THE RIGHT TOOLS & SERVICES

IAEA INSTRUMENTATION SERVICES FOR NUCLEAR APPLICATIONS

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Scientific and technical instruments have been indispensable components of efforts to effectively develop and apply nuclear and radiation technologies for social and economic development. Without the right tools for the job -- and the proper training in how to safely use them -- little progress can be made to achieve desired results.

Over the past 50 years, a range of sophisticated instruments and equipment for peaceful nuclear applications has been developed. These modern and sensitive tools require careful maintenance and service to function correctly.

Through its laboratories in Seibersdorf, Austria, the IAEA is assisting countries to improve their expertise and infrastructures in the repair and servicing of nuclear instruments, as well as in the design and construction of specialized instruments and electronic modules that are not commercially available or meet particular needs. These instruments are applied in a range of fields, including environmental pollution monitoring, industrial research and manufacturing, human health care, and food and agricultural production. Agency activities related to nuclear instrumentation are implemented by the Instrumentation Unit at the Seibersdorf Laboratories, working together with the Agency's Physics Section in the Department of Nuclear Sciences and Applications. All the projects have a strong link to technical cooperation programmes.

This article reviews services and activities related to the development of nuclear instrumentation, and to related training and technical support. The work of the IAEA Instrumentation Unit includes designing and building different types of training kits, often together with scientific fellows from developing countries in which related instrumentation is applied. Additionally, in support of IAEA technical cooperation programmes, specialized training courses are organized involving equipment essential to carrying out projects, and technical support is provided in the selection and evaluation of nuclear instruments. Other services offered to laboratories in Member States include the provision of spare parts and technical documentation, and an electronic mail distribution service for exchanging information on nuclear instrumentation.

These activities fill important needs. Nuclear instrumentation is a rapidly changing field, one heavily influenced by technological advances and innovations that bring improved and more sophisticated tools and equipment into the marketplace. These factors underline the importance of providing technical support and training services to upgrade the capabilities of countries which are appying nuclear applications and tools as part of their national development programmes.

INSTRUMENT DESIGN & DEVELOPMENT

Among the IAEA's activities is the design and construction of instrumentation and electronic modules that are required for implementing project in Member States.

Radiation Monitoring. In support of programmes in Greece, Portugal, and Viet Nam, the IAEA developed a stack monitoring system for nuclear facilities. Computer-based and mounted on a cart, the system is designed to monitor gaseous effluent samples of radioactive particulates, iodine, and noble gases released from a nuclear reactor or other nuclear facilities. The monitor consists of a particulate detector and

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iodine detecotr, both placed in a compact and shielded sampling chamber; a noble gas detector mounted inside the chimney to improve sensitivity; a vacuum pump; an air flow meter; control valves; a programmable logic controller; an amplifier; a single channel analyzer; and high voltage suppliers. The computer and printer can be located 100 meters from the chimney.

A personal computer is used for data acquisition and processing, presentation, recording and reporting results and for warning and alarms. The results are printed out in case of alarm or can be done whenever needed. The monitor presents the air flow rate, radioactivity concentration on the filter of the particulate and iodine channels, and emission rates of radioactive particulates, iodine, and noble gases.

Environmental Monitoring. In support of activities in the field of environmental pollution monitoring, a sample changer and detector positioning system for neutron activation analysis (NAA) was developed. NAA is a commonly used technique in scientific laboratories, and the sample changer ensures that the activated samples for measurement are separated and well-shielded from the detector. The changer picks up the samples from a storage compartment (capable of holding up to 100 samples) and carries them over a distance of 2.5 meters before they are placed in a rotating sample holder in front of a detector. The measurement chamber, shielded with lead, is then automatically closed and the measurement is started. When the measurement is finished, the sample is automatically exchanged. The entire process is controlled by a microprocessor and software that allows the operator to preset the measurement parameters. Integrated control functions and cross checks guarantee that no sample is lost. On-line information keeps the operator continuously informed about the status of the system and allows correction of problems in case an error is reported.

The detector's automatic positioning feature allows the operator to move and set the detector in a longitudinal direction. Dedicated software enables the operator to specify a sequence of measurements, i.e., how often a sample has to be measured at different distances. This is especially important during calibration of a gamma spectrometry system at high count rates, which is often the case in NAA.

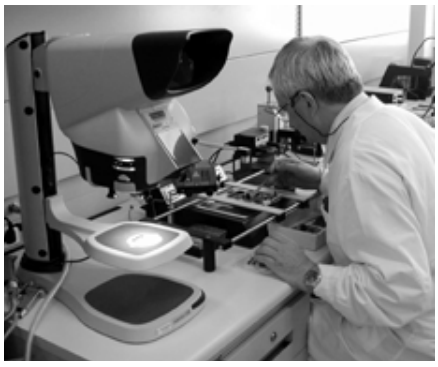
Materials Analysis. A simple and powerful method for analyzing environmental, biological, and geological materials is X-ray Fluorescence (XRF) spectrometry. It has the unique advantage that it can be applied easily to samples of very different nature and requires no or only minimal sample preparation. The method is used worldwide for the analysis of geological materials and for monitoring environmental pollution.

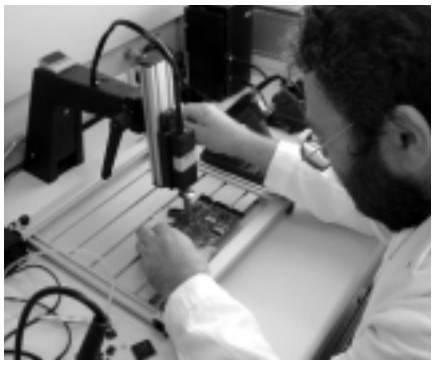
Its widespread applications have made XRF a focal point of the IAEA Instrumentation Unit, which has designed and developed a number of supporting systems. These include a sample changer for an energy-dispersive XRF spectrometer based on a high voltage X-ray tube. The sample changer can hold up to 12 samples. When the control unit is switched on, the changer turns to its zero position and waits until an advance signal from a multi-channel analyzer (MCA) is received. This signal starts rotation of the changer and advances it to the next position. Whenever samples are changed, the MCA receives a busy signal. As soon as the signal disappears, a new measurement starts. The system indicates the completion of one fully cycle with a permanent busy signal to the MCA. Digital displays on the front panel inform the operator about the system's status. The sample changer can easily be adapted to other XRF spectrometers in national analytical laboratories.

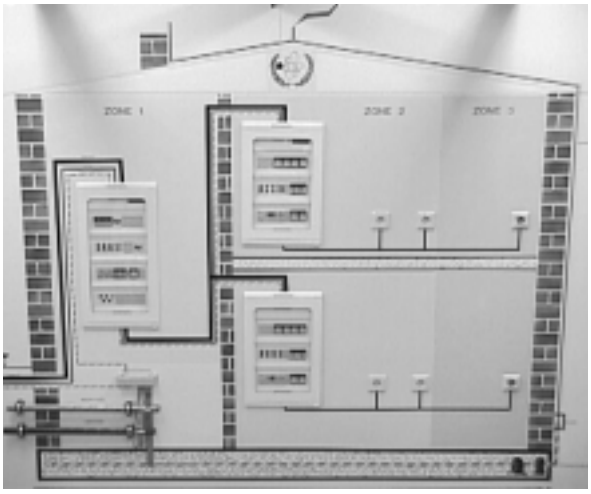
Insect Control. The Mediterranean fruit fly (Medfly) is among the most harmful insects to crops, agricultural economies, and world trade, as it attacks more than 250 species of fruit and vegetables in many parts of the world. One effective method of eradicating or controlling the Medfly, as well as other types of insect pests, is the sterile insect technique (SIT), which is used in integrated area-wide eradication campaigns. Flies are mass-reared in laboratories and then irradiated by gamma radiation, which renders them sterile but otherwise leaves them reproductively active. Mating of the released males with female insects in the wild produces no offspring, thereby suppressing the insect

population over time as more sterile males are reared and released into the control area. SIT has been successfully used in many parts of the world against the Medfly, including Chile, Mexico, and the United States.

For purposes of quality control and efficiency, the IAEA developed a Medfly pupae sorter for use in laboratory rearing operations. It sorts and counts a sample of the pupae according to their colour (brown for males and white for females). The sorter consists of an electro-mechanical unit and a portable compressor. Up to 1000 pupae can be poured into the bowl-shaped feeder tray. As the pupae slowly move to the feeder's rim, a sensor detects their colour and activates an air jet designed to blow the white pupae aside, separating the males from the females. The brown and white pupae can then be collected separately and counted before their further evaluation.







Radiation Dosimetry. Instruments that accurately measure radiation doses are important tools of modern industries and medicine relying upon nuclear and radiation technologies. The Dosimetry Unit of the Seibersdorf Laboratories operates a high-dose measurement system with the alanine used as a transfer dosimeter, for which the Instrumentation Unit developed special equipment to support the calibration according to exact specifications. The calibration has to be carried out in a cobalt-60 Gammacell irradiator at different stable and controlled temperatures. The duration of the irradiation is rather long (up to a few days), and many dosimeters can be placed in the chamber and irradiated simultaneously.

TRAINING TOOLS, COURSES & KITS

The importance of training in maintenance, repair and design of nuclear instruments cannot be underestimated. Courses and training materials must be developed to address technological developments in electronics and the instrumentation needs of scientific and nuclear research centres in developing countries. Training tools and kits have been developed for several purposes.

Electric Power Conditioning. Uninterrupted supply of electric power is crucial for the proper functioning of nuclear and electronic instruments in developing countries. Roughly speaking, about half of all damage to instruments is caused by disturbances in the electric mains supply, and taking protective measures is essential. The Instrumentation Unit has developed a demonstration electricity wall for two basic purposes:

Photos: Top, specialists at the IAEA Laboratories repair electronic modules at work stations. Bottom left, a front view of the training wall for electric power conditioning; right, a close-up of the Medfly pupae sorter.

(Credits: IAEA Seibersdorf Laboratories; Credit: Calma/IAEA)

■ to demonstrate the electric mains supply for a typical laboratory building; the different grounding systems and construction of lightning arresters; the installation of the three zone protection and the equipotential grounding system; and the construction of basic earthing facilities.
■ to carry out exercises on different grounding systems; and to teach the functioning of surge protection.

The training wall is displayed on a large plywood plate, the front of which shows the cross section of a building and the electrical cable connections from an outside transformer station and the internal cables between the distribution boards. The distribution boards, equipotential bars and three-zone surge protection are demonstrated by using real components.

Work Stations & Tools for Repair of Electronic Modules. Digital and electronic instrumentation is increasingly seen in laboratories as examples of what has come to be known as "surface mounted technology (SMT)". The maintenance and repair of these instruments is a challenging task, one requiring its own set of tools including powerful microscopes. The Instrumentation Unit has adapted instruments for training in repair of SMT-based modules and equipment. They include an SMT tool kit for simple assembling and repair; a soldering station with specialized solder pins; and infrared rework stations. One rework station -- which can be used effectively by a relatively inexperienced operator -- is a semi-automatic tool which uses dark infrared emitters to melt the solder. The component is first pointed with a laser beam, the solder is melted with infrared light, and finally the component is soaked by a vacuum pump.

Also developed were kits for training related to the monitoring and control of power supplies. The training kits were either fully designed and constructed at the IAEA Laboratory or simply adapted by using commercially available evaluation kits. They are used not only for the training programme at the Seibersdorf Laboratories, but are also provided on loan to support training activities in developing countries.

Training Courses. The Instrumentation Unit conducts an annual group fellowship training in maintenance of nuclear spectroscopy instruments over a six-month period. Topics covered include the principles of radiation detection; characteristics of spectrometry systems; dosimetry and radiation protection; power conditioning; electrical measurements; fundamentals of digital electronics; microprocessors; power supplies; analog signal processing; multi-channel analyzers; standard interfaces; computer troubleshooting; and special computer boards.

Additionally, the Unit hosts individual on-the-job training in areas including the repair and design of nuclear instruments, computer interfacing, microprocessor applications, and power conditioning.

Other activities include support to the organization of regional or national training courses and workshops. These have been held, for example, in Egypt, Ghana, Zambia, Morocco, Kenya, the Philippines, Jordan, Tunisia, and Ethiopia.

TECHNICAL SUPPORT TO COUNTRIES

A major focus of technical support related to nuclear instrumentation is to assist scientific laboratories and research centres in developing countries.

Under a regional technical cooperation project and a number of national ones, spare parts and technical documentation are provided to 18 countries in Africa. Support is also given for the evaluation and selection of instruments, both in connection with technical cooperation projects and other IAEA programme activities. In recent years, equipment has been evaluated for safeguards purposes, and in support of projects in Syria, Lebanon, and Zambia.

Through another initiative, technical information, updates, and advice about nuclear instrumentation is distributed to African countries using electronic mail. The service was initiated following discussions at a Regional Workshop on Strategies for Maintenance of Scientific Equipment held in Khartoum, Sudan in April 1996. Presently about 50 participants from Africa (and other regions) are registered under the e-mail distribution service, exchanging experience and information that are benefiting their various applications of nuclear instruments. ❐