FIRST STANDARDS (1975 – 1977)

Early Radioactivity SRM Certificates prepared by R. Collé at NBS in the period from April 1975 through June 1977 for the AIF-NBS Radioactivity Measurements Assurance Program for the Radiopharmaceutical Industry.

The program is described in a paper by R. Collé in NBS SP-456 (1976), *Measurements for the Safe Use of Radiation*, pp. 71-76

In all, the SRMs produced and certified during this period were for sixteen different radionuclides (SRM 4400 through SRM 4415) at two activity levels (high H and low L; excepting ^{99m}Tc), involving thirty separate SRM issues:

^{32}P (4406), ^{51}Cr (4400), ^{57}Co (4408), ^{59}Fe (4411), ^{75}Se (4409), ^{85}Sr (4403), ^{99m}Tc (4410), ^{99}Mo (4412), ^{113}Sn (4401), ^{123}I (4414), ^{125}I (4407), ^{131}I (4401), ^{133}Xe (4415), ^{197}Hg (4413), ^{198}Au (4405), ^{201}Tl (4404).

Not all Certificates could be located in Record Files and, therefore, are not available here.

Compiled by R. Collé

8 February 2019

U. S. Department of Commerce
Frederick B. Dent
Secretary

National Bureau of Standards
Richard W. Roberts, Director

National Bureau of Standards Certificate

Standard Reference Material 4400L

Radioactivity Standard

Chromium-51

This Standard Reference Material consists of chromium-51 and carrier in 5. grams of solution in a flame-sealed glass ampoule. The carrier solution contains 723 micrograms of chromium per gram of approximately 1*M* HCL, and has a density of 1.018 ± 0.2% g/ml at 23°C.

The activity of chromium-51 in nuclear transformations per second per gram of solution, as of 1200 EST April 19, 1975, was

$$* \ 2.81_6 \times 10^6 \pm 1.2_5 \ \%*.$$

This Standard Reference Material was measured in the National Bureau of Standards "4π" γ-ionization chamber, which had previously been calibrated with chromium-51 solutions from which quantitative sources had been prepared and calibrated by $4\pi x$-γ coincidence counting.

The uncertainty in the value, 1.2_5 percent, is the linear sum of 0.05 percent, which is the limit of the random error of the ionization-chamber measurements, at the 99-percent confidence level (S_m, where S_m is the standard error computed from 28 readings), and the estimated upper limits of conceivable systematic errors.

The solution from which this Standard Reference Material was prepared was examined for impurities with a Ge(Li)-spectrometer and no gamma-ray impurities were observed. It is estimated that any gamma ray contributing more than 0.01 percent of the emission rate of the chromium-51, would have been detected if it had an energy between 320 and 700 keV. For gamma rays above 700 keV, the detection limit would be 0.0001 percent, and for those less than 320 keV, it would be 0.1 percent.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

J. Paul Cali, Chief
Office of Standard Reference Materials

Washington, D. C. 20234
April, 1975

SRM 4400L-

U. S. Department of Commerce
Frederick B. Dent
Secretary

National Bureau of Standards
Richard W. Roberts, Director

National Bureau of Standards Certificate

Standard Reference Material 4400H

Radioactivity Standard

Chromium-51

This Standard Reference Material consists of chromium-51 and carrier in 5. grams of solution in a flame-sealed glass ampoule. The carrier solution contains 986 micrograms of chromium per gram of approximately 1*M* HCL, and has a density of 1.018 ± 0.2% g/ml at 23°C.

The activity of chromium-51 in nuclear transformations per second per gram of solution, as of 1200 EST April 17, 1975, was

$$* \ 3.42_3 \times 10^8 \pm 1.6_6 \ \%*.$$

This Standard Reference Material was measured in the National Bureau of Standards "4π" γ-ionization chamber, which had previously been calibrated with chromium-51 solutions from which quantitative sources had been prepared and calibrated by $4\pi x$-γ coincidence counting.

The uncertainty in the value, 1.6_6 percent, is the linear sum of 0.05 percent, which is the limit of the random error of the ionization-chamber measurements, at the 99-percent confidence level ($2.771\ S_m$ where S_m is the standard error computed from 28 readings), and the estimated upper limts of conceivable systematic errors.

The solution from which this Standard Reference Material was prepared was examined for impurities with a Ge(Li)-spectrometer and no gamma-ray impurities were observed. It is estimated that any gamma ray contributing more than 0.01 percent of the emission rate of the chromium-51, would have been detected if it had an energy between 320 and 700 keV. For gamma rays above 700 keV, the detection limit would be 0.0001 percent, and for those less than 320 keV, it would be 0.1 percent.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

J. Paul Cali, Chief
Office of Standard Reference Materials

Washington, D.C. 20234
April, 1975

SRM 4400H-

U.S. Department of Commerce
Elliot L. Richardson,
Secretary

National Bureau of Standards
Ernest Ambler, Acting Director

National Bureau of Standards Certificate

Standard Reference Material 4400L-B

Radioactivity Standard

Chromium-51

This Standard Reference Material consists of chromium-51 in grams of carrier solution in a flame-sealed borosilicate-glass ampoule. The solution contains approximately 13 micrograms of chromium per gram of approximately 1-molar hydrochloric acid and has a density of 1.015 ± 0.002 grams per milliliter at 21°C.

The radioactive concentration of the chromium-51 as of 1200 EST December 7, 1976, was

$$*2.022 \times 10^{6}\ s^{-1}g^{-1} \pm 1.38\%*.$$

This Standard Reference Material was measured, relative to a radium-226 reference source, in the National Bureau of Standards "4π"γ pressure ionization chamber which had previously been calibrated, in terms of a radium-226 reference source, with chromium-51 solutions from which quantitative sources had been prepared and 4πx-γ coincidence counted.

The solution from which this Standard Reference Material was prepared was examined for photon-emitting impurities with germanium-spectrometer systems and iridium-192 was found to be present. As of the certification time, the ratio of the activity of iridium-192 to that of chromium-51 was 1.5×10^{-4} ± 20%. It is estimated that any radionuclide emitting a photon with an energy less than 320 keV and having an emission rate greater than 10^{-3} that of the 320-keV gamma ray of chromium-51 would have been detected; the corresponding limit for any gamma ray with an energy greater than 320 keV is 10^{-4}.

The uncertainty in the radioactive concentration of the chromium-51, 1.38 percent, is the linear sum of 0.03 percent, which is the limit of the random error at the 99-percent confidence level (2.878 S_m, where S_m is the standard error computed from independent measurements of 19 samples) and 1.35 percent, which is the estimated upper limit of conceivable systematic errors including the correction for impurities.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

J. Paul Cali, Chief
Office of Standard Reference Materials

Washington, D.C. 20234
December, 1976

SRM 4400L-B-

U.S. Department of Commerce
Elliot L. Richardson,
Secretary

National Bureau of Standards
Ernest Ambler, Acting Director

National Bureau of Standards Certificate

Standard Reference Material 4400H-B

Radioactivity Standard

Chromium-51

This Standard Reference Material consists of chromium-51 in grams of carrier solution in a flame-sealed borosilicate-glass ampoule. The solution contains approximately 1.2 milligrams of chromium per gram of approximately 1-molar hydrochloric acid and has a density of 1.017 ± 0.002 grams per milliliter at 21°C.

The radioactive concentration of the chromium-51 as of 1200 EST December 7, 1976, was

$$*3.900 \times 10^{8}\ s^{-1}g^{-1} \pm 1.62\%*.$$

This Standard Reference Material was measured, relative to a radium-226 reference source, in the National Bureau of Standards "4π"γ pressure ionization chamber which had previously been calibrated, in terms of a radium-226 reference source, with chromium-51 solutions from which quantitative sources had been prepared and 4πx-γ coincidence counted.

The solution from which this Standard Reference Material was prepared was examined for photon-emitting impurities with germanium-spectrometer systems and iridium-192 was found to be present. As of the certification time, the ratio of the activity of iridium-192 to that of chromium-51 was $1.5 \times 10^{-4} \pm 20\%$. It is estimated that any radionuclide emitting a photon with an energy less than 320 keV and having an emission rate greater than 10^{-3} that of the 320-keV gamma ray of chromium-51 would have been detected; the corresponding limit for any gamma ray with an energy greater than 320 keV is 10^{-4}.

The uncertainty in the radioactive concentration of the chromium-51, 1.62 percent, is the linear sum of 0.03 percent, which is the limit of the random error at the 99-percent confidence level (2.878 S_m, where S_m is the standard error computed from independent measurements of 19 samples) and 1.59 percent, which is the estimated upper limit of conceivable systematic errors including the correction for impurities.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

J. Paul Cali, Chief
Office of Standard Reference Materials

Washington, D.C. 20234
December, 1976

SRM 4400H-B-

U.S. Department of Commerce
Elliot L. Richardson,
Secretary
National Bureau of Standards
Ernest Ambler, Acting Director

National Bureau of Standards Certificate

Standard Reference Material 4401L-B

Radioactivity Standard

Iodine-131

This Standard Reference Material consists of iodine-131 in grams of carrier solution in a flame-sealed borosilicate glass ampoule. The solution, which contains approximately 0.03 milligrams LiOH, 0.03 milligrams Na_2SO_3, 0.06 milligrams KI per gram of solution has a density of $0.997_8 \pm 0.001_0$ gram per milliliter at 20.9 °C.

The radioactive concentration of the iodine-131 as of 1800 EST May 19, 1976, was

$$*1.35_9 \times 10^6 \pm 1.6_5\% \ s^{-1}g^{-1}*.$$

This Standard Reference Material was measured, relative to a radium-226 reference source, in the National Bureau of Standards "4π"γ pressure ionization chamber which had previously been calibrated, in terms of a radium-226 reference source, with iodine-131 solutions from which quantitative sources had been prepared and calibrated by $4\pi\beta$ proportional counting.

The solution from which this Standard Reference Material was prepared was examined for photon-emitting impurities with a Ge(Li) spectrometer system and none was observed. It is estimated that any gamma ray with an energy less than 364 keV and having an emission rate greater than 10^{-3} that of the 364-keV gamma ray of iodine-131 would have been detected; the corresponding limit for any gamma ray with energy greater than 364 keV is 10^{-4}.

The uncertainty in the radioactive concentration of the iodine-131, 1.6_5 percent, is the linear sum of 0.04 percent, which is the limit of the random error at the 99-percent confidence level (2.845 S_m, where S_m is the standard error computed from independent measurements of 21 samples) and 1.6_1 percent, which is the estimated upper limit of conceivable systematic errors.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

J. Paul Cali, Chief
Office of Standard Reference Materials

Washington, D. C. 20234
May, 1976

SRM 4401L-B

U.S. Department of Commerce
Elliot L. Richardson,
Secretary
National Bureau of Standards
Ernest Ambler, Acting Director

National Bureau of Standards Certificate

Standard Reference Material 4401H-B

Radioactivity Standard

Iodine-131

This Standard Reference Material consists of iodine-131 in grams of carrier solution in a flame-sealed borosilicate glass ampoule. The solution, which contains approximately 0.3 milligrams LiOH, 0.3 milligrams Na_2SO_3, 0.5 milligrams KI per gram of solution, has a density of $0.998_1 \pm 0.001_1$ gram per milliliter at 22.7 °C.

The radioactive concentration of the iodine-131 as of 1800 EST May 19, 1976, was

$$*1.57_8 \times 10^8 \pm 1.7_4\% \ s^{-1}g^{-1}*.$$

This Standard Reference Material was measured, relative to a radium-226 reference source, in the National Bureau of Standards "4π"γ pressure ionization chamber which had previously been calibrated, in terms of a radium-226 reference source, with iodine-131 solutions from which quantitative sources had been prepared and calibrated by $4\pi\beta$ proportional counting.

The solution from which this Standard Reference Material was prepared was examined for photon-emitting impurities with a Ge(Li) spectrometer system and none was observed. It is estimated that any gamma ray with an energy less than 364 keV and having an emission rate greater than 10^{-3} that of the 364-keV gamma ray of iodine-131 would have been detected; the corresponding limit for any gamma ray with energy greater than 364 keV is 10^{-4}.

The uncertainty in the radioactive concentration of the iodine-131, 1.7_4 percent, is the linear sum of 0.04 percent, which is the limit of the random error at the 99-percent confidence level (2.845 S_m, where S_m is the standard error computed from independent measurements of 21 samples) and 1.7_0 percent, which is the estimated upper limit of conceivable systematic errors.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

J. Paul Cali, Chief
Office of Standard Reference Materials

Washington, D.C. 20234
May, 1976

SRM 4401H-B

U. S. Department of Commerce
Rogers C.B. Morton
Secretary

Bureau of Standards
V. Roberts, Director

National Bureau of Standards Certificate

Standard Reference Material 4402L

Radioactivity Standard

Tin-113-Indium-113m

This Standard Reference Material consists of tin-113 in equilibrium with its daughter product, indium-113m, in grams of solution in a flame-sealed glass ampoule. The chemical form is $SnCl_4$ in approximately 4M HCl, and the density is 1.064 ± 0.002 grams per milliliter at 20.5°C.

The number of indium-113m gamma rays emitted per second per gram of solution at 1200 EST July 1, 1975, was

$$* 5.00_5 \times 10^5 \pm 2.7_4\% *.$$

This Standard Reference Material was measured in the National Bureau of Standards "4π"γ ionization chamber which had previously been calibrated with tin-113-indium-113m solutions from which quantitative sources had been prepared and photopeak-counted with both NaI(Tl)-and Ge(Li)-spectrometer systems.

The uncertainty in the emission rate, 2.7_4 percent, is the linear sum of 0.05 percent, which is the limit of the random error at the 99-percent confidence level ($4.032\,S_m$, where S_m is the standard error calculated from 6 sets of ionization-chamber measurements), and 2.6_9 percent, which is the estimated upper limit of conceivable systematic errors in the preparation of this Standard Reference Material and the calibration of the "4π"γ ionization chamber.

Using an abundance of 64.90 ± 0.20 percent [see attached nuclear data sheet] for the 391.688-keV indium-113m gamma ray, the number of nuclear transformations per second per gram of solution at 1200 EST July 1, 1975, would be

$$* 7.71 \times 10^5 \pm 3.1\% *.$$

The uncertainty in the activity, 3.1 percent, is the linear sum of 2.7_4 percent, which is the uncertainty in the emission rate, and 0.31 percent, which is the error associated with the gamma-ray abundance.

The solution from which this Standard Reference Material was prepared was examined for impurities with a Ge(Li)-spectrometer and scandium-46, cobalt-60, zinc-65, selenium-75, indium-114m and antimony-125 were found to be present. On July 1, 1975, the ratios of the activity of each impurity to the activity of tin-113-indium-113m were

^{46}Sc	2.9×10^{-5}	± 25%
^{60}Co	1.9×10^{-5}	± 25%
^{65}Zn	4.3×10^{-5}	± 50%
^{75}Se	5.7×10^{-4}	± 25%
^{114m}In	7.7×10^{-3}	± 20%
^{125}Sb	7.6×10^{-4}	± 25%

It is estimated that any gamma rays with energies less than 255 keV and contributing more than 0.1 percent of the tin-113-indium-113m activity would have been detected; any gamma rays with energies greater than 255 keV and contributing more than 0.01 percent (of the tin-113-indium-113m activity) would have been detected.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

J. Paul Cali, Chief
Office of Standard Reference Materials

Washington, D.C. 20234
July, 1975

SRM 4402L-

U. S. Department of Commerce
Rogers C.B. Morton
Secretary

Bureau of Standards
W. Roberts, Director

National Bureau of Standards Certificate

Standard Reference Material 4402H

Radioactivity Standard

Tin-113-Indium-113m

This Standard Reference Material consists of tin-113 in equilibrium with its daughter product, indium-113m, in grams of solution in a flame-sealed glass ampoule. The chemical form is $SnCl_4$ in approximately 4M HCl, and the density is 1.056 ± 0.002 grams per milliliter at 21°C.

The number of indium-113m gamma rays emitted per second per gram of solution at 1200 EST July 1, 1975, was

$$*1.09_1 \times 10^8 \pm 3.0\%*.$$

This Standard Reference Material was measured in the National Bureau of Standards "4π"γ ionization chamber which had previously been calibrated with tin-113-indium-113m solutions from which quantitative sources had been prepared and photopeak-counted with both NaI(Tl)-and Ge(Li)-spectrometer systems.

The uncertainty in the emission rate, 3.0 percent, is the linear sum of 0.05 percent, which is the limit of the random error at the 99-percent confidence level ($4.032\ S_m$, where S_m is the standard error calculated from 6 sets of ionization-chamber measurements), and 2.9_5 percent, which is the estimated upper limit of conceivable systematic errors in the preparation of this Standard Reference Material and the calibration of the "4π"γ ionization chamber.

Using an abundance of 64.90 ± 0.20 percent [see attached nuclear data sheet] for the 391.688-keV indium-113m gamma ray, the number of nuclear transformations per second per gram of solution at 1200 EST July 1, 1975, would be

$$*1.69 \times 10^8 \pm 3.3\%*.$$

The uncertainty in the activity, 3.3 percent, is the linear sum of 3.0 percent, which is the uncertainty in the emission rate, and 0.31 percent, which is the error associated with the gamma-ray abundance.

The solution from which this Standard Reference Material was prepared was examined for impurities with a Ge(Li)-spectrometer and scandium-46, cobalt-60, zinc-65, selenium-75, indium-114m and antimony-125 were found to be present.

On July 1, 1975, the ratios of the activity of each impurity to the activity of tin-113-indium-113m were

^{46}Sc	2.9×10^{-5}	± 25%
^{60}Co	1.9×10^{-5}	± 25%
^{65}Zn	4.3×10^{-5}	± 50%
^{75}Se	5.7×10^{-4}	± 25%
^{114m}In	7.7×10^{-3}	± 20%
^{125}Sb	7.6×10^{-4}	± 25%

It is estimated that any gamma rays with energies less than 255 keV and contributing more than 0.1 percent of the tin-113-indium-113m activity would have been detected; any gamma rays with energies greater than 255 keV and contributing more than 0.01 percent (of the tin-113-indium-113m activity) would have been detected.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

J. Paul Cali, Chief
Office of Standard Reference Materials

Washington, D.C. 20234
July, 1975

SRM 4402H -

U.S. Department of Commerce
Rogers C.B. Morton,
Secretary

Bureau of Standards
[illegible], Acting Director

National Bureau of Standards Certificate

Standard Reference Material 4403L

Radioactivity Standard
Strontium-85

This Standard Reference Material consists of strontium-85 and carrier in grams of solution in a flame-sealed glass ampoule. The carrier solution contains 96.2 micrograms of strontium per gram of approximately 1 M HCl and its density is 1.014 ± 0.002 g/ml at 22.4°C.

The activity of the strontium-85 in nuclear transformations per second per gram of solution as of 1200 EST October 3, 1975, was

$$*8.81_8 \times 10^5 \pm 1.2_3\%*.$$

This Standard Reference Material was measured in the National Bureau of Standards "4π"γ ionization chamber, which had previously been calibrated with strontium-85 solutions from which quantitative sources had been prepared and calibrated by x - γ coincidence counting.

The uncertainty in the value of the activity, 1.2_3 percent, is the linear sum of 0.02 percent, which is the limit of the random error at the 99-percent confidence level (2.779 S_m, where S_m is the standard error computed from 27 measurements) and 1.2_1 percent, which is the estimated upper limit of conceivable systematic errors.

The solution from which this Standard Reference Material was prepared was examined for photon-emitting impurities with a Ge(Li)-spectrometer and none was observed. Any radionuclide emitting a photon with energy less than 514 keV and having an emission rate greater than 10^{-3} that of the 514-keV gamma ray of strontium-85 would have been detected; the corresponding limit for any gamma ray with energy greater than 514 keV is 10^{-4}. The activity detection limit for selenium-75, a suspected but unobserved impurity, is 10^{-4} that of strontium-85.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

Washington, D.C. 20234
October, 1975

J. Paul Cali, Chief
Office of Standard Reference Materials

SRM 4403L-

U.S. Department of Commerce
Rogers C.B. Morton,
Secretary
National Bureau of Standards
Ernest Ambler, Acting Director

National Bureau of Standards Certificate

Standard Reference Material 4403H

Radioactivity Standard

Strontium-85

This Standard Reference Material consists of strontium-85 and carrier in grams of solution in a flame-sealed glass ampoule. The carrier solution contains 2.03 milligrams of strontium per gram of approximately 1 M HCl and its density is 1.014 ± 0.002 g/ml at 22.2°C.

The activity of the strontium-85 in nuclear transformations per second per gram of solution as of 1200 EST September 30, 1975, was

$$*1.90_9 \times 10^8 \pm 1.4_2\%*.$$

This Standard Reference Material was measured in the National Bureau of Standards "4π"γ ionization chamber, which had previously been calibrated with strontium-85 solutions from which quantitative sources had been prepared and calibrated by x - γ coincidence counting.

The uncertainty in the value of the activity, 1.4_2 percent, is the linear sum of 0.04_5 percent, which is the limit of the random error at the 99-percent confidence level (2.845 S_m, where S_m is the standard error computed from 21 measurements) and 1.3_7 percent, which is the estimated upper limit of conceivable systematic errors.

The solution from which this Standard Reference Material was prepared was examined for photon-emitting impurities with a Ge(Li)-spectrometer and cesium-134, rubidium-84 and rubidium-86 were observed to be present. On October 1, 1975 at 2300 EST, the ratios of the activity of each impurity to the activity of strontium-85 were

cesium-134	$1.04 \times 10^{-4} \pm 25\%$
rubidium-84	$6.40 \times 10^{-4} \pm 25\%$
rubidium-86	$1.04 \times 10^{-3} \pm 25\%$.

Any other radionuclide emitting a photon with energy less than 514 keV and having an emission rate greater than 10^{-3} that of the 514-keV gamma ray of strontium-85 would have been detected; the corresponding limit for any gamma ray with energy greater than 514 keV is 10^{-4}. The activity detection limit for selenium-75, a suspected but unobserved impurity, is 10^{-4} that of strontium-85.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

Washington, D.C. 20234
October, 1975

J. Paul Cali, Chief
Office of Standard Reference Materials

SRM 4403H-

U.S. Department of Commerce
Juanita M. Kreps
Secretary

National Bureau of Standards
Ernest Ambler, Acting Director

National Bureau of Standards Certificate

Standard Reference Material 4403L-B

Radioactivity Standard

Strontium-85

This Standard Reference Material consists of strontium-85 and carrier in grams of solution in a flame-sealed borosilicate-glass ampoule. The solution, which contains 0.03 milligrams of strontium per gram of approximately 1 molar hydrochloric acid, has a density of 1.016 ± 0.002 grams per milliliter at 22°C.

The radioactive concentration of the strontium-85 at 1200 EST April 20, 1977, was

$$*1.071 \times 10^{6}\ s^{-1}g^{-1} \pm 1.40\%*.$$

This Standard Reference Material was measured, relative to a radium-226 reference source, in the National Bureau of Standards "4π"γ pressure ionization chamber which had previously been calibrated, in terms of a radium-226 reference source, with strontium-85 solutions from which quantitative sources had been prepared and x-γ coincidence counted.

The uncertainty in the value of the radioactive concentration, 1.40 percent, is the linear sum of 0.03 percent, which is the limit of the random error of the ionization-chamber measurements at the 99-percent confidence level (2.831 S_m, where S_m is the standard error computed from independent measurements of 22 samples) and 1.37 percent, which is the estimated upper limit of conceivable systematic errors.

The solution from which this Standard Reference Material was prepared was examined for photon-emitting impurities with a Ge(Li)-spectrometer system and rubidium-84 and rubidium-86 were observed to be present. On April 20, 1977 at 1200 EST, the ratios of the activity of each impurity to the activity of strontium-85 were

rubidium-84	$9.5 \times 10^{-4} \pm 20\%$
rubidium-86	$1.7 \times 10^{-3} \pm 20\%$.

The detection limits for any other impurity gamma rays may be expressed as a percentage of the gamma-ray-emission rate of the 514-keV gamma ray of strontium-85. These limits are approximately 0.1 percent for gamma rays with energies less than 514 keV, and 0.01 percent for those of greater energy.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

Washington, D.C. 20234
April, 1977

J. Paul Cali, Chief
Office of Standard Reference Materials

SRM 4403L-B-

U.S. Department of Commerce
Juanita M. Kreps
Secretary

National Bureau of Standards
Ernest Ambler, Acting Director

National Bureau of Standards Certificate

Standard Reference Material 4404L-B

Radioactivity Standard

Thallium-201

This Standard Reference Material consists of thallium-201 in grams of carrier solution in a flame-sealed borosilicate-glass ampoule. The solution, which contains approximately 9 micrograms $TlNO_3$ per gram of approximately 1 molar HNO_3, has a density of 1.031 ± 0.002 grams per milliliter at 21°C.

The radioactivity concentration of the thallium-201 as of 1000 EST June 14, 1977, was

$$*3.085 \times 10^6\ s^{-1}g^{-1} \pm 1.96\%*.$$

This Standard Reference Material was measured, relative to a radium-226 reference source, in the National Bureau of Standards "4π"γ pressure ionization chamber which had previously been calibrated, in terms of a radium-226 reference source, with thallium-201 solutions from which quantitative sources had been prepared and 4πe-γ coincidence counted using the efficiency extrapolation method.

The solution from which this Standard Reference Material was prepared was examined for photon-emitting impurities with germanium spectrometer systems and only thallium-200 and thallium-202 were found to be present. As of the certification time, the ratio of the activity of each impurity to that of the thallium-201 was

thallium-200	$6.9 \times 10^{-4} \pm 10\%$
thallium-202	$1.2 \times 10^{-4} \pm 10\%$.

The detection limits for any other impurity gamma rays may be expressed as a percentage of the gamma-ray-emission rate of the 167-keV gamma ray of thallium-201. These limits are approximately 0.1 percent for gamma rays with energies less than 167 keV, and 0.01 percent for those of greater energy.

The uncertainty in the radioactivity concentration of the thallium-201, 1.96 percent, is the linear sum of 0.03 percent, which is the limit to the random error at the 99-percent confidence level (2.819 S_m, where S_m is the standard error of the mean computed from independent measurements of 23 samples) and 1.93 percent, which is the estimated upper limit of conceivable systematic errors.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

Washington, D.C. 20234
June, 1977

J. Paul Cali, Chief
Office of Standard Reference Materials

SRM 4404L-B-

U.S. Department of Commerce
Rogers C.B. Morton,
Secretary
National Bureau of Standards
Ambler, Acting Director

National Bureau of Standards Certificate

Standard Reference Material 4405L

Radioactivity Standard

Gold-198

This Standard Reference Material consists of gold-198 in grams of carrier solution in a flame-sealed borosilicate glass ampoule. The carrier solution contains approximately 0.13 mg/ml $KAu(CN)_4$ and 0.08 mg/ml KCN, and its density is 0.998 ± 0.002 g/ml at 22°C.

The activity of the gold-198 in nuclear transformations per second per gram of solution at 1200 EST December 6, 1975, was

$$*5.82_0 \times 10^6 \pm 1.5_4\%*.$$

This Standard Reference Material was measured in the National Bureau of Standards "4π" γ ionization chamber which had previously been calibrated with gold-198 solutions from which quantitative sources had been prepared and measured with 4πβ-proportional and 4πβ-γ coincidence counting systems.

The uncertainty in the value of the activity, 1.5_4 percent, is the linear sum of 0.04 percent, which is the limit of the random error at the 99-percent confidence level (2.831 S_m, where S_m is the standard error computed from 22 groups of measurements) and 1.5_0 percent, which is the estimated upper limit of conceivable systematic errors.

The solution from which this Standard Reference Material was prepared was examined for photon-emitting impurities with a Ge(Li) spectrometer and gold-199 was found to be present. On December 6, 1975 at 1200 EST, the ratio of the activity of gold-199 to that of gold-198 was 0.0236 ± 0.0024. It is estimated that any radionuclide emitting a photon with energy less than 412 keV and having an emission rate greater than 10^{-3} that of the 412 keV gamma ray of gold-198 would have been detected; the corresponding limit for any gamma ray with energy greater than 412 keV is 10^{-4}.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

Washington, D. C. 20234
December, 1975

J. Paul Cali, Chief
Office of Standard Reference Materials

4405L-

U.S. Department of Commerce
Rogers C.B. Morton,
Secretary
National Bureau of Standards
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National Bureau of Standards Certificate

Standard Reference Material 4405H

Radioactivity Standard
Gold-198

This Standard Reference Material consists of gold-198 in grams of carrier solution in a flame-sealed borosilicate glass ampoule. The carrier solution contains approximately 2.2 mg/ml $KAu(CN)_4$ and 1 mg/ml KCN, and its density is 1.015 ± 0.002 g/ml at 22°C.

The activity of the gold-198 in nuclear transformations per second per gram of solution at 1200 EST December 6, 1975, was

$$*5.67_0 \times 10^8 \pm 1.5_5\%*.$$

This Standard Reference Material was measured in the National Bureau of Standards "4π" γ ionization chamber which had previously been calibrated with gold-198 solutions from which quantitative sources had been prepared and measured with 4πβ-proportional and 4πβ-γ coincidence counting systems.

The uncertainty in the value of the activity, 1.5_5 percent, is the linear sum of 0.04 percent, which is the limit of the random error at the 99-percent confidence level (2.831 S_m, where S_m is the standard error computed from 22 groups of measurements) and 1.5_1 percent, which is the estimated upper limit of conceivable systematic errors.

The solution from which this Standard Reference Material was prepared was examined for photon-emitting impurities with a Ge(Li) spectrometer and gold-199 was found to be present. On December 6, 1975 at 1200 EST, the ratio of the activity of gold-199 to that of gold-198 was 0.0236 ± 0.0024. It is estimated that any radionuclide emitting a photon with energy less than 412 keV and having an emission rate greater than 10^{-3} that of the 412 keV gamma ray of gold-198 would have been detected; the corresponding limit for any gamma ray with energy greater than 412 keV is 10^{-4}.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

Washington, D. C. 20234
December, 1975

J. Paul Cali, Chief
Office of Standard Reference Materials

4405H-

U.S. Department of Commerce
Rogers C. B. Morton,
Secretary

National Bureau of Standards
Ernest Ambler, Acting Director

National Bureau of Standards Certificate

Standard Reference Material 4406L

Radioactivity Standard

Phosphorus-32

This Standard Reference Material consists of phosphorus-32 in grams of carrier solution in a flame-sealed borosilicate glass ampoule. The carrier solution is 0.0017 molar phosphoric acid and its density is 0.998 ± 0.002 g/ml at 21.9 °C.

The activity of phosphorus-32 in nuclear transformations per second per gram of solution at 0700 EST October 24, 1975, was

$$*1.48_8 \times 10^6 \pm 1.4_2\%*.$$

The solution from which this Standard Reference Material was prepared was calibrated by $4\pi\beta$ proportional counting of sources prepared from dilutions of the ampoule solution. Confirmatory measurements were made by $2\pi\beta$ ionization-chamber measurements of sources prepared directly from the ampoule solution.

The uncertainty in the value of the activity, 1.4_2 percent, is the linear sum of 0.17 percent, which is the limit of the random error of the $4\pi\beta$ measurements at the 99-percent confidence level ($2.921\ S_m$, where S_m is the standard error computed from measurements on 17 sources) and 1.2_5 percent, which is the estimated upper limit of conceivable systematic errors.

The solution from which this Standard Reference Material was prepared was examined with a Ge(Li) spectrometer for photon-emitting impurities and none was observed. Any photon with an energy in the range of 137 to 1900 keV and an emission rate greater than 10^{-4} that of the beta-ray-emission rate of the phosphorus-32 would have been detected. Assessment of the amount of phosphorus-33 present was made by using a non-linear chi-square-minimization technique for fitting the half-life data obtained by $4\pi\beta$ proportional counting continually over a nine-day period and assuming half lives of 14.29 and 25.4 days for phosphorus-32 and phosphorus-33, respectively. At 0700 EST October 24, 1975, the ratio of phosphorus-33 to phosphorus-32 was 0.0093 ± 0.0019.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

Washington, D.C. 20234
December, 1975

J. Paul Cali, Chief
Office of Standard Reference Materials

SRM 4406L

U.S. Department of Commerce
Rogers C.B. Morton,
Secretary

National Bureau of Standards
Ernest Ambler, Acting Director

National Bureau of Standards Certificate

Standard Reference Material 4406H

Radioactivity Standard
Phosphorus-32

This Standard Reference Material consists of phosphorus-32 in grams of carrier solution in a flame-sealed borosilicate glass ampoule. The carrier solution is 0.0034 molar phosphoric acid and its density is 0.999 ± 0.002 g/ml at 22.0 °C.

The activity of phosphorus-32 in nuclear transformations per second per gram of solution at 0700 EST October 24, 1975, was

$$*2.76_6 \times 10^8 \pm 1.5_2\%*.$$

The solution from which this Standard Reference Material was prepared was calibrated by $4\pi\beta$ proportional counting of sources prepared from dilutions of the ampoule solution. Confirmatory measurements were made by $2\pi\beta$ ionization-chamber measurements of sources prepared directly from the ampoule solution.

The uncertainty in the value of the activity, 1.5_2 percent, is the linear sum of 0.17 percent, which is the limit of the random error of the $4\pi\beta$ measurements at the 99-percent confidence level ($2.921\ S_m$, where S_m is the standard error computed from measurements on 17 sources) and 1.3_5 percent, which is the estimated upper limit of conceivable systematic errors.

The solution from which this Standard Reference Material was prepared was examined with a Ge(Li) spectrometer for photon-emitting impurities and none was observed. Any photon with an energy in the range of 137 to 1900 keV and an emission rate greater than 10^{-4} that of the beta-ray-emission rate of the phosphorus-32 would have been detected. Assessment of the amount of phosphorus-33 present was made by using a non-linear chi-square-minimization technique for fitting the half-life data obtained by $4\pi\beta$ proportional counting continually over a nine-day period and assuming half lives of 14.29 and 25.4 days for phosphorus-32 and phosphorus-33, respectively. At 0700 EST October 24, 1975, the ratio of phosphorus-33 to phosphorus-32 was 0.0093 ± 0.0019.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

Washington, D.C. 20234
December, 1975

J. Paul Cali, Chief
Office of Standard Reference Materials

SRM 4406H-

U. S. Department of Commerce
Rogers C.B. Morton
Secretary
National Bureau of Standards
W. Roberts, Director

National Bureau of Standards Certificate

Standard Reference Material 4407L

Radioactivity Standard

Iodine-125

This Standard Reference Material consists of iodine-125 and carrier in grams of aqueous solution in a flame-sealed glass ampoule. The carrier solution contains 0.050 g/l KI, 0.023 g/l Na_2SO_3, 0.021 g/l LiOH and has a density of 0.997 g/ml ± 0.1_2 percent at 22.6°C.

The activity of the iodine-125 in nuclear transformations per second per gram of solution, as of 2000 EST July 17, 1975, was

$$*8.21_6 \times 10^5 \pm 1.6_5\%*.$$

This Standard Reference Material was calibrated by the sum-peak method [Cf. J. S. Eldridge and P. Crowther, Nucleonics 22, 56 (1964)] using a single 0.8-mm-thick NaI(Tl) crystal with a 0.13-mm-thick beryllium window. Point sources were prepared by quantitative dilution and deposition from several ampoules of the lot prepared.

The uncertainty in the value, 1.6_5 percent is the linear sum of 0.3_0 percent, which is the limit of the random error at the 99-percent confidence level ($3.012\ S_m$, where S_m is the standard error calculated from 14 groups of measurements), and 1.3_5 percent, the estimated upper limit of conceivable systematic errors.

The solution from which this Standard Reference Material was prepared was examined with a Ge(Li)-spectrometer and no gamma-ray impurities were observed. The limit of detection for the 388.6-keV gamma ray of iodine-126 is less than 0.001 percent of the activity of the iodine-125.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

Washington, D.C. 20234
July, 1975

J. Paul Cali, Chief
Office of Standard Reference Materials

SRM 4407L

U. S. Department of Commerce
Rogers C.B. Morton
Secretary

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W. Roberts, Director

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Standard Reference Material 4407H

Radioactivity Standard

Iodine-125

This Standard Reference Material consists of iodine-125 and carrier in grams of aqueous solution in a flame-sealed glass ampoule. The carrier solution contains 0.502 g/l KI, 0.227 g/l Na_2SO_3, 0.209 g/l LiOH, and has a density of 0.997 g/ml ± 0.001_2 percent at 24.0°C.

The activity of the iodine-125 in nuclear transformations per second per gram of solution, as of 2000 EST July 17, 1975, was

$$*1.28_8 \times 10^8 \pm 2.0_2\%*.$$

This Standard Reference Material was calibrated by the sum-peak method [Cf. J. S. Eldridge and P. Crowther, Nucleonics 22, 56 (1964)] using a single 0.8-mm-thick NaI(Tl) crystal with a 0.13-mm-thick beryllium window. Point sources were prepared by quantitative dilution and deposition from several ampoules of the lot prepared.

The uncertainty in the value, 2.0_2 percent, is the linear sum of 0.3_0 percent, which is the limit of the random error at the 99-percent confidence level (3.012 S_m, where S_m is the standard error calculated from 14 groups of measurements), and 1.72 percent, the estimated upper limit of conceivable systematic errors.

The solution from which this Standard Reference Material was prepared was examined with a Ge(Li)-spectrometer and no gamma-ray impurities were observed. The limit of detection for the 388.6-keV gamma ray of iodine-126 is less than 0.001 percent of the activity of the iodine-125.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

Washington, D.C. 20234
July, 1975

J. Paul Cali, Chief
Office of Standard Reference Materials

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t Ambler, Acting Director

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Standard Reference Material 4407H-B

Radioactivity Standard

Iodine-125

This Standard Reference Material consists of iodine-125 in grams of carrier solution in a flame-sealed borosilicate glass ampoule. The solution, which contains approximately 0.36 milligram NaOH, 0.22 milligram LiOH, 0.29 milligram Na_2SO_3, 0.62 milligram KI per gram of solution, has a density of 0.998 ± 0.002 gram per milliliter at 21.3°C.

The radioactive concentration of the iodine-125 as of 1200 EST July 19, 1976, was

$$* \ 8.43_3 \times 10^7 s^{-1} g^{-1} \pm 1.8_5\% *.$$

This Standard Reference Material was calibrated by the sum-peak method [Cf. J.S. Eldridge and P. Crowther, Nucleonics 22, 56 (1964)] using two NaI(Tl) crystals, 0.8mm and 1.6mm thick, with 0.13-mm-thick beryllium windows. Point sources were prepared by quantitative dilution and deposition from several ampoules of the lot prepared.

The solution from which this Standard Reference Material was prepared was examined for photon-emitting impurities with germanium-spectrometer systems and iodine-126 was found to be present. As of the certification time, the ratio of iodine-126 to iodine-125 was $1.4 \times 10^{-6} \pm 0.7 \times 10^{-6}$.

The uncertainty in the radioactive concentration of iodine-125, 1.8_5 percent, is the linear sum of 0.26 percent, which is the limit of the random error at the 99-percent confidence level ($2.71 \ S_m$, where S_m is the standard error computed from 38 independent measurements of 21 sources) and 1.5_9 percent, which is the estimated upper limit of conceivable systematic errors.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W.B. Mann, Chief.

J. Paul Cali, Chief
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ashington, D.C. 20234
July, 1976

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Rogers C.B. Morton,
Secretary
National Bureau of Standards
Ernest Ambler, Acting Director

National Bureau of Standards Certificate

Standard Reference Material 4408M

Radioactivity Standard

Cobalt-57

This Standard Reference Material consists of cobalt-57 and carrier in grams of solution in a flame-sealed glass ampoule. The carrier solution contains 0.62 milligrams of cobalt per gram of approximately 1 molar HCl, and has a density of 1.015 ± 0.001 g/ml at 22°C.

The cobalt-57 activity, in nuclear transformations per second per gram of solution at 1500 EST October 29, 1975, was

$$*7.19_6 \times 10^6 \pm 1.8_5\%*.$$

This Standard Reference Material was measured in the National Bureau of Standards "4π"γ ionization chamber, which had previously been calibrated with cobalt-57 solutions from which quantitative sources had been prepared and calibrated by 4πx-γ coincidence counting.

The material from which the Standard Reference Material was prepared was examined for impurities with a Ge(Li)-spectrometer and cobalt-56 and cobalt-58 were found to be present. On October 29, 1975 at 1500 EST, the ratios of the activity of each impurity to the activity of cobalt-57 were

cobalt-56	$6.45 \times 10^{-4} \pm 10\%$
cobalt-58	$2.01 \times 10^{-4} \pm 10\%$.

It is estimated that any gamma ray of energy greater than 136 keV and having an intensity greater than 10^{-4} that of the 122-keV gamma ray of cobalt-57 would have been detected; any x or gamma ray of energy less than 136 keV and having an intensity greater than 10^{-3} that of the 122-keV gamma ray would have been detected.

The uncertainty in the value, 1.8_5 percent, is the linear sum of 0.07_7 percent, which is the limit of the random error at the 99-percent confidence level (4.604 S_m, where S_m is the standard error calculated from 5 sets of ionization-chamber measurements), and 1.7_7 percent, which is the estimated upper limit of conceivable systematic errors in the preparation and measurement of this Standard Reference Material, including the calibration of the "4π"γ ionization chamber and assessment and corrections for impurities.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

Washington, D. C. 20234 J. Paul Cali, Chief
October, 1975 Office of Standard Reference Materials
SRM 4408M

U.S. Department of Commerce
Rogers C.B. Morton,
Secretary
National Bureau of Standards
Ambler, Acting Director

National Bureau of Standards Certificate

Standard Reference Material 4409L

Radioactivity Standard
Selenium-75

This Standard Reference Material consists of selenium-75 and carrier in grams of solution in a flame-sealed glass ampoule. The solution, which contains 0.17 milligrams of selenious acid per gram of approximately 1 molar hydrochloric acid, has a density of 1.015 ± 0.001 grams per milliliter at 22.2°C.

The activity of the selenium-75 in nuclear transformations per second per gram of solution as of 1200 EST October 14, 1975, was

$$*8.49_4 \times 10^5 \pm 2.5_1\%*.$$

This Standard Reference Material was measured in the National Bureau of Standards "4π"γ ionization chamber, which had previously been calibrated with selenium-75 solutions from which quantitative sources had been prepared and x - γ coincidence counted.

The uncertainty in the value of the activity, 2.5_1 percent, is the linear sum of 0.03 percent, which is the limit of the random error at the 99-percent confidence level (2.831 S_m, where S_m is the standard error computed from 22 measurements) and 2.4_8 percent, which is the estimated upper limit of conceivable systematic errors.

The solution from which this Standard Reference Material was prepared was examined for photon-emitting impurities with a Ge(Li) spectrometer and none was observed. Any radionuclide emitting a photon with energy less than 401 keV and having an emission rate greater than 10^{-3} that of the 264-keV gamma ray of selenium-75 would have been detected; the corresponding limit for any gamma ray with energy greater than 401 keV is 10^{-4}.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

Washington, D.C. 20234
October, 1975

J. Paul Cali, Chief
Office of Standard Reference Materials

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U.S. Department of Commerce
Rogers C.B. Morton,
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National Bureau of Standards Certificate

Standard Reference Material 4409H

Radioactivity Standard
Selenium-75

This Standard Reference Material consists of selenium-75 and carrier in grams of solution in a flame-sealed glass ampoule. The solution, which contains 1.4 milligrams of selenious acid per gram of approximately 1 molar hydrochloric acid, has a density of 1.015 ± 0.002 grams per milliliter at 22.3°C.

The activity of the selenium-75 in nuclear transformations per second per gram of solution as of 1200 EST October 14, 1975, was

$$*6.37_3 \times 10^7 \pm 2.6_8\%*.$$

This Standard Reference Material was measured in the National Bureau of Standards "4π"γ ionization chamber, which had previously been calibrated with selenium-75 solutions from which quantitative sources had been prepared and x - γ coincidence counted.

The uncertainty in the value of the activity, 2.6_8 percent, is the linear sum of 0.03 percent, which is the limit of the random error at the 99-percent confidence level (2.831 S_m, where S_m is the standard error computed from 22 measurements) and 2.6_5 percent, which is the estimated upper limit of conceivable systematic errors.

The solution from which this Standard Reference Material was prepared was examined for photon-emitting impurities with a Ge(Li) spectrometer and none was observed. Any radionuclide emitting a photon with energy less than 401 keV and having an emission rate greater than 10^{-3} that of the 264-keV gamma ray of selenium-75 would have been detected; the corresponding limit for any gamma ray with energy greater than 401 keV is 10^{-4}.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

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J. Paul Cali, Chief
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SRM 4409H-

U.S. Department of Commerce
Juanita M. Kreps
Secretary

National Bureau of Standards
Ernest Ambler, Acting Director

National Bureau of Standards Certificate

Standard Reference Material 4409L-B

Radioactivity Standard

Selenium-75

This Standard Reference Material consists of selenium-75 and carrier in grams of solution in a flame-sealed borosilicate glass ampoule. The solution, which contains 0.18 milligrams of selenious acid per gram of approximately 1 molar hydrochloric acid, has a density of 1.015 ± 0.002 grams per milliliter at 21°C.

The radioactive concentration of the selenium-75 at 1600 EST March 22, 1977, was

$$*7.727 \times 10^5\ s^{-1}g^{-1} \pm 2.48\%*.$$

This Standard Reference Material was measured, relative to a radium-226 reference source, in the National Bureau of Standards "4π"γ pressure ionization chamber which had previously been calibrated, in terms of a radium-226 reference source, with selenium-75 solutions from which quantitative sources had been prepared and x-γ coincidence counted.

The uncertainty in the value of the radioactive concentration, 2.48 percent, is the linear sum of 0.02 percent, which is the limit of the random error of the ionization-chamber measurements at the 99-percent confidence level (2.831 S_m, where S_m is the standard error computed from independent measurements of 22 samples) and 2.46 percent, which is the estimated upper limit of conceivable systematic errors.

The solution from which this Standard Reference Material was prepared was examined for photon-emitting impurities with a Ge(Li)-spectrometer system and none was observed. The detection limits for impurity gamma rays may be expressed as a percentage of the gamma-ray-emission rate of the 264.65-keV gamma ray of selenium-75. These limits are approximately 0.1 percent for gamma rays with energies less than 401 keV and 0.01 percent for those of greater energy.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

Washington, D. C. 20234
March, 1977

J. Paul Cali, Chief
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SRM 4409L-B-

U.S. Department of Commerce
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National Bureau of Standards
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Standard Reference Material 4409H-B

Radioactivity Standard

Selenium-75

This Standard Reference Material consists of selenium-75 and carrier in grams of solution in a flame-sealed borosilicate glass ampoule. The solution, which contains 1.1 milligrams of selenious acid per gram of approximately 1 molar hydrochloric acid, has a density of 1.015 ± 0.002 grams per milliliter at 21°C.

The radioactive concentration of the selenium-75 at 1600 EST March 22, 1977, was

$$*2.643 \times 10^{7}\ s^{-1}g^{-1} \pm 2.58\%*.$$

This Standard Reference Material was measured, relative to a radium-226 reference source, in the National Bureau of Standards "4π"γ pressure ionization chamber which had previously been calibrated, in terms of a radium-226 reference source, with selenium-75 solutions from which quantitative sources had been prepared and x-γ coincidence counted.

The uncertainty in the value of the radioactive concentration, 2.58 percent, is the linear sum of 0.02 percent, which is the limit of the random error of the ionization-chamber measurements at the 99-percent confidence level (2.831 S_m, where S_m is the standard error computed from independent measurements of 22 samples) and 2.56 percent, which is the estimated upper limit of conceivable systematic errors.

The solution from which this Standard Reference Material was prepared was examined for photon-emitting impurities with a Ge(Li)-spectrometer system and none was observed. The detection limits for impurity gamma rays may be expressed as a percentage of the gamma-ray-emission rate of the 264.65-keV gamma ray of selenium-75. These limits are approximately 0.1 percent for gamma rays with energies less than 401 keV and 0.01 percent for those of greater energy.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

Washington, D. C. 20234
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J. Paul Cali, Chief
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Juanita M. Kreps
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National Bureau of Standards
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National Bureau of Standards Certificate

Standard Reference Material 4410H-B

Radioactivity Standard

Technetium-99m

This Standard Reference Material consists of technetium-99m, as sodium pertechnetate, in grams of a saline solution in a flame-sealed borosilicate-glass ampoule. The density of this solution is 1. ± g/mL at °C.

The radioactive concentration of the technetium-99m as of EST January , 1977, was

* $s^{-1}g^{-1}$ ± %*.

This Standard Reference Material was measured, relative to a radium-226 reference source, in the National Bureau of Standards "4π"γ pressure ionization chamber which had previously been calibrated, in terms of a radium-226 reference source, with technetium-99m solutions from which quantitative sources had been prepared and 4πce-γ coincidence counted using the efficiency-extrapolation method.

The uncertainty in the radioactive concentration, percent, is the linear sum of percent, which is the limit of the random error at the 99-percent confidence level (S_m, where S_m is the standard error computed from independent measurements of samples) and 1.49 percent, which is the estimated upper limit of conceivable systematic errors including the correction for the impurity.

The solution from which this Standard Reference Material was prepared was examined for photon-emitting impurities with germanium-spectrometer systems and molybdenum-99 was found to be present. As of the certification time, the ratio of the activity of the molybdenum-99 to that of technetium-99m was . It is estimated that any other gamma ray with an energy less than 140 keV and an emission rate greater than 10^{-3} that of the 140-keV gamma ray of technetium-99m would have been detected; the corresponding limit for any gamma ray with an energy greater than 140 keV is 10^{-4}.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

J. Paul Cali, Chief
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Washington, D.C. 20234
January, 1977

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U.S. Department of Commerce
Juanita M. Kreps
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National Bureau of Standards
Ernest Ambler, Acting Director

National Bureau of Standards Certificate

Standard Reference Material 4410H-C

Radioactivity Standard

Technetium-99m

This Standard Reference Material consists of technetium-99m, as sodium pertechnetate, in grams of a saline solution in a flame-sealed borosilicate-glass ampoule. The density of this solution is 1.003 ± 0.002 g/ml at 20°C.

The radioactivity concentration of the technetium-99m as of 0300 EST October 25, 1977, was

$$* \; 9.992 \times 10^{8} \; s^{-1}g^{-1} \pm 1.54 \; \%*.$$

This Standard Reference Material was measured, relative to a radium-226 reference source, in the National Bureau of Standards "4π"γ pressure ionization chamber which had previously been calibrated, in terms of a radium-226 reference source, with technetium-99m solutions from which quantitative sources had been prepared and 4πce-γ coincidence counted using the efficiency-extrapolation method.

The uncertainty in the radioactivity concentration, 1.54 percent, is the linear sum of 0.02 percent, which is the limit of the random error at the 99-percent confidence level (3.250 S_m, where S_m is the standard error computed from independent measurements of 10 samples) and 1.52 percent, which is the estimated upper limit of conceivable systematic errors including the correction for the impurity.

The solution from which this Standard Reference Material was prepared was examined for photon-emitting impurities with germanium-spectrometer systems and only molybdenum-99 was found to be present. As of the certification time, the ratio of the activity of the molybdenum-99 to that of technetium-99m was $2 \times 10^{-6} \pm 20\%$. It is estimated that any other gamma ray with an energy less than 140 keV and an emission rate greater that 10^{-3} that of the 140-keV gamma ray of technetium-99m would have been detected; the corresponding limit for any gamma ray with an energy greater than 140 keV is 10^{-4}.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

Washington, D.C. 20234
October, 1977

J. Paul Cali, Chief
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SRM 4410H-C-

U.S. Department of Commerce
Elliot L. Richardson,
Secretary
National Bureau of Standards
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National Bureau of Standards Certificate

Standard Reference Material 4413L

Radioactivity Standard

Mercury-197

This Standard Reference Material consists of mercury-197 in grams of carrier solution in a flame-sealed borosilicate glass ampoule. The solution, which contains approximately 20 micrograms of mercuric nitrate per gram of approximately 0.1 molar nitric acid, has a density of 1.001 ± 0.002 grams per milliliter at 21.6°C.

The radioactive concentration of the mercury-197 as of 0400 EST May 5, 1976, was

$$*5.9_4 \times 10^6 \pm 2.9_4\% \ s^{-1}g^{-1}*.$$

This Standard Reference Material was measured, relative to a radium-226 reference source, in the National Bureau of Standards "4π"γ pressure ionization chamber which had previously been calibrated, in terms of a radium-226 reference source, with mercury-197 solutions from which quantitative sources had been prepared and $x_K - \gamma$ coincidence counted.

The solution from which this Standard Reference Material was prepared was examined for photon-emitting impurities with a Ge(Li) spectrometer system and both mercury-197m and mercury 203 were found to be present. As of the certification date, the ratios of the activities of mercury-197m and mercury-203 to mercury-197 were 0.015 ± 0.005 and 0.00005 ± 0.00001, respectively. Any other radionuclide emitting a photon with energy less than 191 keV and having an emission rate greater than 10^{-3} that of the 191-keV gamma ray of mercury-197 would have been detected; the corresponding limit for any gamma ray with energy greater than 191 keV is 10^{-4}.

The uncertainty in the radioactive concentration of the mercury-197, 2.9_4 percent, is the linear sum of 0.06 percent, which is the limit of the random error at the 99-percent confidence level (2.977 S_m, where S_m is the standard error computed from independent measurements of 15 samples) and 2.8_8 percent, which is the estimated upper limit of conceivable systematic errors including the assessment and corrections for impurities.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

J. Paul Cali, Chief
Office of Standard Reference Materials

Washington, D.C. 20234
May, 1976
SRM 4413L-

U.S. Department of Commerce
Elliot L. Richardson,
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National Bureau of Standards
Ernest Ambler, Acting Director

National Bureau of Standards Certificate

Standard Reference Material 4413H

Radioactivity Standard

Mercury-197

This Standard Reference Material consists of mercury-197 in grams of carrier solution in a flame-sealed borosilicate glass ampoule. The solution, which contains approximately 2 milligrams of mercuric nitrate per gram of approximately 0.1 molar nitric acid, has a density of 1.002 ± 0.002 grams per milliliter at 21.7°C.

The radioactive concentration of the mercury-197 as of 0400 EST May 5, 1976, was

$$*6.8_3 \times 10^8 \pm 3.1_1\ \% \ s^{-1}g^{-1}*.$$

This Standard Reference Material was measured, relative to a radium-226 reference source, in the National Bureau of Standards "4π"γ pressure ionization chamber which had previously been calibrated, in terms of a radium-226 reference source, with mercury-197 solutions from which quantitative sources had been prepared and $x_K - \gamma$ coincidence counted.

The solution from which this standard Reference Material was prepared was examined for photon-emitting impurities with a Ge(Li) spectrometer system and both mercury-197m and mercury-203 were found to be present. As of the certification date, the ratios of the activities of mercury-197m and mercury-203 to mercury-197 were 0.015 ± 0.005 and 0.00005 ± 0.00001, respectively. Any other radionuclide emitting a photon with energy less than 191 keV and having an emission rate greater than 10^{-3} that of the 191-keV gamma ray of mercury-197 would have been detected; the corresponding limit for any gamma ray with energy greater than 191 keV is 10^{-4}.

The uncertainty in the radioactive concentration of the mercury-197, 3.1_1 percent, is the linear sum of 0.06 percent, which is the limit of the random error at the 99-percent confidence level (2.977 S_m where S_m is the standard error computed from independent measurements of 15 samples) and 3.0_5 percent, which is the estimated upper limit of conceivable systematic errors including the assessment and correction for impurities.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

J. Paul Cali, Chief
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Washington, D.C. 20234
May, 1976

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U.S. Department of Commerce
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Standard Reference Material 4412L

Radioactivity Standard
Molybdenum-99-Technetium-99m

This Standard Reference Material consists of molybdenum-99 in equilibrium with technetium-99m, as molybdate and pertechnetate, in grams of approximately 3.8 molar nitric acid in a flame-sealed borosilicate glass ampoule. The density of this solution is 1.121 ± 0.003 g/ml at 21.3°C.

The activity of the molybdenum-99 per gram of solution at 1830 EST March 31, 1976, was

$$*3.88 \times 10^6\ s^{-1}g^{-1} \pm 3.3_5\%*.$$

This Standard Reference Material was measured in the National Bureau of Standards "4π"γ pressure ionization chamber which had previously been calibrated with molybdenum-99-technetium-99m solutions from which quantitative sources had been prepared and 4πβ-γ coincidence counted using the efficiency extrapolation method.

The uncertainty in the value of the activity, 3.3_5 percent, is the linear sum of 0.02 percent, which is the limit of the random error of the ionization-chamber measurements at the 99-percent confidence level (2.861 S_m, where S_m is the standard error computed from independent measurements of 20 samples) and 3.3_3 percent, which is the estimated upper limit of conceivable systematic errors.

The solution from which this Standard Reference Material was prepared was examined for photon-emitting impurities with a Ge(Li)-spectrometer system and none was observed. Any radionuclide emitting a photon with energy less than 140 keV and having an emission rate greater than 10^{-3} that of the 140.509-keV gamma ray in a molybdenum-99-technetium-99m equilibrium mixture would have been detected; the corresponding limit for any gamma ray with energy greater than 140 keV is 10^{-4}.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

Washington, D. C. 20234
April, 1976

J. Paul Cali, Chief
Office of Standard Reference Materials

SRM 4412L-

U.S. Department of Commerce
Rogers C.B. Morton,
Secretary
National Bureau of Standards
Richard W. Roberts, Acting Director

National Bureau of Standards Certificate

Standard Reference Material 4412H

Radioactivity Standard

Molybdenum-99-Technetium-99m

This Standard Reference Material consists of molybdenum-99 in equilibrium with technetium-99m, as molybdate and pertechnetate, in grams of approximately 4 molar nitric acid in a flame-sealed borosilicate glass ampoule. The density of this solution is 1.129 ± 0.002 g/ml at 21.6°C.

The activity of the molybdenum-99 per gram of solution at 1830 EST March 31, 1976, was

$$*3.16 \times 10^{8}\ s^{-1}g^{-1} \pm 3.5_3\%*.$$

This Standard Reference Material was measured in the National Bureau of Standards "4π"γ pressure ionization chamber which had previously been calibrated with molybdenum-99-technetium-99m solutions from which quantitative sources had been prepared and 4πβ-γ coincidence counted using the efficiency extrapolation method.

The uncertainty in the value of the activity, 3.5_3 percent, is the linear sum of 0.02 percent, which is the limit of the random error of the ionization-chamber measurements at the 99-percent confidence level ($2.861\ S_m$, where S_m is the standard error computed from independent measurements of 20 samples) and 3.5_1 percent, which is the estimated upper limit of conceivable systematic errors.

The solution from which this Standard Reference Material was prepared was examined for photon-emitting impurities with a Ge(Li)-spectrometer system and none was observed. Any radionuclide emitting a photon with energy less than 140 keV and having an emission rate greater than 10^{-3} that of the 140.509-keV gamma ray in a molybdenum-99-technetium-99m equilibrium mixture would have been detected; the corresponding limit for any gamma ray with energy greater than 140 keV is 10^{-4}.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

Washington, D. C. 20234
April, 1976

J. Paul Cali, Chief
Office of Standard Reference Materials

SRM 4412H-

U.S. Department of Commerce
Juanita M. Kreps
Secretary
National Bureau of Standards
Ernest Ambler, Acting Director

National Bureau of Standards Certificate

Standard Reference Material 4412L-B

Radioactivity Standard

Molybdenum-99-Technetium-99m

This Standard Reference Material consists of molybdenum-99 in equilibrium with technetium-99m, as molybdate and pertechnetate, in grams of approximately 4 molar nitric acid in a flame-sealed borosilicate-glass ampoule. The density of this solution is 1.125 ± 0.005 g/mL at 22.0°C.

The radioactivity concentration of the *molybdenum-99* component of the mixture at 0900 EST March 1, 1977, was

$$*2.072 \times 10^{6}\ s^{-1}g^{-1} \pm 1.58\%*.$$

A dilution of the solution from which this Standard Reference Material was prepared was standardized by $4\pi\beta$-γ coincidence counting using the efficiency extrapolation method, subtracting the contribution of the technetium-99m, also measured by efficiency extrapolation with separate technetium-99m sources.

The uncertainty in the value of the activity, 1.58 percent, is the linear sum of 0.34 percent, which is the limit of the random error of the coincidence measurements at the 99-percent confidence level (3.499 S_m, where S_m is the standard error computed from independent measurements of 8 samples) and 1.24 percent, which is the estimated upper limit of conceivable systematic errors.

The solution from which this Standard Reference Material was prepared was examined for photon-emitting impurities with a Ge(Li)-spectrometer system and none was observed. The detection limits for impurity gamma rays may be expressed as a percentage of the gamma-ray-emission rate of the 140.509-keV gamma ray in the molybdenum-99-technetium-99m equilibrium mixture. These limits are approximately 0.1 percent for gamma rays with energies below that of the 140.509-keV gamma ray and 0.01 percent for those of higher energy.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

Washington, D.C. 20234
March, 1977

J. Paul Cali, Chief
Office of Standard Reference Materials

SRM 4412L-B-

U.S. Department of Commerce
Juanita M. Kreps
Secretary

National Bureau of Standards
Ernest Ambler, Acting Director

National Bureau of Standards Certificate

Standard Reference Material 4412H-B

Radioactivity Standard
Molybdenum-99-Technetium-99m

This Standard Reference Material consists of molybdenum-99 in equilibrium with technetium-99m, as molybdate and pertechnetate, in grams of approximately 4 molar nitric acid in a flame-sealed borosilicate-glass ampoule. The density of this solution is 1.136 ± 0.004 g/mL at 22.3°C.

The radioactivity concentration of the *molybdenum-99* component of the mixture at 0900 EST March 1, 1977, was

$$*3.941 \times 10^{8}\ s^{-1}g^{-1} \pm 1.68\%*.$$

A dilution of the solution from which this Standard Reference Material was prepared was standardized by $4\pi\beta$-γ coincidence counting using the efficiency extrapolation method, subtracting the contribution of the technetium-99m, also measured by efficiency extrapolation with separate technetium-99m sources.

The uncertainty in the value of the activity, 1.68 percent, is the linear sum of 0.34 percent, which is the limit of the random error of the coincidence measurements at the 99-percent confidence level (3.499 S_m, where S_m is the standard error computed from independent measurements of 8 samples) and 1.34 percent, which is the estimated upper limit of conceivable systematic errors.

The solution from which this Standard Reference Material was prepared was examined for photon-emitting impurities with a Ge(Li)-spectrometer system and none was observed. The detection limits for impurity gamma rays may be expressed as a percentage of the gamma-ray-emission rate of the 140.509-keV gamma ray in the molybdenum-99-technetium-99m equilibrium mixture. These limits are approximately 0.1 percent for gamma rays with energies below that of the 140.509-keV gamma ray and 0.01 percent for those of higher energy.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

Washington, D.C. 20234
March, 1977

J. Paul Cali, Chief
Office of Standard Reference Materials

SRM 4412H-B-

U.S. Department of Commerce
Elliot L. Richardson,
Secretary
National Bureau of Standards
Ernest Ambler, Acting Director

National Bureau of Standards Certificate

Standard Reference Material 4414L

Radioactivity Standard

Iodine-123

This Standard Reference Material consists of iodine-123 in grams of carrier solution in a flame-sealed borosilicate glass ampoule. The solution, which contains approximately 0.6 milligram NaOH, 0.025 milligram LiOH, 0.025 milligram Na_2SO_3, 0.046 milligram KI per gram of solution, has a density of 0.998 ± 0.001 gram per milliliter at 21.3°C.

The radioactive concentration of the iodine-123 as of 1100 EST June 16, 1976, was

$$*5.11_9 \times 10^7\ s^{-1}g^{-1} \pm 1.9_1\%*.$$

This Standard Reference Material was measured, relative to a radium-226 reference source, in the National Bureau of Standards "4π"γ pressure ionization chamber which had previously been calibrated, in terms of a radium-226 reference source, with iodine-123 solutions from which quantitative sources had been prepared and $4\pi e$-γ coincidence counted using the efficiency extrapolation method.

The solution from which this Standard Reference Material was prepared was examined for photon-emitting impurities with a Ge(Li) spectometer system and both tellurium-121 and iodine-125 were found to be present. As of the certification time, the ratios of each impurity to iodine-123 were

tellurium-121	$2.5 \times 10^{-5} \pm 20\%$
iodine-125	$3.1 \times 10^{-3} \pm 10\%$.

Any other radionuclide emitting a gamma ray with an energy less than 159 keV and having a gamma-ray-emission rate greater than 10^{-3} that of the 159-keV gamma ray of iodine-123 would have been detected; the corresponding limit for any gamma ray with energy greater than 159 keV is 10^{-4}.

The uncertainty in the radioactive concentration of the iodine-123, 1.9_1 percent, is the linear sum of 0.08 percent, which is the limit of the random error at the 99-percent confidence level (2.977 S_m, S_m is the standard error computed from independent measurements of 15 samples) and 1.8_3 percent, which is the estimated upper limit of conceivable systematic errors.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

J. Paul Cali, Chief
Office of Standard Reference Materials

Washington, D.C. 20234
June, 1976

SRM 4414L-

123I EC DECAY (13.2 H 1) I(min)=0.10%

Radiation Type	Energy (keV)	Intensity (%)	Δ(g-rad/μCi-h)
Auger-L	3.19	95 6	0.0064
Auger-K	22.7	12 3	0.0060
ce-K- 1	127.19 3	14.1 5	0.0382
ce-L- 1	154.06 3	1.90 9	0.0062
ce-MNO- 1	157.99 3	0.41 5	0.0014
X-ray L	3.77	9 4	0.0008
X-ray $K\alpha_2$	27.20170 2	24.7 9	0.0143
X-ray $K\alpha_1$	27.47230 2	46.2 16	0.0270
X-ray Kβ	31	16.0 6	0.0106
γ 1	159.00 3	82.9 4	0.281
γ 7	440.4 5	0.348 17	0.0033
γ 8	505.6 6	0.26 5	0.0028
γ 9	529.0 4	1.05 10	0.0119
γ 10	538.5 5	0.265 17	0.0030

9 weak γ's omitted ($\Sigma I\gamma$ = 0.45%)

FROM:

Nuclear Decay Data for Selected Radionuclides
Edited by M. J. Martin
Oak Ridge National Laboratory
Oak Ridge, Tennessee

March 1976

U.S. Department of Commerce
Elliot L. Richardson,
Secretary
ional Bureau of Standards
t Ambler, Acting Director

National Bureau of Standards Certificate

Standard Reference Material 4414H

Radioactivity Standard

Iodine-123

This Standard Reference Material consists of iodine-123 in grams of carrier solution in a flame-sealed borosilicate glass ampoule. The solution, which contains approximately 1.5 milligrams NaOH, 0.18 milligram LiOH, 0.17 milligram Na_2SO_3, 0.33 milligram KI per gram of solution, has a density of 0.999 ± 0.001 gram per milliliter at 21.8°C.

The radioactive concentration of the iodine-123 as of 1200 EST June 15, 1976, was

$$*5.51_0 \times 10^8 \ s^{-1}g^{-1} \pm 2.1_5\%*.$$

his Standard Reference Material was measured, relative to radium-226 reference source, in the National Bureau of Standards "4π"γ pressure ionization chamber which had previously been calibrated, in terms of a radium-226 reference source, with iodine-123 solutions from which quantitative sources had been prepared and $4\pi e$-γ coincidence counted using the efficiency extrapolation method.

The solution from which this Standard Reference Material was prepared was examined for photon-emitting impurities with a Ge(Li) spectrometer system and both tellurium-121 and iodine-125 were found to be present. As of the certification time, the ratios of each impurity to iodine-123 were

tellurium-121	$7.1 \times 10^{-6} \pm 20\%$
iodine-125	$3.5 \times 10^{-3} \pm 10\%$.

Any other radionuclide emitting a gamma ray with an energy less than 159 keV and having a gamma-ray-emission rate greater than 10^{-3} that of the 159-keV gamma ray of iodine-123 would have been detected; the corresponding limit for any gamma ray with energy greater than 159 keV is 10^{-4}.

The uncertainty in the radioactive concentration of the iodine-123, 2.1_5 percent, is the linear sum of 0.09 percent, which is the limit the random error at the 99-percent confidence level ($4.032\ S_m$, ere S_m is the standard error computed from independent measurements of 6 samples) and 2.0_6 percent, which is the estimated upper limit of conceivable systematic errors.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

J. Paul Cali, Chief
Office of Standard Reference Materials

Washington, D.C. 20234
June, 1976

SRM 4414H-

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
Washington, D.C. 20234

Date: June 1976

To: Users of ^{123}I SRM's 4414H and 4414L

From: W. B. Mann, Chief, Radioactivity Section

Subject: ^{123}I gamma-ray intensities (probabilities per decay)

The ^{123}I gamma-ray intensities (probabilities per decay) tabulated in the Nuclear Data Project compilation, ORNL 5114, March, 1976, and in the Nuclear Data Tables, Vol. 8, Nos. 1-2, Oct., 1970 differ from some recent NBS measurements. Using sources calibrated as to activity by a $4\pi e$-γ coincidence method, the Radioactivity Section has measured with a calibrated germanium detector the probability per decay of 14 ^{123}I gamma rays. The values obtained are listed in the accompanying table together with those given in the Nuclear Data Project tabulations. The NBS data will be submitted to M. Martin at Oak Ridge for inclusion in their subsequent evaluations. Further measurements will be made, however, in an attempt to improve the accuracy of the experimental data.

ICLEAR DATA PROJECT
OAK RIDGE NATIONAL LABORATORY
March 1976
October 1970

RADIOACTIVITY SECTION
NATIONAL BUREAU OF STANDARDS
June 1976

E_γ (keV)	P_γ (%)	P_γ (%)	UNCERTAINTIES		
			Random 1 SE(%)	Estimated[c] Systematic (%)	Estimated Total (%)
159.00	82.9 ± 0.4 [a]	83.1	0.02	5	5
183.7	0.03 ± 0.2 [b]	0.013	6	44	50
192.7	0.03 ± 0.2 [b]	0.027	3.5	17	21
248.3	0.066 ± 0.008 [b]	0.072	1.5	7	9
281.0	0.066 ± 0.008 [b]	0.077	1.5	7	9
346.6	0.10 ± 0.02 [b]	0.12	1.2	7	8
0.4	0.348 ± 0.017 [a]	0.38	0.6	7	8
505.6	0.26 ± 0.05 [a]	0.27	0.9	6	7
529.0	1.05 ± 0.10 [a]	1.22	0.4	6	6
538.5	0.265 ± 0.017 [a]	0.33	0.8	6	7
624.9	0.066 ± 0.008 [b]	0.075	1.9	6	8
687.7	0.025 ± 0.008 [b]	0.022	4.5	15	20
736.1	0.03 ± 0.01 [b]	0.049	2.5	11	13
784.4	0.04 ± 0.01 [b]	0.051	2.5	11	13

(a) ORNL REPORT #5114, March, 1976.

(b) NDT, Vol. 8, Nos. 1-2, October, 1970.

(c) The linear sum of the estimated upper limit of conceivable systematic errors (which includes 2.14% uncertainty in the activity of the sources used plus 1.19% uncertainty due to the half-life correction applied, assuming a half life of 13.20 ± 0.05 hours).

U.S. Department of Commerce
Elliot L. Richardson,
Secretary

National Bureau of Standards
Ernest Ambler, Acting Director

National Bureau of Standards Certificate

Standard Reference Material 4415L

Radioactivity Standard
Xenon-133

This Standard Reference Material consists of xenon-133 and inactive xenon flame-sealed in a Pyrex ampoule having a volume of about 5 ml, a length of 4.5 cm and a diameter of 1.5 cm. The pressure of the gas in the ampoule is approximately 10^3 to 10^4 pascals (10 to 100 torr).

The total activity of the xenon-133 at 1700 EST November 1, 1976, was

* *.

This Standard Reference Material was measured, relative to a radium-226 reference source, in the National Bureau of Standards "4π"γ pressure ionization chamber. This chamber had previously been calibrated, in terms of a radium-226 reference source, with xenon-133 sources which were measured using the NBS length-compensated internal gas counters.

The xenon-133 from which this Standard Reference Material was prepared was examined for photon-emitting impurities with germanium spectrometer systems and both xenon-131m and xenon-133m were found to be present. As of the certification time, the ratios of the impurity activities to that of the principal radionuclide were and for xenon-131m and xenon-133m, respectively. Any other radionuclide emitting a photon with an energy of less than 81-keV and having an emission rate greater than 10^{-3} that of the 81-keV gamma ray of xenon-133 would have been detected; the corresponding limit for any photon with energy greater than 81 keV is 10^{-4}.

The uncertainty in the activity of the xenon-133, percent, is the linear sum of percent, which is the limit of the random error at the 99-percent confidence level (S_m, where S_m is the standard error computed from readings) and percent, which is the estimated upper limit of conceivable systematic errors.

A half life of 5.245 ± 0.006 days for xenon-133 is suggested. This value is the mean of the half lives of the 6 sources of isotopically pure xenon-133 used to calibrate the "4π"γ pressure ionization chamber. The uncertainty, 0.006 day, is the linear sum of 0.003 day, which is the random error at the 99-percent confidence level, and 0.003 day, which is the estimated systematic error.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

J. Paul Cali, Chief
Office of Standard Reference Materials

Washington, D.C. 20234
November, 1976

SRM 4415L-

ATTENUATION

The average wall thickness of the gas ampoules is 0.117 ± 0.015 cm. Ionization-chamber measurements were made on sources with and without a glass shell of the same composition and wall thickness. The average ratio of the intensity transmitted through the additional thickness of glass to the incident intensity was 0.9818 ± 0.0070*.

*The uncertainty, 0.0070, is the statistical tolerance limit computed from 26 samples with 99-percent probability for coverage of 99 percent of the population. See Experimental Statistics, Nat. Bur. Stand., Handbook 91 (1963) pp 1-14, 1-15, and T-11.

U.S. Department of Commerce
Elliot L. Richardson,
Secretary

National Bureau of Standards
Ernest Ambler, Acting Director

National Bureau of Standards Certificate

Standard Reference Material 4415H

Radioactivity Standard
Xenon-133

This Standard Reference Material consists of xenon-133 and inactive xenon flame-sealed in a Pyrex ampoule having a volume of about 5 ml, a length of 4.5 cm and a diameter of 1.5 cm. The pressure of the gas in the ampoule is approximately 1×10^4 to 4×10^4 pascals (100 to 300 torr).

The total activity of the xenon-133 at 2000 EST November 1, 1976, was

* *.

This Standard Reference Material was measured, relative to a radium-226 reference source, in the National Bureau of Standards "4π"γ pressure ionization chamber. This chamber had previously been calibrated, in terms of a radium-226 reference source, with xenon-133 sources which were measured using the NBS length-compensated internal gas counters.

The xenon-133 from which this Standard Reference Material was prepared was examined for photon-emitting impurities with germanium spectrometer systems and both xenon-131m and xenon-133m were found to be present. As of the certification time, the ratios of the impurity activities to that of the principal radionuclide were 0.0075 and 0.0029 for xenon-131m and xenon-133m, respectively. Any other radionuclide emitting a photon with an energy of less than 81-keV and having an emission rate greater than 10^{-3} that of the 81-keV gamma ray of xenon-133 would have been detected; the corresponding limit for any photon with energy greater than 81 keV is 10^{-4}.

The uncertainty in the activity of the xenon-133, percent, is the linear sum of percent, which is the limit of the random error at the 99-percent confidence level (S_m, where S_m is the standard error computed from readings) and 2.48 percent, which is the estimated upper limit of conceivable systematic errors.

A half life of 5.245 ± 0.006 days for xenon-133 is suggested. This value is the mean of the half lives of the 6 sources of isotopically pure xenon-133 used to calibrate the "4π"γ pressure ionization chamber. The uncertainty, 0.006 day, is the linear sum of 0.003 day, which is the random error at the 99-percent confidence level, and 0.003 day, which is the estimated systematic error.

This Standard Reference Material was prepared in the Center for Radiation Research, Radioactivity Section, W. B. Mann, Chief.

J. Paul Cali, Chief
Office of Standard Reference Materials

Washington, D.C. 20234
November, 1976

SRM 4415H-

ATTENUATION

The average wall thickness of the gas ampoules is 0.117 ± 0.015 cm. Ionization-chamber measurements were made on sources with and without a glass shell of the same composition and wall thickness. The average ratio of the intensity transmitted through the additional thickness of glass to the incident intensity was 0.9818 ± 0.0070*.

*The uncertainty, 0.0070, is the statistical tolerance limit computed from 26 samples with 99-percent probability for coverage of 99 percent of the population. See Experimental Statistics, Nat. Bur. Stand., Handbook 91 (1963) pp 1-14, 1-15, and T-11.