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Environmental Monitoring Series

ACTIVITIES AND NEEDS RELATED TO RADIOACTIVITY STANDARDS FOR ENVIRONMENTAL MEASUREMENTS

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FOREWORD

Man and his environment must be protected from the adverse effects of pesticides, radiation, noise, and other forms of pollution, and the unwise management of solid waste. Efforts to protect the environment require a focus that recognizes the interplay between the components of our physical environment--air, water, and land. The National Environmental Research Centers provide this multidisciplinary focus through programs engaged in

- studies on the effects of environmental contaminants on man and biosphere,
- the development of efficient means of monitoring these contaminants, and
- a search for ways to prevent contamination and to recycle valuable resources.

The current and projected increase in the number of nuclear power stations requires expanded monitoring programs at the state and federal level to assure that radiation exposures of persons in the environment remain at an acceptably low level. The Environmental Protection Agency is therefore engaged in a spectrum of activities to assure that the monitoring programs are reliable. These include distributing calibrated radioactivity solutions, undertaking laboratory intercomparisons, and preparing manuals of radiochemical analyses. As part of these activities, the Environmental Protection Agency participated in this symposium arranged by the Subcommittee on the Use of Radioactivity Standards, Committee on Nuclear Science, NAS-NRC, and is publishing the proceedings.

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ABSTRACT

A symposium was held to discuss the needs for radioactivity standards in environmental monitoring programs concerned with population radiation exposure. Papers were presented on "Status of Decay Schemes," "Some Activities and Needs for AEC Regulatory in the Use of Radioactivity Standards," "Standards for Environmental Studies," "Program and Activities of the Quality Assurance Branch, NERC-Las Vegas," "Activities of Commercial Radionuclide Producers," and "Radionuclide Metrology and Quality Assurance." The presentations indicated that numerous radioactivity standards and aids for correctly utilizing them were available. New needs, however, had arisen recently because lower levels of ambient radioactivity must be measured by many more groups due to requirements that population radiation exposure from nuclear power production be as low as practicable. Based on the presentations and resulting discussions, the following actions were recommended: 1) Establish a focal point for systematically planning activities to meet cited needs for decay schemes, specific standards, analytical methods, and quality assurance programs; 2) Develop a clear chain of traceability to the National Bureau of Standards; 3) Prepare guides for standardizing radiation detection and maintaining quality control; and 4) Train qualified analysts to obtain satisfactory analytical results.

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INTRODUCTION AND RECOMMENDATIONS

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Considerable efforts currently are being devoted to measuring radionuclides in effluents from nuclear facilities and in environmental media that may contribute to population radiation exposure. To make certain that the data are accurate, both the U. S. Atomic Energy Commission (AEC) and the U. S. Environmental Protection Agency (EPA) maintain active quality assurance programs. Attainment of a consistent level of accuracy has been found difficult. This is understandable in view of the variety of radionuclides and media, the low radionuclide concentrations, and the specialized nature of the analytical and detection procedures.

The availability and correct use of appropriate radioactivity standards are fundamental requirements for accurately measuring radionuclides. Their importance to radiation protection activities and a program to fulfill needs for standard radioactive material were discussed in a report published in 1970.(1) Since then, the number of measurement programs has increased with the rapid expansion in nuclear power production. Moreover, measurements have had to be more detailed in response to recommendations for achieving lowest practicable radiation exposures. The Subcommittee on the Use of Radioactivity Standards of the Committee on Nuclear Science, NAS-NRC, therefore, arranged this meeting to determine whether additional activities were necessary to meet the needs for radioactivity standards in this field, and EPA has published the proceedings to make this information generally available.

Specialists were invited to present papers on the most important aspects of using radioactivity standards: availability of standardized solutions, of decay schemes needed to interpret calibration, and of guidance for appropriately applying the standards. A quality assurance program being developed for producers and users of radiopharmaceuticals was presented to describe a response to similar problems in a related field. The participants (listed in the Appendix) discussed current needs of users in considerable detail.

Based on these presentations and discussions, the following activities are recommended to the AEC, EPA, and Committee on Nuclear Science to assure the quality of environment-related radioactivity measurements:

(1) Establish a focal point for systematic planning. A schedule of priorities needs to be developed for obtaining "best" decay schemes, specific standards, analytical methods, and quality assurance programs on the basis of the radiation exposure potential and requirements of time and manpower. Ongoing activities concerning radioactivity standards can be evaluated for their applicability to the specialized needs of environmental measurement programs.

(2) Develop traceability to the National Bureau of Standards. In the environmental field, a chain of traceability through either the AEC Health Services Laboratory or the EPA Quality Assurance Branch is envisioned. As a supplement or alternative, cooperative efforts by producers of standards to maintain traceability could be extended to include participation by the analytical laboratories that use standards. Consideration will have to be given to defining traceability with regard to the frequency of test, the magnitude of the acceptable uncertainty, and the fraction (if any) of erroneous intercomparison values that can be accepted.

(3) Prepare guides for standardizing radiation detection and maintaining quality control. The special analytical problems in this field must be considered: measuring extremely low radionuclide levels, distinguishing small increments above "background" levels, preventing contamination of samples and detectors, and evaluating detector stability very precisely. Relatively uniform procedures should be recommended for resolving these problems.

(4) Train qualified analysts. The competence and reliability of individual analysts is usually the most important factor in obtaining satisfactory analytical results. Thus, abrupt decreases in the quality of analytical data are often observed when one analyst leaves his laboratory. For the same reason, laboratories perform some analyses accurately and others inaccurately. The employment of additional qualified analysts would go far toward eliminating these problems.

It is important to note that some related aspects of effluent and environmental measurements were considered to be potentially greater sources of error than radionuclide standardization and instrument calibration. These included sample collection and storage, radiochemical analysis, and data reporting. They should be given at least as much consideration as the appropriate use of radioactivity standards.

References

1. Ad Hoc Panel of the Committee on Nuclear Science, "National Uses and Needs for Standard Radioactive Material", National Academy of Science, Washington, D. C. 20418 (1970).

STATUS OF DECAY SCHEMES

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As most of the members of this Subcommittee well know, the use of radioisotopes is expanding at a rather rapid rate. In a recent paper(1) presented at the IAEA Symposium on Applications of Nuclear Data in Science and Technology, Dr. Weinberg and I prepared a rather cursory table which tried to depict some of the areas of usage and the level of sophistication involved. One of our primary objectives was to try to point out that the applications were many and varied, and hence, so too the actual nuclear data needs.

During the past four years, as Director of the Nuclear Data Project, I have been somewhat concerned with trying to understand and place in perspective the needs of various users--both basic and applied. Some of my thoughts on this were summarized(2) in a paper also presented at the IAEA Symposium. Recently, I have attended sessions at ANS and Society of Nuclear Medicine Meetings in an effort to learn more of the needs in these areas. Let me spend a few minutes here to offer my impressions of the situation.

I'll begin by saying that I've listened to many persons in both the basic and applied areas who <u>want</u>! And I'll state here that, of course, we would be most happy if we could <u>give</u>! However, just as everyone else has to work in an environment with boundaries, so too do we at the Data Project.

Now from my reference frame, the picture seems to be somewhat as follows. There are over 1500 identified radionuclides, which have been studied to varying degrees. During the past four years, the Data Project has provided evaluated compilations on some seventy or more mass chains. In conjunction with the NIRA Program, all of the mass chains with $A > 44$ should be current to within seven years or less by the end of 1974. In addition, the Data Project has produced some specialized compilations such as Radioactive Atoms(3) by Martin and Blichert-Toft, and recently Martin has compiled data on about thirteen additional decay schemes, mainly for fission product gases.

The precise status of our knowledge on many decay schemes fluctuates drastically depending upon the specific circumstances. For instance, in most cases where there is direct decay to the ground state of the daughter product, the absolute normalization for the decay is usually not known, or if so, only rather poorly. Hence, if one is

trying to use such an activity for quantitative purposes, the accuracy achievable will be limited. It seems to me from my attendance at the IAEA Symposium, the ANS and SNM Meetings, and conversations with numerous users, the latter do not always appreciate this point. In general, determination of the absolute normalization factor contributes little insight into the physics involved, whereas the measurement can be rather tedious. Hence, it is not uncommon to find many papers on decay schemes in which the absolute normalization is essentially ignored. Shortly after arriving at the Data Project, I requested the compilers to explicitly indicate in the compilations how each decay scheme has been normalized. It behooves the user to examine such statements, especially if he is interested in the intensity of radiations per 100 decays.

To me, the designation of standards is a human endeavor, and the manner in which this is done very much depends upon the persons involved and probably their impressions of how the "standards" will be applied. However, no matter how this is to be arrived at, I would strongly suggest that the data be examined in sufficient detail to ensure that the "standard data" fall within the bounds of what is actually known.

Now I'd like to spend a few minutes discussing the problems of the data producers, compilers, and users, mainly as they pertain to decay data. I've already noted that data producers, i.e., basic researchers, study decay schemes primarily from the view of trying to learn something of nuclear structure. In addition, they also derive a living from such work, and their pay scale is usually based upon numbers of papers published, and whether or not the content proves of value to an applied user is immaterial.

As regards the data users, we've already noted that they each have a specific use in mind which stipulates what type and quality of data they need.

Now the number of data producers probably outnumbers the compilers by at least 100/1, and the number of users outnumbers the compilers by most probably 1000/1. Hence, to assume that a handful of compilers will be able to satisfy the specific desires of each user is completely unrealistic. Therefore, either the users must be capable of satisfying some of their own needs, or some system has to be worked out that makes it easy to satisfy large numbers of users from a minimal effort. Frankly, I think we've reached the point where the users or the committees which purport to represent them should begin to examine their actual needs in more detail, because obviously, the compilers are going to have to devote more effort to the

criteria of choice of what they compile, as well as the time devoted to same.

References

1. Criteria of Choice for Compilations of Nuclear Data - D. J. Horen and A. M. Weinberg, IAEA Symposium on Applications of Nuclear Data in Science and Technology, Paris, France (March 1973).
2. Nuclear Data Project: Operations, Status, and Plans - D. J. Horen, IAEA Symposium on Applications of Nuclear Data in Science and Technology, Paris, France (March 1973).
3. Radioactive Atoms: Auger-Electron, Alpha-, Beta-, Gamma-, and X-Ray Data, M. J. Martin and P. H. Blichert-Toft, Nuclear Data Tables A8, 1 (1970).

Discussion:

Additional comment by Horen: Funding for the Nuclear Data Project arises from the AEC Division of Physical Research (DPR) in an amount of approximately 1% of that Division's $60 million budget.

Kahn: How much money is provided by "applied agencies"?

Horen: We have never had funding outside the DPR. We have just been given $10,000 for FY 74 by AEC Regulatory for their decay scheme needs. Since our support is mainly provided from basic research programs, we are getting pressure to satisfy the basic researcher's needs. We may have to modify the format.

Kahn: That is indeed a modest sum.

Horen: "Applied users" will have to define their decay scheme needs.

Kastner: Is there a correlation between the amount of money needed and the "resolution" of the data?

Horen: Certainly, the greater detail needed for highly specialized needs requires more time. Beyond a certain accuracy, there is little to be gained for nuclear physics purposes. Applied users' needs require more effort due to the necessity for absolute normalization.

Kastner: Can you identify government agencies or other groups that should support this effort?

Horen: It is up to the users themselves to define their needs precisely.

Kahn: How can SOURS arrange for compilations of simplified decay schemes?

Horen: I suggest that SOURS prepare documents justifying the defining of the needs of users and then approach each concerned agency for financial support. I would like to ask that there be a feed-back of information to AEC-DPR as to the usefulness of the compilations.

Meyers: I would like to mention the dosimetry data bank that is supported by various agencies at Oak Ridge Associated Universities. It is directed by Roger Cloutier.

Kastner: I suggest that SOURS be a "funnel" for feed-back of information to compilers. I think SOURS could help define format for simplified decay schemes and could be the group to recommend changes in values used in practice.

Kahn: How could financial support be obtained by defining needs and for preparation of additional simplified decay schemes?

Kastner: Additional funding could be shifted from other programs if justification is presented.

Meyers: FDA support would probably be available, but not for 1500 nuclides. I would suggest 15 or 20--possibly 40. New radiopharmaceuticals require valid data.

Jarvis: EPA might be able to give support, but again for 20-30 radionuclides.

SOME ACTIVITIES AND NEEDS FOR AEC REGULATORY IN THE USE OF RADIOACTIVITY STANDARDS

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I would like to thank the subcommittee for inviting a representative of AEC Regulatory to participate in these discussions. I plan to first describe our activities which require laboratory support and some of our experiences with regard to radioactivity standards. Then, I will speak about some of the needs we have either encountered or can foresee relating to Regulatory's own measurement programs, licensees' analytical requirements and those of companies performing analytical measurements for licensees. Our general approach to these needs may differ from many participants in these discussions because our need for accuracy is different from that of most research and development laboratories.

Regulatory's major need for laboratory capability is to obtain reasonable assurance that the results of licensee's analytical measurements and subsequent reports are valid. In addition, it is our desire that the results be relatable to our national standards organization, the National Bureau of Standards. These efforts are involved in two major programs - 1) safeguards and 2) independent effluent and environmental measurements.

The safeguards program, through its field inspection program, independently verifies those components of a facility's material balance which are not verified by a second party (e.g., the receiver of a shipment as well as the shipper in order to determine the amount of material involved in the transaction). This is done by both destructive analyses (offsite) and by non-destructive equipment at the site. We plan to increase the percentage of non-destructive analyses over the next several years so that by 1978, over 75% will be done this way. This will be accomplished by adding more measurement vans and upgrading the equipment in our present vans. However, there will continue to be a need for destructive analytical capability because of its accuracy over present non-destructive analytical methods.

At present, there are two major classes of safeguards standards available. The first is a group of high purity, extremely well-characterized materials, prepared in AEC facilities and certified and distributed by the NBS as Standard Reference Materials (SRM). The second is a group

of working standards, prepared and standardized against SRMs and distributed by various AEC and contractor laboratories.

We are in the process of soliciting the views of various AEC and contractor laboratories and special nuclear material licensees in order to project the needs for uranium and plutonium certified standard materials for elemental and isotopic assay through 1980. We have sent out a letter asking for their views as to new standards needed and the rate at which the respondents might purchase these new standards. This information would be made available to the subcommittee, if desired.

In addition to these standards which are used for destructive testing, we also utilize working standards in suitable configurations for onsite testing in our vans. These are essentially secondary standards for nondestructive testing which are standardized against SRMs.

The program for independent measurements of plant effluent and environmental effects has several components. For the past few years special evaluations have been conducted at operating nuclear power plants to assist Regulatory in standards development and in the review of reactor designs by empirically determining the value of key variables in models describing the release, transport, and uptake of radionuclides. This has included in-depth measurements at six boiling water reactors (BWR) and a field study to determine the fate of iodine from three reactors in various media in the environment. In addition, we are currently conducting source term measurements at a pressurized water reactor and anticipate future studies at a fuel reprocessing plant, high temperature gas cooled reactor, fuel fabrication facilities, possibly uranium ore processing mills and tailings piles and other AEC licensed facilities which may have a significant impact on the environment. During both of the studies already conducted, BWRs and the iodine pathway study, we have had the problem of relating data from the several laboratories involved in the studies. At one of the BWRs, there were six laboratories analyzing different samples from the reactor. In connection with this study, we asked the NBS to supply both standards and unknown test sources to these six laboratories for the purpose of intercomparing their ability to detect and identify radionuclides commonly found in reactor effluents. NBS prepared a standard containing seven radionuclides and an unknown solution with six radionuclides of somewhat different radionuclide composition. The NBS has previously reported the results of the intercomparison.

In the iodine pathway study, we have a similar problem of intercomparison which is compounded by the participation

of nine laboratories in this study and the fact that these were low level environmental measurements of a radionuclide with a short half-life. In this case, we called on NBS to prepare, on short notice, low level I-131 liquid standards to be distributed to the study participants. In addition, we had planned to prepare a grass sample spiked with I-131 and have this intercompared among the various laboratories during the study. However, this had to be postponed until the conclusion of the study because, as Dr. Kahn pointed out, the spiked grass sample could conceivably contaminate laboratory equipment because its activity would be quite high compared to the barely perceptable levels we were finding the environment. In addition, uniform concentrations of iodine in the grass is difficult to achieve. It would probably be best to have each laboratory count the same sample but this is not practical because of the transport times involved and the different methods of sample preparations by each of the laboratories.

The laboratory analyses for these studies mentioned above are performed primarily by AEC contractor laboratories and occasionally by other government laboratories. The needs of these sophisticated laboratories relating to radioactivity standards will be adequately covered by John Harley in his presentation and other presentations during this meeting so I will not go into these needs.

Another major laboratory program which Regulatory has embarked upon is our collaborative monitoring program with the States. In this program the States will split or obtain duplicate effluent and environmental samples for the purpose of verifying a licensee's results which are required to be reported to the AEC. In addition, we have specified that the verified results should be traceable to the NBS. This presents a two fold problem. There is a need, first, to design a program to assure traceability of States' and licensees' analyses results to the NBS and secondly, to upgrade the capability of the States to the point where an attempt to accomplish traceability would be meaningful. To this end, the NBS is currently working with our laboratory, the Health Services Laboratory (HSL). The States, in turn, will not be directly traceable to the NBS but rather will achieve some form of traceability through standards prepared by HSL, analysis of duplicate samples and test solutions and other means. In some States this process will not be difficult; others will require much assistance before they reach this point of accomplishment. HSL has visited most of the contract States to gain an insight as to their capability and has begun to provide them with several of their own secondary standards in order to calibrate their systems. In addition, it is necessary

in some cases to instruct these State laboratories in the proper use of standards. In other words, we are attempting to develop a system whereby HSL will be directly traceable to the NBS and the States and ultimately licensees would be relatable to the NBS through HSL. We anticipate this will be a continuing program which will require a significant portion of HSL's time both in analyzing NBS standards and test solutions and HSL preparing secondary calibration standards and unknowns.

The AEC-State collaborative program is designed to provide some verification of the analytical capability of licensees and their laboratory contractors. What we are trying to do is give some credibility to the massive amount of environmental and effluent data we receive. But the problem of providing credibility to data should not be ours alone. Licensees and environmental consultant laboratories must be willing to conduct workable quality control programs. In order to do that, however, appropriate standards, especially environmental standards, must be made available. The AEC places a great emphasis on quality assurance and quality control in the construction and operation of nuclear power plants in relation to safety. Similar emphasis on quality control in effluent and environmental programs can be expected in the near future. If commercial suppliers, environmental consultants or other government agencies cannot provide appropriate standards for acceptable quality control programs or these laboratories providing environmental analyses do not conduct satisfactory quality control programs, the AEC may be reluctantly forced to become directly involved.

The AEC is now in the process of considering an amendment to its regulations which would specify design objectives for the "as low as practicable" philosophy. At such time as that rule, Appendix I to Part 50, is adopted, there will be increased emphasis on the measurement of lower levels of radioactivity in the environment. As you may be aware, the technical specifications of several reactor licenses already require the determination of I-131 in milk to 0.5 pCi/liter at the time of sampling. This corresponds to an annual dose of less than 5 mrem/year to the thyroid of a child drinking a liter of milk per day.

In the future there seems little doubt that environmental monitoring of both sea water and fresh water will be required to determine concentrations of radionuclides at very low levels. A need exists to establish "natural standards" of radionuclides in these media. In such development, the AEC must be assured of a proper mode of preparation and storage in the "standards" such that the media will not deteriorate with time. In addition, the chemical stability of the radioactive species

composing the constituents for analysis must also be assured over long periods of time.

Most AEC licensees of nuclear facilities do not have the laboratory or support facilities which the laboratory people at this meeting can call upon. They are not in a position to prepare environmental standards or any other secondary standards or even to check the standards supplied. For these people, who in a sense cannot defend themselves, we should devise a system which will, first of all, provide an adequate selection of necessary standards and additionally provide information to enable the user to employ the standards correctly. One of the recommendations of this subcommittee in its previous report was the "The central agency responsible for supplying standards" presumably the NBS, "should undertake an active program to aid users of radioactivity standards through training courses" and "published instruction material". That recommendation is still valid and we would hope that the NBS would be able to obtain the resources to implement that recommendation.

At this time the NBS is attempting to develop the concept of traceability to provide a link between the user and the national and international measurements systems. This is a difficult task but we would encourage the NBS to give this prime attention. Regulatory does not require a high degree of accuracy in the determination of activities contained in effluent and environmental samples. In most analyses, a measurement accurate to ± 25% of the true value is sufficient for the purposes of Regulatory Operations. As a consequence, secondary standards that can be related to appropriate NBS primary standards can fulfill virtually all of Regulatory's needs as required for environmental monitoring. We feel it is not very important for licensees and State laboratories to obtain expensive NBS standards which have a 2% error when other less precise standards may suffice. At the present time, we do not perceive the accuracy of standards to be primary problem for Regulatory and its licensees. The standards problem may be a question of confidence in the manufacturer or distributor of these secondary standards. If the NBS develops their traceability concept to a point where it is convenient and feasible for commercial suppliers to establish formal traceability with the NBS, I would suspect that users and government agencies would require traceability as a condition of doing business. Consequently, we urge the NBS to develop fully this concept and make it known to the industry, and encourage standards manufacturers and distributors to participate in achieving traceability to the NBS.

Another source of concern to the industry as well as Regulatory is the chemical form of activity that is passed through traps, filters, etc. and into the environment. In general, the molal concentrations of these chemical forms are very low and their chemical compositions are not well known, if at all. In the determination of efficiencies of removal mechanisms and systems, a need exists to have a capacity to produce reproducibly or to maintain discrete highly diluted chemical forms (particularly, iodine) at known concentrations within appropriate diluent gases.

I would also like to mention another situation of growing concern to us. Several long-lived radionuclides that result from fission or capture are produced in relatively large quantities in reactors. Minute quantities of these radionuclides, as a consequence, are often difficult to measure by direct counting. Methods are available than can increase the sensitivities of these measurements by means of neutron or charged particle bombardments of samples followed by analyses of the product nuclide(s). (This is particularly true for I-129 and Tc-99). A need exists for the development of standardized systems and procedures that allow accurate determinations of target nuclides by means of nuclear interactions.

Earlier in this meeting, Dr. Horen spoke about the availability of decay schemes. We were glad to see this topic on the agenda because one of Regulatory's pressing needs is the available of this kind of information for the calculation of dose to individuals and the measurement of radioactivity. Consistency in the use of disintegration schemes and energies by all parties involved in the licensing process may not solve any of our major licensing problems but it would certainly remove a current annoyance, i.e., differing decay schemes used by several persons.

While I have the attention of this subcommittee I would like to take the opportunity to relay some of the complaints I have heard about standards which are currently available. First, sufficient information about these standards is not always available. It would allow the user much more flexibility if he knows both the total quantity of radioactivity in a solution plus the concentration. In addition, the distributor should provide the purchaser not only with a certificate indicating the decay rate and concentration, but also the method used for calibrating the radionuclide, the decay scheme, and clear instruction on how to use the standards. Second, frequently the certifications for standards are late in arriving. It is not at all helpful to have a standard certificate arrive two or more months after the standard. Usually a standard is ordered because it is needed immediately. Third, standard solutions should be well characterized, i.e., how

much carrier, whether acidified, concentration of acid, other additives, if any, and any other pertinent characteristics of the standard.

In summary, the AEC through licensees and State contracts is requiring a large number of fairly sophisticated radioactivity analyses. These analyses tell us and the public how the environment is being affected. However, in general, these are not performed by large sophisticated laboratories where special standards or reference materials can be readily developed. These laboratories have limited expertise and have to place a greater emphasis on "production", i.e., production of power or number of analyses, rather than quality assurance. For these laboratories we feel a reasonable variety of secondary standards and reference materials which are relatable to the NBS measurements systems should be available in order for them to make measurements which are accurate to within 25% of the true value and to conduct adequate quality control programs. We support the NBS's idea of traceability and feel that broader utilization of that concept will help us in our overall objectives.

Discussion:

Seidel: Have you thought further about the definition of "traceability to NBS"?

Weiss: We have a contract with NBS and are hoping that NBS will develop the concept of "traceability".

Seidel: The concept of "traceability" is of concern to our AIF subcommittee of industrial users. Our approach is to use "round-robins" with participating manufacturers analyzing a standard sample, and if a manufacturer's result is erroneous, NBS would attempt to determine the reason.

Coffman: May I comment about AEC-owned facilities? We have about 30 facilities providing annual environmental monitoring reports. These facilities spend 5-10 million dollars per year--150 to 250 thousand dollars per year at each site--for environmental monitoring programs. We've been finding that a lot of our problems are not associated with the physical standards or with counting, but rather with the collection of samples or placement of the monitoring system, etc. The procedures and techniques of analysis are where the major inaccuracies are being introduced. In addition, there is little or no inter-facility comparability. We have started a contract to be coordinated by Battelle (BNWL) and involving other laboratories to determine current capabilities of all AEC-owned facilities. We will have recommended and preferred procedures for environmental monitoring.

Kahn: You say you are supporting a program?

Coffman: Yes, for FY 1974 we have committed $50,000. We hope we can fund it at approximately $100,000 per year and have an end product in about 18 months.

Flynn: Does this deal with collection procedures and sample preparation techniques?

Coffman: Yes, the contractor is supposed to conduct a survey of existing practices within AEC facilities throughout the nation and critically evaluate them (categories: soil sampling, Pu soil analysis, air sampling techniques, etc.).

Eldridge: Battelle is doing the work?

Coffman: Yes, Carl Unruh, Jack Corbin *et al*, are supposed to develop a current capabilities document which defines deficiencies and gaps in environmental monitoring practices. After that, we're supposed to develop a program with John Harley, Claude Sill, and others that will result (at least within the AEC) in a consensus document of recommended and preferred methods of sampling in the environment. We hope this will be a useful document and that we can do it for about $200,000. It's supposed to contain a "what if" section. That is, if you set limits at a certain level, then the capabilities at that level are to be given.

Kahn: You may know that EPA has a document on environmental surveillance with a table that tries to approach this complicated subject, and I'm sure that years will be devoted to debating the consequences of each approach.

Flynn: At this stage of production reactor knowledge, it might be appropriate to propose a "round-robin" for low-level tritium analyses for laboratories that are required to perform them. I have a feeling from talking to several people that monumental errors may be made if suitable techniques are not used. This would have to do with counting techniques.

Weiss: Compared to some other problems, H-3 analyses have been pretty good. Occasionally we see a problem where a licensee fails to distill a sample, but it is not a problem with standards.

Jarvis: We are sending out about 38 samples of HTO to state and private laboratories on a monthly basis, and we don't see much of a problem. Tritium is not very difficult; however, we do see problems with Sr-89,90 determinations.

Kahn: Returning to the "traceability" question--Is it correct that NBS will develop the concept and then publish a document describing it?

Mann: It is not enough that a standard be bought from NBS or anyone else to establish traceability. The only way that complete traceability can be established between a lab and NBS would be when NBS could send any radioactive solution to the laboratory and get a correct answer back within some stated accuracy--then that laboratory would be "traceable" to the NBS measurement system. Due to the ephemeral nature of radioactive standards, you may have traceability today but not tomorrow.

Seidel: It becomes a commercial question too. Some agencies wish to buy standards that are "NBS traceable". We then ask them what they mean. We sometimes get back the comment, "Well, say you have an NBS standard or something like that". Many times these comments are from a purchasing agent.

Mann: Due to this ephemeral nature of radioactivity standards, you can not have traceability in itself. The traceability really lies in the reputation of the laboratory in having good personnel and in doing reliable work. It is physically impossible for NBS to participate in every EPA round-robin. It would be valid for EPA to establish traceability with NBS and then conduct intercomparisons within their jurisdiction.

Kahn: You have given a broad definition, but is there a quantitative numerical definition of "traceability"?

Mann: I will describe the routes of traceability on an international and national basis. We used to have traceability with other national standards laboratories through BIPM, but that organization has not conducted any tests in several years. We have traceability studies with the Canadian NRC and AECL and the British NPL at the present time at the international level. We have strong interactions with AEC, Atomic Industrial Forum, and the College of American Pathologists at present. We have weak or non-existent interactions with the Food and Drug Administration. Interactions with the Environmental Protection Agency have taken place through some nuclear power effluent round-robins. These are quality control interactions. With FDA we have had some input in trying to revise the chapter on radioactivity in the U. S. P., which is sorely needed. Through the AEC, AIF, etc., traceability could be established with state health labs, standards suppliers, hospitals, etc. Occasionally we might have direct interaction with lower echelon laboratories.

Kahn: Is "traceability" going to be defined in the near future?

Mann: I have given our interpretation.

Kahn: What about the situation where a laboratory gets half of a series of test samples "right" and half "wrong"?

Mann: Seidel's A. I. F. group is trying to become associated with an ANSI group to make recommendations that will be accepted. At the Bureau of Standards we have in mind (not in practice yet due to a shortage of manpower) being able to send out people to visit laboratories for solving discrepancy problems. We are trying to organize a seminar for nuclear medicine workers in November. There has been little or no interest. Perhaps there will be more when it is publicized. In an industry round-robin, one laboratory was about 20% out in their value. In attempting to find out if there was any problem that NBS might help solve, the reply was given: "So what, the other laboratories probably spent more time on it". However, the industrial round-robin was the best of the lot.

Brantley: If the AIF is able to set up this pyramid with ANSI and get procedures established, then FDA and AEC - Regulatory have the ability to make all users and licensees "toe the line". There needs to be a driving force to require conformity in measurements.

Weiss: We are experiencing quality assurance problems with results supplied by some of our licensees that use commercial analytical services. There is not a proper concern about the quality of the results by some of our licensees.

Kastner: Is the NBS going to prepare other types of standards than those now supplied (e.g., simulated soils)?

Hutchinson: We are working with some sediments and are preparing to characterize them for radionuclide content.

Coffman: There is confusion about the use of "traceability" and "quality assurance" in these loose terms and I feel that generic definitions are needed.

Seidel: The definition must be a general one that most manufacturers can adhere to. Our subcommittee sent out letters to about 50 laboratories involved in radioactivity measurements inviting their participation in a "round-robin" analysis of cobalt-57. Only 16 laboratories participated, and of this latter group, only 9 sent in results. It is difficult to instruct a user how to use a standard. It is extremely difficult to prepare simulated standards. It is necessary to use equipment for preparation of such simulated standards similar to that used for the measurements.

Horen: The only solution to quality assurance is in educating personnel involved in making radioactivity determinations.

Eldridge: Has there been consideration about certification of "metrologists"?

Mann: We have been asked to rewrite Handbook 80. This is part of our educational effort.

Meyers: Each batch of antibiotics is certified and a master standard is set aside and is made available for calibration purposes.

Kahn: For years, SOURS has been searching for definitions. Maybe we should term present standards as "master standards".

Mann: Our standards (NBS) are called "national standards".

Kastner: I would suggest that SOURS publish recommendations for several topics included in these discussions.

STANDARDS FOR ENVIRONMENTAL STUDIES

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The study of radioactivity and radiation in the environment can include natural sources, fallout from nuclear weapons or effluents from nuclear facilities. In most cases it is necessary to distinguish among these sources by radiochemistry or by measurement with some qualitative distinction such as spectrometry. The majority of the measurements are of concentrations of radioactive materials in the laboratory or the field. Some direct dose measurements are made while other dose estimates are derived from in situ measurements of concentrations.

To carry out a program of this type requires three types of standard materials. The first is the calibration standard, either for energy or quantity of a specific radionuclide. The second is the radioactive tracer for checking the recovery in radiochemical procedures. The third is the standard sample which can be used to test the overall performance of the analytical system being used. Most of these do not require an accuracy of greater than ± 5% and even greater variations are possible for the tracer solutions.

It is probably worthwhile pointing out at this time that AEC policy is to request that standards be traceable to NBS. This is not a regulation and at the present time it would not be possible to comply with such a regulation.

In the main part of this paper I will try to indicate the recent experience of the Health and Safety Laboratory with the three types of standards mentioned above.

Calibration Standards

We require calibration standards for field and laboratory gamma spectrometers, and laboratory alpha counters and spectrometers and beta counters. In addition it is necessary to have sources for calibrating the steel-walled high pressure ionization chambers used in our dose studies.

The philosophies of calibration in our field and laboratory gamma spectrometers differ. The field work is mostly carried out with germanium diodes and point sources of about 1 microcurie are used to determine the photopeak area per unit flux. This group tends to require sources for each radionuclide that is to be measured in the field.

The laboratory spectrometers are calibrated for energy with a single thorium-228 source. This is satisfactory since the system is linear to one part in four thousand. For efficiency calibration, a relative efficiency curve is drawn up for an uncalibrated radium-226 source plus a cerium-144 source for lower energies. Absolute calibration is performed with a cesium-137 source of about 0.1 microcurie. The sodium iodide detectors of course require a standard for each radionuclide in the library, but fortunately these are being used very rarely.

Calibrations of alpha and beta counters and the alpha spectrometers require solution standards to allow preparation of the needed form of standard. The same holds for the Cs-137 gamma spectrometer standards where we use four different geometries.

The high pressure ion chambers are field instruments and require source strengths in the neighborhood of 1 millicurie. The usual calibration requires six to seven sources in the energy range from americium-241 to sodium-24. Most of the energies are below 200 keV and a constant potential x-ray machine is also used to assist in calibration. It should be pointed out that the field spectrometers and ion chambers when used together supply a needed redundancy to build up our confidence in dose estimates.

The procedures used at HASL for standardization are described in our Procedures Manual (USAEC Report HASL-300, revised annually). A critical feature that is not described is a program of intercomparison of samples and standards with other laboratories in the United States and overseas.

The following table shows the HASL standards requirements for 1971 and 1972, and the added radionuclides needed this year. An odd requirement was preparation of a 5 mCi Ra-226 solution standard to be used as a high-level Rn-222 source.

Preparation of Standards (1971)

Alpha: Po-208 (2), Po-210 (2), U-232 (2), Pu-236 (3), Pu-238 (2), Pu-239 (7), Am-241 (2), Am-243 (3), Cm-244

Beta: P-32, Ca-45, Co-60, Sr-89, Sr-90 (2), Y-91, Zr-95, Nb-95, Ru-103 (2), Ru-106, I-131 (2), Cs-134, Cs-137 (4), Ce-141 (3), Ce-144 (2), W-185, Au-198, Tl-204, Pb-210 (2)

Electron Capture: Be-7, Mn-54, Sr-85 (2), Y-88 (2)

Positron-Electron Capture: Na-22 (4), Zn-65

Electrodeposited Alpha Sources:

Mixed Alpha	16	Pu-238	3
Th-228	1	Pu-239	27
U-232	1	Am-241	2
U-238	2	Am-243	10
Pu-236	26	Cm-244	2

Preparation of Standards (1972)

Alpha: Am-241, Am-243, Cm-243, Cm-244, Pu-238, Pu-239, Pu-242 (3), Po-208, Po-210, Ra-226, Th-228

Beta: Ca-45, Ce-141, Ce-144, Cs-134, Cs-137, Co-60 (2), Au-198, I-131, Fe-59, Pb-210, Pr-143, Sr-89, Sr-90, W-185

Electron Capture: Be-7, Cr-51, Co-57, Mn-54 (2), Sr-85, Y-88 (2)

Positron-Electron Capture: Co-58

Electrodeposited Alpha Sources:

Mixed Alpha	8
U-238	6
Pu-238	3
Pu-239	10
Pu-242	2

Preparation of Standards (1973)*

Sb-124, Ba-140, Pu-236, Tl-204, U-232, Zr-95

* List of those not standardized in 1972, only

Tracers

Radioactive tracers are not basically standards but they have many of the same requirements with respect to purity and preparation so that we tend to treat them the same as our standard solutions. They are mostly needed for alpha or beta activity studies and for stable element work. Since they are used for estimating radiochemical recovery they are usually standardized adequately at the time the samples are run.

A number of tracers required for radiochemical studies are listed in the following table.

Tracer	Use
Be-7	Stable Be
Sr-85	Stable Sr, Sr-90
Tc-99m	Tc-99
I-131	I-129
Ba-133	Po-210
Pb-212	Stable Pb, Pb-210
U-232	Natural U
Th-234	Th-228
Pu-236	Pu-238, 239
Pu-242	Pu-238, 239
Am-243	Am-241

Standard Samples

It is highly desirable to have standard samples available for checking overall performance in radiochemical analysis. Spikes are generally not satisfactory for radiochemistry, since they do not have the added radionuclide in the same form as in the sample. It is probably an impossible task to set up a stock for all radionuclides in all sample matrices. We have about 20 total standard samples which is many fewer than desirable. These are all "natural" samples and became standards through multiple analysis at several laboratories. The quantities prepared were sufficient so that stocks for many years are available (e.g., 500 lbs of soil, 500 lbs of milk powder).

I do not see any simple solution to the standard sample problem, but certainly cooperation among the environmental laboratories will be needed.

Special Problems

Some standard problems cannot be readily solved in our own laboratory. While they are not widespread requirements, it is possibly worthwhile to list them.

1. Standards for very high energy gamma emitters, particularly N-16, which is a problem in reactor monitoring.

2. Standards for the noble gases emitted by nuclear reactors, since it is now necessary to know the composition of releases.

3. Standard distributed sources for test of field equipment and airborne spectrometers.

Additional comments by Harley: I think that the concept of a standard procedure is a backward step. Quality control is an essential part of laboratory operations. Recently a contracting laboratory began having drifts in its quality control. This happened just before the chief chemist of that laboratory left. After the chemist left, we asked that the contract be requalified. The laboratory quoted the "fine print" and said that the contract was with the laboratory and not with its employees. We asked the laboratory to requalify with 6 samples and their average deviation was 45%. It is an individual matter and I think we may end up with "Certified Public Analysts" or something like that.

The Health and Safety Laboratory is the only lab in the AEC General Manager's Office. Our function is to develop procedures and perform research.

Discussion:

Kahn led a general discussion of the meaning of "true value" as applied to radioactivity measurements. The consensus was that "true value" had to be discussed in terms of statistical uncertainties.

Kahn: Is there any need for SOURS to organize studies related to entire procedures that go from sample collection through measurement process? The subcommittee is not engaged in such activities, but they might be desirable.

Kastner: I can see the subcommittee involved in two programs: one part would be to set up a measurement program at a reactor site with a group of participants. The second part would be to prepare standards for such a program.

Harley: The problem with so many intercomparisons is that it's difficult to get any work done.

Kahn: In order to have good quality control, isn't it necessary for a laboratory to spend somewhat more than 5% of its time conducting standardizations, intercomparisons, etc.?

Harley: Fifteen percent of our samples are quality control samples: blanks, standards, and blind duplicates.

Kahn: Is there a study related to the need for multiple standards and matrices for environmental samples? Is the AEC conducting a study of this type?

Sill: A lab that determines strontium-90 in milk with good results would not necessarily be able to use the same procedure for soil samples. In our laboratory, we are able to spend only 5% of the time for quality control due to large sample loads. More attention needs to be paid to statistical uncertainties of results. Some laboratories report counting uncertainties only. This causes difficulties in determining whether two results are the same or different. Pipette calibrations, timer checks, etc., are problem areas that need to be checked on and carried through in the error analysis.

Mann: If the statement of error accompanying a standard is done properly, then it does not matter whether it is called "primary", "secondary", etc. Our certificates indicate the method of calibration with a detailed error analyses and are not distinguished as primary or secondary calibrations. We report the 99% confidence level.

Hutchinson: How many sample matrices are needed for standards?

Sill: The more the better. Different soils with differing chemical characteristics influence the choice of chemical separation procedures.

Kastner: Enormous differences exist between, say, soils from Florida and Minnesota. Monitoring programs need to take into account different soil characteristics.

Cobalt-60 in a marine environment may behave differently than in other environments.

Sill: We're not suggesting an infinite number of standards, but the farther you get away from the several standards used in a program, the higher the probability you will miss something.

Kahn: Is there any written guidance available to laboratories that you deal with at the present time, or will such guidance be available later?

Sill: We provide standards with known disintegration rates and then provide unknown samples to check their methods and calibrations. These are state laboratories.

Kahn: How many states have participated?

Sill: Fifteen. Only 2 or 3 state laboratories are well qualified. Most of the rest are real novices and need to be "led by the hand".

Programs and Activities of the Quality Assurance Branch, National Environmental Research Center-Las Vegas

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I. INTRODUCTION

Environmental measurements are made daily by many different Federal, State, local, and private agencies. The data from these measurements are used by the U.S. Environmental Protection Agency (EPA) for a wide variety of purposes, including estimates of doses and health effects, the establishment of standards and guides, and for enforcement activities. It is therefore imperative that the precision and accuracy of the data be assured in order that policy decisions concerning environmental quality are based on valid and comparable data.

The Quality Assurance Program of the EPA is designed to encourage the development and implementation of quality control procedures at all levels of sample collection, analysis, data handling, and reporting. Quality control responsibilities, in the radiation area, have been assigned to the Quality Assurance Branch at the EPA's National Environmental Research Center-Las Vegas. This office, as an integral part of its overall quality assurance effort, conducts laboratory intercomparison studies and prepares and distributes a variety of calibrated low-level radioactive samples for use in the laboratories of Federal, State, and private agencies.

The major objective of this program is to encourage the development of intralaboratory and interlaboratory quality control procedures and thus ensure that the data being supplied to the EPA are valid. Providing accurately calibrated samples and a variety of cross-checks assists laboratories in calibrating new instruments, implementing and maintaining routine instrument calibration programs, evaluating analytical procedures, and developing and revising data processing programs, and in the maintenance of an internal cross-check program.

II. BACKGROUND

When the U.S. Environmental Protection Agency (EPA) was formed in December 1970, the Analytical Quality Control Service (AQCS), located at Winchester, Massachusetts, was transferred from the Bureau of Radiological Health to the EPA.

Beginning in 1962, the AQCS provided radiochemical standards and quality control for analytical measurements to the Public Health Service and to State radiological health programs. This laboratory also carried out a number of cross-check studies and technical experiments with both governmental and private agencies.

In addition to the AQCS program, an extensive intralaboratory radiation quality control program, as well as cooperative activities with State agencies, the AEC, WHO, and the IAEA, were being conducted for a number of years at the NERC-LV.

During November, 1972, the positions, functions, and responsibilities of the AQCS were transferred to the NERC-LV, merged with the existing quality control program, and designated as the Office of Quality Assurance-Radiation. More recently this program, as a result of the Center's reorganization program, has been designated the Quality Assurance Branch of the Division of Technical Services.

III. CURRENT ACTIVITIES

A. Laboratory Performance Studies

A number of laboratory performance studies ("cross-checks") involving the analysis of radionuclides in environmental media are conducted on a continuing basis. These studies enable participating laboratories to maintain checks on their internal quality control programs and assist them in documenting their data.

1. Types of Studies.

Studies currently in operation or scheduled involve samples of most media including milk, water, air, soil, food, urine, and gases. The types of samples, the quantities supplied, the activity levels involved, and other pertinent information concerning the samples are summarized in Table I. The distribution schedule for 1973-1974 appears in Table II.

2. Participation

a. Cooperation with States

At present 38 State laboratories are participating in the intercomparison studies either on a full-time or part-time basis.

b. Interaction with Federal and International Agencies

Interlaboratory programs are maintained with other EPA laboratories and with other Federal and International agencies. Included are the AEC, the U.S. Army and Air Force, and the U.S. Geological Survey. In

TABLE I

SUMMARY OF CROSS-CHECK PROGRAMS

SAMPLE	ANALYSIS	ACTIVITY / ISOTOPE	QUANTITY SUPPLIED	PRESERVATIVE	DISTRIBUTION	TIME FOR ANALYSIS & REPORT
Milk	^{89}Sr, ^{90}Sr, ^{131}I, ^{137}Cs, ^{140}Ba, K	< 200 pCi/l	~ 4 liters	Formalin	Monthly	6 weeks
Water						
Gross α, β	Gross α, β*	< 100 pCi/l	~ 4 liters	0.5 N HNO_3	Bimonthly	4 weeks
Gamma	^{60}Co, ^{106}Ru, ^{124}Cr, ^{137}Cs, ^{51}Cr, ^{65}Zn	< 500 pCi/l	~ 4 liters	0.5 N HNO_3	Bimonthly	4 weeks
^{3}H	^{3}H	< 3500 pCi/l	~ 60 ml	none	Monthly	4 weeks
^{239}Pu	^{239}Pu*	< 10 pCi/l	~ 4 liters		Semiannually	6 weeks
^{226}Ra	^{226}Ra	< 20 pCi/l	~ 4 liters	0.5 N HNO_3	Quarterly	6 weeks
Air						
Gross α, β	Gross α, β*	< 200 pCi/sample	3 - 2" or 4" diam. air filters	none	Quarterly	4 weeks
^{239}Pu	^{239}Pu*	< 2 pCi/sample	3 - 2" or 4" diam. air filters	none	Quarterly	6 weeks
Soil	^{239}Pu	< 50 pCi/sample	~ 100 g	none	Semiannually	6 weeks
Diet	^{89}Sr, ^{90}Sr, ^{131}I, ^{137}Cs, ^{140}Ba, K	< 200 pCi/kg	3 - 4-liter samples	Formalin	Quarterly	6 weeks
Urine	^{3}H	< 3500 pCi/l	~ 60 ml	Formalin	Quarterly	4 weeks
Gas	^{85}Kr, ^{133}Xe	< 20 pCi/ml	10 liters	none	Semiannually	6 weeks

*Laboratories are required to have the necessary licenses before receiving these samples.

TABLE II

CROSS-CHECK SAMPLE DISTRIBUTION SCHEDULE

Numbers 1, 2, 3 & 4 indicate week of the month.

Month	Milk	Water					Air Filter		Soil	Diet	Urine	Gas
	Sr,γ	Gross α,β	γ	^{3}H	^{239}Pu	^{226}Ra	Gross α,β	^{239}Pu	γ,^{239}Pu	Sr,γ	^{3}H	^{133}Xe,^{85}Kr
1973												
Aug	1	3		2						2		
Sep	1		4	2				3			2	
Oct	1	3		2			3			4		4
Nov	1		4	2	2	3						
Dec	1	3		2					3		2	
1974												
Jan	1		4	2		3		3				
Feb	1	3		2			3			4		
Mar	1		4	2							2	
Apr	1	3		2						4		3
May	1		4	2	2	3						
Jun	1	3		2			3		4		2	
Jul	1		4	2		3		3				

addition, the Argonne, Los Alamos, and Lawrence Livermore laboratories, as well as the National Laboratories of Canada and New Zealand, participate in some phases of the program.

c. Liaison with Nuclear Facility Operators

The Quality Assurance program also maintains liaison with nuclear facility operators. There are 12 nuclear facility operators and/or their contractors participating, on a voluntary basis, in one or more of the cross-check programs.

B. Distribution of Calibrated Samples

Since radionuclides, with the low level activities ordinarily required for the calibration of instruments and/or the testing of radiochemical procedures, are not available from commercial sources, the Quality Assurance Branch maintains an inventory of 30 different radionuclides. The radionuclides listed in Table III are available for immediate delivery, while those indicated in Table IV will become available on the dates indicated.

The calibrated samples, with activities ranging from approximately 10,000 dpm/gm to 50,000 dpm/gm, are sent upon request to any Federal, State, local or private laboratory involved in, or concerned with, environmental radiation measurements.

To assure the accuracy of the samples, which are prepared by diluting higher-level standards obtained from both government and commercial sources, calibration facilities are maintained. To check the accuracy of dilutions, aliquots of alpha or beta emitters are taken from the stock solution, prepared for counting, and their activity determined using appropriate counting instruments. The solution is then pipetted into 5 ml glass ampoules, weighed, and immediately flame sealed. All solutions of gamma-emitting nuclides are pipetted directly into ampoules, weighed, flame sealed, and counted.

C. Collaborative Studies

To effectively carry out its mission, it is necessary for the Quality Assurance Program to aid in the development, testing, and promulgation of standard methods.

This program, therefore, assists other federal laboratories, technical societies, and international agencies in the testing and evaluation of radiochemical procedures and instrumental methods through the round-robin testing of materials.

IV. PLANNED ACTIVITIES

A. The Development of Standard Procedures and/or Standard Reference Methods

Although a number of methods and procedures for the analysis of environmental samples have been published by various governmental agencies, laboratories, and/or

NUCLIDE	TYPE OF EMISSION	HALF-LIFE
^{90}Sr	β^-	27.7 y
^{3}H	β^-	12.26 y
^{131}I	β^-, γ	8.05 d
^{140}Ba	β^-, γ	12.8 d
^{22}Na	β^+, γ	2.62 y
^{54}Mn	γ	303 d
^{65}Zn	γ	245 d
^{137}Cs	β^-, γ	30 y
^{60}Co	β^-, γ	5.26 y
^{59}Fe	β^-, γ	45.6 d
^{95}Nb	β^-, γ	35.0 d
^{95}Zr-Nb	β^-, γ	65.5 dd
^{106}Ru	β^-	368 d

TABLE III

Calibrated Sample Distribution Schedule

NUCLIDE	TYPE OF EMISSION	HALF-LIFE†	MONTH AVAILABLE
^{46}Sc	β^-, γ	83.9 d	September 1973
^{85}Sr	γ	64.0 d	"
^{89}Sr	β^-, γ	52.7 d	"
^{203}Hg	β^-, γ	46.9 d	"
^{226}Ra***	α, γ	1602 y	"
^{232}Th***	α	1.41×10^{10} y	"
^{51}Cr	γ	27.8 d	October 1973
^{58}Co	β^+, γ	71.3 d	"
^{75}Se	γ	120 d	"
^{103}Ru	β^-, γ	39.5 d	"
^{124}Sb	β^-, γ	60.4 d	"
^{125}Sb	β^-, γ	2.7 y	"
^{144}Ce	β^-, γ	284 d	"
^{238}U ***	α	4.51×10^{9} y	"
^{239}Pu*	α	24390 y	November 1973
^{241}Am**	α, γ	458 y	"
^{63}Ni	β^-	92 y	"
^{99}Tc	β^-	2.12×10^{5} y	"
^{110m}Ag	β^-, γ	255 d	"
^{134}Cs	β^-, γ	2.04 y	"
^{141}Ce	β^-, γ	32.5 d	December 1973

TABLE IV

Calibrated Sample Distribution Schedule

NUCLIDE	TYPE OF EMISSION	HALF-LIFE†	MONTH AVAILABLE
^{35}S	β^-	87.9 d	January 1974
^{45}Ca	β^-	165 d	"
^{56}Co	β^+, γ	77.3 d	"
^{88}Y	γ	108 d	"
^{109}Cd	γ	453 d	"
^{32}P	β^-	14.3 d	February 1974
^{55}Fe	γ	2.6 y	"
^{133}Ba	γ	10 y	"
^{147}Pm**	β^-	2.62 y	"
^{185}W	β^-	75 d	"
^{204}Tl	β^-	3.81 y	"
^{57}Co	γ	270 d	March 1974
^{125}I	γ	60.2 d	"
^{139}Ce	γ	140 d	"
^{96}Rb	β^-, γ	18.66 d	April 1974
^{182}Ta	β^-, γ	115 d	"
^{195}Au	γ	183 d	May 1974

† Lederer, C., et al., Table of Isotopes, sixth edition, John Wiley and Sons, New York 1967. Recommended half-lives will be indicated on the certificate accompanying each sample.

* Special Nuclear Material License required.

** Byproducts License required.

*** Possible State license required.

TABLE IV continued

standard setting groups, few if any have been widely accepted as "standard methods". This lack of standard methods and procedures results in data which are not truly comparable and is probably the major weakness in the area of quality assurance. Until such time as standard methods (or standard reference procedures) are developed, published, and accepted, a true quality assurance program cannot exist. Moreover, before a true comparison and/or evaluation of laboratories can be conducted, uniform methods are required to insure the comparability of data. Thus the development and promulgation of standard methods must be accomplished before the quality assurance program can be further expanded.

In order to alleviate this problem the Quality Assurance Branch will begin early in 1974 to examine and evaluate the methods currently being used for the analysis of environmental samples containing radionuclides. Upon completion of this evaluation, the Quality Assurance Branch will recommend standard methods (or standard reference methods) which should be accepted and promulgated by the EPA.

B. The Publication of a Handbook on Quality Control Methods and Procedures

A handbook,(1) similar to that recently published by the Analytical Quality Control Laboratory, NERC-Cincinnati, will be developed and published. This publication, as envisioned by the Quality Assurance Branch staff, will be designed for laboratory directors and other professional personnel who have responsibility for radiation data. The handbook will be primarily concerned with the quality control of chemical and instrumental tests and measurements. Sufficient information will be included to enable the reader to develop and implement an analytical quality control program.

C. The Development of New or Improved Analytical Methods

There is a need for research on new and/or improved methods of analyzing samples for certain radionuclides. This is particularly true for Iodine-131, Iodine-129, Krypton-85, and Xenon-133. For example, a definite need exists to develop an analytical method which will lower the detection limits for measuring Iodine-131 concentrations in both milk and aqueous solutions.

Recent reports have indicated that measurable levels of Iodine-129 have been found in the environment in the vicinity of nuclear fuel reprocessing facilities.(2,3) Since the measurement of low levels of radionuclides in critical pathways is important, a rapid means of analyzing samples for Iodine-129 content must be developed, tested, and standardized.

Standards and cross-check procedures for gas samples including Krypton-85 and Xenon-133 are currently being tested.

D. Expansion of Quality Assurance to Other Aspects of Monitoring

In order to assure the quality of all data it is necessary to develop, implement, and maintain quality control procedures for all aspects of the monitoring program from sampling site selection to data handling and reporting activities. To implement such a comprehensive quality control program, the staff at the NERC-LV plans to develop and issue a series of guidelines dealing with the collection and handling of environmental samples. These guidelines will discuss the equipment and materials required to collect, preserve, and transport samples from specific media, sampling periods, and essential quality control information. Other guidelines, dealing with the operational parameters and design characteristics of both monitoring networks and instrumentation, will be developed and procedures for routine field calibration of monitoring instruments will be published.

To supplement and reinforce the published guidelines an instructional program will be instituted. This program will involve workshops, seminars, and "on-the-job" training in quality control procedures for both management and technical personnel.

References

1. Handbook for Analytical Quality Control in Water and Wastewater Laboratories. Technology Transfer. EPA, Analytical Quality Control Laboratory, NERC-Cincinnati (June 1972).

2. Magno, P. T., T. C. Reavey, and J. C. Apidianakis, Iodine-129 in the environment around a nuclear fuel reprocessing plant, ORP/SID 72-5. EPA, Office of Radiation Programs, Rockville, Maryland (October 1972).

3. Bentley, W., 1971 annual report of environmental radiation in New York State. State of New York, Department of Environmental Conservation, Albany, New York (July 7, 1972).

Additional comment by Jarvis: Request forms and literature describing our services will be available in September.

Discussion:

Kastner: How do you pay for this service? Do you recover costs?

Jarvis: So far we have not. There has been some discussion about charging for the calibrated samples, especially for industry.

Mann: To some extent, this service is undermining the efforts of NBS. You cannot expect laboratories that can obtain free materials from EPA to pay $60 to $100 for standards from NBS. This destroys the concept of traceability to NBS.

Kastner: If you are interacting with EPA, then traceability can be maintained.

Mann: At the present time we are not intereacting. We have very weak links with the Food and Drug Administration, Environmental Protection Agency, and Bureau of Radiological Health. In a nutshell, I disapprove of the distribution of free standards.

The College of American Pathologists, Atomic Industrial Forum, and AEC have gotten us in a position that we can devote the time and energy for intercomparison purposes.

Harley: When laboratories are analyzing intercomparison samples identified as such, the quality of results goes up. It is desirable that such samples not be identified if they are to be useful in a quality control sense.

Sill: We need standard solutions for instrument calibrations; however, we also need "real world" samples for checking the competence of a laboratory. This is one area where I would cast a negative vote against the EPA program since their samples are all water soluble standards. Reactor rad-waste materials can be completely different from settling basin samples as to adsorption properties. You cannot check up on these type problems by simply analyzing standards. There is an effort on my part to prepare standards that will be homogeneous at higher levels than those from HASL. For reactor surveillance methods, you need standards at higher levels than those available as fall-out standards from HASL. I would recommend that SOURS expand its scope to include low-level samples.

Flynn: With the complexity of equipment and sample types for analysis, there should be some way to certify that people doing analyses have competence for the measurements.

ACTIVITIES OF COMMERCIAL RADIONUCLIDE PRODUCERS

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In 1973, more than 100 radionuclides will be produced by U.S. industry for use by industry, hospitals, and universities. The value of these products at the end use level will be greater than $80,000,000 in 1973. Radiopharmaceuticals will account for 65% of the total, labeled compounds and radiochemicals for 20%, and radioactive sources for 15%.

This industry is based on four kinds of radioactivity measurements:

1. Amount of radioactivity
2. Concentration of radioactivity
3. Radionuclidic purity
4. Radiochemical purity.

Over the last 25 years "standards" for measurement of these quantities have been established, ranging from highly sophisticated ones to highly informal ones. Most of them are of the latter quality and this fact has led to serious questions and problems in the industries that produce them and the users of them.

At the present time, NBS has established standards for only 27 radionuclides of the 100 or more used. In addition, even some of these 27 are not in a convenient physical form or intensity, i.e., micro- instead of millicuries or on tape instead of in a vial. In the absence of absolute or convenient standards, producers and users resort to derived secondary standards based on instruments calibrated with the absolute standards and on using decay schemes that may come from any one of many sources. Different groups of users tend to use different decay schemes so that it is possible for two different groups to be using two different millicuries.

To compound these basic difficulties, there are thousands of users of radioactivity, varying from those with an extremely high degree of sophistication to others who appear to have only the most elementary knowledge and capability of measuring radioactivity.

About three to four years ago, it became apparent that these problems were building to a degree that was no longer tolerable to the users, the producers or the government agencies that regulate the industry. We must admit that

the efforts of producers and users and government to meet the problems in the last three years have been difficult, confused, and, in some cases, ludicrous. However, some of the activities now in progress offer us hope that something may now be done.

If we examine the needs of producers, users and governmental agencies for standards, we find several common requirements:

1. Activity standards
2. Instrument calibration standards
3. Calibration protocols
4. Standards for the certification of statistics (counting accuracy)
5. Internal quality assurance controls
6. Decay schemes.

Some specific examples of problems that have arisen in the last 2-5 years will illustrate the need for more and better standards.

. Gallium-67 is finding a growing market in nuclear medicine as a diagnostic radionuclide. This nuclide was originally produced at ORNL but it is now also produced in industry. There is as yet no agreement on a decay scheme and assays for this nuclide have disagreed by as much as 30%. Fortunately, users and producers are resolving this problem by round-robin experiments to achieve at least a uniform millicurie. It remains to be determined, however, what the absolute millicurie is for this radionuclide.

Use of xenon-133 is rapidly growing in lung studies. NBS has now developed a microcurie standard while ORNL has a multicurie gas reference standard developed by cross-calibration studies. However, the principal use requires assay in the 10-100 millicurie range. The dose calibrators that are now so widely used by nuclear medicine departments vary by a factor of 2 at these levels.

Barium-133, a widely used, long-lived instrument-calibration standard, has been used for years assuming a half-life of 7.2 years, although values from 7-10 years had been reported. It now appears that 10.5 years is probably the most nearly correct value but no uniform agreement has been reached.

Iodine-125, used extensively in <u>in vitro</u> pharmaceutical testing, is widely mishandled in assay procedures. Although standards for activity are available, many users are unaware of the problems raised by absorption of its soft x-ray in vial walls and solvents. Protocols for its assay need to be widely distributed.

This same kind of situation has come up in recent months in the cases of Cobalt-60 and Cesium-137 nuclides for which standards have long existed but not in the form in which the discrepancy arose.

Finally, three decay scheme compilations are used extensively in the radionuclide industry:

1. Nuclear Data Tables
2. MIRD nuclear data tables from Society of Nuclear Medicine
3. Isotope Tables by Lederer, et al.

It takes very little time to discover basic disagreement among these tables, disagreements that can lead to widely varying assay results.

We would now like to review some of the commercial and user activities in establishing committees to resolve some of these problems. In June 1972, the Atomic Industrial Forum (AIF) and NBS called a meeting at NBS of various manufacturers of radioactivity standards. The meeting was called to consider the need for industry standards on quality assurance, statistics, and radioactivity. As an outgrowth of this meeting, the AIF Committee on Radioisotope Production and Distribution established a Subcommittee, chaired by Carl Seidel, to investigate the needs and possible solutions. After several meetings during the last year, this Subcommittee obtained the enthusiastic participation of most manufacturers and identified several areas in which they feld industrial cooperation was needed. In June of this year, the group made a formal request to Marshall Little, Chairman of ANSI Committee N-44, to be recognized as ANSI Subcommittee N-44.4 a Subcommittee on Radioactivity Measurements. They described their goals as

1. Uniformity in reporting the accuracy of measurements of radioactive standards
2. Initiation of a Quality Assurance Program for manufacturers to include a Round-Robin Calibration Program under the sponsorship of NBS
3. Developing and publishing recommended procedures for measuring radioactivity.

This committee has now established a membership and a list of companies and individuals who wish to be kept informed of developments. They have recently adopted the principles of ICRU Report 12 on "Certification of Standardized Radioactive Sources" as the standards for the certification of reference standards manufactured by them.

In cooperation with NBS, they are working on a schedule of round-robins to cover Co-57, I-129, C-14, Hg-203, and Xe-133. Preliminary results have just been obtained on Co-57.

Their activities have now expanded from covering just the development of standards for the manufacturers of radioactivity standards to include standards for other areas (producers of radiopharmaceuticals and instruments)

since they have found that their problems are essentially the same.

Their inclusion of the radiopharmaceutical area grew out of another meeting held in the fall of 1972, attended by representatives of the FDA, BRH, NBS, and the AIF. The attendees at this meeting concluded that a program of quality assurance and improved and expanded radioactivity standards was needed by manufacturers of radiopharmaceuticals to satisfy the requirements of FDA and DOB-AEC in licensing and regulation of radiopharmaceuticals.

Although this conclusion was reached, no such effort has been started, primarily because no one person has taken the lead in organizing the effort. After recent reviews of the situation, the Chairman of the AIF Committee on Radiopharmaceuticals, which represents most of the manufacturers, has agreed that it might be more effective for this activity to be taken over by the proposed ANSI N-44.4. This would require the addition to the committee of people from the radiopharmaceutical companies. We believe that many of the problems of the two sets of manufacturers are so similar that this approach can cut the time and effort required.

Two other commercial activities that should be included are sponsored by ASTM and SAMA. ASTM Committee E 10.05 has been established to write procedures for using and calibrating Ge(Li) and NaI(Tl) detector systems. SAMA has established a committee to develop liquid scintillation standards that will eventually be expanded to include simulated I-125 standards for radioimmunoassay. These standards would be specifically designed for automatic equipment manufactured by the member companies.

As contrasted to these commercially oriented committees, there are several areas of activity that are primarily user oriented but include enough commercial participation to be included in this review. The oldest of these is sponsored by the College of American Pathologists (C.A.P.) as a part of their program to evaluate performance of hospitals and individual departments in these hospitals. This program is paid for by the individual hospital and consists of periodic distributions by NBS of an unknown radionuclide. The participant reports his analysis of amount and identity of this program. We understand, however, that the results indicate considerable need for improvement in the capabilities of the hospitals and that, thus far, the participation has been very poor.

Still another program aimed at nuclear medicine departments of hospitals originated three years ago as a Committee on Quality Control and Standards of the New England Chapter of the Society of Nuclear Medicine and the

New England Radiological Physics Organization (NEPO). This Committee has developed reference standards and protocols for using these standards for one model of gamma scintillation camera and most models of the dose calibrators that are so widely used by hospitals today. This program and the protocols are actively carried out in New England by a Nuclear Medicine Quality Control Center operating out of Boston University Medical Center. The first year's operation was supported by the New England Regional Commission. It is now supported by fees received from hospitals for the service.

In June 1973, the Society of Nuclear Medicine established a program to extend this regional activity to all areas of the United States. It has formed a national committee, has appropriated $20,000 to carry out the work, and is looking for an additional $20,000 from a government agency to complete the funding. It is not yet clear whether the program will go ahead without the additional funding.

Another committee that was established a few years ago is ANS-16. Its main accomplishment to date has been a questionnaire on Proposed Standards Activities. A tabulation of the results is attached. The future of this group depends on its success in replacing Sam Reynolds who has resigned as Chairman.

We cannot vouch for the completeness of this review of commercial activities, but we believe it covers the major efforts. We believe it also shows that the needs for improved standards have been recognized and accepted by industry.

TABULATION OF QUESTIONNAIRE REPLIES

	Proposed Standards Activities	Other Interested Organizations
1	a) Reference Materials b) Nuclear Data (half-lives, decay schemes, cross sections, etc.) c) Radioanalytical Methods d) Activation analysis	NBS, ORNL, FDA, ANSI N11, CAP
2	Measurement of Contrast and Definition applicable to Medical Scintillation Photography	ANSI N44, SNM
3	Radiochemical Purity of Materials Used in Isotope Generator Systems	NBS, ORNL, ANSI N11
4.	Neutron Sources and Techniques a) calibration and measurement of flux b) standard sources c) index quality indicators d) dosimetry e) cross-sections	NBS, ANSI N43, ANSI N44, ANSI N11, IAEA, ASTM, ANR
5.	Biomedical Applications - Encapsulated power sources, traces and therapeutic materials	AEC-ENEA, ANSI N44, SNM
6.	Medical Internal Radiation Dose	NCRP, HEW-BRH, ANSI N44
7.	Photon Energy Absorption Coefficients	NBS
8.	Toxicity of Heavy Metals	FDA, AOAC
9.	Isotope Packaging and Container Transport Standards	AEC-IAEA, ORNL, DOT, ANSI N14
10.	a) Standards for Testing and Qualifying Sources b) Performance Standards for Sources	ORNL, ARC, ANSI N43 ANSI N44
11.	Underwater Dosimetry	NCRP (SC-35)
12.	Ratings (curies) of large sources	ANSI N43, ANSI N44
13.	Particle Accelerators	ANSI N43, ANSI N44
14.	Low-Energy X-Rays	AEC, ANSI N43
15.	Containment of Radioactive Sources with respect to: a) corosion resistance b) fire resistance c) useable radiation	ASTM, ANSI N43, ANSI N44

16.	Dosimetry of X-Rays greater than 10 MeV	ICRU, NCRP, NBS, ANSI N43 ANSI N44, AAPM
17.	Isotopic Purity of Radiopharmaceuticals	AAPM, ANSI N44
18.	Modular Instrument Standards	ANSI N42, IEEE, ASTM, ANIM, ORNL
19.	Film Badge Testing Standards	AEC, ASTM, ANSI N13
20.	a) Biological Standards - Analytical Limitations b) Standard Techniques for Trace Element Analysis	ASTM, ANSI N11
21.	Physical Sizes for Standard Amounts (millicuries) of Useful Radioisotopes	ANSI N43, ANSI N44, AEC, ORNL
22.	Accuracy of Calibration Sources	ANSI N43, ANSI N44, NBS, ORNL, AEC
23.	Calibration of Analytical Instruments	ANSI N43, ANSI N44, NBS, ORNL, ARC, ANIM, IEEE
24.	Radiation Detectors	IEEE, ANSI N42, ANSI N13
25.	Radioisotope Heat and Power Sources for Space, Terrestrial and Ocean Use	AEC, ORNL, ANSI N43, IAEA NASA & U.S. Naval Facilities Engineering Command
26.	Long Term Integrating Type Dosimeters for Use in Nuclear Generating Stations	AEC, AECL, IEEE, ANSI N18 ANSI N42

ANSI - American National Standards Institute
ANIM - Association of Nuclear Instrument Manufacturers
IEEE - Institute of Electrical & Electronic Engineers
ASTM - American Society for Testing Materials
AAPM - American Association of Physicists in Medicine
AOAC - Association of Official Analyzing Chemists
SNM - Society of Nuclear Medicine
CAP - College of American Pathologists
ANR - Association of Neutron Radiographers

Discussion:

Kahn: How many years will be required before all commonly utilized radionuclides have been covered in "round-robins"?

Seidel: This is a continuing program and will require several years before most common radionuclides have been surveyed. There has not been enough publicity about standards' activities. Perhaps SOURS could serve as a "sounding board".

Kastner: Concerning nuclear data compilations, has there been cooperation between MIRD of the Society of Nuclear Medicine and the Nuclear Data Group?

Horen: The MIRD version that's coming out is based on Nuclear Data Sheets.

Kahn: It is based on the editor's judgement for many nuclides. It would be nice to know that there was agreement between MIRD and the Nuclear Data Group.

Meyers: Perhaps SOURS could be a body to referee decay scheme differences. It would be desirable to have a group outside the U.S. Government to arbitrate and recommend changes. Selenomethionine (Se-75) is an example of a radiopharmaceutical in which decay scheme data are sent out on a package insert. These data are used by physicians for dose calculations, standardizations, etc. It would be desirable that the latest recommended values be incorporated in such package inserts.

Seidel: Our committee recommended that Nuclear Data Tables be used whenever possible; in any case, the decay scheme reference should be cited.

Baerg: Could we hear the results of the AIF round-robin on Cobalt-57?

Seidel: It's hard to show everything about the intercomparison. Of 8 results, three were outside the NBS error limits. All the rest overlapped to some extent. Only one result was more than 5% off.

RADIONUCLIDE METROLOGY AND QUALITY ASSURANCE

W. B. Mann

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A series of six papers was given by members of the National Bureau of Standards (NBS) Radioactivity Section at the First International Summer School on Radionuclide Metrology held in Herceg Novi, Yugoslavia, in August and September 1972.(1-6) A seventh paper on Statistical Methods Applicable to Counting Experiments and Evaluation of Experimental Data was also given by Dr. H. H. Ku of the Statistical Engineering Laboratory.(7)

With this recent outpouring of information from NBS, it is difficult to prepare a review paper for this meeting that is not grossly repetitive. I would therefore prefer to refer the members of the Subcommittee to these publications, in Nuclear Instruments and Methods.

In lieu of offering a detailed rehash of what has already been prepared for publication, I can perhaps be permitted to refer to just one subject, namely the question of traceability of radioactivity measurements to NBS.

As I mentioned two years ago at the Las Vegas Tritium Symposium,(8) organized by the University of Nevada and the Environmental Protection Agency, "we at the National Bureau of Standards do not consider that our mission is fulfilled merely by the issuing of standards. Only when concordant measurements based on these standards come back from other laboratories do we feel that we have succeeded...".

With a radionuclide industry burgeoning to close to $100M per annum sales, predominantly in the techniques of nuclear medicine involving 8,000 to 10,000 hospital and medical laboratories, it is clearly an impossible task for NBS to maintain, in a practical way, traceability to every user in the field.

The concept of traceability can be achieved in at least two ways. Any laboratory will be considered traceable to us if it can either (i) calibrate an unknown sample supplied by NBS, and known to NBS, and obtain a result that is within a certain specified range from the NBS result, or (ii) the laboratory can produce calibrated reference sources, of which one or more can be calibrated by NBS and found to be consistent within an acceptable range. For different purposes different ranges of value will be

acceptable and a laboratory could consider whether it wished to be one-percent, ten-percent, or, say, thirty-percent traceable to NBS.

With a view to achieving such traceability we have carried out a number of "round-robin" exercises under the auspices of the College of American Pathologists (CAP), the Atomic Energy Commission (AEC), and the Atomic Industrial Forum (AIF). The first such round-robin traceability study was organized by CAP and took place in October 1970, when some 25 samples of iron-59, calibrated by NBS but unknown to the participants were distributed for both radionuclidic identification (together with a radionuclidic impurity check) and activity measurement. Since that time cobalt-57, iodine-125, and iodine-131 "unknowns" have been distributed to participating laboratories for identification and calibration under CAP auspices. In addition a further test was organized, with the CAP, in which the participants were asked to inject a known amount of about 50 microcuries of chromium-51 in solution into a serum bottle and to send it to NBS for verification.

In the case of the AEC, test solutions containing known amounts of various gamma-ray emitting radionuclides, covering the energy range from about 0.08 to 1.8 MeV, were sent for identification and calibration to the monitoring laboratories for different nuclear-power reactors and also to the AEC Health Services Laboratory at Idaho Falls. The certificate and report of calibration of typical calibration and test sources are appended. Such a report can be supplied to the participant either before or after he has submitted his results, according to his wishes.

Lastly we have carried out a traceability study on behalf of the AIF Committee on the Radioisotope Production and Distribution's Subcommittee of Manufacturers of Radioactive Reference Standards. This subcommittee composed of representatives of industrial producers of different forms of radioactive materials was organized with a view to recommending procedures for the calibration of such materials, and to achieving uniformity of reporting, and traceability to NBS. Under the auspices of the subcommittee, we have distributed "unknown" solutions of cobalt-57 to 13 commercial companies for identification and measurement.

The results submitted by commercial companies were not greatly dispersed, but other values have ranged from 2% to 391% of the NBS value. Various publications by the various bodies concerned are now being processed and the first of the NBS contributions at Herceg Novi gives summaries of one nuclear-power-reactor study and three CAP studies, namely those of iron-59, iodine-131, and chromium-51.

As I mentioned earlier, NBS cannot maintain direct calibration traceability to every user of radioactive material in the field for every available radionuclide. We therefore envisage traceability as a pyramid structure with the International Bureau of Weights and Measures, or, in the case of the developing countries, the International Atomic Energy Agency, organizing traceability, or the consistency of measurement, on the international level.

Then, in turn, the national standardizing laboratories should be responsible for the consistency of radioactivity measurements in their own countries. In the United States we would expect that industrial producers of radioactive materials and reference sources, and the quality control laboratories, such as those of the AEC, EPA, and Food and Drug Administration (FDA), would be traceable to NBS. These laboratories, in turn, would assure traceability to, say, state health laboratories, nuclear-power reactor licensees' monitoring laboratories, EPA sampling laboratories, and so on.

Occasionally NBS could be expected to carry out traceability studies directly to the lower echelons of the pyramid, but limitations of manpower currently preclude too much of an effort in that direction.

Lastly I would like to digress for a moment on what really constitutes traceability to the national and international radioactivity measurements system. The life of a radioactivity standard is generally quite limited and none can be indefinitely preserved. We establish traceability in I-131 measurements with a laboratory in the broad field of such measurements today, but what about tomorrow, next month or next year? Clearly such intercomparative measurements cannot be carried out every week with of the order of 10,000 hospital and medical laboratories. Ultimately NBS can only maintain traceability with these laboratories through the commercial producers of radioactive materials and radiopharmaceuticals. Perhaps we will be able to certify a limited number of laboratories as being an acceptable next stage of the traceability pyramid. At the moment the admirable CAP effort covers only some 50 medical laboratories out of the order of 10,000!

Ultimately traceability becomes synonymous with consistency, credibility and competence. If a laboratory is found to be consistent with NBS, within a given range of values, in its measurement of, say, twelve different radionuclides a year, then the personnel of that laboratory have demonstrated a pattern of reliability and continuing competence to assume that their calibrations of several hundred radiopharmaceutical labelled compounds, and other radioactive materials are equally competent.

Radioactivity is ephemeral and passing and the problems of traceability to NBS in radioactivity measurements are just about inversely proportional in magnitude to the half lives of the radioactive materials under consideration!

Many members of the Radioactivity Section have contributed to these traceability exercises, particularly Miss L. M. Cavallo, Dr. J. M. R. Hutchinson, Dr. B. M. Coursey and Dr. J. R. Noyce. Much of the pioneer work in the CAP intercomparisons was undertaken by our late colleague, Samuel B. Garfinkel.

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U. S. Department of Commerce
Peter G. Peterson
Secretary

National Bureau of Standards Certificate

Standard Reference Material 4242-B

Mixed Radionuclide Gamma-Ray Emission-Rate Standard

This sample consists of manganese-54, cobalt-57, cobalt-60, yttrium-88, cadmium-109, tin-113-indium-113m, and cesium 137-barium-137m in 48.4 grams of approximately 4N HCl in a flame-sealed borosilicate glass bottle of specified dimensions.

This sample was made by weighing an aliquot of a calibrated radionuclide mixture into the bottle containing the acid, and flame sealing. The gamma-ray-emission rates of the solutions used to prepare the radionuclide mixture were determined by means of the NBS calibrated $4\pi\gamma$ ionization chamber, and assumed nuclear decay parameters.

The nuclear gamma-ray-emission rates at 1200 EST June 1, 1972, are shown in the table below.

Nuclide	γ-Ray Energy(MeV)*	γ-Ray Intensity(%)*	Half Life	γ/s	Errors % Random	System	Total
^{109}Cd	0.0877		1.2727y	752.5	0.3	2.7	3.0
^{57}Co	0.122	85.6±0.2	271.76d	1340	0.1	2.2	2.3
^{113}Sn-^{113m}In	0.392		115.31d	739.4	0.1	2.8	2.9
^{137}Cs-^{137m}Ba	0.662	84.6±0.4	29.93y	2041	0.1	1.9	2.0
^{54}Mn	0.835	99.978±0.002	312.27d	2278	0.1	2.5	2.6
^{60}Co	1.173	99.88±0.02	5.261y	4101	0.1	1.3	1.4
	1.333	100		4104	0.1	1.3	1.4
^{88}Y	0.898	93.4±0.7	106.61d	883.2	0.1	2.9	3.0
	1.836	99.37±0.02		940.0	0.1	2.2	2.3

*Nuclear Data Tables, A8, Nos. 1-2 (Oct. 1970).

The total uncertainties in the gamma-ray-emission rates are the linear sums of the respective random errors (limit of random error at the 99-percent confidence level), the above-stated errors in the gamma-ray intensities, and the estimated upper limits of conceivable systematic errors.

The gamma-ray-emission rate of all other observed contaminants was less than 0.02 percent of the total gamma-ray-emission rate on June 1, 1972.

This standard was prepared in the NBS Center for Radiation Research, Nuclear Radiation Division, Radioactivity Section, W. B. Mann, Chief.

Washington, D.C. 20234
May 1972

J. Paul Cali, Chief
Office of Standard Reference Materials

4242-B- 4

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 4252

Mixed Radionuclide Radioactivity Standard

This standard consists of chromium-51, manganese-54, cobalt-58, iron-59, cobalt-60, zinc-65, cesium-134, cesium-137, and cerium-144 in 478.0 grams of approximately 4N HCl in a flame-sealed borosilicate glass bottle of standard dimensions. The solution also contains approximately 15 ppm by weight of stable cation carrier for each of the radionuclides listed above.

This standard was made by weighing an aliquot of a calibrated radionuclide mixture into the bottle containing the acid. This calibrated mixture was prepared by mixing standardized solutions of the individual radionuclides.

The cerium-144 was calibrated by gamma-ray intercomparison with material which had previously been standardized by $4\pi\beta$-γ coincidence counting. The radioactivities of the other standardized solutions used were determined by means of the NBS calibrated $4\pi\gamma$-ionization chamber.

The radioactivities of the constituents in nuclear transformations per second at 1200 EST January 15, 1973, are shown in the table below.

Radionuclide	ntps	Uncertainty % Random	Systematic	Total
^{51}Cr	1705	0.1	4.2	4.3
^{54}Mn	3336	0.1	2.5	2.6
^{58}Co	3661	0.1	2.9	3.0
^{59}Fe	3291	0.1	2.6	2.7
^{60}Co	7072	0.1	1.3	1.4
* ^{65}Zn	6251	0.1	2.6	2.7
^{134}Cs	1108	0.1	2.5	2.6
** ^{137}Cs	4958	0.1	2.0	2.1
^{144}Ce	3304	0.7	2.3	3.0

* Assuming a gamma-ray intensity of 50.6 ± 0.4% for the 1.115-MeV gamma ray.

** Assuming a gamma-ray intensity of 85.0 ± 0.3% for the 0.662-MeV gamma ray.

The uncertainties in the radioactivities are the 99-percent-confidence limits for the random error components, and the linear sums of the estimated upper limits of conceivable systematic errors.

This standard contains cobalt-57 as an impurity. The cobalt-57 activity was less than 0.1 percent of the total activity on January 15, 1973. The gamma-ray energy spectrum of the standard was examined with a Ge(Li)-spectrometer, and no other impurity was observed.

This standard was prepared in the NBS Center for Radiation Research, Applied Radiation Division, Radioactivity Section, W. B. Mann, Chief.

Washington, D.C. 20234
January 1973

J. Paul Cali, Chief
Office of Standard Reference Materials

4252-5

Notes on the Use of Mixed Radionuclide Radioactivity Standards:

SRM-4252 and SRM-4253

The table below gives the gamma-ray energies, their intensities and the half-lives for the component radionuclides in SRM-4252 and SRM-4253. The values given for energies and intensities were taken from Nuclear Data Tables, A8, Nos. 1-2(Oct. 1970) unless otherwise indicated. The half-lives listed are N.B.S. measured values. The underlined gamma-ray energies were found to be a convenient set for use in the assay of these mixtures as unknowns.

Radionuclide (Parent)	γ-Ray Energy (MeV)	γ-Ray Intensity (%)		Half-Life
^{51}Cr	0.3201	9.9	1[a]	27.79d
^{54}Mn	0.8348	99.978	2	312.27d
^{58}Co	0.8106	99.44	2	71.3d
	0.8636	0.69	2	
	1.6748	0.53	2	
^{59}Fe	0.1425	0.81	7	44.52d
	0.1922	2.8	3	
	0.3348	0.30	5	
	0.3827	0.022	5	
	1.0993	56	1	
	1.2916	44	1	
	1.4818	0.056	12	
^{60}Co	1.1732	99.88	2	5.261y
	1.3325	100		
^{65}Zn	1.1155	50.6	4	243.79d
^{134}Cs[b]	0.4754	1.50	3	2.0632y
	0.5633	8.47	17	
	0.5694	15.36	31	
	0.6047	98	1	
	0.7958	84.9	22	
	0.8018	8.61	22	
	1.0390	1.01	2	
	1.1681	1.84	4	
	1.3651	3.11	8	
^{137}Cs[b]	0.6616	85.0	3	29.93y
^{144}Ce	0.08012	1.54	15	284.19d
	0.09995	0.038	4	
	0.13353	10.8	5	
^{144}Pr[c]	0.6965	1.51	5	17.28m
	1.4891	0.29	2	
	2.1857	0.74	3	

[a] 9.9 ± 0.1

[b] The latest recommended values for these intensities were obtained from Dr. Murray Martin, Oak Ridge National Laboratory.

[c] Praseodymium-144 is in secular equilibrium with cerium-144.

USCOMM-NBS-DC

Discussion:

Hutchinson: New standards being prepared by NBS are: chromium-51, silver-110m, iron-55 (X-ray calibration point source), blanks for radon counting, mercury-203, yttrium-88, cerium-139, set of mixed radionuclides and standards (this is an annual set), xenon-133, cadmium-109, thorium-229, strontium-89, strontium-90, and a mixed sample of strontium-89,-90. Our development activities include gaseous standards, sediment standards, and a "dose calibrator" kit.

APPENDIX: PARTICIPANTS

A. P. Baerg,* National Research Council, Canada
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* member of Subcommittee on the Use of Radioactivity Standards
**presented paper

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16. ABSTRACT

A symposium was held to discuss the needs for radioactivity standards in environmental monitoring programs concerned with population radiation exposure. Papers were presented on "Status of Decay Schemes," "Some Activities and Needs for AEC Regulatory in the Use of Radioactivity Standards," "Standards for Environmental Studies," "Program and Activities of the Quality Assurance Branch, NERC-Las Vegas," "Activities of Commercial Radionuclide Producers," and "Radionuclide Metrology and Quality Assurance." The presentations indicated that numerous radioactivity standards and aids for correctly utilizing them were available. New needs, however, had arisen recently because lower levels of ambient radioactivity must be measured by many more groups due to requirements that population radiation exposure from nuclear power production be as low as practicable. Based on the presentations and resulting discussions, the following actions were recommended: 1) Establish a focal point for systematically planning activities to meet cited needs for decay schemes, specific standards, analytical methods, and quality assurance programs; 2) Develop a clear chain of traceability to the National Bureau of Standards; 3) Prepare guides for standardizing radiation detection and maintaining quality control; and 4) Train qualified analysts to obtain satisfactory analytical results.

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