CALIBRATED NUCLIDES - AN IAEA SERVICE

In 1964 the Agency's laboratories at Seibersdorf are undertaking distribution of calibrated radionuclides for the third year. This service has met with a response which shows that it meets an important need, and in 1964 the programme is being further extended.

The Agency's laboratories began their operations in 1959, and in this field preliminary investigation was first of all carried out on methods - notably of absolute measurements of radioactivity and of standardization. Then in January 1962 the distribution began of calibrated radioactive solutions of twelve different nuclides. Laboratories, hospitals and clinics using radionuclides for industrial, medical and biological purposes were enabled to calibrate their measuring instruments by means of these samples. More than 750 requests were received in the first year from about 70 institutions in 31 Member States.

In 1963 the work was carried further. About 1200 requests were received from more than 100 institutions in more than 40 Member States. With the development of the use of radioisotopes in Member States, previous experience suggests that requests in 1964 will be still more numerous.

How the Need Arose

The problem of measuring radioactivity in absolute units is no new one; it arose with the first discoveries of natural radioactivity. Research was done on this subject for many years in a number of laboratories where radioactivity was an important feature of the work. But in the nineteen-thirties, when artificial radioactive substances came into use, the question became acute. The naturally-occurring radionuclides numbered only a few dozen, but the number of artificially-produced nuclides multiplied rapidly, so that within a few years there were several hundreds. Today there are more than a thousand.

At the Seibersdorf laboratory. Counting apparatus used for the absolute calibration of beta-emitting nuclides

With this growth in the quantity and variety of radionuclides available for scientific, technological and industrial use, the problem of determining absolute activity became correspondingly great. Every nuclide must be studied separately. There is no general method of measuring activity valid for all; the method for a particular nuclide depends on its individual nuclear properties and its chemical nature, and the method must be designed accordingly.

This individuality makes all the more desirable a common approach by interested institutions, and uniformity of standards. Research developed largely independently in the different laboratories of the countries advanced in this field and tended to remain somewhat isolated. Nearly every laboratory had its own techniques, so that there was an evident need to standardize the methods themselves. It was therefore appropriate for the Agency to make a close survey of the methods being used in various laboratories, to study them in detail, check the results being obtained and so by degrees to evolve standard methods.

These standard methods give results which are tested by inter-comparisons between about thirty specialized laboratories, most of them in Europe and the United States. These comparisons are organized under the auspices of the International Bureau of Weights and Measures. Since only two or three radionuclides are considered per year in these inter-comparisons, the Agency makes in addition its own unofficial checks by means of inter-laboratory comparisons. It provides an internal check on the IAEA's own work and methods. The procedure is usually followed in respect of radionuclides which are relatively new or which have only recently come to have significant practical applications; it is then useful for the Agency laboratory to check its methods of dealing with these nuclides before they are distributed.

From the beginning, the Agency has selected the radionuclides for distribution according to their practical usefulness. At the outset the most important applications were in medicine and biology. By the end of 1961 the checks showed that the IAEA laboratories were achieving results of sufficient accuracy to enable the creation of the distribution service, and it was decided to do so in order to enable hospitals, universities and other laboratories to check their own methods and techniques and to calibrate their own equipment.

Widening Programme

The programme of distribution began with calibrated solutions of twelve different radionuclides, viz. phosphorus-32, iodine-131, gold-198, cerium-144, sodium-22, cobalt-60, strontium-90 (+ yttrium-90), strontium-89, iron-59, sulphur-35, barium-140 and caesium-137.

In 1963 the programme was expanded. Ten beta and beta-gamma emitting nuclides were distributed in the form of standard solutions; they included most of those on the previous list with the addition of mercury-203. In addition, a group of electron-capture nuclides was supplied, consisting of chromium-51, manganese-54, iron-55 and zinc-65. These nuclides emit no corpuscular rays (alpha or beta rays) but only X-rays, gamma rays, or both. Another radionuclide, caesium-132, was produced for calibrating whole-body monitors by in vivo experiments.

One of the products in most demand has been "mock iodine", of which the Agency has distributed about 100 samples in some dozens of hospitals which find this product more useful for the purpose than radioactive iodine itself. Mock iodine is a mixture of radionuclides of barium and caesium, both gamma emitters. The result is a gamma spectrum which is virtually the same as that given out by iodine-131, which is widely used in disorders of the thyroid. The iodine has a half-life of a few days only, whereas the mock iodine mixture remains good for about four years. Doctors are thus able to test their equipment used for the iodine-131 uptake test by means of a long-lived standard.

For 1964, the Agency is offering calibrated solutions of iodine-131, chromium-51, strontium-90, sulphur-35 and iron-55. An innovation this year is the provision of complete sets of calibrated solid gamma sources, intended primarily for calibrating scintillation spectrometers, but useful also in testing any other gamma detector. The set of eight nuclides consists of americium-241, cobalt-57, mercury-203, sodium-22, caesium-137, manganese-54, cobalt-60 and yttrium-88. The gamma energy of the first is 60 keV and that of each succeeding nuclide is progressively higher, so that in combination they give a range covering a wide energy band up to 1850 keV.

The distribution of caesium-132 standardized samples will be continued.

The programme of distribution will be expanded in 1965 to include new electron capture nuclides. The earlier samples contained comparatively low activities, but stronger sources such as iridium-192 and cobalt-60 - widely used for industrial radiography - will also be calibrated.

How It Is Done

Broadly speaking, the work of producing a calibrated radionuclide begins with a radioactive preparation - commonly in solution - of the radionuclide in a stable chemical form. The specific activity of the solution must not be modified by any change other than the normal radioactive decay of the nuclide.

Then the specific activity of the solution is determined - that is, the number of disintegrations per second which take place in the solution per unit of mass. The method of determining this specific activity varies according to the radioactive properties of the particular radioisotope.

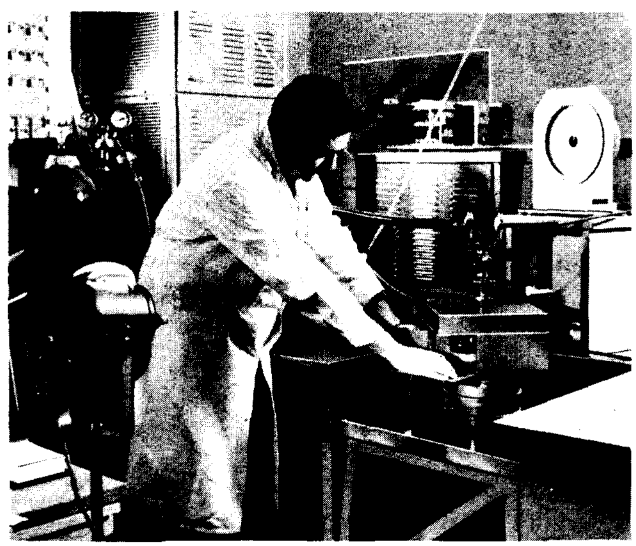
The preparation is then enclosed in a sealed ampoule, which is dispatched by air to the requesting laboratory. About two weeks before this, preliminary advice is sent, giving particulars of the flight number and time of arrival, details of the standard sample, a short description of the method of calibration used by the IAEA, and the date of reference.

The Agency gives a provisional certificate of the specific activity of the sample at a date (reference date) some days after the sample is due to reach the client - usually about a week later. This ensures that the receiving laboratory will be able to do its work with the sample on that date.

On the day (reference date) named in the provisional certificate, the Agency laboratory repeats the measurement in order to determine the precise specific activity at the same time as the work is actually being carried out in the client laboratory. The Agency then sends a definitive certificate to the receiving laboratory; any irregularities which may have been revealed by the IAEA measurements are mentioned in the final certificate. This enables the receiving laboratory to make an exact comparison of its results with those of the Agency.

The accuracy of the Agency's results depends on the nature of the radionuclide and is normally

A counting assembly used at Seibersdorf for the calibration of electron-capture nuclides



within one to two per cent. In special cases it can be better - according to the radionuclide concerned. The IAEA can guarantee its values, so that if the receiving laboratory obtains a result which is more than one to two per cent in error, its methods are in need of improvement.

The purposes of the receiving laboratories in using these samples vary. A physics laboratory, for example, may be interested in methods of absolute measurement, and will use its sample accordingly. A medical laboratory, on the other hand, will be interested primarily in the response of its counting equipment to a sample of known radioactive strength; such a laboratory will use the sample as a means of calibrating its instruments.

The Agency is in a unique position to carry out work in this field of measurement and calibration on an international basis. Its plans include provision for making absolute measurements of radioactive samples at the request of Member States, development of improved apparatus for calibrating electron-capture nuclides, and development of other new research methods and techniques.

A study of calibration of slow and fast neutron fluxes in reactors is planned, with a view to providing standard foils for neutron dosimetry; these foils are threshold detectors, each of them being activated by a given minimum neutron flux.

In order to assist calibration of chemical dosimeters and cavity ionization chambers, IAEA may also undertake absolute measurement of gamma doses from cobalt-60.

Future plans envisage a number of useful possible activities, but the programme is being kept flexible and will be adapted to the requirements of Member States, with the emphasis always on nuclides of immediate practical significance.

MEMBERS AND ASSOCIATES OF THE AGENCY

Nearly eight years have elapsed since the IAEA draft Statute was submitted to the conference of 81 nations which was convened at the United Nations headquarters in 1956. Since then the membership has grown steadily, and the Agency has also established affiliations with a large number and variety of other organizations - a reflection of the numerous fields in which atomic energy has become significant.

At the conclusion of the conference in October 1956, representatives of 70 States signed the Statute, and 10 more did so within 90 days. These accessions had to be ratified and, by the end of 1957, 59 States had done so and become Members. Others followed from year to year, Iraq becoming the 70th Member State in March 1959 and Uruguay the 80th in January 1963; several more have still to do so. Thanks to the emergence of new independent States, new applications continue; the seventh General Conference in 1963 approved those of Algeria, Cameroun, Gabon, the Ivory Coast and Nigeria. Subject to the completion of formalities (already finalized by Algeria, the Ivory Coast and Gabon), this brings the membership to 88.

The Agency quickly established links with other members of the United Nations family. The first was with the United Nations itself under whose aegis the Agency was established. Because of the particular significance of atomic energy and the possibility of diverting it to non-peaceful uses, the IAEA - unlike the specialized agencies of the United Nations - is directly linked by its Statute to the General Assembly of the United Nations, and may also report to the Security Council as the organ bearing the main responsibility for the maintenance of international peace and security. In other respects IAEA resembles the specialized agencies, and like them reports to the Economic and Social Council of the United Nations each year on its work of interest to that body.

Shortly after the Agency was set up it concluded a series of agreements to spell out its co-operation with various specialized agencies: namely the International Labour Organisation, Food and Agriculture Organization, United Nations Educational, Scientific and Cultural Organization, World Health Organization, International Civil Aviation Organization, World Meteorological Organization and the Inter-Governmental Maritime Consultative Organization. Agreements were also made with certain regional intergovernmental bodies dealing with the peaceful uses of atomic energy: namely the European Nuclear Energy Agency (of the Organisation for Economic Co-operation and Development) and the Inter-American Nuclear Energy Commission (of the Organization of American States). The Agency is