Radiation protection in the workplace

Emphasizing the control of internal radiation exposure

by Franz-Nikolaus Flakus

Potential radiation hazards are inherent in all of the many uses of ionizing radiation. Occupational radiation protection, among its goals, aims at limiting the exposure of workers both to external radiation and to internal contamination.

The control of internal radiation exposure is a very complex task that deserves emphasis in any radiation protection programme. Monitoring inhaled and ingested contaminants is more difficult than measuring external radiation, and health physicists are paying increasing attention to tracking internal exposures. Individual reports presented at the last international symposium on radiation contamination in man revealed considerable progress during the past decade.*

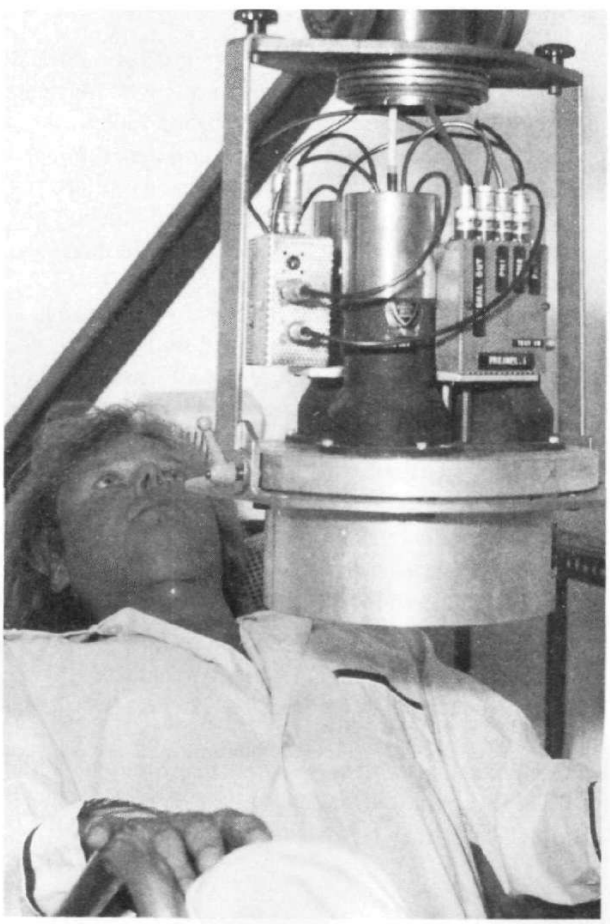
Two basically different approaches predominate in the direct measurement of internal radiation. Highly sophisticated and expensive counting equipment can be designed to obtain as much information as possible (for instance, spatial distribution of radioactivity in the body through multi-detector measurement and data processing by computers). On the other hand, health physicists have searched for low-cost, simplified and yet accurate methods.

Methods for determination of radioactive contamination in man are being adapted to the specific situation encountered in practice. However, it is now evident that with complex problems, such as in work with plutonium, comprehensive investigations should be routine. In such situations, an integrated control and assessment programme for monitoring internal exposure, making use of all techniques available, needs to be put into practice.

Monitoring objectives

Monitoring schemes are determined by the philosophy of protection against the risks of radiation, by the models used to translate this philosophy into a scheme of practical measurements, and by the measurements and methods that are realistically possible. In practice, for example, there is a gradual progression in the objectives of monitoring as the expected dose levels rise.

Use of a whole-body counter is one direct way of measuring radiation exposure.



Mr Flakus is a senior staff member in the Agency's Division of Nuclear Safety.

* International Symposium on "Assessment of Radioactive Contamination in Man", held in Paris 19–23 November 1984 at the invitation of the Government of France. The symposium, organized by the IAEA in co-operation with the World Health Organization (WHO), follows previous ones on this topic convened in 1964 and 1971. Proceedings of the 1984 meeting (series number STI/PUB/674) now are available from IAEA's Division of Publications and may be ordered through the addresses noted in this issue's *Keep Abreast* section.

At the lower levels, the objective is to ensure that the environment is acceptable; at the higher levels the aim is to assess the doses to the individual. A level marking the transition between these two approaches was suggested at the conference.

Direct methods of assessment

Direct methods of assessment – that is, whole and partial body counting – were the focal point of two symposium sessions. Considerations included technical aspects such as performance studies of various types of radiation detectors and spectrometers, geometries employed, calibration, optimization of detector positioning, and complex set-ups for obtaining multi-matrix information with data processing by computers. The symposium also addressed the questions of how often to monitor and how to interpret the measured results.

Results were described of investigations carried out by five laboratories working together within a co-ordinated research programme of the IAEA. The researchers examined the validity of a realistic phantom of the male thorax (with suitably labelled lungs and ancillary attenuating overlayers) used for calibrating X-ray counters. Also stressed was the need for calibrations with realistic phantoms that can take into account anatomical variability and non-uniform distributions of activity.

Monitoring for plutonium

External monitoring for plutonium intakes is difficult, and the subject of internal contamination with plutonium received special attention during the symposium. A number of scientists described direct and indirect measurement methods for this element and outlined the complexities in interpretation of measured results.

In the ultimate decision for the design of a direct monitoring system, various factors must be weighed, including type of radiation to be measured, type and number of detectors, and time needed for a single measurement. One participant proposed a method ("relative mass resolution") to enable ready comparison of alternative designs. Also presented was a fast method for evaluating plutonium in urine that accelerates bodily excretions and thus combines analysis with treatment for contamination.

Assessment programmes and experience

Thirteen papers were presented on routine and special assessment programmes and experience of various nuclear fuel cycle facilities, hospitals, and research institutes.

One project described was a Canadian study undertaken to determine the feasibility of using more easily measurable parameters – such as results from urine analysis – to make estimates of chronic intakes by workers employed in fabrication of uranium fuels.

In uranium mines, up to 70% of the total "effective dose-equivalent" is due to inhalation. Internal dosimetry for uranium mining and milling workers is thus different from that for workers in other nuclear fuel cycle facilities.

One paper demonstrated convincingly that an indicator radionuclide, caesium-137, may be successfully used as a monitor for exposures to mixed fission products in nuclear fuel reprocessing plants. Evidence to date also establishes that whole-body counters measure uniformly distributed internal contamination of gamma emitters with energies above 200 keV correctly within about 20 per cent.

For personnel who work with radioisotopes in medicine, reports at the symposium showed that iodine isotopes are probably the most frequent source of contamination for them.

Codes, methods, models

One scientist outlined his use of a computer program to make estimates of the amount of plutonium systematically deposited over prolonged periods. The method uses results from urine samples, and is especially helpful when intermittent acute exposures may have occurred. Another participant suggested the extension of this method to similar problems.

A team of researchers described a code that was developed to estimate initial intake of radioactive contaminants by nuclear power plant workers. This uses data from whole-body counting and bioassay.

Studies of radioactive contamination

As a result of the global fallout from nuclear weapon tests, several plutonium isotopes are present in minute amounts in the tissues of the general population. Comprehensive determinations of concentrations of plutonium isotopes in autopsy tissues were reported, and the results obtained may serve as base-line levels to detect any future changes in plutonium uptake by man.

A study was reported on uptake of carbon-14, a weak, pure beta emitter whose presence within the body can be assessed only through analysis of excreted activity. A model describing the retention of carbon-14 was derived and integrated into a more generalized model of carbon metabolism. Another reported study described work undertaken to estimate dose to man from organically bound tritium and free-water tritium.

Radioactive contamination also occurs from natural radioactivity. For several years lead-210 was analysed in urine samples from a group of workers employed for up to 20 years in the coal and fertilizer industries. These investigations demonstrated that long-term exposure to low-level radiation can be reliably gauged.