Radiation Monitors

Exposure rate meter

1. Introduction and rationale

To measure exposure rates, use is often made of an ionisation chamber detector or a Geiger-Müller detector. The unit in which the result of the measurement is expressed may differ for different devices. One may encounter mR/h, mrad/h, mGy/h or mSv/h. The manufacturer ensures that the exposure rate measured is as independent as possible from the energy of the radiation. A radiation monitor can be equipped with an alarm which goes off at a pre-set threshold value. In the case of an ionisation chamber, the amplification depends strongly on the applied voltage. Through aging, the gain can decrease, such that a higher voltage is necessary to obtain the correct meter indication.

2. Frequency

It is recommended that this check is integrated into an overall maintenance programme that takes place roughly annually.

3. Method

The simplest way to check the equipment is to measure the exposure rate of a point source of known intensity held at a fixed distance from the detector. For devices with an alarm setting, its correct operation must be checked.

4. Requirements

A solid point source of not too high an intensity (about 100 MBq).

5. Procedure

Position the point source in front of the detector at a fixed distance (e.g. 0,5 m) and record the measured exposure rate. To test the alarm setting, a source of greater intensity can be used or alternatively the distance between the source and the detector can be reduced until the expected exposure rate is achieved.

6. Analysis and interpretation

Calculate the exposure rate per MBq, adjust for decay if necessary. Archive and collect the measurements in a spreadsheet such that the exposure rate is monitored during its lifetime.

7. Action thresholds and actions

Repairs must take place if there is a deviation of more than 25% from the initial measurement or from the specifications. If the exposure rate plot visualises a decreasing trend over time, actions should be considered.

8. Pitfalls and remarks

Most exposure rate meters are capable of being used without a main power supply (using built-in batteries). In that case, regular battery inspection and recharging when required, is necessary.

9. Literature

- Cherry SR, Sorensen JA, Phelps ME: Physics in Nuclear Medicine, 3rd ed. Philadelphia, Pa: Saunders/ Elsevier Science, 2003. ISBN 0-7216-8341-X

Contamination monitor

1. Introduction and rationale

In the case of a possible surface contamination with radioactive materials, equipment must be available to detect this. This equipment can also be used to check the outcome of any cleaning activities. Geiger-Müller detectors or gas-filled proportional counter tubes with a large surface (e.g. 10×10 cm^2) are suitable for this application. Smaller Geiger-Müller detectors or small scintillation counters can be used for this purpose as well. In all cases, the measurement of the number of cps must serve as a measure for the existing contamination. If a quantification of the number of Bq/cm^2 is necessary, the equipment must be calibrated for this purpose. Often the manufacturer includes a conversion table or chart such that corrections can be carried out for different radionuclides and/or different distribution shapes of the contamination (point-shaped or uniform over a large surface). Modern radiation monitors have a built-in conversion table; therefore, a contamination measurement can be carried out, and the contamination can be read off directly in Bq/cm^2 for the chosen radionuclide.

2. Frequency

It is recommended that this check is integrated into an overall maintenance programme that takes place roughly annually.

3. Method

Global measurement

In the event that the detector is only being used to get an overall impression of contamination, periodic measurements of a point source with a known source intensity at a fixed distance from the detector will suffice.

Quantitative

For quantitative measurements of surface contamination of about the maximum permissible contamination of 4 Bq/cm^2, one can measure contamination that is uniformly distributed over a large surface area (10×10 cm^2).

4. Requirements

Global measurement

A solid point source, e.g. ^{57}Co or ^{99m}Tc of approximately 0,5 MBq.

Quantitative

For the quantitative measurement, a source is needed which has a surface of 10×10 cm^2, with accurately known activity amounting to about 10 Bq/cm^2. One can create this source oneself by allowing 1 ml of a ^{99m}Tc solution to decay to the extent that the activity has reduced to approximately 1,0 kBq. This activity must then be distributed as evenly as possible, drop by drop, onto a piece of filter paper of 10×10 cm^2, after which it is allowed to dry. Perform the measurement in an environment where contamination can be avoided.

5. Procedure

Global measurement

Position the point source centrally in front of the detector at a fixed distance (e.g. 0,5 m) and measure the count rate.

Quantitative

Hold the detector flat against the source and measure the count rate.

6. Analysis and interpretation

Calculate the number of cps per MBq or Bq/cm^2 and collect the annual measurements in a spreadsheet.

7. Action thresholds and actions

If there is a deviation of more than 25% from the initial measurement or from the specifications, repairs must be made.

8. Pitfalls and remarks

a. Some detectors have very thin entrance windows, which are easily damaged, such that the meter reading is not correct. In such a case, regular checks with a calibration source are necessary.

b. Most contamination monitors are capable of being used without a main power supply (using built-in batteries). In that case, regular battery inspection and recharging when required, is necessary.

9. Literature

- Cherry SR, Sorensen JA, Phelps ME: Physics in Nuclear Medicine, 3rd ed. Philadelphia, Pa: Saunders/ Elsevier Science, 2003. ISBN 0-7216-8341-X

Personal dosimeters

1. Introduction and rationale

For registration and direct (readable) checking of the cumulative radiation dose that employees receive during their work, a personal dosimeter can be used. Modern electronic personal dosimeters have an ionisation chamber, which is “read out” by integrating the ionisation current over a certain (often adjustable) time, and converting these values with the aid of an inbuilt microprocessor into a dose rate and dose over an adjustable time. The measured values are stored in the microprocessor and can be read out, either directly on the display or through a PC. One can choose to have an alarm go off at a certain dose or dose rate. The display can show different parameters; usually the

cumulative dose from the time of zeroing the meter.
The energy dependence is usually acceptable. If the measured dose is shown in Sv, this is identical to Gy: the conversion factor is (almost always) equal to 1.

2. Frequency
As a minimum frequency, it is recommended to integrate this check into a comprehensive maintenance programme that takes place roughly annually.

3. Method
Position the dosimeter for a certain time at a certain distance from a radioactive source. Then read the meter.

4. Requirements
A source (for example, ^{99m}Tc) with an activity of approximately 500 MBq. A sheet of paper with a circle (e.g. radius 50 cm) with its centre marked.

5. Procedure
Set all available dosimeters to indicate zero on the meter. Place the meters on the circle. Position the ^{99m}Tc source in the centre of the circle and allow the ^{99m}Tc source to 'totally' decay (start the test on Friday evening). Read off the dosimeters (on Monday morning). Choose the distance and the source intensity such that approximately 80% of the maximum measurement range is used.

6. Analysis and interpretation.
Calculate the expected radiation dose.
Compare the measured results of all the dosimeters with the calculated value.

7. Action thresholds and actions
If there is more than a 10% difference between the calculated value and the meter indication found, action must be taken.

8. Pitfalls and remarks
a. The distance between the source and the dosimeter should not be too small in view of the reproducibility of the measurement. For that reason, a relatively strong source is necessary, and ^{99m}Tc is selected as the source. Because the half-life is short compared to the necessary irradiation time, the decay of the source must be taken into account. This calculation is relatively simple as irradiation takes place 'to infinity'.
b. During irradiation, no interfering sources may be present. For this reason, irradiation over the weekend was chosen.

9. Literature

- Cherry SR, Sorensen JA, Phelps ME: Physics in Nuclear Medicine, 3rd ed. Philadelphia, Pa: Saunders/ Elsevier Science, 2003. ISBN 0-7216-8341-X