

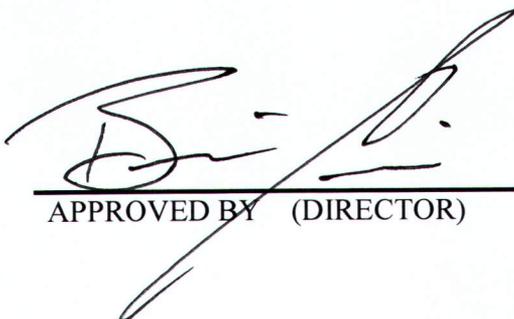
The Administrative Procedure Act requires the publication of substantive policy statement currently in use, including its full text, if practicable. (A.R.S. § 41-1091.01). Substantive policy statements are written expressions which inform the general public of an agency's current approach to rule or regulation practice. This substantive policy statement is advisory only. A substantive policy statement does not include internal procedural documents that only affect the internal procedures of the agency and does not impose additional requirements or penalties on regulated parties or include confidential information or rules made in accordance with the Arizona administrative procedure act. If you believe that this substantive policy statement does impose additional requirements or penalties on regulated parties you may petition the agency under section 41-1033, Arizona Revised Statutes, for a review of the statement.

NOTICE OF SUBSTANTIVE POLICY STATEMENT

ARIZONA RADIATION REGULATORY AGENCY

[ARRA-REG-8.34]

- 1. Subject of the substantive policy statement and the substantive policy statement number by which the policy statement is referenced:**
Monitoring Criteria and Methods to Calculate Occupational Radiation Doses
- 2. Date the substantive policy statement was issued and the effective date of the policy statement if different from the issuance date:**
Effective August 1994
- 3. Summary of the contents of the substantive policy statement:**
Provides criteria acceptable to ARRA that may used by the regulated community to determine when monitoring is required; describes methods acceptable to ARRA for calculating occupational doses when the intake is known.
- 4. A statement as to whether the substantive policy is a new statement or a revision:**
This is a current policy statement.
- 5. The agency contact person who can answer questions about this substantive policy statement:**
Name: Brian Goretzki, RAM Program Manager
Address: Arizona Radiation Regulatory Agency
4814 South 40th Street
Phoenix, AZ 85040
Telephone: (602) 255-4840


APPROVED BY (DIRECTOR) 11/30/16
DATE

Policy Number: ARRA-REG-8.34
Effective Date: August, 1994

Subject Title: Monitoring Criteria and Methods to Calculate Occupational Radiation Doses

A. INTRODUCTION

Monitoring of an individual's external radiation exposure is required by R12-1-419 A. if the external occupational dose is likely to exceed 10% of the dose limit appropriate for the individual (i.e. adult, minor, or declared pregnant woman). External radiation monitoring is also required by R12-1-419 A.3. for individuals entering a high or very high radiation area and by R12-1-419 A.4. for individuals using a medical fluoroscope.

Monitoring of the intake of radioactive material is required by R12-1-419 B. if the intake is likely to exceed 0.1 ALI(annual limit on intake) during the year for an adult worker or the committed effective dose equivalent is likely to exceed 0.5 mSv (0.05 rem) for the occupationally exposed minor or declared pregnant woman.

In the revised Article 4, "Standards for Protection Against Radiation," R12-1-408 establishes radiation dose limits for occupationally exposed adults. These limits apply to the sum of the dose received from external exposure and the dose received from internally deposited radioactive material. In R12-1-408 A.1., the annual limits for adults are (i)0.05 Sv (5 rems) total effective dose equivalent or (ii) 0.5 Sv (50 rems) total organ dose equivalent to any single organ or tissue (other than the lens of the eye), whichever is more limiting. The occupational dose limits for minor in R12-1-414 are 10% of the dose limits for adults, and R12-1-415 establishes a dose limit for the embryo/fetus of 0.005 Sv (0.5 rem) during the entire pregnancy.

The "total effective dose equivalent" is defined as the sum of the "deep-dose equivalent" (for external exposures) and the "committed effective dose equivalent" (for internal exposures). The total organ dose equivalent limit of 0.5 Sv (50 rems) specified in R12-1-408 A.1.b. applies to the sum of the "deep-dose equivalent" and the "committed dose equivalent" to any organ or tissue. The requirements of R12-1-409 are from summing external and internal doses to demonstrate compliance with the dose limits of R12-1-408.

The Article 4 requirements for recording individual monitoring results are contained in R12-1-419. When monitoring is required under R12-1-419, the monitoring results must be recorded on Agency Form Z or equivalent. Any information collection activities mentioned in this regulatory guide are contained as requirements in Article. If which provides the regulatory basis for this guide.

B. DISCUSSION

This guide provides criteria acceptable to the Agency staff that may be used by licensees and registrants to determine when monitoring is required, and it describes methods acceptable to the Agency staff for calculating occupational doses when the intake is known. Guidance on

calculating doses to the embryo/fetus is contained in Regulatory Guide 8.36, "Radiation Dose to the Embryo/Fetus." Regulatory Guide 8.9, "Interpretation of Bioassay Measurements" will provide guidance on determining intakes from bioassay results. Guidance on determining intakes from air sampling measurements is contained in Regulatory Guide 8.25, "Air Sampling in the Workplace." Guidance on recording the calculated doses onto Agency Forms Y and Z is described in Regulatory Guide 8.7, "Instructions for Recording and Reporting Occupational Radiation Exposure Data. " The appendix to this guide gives examples of internal and external doses for entry onto Agency Form Z.

C. REGULATORY POSITIONS

1. MONITORING CRITERIA

The monitoring requirements in Article 4 are summarized in Table I. For external dose monitoring, R12-1-419 A. requires the use of individual monitoring devices. Articles 5 and 6 also have some individual monitor' requirements. Individual monitoring devices are not required for monitoring the intake of radioactive material,' The monitoring requirements apply separately to each external dose type (i.e. deep-dose equivalent, shallow-dose equivalent to the skin, eye dose equivalent, and shallow-dose equivalent to the extremities).

1.1 Evaluation of Likely Annual Occupational Dose

Evaluation of the likelihood of doses exceeding 10% of the limit should be based on the potential occupational dose to the individual for the year. Doses that may have been received or will be received during the year from other licensees or registrants are not included in the determination of monitoring requirements. The requirements of R12-1-419 refer to each licensee or registrant. Each licensee or registrant makes the determination independently. It would not be appropriate to base the monitoring requirements at one facility on exposure conditions at a different facility.

Rather, the need for monitoring at a facility should be based on the exposure conditions at that facility only.

Evaluations of previous dosimetric or bioassay data may be considered in projecting doses. The use of and credit for respiratory protective equipment may be considered in the evaluations, provided use of the equipment is in compliance with the requirements of R12-1-425. Surveys of dose rates and estimates of occupancy times may be used to estimate expected external doses. Measurements and predictions of airborne radionuclide concentrations and the expected duration of exposure may be used to predict radionuclide intakes. The potential for unlikely exposures and accident conditions need not be considered because these event, by definition, are not likely.

1.2 Establishing Categories of Workers for Monitoring

If groups or categories of workers are exposed to similar radiological conditions, a single evaluation may be us to determine the need for monitoring. For simplicity, licensees and registrants may establish routine operational guideline for categories of workers who will be

monitored. For example, the operator may establish criteria or procedures for monitoring based upon anticipated area access or work functions.

1.3 Change in Exposure Conditions

If an individual's radiation exposure conditions change during the year, the need to provide individual monitoring should be reevaluated.

For example, consider an x-ray facility which when it opened six months ago performed very few x-ray exams. Now the number has tripled. A reevaluation is needed to determine whether the individual working with the unit needs to be monitored. Another example, consider an unmonitored individual whose work assignment is changed from periodic delivery of supplies to a restricted area to performing maintenance activities within a radiation area. Under this new job assignment, if management determines that the workers dose is likely to exceed 10% of the limit, R12-1-419 requires that monitoring be provided. When monitoring is provided R12-1-419 C. requires the monitored doses be recorded.

Similarly, if reevaluation of a monitored individual's anticipated annual occupational dose indicates that the dose is likely to be below the 10% limit, monitoring may be terminated. Even when the doses are actually below the 10% limit, the doses measured while monitoring was provided must be recorded pursuant to R12-1-419 C. because the monitoring was provided to meet R12-1-419 A.

1.4 Monitoring Performed but Not Required by R12-1-419 A.

Individual monitoring may be conducted for reasons other than those noted in R12-1-419 A. While the results of required monitoring are subject to the dose recording requirements of R12-1-419 C., the results of monitoring provided when not required by R12-1-419 A. are not subject to those dose recording requirements.

Surveys and monitoring results that serve as confirmatory measures are not subject to the individual dose record keeping requirements of R12-1-419 C. provided such results confirm that the actual individual doses are less than 10% of the limits. These surveys and monitoring results may be used to meet R12-1-418 requirements. An example of confirmatory monitoring is an individual's annual bioassay measurement used as confirmation of the adequacy of airborne control measures. Another example is placing monitoring device, such as thermoluminescence dosimeters (TLDs), on a sample of workers to provide confirmation that doses are not above those anticipated.

1.5 Detection Sensitivity

The monitoring criteria contained in R12-1-419 A. do not establish required levels of detection sensitivity, e.g., the lower limit of detection (LLD). For example, it may not be feasible to actually confirm intakes of 10% of the ALI, particularly for bioassay measurements of some alpha-emitting radionuclides. Therefore, monitoring thresholds should not be considered requirements on the sensitivity of a particular measurement. Workplace monitoring and

occupancy factors should be considered, as appropriate, in evaluating potential exposures and monitoring requirements.

2. DETERMINATION OF EXTERNAL DOSES

There are three dose limits included in R12-1-419 A. that apply to external exposure:

- deep-dose to the whole body (0.05 Sv or 5 rems),
- shallow-dose to the skin or extremities (0.5 S. or 50 rems), and
- dose to the lens of the eye 0.15 Sv or 15 rems).

According to the definitions in R12-1-102, the deep-dose equivalent to the whole body is considered to be at a tissue depth of 1 cm (1,000 mg/cm²), shallow-dose equivalent to the skin or extremities at 0.007 cm (7 mg/cm²), and eye dose equivalent at 0.3 cm (300 mg/cm²). In evaluating the eye dose equivalent, it is acceptable to take credit for the shielding provided by protective lenses.

2.1 Placement of Individual Monitoring Devices

External dose is typically determined by the use of individual monitoring devices, such as film badges and thermoluminescence dosimeters (TLDs). The device for monitoring the whole body dose should be placed near the location expected to receive the highest dose during the year (R12-1-408 C.). When the whole body is exposed fairly uniformly, the individual monitoring device is typically worn on the front of the upper torso. If the radiation dose is highly nonuniform or if a protective (lead) apron is worn, causing a specific part of the whole body (head, trunk, arms above the elbow, or legs above the knees) to receive substantially higher dose than the rest of the whole body, the individual monitoring device should be placed near that part of the whole body expected to receive the highest dose. For example, if the dose rate to the head of an individual is expected to be higher than the dose rate to the trunk of the body, a monitoring device should be located on or close to the head so as to measure the dose received by the head. (Note: When only one individual monitoring device is used to determine the effective dose equivalent for external radiation pursuant to R12-1-408 C.2., it shall be located at the neck outside the protective apron. When a second individual monitoring device is used, for the same purpose, it shall be located under the protective apron at the waist.)

If post exposure evaluations indicate that the maximum dose to a part of the whole body was substantially higher than the dose measured by the individual monitoring device, an evaluation should be made to estimate the actual maximum dose. When a protective apron is used in diagnostic x-ray facilities the following may be used to evaluate the exposure:

- When only one individual monitoring device is used and it is located at the neck outside the protective apron, and the reported dose exceeds 25 % of the limit specified in R12-1-408 A., the deep-dose equivalent value multiplied by 0.30 shall be the effective dose equivalent for external radiation for x-rays of less than 150kVp.

- When individual monitoring devices are worn, both under the protective apron at the waist and outside the protective apron at the neck, the effective dose equivalent for external radiation shall be the assigned value of the sum of the deep-dose equivalent reported for the individual monitoring device worn at the waist under the apron multiplied by 1.5 and the deep-dose equivalent reported for the individual monitoring device located at the neck outside the protective apron multiplied by 0.04.

2.2 Pregnant Individuals Working with Fluoroscopic Equipment

An individual monitoring device used for the dose to an embryo/fetus of a declared pregnant woman, pursuant to R12-1-415 A., shall be located under the protective apron at the waist. (Note: It is recognized that, in the specific work environment of medical fluoroscopic equipment, the dose to the embryo/fetus tissue is overestimated by the individual monitoring device because of overlying tissue of the pregnant individual. A qualified expert, such as a medical physicist who is certified by the American Board of Radiology in Diagnostic Radiological Physics or in Radiological Physics should be consulted to determine the dose to the embryo/fetus for the rare occasion in which this individual monitoring device has a monthly reported dose equivalent value in excess of 0.5 mSv (50 mrem). Therefore, for the purposes of Article 4, the value to be used for determining the dose to an embryo/fetus pursuant to R12-1-415 C.1. for occupational exposure to radiation from medical fluoroscopic equipment may be the value reported by the individual monitoring device worn at the waist underneath the protective apron which has been corrected for the particular individual and her work environment by a qualified expert). A second individual monitoring device is required for a declared pregnant woman.

2.3 Extremity Monitoring

If the licensee or registrant determine that extremity monitoring is required, it may be appropriate to use an extremity dosimeter for some, but not all, radiation exposure. The licensee or registrant could supply an extremity dosimeter when exposure is nonuniform. When exposure is uniform, the shallow-dose equivalent measured by a torso dosimeter would be representative of the shallow dose equivalent to the extremities, and separate extremity monitoring would not be needed. If protective gloves are used, it is acceptable to place the extremity monitor inside the gloves with the hand(s).

3. CALCULATION OF COMMITTED EFFECTIVE DOSE EQUIVALENT FROM INHALATION.

The internal dose component needed for evaluating the total effective dose equivalent is the committed effective dose equivalent. The committed effective dose equivalent is the 50 year dose equivalent that results when radioactive material is taken into the body, whether through inhalation, ingestion, absorption through the skin, accidental injection, or introduction through a wound. The contribution from all occupational intakes for these modes of which the total committed effective dose equivalent is being evaluated. The regulatory requirements for determining the internal dose are in R12-1-411.

Some noble gases in Appendix B to Article 4 do not have inhalation ALI values listed and are listed "submersion" class. For these radionuclides, the internal dose is negligible compared to the

external dose. These radionuclides may be excluded from the determination of internal dose. There are at least five methods acceptable to the Agency staff for calculating committed effective dose equivalent for inhaled radioactive materials. The five methods are described below.

3.1 Use of Federal Guidance Report No. 11

Federal Guidance Report No. 11 (Ref. 1) lists the committed effective dose equivalent per unit intake by inhalation in sieverts per becquerel in its Table 2.1. These values may be used directly after converting the units as necessary. To convert sieverts per becquerel to rem per microcurie, $\text{Sv/Bq} \times 3.7 \times 10^6 = \text{rem}/\mu\text{Ci}$.

3.2 Use of Stochastic Inhalation ALIs from Article 4

ALI values have been established for individual radionuclides and are presented in Table 1 in Appendix B to Article 4. The ALI values for inhalation, presented in column 2 in Table 1, correspond to a committed effective dose equivalent of 0.05 Sv (5 rems) or a committed dose equivalent of 0.5 Sv (50 rems) to any individual organ or tissue, whichever is more limiting. If the ALI value presented in Table 1 is limited by the 0.5 SV (50 rems) committed dose equivalent, the controlling organ is listed directly below the ALI value, and the stochastic ALI value based on the 0.05 Sv (5 rems) committed dose equivalent is listed in parentheses directly below the organ name. If a stochastic ALI is listed in parentheses, that value should be used to calculate the committed effective dose equivalent. The committed effective dose equivalent for each radionuclide may be calculated, using the estimated radionuclide intake by Equation 1.

$$H_{i,E} = 5 I_i / ALI_{i,E} \quad \text{Equation 1.}$$

where

$H_{i,E}$ = Committed effective dose equivalent from radionuclide i (rems)

I_i = Intake of radionuclide i by inhalation during the calendar year (μCi) (If multiple intakes occurred during the year, I_i is the sum of all intakes.)

$ALI_{i,E}$ = Value of the stochastic inhalation ALI (based on the committed effective dose equivalent) from Column 2 of Table 1 in Appendix B to Article 4 (μCi).

5 = Committed effective dose equivalent from intake of 1 ALI.

If intake of more than one radionuclide occurred, the total committed effective dose equivalent is the sum of the committed effective dose equivalents for all radionuclides.

The ALIs in Article 4 are based on a particle distribution with a 1-micron activity median aerodynamic diameter. Those ALIs may be used regardless of the actual diameter. However, the Agency allows adjustment of the ALIs to account for particle size, but only with prior approval from the Agency R12-1-411 C.

3.3 Use of DACs from Article 4

Committed effective dose equivalent may also be calculated from exposures expressed in terms of DAC-hours. If the DAC in Appendix B to Article 4 for a radionuclide represents a stochastic value (i.e., the corresponding ALI does not have a name of an organ below it), the DAC may be used directly. If Appendix B to Article 4 does not list a stochastic DAC, which will be the case any time there is a stochastic ALI value in parentheses, it is preferred (but not required) that the licensee calculate and use a stochastic DAC. The stochastic DAC can be calculated by the following equation:

$$DAC_{stoc,i} = ALI_{stoc,i} / 2.4 \times 10^9 \quad \text{Equation 2}$$

where

$DAC_{stoc,i}$ = The stochastic DAC for radionuclide i ($\mu\text{Ci/ml}$)

$ALI_{stoc,i}$ = The stochastic ALI for radionuclide i (μCi)

2.4×10^9 = The volume of air inhaled by a worker in a workyear (ml).

$$H_{i,E} = 5 C_i t / 2000 DAC_{stoc,i} \quad \text{Equation 3}$$

where

$H_{i,E}$ = Committed effective dose equivalent from radionuclide i (rems)

C_i = The airborne concentration of radionuclide i to which the worker is exposed ($\mu\text{Ci/ml}$)

t = The duration of exposure (hours)

2000 = The number of hours in a workyear

5 = Committed effective dose equivalent from annual intake of 1 ALI or 2000 DAC-hours (rems).

If there is a mixture of several radionuclides, it is permissible to disregard certain radionuclides in the mixture if they are present in relatively small quantities R12-1-411 G. These radionuclides may be disregarded if the following conditions are met:

1. The concentration of any radionuclide disregarded is less than 10% of its DAC;

3.4 Use of ICRP Publication 30

The supplements to ICRP Publication 30 (Ref. 2) list "weighted committed dose equivalent to target organs or tissues per intake of unit activity" for inhalation in sieverts per becquerel. The sum of the values given is the committed dose equivalent. ICRP Publication 30 does not give the

sum, but the licensee can easily add the values given to calculate the sum. Then it is only necessary to make any required conversion to rems.

3.5 Use of Individual or Material-Specific Information

Agency regulations R12-1-411 C. state "When specific information on the physical and biochemical properties of the radionuclides taken into the body or the behavior of the material in an individual is known, the licensee may.... use that information to calculate the committed effective dose equivalent ... " No prior Agency approval is required for using this approach, but records must be kept.

This approach requires the licensee to do considerably more work and to have greater technical expertise than other approaches. Thus, the approach is unlikely to be attractive to most licensees for small routine intakes. On the other hand, it might be attractive in the case of accidental large exposures if more accurate information would lead to a shorter estimate of the actual dose.

When this approach is used, the dose to organs not "significantly irradiated" may be excluded from the calculation (R12-1-409 B.3.).

4. CALCULATION OF COMMITTED EFFECTIVE DOSE EQUIVALENT DUE TO INGESTION

There are annual limits on intake (ALIs) for occupational ingestion or radioactive material. Only one ingestion ALI is given for each radionuclide, whereas for inhalation a different ALI was given for each solubility class. Solubility classes are not used for ingestion. The ingestion ALI for each radionuclide is used for all chemical forms of that radionuclide.

If ingestion has occurred, the methods of determining the committed effective dose equivalent are similar to the methods used for estimating inhalation dose. Four acceptable methods are described here.

Some noble gases in Appendix B to Article 4 do not have ingestion ALI values listed and are listed "submersion" class. For these radionuclides, the internal dose is negligible compared to the external dose. These radionuclides may be excluded from the determination of internal dose.

4.1 Use of Federal Guidance Report No. 11

Federal Guidance Report No. 11 (Ref. 1) lists the committed effective dose equivalent per unit intake by ingestion in sieverts per becquerel in its Table 2.2. These values may be used directly after converting the units as necessary. convert sieverts per becquerel to rem per microcurie, $\text{Sv/Bq} \times 3.7 \times 10^6 = \text{rem}/\mu\text{Ci}$.

4.2 Use of Stochastic Ingestion ALIs from Article 4

ALI values have been established for individual radionuclides and are presented in Table 1 in Appendix B to Article 4. The ALI values for stochastic ingestion, presented in column 1 in Table 1, correspond to a committed effect dose equivalent of 0.05 Sv (5 rems). The committed

effective dose equivalent for each radionuclide may be calculated, using the estimated radionuclide intake by Equation 4.

$$H_{i,E} = 5 I_i / ALI_{i,E} \quad \text{Equation 4}$$

where

$H_{i,E}$ = Committed effective dose equivalent from radionuclide i (rems)

I_i = Intake of radionuclide i by ingestion during the calendar year (μCi) (If multiple intakes occurred during the year, I_i is the sum of all intakes.)

$ALI_{i,E}$ = Value of the stochastic ingestion ALI (based on the committed effective dose equivalent) from Column 1 of Table 1 in Appendix B to Article 4 (μCi).

5 = Committed effective dose equivalent from intake of 1 ALI.

If intake of more than one radionuclide occurred, the total committed effective dose equivalent is the sum of the committed effective dose equivalents for all radionuclides.

4.3 Use of ICRP Publication 30

The supplements to ICRP Publication 30 (Ref. 2) list "weighted committed dose equivalent to target organs or tissue per intake of unit activity" for oral intake in sieverts per becquerel. The sum of the values given is the committed dose equivalent. ICRP Publication 30 does not give the sum, but the licensee can easily add the values given to calculate the sum. Then it is only necessary to make any required conversion to rems.

4.4 Use of Individual or Material-Specific Information

Agency regulations R12-1-411 C. state "When specific information on the physical and biochemical properties of the radionuclides taken into the body or the behavior of the material in an individual is known, the licensee may... use that information to calculate the committed effective dose equivalent ... " No prior Agency approval is required for using this approach, but records must be kept.

5. DETERMINATION OF ORGAN-SPECIFIC COMMITTED DOSE EQUIVALENTS

The internal dose component needed for demonstrating compliance with the dose limits specified in R12-1-408 A.1.b. is the organ-specific committed dose equivalent. The organ committed dose equivalent is calculated for an individual organ. Tissue weighing factors are not used.

Organ-specific committed dose equivalents need to be calculated only if the committed effective dose equivalent exceeds 0.01 Sv (1 rem) or if an overexposure has occurred, because if the committed effective dose equivalent is less than 0.01 Sv (1 rem) and no overexposure has occurred, the 0.5 Sv (50 rems) nonstochastic organ dose limit cannot be exceeded.

Five acceptable methods to calculate the organ-specific committed dose equivalent are described here.

5.1 Use of Federal Guidance Report No. 11

One method of calculating the organ-specific committed dose equivalent is to use the factors in Federal Guidance report No. 11 (Ref. 1). The organ-specific exposure-to-dose factors presented in Table 2.1 (for inhalation) and Table 2.2 (for ingestion) of Federal Guidance Report No. 11 provide acceptable data for calculating individual organ doses based on intakes as follows:

$$H_{i,T} = I_i \times DCF_i \times 3.7 \times 10^6 \quad \text{Equation 5}$$

where

- $H_{i,T}$ = Committed dose equivalent to the tissue or organ from radionuclide i (rems)
- I_i = Intake of radionuclide i (μCi)
- DCF_i = Dose conversion factor for radionuclide i from Table 2.1 or 2.2 in Federal Guidance Report No. 11 (Sv/Bq)
- 3.7×10^6 = Conversion factor to convert from Sv/Bq to rem/ μCi .

5.2 Use of Nonstochastic Inhalation ALIs from Article 4

It is possible to calculate organ-specific committed dose equivalents for those radioactive materials for which nonstochastic ALIs are give in Article 4. (Nonstochastic ALIs are those in which the organ is identified underneath the ALI in Appendix B to Article 4). The equation is:

$$H_{i,T} = 50I_i/ALI_{i,T} \quad \text{Equation 6}$$

where

- $H_{i,T}$ = Committed dose equivalent to tissue or organ T from radionuclide i (rems)
- I_i = Intake of radionuclide i by inhalation during the calendar year (μCi)
- $ALI_{i,T}$ = Value of the nonstochastic inhalation ALI for radionuclide i (based on the organ-specific committed dose equivalent) From Column 2 of Table 1 in Appendix B to Article 4 (μCi)
- 50 = Committed dose equivalent to maximum-exposed organ from inhalation of 2000 DAC-hours (rems).

5.3 Use of DACs from Article 4

If a radionuclide has an ALI based on a nonstochastic dose limit to the organ, the corresponding DAC may be use to calculate the organ-specific committed dose equivalent to the organ with the highest dose using the following equation:

$$H_{i,T} = 50C_i t / 2000 \text{DAC}_i \quad \text{Equation 7}$$

where

- $H_{i,T}$ = Committed dose equivalent to tissue or organ T from radionuclide i (rems)
- C_i = The concentration of radionuclide i ($\mu\text{Ci}/\text{ml}$)

DAC _i	=	The nonstochastic DAC for radionuclide i ($\mu\text{Ci}/\text{ml}$)
t	=	The duration of the exposure (hours)
2000	=	The number of hours in the workyear
50	=	Committed dose equivalent to maximum-exposed organ from annual intake of 1 ALI or 2000 DAC-hours (rems).

If intakes during the monitoring period are from more than one radionuclide and the organ receiving the highest dose are different from each radionuclide, this method may substantially overestimate the maximum organ dose. In this situation, the licensee may wish to use one of the other methods.

5.4 Use ICRP Publication 30

The supplements to ICRP Publication 30 (Ref. 2) list "weighted committed dose equivalent to target organs or tissues per intake of unit activity" in sieverts per becquerel, to significantly exposed organs. The sum of the values given is the committed dose equivalent. ICRP Publication 30 does not give the sum, but the licensee can easily add the values given to calculate the sum. Then it is only necessary to make any required conversion to rems.

5.5 Use of Individual or Material-Specific Information

Agency regulations R12-1-411 C. state "When specific information on the physical and biochemical properties of the radionuclides taken into the body or the behavior of the material in an individual is known, the licensee may... use that information to calculate the committed effective dose equivalent ... " Although not explicitly stated, the or specific committed dose equivalent may also be calculated based on specific information. No prior Agency approval is required for using this approach, but records must be kept.

In general, if specific information is used to calculate the committed effective dose equivalent, it should also be used to calculate the organ-specific dose equivalent so that both dose calculations have the same basis.

6. DOSES FROM INTAKES THROUGH WOUNDS OR ABSORPTION THROUGH THE SKIN

According to R12-1-409 D., the licensee must evaluate and to the extent practical, account for intakes through wounds or skin absorption. (Dose from tritium absorption through the skin is taken into account in the DAC value in Appendix B to Article 4). As a practical matter, the intake by skin absorption of airborne radioactive material usually does not need to be considered because it will be negligible compared to the intake from inhalation. It may be necessary to consider absorption through the skin when solution containing dissolved radioactive material come in contact with the skin.

7. RECORDING OF INDIVIDUAL MONITORING RESULTS

The requirements for recording individual monitoring results are contained in R12-1-419 C., which requires that the recording be done on Agency Form Z or equivalent. Agency Form Z is used to record, on an annual basis, doses received. Thus, for workers who work for the same licensee or registrant for the entire year, the monitoring period will normally be January 1 to December 31. The monitoring year may be adjusted as necessary to permit a smooth transition from one monitoring year to another;

- so long as the year begins and ends within the month of January,
- the change is made at the beginning of the year, and
- no day is omitted or duplicated in consecutive years.

A copy of Agency Form Z and instructions for filling it out are contained in Regulatory Guide 8.7, "Instructions for Recording and Reporting Occupational Exposure Data. "

7.1 Summation of External and Internal Doses

Summation of external and internal doses is required in R12-1-409 when both external monitoring and internal monitoring of an individual are required to meet R12-1-419. The requirement for summation applies to the occupationally exposed adult and minor and to the embryo/fetus of a declared pregnant woman.

The requirements for summation of external and internal doses specified in R12-1-4409 A. are not applicable to the shallow-dose equivalent to the skin or extremities or to the eye dose equivalent. Only external dose is considered in evaluation the shallow-dose equivalent to the skin and the extremities and the eye dose equivalent.

Total effective dose equivalent is calculated by summing the external component (deep-dose equivalent) and the internal (committed effective dose equivalent). Likewise, the total organ dose equivalent is calculated by summing the external exposure component (deep-dose equivalent) and the internal component to the organ or tissue (committed dose equivalent to any organ or tissue).

7.2 Roundoff of Doses

Licensees and registrants should avoid entering doses on Agency Form Z with more significant figures than justified in the precision of the basis measured values. In general, it is appropriate to enter dose values with two significant figures on Agency Form Z using the standard rule for roundoff. Thus, a computer-generated calculated dose of "1.726931 rems" should be entered on Agency Form Z as "1.7 rems." However, licensees and registrants should generally carry at least three significant figures in calculation to avoid loss of accuracy due to multiple roundoffs.

In addition, licensees and registrants should not enter doses smaller than 0.01 mSv (0.001 rem) on Agency Form Z because smaller values are insignificant relative to the dose limits. Therefore, a calculated committed effective dose equivalent of "0.006192 rem" should be entered as "0.006 rem," and a value of "0.000291 rem" should be entered as "0 rem."

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants, registrants, and licensees regarding Agency plans for using this regulatory guide. Except in those cases in which an applicant proposes an acceptable alternative method for complying with specified portions of the Agency's regulations, the methods described in this guide will be used in the evaluation of applications for new licenses or registrations, renewals and amendments and for evaluating compliance with Article 4.

REFERENCES

1. K.F. Eckerman, A.B. Wolbarst, and A.C.B. Richardson, "Limiting Values of Radionuclide Intake and Concentration and Dose Conversion Factors for Inhalation, Submersion, And Ingestion." Environmental Protection Agency, Federal Guidance Report No. 11 (EPA 520/1-8-020), September 1988. This report may be purchased from the National Technical Information Service, Springfield, VA 22161. For information and credit card sales, call (703) 487-4650.
2. International Commission on Radiological Protection. "Limits for Intakes of Radionuclides by Workers," ICRP Publication 30 (7-volume set, including supplements), Pergamon Press Inc., 1982.