ALPHA- AND BETA-PARTICLE-EMITTING SOLID SOURCE CALIBRATIONS

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 NIST $2\pi\alpha$ proportional (small-area), NIST $2\pi\alpha/\beta$ proportional (large-area), passive implanted planar silicon (PIPS), and NIST table (external counters).

Scope

These procedures cover 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 NIST table. 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. 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 $2\pi\alpha$ proportional counter
- Large-area $2\pi\alpha/\beta$ proportional counter
- PIPS counter
- NIST table external counter
- Computer with data collection and reduction capabilities
- P-10 counting gas tanks, attachments, and controls
- Associated electronic equipment including voltage supply 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 Excel spreadsheet file “CheckSA” for the small-area counter and the spreadsheet file “CheckLA” for the large-area counter, found in the “Excel Files” folder in the current “old data C folder” accessed on the desktop of the investigator conducting the calibrations.

Validation of Software

Validation of manual calculation of experimental results is performed by comparing values found using data processing software. This is performed upon 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 exclusively for these procedures and by authorized personnel.

Health and Safety Precautions

Radiation Safety

Radiation safety training and assessment services are provided by the NIST Gaithersburg Radiation Safety Division (GRSD). Rooms containing radioactive sources are kept locked at all times 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 GRSD procedures.

Electrical Safety

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

Procedures

Preliminary

• Customer contact: give specifications for physical dimensions and activity limits, emphasize that source must be electrically conductive. Obtain a copy of the purchasing documentation. Provide customer with NIST shipping address, indicating GSRD Building 245, Room B131 to ensure that GRSD receives the package directly.
• NIST paperwork and acceptance procedure- submit completed NIST 364, “Radioactive Material Request,” for approval before arrival of materials. Forward a

copy of the customer purchasing documentation to calibration services with a request for a test folder.

Source Receipt from GRSD

• Review 364 to determine if any contamination was found on source and packaging materials during GRSD 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 GRSD-assigned radioactive source, RS, number) on the log sheet.
• Test check measurements - perform measurement of a calibrated alpha- or beta-particle emitting standard to ensure the system is operating correctly.
• Test folders – record the test folder 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: standard reference source, submitted source(s), and, finally, background. Counting times are adjusted so that 10^6 counts are collected from each source. The functioning of the instrument is checked by comparing the measurement results for the standard, corrected for decay and background, with previous results. The manual calculations, to be described in the Alpha and Beta Laboratory Procedures document (ABLP), are cross-checked with computer software calculations. The data is reduced and corrected, as described in the ABLP. The results are reviewed and used to create calibration reports. The calibration report is checked, proof-read, signed, and sealed. Copies of the report are made for the current alpha and beta test record binder and the test folder before the original is sent to the customer. Calibration results are stored both in binders and in the computer; the binder storage and computer access are both securely maintained. The dates that the calibration is performed and the report is submitted to the customer are recorded in the test folder system (CSS) 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 counters.

At the completion of measurements and calculations, results are entered into a spreadsheet. Results for sources that have been calibrated in the past are compared to previous results, taking into account 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.

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 References).

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 – obtained by measurements with sources of varying and known activities

Extrapolation– estimated from largest possible variability in assumed extrapolation functionality

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, September 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, January 2000.

Records

Customer log sheets include customer name and contact information, date received, kind of source, source number and identification including RS and test folder numbers, date calibrated, and date returned to customer. Copies of the purchase order, shipping documentation, and the 364 forms are kept with the logsheet.

Alpha and beta test record book includes hard copy of the data, data reduction and related calculations, calibration results, customer calibration spreadsheets, copy of certificate, and the documents described above. Computer records include unsigned copies of certificates and spreadsheets used to check standards and customer calibration sources.

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 calibrations.

Filing and Retention

All paper copies of customer files are stored in the alpha- and beta-test binders kept in the laboratory (building 245 room E107) or the investigators office (building 245 room C111). All customer-related electronic files are stored on password-protected systems in the laboratory (building 245 room E107), the investigator’s desktop computer (building 245 room C111), or protected shared network drive.
Copies of the alpha and beta laboratory procedures are kept in the laboratory where the equipment is used (building 245, room E107) and in the investigator’s office (building 245, room C111).

The RPD Quality Manager shall maintain the original and past versions of this RPD Procedure. See Guide RPD-G-01 for additional policies on Procedure maintenance.

APPENDIX A

Table of Uncertainties

Factor	Type A Uncertainty (1σ) percent	Type B Uncertainty (1σ) percent
Counting statistics	0.1	
Background	0.1	
Live time		0.1
Extrapolation		0.7
Uncertainties Combined in Quadrature	0.14	0.7
Expanded Uncertainty (k = 2, an approximate level of confidence of 95 %.)	1.4	

APPENDIX B

National Institute of Standards & Technology

REPORT OF CALIBRATION

for

COMPANY, INCORPORATED

TOWNESVILLE, STATE

Radionuclide	Linolium-200
Source identification	4321
2π alpha-particle counting rate	$1.000 \times 10^{2}\ s^{-1}$ [(1)]*
Expanded uncertainty ($k = 2$)	1.5 percent [(2)]
Reference time	16 June 2015
Measuring instrument	NIST $2\pi\alpha/\beta$ proportional counter [(3)]
Measurements Performed by	

Lynne King, Physical Scientist

For the Director,
National Institute of Standards and Technology by

Michael P. Unterweger, Group Leader Radioactivity Group Physical Measurement Laboratory	Lisa R. Karam, Division Chief Radiation Physics Division Physical Measurement Laboratory

Gaithersburg, MD 20899
Report Issued: July 2015
Service ID No.: 43030C
NIST Folder No.: XXXXXX-XX

*Notes on back

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NOTES

(1) The total number of alpha particles counted per second emitted into a 2π-steradian geometry (including those scattered).

(2) 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, $u_c = 0.74$ 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	0.11 percent
b) pulse-height extrapolation	0.70 percent
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

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 AC-8171.

For further information, contact Michael P. Unterweger at (301) 975-5536 or Lynne King at (301) 975-5544.

NIST Folder No.: XXXXXX-XX
Source Identification: 4321

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