The Laboratories at Seibersdorf: Multi-disciplinary research & support centre

Set up 26 years ago, the Agency's Laboratories are building for the future

by Pier Roberto Danesi

Over the past quarter century, the Agency's nuclear research Laboratories at Seibersdorf, Austria, just outside Vienna, have been instrumental to the efforts of scientists to learn and apply nuclear techniques for practical benefits in industry, medicine, agriculture, and other fields. As the sole organization within the United Nations system that operates its own system of laboratories, the IAEA is in a unique position to meet many scientific and technical needs of international development.

Established in 1961, the Laboratories are a product of initiative and co-operative support. Their nucleus had actually been formed some 2 years earlier, when a handful of Agency scientists and technicians set up a physics laboratory, a chemistry laboratory, and an electronics workshop in the basement of Vienna's Grand Hotel, which served as the IAEA's headquarters for more than two decades. The move from the hotel "basement" to larger facilities in the Austrian countryside followed a donation of US $600 000 from the United States, the lease of land adjoining the premises of the Austrian Nuclear Centre for a nominal rent of one Austrian schilling per year, and the donation of valuable equipment by many Member States. By 1964, the work had expanded further following establishment of co-operative ties between the IAEA and Food and Agriculture Organization (FAO) of the United Nations: in Vienna at Agency headquarters, through the Joint FAO/IAEA Division, and in Seibersdorf, through an agricultural laboratory.

The evolution continues today in the co-operative spirit of those early years. In 1986, the agricultural laboratory was upgraded with the addition of a new wing equally funded by the FAO and IAEA and by donations of research equipment and supplies from Canada, Poland, and the United States. In June 1987, another important step was taken when the Agency's Board of Governors approved a proposed expansion of the main building's training and research facilities. More and more IAEA Member States, primarily developing countries, are requesting laboratory and on-the-job training opportunities at Seibersdorf for their scientists and scientific fellows. *(See accompanying table.)* Voluntary contributions from Member States will fund the expansion and donations totalling US $1.4 million have been pledged by Austria and the United States.

Today, a staff of 169 representing about 40 different nationalities carries out the Laboratories' multi-faceted mission in support of Agency research, training, and technical assistance programmes. Their work spans nuclear and related experimental studies, analysis, and education, as well as analytical services to support the IAEA's system of international safeguards that helps ensure nuclear energy's peaceful uses. Organizationally, there are three branches:

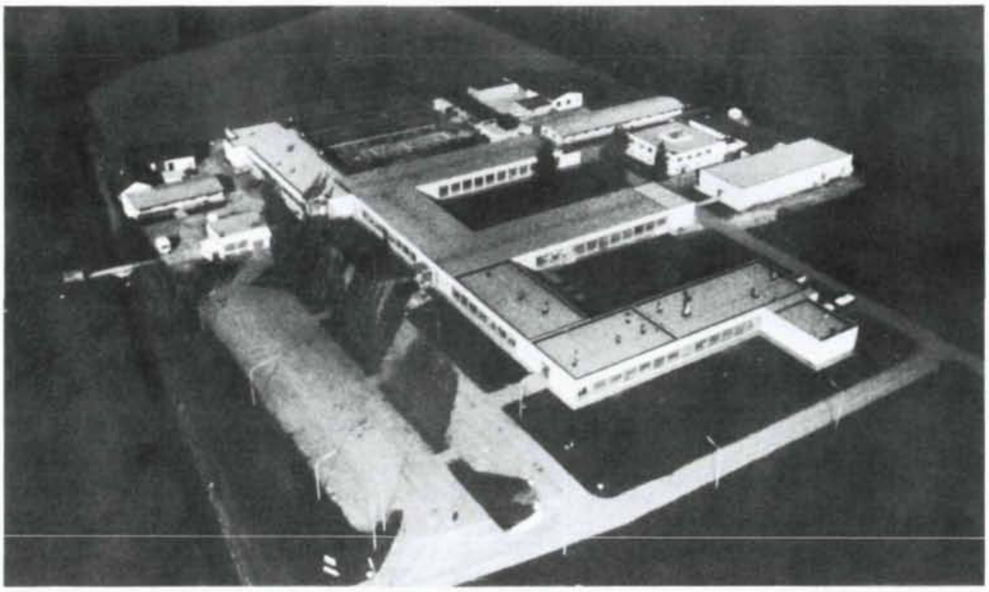
- *Agriculture Laboratory,* which has units for soil science, plant breeding, agrochemicals, entomology, and animal science
- *Physics-Chemistry-Instrumentation (PCI) Laboratory,* whose four units are chemistry, dosimetry, instrumentation and physics, and isotope hydrology
- *Safeguards Analytical Laboratory (SAL),* which has one unit for isotopic analysis and another for chemical analysis of nuclear material samples collected during IAEA inspections of nuclear facilities.

Common components are the radiation protection and maintenance units, the mechanical workshop, a library, and administration.

Training at Seibersdorf covers the range of activities and typically involves:

- *In-service training of fellows,* whereby one person is given the opportunity to work alongside a staff scientist from 2 to 12 months on the application of nuclear techniques to the solution of a practical problem
- *Training courses,* which are characterized by formal lectures, delivered by scientists from IAEA and other institutes, and practical exercises. Since 1978, for example, the agriculture laboratory has hosted 12 interregional courses in soil science attended by 225 participants. Additionally, nearly 100 scientists from developing countries have participated in five plant breeding courses, while nearly 40 others have attended two interregional courses on animal nutrition. Courses generally last from 4 to 10 weeks and traditionally have been limited to only 20 participants because of space limitations. Demand is far higher, however, as about 100 or more qualified government-sponsored applications are usually received for each course.
- *Group training,* whereby four to six IAEA fellowship holders work together for up to 6 months to learn about a specific practical topic (for example, nuclear electronic instrumentation and maintenance). It includes technical tutoring, hands-on experience, periodical lecturing, and direct supervision of experiments.

Dr Danesi is Head of the Seibersdorf Laboratories. Also contributing to the article were the heads of the three branch laboratories and their units.



Aerial view of Seibersdorf Laboratories.

Agriculture laboratory

Work at the agriculture laboratory over the years has benefited greatly through contributions from FAO, the International Rice Research Institute (IRRI), and several Agency Member States, including Austria, Canada, Italy, Japan, Poland, and United States. Among the laboratory's main activities and achievements:

Soil science unit.* The unit has acquired a leading international position in the use of isotope techniques for more efficient and economical fertilizer use. The methodology for using nitrogen-15 to quantify the amount of biologically fixed nitrogen in field-grown grain legumes was developed at the unit's laboratories. Further research is being done to measure nitrogen fixed in various systems and to improve crop yield and nitrogen fixation by grain legumes. Routine analytical services for determination of nitrogen-15 have been provided to more than 100 contractors without appropriate laboratory facilities of their own who participate in Agency co-ordinated research programmes and technical co-operation projects. The unit also evaluates natural rock phosphates using a radioisotope technique for various developing countries taking part in the FAO's fertilizer programme. Specialized laboratories in soil microbiology, soil physics, and plant physiology have been set up in connection with this and related work.

* For a fuller report on the unit's work and Agency programmes in this field, see the *IAEA Bulletin*, Vol. 29, No. 2 (1987).

Plant breeding unit. The unit's basic purpose is to develop and advise on the methodology of genetic improvement in crop species obtained through radiation-induced mutations. Because crop species vary in reproductive capacity, a straightforward, universal approach is not sufficient. Several important crop species — such as bananas and plantains — are difficult to improve genetically by conventional plant breeding because of sterility (no seed-setting) or because of lack of desirable characteristics (disease or pest resistance) in the available germplasm. Through *in-vitro* technology, in combination with mutation induction, the unit seeks to alleviate some constraints on genetic improvement. Work has started, for example, on *in-vitro* mutagenesis at the unit's fully equipped tissue culture laboratory. One overall aim has been the development of methods that assure the highest possible reproducibility in mutagenic treatments. The unit has actively contributed to the monitoring of neutron irradiation doses applied to plant material, mainly seeds, and to the establishment of accurate treatments with chemical mutagens.

Since plant breeding should be conducted in the environment

Scientific fellowship training at Seibersdorf Laboratories, 1981–86

	Fellows trained (number/man-months)		Training courses
1981	19	74.75	1
1982	26	129.5	2
1983	23	137.0	2
1984	26	176.5	2
1985	42	223.5	3
1986	62	221.5	4

Growth chambers for *in-vitro* cultures at the agriculture laboratory's plant-breeding unit.

where improved varieties are to be grown, the unit trains scientists who will return to work in their home countries and fulfills requests of institutes for radiation treatments of plant materials. This service, which is done cost free, includes around 500 gamma-ray and fast-neutron treatments per year.

Entomology unit.* The unit works almost exclusively on the sterile insect technique (SIT) for biological control of insect pests. Laboratory-reared insects are exposed to sterilizing doses of radiation without substantially altering their behaviour when they are released in the natural environment. When mass-reared sterilized insects released in infested areas mate with wild insects, they do not produce viable offspring, and the insect population gradually declines. By repeating the procedure over successive generations, the pest can be eradicated. SIT procedures have been developed at Seibersdorf for two insect species: the Mediterranean fruit fly *(Ceratitis capitata)* and the tsetse fly *(Glossima palpalis palpalis)*. The medfly causes damage to more than 200 varieties of fruits and vegetables, making it one of the most economically important pests in the world. In Mexico, annual estimated savings of US $500 million are being realized from a SIT programme to whose development Seibersdorf contributed. Research now aims to improve mass-rearing technology and to lower costs by using local diet ingredients for feeding and by producing a strain of flies in which only males are reared to maturity. This will cut the cost almost in half, since only males are needed for release in a successful SIT operation.

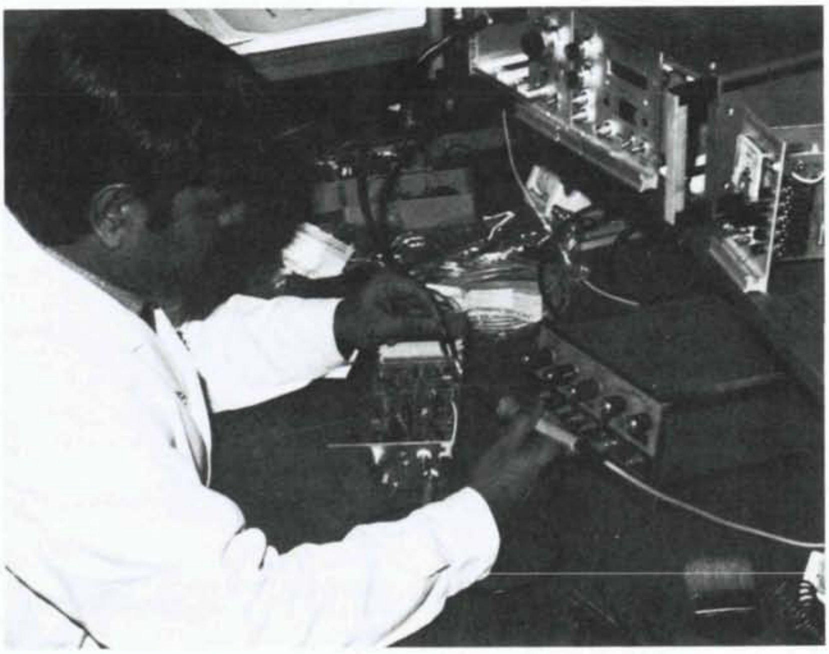
Another SIT operation, for which a back-up colony of flies was kept in the unit's laboratory, has eradicated a species of tsetse fly from a 1500-square kilometre agricultural zone in central Nigeria. The Nigerian Government has now recommended its expansion over a proposed target area of 12 000 square kilometres. Tsetse flies — vectors of trypanosomes that cause sleeping sickness in human beings and fatal infections in cattle — are one main obstacle to rural development in many African countries. While the fly's natural low rate of reproduction makes the tsetse a good target for SIT control, it is also a major obstacle to laboratory mass rearing. In recent years research at the unit has led to the development of a new cost-efficient rearing system. The live animals on which the flies were fed have been replaced by an *in-vitro* system in which they take their blood through a silicone membrane. Work now includes efforts to improve and adapt feeding and mass-rearing procedures to different tsetse species.

Agrochemicals unit. First established in 1982, the unit focuses on environmental consequences of agrochemical applications. One project, with special relevance to African countries, is studying the fate of trypanocide drugs, and their degradation products, in serum milk and meat samples. Another project is concerned with pesticide formulations and their residues in agricultural products. Labelled isotopes are used to analyse chemical degradation in natural systems through laboratory studies and greenhouse experiments that aim to minimize the quantities of agrochemicals that must be used.

Animal science unit. Animal reproduction, nutrition, and disease diagnosis are major areas of work. One main factor influencing livestock productivity is reproductive performance, especially in the female. A sensitive indicator of the reproductive activity of the cow, ewe, goat, and other animals is the level of the circulating female hormone, progesterone. The unit has developed a viable radioimmunoassay (RIA) kit for measuring this hormone in milk and blood and is presently distributing 200 kits per month to some 90 institutes in developing countries. Using such hormone measurements in conjunction with conventional reproductive and productive parameters, researchers have been able to identify the major factors that limit reproductive efficiency: livestock mismanagement, nutritional deficiencies, and the high incidence of disease. The unit also provides a

* For a fuller report on the unit's work and Agency programmes in this field, see the *IAEA Bulletin*, Vol. 29, No. 2 (1987).

service to contracted researchers who wish to evaluate the nutritional potential of alternative animal feed sources, such as agricultural by-products, alkali/ammonia-treated straws, and others. The apparatus used for this purpose — a Rumen Simulation Technique (Rusitec) — simulates the ruminant's digestive functions and is often called the "artificial cow". The technique screens "feeds" for their potential nutritional value before their testing in expensive and time-consuming feeding trials in the host country. Diagnostic kits for the rapid and accurate diagnosis of major diseases caused by viruses, bacteria, and parasites which through high morbidity and mortality reduce the productivity of livestock enterprises have also been developed. The unit supplies specifically designed kits for the diagnosis and study of rinderpest, brucellosis, babesiosis, and trypanosomiasis.



At the PCI laboratory, a scientist works at the single-channel analyser.

The PCI laboratory

The PCI Laboratory was formed in June 1985 by grouping the professional and technical laboratory staff previously working separately in chemistry, dosimetry, physics, electronics, computer applications, and isotope hydrology. Among its major activities and achievements:

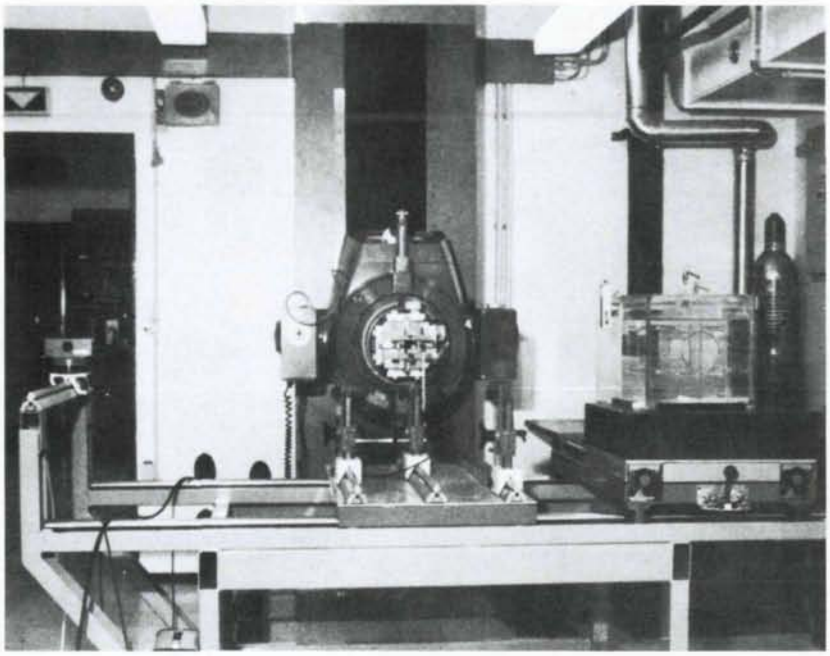
Chemistry unit. The unit assists in solving several problems related to trace elements in nutrition and the environment by using a wide range of modern nuclear and micro-analytical techniques. These include neutron activation analysis (NAA), inductively coupled plasma atomic emission spectrometry (ICP-AES), atomic absorption spectrometry (AAS), laser fluorimetry, liquid scintillation counting, and nuclear spectroscopic measurements. One focus is on the analysis of trace elements in human diets, hair, human kidney, liver, body fluids, air, water, plant, and soil samples. Analytical capabilities have improved recently through development of new simple radiochemical procedures for the simultaneous determination of several toxic and other elements that play a significant biological role. These include mercury, selenium, copper, manganese, cadmium, molybdenum, and chromium. Annually, about 5000 determinations are carried out to assess elements in 1500 different materials, through NAA and gamma-ray spectrometric analysis.

The unit also works in the detection and determination of low-level radioactivity in the environment and in food. Under the programme, called Radioactivity Fallout Monitoring in Environment and Food (MEF), the unit performs measurements and recommends reference methods for determining key radioactive contaminants in air, water, soil, grass, and principal foodstuffs. This work helps to provide national authorities and international organizations such as FAO, World Health Organization (WHO), World Meteorological Organization (WMO), and United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) with reliable and comparable data. Separately, the unit also supports the WMO's Background Air Pollution Monitoring Network by analysing precipitation and air filter samples for 10 polluting elements, including lead and cadmium.

For a report on the unit's Analytical Quality Control Services (AQCS), see the accompanying box.

Dosimetry unit. This unit serves as a central laboratory in the IAEA/WHO Network of Secondary Standard Dosimetry Laboratories (SSDLs), which was formed in the 1970s to promote and maintain measurement standards for dosimetry in radiotherapy and in radiation protection. The dosimetry standards of the SSDLs are calibrated against primary standards of leading metrology laboratories in the international measurement system to ensure precise dose control. About 60 laboratories, 46 of them in developing countries, now participate in the network. Besides organizing SSDL intercomparison runs and performing calibrations, the unit trains SSDL staff, undertakes technical missions, and develops special equipment and laboratory devices for the SSDLs to improve dosimetric accuracy.

Another joint undertaking of the IAEA and WHO is a postal dose intercomparison service for radia-



A cobalt-60 source at the dosimetry unit.

tion therapy centres using thermoluminescent dosimeters (TLDs). The unit prepares and calibrates TLDs that are mailed through WHO to participating hospitals and clinics in developing countries. There they are exposed under defined conditions to what the hospital laboratory believes is a specified dose and returned to Seibersdorf, where they are read and evaluated. The unit compares its readout with the quoted dose and reports any difference to the medical facility through WHO, suggesting possible causes and proposing appropriate action. Every year 100-150 TLD sets are evaluated.

Instrumentation and physics unit. In the early 1960s, calibration and distribution of radioactive sources and the development of reliable methods for measurement of radiation doses was a major task. Techniques were elaborated for absolute measurement of radioactivity, nuclear measurement equipment was developed, and intercomparisons were done for absolute radioactivity determination of various radionuclides. Radioactive sources of 15-20 different radionuclides, including a number of mixed sources, were prepared, calibrated, and distributed to users in different countries. Additionally, the half-lives of several radionuclides were redetermined. Today, work mainly involves nuclear instrumentation applications in soil physics so that guidelines and advice for selecting appropriate nuclear or non-nuclear methods for soil water management can be provided. Participating scientists from both developing and developed countries carry out field and laboratory experiments. Participants in training programmes are offered extensive field practice in the use of neutron and gamma density gauges to measure soil water content. They make field measurements and use the data in classroom exercises to estimate water requirements of crops. The unit also designs, builds, and maintains electronic and microprocessor-based equipment used in Agency training and research activities, and develops and advises on computer applications for the acquisition, transfer, and processing of data. Requests for on-the-job training on various aspects of design, assembly, operation, service, and maintenance of electronic and nuclear measuring equipment are continuously increasing. More than 200 sets of nuclear electronics learning kits have been prepared and distributed to institutes around the world.

Isotope hydrology unit.* Most of the unit's work concerns the use of stable and radioisotopes to study the origin and availability of groundwater and how fast it is being renewed. Nearly 1200 water samples are analysed each year using highly sensitive measurement instruments in support of Agency research programmes and technical assistance projects worldwide. Similar services are also carried out for 47 of the 164 stations of the IAEA/WMO worldwide precipitation network. For this network, about 500 water samples are analysed each year for deuterium, oxygen-18 and, in most cases, for their tritium content. Samples from the remaining stations are measured in co-operation with laboratories of the IAEA's Member States. For reference and intercomparison purposes, the unit stocks and organizes shipment for samples covering a range of isotopic compositions in natural materials, such as water, carbonates, sulfates, sulfides, nitrogen, and natural gases. Inter-

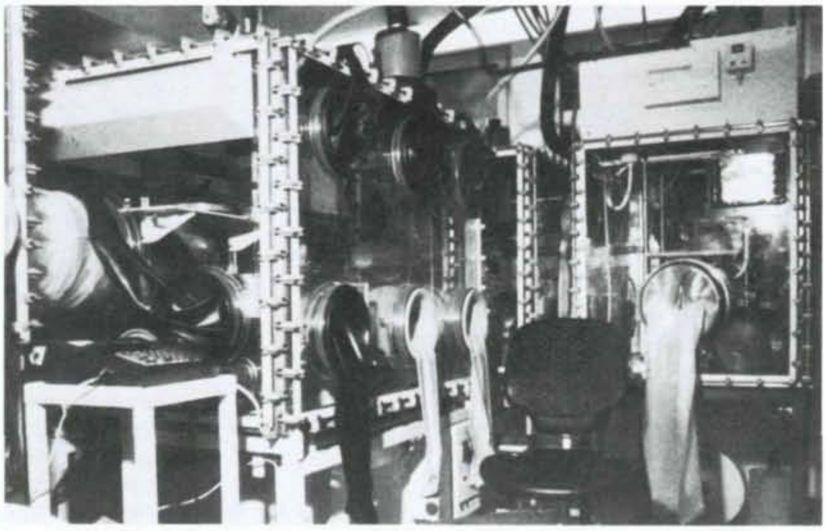
* For a fuller report on the work of the unit and the Agency's programme in hydrology, see the *IAEA Bulletin*, Vol. 29, No. 2 (1987).

At the chemistry unit, a liquid scintillation counter for strontium-90 and tritium.

comparison runs of tritium and stable isotope reference materials are done regularly to assist laboratories in different countries to check their analytical performance. The unit also assists countries with installation of isotope hydrology laboratories and develops standard measurement procedures.

Safeguards analytical laboratory (SAL)

Now into its 11th year of operations, SAL provides analytical support to the IAEA's application of safeguards of nuclear facilities and materials. Through its two units, it performs chemical and isotopic analysis of samples of nuclear materials collected during IAEA inspections at safeguarded nuclear facilities. It also helps train safeguards inspectors; contributes to designing and testing safeguards sampling procedures and inspection equipment; and assists in operating a network of 18 analytical laboratories (NWAL) around the world that take part in analyses of safeguarded nuclear materials. Annually, SAL alone analyses about 1200 samples of uranium, plutonium, and spent fuel.*



Glove boxes at SAL's chemical analysis unit.

* For a fuller report on the Safeguards Analytical Laboratory and its work, see the *IAEA Bulletin*, Vol. 28, No. 4 (1986).

Quality control services for analytical laboratories

by J.J. LaBrecque, S. Ballestra and R. Schelenz

Since the beginning of the IAEA in 1957, the importance of analytical quality control was of major concern, especially for radionuclide measurements. By 1959, a laboratory had been set up by a handful of scientists and technicians in the basement of the Agency's headquarters at the Grand Hotel in Vienna. A similar laboratory was established 3 years later in Monaco to cover marine interests. Activities focused on radioisotope calibration to resolve measurement differences between laboratories all over the world. To this day, standardization and intercalibration remain key services of not only the Seibersdorf Laboratories' chemistry unit but of other Agency branches as well, especially the International Laboratory of Marine Radioactivity (ILMR) in Monaco.

The programme today is known as Analytical Quality Control Services (AQCS). It basically provides for intercomparison studies and reference materials for radionuclides and for major, minor, and trace elements, stable isotope ratios, spectra analysis and even some organic compounds as analytes.

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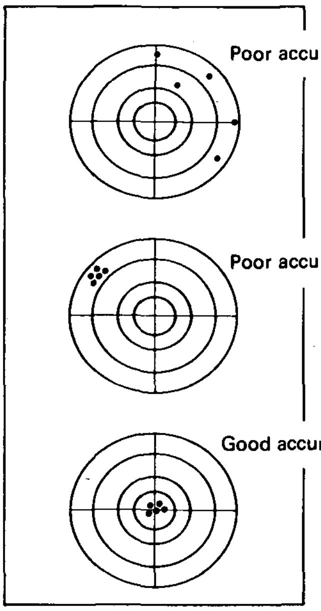
Background of programme

For reliable results, chemical measurements have two important properties: precision and accuracy. A measurement may be precise without being accurate. *(See accompanying diagramme.)* Precision is nothing more than reproducibility of the measurement; this can easily be accomplished by determining the analyte of interest in the same sample in the same way a number of times. However, accuracy (the closeness to the true value) in most cases requires more detailed procedures, such as:

- *Performing the measurement by many different analytical techniques, methods, and analysts.* If these different measurements are in good agreement, the results can be assumed to be accurate. But in some cases, only one analytical technique for a specific determination exists and even when a variety is available, a particular laboratory frequently has only the resources for one method and/or technique.
- *Participation in intercomparison studies.* The agreement of the results reported from a particular laboratory with the recommended value obtained from a rigorous statistical evaluation of all the results is a measure of the accuracy for that specific determination. In this case, the



intercomparison samples should be, as far as possible, similar in composition (matrix) and concentration to the routine samples. A large number of intercomparison studies are required regularly, but they are organized on a rather limited basis and, therefore, many important matrices and/or analytes have not yet been studied.

- *Use of reference materials which are as similar as possible to the materials to be analysed.* Agreement between the recommended and measured values is then a measure of the accuracy for that specific determination. Since the preparation and certification of reference materials is difficult, time-consuming, and costly, many important materials and/or analytes are not presently available from any source.

IAEA's range of services

Since 1983, the Agency has been providing about 1500 comparison samples and reference materials per year to laboratories all over the world so that they can themselves assess and control the quality of their work. Such a control is necessary, since their results may be the basis upon which economic, administrative, medical, or legal decisions are taken.

In general, a reference material is the result of an intercomparison study in which certain analytes can be recommended after a rigorous statistical evaluation and certification criteria. In some cases, an intercomparison study does not result in a reference material because of lack of sufficient data or the quality of the data. Normally about 50 laboratories request to take part in radionuclide intercomparison studies and over 100 seek participation in trace element studies.

Intercomparison and reference samples currently available from the IAEA cover a wide range of materials and analytes in different concentration ranges for various types of measurements. As Agency requirements expand and new analytical techniques evolve, more samples may be added. For example, the programme is now studying determination of macro neutron absorption cross-sections by nuclear measurements and stable isotope ratios by mass spectrometry for life science applications.

Available reference materials can be grouped in four basic areas:*

- *Nuclear materials and stable isotope standards.* Three thorium ores and seven uranium ores are available with different concentration ranges to serve exploration and exploitation purposes. An uranium oxide material for trace impurities, and two stable isotope materials of water for hydrological investigations are also provided. Finally, gamma-ray spectra for evaluation of computer software exist.
- *Environmental materials.* For environmental levels of radioactivity, lake-sediment and soil samples from Austria are available as natural matrix standards and a simulated air filter sample. Also on hand are two other lake-sediment samples, a soil sample, a feldspar sample, and a synthetic fresh-water sample for trace elements and some minor and major elements.
- *Biological materials.* To meet the needs of various activities in life sciences, several materials including an animal bone and milk powder were prepared and are available for the determination of selected radionuclides. Another milk and whey powder sample with elevated levels of radioactivity affected by the Chernobyl nuclear power plant accident are being analysed as intercomparison samples. Other materials with environmental levels of trace elements are also available: milk powder, freeze-dried animal blood, rye flour, cotton cellulose, hay powder, animal muscle, animal bone, horse kidney, and mixed human diet.
- *Materials of marine origin.* Natural matrix standards for radioactivity measurements for marine sediments, marine algae, and fish flesh are available. For trace elements, marine sediment, dried copepoda, fish flesh, and mussel tissue are provided. Three materials — dried copepoda, fish flesh, and mussel tissue — have been certified for various organic compounds.

Currently, both the Seibersdorf chemistry unit and the Monaco Laboratory are preparing intercomparison samples affected by the Chernobyl nuclear power plant accident with elevated radioactivity. These will appear in the future annual catalogue of the AQCS Programme, which is available upon request from the Seibersdorf Laboratories.

* Each one of the reference materials has a complete report on its respective intercomparison study, which can be supplied free of charge upon request from the AQCS Programme, IAEA, Seibersdorf Laboratory, P.O. Box 100, A-1400 Vienna, Austria. Further technical information on the materials of marine origin can be obtained from the International Laboratory of Marine Radioactivity, Oceanographic Museum, Monaco-Ville, Principality of Monaco.