



National Institute of Standards & Technology

Certificate

Standard Reference Material 4967 Radioactivity Standard

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| Radionuclide | Radium-226 ^{(1)*} |
| Source identification | SRM 4967 |
| Source description | Liquid in a 5-mL, flame-sealed NIST borosilicate-glass ampoule ⁽²⁾ |
| Solution composition | Approximately 1.4 mol•L ⁻¹ HCl ⁽³⁾ containing 1.74 mg BaCl ₂ per gram of solution ⁽⁴⁾ and Ra ⁺² ⁽⁵⁾ |
| Solution density | 1.019 ± 0.001 g•mL ⁻¹ at 22 °C ⁽⁶⁾ |
| Solution mass | 5.1167 ± 0.0027 g ⁽⁷⁾ |
| Radium-226 activity concentration | 2729 Bq•g ⁻¹ ⁽⁸⁾ |
| Reference time | 1200 EST 9 September 1991 |
| Overall uncertainty | 1.18 percent ⁽⁹⁾ |
| Half life | 1600 ± 7 years ⁽¹⁰⁾ |
| Calibration method | NIST pressurized "4π"γ ionization chamber "A" calibrated with the national radium standards ⁽¹¹⁾ ; and confirmatory measurements ⁽¹²⁾ |

This standard reference material was prepared in the Physics Laboratory, Ionizing Radiation Division, Radioactivity Group, Dale D. Hoppes, Group Leader.

Gaithersburg, MD
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NOTES

- (1) This standard was prepared by gravimetric dilutions of the "1947 series" of ^{226}Ra standards which were recalibrated at NIST (NBS) in 1967. The "age" of the radium, with accompanying in-growth of ^{210}Pb , is at least 44.3 years.
- (2) Approximately five milliliters of solution. Ampoule specifications:
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|----------------------|------------------------|
| body diameter | 16.5 ± 0.5 mm |
| wall thickness | 0.60 ± 0.04 mm |
| barium content | less than 2.5 percent |
| lead oxide content | less than 0.02 percent |
| other heavy elements | trace quantities |
- (3) Corresponding to a 14.9% (by weight) solution of NIST, high-purity, vacuum-distilled hydrochloric acid (nominal $10 \text{ mol} \cdot \text{L}^{-1}$) in doubly-distilled water.
- (4) The BaCl_2 reagent used to prepare the carrier solution was measured in a $\text{NaI}(\text{TI})$ well counter and found to contain $\leq 0.01 \text{ Bq } ^{226}\text{Ra}$ per gram of BaCl_2 .
- (5) The atom ratio of barium carrier to radium in the solution is approximately 2.5×10^4 .
- (6) The uncertainty in the density is three times the standard deviation of the mean for three independent gravimetric determinations. Confirmatory measurements based on the total master solution mass and individually dispensed masses in known volumes were in agreement.
- (7) Mean mass of the dispensed solution in the ampoule. The uncertainty is three times the standard deviation of 19 individually weighed masses of solution from which the mean mass was calculated.
- (8) Corresponding to $7.461 \times 10^{-8} \text{ g } ^{226}\text{Ra}$ per gram of solution assuming a conversion factor of $36.576 \text{ kBq} \cdot \mu\text{g}^{-1}$.
- (9) The overall uncertainty, 1.18 percent, was formed by taking three times the quadratic combination of the standard deviation of the mean, or approximations thereof, for the following component uncertainties:
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| a) four ion chamber "A" measurements on samples of 2 dilutions | 0.051 percent |
| b) twenty-two comparative ion chamber "A" measurements on 8 "1947(1967 recalibrated) series" of ^{226}Ra standards | 0.040 percent |
| c) ion chamber calibration for the "1947(1967 recalibrated) series" [with respect to the "radiation balance" primary measurements on the "1957 series" and national radium standards (see note 11)] | 0.34 percent |
| d) gravimetric dilution factor | 0.1 percent |
| e) half-life correction | 0.0046 percent |
| f) ^{226}Ra mass to activity conversion | 0.16 percent |
- (10) NCRP Report No. 58, 2nd ed., Appendix A3 (Feb. 1985).
- (11) For further details on NIST (NBS) radium series calibrations see W.B. Mann, et al., J. Res. NBS **62**, 21-26 (1959). The 1967 recalibration of the "1947 series" and "1957 series" intercomparisons were made with chamber "A".
- (12) For confirmation, this ^{226}Ra standard series was also directly compared against preparations of the "1947" (1967 recalibration), "1978", and "1984" ^{226}Ra series by ^{222}Rn analyses with the NIST pulse-ionization-chamber Primary Radon Measurement System [R. Collé, et al., J. Res. NIST **95** 155-165 (1990); J.M.R. Hutchinson, et al., Appl. Rad. Isot. **43**, 175-189 (1992)], by liquid scintillation counting, and by $\text{NaI}(\text{TI})$ well-crystal and Ge γ -spectrometry.

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