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NOTE

Throughout this report and its annexes cross-references are denoted by a letter followed by a number: the letter refers to the relevant technical annex (see Table of Contents) and the number is that of the relevant paragraph. Within each technical annex, references are made to its individual scientific bibliography by a number without any preceding letter.

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ANNEXES

Annex E
METHODS OF MEASUREMENT

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I. INTRODUCTION

1. The ultimate purpose of radiological measurements of concern to the Committee is the estimation of tissue dose from natural sources, man-made sources and environmental contamination. In some cases, however, measurements of radioactivity are also of primary concern. It is emphasized that new and improved methods are constantly being developed.

2. It is customary to classify measurements of this nature into categories relating to the method used, i.e., direct or indirect. Direct exposure rate measurements are those made with ionization chambers or instruments calibrated in terms of air ionization. Indirect methods are those where exposure rate is calculated from activity measurement. The rates of exposure from medical and industrial practice and from terrestrial and cosmic radiation are sufficiently high to allow direct measurement. Exposure rates from other sources are low and the dose rate must usually be estimated indirectly by activity measurement and subsequent calculation.

Direct measurements

3. Routine direct determination of external exposures usually involves the measurement of gas ionization, as the relationship between energy absorption and ionization is relatively independent of energy. Any ionization chamber with an air equivalent wall may be used for the measurement, but it must be standardized periodically against a free air chamber.[1]

4. Scintillation counters, films and geiger counters can be used for rough estimation of exposure or exposure rate, but they can give erroneous results in mixed radiation fields. They can be valuable, however, if the composition of the field is known and they have been calibrated under similar conditions.

Indirect measurements

5. The indirect determination of exposures from radioactive sources, such as deposited fall-out or radioisotopes in the body, is more complex. It involves consideration of methods of sampling, radiochemistry and activity measurement. Methods for these are outlined in the following sections. The necessary dose computations are described in annexes B, C, and D.

II. SAMPLING

6. The determination of activity in the atmosphere, fall-out deposit, soil, foodstuff and human tissue requires the collection of samples representative of a given geographic region. Although this is difficult from a technical and statistical viewpoint, there are recognized methods.[2,3] It is recommended that the sampling of the environment and the biological materials be co-ordinated.

7. Radioactive material may be present in the atmosphere in gaseous or particulate form, each requiring its own sampling method. For measurement of radioactive gases, the sample must be obtained by collecting a measured volume of air in a suitable container[4–7] or by drawing a measured volume of air through an activated charcoal trap.[4,5,8] Both filters[4,5,9–14] and electrostatic precipitators are suitable for collection of airborne particulates.[5,11] These methods may also be used for very rough estimates of gaseous activities having solid daughters.[15,16] Deposited fall-out activity may be collected periodically by a high-walled pot[12–14,17–21] or high-walled funnel,[22–24] or the accumulated deposit may be obtained from soil samples.[25,26,D14]

8. It is not possible at present to state the absolute efficiency of any device for the collection of fall-out deposition. The high-walled pot is recommended as an arbitrary basis of comparison for other methods.

9. Samples of foodstuff should represent the regional diet, and should be selected with reference to the isotope of interest. Although it is advisable to take samples frequently, it is more economical to analyse a composite representing one or more months' collection.

10. The *in vivo* measurement of radioactive strontium or radium by whole body spectrometry is inadequate at present. Therefore samples of bone are required for estimation of the skeletal burden in man. Specifications for sampling have been given.[25,D66]

III. RADIOCHEMISTRY AND ACTIVITY MEASUREMENT

11. Radon may be measured by alpha counting in an ionization chamber[11,27,28] or scintillation counter.[29,30] The techniques suitable for air samples are also adequate for samples of exhaled breath for evaluation of

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the radium body burden. Standards may be prepared from commercially available radium solutions.[31,32]

12. The determination of strontium activity in the various materials described above involves preparation of the sample, separation of strontium and measurement of the activity.

13. The preparation depends on the type of sample: (*a*) soil from which strontium is removed satisfactorily by a 6M HCl leach; and (*b*) rainwater, foodstuffs and bone, which are best treated by wet or dry ashing with subsequent solution in mineral acid. Following this treatment strontium is radiochemically purified. Y^{90} is allowed to grow to equilibrium, is separated from the parent and measured in a beta counter, thus giving the Sr^{90} content of the sample.[25,26,33-39] The activity of any Sr^{89} present can be determined by difference. A moderately low background counter (5 to 10 cpm) is satisfactory for all samples but human bone, which requires counters with a background of about 1 cpm. The counting procedure must be calibrated with an absolute standard in order to convert the values obtained to disintegration rate. Reference samples for Sr^{90} are available for inter-calibration purposes through the Secretariat of the United Nations Scientific Committee on the Effects of Atomic Radiation and also commercially.[31]

14. The determination of total beta activity involves only preparation of the sample and measurement of the activity. Rainwater activity may be concentrated satisfactorily by evaporation[33,38] or by absorption on ion exchange resins.[23,24] Air filters or the residues from rainwater may be counted directly or dry-ashed prior to measurement of activity.[23,33,38,40] Useful information may be obtained by determination of beta or gamma activity. The conversion of counting data to disintegration rates is difficult; the best standardization is accomplished with mixed fission products from a short irradiation but natural potassium is more generally available and has suitable radiation characteristics.

15. The Cs^{137} burden of humans living in a contaminated environment can best be measured *in vivo* with a whole body spectrometer.[41-45] Gamma spectroscopy is also useful for direct determination of this radioisotope in other materials.[46,47] Radiochemical separation techniques have been described which allow measurement of the caesium beta or gamma activity without energy discrimination.[33,35,38,39] Adequate standards have not been available until recently.[31] An accuracy of $\pm$ 25 per cent may be obtained by comparison of the beta activities of the Cs^{137} with a Sr^{90} standard. An intercomparison programme for development of Cs^{137} standards is desirable.

16. The I^{131} burden in humans can best be measured *in vivo* by scintillation counting of the thyroid with energy discrimination.[48-51] Also, gamma spectroscopy is useful for direct determination of this radioisotope in other materials, though radiochemical techniques have been described which allow measurement of the separated iodine activity.[52,53] Adequate standards are commercially available.[54]

17. The determination of radium involves preparation of a sample solution as for Sr^{90} followed by measurement either by a radon emanation technique[55] or by radiochemical separation and alpha counting of the radium.[56,57] Standards are commercially available.[31,32]

18. The current radiochemical literature describes methods for many other nuclides, (fission products, induced activities, fissionable materials and natural isotopes) which would appear to be completely satisfactory in most instances.

References

1. United States Department of Commerce, National Bureau of Standards Handbook 62: *Report of the International Commission on Radiological Units and Measurements (ICRU)* (1957).
2. Deming, W. E.: *Some theory of sampling.* John Wiley and Sons, Inc., New York (1950).
3. Snedecor, G. W.: *Statistics.* Iowa State College Press, Ames, Iowa, 4th ed. (1946).
4. Goldman, F. H., and Jacobs, M. B.: *Chemical methods in industrial hygiene.* Interscience, London (1953).
5. Elkins, H. B.: *The chemistry of industrial toxicology.* John Wiley and Sons, Inc., New York (1950).
6. Harley, J. H., Jetter, E., and Eisenbud, M., A.M.A. Archives of Ind. Hyg. and Occupat. Med., *4,* 1-9 (1951).
7. Grove, W. P., and Clack, B. N., Brit. J. of Radiol., Suppl. *7,* 120-123 (1957).
8. Hursh, J. B., Nucleonics *12,* No. 1, 62-65 (1954).
9. Harris, W. B., LeVine, H. D., and Eisenbud, M., A.M.A. Archives of Ind. Hyg. and Occupat. Med., *7,* 490-502 (1953).
10. Steward, N. G., Crooks, R. N., and Fisher, E. M. R., UN document A/AC.82/G/R.20.
11. Hultqvist, B.: *Studies on naturally occurring ionizing radiations.* Kungl. Svenska Vetenskapsakademiens Handlingar, Series 4, vol. 6, No. 3. Stockholm (1956) and UN document A/AC.82/G/R.15, Part 4.
12. Alba A., F., Beltrán, V., Brody, T. A., Lezama, H., Moremo M., A., Tejera, A., and Vásquez B., M., UN document A/AC.82/G/R.5.
13. Labeyrie, J., UN document A/AC.82/G/R.16, Part I-1.
14. Martell, E. A., UN document A/AC.82/G/R.21.
15. Wilkening, M. H., Rev. Sci. Inst. *23,* 13-16 (1952).
16. Harley, J. H., Nucleonics, *11,* No. 7, 12-15 (1953).
17. Shirvaikar, V. V., and Vohra, K. G., UN document A/AC.82/G/R.32.
18. Hvinden, T., UN document A/AC.82/G/R.92.
19. Harley, J. H., Hardy, Jr., E. P., Whitney, I. B., and Eisenbud, M., UN document A/AC.82/G/R.93.
20. Blok, J., UN document A/AC.82/G/R.184.
21. Boulenger, R., UN document A/AC.82/G/R.209.
22. Stewart, N. G., Osmond, R. G. D., Crooks, R. N., and Fisher, E. M., UN document A/AC.82/G/R.143.
23. Edvarson, K., UN document A/AC.82/G/R.149.
24. Welford, G. A., and Harley, J. H., Presented at the American Chemical Society Meeting in San Francisco on April 14, 1958. To be published in Analytical Chemistry.
25. Bryant, F. J., Chamberlain, A. C., Morgan, A., and Spicer, G. S., UN document A/AC.82/G/R.30.
26. Hamada, G. H., and Hardy, Jr., E. P., United States Atomic Energy Commission report HASL-33 (1958).
27. Curtiss, L. F., and Davis, F. J., J. Res. Nat. Bur. Stand. *31,* 181-195 (1943).
28. Pradel, J., UN document A/AC.82/G/R.16, Part I-3.
29. Pittendrigh, L. W. D., Atomic Energy Research Establishment, Harwell, England, report AERE HP/M 83 (1954).

30. Van Dilla, M. A., and Taysum, D. H., Nucleonics *13*, No. 2, 68-69 (1955).
31. Standard samples are available at National Bureau of Standards, United States Department of Commerce, Washington 25, D.C., U.S.A.
32. Standard samples are available at The Radiochemical Centre, Amersham, England.
33. Health and Safety Laboratory, *Manual of Standard Procedures*. United States Atomic Energy Commission report NYO-4700 (1957).
34. Michon, G., UN document A/AC.82/G/R.16 Part I-2.
35. Kurchatov, V. V., UN document A/AC.82/G/R.40.
36. Canada: Report to the United Nations Scientific Committee on the Effects of Atomic Radiation, UN document A/AC.82/G/R.98.
37. Netherlands: Report to the United Nations Scientific Committee on the Effects of Atomic Radiation, UN document A/AC.82/G/R.110.
38. Osmond, R. G., Pratchett, A. G., and Warricker, J. B., UN document A/AC.82/G/R.132.
39. Saito, N., UN document A/AC.82/G/R.135.
40. Lockhart, Jr., L. B., Baus, R. A., and Blifford, Jr., I. H., UN document AC.82/G/R.124.
41. Anderson, E. C., Brit. J. of Radiol., Suppl. 7, 27-32 (1957).
42. Burch, P. R. J., Brit. J. Radiol., Suppl. 7, 20-26 (1957).
43. Rundo, J., 1956/1957, UN document A/AC.82/G/R.167.
44. Owen, R. B., Brit. J. Radiol. Suppl. 7, 33-37 (1957).
45. Marinelli, L. D., Brit. J. of Radiol. Suppl. 7, 38-43 (1957).
46. Iredale, P., and Humphreys, D. L. O., UN document A/AC.82/G/R.152.
47. Booker, D. V., Phys. in Med. and Biol. *2*, 29-35 (1957).
48. Gunther, R. L., and Jones, H. B., United States Atomic Energy Commission report UCRL-2689 and addendum (1954).
49. Franco, V. H., Botelho, L., Clode, W., Baptista, A. M., Fernandez, M. A. P., and Martins, M. L., Proc. Int. Conf. Peaceful Uses Atomic Energy, United Nations *10*, 298-307 (1956).
50. Francis, J. E., and Bell, P. R., Proc. Int. Conf. Peaceful Uses Atomic Energy, United Nations *14*, 193-203 (1956).
51. Hine, G. J., Burrows, B. A., and Ross, J. F., Nucleonics, *15*, No. 1, 54-56 (1957).
52. Schrodt, A. G., Proceedings of the Second Annual Meeting on Bio-Assay and Analytical Chemistry, October 11 and 12, 1956. Los Alamos Scientific Lab., N. Mex., report WASH-736 (1957).
53. Bergh, H., Finstad, G., Lund, L., Michelsen, O., and Ottar, B., UN document A/AC.82/G/R.113.
54. Standard samples can be obtained from Nuclear-Chicago Corporation, 223 West Erie Street, Chicago 10, Ill., U.S.A.
55. Hudgens, J. E., Benzing, R. O., Cali, J. P., Moyer, R. C., and Nelson, L. C., Nucleonics, *9*, No. 2, 14-21 (1951).
56. Harley, J. H., and Foti, S., Nucleonics, *10*, No. 2, 45-47 (1952).
57. Kirby, H. W., Anal. Chem. *25*, 1238-1241 (1953).

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Appendix

LIST OF SCIENTIFIC EXPERTS

The scientific experts who have taken part in the preparation of the report while attending Committee sessions as members of national delegations are listed below. The Committee must also express its appreciation to the many individual scientists not directly connected with national delegations whose voluntary co-operation and good will contributed in no small measure to the preparation of the report.

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