

NRC Regulations and Guidance for Internal Dosimetry

Professional Training Programs

Oak Ridge Associated Universities

Objectives

- To review the regulatory dose quantities and limits.
- To review the regulatory requirements for monitoring for internal dose.
- To review relevant published guidance.

TODE

- The dose to an organ is the sum of all dose to that organ from radioactive material in it and all other organs, plus dose from external irradiation.
- The result is called the total organ dose equivalent (TODE).

TODE

- The TODE (other than lens of the eye) must be <0.5 Sv/yr (50 rem/yr) for occupationally exposed adults. 10 CFR 20.1201(a)(1)(ii)
- The TODE must be <50 mSv/yr (5 rem/yr) for occupationally exposed minors. 10 CFR 20.1207
- $TODE = CDE + DDE$

CDE

The internal dose component of the TODE is a 50-year integrated dose, called the committed dose equivalent (CDE) to an organ.

TEDE

- The total effective dose equivalent (TEDE) is the sum of the weighted CDEs and external dose.

- $TEDE = CEDE + DDE$

TEDE

The TEDE must be:

- < 50 mSv/yr (5 rem/yr) for occupationally exposed adults. 10 CFR 20.1201(a)(1)(i)
- < 5 mSv/yr (500 mrem/yr) for occupationally exposed minors. 10 CFR 20.1207
- < 5 mSv (500 mrem) to the embryo/fetus of a declared pregnant woman for the gestation period. 10 CFR 20.1208
- < 1 mSv/yr (100 mrem/yr) to a member of the general public. 10 CFR 20.1301(a)(1)

CEDE

- The CEDE is the sum of the weighted CDEs from significantly irradiated organs.
- Sensitive organs have larger weighting factors.
- The committed effective dose equivalent (CEDE) represents the same risk to the worker (from intakes) as uniform external irradiation.

Dose Quantities

Population	Dose Limit
Adult Worker	5 rem TEDE 50 rem TODE 15 rem eye dose equivalent
Minor Worker	500 mrem TEDE 5 rem TODE 1.5 rem eye dose equivalent
Member of the Public	100 mrem, with only 10 mrem from airborne emissions
Embryo/fetus of Declared Pregnant Worker	500 mrem during gestation period

Secondary Derived Limits

- The previously discussed dose limits are primary dose limits.
- There are two secondary derived limits that are useful for individual dose control and determining compliance with primary dose limits.

Annual Limit on Intake (ALI)

- The *Annual Limit on Intake (ALI)* is the amount of a single radionuclide that would deliver a CEDE of 50 mSv (5 rem) or a CDE 0.5 Sv (50 rem).
- It is useful as a benchmark figure for controlling dose.

ALI

Values of ALIs are listed in NRC regulations [10 CFR 20, Appendix B](#), ICRP 30, or Federal Guidance Report No. 11.

Derived Air Concentration (DAC)

- The DAC is the concentration of a single radionuclide in air that if breathed by reference man for a full working year (2000 hours), would result in an intake of one ALI.
- It is also useful as a benchmark figure for controlling dose since measured concentrations of radionuclides in air are easy to obtain from air sampling results.

DAC

Tables of DACs can be found in [10 CFR 20, Appendix B](#), in ICRP 30, and in Federal Guidance Report No. 11.

DAC

The DAC fraction, or percent of the DAC, is calculated by the following formula:

$$\text{DAC Fraction} = \frac{\text{measured airborne concentration}}{\text{appendix B DAC}}$$

DAC

If more than one radionuclide is present in the air, then the DAC fraction is calculated using the sum of the fractions rule:

$$\text{DAC} = \frac{\text{Concentration A}}{\text{DAC A}} + \frac{\text{Concentration B}}{\text{DAC B}} + \frac{\text{Concentration C}}{\text{DAC C}}$$

Controlling Dose with the DAC

- A useful operational quantity is called DAC-hours (DAC-hrs), the product of the DAC fraction and the exposure (stay) time in hours.
- Dose is easily determined by multiplying DAC-hrs by a dose conversion of 2.5 mrem per DAC-hr for a stochastic DAC value or 25 mrem for a nonstochastic DAC value.

Controlling Dose

- The following formula represents the dose calculation for a stochastic DAC.

$$\text{Dose} = \left(\frac{\text{airborne concentration}}{\text{appendix B DAC}} \right) \left(\frac{\text{stay time (hrs)}}{1} \right) \left(\frac{2.5 \text{ mrem}}{1 \text{ DAC} - \text{hr}} \right)$$

Controlling Dose

DAC and ALI values may be used to determine the individual's dose and to demonstrate compliance with the occupational dose limits. 10 CFR 20.1201(d)

Determining Internal Dose

Internal dose may be assessed using:

- measured air concentrations
- measured activity in the body
- measured activity excreted from the body
- combinations of the above 10 CFR 20.1204
(a)

Using Air Concentrations

- It is assumed that an individual breathes air at the measured concentration, unless respiratory protection is used. 10 CFR 20.1204 (b)
- However, the licensee must also demonstrate that the measured concentration is representative of the worker's breathing zone.

Individual Monitoring (Internal)

- The RSO must evaluate which workers need to be monitored for intakes.
- It is often easier to identify these workers than to identify the group of workers that must wear dosimeters.

Who must be monitored?

NRC regulations ([10 CFR 20.1502](#)) require monitoring for the following workers:

- workers likely to receive an intake greater than 10% of the applicable ALI in table 1, columns 1 and 2 of Appendix B, 10 CFR 20
- declared pregnant women likely to receive a CEDE greater than 1 mSv (100 mrem) during the pregnancy

Who should be monitored?

The RSO should examine the following types of areas to identify individuals who may need to be in an internal monitoring program:

- airborne radioactivity areas
- heavily contaminated or dusty areas
- areas where respirators are used
- areas where large quantities of tritium are handled
- Laboratories where volatile radioactive materials, such as many radioiodines, are handled

Who should be monitored?

- Reviewing the information on the license or permit(s) issued under the license can give the RSO an idea of where intakes could occur.
- A survey of monitoring criteria indicated that few institutions used the 10% of the ALI criterion.
- No consistent criteria were identified, but some were:
 - radioactivity, independent of form
 - radionuclide and form
 - activity present in a single use, single order, or over a designated time span (week, months, year)

Internal Monitoring Program

- Once workers to be monitored have been identified, the RSO must design a program for monitoring them.
- NRC regulations ([10 CFR 20.1204](#)) allow estimates of intakes to be made from air sampling results or bioassay. The RSO must determine the best method to use for each situation or group of workers.

Internal Monitoring Program

- The internal monitoring program must be a documented part of the RPP. It must include:
 - the type of monitoring performed
 - the frequency of bioassay
 - the length of the monitoring period
- The frequency and length of the monitoring period is heavily dependent on the capabilities of the analytical laboratory analyzing the results.

Training

- The RSO is responsible for training each monitored worker.
- The training should be standardized and documented.

Training

The training should include:

- why monitoring for intakes for this worker is necessary
- the types of monitoring to be performed (air sampling or bioassay)
- the worker's responsibility to provide requested bioassay samples
- the worker's responsibility to notify the RSO if he/she is occupationally exposed outside of work (part-time jobs, etc.)
- the worker's responsibility not to contaminate, falsify or tamper with bioassay samples

Training

- the worker's responsibility to notify the RSO of previous exposure during the year while with another employer, allowing the RSO to obtain these records and include the accumulated dose in the worker's yearly total.
- encouraging women to declare pregnancy early allowing the RSO to adequately plan for and control the dose to the fetus.

Records

Examples of important records are:

- monitoring results
- declarations of pregnancy
- incident reports

References

- NRC (1992). Nuclear Regulatory Commission, “Monitoring Criteria and Methods to Calculate Occupational Radiation Doses,” Reg Guide 8.34 (NRC, Washington, DC).
- O’Brien, S.L. et al., *Howard Hughes Medical Institute Dose Assessment Survey*. Health Physics 71(6):966-969;1996.