are also problems in placing the trainees for on-the-job training in such activities on construction sites in industrialized countries.

The symposium concluded with a discussion of recommendations to the Agency related to the future programme in QA. These recommendations stress a need for the development of lower-level documents, such as manuals and procedures, for practical use.

Specific emphasis was given to the Agency's programme in training QA personnel through all existing forms of technical assistance to developing countries. Finally it was considered that the Agency should assist Member States by organizing and implementing audits of the QA programme in various phases of a nuclear project. The audit team should consist of international QA experts, and the Agency's QA Code and Safety Guides should be used as the reference documents.

Low-level counting methods

Low-level measurements of radioactivity in the environment are increasingly useful for environmental protection, studies of processes in nature, and other fields like radiocarbon dating, or prospection for minerals and water. The last IAEA symposium on low-level counting methods was organized in Monaco in 1967 Since that time significant improvements in methods and instrumentation have been made, resulting in higher sensitivity for identifying and determining radionuclides existing in the environment. Therefore, a lot of new work was presented at this symposium*.

Radioactive material in the environment has several sources·

- Primordial radioisotopes of uranium-thorium series, potassium, etc. in the earth's crust;
- Continuous production by cosmic radiation;
- Production by nuclear explosions; and
- Release by nuclear installations.

These radionuclides become a part of different components of nature. By their radioactivity they label particular components on the local, regional, or global scale making it easy to study physical, chemical, and biological processes in the geo-, hydro- and biospheres. Low-level counting methods are especially important for nuclear waste disposal problems and uranium ore exploitation.

The papers presented and the discussions showed the great progress in recent years in the construction of low-background and high-sensitivity instruments used in laboratories or in the field. Detection limits for all radionuclides have been lowered by using specially selected construction materials which are low in radioactivity, anti-coincidence shields, and efficient detectors Special methods have been developed for isolation or enrichment of particular radionuclides in environmental samples. In the case of the actinides, low-level spectrometry is competitive with neutron activation analysis.

Among the new detectors discussed at the symposium was a multicrystal gamma-ray coincidence spectrometer with six NaI(Tl) scintillators whose improved precision has been demonstrated in measurement of Al-26 and Na-22 in meteorite samples. An extremely low background gamma-ray spectrometer was described in which an intrinsic germanium detector is surrounded by five NaI(Tl) crystals as anti-coincidence shielding and a

The programme of the symposium

Gamma-ray spectrometry,

Low-level alpha and beta particles counting;

Detection of actinides,

Tritium enrichment and counting;

Radiocarbon counting,

Accelerator-based techniques and other new methods for low-level measurements.

* International symposium on methods of low-level counting and spectrometry, organized by the IAEA in co-operation with the Hahn-Meitner Institut für Kernforschung in Berlin (West), 6–10 April 1981.

coincidence gamma detection system Selection of low-radioactivity construction materials is a very important factor in all low-level counting systems as a number of papers describing gamma-spectrometer design demonstrated.

Field probes can now detect actinides *in situ* down to activities as low as 10 nCi g^{-1}. Low-level gamma-ray probes have been used for bore-hole logging of snow and ice in Antarctica and in the French Alps, for rapid determination of the mean annual snow accumulation. In Japan a low-level portable gamma spectrometer has been used for measurement of radionuclides in cultural monuments destroyed in Hiroshima and Nagasaki.

Data acquisition and processing systems, and use of "on-line" microcomputers, facilitate the operation of the low-level counting laboratories. Good progress has also been achieved in chemical methods of element and isotope separation e g. Tc-99 assay. Other radioisotopes such as Ar-37, Ar-39, Si-32 exist in extremely low concentrations but can be now counted by decreasing detector backgrounds to ultimate lower limits in special underground counting chambers Declining environmental tritium concentrations have stimulated development of larger enrichment cells and more sensitive liquid scintillation counters

In C-14 measurements the lowest background is achieved by using improved anti-coincidence shields. Dating of samples of milligram-quantity is now possible through development of proportional counters with a very small volume or through mass-spectrometry of accelerated ion beams. The possibility has been thus extended for radiocarbon dating of objects of high value for culture, archaeology, etc. as well as in cases where the sample size is very limited (oceanography, glaciology, environmental research). Nowadays, a sample of only a few grams of carbon can be analysed by a high-precision apparatus with an error of 0.15% corresponding to only 12 years in age.

New techniques have been introduced in the field of low-level measurements, including the application of mass-spectrometry for determination of He-3/He-4 isotope ratio and thus tritium determination. Laser-induced fluorescence techniques presented are sensitive enough to detect trace amounts of uranium (down to 10^{-4} parts per billion) in water samples. Sediments can now be dated using the method of particle-track analysis for thorium-230 and lead-210