

IONIZING RADIATION

be calculated. If the exposure rate is 2.5 mR/hr, 40 hours will result in 100 rads (neglecting the conversion factor that arises from the fact that exposure to one roentgen results in a dose of 98 ergs/gm, while 1 rad equals 100 ergs/gm). If the exposure rate is 10 times higher, then the time must be reduced to one-tenth for the same dose (in the example, 100 rads) (See the earlier section on "Radioactive Decay" for discussion of definitions).

In practice, the dose received in getting a task done can be spread over several employees so that no one person will exceed the guide levels. Only necessary exposures should be planned for a work task. The available cumulative exposure can be calculated from the formula $(Age-18)5$ rem, with a maximum of 5 rem per year. If none is received in a particular year, then that 5 rem is carried forward in that employees "bank," and can be reserved for a future need. But the RPG (radiation protection guide) limits its use to a maximum of 3 rem in any 13 consecutive week period, providing no more than 5 rem is used in a year. In practice, the exposure rate (roentgens/hour) would be measured with an instrument. Direct reading dosimeters are available, as are those that emit sound (a chirp) at a preset exposure rate.

Detecting and measuring external radiation: instruments

Instruments for monitoring and survey work to detect external radiation are available from many commercial sources. Instruments must be checked frequently for operation and calibration, and a dependable source of maintenance service must be available, especially for portable instruments.

Instruments may be used to detect or locate sources of radiation or to measure radiation. Selection from the variety of choices of type and manufacture is based not only upon the kinds of radiation to be encountered but also upon the reliability, operating characteristics, and vendor's service capabilities.

Some instruments are designed to detect only one type and level of radiation, such as low-level alpha radiation. Others will detect several types and levels of radiation.

Several air samplers are available. These may be purchased complete, or the fans

(vacuum pumps) may be ordered separately and then equipped with a specially constructed, filter paper holder and an air-flow indicator. The filter media must then be counted with a system for alpha or beta-gamma counting, such as a scaler, alpha probe, or beta-gamma tube. Gas flow proportional counters are also available.

If no prior experience exists in selection, obtain help from an experienced person as there are many types of specialized equipment. Detectors can be ionization chambers, Geiger counters, proportional counters or scintillation counters. Portable survey instruments may consist of ionization chamber rate meters, beta-gamma ionization chambers, Geiger counters, beta-gamma Geiger counters, beta-gamma scintillation counters, alpha survey meters, or tritium sniffers. Fixed monitors may consist of beta-gamma detectors, air monitors, or area monitors. Neutron monitors are available for slow, intermediate, and fast neutrons. Specialized equipment is available for counting with counters and scalers. Personnel monitoring systems exist for contaminated hands, shoes, or clothing.

For further information see *Health Physics Instrumentation*, J. S. Handloser (Pergamon Press, 1959); *Safe Handling of Radioisotopes—Health Physics Addendum—Safety Series No. 2*, International Atomic Energy Agency (Vienna, 1960), especially pp. 34-46, *Radiological Monitoring Methods and Instruments*, NBS Handbook 51 (1952), pp. 7-18, and *Nuclear Instruments and Their Uses*, A. H. Snell (ed.) (John Wiley, 1962), pp. 425-442.

Monitoring, surveying, and personnel monitoring

The extent and type of monitoring for detection of external radiation are determined largely by experience and the nature of the source of radiation.

- For example, if the radiation field is limited by the nature of the source of the radiation and the protective devices low, film badges or dosimeters worn by the exposed employees may be completely adequate.

- Some operations emit radiation at levels which would be excessive for 40-hr exposure. On these operations, fixed monitoring equipment of the recording and