

NRC Regulations and Guidance for Internal Dosimetry



Oak Ridge Associated Universities

Learning Objectives

- Describe the regulatory requirements and guidance for assessing internal dose
- Describe the regulatory requirements and guidance for monitoring for intakes
- Describe the requirements for recording and reporting dose

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

20.1204(a)

Using Air Concentrations

- It is assumed that an individual breathes air at the concentration where the individual is present, unless respiratory protection is used.

20.1204 (b)

Using Air Concentrations (cont'd)

- If air sampling is to be used to assess worker intakes, then each frequently occupied work location should have its own air sampler.

Reg. guide 8.25

Using Air Concentrations (cont'd)

- The air samplers should be placed as close to the breathing zone (BZ) of the worker as practical.

Reg. guide 8.25

Using Air Concentrations (cont'd)

- When air sampling results will be used to determine the intake and dose of record, the licensee may have to demonstrate that the sampled air is representative of the worker's BZ air.

Reg. guide 8.25

Using Air Concentrations (cont'd)

- Representativeness can be demonstrated by comparing air sampling results with:
 - lapel sampler results
 - bioassay results
 - multiple air samples near the BZ
 - quantitative air flow studies
- Reg. guide 8.25

Using Air Concentrations (cont'd)

- If results show that the sampled air is not representative of the worker's BZ, the licensee may need to:
 - relocate samplers
 - switch to lapel sampling
 - use bioassay to assess intake
- Reg. guide 8.25

Using Air Concentrations (cont'd)

- When sampled air is not representative of the worker's BZ, the licensee should correct intake estimates made within the last year and subsequent to the previous demonstration of representativeness.

Reg. guide 8.25

Using Air Concentrations (cont'd)

- The DAC fraction, or percent of the DAC, is used to control and assess dose. It is calculated by the following formula:

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

Using Air Concentrations (cont'd)

- A useful operational quantity is DAC-hours (DAC-hrs), the product of the DAC fraction and the exposure (stay) time in hours.

Using Air Concentrations (cont'd)

- Dose is easily determined by multiplying DAC-hrs by a dose conversion of 2.5 mrem/DAC-hr for a stochastic DAC value or 25 mrem/DAC-hr for a nonstochastic DAC value.

Using Air Concentrations (cont'd)

- The licensee may use the specific physical and biochemical properties of the radionuclides taken into the body to calculate CEDE, but shall document that information in the individual's dose record.

20.1204 (c)

Using Air Concentrations (cont'd)

- The licensee may request (prior) approval from the NRC to adjust ALI and DAC values to reflect actual physical and chemical characteristics of airborne radioactive material (e.g. aerosol size distribution)

20.1204 (c)(2)

Respiratory Protection

- A licensee may make allowance for the use of respiratory protective equipment in assigning dose.

Reg. guide 8.15

Respiratory Protection (cont'd)

- The inhaled concentration may be initially estimated by dividing the ambient concentration in air by the protection factor specified in Appendix A of 10 CFR 20.
Reg. guide 8.15

Respiratory Protection (cont'd)

- The licensee's respiratory protection program shall include necessary surveys and bioassays to evaluate actual intakes.

20.1703(c)(2)

Respiratory Protection (cont'd)

- If a later measurement indicates that the respirator user's intake was greater than initially estimated, the larger quantity is to be used to assign dose.

Reg. guide 8.15

Respiratory Protection (cont'd)

- If the intake is less than the initial estimate, the lesser quantity may be used.

Reg. guide 8.15

Mixtures

- There are two ways to assess dose for mixtures of known radionuclide concentrations:
 - sum of the ratios of the concentration to the appropriate DAC for each radionuclide in the mixture
 - ratio of the total concentration to the most restrictive DAC

20.1204 (e)

Mixtures (cont'd)

- Here is an example of the sum of the ratios of the concentration to the appropriate DAC method:

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

Mixtures (cont'd)

- The licensee may separately assess the contribution of fractional intakes of Class D, W, or Y compounds to the CEDE by treating these in the same way as a mixture.

20.1204 (c)(3)

Mixtures (cont'd)

- If the concentration of one or more of the radionuclides in the mixture is not known, the most restrictive DAC of any radionuclide in the mixture must be used.

20.1204(f)

Mixtures (cont'd)

- The licensee may disregard radionuclides in a mixture if three conditions are met:
 - the licensee uses the total activity of the mixture to determine compliance (e.g. gross beta and gamma spectrometry analyses together)

Mixtures (cont'd)

- the concentration of the radionuclide is
< 10% of its DAC
- the sum of the disregarded radionuclides is
<30% of 1 DAC
20.1204 (g)

Mixtures (cont'd)

Radionuclide	Concentration	DAC	% of DAC
Co-60, Class Y	2E-9	1E-8	20
Ni-63, Class W	8E-7	1E-5	8
Zn-65, Class Y	6E-9	1E-7	6
I-131, Class D	1.9E-9	2E-8	9.5
Cs-137, Class D	3.9E-6	4E-5	9.8

The last 4 radionuclides are present at <10% DAC. But the sum of the 4 percentages is 33.3%. The licensee can disregard any 3 of the 4.

Using Bioassay

- The licensee may use specific information on the behavior of radionuclides in the individual's body to calculate CEDE, but shall document that information in the individual's dose record.

20.1204 (c)

Using Bioassay (cont'd)

- When the licensee chooses to use bioassay measurements to assess intakes of Class Y material, the licensee may delay the recording and reporting of the assessments for periods up to 7 months (except for reportable events).
20.1204 (d)

Individual Monitoring

- The licensee must identify the workers who must be monitored for intakes.
- The following workers *must* be monitored:
 - workers likely to receive an intake $>10\%$ of the applicable ALI

Who *must* be monitored?

- declared pregnant women likely to receive a CEDE >1 mSv (100 mrem) during the pregnancy
- minors likely to receive a CEDE >1 mSv/yr (100 mrem/yr) 10 CFR 20.1502(b)
- *(Note that the monitoring requirement for declared pregnant women and minors changed since some of the Reg guides were published)*

Who *should* be monitored?

- The licensee should examine the following areas to identify individuals who may need to be in an internal monitoring program:
 - airborne radioactivity areas
 - heavily contaminated or dusty areas

Who *should* be monitored? (cont'd)

- areas where respirators are used
- areas where large quantities of tritium are handled
- laboratories where volatile radioactive materials, such as many radioiodines, are used

Who *should* be monitored? (cont'd)

- Reviewing information on the license or permit(s) issued under the license can give one an idea of where intakes could occur.
- These evaluations can be made for groups of workers with similar job functions or in similar work areas, and need not be made on an individual basis.

Reg. guide 8.34

Dose to the Embryo/Fetus

- The dose to the embryo/fetus is the sum of:
 - DDE to the declared pregnant woman
 - dose from radionuclides in the embryo/fetus
 - dose from radionuclides in the mother
- 20.1208 (c)(2)

Embryo/Fetus (cont'd)

- The appropriate dose quantity is the dose equivalent to the embryo/fetus for the duration of the pregnancy.
- CEDE, CDE, or EDE are not appropriate for the dose to the embryo/fetus for the gestation period.

Reg. guide 8.36

Embryo/Fetus (cont'd)

- The dose to the embryo/fetus should include the contribution from intakes that occurred prior to conception if the maternal burden at the time of pregnancy exceeds 1% of the SALI.
Reg. guide 8.36

Embryo/Fetus (cont'd)

- Reg guide 8.36 describes 2 methods to determine the dose to the embryo/fetus:
 - the simplified approach, where the dose to the embryo/fetus is considered similar to the dose to the maternal uterus.
 - the more detailed approach, using gestation time-dependent dosimetric data.

Embryo/Fetus (cont'd)

- The simplified method may be used for demonstrating compliance with the dose limit for the entire gestation period.

Reg. guide 8.36

Embryo/Fetus (cont'd)

- The simplified approach will result in overestimates of the dose to the embryo/fetus for some radionuclides, particularly those with long physical half lives and long biological retention.

Reg. guide 8.36

Embryo/Fetus (cont'd)

- For these radionuclides, the approach using gestation time-dependent dose factors will provide more realistic results.

Reg. guide 8.36

Embryo/Fetus (cont'd)

- Both methods consist of multiplying the radionuclide content in the maternal blood by the appropriate dose factor to determine the dose to the embryo/fetus.

Reg. guide 8.36

Internal Dosimetry Program

- The internal dosimetry program must be documented and part of the licensee's overall radiation protection program.

20.1101 and 20.2102

Internal Dosimetry Program (cont'd)

- The program should include:
 - an air monitoring program (real-time, fixed, and/or portable devices)
 - an individual monitoring program (air monitoring or bioassay)
 - a dose evaluation program

Internal Dosimetry Program (cont'd)

- The program should include specific information such as:
 - technical basis documentation (for air monitoring and bioassay programs)
 - written policies and procedures
 - defined criteria for identifying workers to be monitored

Internal Dosimetry Program (cont'd)

- defined criteria and actions for identifying workers with suspected intakes
- adequate detection capability and quality of bioassay measurements
- defined program to report internal doses to workers, management, and NRC
- etc., etc.

Training

- Each monitored worker should be trained.
- The training should be standardized and documented.
- The training should include:
 - why monitoring for intakes for this worker is necessary

Training (cont'd)

- the types of monitoring to be performed (air sampling or bioassay)
- the worker's responsibility to provide requested bioassay samples
- the worker's responsibility not to contaminate, falsify or tamper with bioassay samples

Training (cont'd)

- the worker's responsibility to notify management of previous exposure during the year while with another employer, allowing the records to be transferred and included in the worker's total accumulated dose.
- educating women about the purpose of a formal declaration of pregnancy.

Records

- The licensee must keep records of the results of measurements and calculations used to determine individual intakes and dose.

20.2103 (b)(2)

20.2106

Records (cont'd)

- Examples of important records are:
 - air sampling results
 - individual monitoring results
 - declarations of pregnancy
 - incident reports

Records (cont'd)

- 10 CFR 20.2106 requires that the licensee maintain records of intakes and information used to calculate CEDE on NRC Form 5 or equivalent.

NRC FORM 5
10-921
10 CFR PART 20

U.S. NUCLEAR REGULATORY COMMISSION

APPROVED BY OMI NRC 3150-0005
EXPIRES:

OCCUPATIONAL EXPOSURE RECORD FOR A MONITORING PERIOD

ESTIMATED BURDEN IN RESPONSE TO COMPLY WITH THIS INFORMATION COLLECTION REQUEST MINUTES FORWARD COMMENTS REGARDING BURDEN ESTIMATE TO THE INFORMATION AND RECORDS MANAGEMENT BRANCH (INRB 7214), U.S. NUCLEAR REGULATORY COMMISSION, WASHINGTON, DC 20555, AND TO THE PAPERWORK REDUCTION PROJECT (3150-0005), OFFICE OF MANAGEMENT AND BUDGET, WASHINGTON, DC 20503.

1. NAME (LAST, FIRST, MIDDLE INITIAL) <i>McGuire, Stephen A.</i>	2. IDENTIFICATION NUMBER <i>113-34-8964</i>	3. ID TYPE <i>SSN</i>	4. SEX <input checked="" type="checkbox"/> MALE <input type="checkbox"/> FEMALE	5. DATE OF BIRTH <i>11-18-42</i>
6. MONITORING PERIOD <i>1-1-94 to 12-31-94</i>	7. LICENSEE NAME <i>XYZ Corp.</i>	8. LICENSE NUMBER(S) <i>SNM-944</i>	9A. <input checked="" type="checkbox"/> RECORD <input type="checkbox"/> ESTIMATE	9B. <input checked="" type="checkbox"/> ROUTINE <input type="checkbox"/> P&C

INTAKES				DOSES (in rem)	
10A. RADIONUCLIDE	10B. CLASS	10C. MODE	10D. INTAKE IN μ CI		
<i>U-238</i>	<i>D</i>	<i>H</i>	<i>0.022</i>	DEEP DOSE EQUIVALENT (IDE)	¹¹ <i>1.4</i>
<i>U-235</i>	<i>D</i>	<i>H</i>	<i>0.0031</i>	EYE DOSE EQUIVALENT TO THE LENS OF THE EYE (LDE)	¹² <i>1.7</i>
<i>U-234</i>	<i>D</i>	<i>H</i>	<i>0.060</i>	SHALLOW DOSE EQUIVALENT, WHOLE BODY (SDE, WB)	¹³ <i>1.9</i>
<i>Cs-137</i>	<i>D</i>	<i>H</i>	<i>1.87</i>	SHALLOW DOSE EQUIVALENT, MAX EXTREMITY (SDE, ME)	¹⁴ <i>NR</i>
<i>Ce-144</i>	<i>Y</i>	<i>H</i>	<i>2.07</i>	COMMITTED EFFECTIVE DOSE EQUIVALENT (CEDE)	¹⁵ <i>1.3</i>
				COMMITTED DOSE EQUIVALENT, MAXIMALLY EXPOSED ORGAN (CDE)	¹⁶ <i>6.2</i>
				TOTAL EFFECTIVE DOSE EQUIVALENT (BLOCKS 11 + 15) (TEDE)	¹⁷ <i>2.7</i>
				TOTAL ORGAN DOSE EQUIVALENT, MAX ORGAN (BLOCKS 11 + 16) (TODE)	¹⁸ <i>7.7</i>
				19. COMMENTS <i>Value in Box 18 is not equal to sum of Box 11 plus Box 16 because rounding to two significant figures was not done until the final step.</i>	

20. SIGNATURE -- LICENSEE

Sum

21. DATE PREPARED

1-31-95

Records (cont'd)

- The recording requirements apply to workers for whom monitoring is *required*.
- If monitoring is not required, there are no record-keeping or reporting requirements regarding the exposure.

Reg. guide 8.7

Records (cont'd)

- The licensee may record "NR" in the appropriate line of NRC Form 5 for monitoring that is not required.

Reg. guide 8.7

Records (cont'd)

- If a later evaluation indicates that a worker will require monitoring, the dose received when monitoring was not provided should be estimated, recorded, and reported.

Reg. guide 8.7

Records (cont'd)

- If a prospective evaluation indicates that monitoring is required, then recording and reporting of the results is required, regardless of the actual dose received.

20.2106 (a) and 20.2206 (b)

Records (cont'd)

- Determination of current year dose at other facilities is required for individuals for whom monitoring is required.

20.2104

- The individual to be monitored must provide an NRC Form 4 or equivalent.

20.2104

NRC FORM 4
(6-92)
10 CFR PART 20

U.S. NUCLEAR REGULATORY COMMISSION

APPROVED BY OMB NO. 3150-0005
EXPIRES:

CUMULATIVE OCCUPATIONAL EXPOSURE HISTORY

ESTIMATED BURDEN PER RESPONSE TO COMPLY WITH THIS INFORMATION COLLECTION REQUEST: MINUTES. FORWARD COMMENTS REGARDING BURDEN ESTIMATE TO THE INFORMATION AND RECORDS MANAGEMENT BRANCH (MNBB 7714), U.S. NUCLEAR REGULATORY COMMISSION, WASHINGTON, DC 20555, AND TO THE PAPERWORK REDUCTION PROJECT (3150-0005), OFFICE OF MANAGEMENT AND BUDGET, WASHINGTON, DC 20503.

1. NAME (LAST, FIRST, MIDDLE INITIAL)				2. IDENTIFICATION NUMBER		3. ID TYPE		4. SEX MALE <input type="checkbox"/> FEMALE <input type="checkbox"/>		5. DATE OF BIRTH	
6. MONITORING PERIOD		7. LICENSEE NAME		8. LICENSE NUMBER		9. RECORD ESTIMATE <input type="checkbox"/> NO RECORD <input type="checkbox"/>		10. ROUTINE <input type="checkbox"/> PSE <input type="checkbox"/>			
11. DDE	12. LDE	13. SDE, WB	14. SDE, ME	15. CEDE	16. CDE	17. TEDE		18. TODE			
6. MONITORING PERIOD		7. LICENSEE NAME		8. LICENSE NUMBER		9. RECORD ESTIMATE <input type="checkbox"/> NO RECORD <input type="checkbox"/>		10. ROUTINE <input type="checkbox"/> PSE <input type="checkbox"/>			
11. DDE	12. LDE	13. SDE, WB	14. SDE, ME	15. CEDE	16. CDE	17. TEDE		18. TODE			
6. MONITORING PERIOD		7. LICENSEE NAME		8. LICENSE NUMBER		9. RECORD ESTIMATE <input type="checkbox"/> NO RECORD <input type="checkbox"/>		10. ROUTINE <input type="checkbox"/> PSE <input type="checkbox"/>			
11. DDE	12. LDE	13. SDE, WB	14. SDE, ME	15. CEDE	16. CDE	17. TEDE		18. TODE			
6. MONITORING PERIOD		7. LICENSEE NAME		8. LICENSE NUMBER		9. RECORD ESTIMATE <input type="checkbox"/> NO RECORD <input type="checkbox"/>		10. ROUTINE <input type="checkbox"/> PSE <input type="checkbox"/>			
11. DDE	12. LDE	13. SDE, WB	14. SDE, ME	15. CEDE	16. CDE	17. TEDE		18. TODE			
6. MONITORING PERIOD		7. LICENSEE NAME		8. LICENSE NUMBER		9. RECORD ESTIMATE <input type="checkbox"/> NO RECORD <input type="checkbox"/>		10. ROUTINE <input type="checkbox"/> PSE <input type="checkbox"/>			
11. DDE	12. LDE	13. SDE, WB	14. SDE, ME	15. CEDE	16. CDE	17. TEDE		18. TODE			
6. MONITORING PERIOD		7. LICENSEE NAME		8. LICENSE NUMBER		9. RECORD ESTIMATE <input type="checkbox"/> NO RECORD <input type="checkbox"/>		10. ROUTINE <input type="checkbox"/> PSE <input type="checkbox"/>			
11. DDE	12. LDE	13. SDE, WB	14. SDE, ME	15. CEDE	16. CDE	17. TEDE		18. TODE			
6. MONITORING PERIOD		7. LICENSEE NAME		8. LICENSE NUMBER		9. RECORD ESTIMATE <input type="checkbox"/> NO RECORD <input type="checkbox"/>		10. ROUTINE <input type="checkbox"/> PSE <input type="checkbox"/>			
11. DDE	12. LDE	13. SDE, WB	14. SDE, ME	15. CEDE	16. CDE	17. TEDE		18. TODE			
19. SIGNATURE OF MONITORED INDIVIDUAL		20. DATE SIGNED		21. CERTIFYING ORGANIZATION		22. SIGNATURE OF DESIGNEE		23. DATE SIGNED			

NRC FORM 4 (6-92)

NRC Form 4

Records (cont'd)

- The licensee *should* verify the information provided on NRC Form 4, although it is not required.

Reg. guide 8.7



Records (cont'd)

- The licensee shall attempt to obtain records of a worker's lifetime cumulative dose.
- The record can be a written estimate provided by the worker, or a current NRC Form 4 signed by the individual.

Reg. guide 8.7

Records (cont'd)

- Whole body doses recorded on NRC forms 4 and 5 prior to the revised 10 CFR 20 can be considered the same as the TEDE for purposes of assessing prior dose.

Reg. guide 8.7

Records (cont'd)

- The dose history of workers expecting to participate in planned special exposures must be completely documented, or the planned special exposure is not permitted.

Reg. guide 8.7

Records (cont'd)

- CDEs for organs need only be calculated if the CEDE > 1 rem, or if an overexposure has occurred.

Reg. guide 8.34

Records (cont'd)

- If during the year the dose to date exceeds 1 rem CEDE, or the worker receives an overexposure in another dose category, the CDE to the maximally exposed organ must be calculated, recorded, and reported.

Reg. guide 8.7

Records (cont'd)

- When specific information on the physical and biochemical properties of radionuclides in a worker was used to calculate dose, the information used should also be part of the record.

20.1204(c)

Records (cont'd)

- Confirmatory measurements (e.g. annual bioassay) are not subject to individual dose record keeping, but should be kept with survey records.
Reg. guide 8.34

Records (cont'd)

- 20.2206 (a) lists seven categories of licensees who must annually report to the NRC the individual monitoring results of workers required to be monitored.

Records (cont'd)

- The licensee categories are:
 - nuclear power plants
 - industrial radiography companies
 - fuel processing, fabricating, or reprocessing facilities
 - geologic repository operations
 - independent spent fuel storage installations

Records (cont'd)

- radioactive waste brokers
- facilities who process or manufacture certain radioactive materials for distribution.
- The reporting shall be on NRC Form 5 and may be submitted electronically.

Records (cont'd)

- Reg. guide 8.7 provides licensees the electronic media format for submitting the dose information.
- The NRC maintains the Radiation Exposure Information Reporting System (REIRS) with the submitted information.

Summary

- The regulatory requirements and guidance for assessing internal dose were reviewed.
- The regulatory requirements and guidance for monitoring for intakes were reviewed.
- The requirements for keeping records and reporting dose were reviewed.

References

- O'Brien, S.L. et al., *Howard Hughes Medical Institute Dose Assessment Survey*. Health Physics 71(6):966-969;1996.
- U.S. NRC 10 CFR Part 20, *Standards for Protection Against Radiation*.

References (cont'd)

- U.S. NRC Reg Guide 8.7, *Instructions for Recording and Reporting Occupational Radiation Exposure Data*. 6/92.
- U.S. NRC Reg Guide 8.9, *Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program*. 7/93.

References (cont'd)

- U.S. NRC Reg Guide 8.25, *Air Sampling in the Workplace*. 6/92.
- U.S. NRC Reg Guide 8.34, *Monitoring Criteria and Methods to Calculate Occupational Radiation Doses*. 7/92.
- U.S. NRC Reg Guide 8.36, *Radiation Dose to the Embryo/Fetus*. 7/92.