety Division (RSD). Rooms containing radioactive sources are kept locked when not occupied and are accessible only to designated members of the Radiation Physics Division and emergency response personnel. Sources are handled by operators using gloves. Radiation signage is posted in the relevant

areas. Basic radiation monitoring and smear counting are handled in accordance with standard RSD procedures. Additional hazard mitigation efforts are practiced as described in the Safety Evaluation 0002 and the associated standard operating procedures.

Electrical Safety

All high voltages are encased in protective boxes and cannot be easily opened.

Procedures

Preliminary

- Customer contact: when customers request information prior to placing orders they are given specifications for physical dimensions and activity limits, emphasizing that submitted sources must be electrically conductive. Customers are directed to place their order on the E-commerce storefront, or to contact calibration service staff for assistance in setting up a profile in the system. A copy of the purchasing documentation is obtained for the test binder. The customer is provided the NIST shipping address, including the assigned RS number and indicating RSD Building 245, Room H113 to ensure that RSD receives the package directly. They are also instructed to wait until safety paperwork is approved before shipping.

- NIST paperwork and acceptance procedure: submit NIST 364, “Radioactive Material Request,” for approval via the Radiation Safety Information Management System (RSIMS). Once approved the customer is notified to ship the source(s). After receipt, the source(s) are cleared by RSD, the order is updated in e-commerce to reflect the source(s) have arrived and measurements will begin.

Source Receipt from RSD

- Review 364 to determine if any contamination was found on source and packaging materials during RSD check-in.
- Inspection for damage - if damage such as broken seals has occurred, the customer will be notified before proceeding with the calibration.
- Record identification information (including RSD-assigned radioactive source RS #) on the log sheet.
- Test check measurements - perform measurement of the alpha- or beta-particle emitting standard to ensure the system is operating correctly.

- E-commerce orders – record the order number assigned to the calibration.

Note dates of all steps completed including material received and returned on the log sheet.

General Operational Procedures

The measurements are taken in the following order: background, standard reference source, submitted source(s), and finally, blank. Counting times are adjusted so that 10^6 counts are collected from each source, whenever possible. The functioning of the instrument is checked by comparing the measurement results for the standard, corrected for decay and background, with previous results. The spreadsheet calculations, described in the Alpha and Beta Laboratory Procedures document (ABLP), are cross-checked with computer software calculations. The data are corrected and reduced, as described in the ABLP. The results are reviewed and used to create calibration reports. The calibration report is checked, proof-read, and signed. Copies of the report are made for the current alpha and beta test record binder and an electronic version is uploaded to the order. Calibration results are stored both in binders and in the computer; the binder storage and computer access are both securely maintained. The calibration date and other important dates are recorded in the test record binder with other pertinent information.

Calibration Procedures

Procedures for calibrations using four instruments are described in the ABLP: (1) small-area, (2) large-area, (3) PIPS and (4) external counter.

At the completion of measurements, calculations, and corrections, results are entered into a comparison spreadsheet. Results for sources that have been calibrated in the past are compared to previous results, accounting for decay. The difference should be less than 2 % or further investigation is necessary. Results for sources that have not been previously calibrated are compared to manufacturers' certified, or customer provided, values. When these values differ by greater than 2 %, uncertainties for the values are summed and compared to the difference. If the values differ by more than the combined uncertainties, other factors (ex. age and condition) are considered, the customer may be asked to provide more information about the source and how it has been used.

Determination of Uncertainties

The basis for the determination of uncertainties associated with alpha- and beta-particle calibrations is *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results* (see reference #2).

Uncertainty components are given below. All uncertainties are Type B except for counting statistics and background, which are Type A.

Significant Uncertainties

Counting statistics - this value was obtained from the standard deviation of replicate measurements

Background – based on statistical estimate

Live-time – determined from systematic tests using a NIST live-time module (see reference #6)

Extrapolation– estimated from largest possible variability in assumed extrapolation functionality, geometry of the source will impact the method of extrapolation (see reference #5)

Self-absorption and scattering from source and support - estimated from customer stated source thickness and inaccuracies in back-scattering factors

Recognized Uncertainties

The following uncertainties are recognized but are not significant.

Counter geometry - the values were obtained from estimated mechanical accuracies measurements made on the systems

Extension and non-uniformity of the sources- this was derived from known limitations in the accuracies of measurements because of source size

Scattering in/on detector – estimated from known parameters

Transmission through detector (no count) – based on comparisons with standards using other direct measurement methods

References

1. The Standardization of Alpha-Particle Sources, L.L. Lucas. Proceedings of the ASTM Conference of Effluent and Environmental Surveillance, July 9-14, 1978, Johnson, Vermont, in ASTM Spec. Tech. Publ. 698, pp. 342-354 (1980).

2. Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results, Barry N. Taylor and Chris Kuyatt. NIST Technical Note 1297, (1994).

3. Alpha-Particle Calibrations, J. M. Robin Hutchinson. N.B.S. Special Publication 250-5, U.S. Government Printing Office, Washington D.C. 20402-9325 (1987).

4. Counting Yields for Beta and Alpha Particle Sources, Martin Berger. NISTIR 6464, (2000).

5. Large area alpha sources with a lip: Integral counting and spectral distortions, King, L; Fitzgerald, R ; Tosh, RE. Applied Radiation and Isotopes. V134, April 2018, pp.376-379 (2018).

6. Accurate Integral Counting using Multi-Channel Analyzers (MCAs), Fitzgerald, R.; King, L., Applied Radiation and Isotopes. V159, May 2020 (2020)

Records

Log sheets include customer name and contact information, date received, kind of source, source number and identification including RS and e-commerce order numbers, date calibrated, and date returned to customer. Copies of the shipping, and RSD check records are kept with the log sheet.

Alpha and beta test record binders include hard copies of calibration results, customer calibration spreadsheets, certificates/reports, and the records described above. Electronic records include data processing spreadsheets with spectra, copies of certificates/reports and spreadsheets used to compare standard and customer calibration source measurement results, as well as a scanned copy of the paperwork package kept in the binder.

Documents

Alpha and Beta Laboratory procedures include the detailed step-by-step instructions for the use of each of the four counters, the data collection and reduction file names and file locations for these calibration files.

Filing and Retention

All paper copies of customer files are stored in the alpha- and beta-test binders kept in building 245 room H220 or the investigators office (building 245 room C300-WSAD). All customer-related electronic files are stored on password-protected laboratory computers (building 245 room H220), the investigator's computer (building 245 room C300-WSAD), or the division protected shared network drive. Each of the above computers is backed up on an external drive maintained by the investigator.
Copies of the alpha and beta laboratory procedures are kept in the laboratory where the equipment is used (building 245, room H220) and in the investigator's office (building 245, room C300-WSAD).

APPENDIX A

Table of Uncertainties

Factor	Type A Relative Uncertainty (k=1) percent	Type B Relative Uncertainty (k=1) percent
Counting statistics	0.04-2.10	
Background	0.1	
Live time		0.20-2.25
Extrapolation		0.20-5.20
Uncertainties Combined Quadrature	0.11-2.10	0.28-5.70 in
Relative Expanded Uncertainty (k = 2, an approximate level of confidence of 95 %.)		0.60-12.20

APPENDIX B

National Institute of Standards & Technology

REPORT OF CALIBRATION

for

Company, Incorporated
123 Standards Drive
Towntown, State 03691

Radionuclide	Lynolium-239
Source identification	L5389
2π alpha-particle counting rate	2.416×10^2 s^{-1} (1)*
Expanded uncertainty ($k = 2$)	1.2 percent (2)
Measurement date (Reference time)	12:00 EST, 09 January 2023
Measuring instrument	NIST 2πα/β proportional counter (3)

Measurements Performed by

Lynne King, Physical Scientist

Approved by,

Brian E. Zimmerman, Leader
Radioactivity Group
Physical Measurement Laboratory

Alan K. Thompson, Acting Chief
Radiation Physics Division
Physical Measurement Laboratory
For the Director of the National Institute of Standards and Technology

Gaithersburg, MD 20899
Report Issued: February 2023
Service ID No.: 43030C
Order No.: 682.04/O-123457891-23

*Notes on back

Page **1** of **2**

NOTES

(1) Radionuclide identification is based on information provided by the customer or the manufacturer's report. Unless stated, there has been no attempt to confirm this information or identity impurities.

(2) The result relates only to the source calibrated, L5389. The 2π alpha-particle counting rate is the total number of alpha particles counted (including those scattered) per second emitted into a 2π-steradian geometry and is traceable to the NIST standard for the second. Five measurements are taken with a sum-total of one million or more counts. The 2π alpha-particle counting spectra are reduced, background subtracted, extrapolated to zero energy, decayed to reference time, and integrated . The result is corrected for dead-time and rounded to four significant figures. The data are reviewed for accuracy by at least one other person familiar with the method.

(3) The uncertainty analysis methodology and nomenclature used for the reported uncertainties are based on uniform NIST guidelines and are compatible with those adopted by the principal international metrology standardization bodies [cf., B.N. Taylor and C.E. Kuyatt, *NIST Technical Note 1297* (1994)].

The combined standard uncertainty, u_c = 0.62 percent, is the quadratic combination of the standard deviations (or standard deviations of the mean where appropriate), or approximations thereof, for the following component uncertainties:

a)	one standard deviation of the mean of five measurements	0.09 percent
b)	pulse-height extrapolation Difference in the extrapolated value between the estimate based on horizontal extrapolation from the minimum point on the spectrum to that from the same spectral point to zero count rate at zero energy	0.58 percent
c)	live-time correction Estimate of uncertainty in the live-time correction determined from systematic tests using a NIST live-time module	0.20 percent

The expanded uncertainty, U = 1.2 percent, is obtained by multiplying u_c by a coverage factor of k = 2 and is assumed to provide an uncertainty interval of approximately 95 percent confidence.

(3) The functioning of the instrument is checked by comparing measurement results corrected for decay and background, of the plutonium standard AC-8171.

For further information, contact Brian Zimmerman at (301) 975-4338 or Lynne King at (301) 975-5544.

Order No.:682.04/O-123457891-23
Source Identification: L5389

National Institute of Standards & Technology

REPORT OF CALIBRATION

for

Company, Incorporated
123 Standards Drive
Towntown, State 03691

Radionuclide	Lynolium-238
Source identification	FJ538
2π alpha-particle counting rate	1.455×10^5 s^{-1} (1)*
Expanded uncertainty ($k = 2$)	4.3 percent (2)
Measurement date FJ514 (Reference time)	12:00 EST, 30 January 2023
Measuring instrument	NIST 2πα/β proportional counter (3) and "external" Si counter

Measurements Performed by

Lynne King, Physical Scientist

Approved by,

Brian E. Zimmerman, Leader
Radioactivity Group
Physical Measurement Laboratory

James M. Adams, Acting Chief
Radiation Physics Division
Physical Measurement Laboratory
For the Director of the National Institute of Standards and Technology

Gaithersburg, MD 20899
Report Issued: February 2023
Service ID No.: 43030C
Order No.: 682.04/O-123457890-23

*Notes on back

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NOTES

(1) Radionuclide identification is based on information provided by the customer or the manufacturer's report. Unless stated, there has been no attempt to confirm this information or identity impurities.

(2) The result relates only to the source calibrated, FJ538. The 2π alpha-particle counting rate is the total number of alpha particles counted (including those scattered) per second emitted into a 2π-steradian geometry and is traceable to the NIST standard for the second. Five measurements are taken with a sum-total of one million or more counts. The 2π beta-particle counting spectra are reduced, background subtracted, extrapolated to zero energy, decayed to reference time, and integrated. The result is corrected for dead-time and rounded to four significant figures. The data are reviewed for accuracy by at least one other person familiar with the method.

Due to the high activity of FJ538, the 2π alpha-particle counting rate, was determined by using an "external" counter to measure the ratio of the count rate for FJ538 to that of a lower-activity source (FJ514), then scaling that ratio by the measured 2π alpha-particle counting rate of FJ514. The "external" measurements were averaged over the same 5 positions on each source.

(3) The uncertainty analysis methodology and nomenclature used for the reported uncertainties are based on uniform NIST guidelines and are compatible with those adopted by the principal international metrology standardization bodies [cf., B.N. Taylor and C.E. Kuyatt, *NIST Technical Note 1297* (1994)].

The combined standard uncertainty, u_c = 2.13 percent, is the quadratic combination of the standard deviations (or standard deviations of the mean where appropriate), or approximations thereof, for the following component uncertainties:

a)	measurement variability Combinations in quadrature of the standard deviations of the mean for: 2π alpha-particle counting rate of FJ514 (0.04 %, N=5), "external" counting rate averaged over 5 positions (each an average of 3 repeat measurements) for FJ538 (1.19 %, N=5) and FJ514 (1.35 %, N=5)	1.80 percent
b)	pulse-height extrapolation Difference in the extrapolated value between the estimate based on horizontal extrapolation from the minimum point on the spectrum to that from the same spectral point to zero count rate at zero energy	1.08 percent
c)	live-time correction of value for FJ514 Estimate of uncertainty in the live-time correction determined from systematic tests using a NIST live-time module	0.38 percent

The expanded uncertainty, U = 4.3 percent, is obtained by multiplying u_c by a coverage factor of k = 2 and is assumed to provide an uncertainty interval of approximately 95 percent confidence.

(3) The functioning of the instrument is checked by comparing measurement results corrected for decay and background, of the plutonium standard AC-8171.

For further information, contact Brian Zimmerman at (301) 975-4338 or Lynne King at (301) 975-5544.
Order No.: 682.04/O-123457890-23
Source Identification: FJ538

National Institute of Standards & Technology

REPORT OF CALIBRATION

for

Company, Incorporated
123 Standards Drive
Towntown, State 03691

Radionuclide	Kinetium-90
Source identification	LK406
2π beta-particle counting rate	4.644×10^2 s^{-1} (1)*
Expanded uncertainty ($k = 2$)	1.5 percent (2)
Measurement date (Reference time)	12:00 EST, 15 January 2023
Measuring instrument	NIST $2\pi\alpha/\beta$ proportional counter (3)

Measurements Performed by

Lynne King, Physical Scientist

Approved by,

Brian E. Zimmerman, Leader
Radioactivity Group
Physical Measurement Laboratory

Alan k. Thompson, Acting Chief
Radiation Physics Division
Physical Measurement Laboratory
For the Director of the National Institute of Standards and Technology

Gaithersburg, MD 20899
Report Issued: February 2023
Service ID No.: 43040C
Order No.: 682.04/O-123457894-23

*Notes on back

NOTES

(1) Radionuclide identification is based on information provided by the customer or the manufacturer's report. Unless stated, there has been no attempt to confirm this information or identity impurities.

(2) The result relates only to the source calibrated, LK406. The 2π beta-particle counting rate is the total number of beta particles counted (including those scattered) per second emitted into a 2π-steradian geometry and is traceable to the NIST standard for the second. Five measurements are taken with a sum-total of one million or more counts. The 2π beta-particle counting spectra are reduced, background subtracted, extrapolated to zero energy, decayed to reference time, and integrated. The result is corrected for dead-time and rounded to four significant figures. The activity was calculated using the counting yield from M.J. Berger, NISTIR6464, Counting Yields for Beat and Alpha Sources (2000), supplemental-unpublished data, and information supplied by the manufacturer. North American Scientific states that Kinetium-90 is dispensed gravimetrically onto aluminum and covered with 0.9 mg/cm² aluminized mylar. The calculated activity for Kinetium-90 was 3.161×10^2 Bq on 15 March 2020 using an average depth of 0 μm. The data are reviewed for accuracy by at least one other person familiar with the method.

(3) The uncertainty analysis methodology and nomenclature used for the reported uncertainties are based on uniform NIST guidelines and are compatible with those adopted by the principal international metrology standardization bodies [cf., B.N. Taylor and C.E. Kuyatt, *NIST Technical Note 1297* (1994)].
The combined standard uncertainty, u_c = 0.75 percent, is the quadratic combination of the standard deviations (or standard deviations of the mean where appropriate), or approximations thereof, for the following component uncertainties:

a)	one standard deviation of the mean of five measurements	0.16 percent
b)	pulse-height extrapolation Difference in the extrapolated value between the estimate based on horizontal extrapolation from the minimum point on the spectrum to that from the same spectral point to zero count rate at zero energy	0.70 percent
c)	live-time correction Estimate of uncertainty in the live-time correction determined from systematic tests using a NIST live-time module	0.20 percent

The expanded uncertainty, U = 1.5 percent, is obtained by multiplying u_c by a coverage factor of k = 2 and is assumed to provide an uncertainty interval of approximately 95 percent confidence.

(3) The functioning of the instrument, which is a primary standard, is checked by comparing measurement results corrected for decay and background, of the plutonium standard DT178.

For further information, contact Brian Zimmerman at (301) 975-4338 or Lynne King at (301) 975-5544.
Order No.:682.04/ O-123457894-23
Source Identification: LK406

National Institute of Standards & Technology

REPORT OF CALIBRATION

for

Company, Incorporated
123 Standards Drive
Towntown, State 03691

Radionuclide	Lynolium-241 and Caldonium-148
Source identification	LK675
2π alpha-particle counting rate	6.282×10^2 Bq (1)*
Expanded uncertainty ($k = 2$)	1.5 percent (2)
Relative Activity	^{241}Ln: 52.5 ± 1.1 percent(3) ^{148}Ci: 47.5 ± 1.1 percent
Measurement date (Reference time)	12:00 EST, 12 January 2023
Measuring instrument	NIST 2πα/β proportional counter (4) and a passive implanted planar silicon (PIPS) detector

Measurements Performed by

Lynne King, Physical Scientist

Approved by,

Brian E. Zimmerman, Leader
Radioactivity Group
Physical Measurement Laboratory

Alan K. Thompson, Acting Chief
Radiation Physics Division
Physical Measurement Laboratory
For the Director of the National Institute of Standards and Technology

Gaithersburg, MD 20899
Report Issued: February 2023
Service ID No.: 43050C
Order No.: 682.04/O-123457895-23

*Notes on back

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NOTES

(1) Radionuclide identification is based on information provided by the customer or the manufacturer's report. Unless stated, there has been no attempt to confirm this information or identity impurities.

(2) The result relates only to the source calibrated, LK675. The 2π alpha-particle counting rate is the total number of alpha particles counted (including those scattered) per second emitted into a 2π-steradian geometry and is traceable to the NIST standard for the second. Five measurements are taken with a sum-total of one million or more counts. The 2π alpha-particle counting spectra are reduced, background subtracted, extrapolated to zero energy, decayed to reference time, and integrated. The result is corrected for dead-time and rounded to four significant figures. The data are reviewed for accuracy by at least one other person familiar with the method.

(3) The uncertainty analysis methodology and nomenclature used for the reported uncertainties are based on uniform NIST guidelines and are compatible with those adopted by the principal international metrology standardization bodies [cf., B.N. Taylor and C.E. Kuyatt, *NIST Technical Note 1297* (1994)].

The combined standard uncertainty, u_c = 0.73 percent, is the quadratic combination of the standard deviations (or standard deviations of the mean where appropriate), or approximations thereof, for the following component uncertainties:

a)	one standard deviation of the mean of five measurements	0.10 percent
b)	pulse-height extrapolation Difference in the extrapolated value between the estimate based on horizontal extrapolation from the minimum point on the spectrum to that from the same spectral point to zero count rate at zero energy	0.70 percent
c)	live-time correction Estimate of uncertainty in the live-time correction determined from systematic tests using a NIST live-time module	0.20 percent

The expanded uncertainty, U = 1.5 percent, is obtained by multiplying u_c by a coverage factor of k = 2 and is assumed to provide an uncertainty interval of approximately 95 percent confidence.

(3) The reported uncertainties in the relative activities are expanded uncertainties (k=2) and are computed, as above, from the following:

a) estimated standard deviation due to counting statistics	
^{241}Ln	0.22 percent
^{148}Ci	0.24 percent
b) estimated standard deviation for variations in the fitting function	0.5 percent
c) uncertainties due to background	0.1 percent

(4) The functioning of the instrument is checked by comparing measurement results corrected for decay and background, of the plutonium standard AC-8171.

For further information, contact Brian Zimmerman at (301) 975-4338 or Lynne King at (301) 975-5544.

Order No.:682.04/ O-123457895-23

Source Identification: LK675

Page **2** of **2**

APPENDIX C

Special Tests; 43031S

This addendum is to explain the additional procedures for the calibration of sources, outside the source descriptions listed for services; 43030C, 43040C, and 43050C, and for proficiency testing to meet the requirements for ISO 17043:2010. The procedures and measurements described in the body of this procedure are applicable to these tests. Additional measurements may be necessary when detailed analysis is requested or required.

Procedures

For the calibration of sources not eligible for services 43030C, 43040C, and 43050C:

The objective of the test should be clearly communicated prior to the ordering of this service. A detailed description of the source's physical and radiological characteristics is necessary. When a blind test is required, the material is obtained by NIST and shipped to the customer.
The feasibility of conducting measurements and meeting the test objectives are assessed. Any limitations to the quality of the data are identified and discussed. An estimated cost is calculated based on the assessment and submitted to calibration services for attachment to the order in e-commerce.
The subsequent procedures are found in the main body of this document.

For proficiency tests:

These proficiency tests comply with the NIST QMS ISO/IEC 17025:2017 Appendix F for proficiency testing. This sub-level quality document provides the details of the additional requirements of ISO 17043:2010 for this measurement service proficiency test program.

Design of proficiency testing schemes

The protocol for each proficiency test will include the following details, taken from QMI, Appendix F, included below. Each participant will receive a personalized proficiency test protocol. A sample protocol is provided in this procedure with the required elements identified by the corresponding letter in red font.
a) the name and location of the NIST ***measurement service***;
b) identification of the ***proficiency testing*** program manager and other personnel involved in the design and operation of the ***proficiency testing*** scheme;

c) the activities to be conducted by NIST ***collaborators*** and the names and addresses of NIST ***collaborators*** involved in the operation of the ***proficiency testing*** scheme; collaborations do not exist for this proficiency test.
d) criteria to be met for participation if applicable;
e) the number and type of expected ***participants*** in the ***proficiency testing*** scheme;
f) selection of the measurand(s) or characteristic(s) of interest, including information on what the participants are to identify, measure, or test for in the specific ***proficiency testing round***;
g) a description of the range of values or characteristics, or both, to be expected for the ***proficiency test items***;
h) the potential major sources of errors involved in the area of ***proficiency testing*** offered;
i) requirements for the production, quality control, storage and distribution of ***proficiency test items***;
j) reasonable precautions to prevent collusion between ***participants*** or falsification of results, and procedures to be employed if collusion or falsification of results is suspected;
k) a description of the information which is to be supplied to ***participants*** and the time schedule for the various phases of the ***proficiency testing*** scheme;
l) for continuous ***proficiency testing*** schemes, the frequency or dates upon which proficiency test items are to be distributed to ***participants***, the deadlines for the return of results by ***participants*** and, where appropriate, the dates on which testing or measurement is to be carried out by ***participants***;
m) any information on methods or procedures which ***participants*** need to use to prepare the test material and perform the tests or measurements;
n) procedures for the test or measurement methods to be used for the homogeneity and stability testing of proficiency test items and, where applicable, to determine their biological viability;
o) preparation of any standardized reporting formats to be used by ***participants***;
p) a detailed description of the statistical analysis to be used;
q) the origin, ***metrological traceability,*** and ***measurement uncertainty*** of any ***assigned values***;
r) criteria for the evaluation of performance of ***participants***;
s) a description of the data, interim reports, or information to be returned to ***participants***;
t) a description of the extent to which ***participant*** results, and the conclusions that will be based on the outcome of the ***proficiency testing*** scheme, are to be made public; and
u) actions to be taken in the case of lost or damaged ***proficiency test items***.

Procurement of proficiency test item(s)

An appropriate radioactive material and geometry are identified and transferred or purchased specifically for testing. Initial measurements are conducted by NIST in the alpha/beta laboratory. The material is dedicated to use for the test until the proficiency test is complete.

Homogeneity and stability

Initial measurements will result in multiple sets of data that are analyzed to ensure consistency. These measurements will be repeated as frequently as needed depending upon the half-life of the radionuclide and the number of participants. The physical condition of the material will be examined with each set of measurements to identify any changes and possible damage. Results from subsequent and final measurements taken at NIST will be compared to the initial results to determine if identified or unidentified changes constitute damage to the source that may impact participants' results.

Cancelled tests

If test material damage has compromised the reproducibility of measurement data or the test material is lost, the test will be stopped. Other unexpected circumstances that may require test cancelation or postponement include source contamination, equipment failure, and restricted laboratory access.

Statistical design

The statistical design used for proficiency test data is the same as that used for the calibration service 43030C. Five measurements are taken with a sum-total of one million or more counts. The spectra are integrated, reduced, background subtracted, and extrapolated to zero energy to find the NIST value that is compared to the participant's result. Appendix A is a table of the uncertainties applicable to this test. The uncertainty analysis methodology and nomenclature used for the reported uncertainties are based on uniform NIST guidelines and are compatible with those adopted by the principal international metrology standardization bodies (see Ref. 2).

NIST does not assign a pass or fail status to completed test. If the accreditation program deems a test failed, the NIST technical coordinator can be contacted to discuss possible sources of error.

Assigned values

The 2π particle counting rate is the total number of particles counted (including those scattered) per second emitted into a 2π-steradian geometry and is traceable to the

NIST standard for the second. The 2π particle counting rate is found by measuring a radioactive source on one the primary standard measuring instruments; NIST small-area 2πα, NIST large-area 2πα/β and expressed in units of counts per second. This realization of the 2π particle emission rate for the source establishes the National Standard, which can in turn be transferred to other measurement facilities through suitable measuring instruments, thus enabling traceability to the National Standard.

Method or procedure

The participant must have a windowless-gas flow 2π proportional counting primary standard measuring instrument. Using their established measurement methods and procedures, the participant will find and provide NIST with the resulting particle count rate for the material distributed for the test. The reference date and uncertainty will also be reported.

Instructions for participants

The proficiency test is requested by the participant or group of participants. The dates for the test are determined on a mutually agreed upon schedule and adjusted as needed for procurement of test material. Instructions for the test are provided in the test protocol.

Proficiency test items handling and storage

Upon receipt, the test material is received by NIST RSD checked and added to the NIST Radioactive Materials inventory. Results are reported prior storage in the alpha/beta laboratory where NIST measurements will be taken. With each shipment from NIST the test material will be loaned to the participant(s) until the return shipment is received. The test material will again be checked by RSD, before returning to the alpha/beta laboratory for measurement and/or storage. RSD leak test results will be the first inspection for damage with each shipment to NIST.

Distribution of proficiency test sources

The test material is securely packed in reusable boxes. Department of Transportation (DOT) standards are met when packaging, labeling and marking, and preparing documents for shipment, 49 CFR 173. In order to protect the measurand value, a range or over-estimate will be used for the activity on all shipping documentation. The cost of shipping shall be the responsibility of the shipper.

Proficiency testing analysis and evaluation

The data analysis and records are handled as described in the **Records** and **Filing and Retention** sections for these calibration services. The performance evaluation is

limited to a direct comparison expressed as a percent difference. Generally, NIST commentary is not provided since the accrediting body will apply criteria and analyze the results. When results vary greatly some participants may be encouraged to check the calculations and equipment settings.

Reports

The NIST report of proficiency test for each test will include the following details, taken from QMI, Appendix F. A sample report is provided in this procedure with the required elements identified by the corresponding letter in red. NIST proficiency testing reports include the following, unless it is not applicable or the NIST proficiency testing program has valid reasons for not doing so:

a) the name and contact details for the NIST ***proficiency testing*** program;
b) the name and contact details for the coordinator;
c) the name(s), function(s), and signature(s) or equivalent identification of person(s) authorizing the report;
d) an indication of which activities are performed by the ***participant(s)***;
e) the date of issue and status (e.g. preliminary, interim, or final) of the report;
f) page numbers and a clear indication of the end of the report;
g) a statement of the extent to which results are confidential;
h) the report number and clear identification of the proficiency testing scheme;
i) a clear description of the ***proficiency test items*** used, including necessary details of the ***proficiency test item's*** preparation and homogeneity and stability assessment;
j) the ***participants'*** results;
k) statistical data and summaries, including ***assigned values*** and range of acceptable results and graphical displays;
l) procedures used to establish any assigned value;
m) details of the ***metrological traceability*** and ***measurement uncertainty*** of any assigned value;
n) procedures used to establish the standard deviation for proficiency assessment, or other criteria for evaluation;
o) ***assigned values*** and summary statistics for test methods/procedures used by each group of ***participants*** (if different methods are used by different groups of ***participants***);
p) comments on ***participants'*** performance by the NIST ***proficiency testing*** program and technical advisers;
q) information about the design and implementation of the ***proficiency testing scheme***;
r) procedures used to statistically analyze the data;

s) advice on the interpretation of the statistical analysis, only when applicable; and
comments or recommendations, based on the outcomes of the *proficiency testing round,* only when applicable. When it is necessary to issue a new or amended report for a *proficiency testing scheme*, the report includes the following:

a) a unique identification;
b) a reference to the original report that it replaces or amends; and
c) a statement concerning the reason for the amendment or re-issue.

Communication with participants

The NIST calibration ordering system includes the option to request proficiency testing and provides the following details.

a) documented eligibility criteria for participation;
b) confidentiality arrangements; and
c) details of how to apply.

If changes to the ***proficiency test scheme*** design or operation are required, the participant will be notified by email. If the results conclude in a performance that the participant needs to appeal, a retest will be offered at the expense of the participant, after an investigation by NIST and the participant. The participant must communicate the error of the previous test and the reason for the request to retest. If an error was made by NIST, the proficiency test will be repeated at no expense to the participant. If no reason is determined for poor performance, the test can be repeated at the expense of the participant. The communication with the participant is documented in the data file associated with the proficiency test. If statements of participation or performance are issued by a NIST ***proficiency testing*** program, the statements will contain sufficient information as to not be misleading.

National Institute of Standards and Technology

PROFICIENCY TEST PROTOCOL FOR ALPHA CALIBRATIONS

For

The Participants complete name and address

Reference Standard Identification: AB1234
NIST Order # O-123457896-23

A NIST Proficiency Test is being conducted to determine the capabilities of the calibration facility of each participant to transfer a NIST reference standard measurement of the 2π emission rate from a standard alpha particle emitting radioactive source using a gas flow proportional counter and by such, demonstrating NIST traceability.

NIST Technical Coordinator (b): Lynne King

Participating Laboratory Technical Contact (e): Contact Name

Start of Test: Month, Year (k)

Anticipated Completion of Test: Month, Year (k)

Information on technical aspects of this report can be obtained from Lynne King, National Institute of Standards and Technology, 100 Bureau Drive Stop 8462, Gaithersburg, MD 20899,
(301) 975-5544, lynne.king@nist.gov.

Report format revised: September 22, 2022
U.S. Department of Commerce

Procedure

To fulfill the testing requirement for *accreditation body*, the *Participant* (e) or *Group of Participants* have requested a proficiency test with NIST, *if applicable*. One (or more) Wide Area Alpha Source(s) has been procured by NIST and the 2π alpha-particle emission rate (g) from this source has been realized. The realization of the 2π alpha-particle emission rate for this source on one of the NIST primary standards; small-area $2\pi\alpha$ proportional counter, large-area $2\pi\alpha/\beta$ proportional counter in the alpha/beta laboratory building 245, room H220 (a) at NIST Gaithersburg establishes the National Standard, which can in turn be transferred to other measurement facilities through suitable measuring instruments, thus enabling traceability to the National Standard (q).

This protocol for proficiency testing involves the realization of the 2π alpha-particle counting rate from a solid-metal, alpha-particle-emitting anodized aluminum source by each of the participating facilities. After the participating facility uses their own counting system to determine the 2π emission rate from the source sent by NIST, the source shall be sent to the next participating facility or back to NIST as indicated in the shipping section of this protocol. The participants shall provide NIST with the results of the measurement of the 2π emission rate found at their facility in units of counts/second (s^{-1}) and the associated uncertainty as a percent. The comparative results will be included in a Report of Traceability issued upon the completion of the test. The results will reveal the degree to which the participating calibration facility demonstrated proficiency in the measurement of alpha-particle counting rate under the conditions of the said facility at the time of the proficiency test. Questions or concerns should be directed to the NIST technical contact listed in this protocol and no communication concerning the test should exist amongst participants until the results of all tests have been issued by NIST. (j)

Criteria to be met for participation (d)

The participant must have a measurement method capable of producing results in the units of the measurand or in units that can be converted to the units of the measurand. The method must not depend upon a destructive assay. The source shall remain unchanged by the method.

Deliverables to NIST by each participant (f)

Upon the completion of the test, each participant shall provide the value of the 2π alpha-particle counting rate in the units s^{-1}, the reference time indicating the date measured, the expanded uncertainty, and the measuring instrument used. In addition, please include any corrections applied.

Source handling, storage, and measurement in the NIST facility: (n)

Upon arrival, the source and packaging are checked for contamination. The back of the source And any packaging material that has been in contact with the active area of the source are checked for alpha contamination. The active area of the source is not touched during this process. The source is kept in a closed box while not in use. Backgrounds are taken and subtracted from the measurement. A check source is measured first to ensure proper functioning of the measurement system. Initial measurements will result in multiple sets of data that are analyzed to ensure consistency. These measurements
will be repeated as frequently as needed depending upon the half-life of the radionuclide and the number of participants. The physical condition of the material will be examined with each set of measurements to identify any changes and possible damage. Results from subsequent and final measurements taken at NIST will be compared to the initial results to determine if identified or unidentified changes constitute damage to

the source that may impact participants results.

Source: NISTDGN Eckert and Ziegler Alpha Wide Area Reference Source 13316-17
Product code: PPRBl6637
Drawing: Dimensions of active surface: VZ-1367-001
Overall dimensions: 25mm 30mmx 3mm
Source ID:
Radionuclide:
NIST Measuring Instrument: Large-Area $2\pi\alpha$ gas proportional counter 13317-17
Potential Applied to wires: 750 volts
Gas: P-10, Argon methane mixture
Orientation: The center of the chamber platform
Distance: X cm from the wires.

Participants Source Handling, Storage, and Shipping Instructions

Each participant shall keep the source for no more than 3 weeks to complete the measurement. (k) Upon arrival, the source and packaging are checked for contamination. The back of the source and any packaging material that has been in contact with the active area of the source are checked for contamination. The active area of the source is not touched during this process. (m) The source is kept in a closed box while not in use. (i)

Please follow the schedule and dates listed below to avoid delays. The cost of shipping shall be the responsibility of the shipper. All shipments shall be made overnight to avoid long transient times and damage to the sources. Please avoid shipping over a weekend. Below is the contact information required for the proper shipment of the source. The tracking information will be provided by the participant and shipping insurance shall cover the cost of replacement in case of loss or damage. (u)

If a change is required contact the NIST coordinator. If changes are necessary, the affected participants will be notified as soon as possible. The final participant should return the chamber to NIST using the address shown below.

Shipping Addresses

First Participant
Ship to next participant no later than (k) Thursday March 30, 2022 ATTN: **Adam One**
The First Corporation
111 A Place
City, ST 12341
Phone: (123) 456-7891
Email: adam.1@first.plc

Second Participant
Ship to next participant no later than (k) Thursday April 27, 2022 ATTN: **Beth Two**
The Second Command
U.S. Department of Commerce

222 B Court
City, ST 12342

Phone: (123) 456-7892
E-Mail:
beth.2@second.plc

Third Participant
Ship to next participant no later than (k) Thursday May 25,2017 ATTN: **Chad Three**
The Third Place
333 C Street
City, ST 12343

Phone: (123) 456-7893
Email: chad.3@third.plc

Fourth Participant
Ship back to NIST no later than (k) Thursday June 22, 2017
ATTN: **Darlene Four**
444 D Lane
City, ST 12344

Phone: 123-456-7894
Email: darlene.4@forth.plc

NIST Return Address and Contact Information

National Institute of Standards and Technology
ATTN: RS #
100 Bureau Dr., Bldg. 245, Room H113
(RSD) Gaithersburg, MD 20899

Phone: 301-975-5544
Email: lynne.king@nist.gov

Participant Results (o)

Each participant shall provide NIST with a single value found from the facilities measurement(s), the reference time for the value, and any corrections applied. The uncertainty for this value should also be included. The measurement method can be provided by listing the instrument used.

Canceled tests

If test material damage has compromised the reproducibility of measurement data or the test material is lost, the test will be stopped. Other unexpected circumstances that may require test cancelation or postponement include source contamination, equipment failure and restricted laboratory access. If collusion or falsification of the results is suspected then the test will be terminated, fees applied and another test with associated fees will be required.

U.S. Department of Commerce

NIST Final Report (s)

At the conclusion of the test each participant will receive a report. Final reports can be downloaded from the order in the participant's e-commerce account. Upon request, the report can be e-mailed once the account payment has been confirmed. Each report will include, NIST: results, reference time, uncertainty, and measurement method as well as the participants: results, reference time, uncertainty, and the measurement method when specified, and the participants difference from NIST as a percentage.

Potential Sources of Error (h, m)

Unstable gas flow or incorrect gain and voltage settings can contribute to error. Particle type and energy should be considered when determining settings.

Statistical Design (d, p, r)

At NIST, the source is measured 5 times with a sum-total of one million or more counts. The standard deviation of these measurements is used in the uncertainty analysis. The proficiency test is a comparison of the measurement results at NIST and the participating facility. The criteria for the comparison are established by the accreditation program, not by NIST. NIST does not assign a pass or fail status to completed tests. If the accreditation program deems a test failed, the NIST technical coordinator can be contacted to discuss possible sources of error.

Confidentiality, Collusion and Falsification (j, t)

Access to identification of the test results is limited to authorized quality management system calibration staff. Summary reports may be published but the identity of the participants is withheld. It is the decision and responsibility of the participant to submit proficiency test results to the accreditation organization. If collusion or falsification of the results is suspected then the test will be terminated, fees applied and another test with associated fees will be required.

Sample Report

National Institute of Standards & Technology

REPORT OF PROFICIENCY TEST

LYNOLIUM-238

Participant	Source Supplier, Incorporated (a) 123 Standards Drive Towntown, State 03691	
Source identification	LX648	
Source description	Lynolium-238 large-area alpha [1]* (i)	
	NIST DATA	**PARTICIPANT'S DATA**
2π alpha-particle counting rate (o)	$2.981 \times 10^4\ s^{-1}$ [2]	$3.037 \times 10^4\ s^{-1}$ (j)
Reference time (o)	October 2, 2022	October 16, 2022
Expanded uncertainty (o)	1.4 percent [3]	2.5 percent
Difference from NIST		1.91 percent (p)
Measuring instrument (o)	NIST large-area $2\pi\alpha$ proportional counter [4]	Gas proportional counter (d)

Measurements performed by

Lynne King, Physical Scientist

Approved by,

Brian E. Zimmerman, Leader (c)
Radioactivity Group
Physical Measurement Laboratory

Alan K. Thompson, Acting Chief (c)
Radiation Physics Division
Physical Measurement Laboratory
For the Director of the National Institute of Standards and Technology

Gaithersburg, MD 20899
Final Report Issued: October 2022 (e)
Service ID No.: 43031S
NIST Order No.: 682.04/O-123457896-23 (h)

*Notes on page 3

(over)

Page 1 of 3 (f)

As guidance for the proper use of this Report, it should be emphasized that the National Institute of Standards and Technology is concerned only with fostering good measurements capability and consistency with the national measurements system. The assurance of the proper application of that capability to the ultimate consumer products is the responsibility of each manufacturer of these products and of the Federal regulatory agencies.

A continuing traceability program in radioactivity demonstrates, to the degree established by the periodic assays of calibrated radioactivity samples, a continuing competence to maintain the instrument systems and standards necessary for accurate measurement. Such a program cannot, however, endorse each and every measurement or the final product, any more than a spot check can vouch for every unchecked item. Care should be taken, therefore, not to imply such endorsement. The proper use of this Report is governed by section 200.114 of Title 15 of the Code of Federal Regulations. These regulations may be met if Reports are quoted only in their entirety. Excerpts out of context may be misleading.

NOTES

(1) Source Supplier Inc. states that the active dimension of the source is 127 mm x 205 mm with a total source dimension of 143 mm x 219 mm, and a thickness of 7 mm. Radionuclide identification is based on information provided by the customer or the manufacturer's report. Unless stated, there has been no attempt to confirm this information of identify impurities.

(2) The result relates only to the source calibrated, LX648. The 2π alpha-particle counting rate is the total number of alpha particles counted (including those scattered) per second emitted into 2π-steradian geometry and is traceable to the NIST standard for the second. Five measurements are taken with a sum-total of one million or more counts. The 2π alpha-particle counting spectra are reduced, background subtracted, extrapolated to zero energy, decayed to referenced time, and integrated. The result is corrected for dead-time and rounded to four significant figures. The data are reviewed for accuracy by at least one other person familiar with the method. (l)

(3) The uncertainty analysis methodology and nomenclature used for the reported uncertainties are based on uniform NIST guidelines and are compatible with those adopted by the principal international metrology standardization bodies [cf., B.N. Taylor and C.E. Kuyatt, *NIST Technical Note 1297* (1994)].

The combined standard uncertainty, $u_c = 1.2$ percent, is the quadratic combination of the standard deviations (or standard deviations of the mean where appropriate), or approximations thereof, for the following component uncertainties: (l,r)

a)	one standard deviation of the mean of five measurements (n)	0.10 percent
b)	pulse-height extrapolation Difference in the extrapolated value between the estimate based on horizontal extrapolation from the minimum point on the spectrum to that from the same spectral point to zero count rate at zero energy	0.70 percent
c)	live-time correction Estimate of uncertainty in the live-time correction determined from systematic tests using a NIST live-time module	0.20 percent

The expanded uncertainty, $U = 2.5$ percent, is obtained by multiplying u_c by a coverage factor of $k = 2$ and is assumed to provide an uncertainty interval of approximately 95 percent confidence. (m,r)

(4) The functioning of the instrument is checked by comparing measurement results corrected for decay and background, of the plutonium standard AC-8171.

(5) The proficiency test protocol corresponding to the NIST order number below was designed for implementation by the participant for the measurement of the source identified below. (g) The test results will remain confidential, any published summary reports will exclude identification of the participant. (q)

For further information contact Brian Zimmerman at (301) 975-4338 or Lynne King at (301) 975-5544. (b)

NIST Order No.: 682.04/O-123457896-23 (h)
Source Identification: LX648 (h)

Page 3 of 3 (f)

Non-PT Reports

National Institute of Standards & Technology

REPORT OF TEST

for

Company, Incorporated
123 Standards Drive
Towntown, State 03691

Radionuclide	Lynolium-239 (1)*
Source identification	L5389
2π alpha-particle counting rate	2.416×10^{2} s^{-1} (2)
Expanded uncertainty ($k = 2$)	1.2 percent (3)
Measurement date (Reference time)	12:00 EST, 09 November 2022
Measuring instrument	NIST 2πα/β proportional counter (4)

Measurements Performed by

Lynne King, Physical Scientist

Approved by,

Brian E. Zimmerman, Leader
Radioactivity Group
Physical Measurement Laboratory

Alan K. Thompson, Acting Chief
Radiation Physics Division
Physical Measurement Laboratory
For the Director of the National Institute of Standards and Technology

Gaithersburg, MD 20899
Report Issued: November 2022
Service ID No.: 43031S
Order No.: 682.04/O-123457891-22

*Notes on back

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NOTES

(1) Radionuclide identification is based on information provided by the customer or the manufacturer's report. Unless stated, there has been no attempt to confirm this information or identify impurities.

(2) The result relates only to the source calibrated, L5389. The 2π alpha-particle counting rate is the total number of alpha particles counted (including those scattered) per second emitted into a 2π-steradian geometry and is traceable to the NIST standard for the second. Five measurements are taken with a sum-total of one million or more counts. The 2π alpha-particle counting spectra are reduced, background subtracted, extrapolated to zero energy, decayed to reference time, and integrated. The result is corrected for dead-time and rounded to four significant figures. The data are reviewed for accuracy by at least one other person familiar with the method.

(3) The uncertainty analysis methodology and nomenclature used for the reported uncertainties are based on uniform NIST guidelines and are compatible with those adopted by the principal international metrology standardization bodies [cf., B.N. Taylor and C.E. Kuyatt, *NIST Technical Note 1297* (1994)].

The combined standard uncertainty, $u_c = 0.62$ percent, is the quadratic combination of the standard deviations (or standard deviations of the mean where appropriate), or approximations thereof, for the following component uncertainties:

a)	one standard deviation of the mean of five measurements	0.09 percent
b)	pulse-height extrapolation Difference in the extrapolated value between the estimate based on horizontal extrapolation from the minimum point on the spectrum to that from the same spectral point to zero count rate at zero energy	0.58 percent
c)	live-time correction Estimate of uncertainty in the live-time correction determined from systematic tests using a NIST live-time module	0.20 percent

The expanded uncertainty, $U = 1.2$ percent, is obtained by multiplying u_c by a coverage factor of $k = 2$ and is assumed to provide an uncertainty interval of approximately 95 percent confidence.

(3) The functioning of the instrument is checked by comparing measurement results corrected for decay and background, of the plutonium standard AC-8171.

For further information, contact Brian Zimmerman at (301) 975-4338 or Lynne King at (301) 975-5544.

NIST Order No.:682.04/O-123457891-22
Source Identification: L5389

National Institute of Standards & Technology

REPORT OF TEST

for

Company, Incorporated
123 Standards Drive
Towntown, State 03691

Radionuclide	Lynolium-239 (1)*
Source identification	L5389
Activity	4.737×10^{2} s^{-1} (2)
Expanded uncertainty ($k = 2$)	2.4 percent (3)
Measurement date (Reference time)	12:00 EST, 09 November 2022
Measuring instrument	NIST 2πα/β proportional counter (4)

Measurements Performed by

Lynne King, Physical Scientist

Approved by,

Brian E. Zimmerman, Leader
Radioactivity Group
Physical Measurement Laboratory

Alan K. Thompson, Acting Chief
Radiation Physics Division
Physical Measurement Laboratory
For the Director of the National Institute of Standards and Technology

Gaithersburg, MD 20899
Report Issued: November 2022
Service ID No.: 43031S
Order No.: 682.04/O-123457891-22

*Notes on back

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NOTES

(1) Radionuclide identification is based on information provided by the customer or the manufacturer's report. Unless stated, there has been no attempt to confirm this information or identify impurities.

(2) The result relates only to the source calibrated, L5389. The 2π alpha-particle counting rate is the total number of alpha particles counted (including those scattered) per second emitted into a 2π-steradian geometry and is traceable to the NIST standard for the second. Five measurements are taken with a sum-total of one million or more counts. The 2π alpha-particle counting spectra are reduced, background subtracted, extrapolated to zero energy, decayed to reference time, and integrated. The result is corrected for dead-time and rounded to four significant figures. The activity is calculated by dividing by the efficiency, 0.51. The data are reviewed for accuracy by at least one other person familiar with the method.

(3) The uncertainty analysis methodology and nomenclature used for the reported uncertainties are based on uniform NIST guidelines and are compatible with those adopted by the principal international metrology standardization bodies [cf., B.N. Taylor and C.E. Kuyatt, *NIST Technical Note 1297* (1994)].

The combined standard uncertainty, $u_c = 1.18$ percent, is the quadratic combination of the standard deviations (or standard deviations of the mean where appropriate), or approximations thereof, for the following component uncertainties:

a) one standard deviation of the mean of five measurements — 0.09 percent

b) pulse-height extrapolation — 0.58 percent

Difference in the extrapolated value between the estimate based on horizontal extrapolation from the minimum point on the spectrum to that from the same spectral point to zero count rate at zero energy

c) live-time correction — 0.20 percent

Estimate of uncertainty in the live-time correction determined from systematic tests using a NIST live-time module

d) efficiency — 1.0 percent

The expanded uncertainty, $U = 2.4$ percent, is obtained by multiplying u_c by a coverage factor of $k = 2$ and is assumed to provide an uncertainty interval of approximately 95 percent confidence.

(3) The functioning of the instrument is checked by comparing measurement results corrected for decay and background, of the plutonium standard AC-8171.

For further information, contact Brian Zimmerman at (301) 975-4338 or Lynne King at (301) 975-5544.

NIST Order No.:682.04/O-123457891-22
Source Identification: L5389

Page 2 of 2

National Institute of Standards & Technology

REPORT OF TEST

for

Company, Incorporated
123 Standards Drive
Towntown, State 03691

Radionuclide	Kinetium-99 (1)*
Source identification	LK801
2π beta-particle counting rate	4.644×10^{2} s^{-1} (2)
Expanded uncertainty ($k = 2$)	2.6 percent (3)
Measurement date (Reference time)	12:00 EST, 03 November 2022
Measuring instrument	NIST 2πα/β proportional counter (4)

Measurements Performed by

Lynne King, Physical Scientist

Approved by,

Brian E. Zimmerman, Leader
Radioactivity Group
Physical Measurement Laboratory

Alan K. Thompson, Acting Chief
Radiation Physics Division
Physical Measurement Laboratory
For the Director of the National Institute of Standards and Technology

Gaithersburg, MD 20899
Report Issued: November 2022
Service ID No.: 43031S
Order No.: 682.04/O-123457891-22

*Notes on back

NOTES

(1) Radionuclide identification is based on information provided by the customer or the manufacturer's report. Unless stated, there has been no attempt to confirm this information or identity impurities.

(2) The result relates only to the source calibrated, LK801. The 2π beta-particle counting rate is the total number of beta particles counted (including those scattered) per second emitted into a 2π-steradian geometry and is traceable to the NIST standard for the second. Five measurements are taken with a sum-total of one million or more counts. The 2π beta-particle counting spectra are reduced, background subtracted, extrapolated to zero energy, decayed to reference time, and integrated. The result is corrected for dead-time and rounded to four significant figures. The data are reviewed for accuracy by at least one other person familiar with the method.

(3) The uncertainty analysis methodology and nomenclature used for the reported uncertainties are based on uniform NIST guidelines and are compatible with those adopted by the principal international metrology standardization bodies [cf., B.N. Taylor and C.E. Kuyatt, *NIST Technical Note 1297* (1994)].

The combined standard uncertainty, $u_c = 1.32$ percent, is the quadratic combination of the standard deviations (or standard deviations of the mean where appropriate), or approximations thereof, for the following component uncertainties:

a)	one standard deviation of the mean of five measurements	0.05 percent
b)	pulse-height extrapolation Difference in the extrapolated value between the estimate based on horizontal extrapolation from the minimum point on the spectrum to that from the same spectral point to zero count rate at zero energy	1.30 percent
c)	live-time correction Estimate of uncertainty in the live-time correction determined from systematic tests using a NIST live-time module	0.20 percent

The expanded uncertainty, $U = 2.6$ percent, is obtained by multiplying u_c by a coverage factor of $k = 2$ and is assumed to provide an uncertainty interval of approximately 95 percent confidence.

(4) The functioning of the instrument is checked by comparing measurement results corrected for decay and background, of the strontium/yttrium standard DT178.

For further information, contact Brian Zimmerman at (301) 975-4338 or Lynne King at (301) 975-5544.

Order No.:682.04/O-123457892-22
Source Identification: LK801

Page 2 of 2

National Institute of Standards & Technology

REPORT OF TEST

for

Company, Incorporated
123 Standards Drive
Towntown, State 03691

Radionuclide	Kinetium-90 (1)*
Source identification	LK406
2π beta-particle counting rate	4.644×10^{2} s^{-1} (2)
Expanded uncertainty ($k = 2$)	1.5 percent (3)
Measurement date FK514 (Reference time)	12:00 EST, 15 March 2022
Measuring instrument	NIST 2πα/β proportional counter (4)

Measurements Performed by

Lynne King, Physical Scientist

Approved by,

Brian E. Zimmerman, Leader
Radioactivity Group
Physical Measurement Laboratory

Alan K. Thompson, Acting Chief
Radiation Physics Division
Physical Measurement Laboratory
For the Director of the National Institute of Standards and Technology

Gaithersburg, MD 20899
Report Issued: April 2022
Service ID No.: 43031S
Order No.: 682.04/O-123457894-20

*Notes on back

NOTES

(1) Radionuclide identification is based on information provided by the customer or the manufacturer's report. Unless stated, there has been no attempt to confirm this information or identify impurities.

(2) The result relates only to the source calibrated, LK406. The 2π beta-particle counting rate is the total number of beta particles counted (including those scattered) per second emitted into a 2π-steradian geometry and is traceable to the NIST standard for the second. Five measurements are taken with a sum-total of one million or more counts. The 2π beta-particle counting spectra are reduced, background subtracted, extrapolated to zero energy, decayed to reference time, and integrated. The result is corrected for dead-time and rounded to four significant figures. The activity was calculated using the counting yield from M.J. Berger, NISTIR6464, Counting Yields for Beat and Alpha Sources (2000), supplemental-unpublished data, and information supplied by the manufacturer. North American Scientific states that Kinetium-90 is dispensed gravimetrically onto aluminum and covered with 0.9 mg/cm² aluminized mylar. The calculated activity for Kinetium-90 was 3.161×10^2 Bq on 15 March 2022 using an average depth of 0 µm. The data are reviewed for accuracy by at least one other person familiar with the method.

(3) The uncertainty analysis methodology and nomenclature used for the reported uncertainties are based on uniform NIST guidelines and are compatible with those adopted by the principal international metrology standardization bodies [cf., B.N. Taylor and C.E. Kuyatt, *NIST Technical Note 1297* (1994)].

The combined standard uncertainty, $u_c = 0.75$ percent, is the quadratic combination of the standard deviations (or standard deviations of the mean where appropriate), or approximations thereof, for the following component uncertainties:

a)	one standard deviation of the mean of five measurements	0.16 percent
b)	pulse-height extrapolation Difference in the extrapolated value between the estimate based on horizontal extrapolation from the minimum point on the spectrum to that from the same spectral point to zero count rate at zero energy	0.70 percent
c)	live-time correction Estimate of uncertainty in the live-time correction determined from systematic tests using a NIST live-time module	0.20 percent

The expanded uncertainty, $U = 1.5$ percent, is obtained by multiplying u_c by a coverage factor of $k = 2$ and is assumed to provide an uncertainty interval of approximately 95 percent confidence.

(3) The functioning of the instrument is checked by comparing measurement results corrected for decay and background, of the plutonium standard DT178.

For further information, contact Brian Zimmerman at (301) 975-4338 or Lynne King at (301) 975-5544.

Order No.:682.04/O-123457894-20
Source Identification: LK406

National Institute of Standards & Technology

REPORT OF TEST

for

Company, Incorporated
123 Standards Drive
Towntown, State 03691

Radionuclide	Lynolium-241 and Caldonium-148 (1)*
Source identification	REM00120401
2π alpha-particle counting rate	3.141×10^{2} s^{-1} (2)
Expanded uncertainty ($k = 2$)	2.5 percent (3)
Relative Activity	^{241}Ln: 52.5 ± 1.1 percent(4) ^{148}Ci: 47.5 ± 1.1 percent
Measurement date (Reference time)	12:00 EST, 12 March 2022
Measuring instrument	NIST 2πα/β proportional counter (5) and a passive implanted planar silicon (PIPS) detector

Measurements Performed by

Lynne King, Physical Scientist

Approved by,

Brian E. Zimmerman, Leader
Radioactivity Group
Physical Measurement Laboratory

Alan K. Thompson, Acting Chief
Radiation Physics Division
Physical Measurement Laboratory
For the Director of the National Institute of Standards and Technology

Gaithersburg, MD 20899
Report Issued: June 2022
Service ID No.: 43031S
Order No.: 682.04/O-123457895-22

*Notes on back

NOTES

(1) Radionuclide identification is based on information provided by the customer or the manufacturer's report. Unless stated, there has been no attempt to confirm this information or identify impurities.

(2) The result relates only to the source calibrated, REM00120401. The 2π alpha-particle counting rate is the total number of alpha particles counted (including those scattered) per second emitted into a 2π-steradian geometry and is traceable to the NIST standard for the second. Five measurements are taken with a sum-total of one million or more counts. The 2π alpha-particle counting spectra are reduced, background subtracted, extrapolated to zero energy, decayed to reference time, and integrated. The result is corrected for dead-time and rounded to four significant figures. The data are reviewed for accuracy by at least one other person familiar with the method.

(3) The uncertainty analysis methodology and nomenclature used for the reported uncertainties are based on uniform NIST guidelines and are compatible with those adopted by the principal international metrology standardization bodies [cf., B.N. Taylor and C.E. Kuyatt, *NIST Technical Note 1297* (1994)].
The combined standard uncertainty, $u_c = 0.73$ percent, is the quadratic combination of the standard deviations (or standard deviations of the mean where appropriate), or approximations thereof, for the following component uncertainties:

a)	one standard deviation of the mean of five measurements	0.10 percent
b)	pulse-height extrapolation Difference in the extrapolated value between the estimate based on horizontal extrapolation from the minimum point on the spectrum to that from the same spectral point to zero count rate at zero energy	0.70 percent
c)	live-time correction Estimate of uncertainty in the live-time correction determined from systematic tests using a NIST live-time module	0.20 percent

The expanded uncertainty, $U = 1.5$ percent, is obtained by multiplying u_c by a coverage factor of $k = 2$ and is assumed to provide an uncertainty interval of approximately 95 percent confidence.

(3) The reported uncertainties in the relative activities are expanded uncertainties (k=2) and are computed, as above, from the following:

a) estimated standard deviation due to counting statistics	
^{241}Ln	0.22 percent
^{148}Ci	0.24 percent
b) estimated standard deviation for variations in the fitting function	0.5 percent
c) uncertainties due to background	0.1 percent

(4) The functioning of the instrument is checked by comparing measurement results corrected for decay and background, of the plutonium standard AC-8171.

For further information, contact Brian Zimmerman at (301) 975-4338 or Lynne King at (301) 975-5544.
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