National Uses and Needs for Standard Radioactive Materials (1970)

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NATIONAL USES AND NEEDS FOR STANDARD RADIOACTIVE MATERIALS

A Report by an Ad Hoc Panel
of the
Committee on Nuclear Science
National Research Council

NATIONAL ACADEMY OF SCIENCES
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INTRODUCTION

Availability of a wide range of accurate radioactivity standards is a basic necessity for nuclear research, safe application of radionuclides in medicine and technology, and radiation protection of the public. Recently, dissatisfaction with standards has been expressed both in print[1] and orally to the Subcommittee on the Use of Radioactivity Standards of the Committee on Nuclear Science of the National Research Council.[2] The Committee, therefore, organized an *ad hoc* Panel to consider the status of and need for radioactivity standards in the United States. The Panel activities were funded by the Divisions of Biology and Medicine and Isotopes Development of the Atomic Energy Commission (AEC).

This report presents the conclusions of the Panel and its recommendations to improve the availability and dependability of standards. Information was derived from:

1. Answers to a questionnaire sent to persons and institutions whose addresses were provided by the National Bureau of Standards (NBS) and the AEC;
2. Discussions by Panel members;
3. Presentations to the Panel by users and producers of standards;
4. Direct interviews with selected users by the Panel's secretary.

The information obtained from the questionnaire and interviews is summarized in the Appendix.

RECOMMENDATIONS

1. The U.S. Government should appoint one government agency as the central supplier of radioactivity standards. The National Bureau of Standards has a capable and experienced staff and is the logical agency to provide this service.
2. The central supplier should provide standards at 1-3 percent accuracy and perform research and development at greater accuracy as needed to calibrate its own instruments, maintain professional competence, participate in international comparisons, and respond to special users' needs.
3. The central supplier should be funded on the basis of needs for standards that transcend the short-term balance of sales versus expenditures. Appropriate agencies for

funding, based on current use of standards, include the Atomic Energy Commission, the Public Health Service, the National Science Foundation, and the National Bureau of Standards.

4. The central supplier should undertake an active program to inform potential users of the availability of standards and to develop standards based on users' needs. Utilization of professional societies and other appropriate groups is recommended for these purposes.

5. The central agency responsible for supplying standards should undertake an active program to aid users of radioactivity standards through training courses, published instruction material, counter calibration services, and distribution of intercomparison samples.

6. The U.S. Government, through appropriate agencies, should encourage uniform use of standards for public and occupational health protection.

7. Commercial suppliers should be encouraged to specialize in the preparation of custom (i.e., unusual) standards, standards of 3-10 percent accuracy, and calibrated sources. Careful certification of standards and traceability of values to the National Bureau of Standards are essential.

RADIOACTIVITY STANDARDS UNDER CONSIDERATION

Interest was greatest in standards in aqueous solution--pure radionuclides that are accurately measured in terms of disintegrations per unit time (i.e., curies) per amount (grams) of solution. Decay is by emission of alpha particles, beta particles, electrons, x rays, and gamma rays and by electron capture. Concentrations of interest range from picocuries to millicuries per gram.

Need for other types of radioactivity standards was also discussed. These include solid and gaseous standards in various forms, energy standards, radiation-exposure standards, and instrument-performance standards. In particular, a need was indicated for solid and point sources whose strength is expressed in terms of number of particles or quanta of a particular kind of energy emitted per unit time.

Standardized solutions of radionuclides should be clearly distinguished from routinely measured solutions. A radioactivity standard must be meticulously calibrated and described in a detailed certificate with respect to degree of accuracy, purity, standardization techniques, and assumptions concerning the decay scheme.[3]

STATE OF THE ART

Experts can prepare most radioactivity standards to an accuracy of 0.1 to 1 percent; competent workers in this field usually prepare and measure standards within 1 to 5 percent. To attain even the lesser accuracy, extensive knowledge and experience are required because of the unusual chemical behavior of substances at low concentration, occurrence of radioactive impurities, complexities of decay schemes, special requirements for sample deposition, and instrumental problems.[4-6] Preparation of satisfactory radioactivity standards requires considerable time, dedication, and continuity of effort.

USE OF STANDARDS

Radioactivity standards are commonly used to calibrate a radiation detection instrument so that disintegration rates can thereafter be computed from instrument readings. Standards are used subsequently to check instrument calibration, especially after changes or repairs, and to extend calibration to other radionuclides, energy ranges, or types of radiation.

Most radioactivity measurements do not require a calibrated detector because they are only relative; for example, the initial and final count rates of a radionuclide may be compared as it passes through a system. Even laboratories that specialize in relative measurements, however, frequently need to determine absolute radioactivity values, if only to assess the potential radiation hazard from using and discharging radionuclides.

Fields in which radioactivity standards are vitally necessary include public health, medicine, and nuclear science.

Public Health

Radioactive effluents, radioactive materials handled by workers, and media such as food and water to which populations are exposed are measured for radionuclide content to assure that no radiation hazard exists. The public has been concerned especially with fallout from atmospheric nuclear testing and discharges from nuclear power stations, but other producers and users of radionuclides must also quantify radionuclides to provide health protection for workers and the

public. Accuracy of measurement becomes more important as radiation exposures from handled, transported, or discharged radionuclides approach recommended limits.

Medicine

The concentration of a radiopharmaceutical is measured to achieve diagnosis or therapy at the lowest feasible radiation exposure to the patient. Dosages of radiopharmaceuticals and tracers must be neither more nor less than prescribed by the physician. The practice of nuclear medicine has become widespread; millions of patients are given radioisotopes annually.[7] In this practice, it is frequently useful to have standards for calibrating and maintaining appropriate operating characteristics of nuclear detection equipment (i.e., standards to assure appropriate operating characteristics for both integral counting and spectral distribution).

Nuclear Science

Nuclear properties such as fission yields, reaction cross sections, and decay schemes are determined by absolute measurement of radioactivity, which requires highly precise standards. Many of these measurements have important technological applications, for example, the determination of production cross sections in reactors. Their application in nuclear science is widespread; absolute measurement of radionuclides either singly or in pairs is used in age determinations for geological and historical information and in quantification of radionuclides in the environment and in extraterrestrial samples.

RADIONUCLIDE SALES

Reasonably accurate measurement instruments must be available to commercial suppliers of radionuclides, an industry whose 1969 sales were $66 million.[8] Accurate measurement by suppliers is especially important because purchasers who perform only relative measurements may rely on the supplier's rating to determine what amount of radionuclide is safe for use or discharge.

AVAILABILITY OF STANDARDS

The primary domestic source of radioactivity standards in most countries is the national standardization organization. In the United States, the NBS was established by statute as the sole source of federally certified standards. The Radioactivity Section of NBS has established an estimable record in developing standards and techniques for standardization, supplying standards, standardizing solutions submitted by others, and participating in international intercomparisons.[4] Currently, NBS provides the following services[9]:

1. Distributes through the Office of Standard Reference Materials 15 radionuclides as solution standards and 13 radionuclides in other forms;
2. Offers for a fixed fee a calibration service for 31 radionuclides in terms of the description submitted by the requestor;
3. Performs nonroutine calibrations at cost;
4. Develops reference materials to meet national needs.

Shortage of personnel has kept nonroutine services at a negligible level.

Eleven commercial suppliers of radioactivity standards were identified in the United States in 1969.[10] These commercial suppliers offer many more standards than does NBS. Few, if any, provide the detailed standard certification given by NBS or assure traceability to NBS through standardization of aliquots by NBS or calibration of counters with NBS standards.

Among foreign suppliers, the International Atomic Energy Agency (IAEA), Vienna, Austria; the Radiochemical Centre, Amersham, England; and the Radiation Measurement Laboratory, Saclay, France, are notable. The IAEA standards are of very high quality and can be obtained at low cost. The English and French laboratories each offer more than twice the number of standard items offered by the NBS.

Many users of radioactivity standards in the United States either prepare their own standards or attempt to check purchased standards by independent calibration and by comparison with standards from other suppliers. Some large users maintain central laboratories that purchase, check, and distribute standards and prepare their own if necessary. The Bureau of Radiological Health, U.S. Public Health Service, performs this function through the Analytical Quality Con-

trol Service; its radioactivity standards are also distributed to state and local health departments upon request. At the National Institutes of Health, all standards pass through the Radiation Safety Section. The AEC laboratories maintain groups that prepare or check radioactivity standards.

PROBLEMS OF USERS

Users' complaints fall into two basic categories: (1) the NBS does not prepare or calibrate many of the needed standards, and (2) some standards purchased from commercial suppliers are highly unsatisfactory. Some standards are in error by orders of magnitude; even standards that are outside the indicated error limits shown by the supplier for some standards are unacceptable. While some of the complaints may reflect ignorance or error on the part of the user, especially if he is a specialist in a field remote from radionuclide standardization, the Panel finds that many of the complaints are valid. The NBS standardizes and calibrates far too few radionuclides, in view of the many that are used or encountered in the environment. Further, communication between NBS and users appears to be insufficient for informing NBS of users' needs and acquainting less knowledgeable users with NBS services. Concerning unsatisfactory standards from commercial suppliers, even a few errors awaken distrust and cause much time and effort to be expended by users in checking purchased standards or in preparing their own. Lack of detailed certification of standards prepared by commercial suppliers appears to contribute to the users' distrust.

PROBLEMS OF SUPPLIERS

The scope of the Radioactivity Section of NBS, which has done remarkably well with a small, dedicated staff in making radioactivity standards available in the United States, is limited by insufficient financial support and the requirement that a substantial fraction of the cost of standard preparations be recovered through sales. Thus, only standards in relatively high demand are prepared, and few new standards are developed each year.

The cost of maintaining a large, competent staff for preparing a large selection of standards may be uneconomical for commercial suppliers in the United States. At present,

although many radionuclides are in demand, only a few are used in quantity. Among smaller commercial suppliers of standards, it has been noted that because some do not have the necessary staff and instruments they simply repackage radioactivity solutions and sell them as standards.

TABLE 1 Questionnaire Responses

1. Scientific Field	Percentage of Respondents
Biology	11
Chemistry	12
Environment	24
Medicine	18
Physics	11
Technology	16
General	8
2. No. of Nuclides Assayed	**Percentage**
1-2	16
3-5	21
6-10	25
11-20	21
21-30	6
>30	11
3. Sources of Standards	**Percentage**
In-house	51
NBS	43
IAEA	19
U.S. commercial	71
Other	15
4. Awareness of Respondents	**Percentage**
Knew of:	
NBS standards	81
Fixed-price calibration	57
Custom calibration	45
Standards subcommittee	46
Monographs	29

TABLE 2 Radioactivity Standards Most Requested

^{125}I	^{207}Bi
^{133}Xe	^{56}Co
^{99m}Tc	^{58}Co
^{51}Cr	^{152}Eu
^{75}Se	^{154}Eu
^{99}Mo	^{26}Al
^{236}Pu	^{252}Cf

TABLE 3 Case Histories on Unsatisfactory Standards

Reported by	Nuclide(s)	Problem
Federal agency	Various	Set of 8; -69% to +141% of rated values; 2 within stated accuracy (Ref. 1)
Federal agency	^{57}Co	3 suppliers, certified to 3-6%; 25% spread (Ref. 1)
Federal agency	^{137}Cs	0.01 to 1 μCi desired; 3 suppliers tried, 1 succeeded (Marlow, in Ref. 12)
Federal agency	Various	6 custom ordered; 2 off 50%
Federal agency	Alpha	Contamination with β-γ activity
Private company	^{95}Zr	Ordered ^{95}Zr, received ^{95}Nb
Private company	^{58}Co	Certified 3%, off 15%
State hospital	Various	Wrong nuclides sent
State hospital	^{51}Cr, ^{32}P	Off tenfold
Federal contractor	^{226}Ra	Supplier said "as ordered," refused to give assay method, etc.
Federal agency	^{131}I (μCi)	Sent ^{32}P at mCi level instead
Federal contractor	^{35}S	3 suppliers, 11% spread; certified to 5-10%
Federal contractor	^{110m}Ag	Predominantly ^{108m}Ag; replacement, two bottles, 42% difference

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