STATE OF FLORIDA
DEPARTMENT OF HEALTH
BUREAU OF RADIATION CONTROL

REGULATORY GUIDE

Regulatory Guide 3.34
Revision 2

Issuance Date: December 2000

MONITORING CRITERIA AND METHODS TO CALCULATE OCCUPATIONAL RADIATION DOSES

A. INTRODUCTION

Monitoring of an individual's external radiation exposure is required by subsection 64E-5.315(1), Florida Administrative Code, (F.A.C.), if the external occupational dose is likely to exceed 10% of the dose limit appropriate for the individual (i.e., an adult, minor, or declared pregnant woman). External radiation monitoring is also required by paragraph 64E-5.315(1)(c), F.A.C., for any individual entering a high or very high radiation area.

Monitoring of the intake of radioactive material is required by section 64E-5.315(2), F.A.C., 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 (CEDE) is likely to exceed 50 millirem (0.5 mSv) for the occupationally exposed minor or declared pregnant woman.

In the revised Chapter 64E-5, F.A.C., Part 3, "Standards for Protection Against Radiation," section 64E-5.304, F.A.C., establishes radiation dose limits for occupationally exposed adults. These limits apply to the sum of the dose received from external exposure and the dose from internally deposited radioactive material. In paragraph 64E-5.304(1)(a), F.A.C., the annual limits for adults are specified as (i) 5 rem (0.05 Sv) total effective dose equivalent (TEDE) or (ii) 50 rem (0.5 Sv) total organ dose equivalent (TODE) to any single organ or tissue (other than the lens of the eye), whichever is more limiting. The occupational dose limits for minors in section 64E-5.310, F.A.C., are 10% of the dose limit for adults, and section 64E-5.311, F.A.C., establishes a dose limit for the embryo/fetus of 500 millirem (0.005 Sv) during the entire pregnancy.

The TEDE is defined as the sum of the deep dose equivalent (DDE) (i.e., external exposures) and the CEDE (i.e., internal exposures). The TODE limit of 50 rem (0.5 Sv) specified in subparagraph 64E-5.304(1)(a)2, F.A.C., applies to the sum of the DDE and the CEDE to any individual organ or tissue. The requirements in section 64E-5.305, F.A.C., are for summing external and internal doses to demonstrate compliance with the dose limits of section 64E-5.304, F.A.C.

Requirements for recording individual monitoring results are contained in section 64E-5.339, F.A.C. When monitoring is required under section 64E-5.316, F.A.C., the monitoring results must be recorded on DOH Form DH 1622 or an equivalent form.

B. DISCUSSION

This guide provides criteria acceptable to the department that may be used by licensees to determine when monitoring is required, and it describes methods acceptable to the department for calculating occupational doses when the intake is known. Guidance on calculating doses to the embryo/fetus is contained in Regulatory Guide 3.36, "Radiation Dose to the Embryo/Fetus" Regulatory Guide 3.9, "Interpretation of Bioassay Measurements" (under development) and will provide guidance on determining intakes from bioassay results. Guidance on determining intakes from air sampling measurements is contained in Regulatory Guide 3.25, "Air Sampling in the Workplace" (under development). Guidance on recording the calculated doses for DOH Forms DH 1623 and DH 1622 is described in Regulatory Guide 6.7, "Instructions for Recording and Reporting Occupational Radiation Exposure Data."

The appendix to this guide gives examples of the calculations of internal and external doses for entry on DOH Form DH 1622.

C. REGULATORY POSITIONS

1. Monitoring Criteria

The monitoring requirements in Part III of Chapter 64E-5, F.A.C., are summarized in Table 1. For external dose monitoring, subsection 64E-5.315(1), F.A.C., requires the use of individual monitoring devices (i.e., personnel monitoring or PM badges). 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 employment by another licensee are not included in the determination of monitoring requirements. The requirements in section 64E-5.315, F.A.C., refer to each licensee. Each licensee makes the determination independently. It would not be appropriate to base the monitoring requirements at one licensee's facility on exposure conditions at a different licensee's 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 section 64E-5.319, F.A.C. 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 events, 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 used to determine the need for monitoring. For simplicity, licensees may establish routine operational guidelines for categories of workers who will be monitored. For example, licensees may establish criteria or procedures for monitoring based on 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 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 the licensee determines that the worker's dose is likely to exceed 10% of the limit, section 64E-5.315, F.A.C., requires that monitoring be provided. When monitoring is required, section 64E-5.339, F.A.C., requires that the monitored doses be recorded.

Similarly, if re-evaluation of a monitored individual's anticipated annual occupational dose indicates that the dose is likely to be below 10% of the limits, monitoring may be terminated. Even when the doses are actually below 10% of the limit, the doses measured while monitoring was provided must be recorded pursuant to section 64E-5.339, F.A.C., because the monitoring was provided to satisfy section 64E-5.315, F.A.C.

1.4 Monitoring Performed but not Required by Section 64E-5.315, F.A.C.

Individual monitoring may be conducted for reasons other than those noted in section 64E-5.315, F.A.C. While the results of required monitoring are subject to the dose recording requirements of section 64E-5.339, F.A.C., the results of monitoring provided when not required 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 subsection 64E-5.339(1), F.A.C., provided such results confirm that actual individual doses are less than 10% of the limits. These surveys and monitoring results may be used to meet section 64E-5.314, F.A.C., 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 PM devices, such as thermoluminescent dosimeters (TLDs), on a sample of workers to confirm that doses are not above those anticipated.

Table 1
Summary of Monitoring Requirements Specified in Part III of Chapter 64E-5, F.A.C.

The use of individual monitoring devices (i.e., PM badges) for external dose is required:

- For adults who are likely to receive an annual dose in excess of any of the following (each evaluated separately):
  - 0.5 rem (0.005 Sv) deep dose equivalent.
  - 1.5 rem (0.015 Sv) eye dose equivalent.
  - 5 rem (0.05 Sv) shallow dose equivalent to the skin.
  - 5 rem (0.05 Sv) shallow dose equivalent to any extremity.
- For minors who are likely to receive an annual dose in excess of any of the following (each evaluated separately):
  - 0.05 rem (0.5 mSv) deep dose equivalent.
  - 0.15 rem (1.5 mSv) eye dose equivalent.
  - 0.5 rem (0.005 Sv) shallow dose equivalent to the skin.
  - 0.5 rem (0.005 Sv) shallow dose equivalent to any extremity.
- For declared pregnant women who are likely to receive an annual dose from occupational exposure in excess of 50 millirem (0.5 mSv) deep dose equivalent, although the dose limit applies to the entire gestation period.
- For individuals entering a high or a very high radiation area.

Internal exposure monitoring (not necessarily individual monitoring devices) is required:

- For adults likely to receive in 1 year an intake in excess of 10% of the applicable ALIs for ingestion and inhalation
- For minors and declared pregnant women likely to receive in 1 year a CEDE in excess of 500 millirem (0.5 mSv).

1.5 Detection Sensitivity

The monitoring criteria contained in section 64E-5.315, F.A.C., 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 section 64E-5.304, F.A.C., that apply to external exposure: deep dose to the whole body (5 rem or 0.05 Sv), shallow dose to the skin or extremities (50 rem or 0.5 Sv), and dose to the lens of the eye (15 rem or 0.15 Sv). According to the definitions in section 64E-5.101, F.A.C., the DDE to the whole body is considered to be at a tissue depth of 1 cm (1000 mg/cm^2), shallow dose equivalent to the skin or extremities at 0.007 cm (7 mg/cm^2), and eye dose equivalent at 0.3 cm (300 mg/cm^2). 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 PM badges such as film badges, TLDs and optically stimulated thermoluminescent dosimeters (OSLDs). PM badges used to monitor whole body doses should be placed near the location expected to receive the highest dose during the year [subsection 64E-5.304(3), F.A.C.]. When the whole body is exposed fairly uniformly, the badge is typically worn on the front of the upper torso.

If the radiation dose is highly non-uniform, causing a specific part of the whole body (head, trunk, arms above the elbow, or legs above the knees) to receive a substantially higher dose than the rest of the whole body, the PM badge 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 badge should be located on or close to the head so as to measure the dose received by the head.

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 badge, an evaluation should be conducted to estimate the actual maximum dose.

2.2 Use of More Than One Dosimeter

An acceptable alternative approach for highly non-uniform radiation fields is to use more than one badge to separately track doses to different parts of the whole body. At the end of the year, each of the doses for each location would be summed. The DDE to be recorded would be that of the badge location receiving the highest dose.

2.3 Extremity Monitoring

If the licensee determines that extremity monitoring is required, it may be appropriate to use an extremity dosimeter for some, but not all, radiation exposure. The licensee 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 dosimeter under the gloves.

3. Calculation of Committed Effective Dose Equivalent from Inhalation

The internal dose component needed for evaluating the TEDE is the CEDE. The CEDE is the 50 year effective dose equivalent (EDE) 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 contributions from all occupational intakes for these modes of intake are added over the yearly time period for which the total CEDE is being evaluated. The regulatory requirements for determining internal dose are in section 64E-5.307, F.A.C.

Some noble gases in "State of Florida Bureau of Radiation Control ALIs, DACs, and Effluent Concentrations," July 1993, 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 the internal dose.

There are at least five methods acceptable to the department for calculating CEDE from 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 CEDE per unit intake by inhalation in sieverts per becquerel in its Table 2.1. These values may be used directly after converting the units from sieverts per becquerel to rem per microcurie (Sv/Bq x 3.7 x 10^6 = rem/μCi).

3.2 Use of Stochastic Inhalation ALIs from Part 3, Chapter 64E-5, F.A.C.

ALI values have been established for individual radionuclides and are presented in Table 1 in "State of Florida Bureau of Radiation Control ALIs, DACs, and Effluent Concentrations," July 1993. The ALI values for inhalation, presented in Column 2 in Table 1, correspond to a CEDE of 5 rem (0.05 Sv) or a committed dose equivalent (CDE) of 50 rem (0.5 Sv) to any individual organ or tissue, whichever is more limiting. If the ALI value presented in Table 1 is limited by the 50 rem CDE, the controlling organ is listed directly below the ALI value, and the stochastic ALI value based on the 5 rem CEDE is listed in parentheses directly below the organ name.

Equation 1

$$H_{i,E} = \frac{5\, I_i}{ALI_{i,E}}$$

$H_{i,E}$ = CEDE from radionuclide i (rem)

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 CEDE) from Column 2 of Table 1 in "State of Florida Bureau of Radiation Control ALIs, DACs, and Effluent Concentrations," July 1993 (μCi)

5 = CEDE from intake of 1 ALI (rem)

If intakes of more than one radionuclide occurred, the total CEDE will be the sum of the CEDEs for all radionuclides. If a stochastic ALI is listed in parentheses, that value should be used to calculate the CEDE. The CEDE for each radionuclide may be calculated, using the estimated radionuclide intake, by Equation 1.

The ALIs in "State of Florida Bureau of Radiation Control ALIs, DACs, and Effluent Concentrations," July 1993, are based on a particle distribution with a 1 micron activity median aerodynamic diameter. Those ALIs may be used regardless of the actual median diameter. However, the department allows adjustment of ALIs to account for particle size, but only with prior approval from the department [subsection 64E-5.307(3), F.A.C.].

3.3 Use of DACs from Part III, Chapter 64E-5, F.A.C.

CEDE may also be calculated from exposures expressed in terms of DAC hours. If the DAC in "State of Florida Bureau of Radiation Control ALIs, DACs, and Effluent Concentrations," July 1993, for a radionuclide represents a stochastic value (i.e., the corresponding ALI does not have the name of an organ below it), the DAC may be used directly. If "State of Florida Bureau of Radiation Control ALIs, DACs, and Effluent Concentrations," July 1993, 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 from the stochastic ALI (the ALI in parentheses) by the following equation:

Equation 2

$$DAC_{stoc,i} = \frac{ALI_{stoc,i}}{2.4 \times 10^{9}}$$

$DAC_{stoc,i}$ = The stochastic DAC for radionuclide i (μCi/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 work year (ml)

Then:

Equation 3

$$H_{i,E} = \frac{5\ C_i t}{2000\ DAC_{stoc,i}}$$

$H_{i,E}$ = CEDE from radionuclide i (rem)

C_i = The airborne concentration of radionuclide i to which the worker is exposed (μCi/ml)

t = The duration of the exposure (hours)

2000 = The number of hours in a work year

5 = CEDE from annual intake of 1 ALI or 2000 DAC hours (rem)

If there is a mixture of several radionuclides, it is permissible to disregard certain radionuclides in the mixture that are present in relatively small quantities [subsection 64E-5.307(7), F.A.C.]. 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; (2) the sum of these percentages for all of the radionuclides disregarded in the mixture does not exceed 30%; and (3) the licensee uses the total activity of the mixture in demonstrating compliance with the dose limits and monitoring requirements.

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 CEDE. ICRP Publication 30 (Ref. 2) does not give the sum, but the licensee can easily add the values given to calculate the sum. Then it is only necessary to convert from sieverts per becquerel to rem per microcurie (3.7×10^{6} x Sv/Bq = rem/μCi).

3.5 Use of Individual or Material Specific Information

Department regulations [subsection 64E-5.307(3), F.A.C.] state that "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 department 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 the 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 better estimate of the actual dose.

When this approach is used, the dose to organs not "significantly irradiated" may be excluded from the calculation [subsection 64E-5.305.(2)(c), F.A.C.].

4. Calculation of Committed Effective Dose Equivalent due to Ingestion

There are annual limits on intake (ALIs) for occupational ingestion of 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 given for each radionuclide is used for all chemical forms of that radionuclide.

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

Some noble gas radionuclides in "State of Florida Bureau of Radiation Control ALIs, DACs, and Effluent Concentrations," July 1993, do not have ingestion ALI values listed because the ingestion pathway does not contribute significantly to the dose. These radionuclides may be excluded from the determination of the internal dose from ingestion.

4.1 Use of Federal Guidance Report No. 11

Federal Guidance Report No. 11 (Ref. 1) lists in its Table 2.2 the committed effective dose equivalent per unit of intake by ingestion in sieverts per becquerel. These values may be used directly after converting the units from sieverts per becquerel to rems per microcurie (by multiplying the Sv/Bq value by 3.7×10^6).

4.2 Use of Stochastic Ingestion ALIs from Part III, Chapter 64E-5, F.A.C.

If the amount of ingested radioactive material is known, the stochastic ingestion ALIs from Column 1 of Table 1 in "State of Florida Bureau of Radiation Control ALIs, DACs, and Effluent Concentrations," July 1993, may be used. Equation 4 may be used for this determination.

Equation 4

$$H_{i,E} = \frac{5\ I_i}{ALI_{E,oral}}$$

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

I_i = Intake of radionuclide i by ingestion during the calendar year (μCi)

$ALI_{E,oral}$ = Value of the stochastic ingestion ALI for the CEDE from Column 1 of Table 1 in "State of Florida Bureau of Radiation Control ALIs, DACs, and Effluent Concentrations," July 1993 (μCi)

5 = CEDE from intake of 1 ALI (rem)

4.3 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 oral intake in sieverts per becquerel. The sum of the values given is the CEDE. ICRP Publication 30 does not give the sum, but the values given can easily be added to calculate the sum. Then it is only necessary to convert from sieverts per becquerel to rem per microcurie (by multiplying the Sv/Bq value by 3.7×10^6).

4.4 Use of Individual or Material Specific Information

Department regulations [subsection 64E-5.307(3), F.A.C.] allow the CEDE to be calculated based on specific information on the physical and biochemical properties of radionuclides taken into the body of a specific worker. The doses due to ingestion can be calculated using the specific information previously described for inhalation.

5. Determination of Organ-Specific Committed Dose Equivalents

The internal dose component needed for demonstrating compliance with the dose limit specified in subparagraph 64E-5.304(1)(a)2, F.A.C., is the organ-specific CDE. The organ-specific CDE is calculated for an individual organ. Tissue weighting factors are not used.

Organ-specific CDEs need be calculated only if the CEDE exceeds 1 rem or if an overexposure has occurred, because if the CEDE is less than 1 rem and no overexposure has occurred, the 50 rem nonstochastic organ limit cannot be exceeded. Five acceptable methods to calculate the organ-specific CDE are described here.

5.1 Use of Federal Guidance Report No. 11

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

Equation 3

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

$H_{i,T}$ = CEDE 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 "State of Florida Bureau of Radiation Control ALIs, DACs, and Effluent Concentrations," July 1993.

It is possible to calculate organ specific CDEs for those radioactive materials for which nonstochastic ALIs are given in Part III, Chapter 64E-5, F.A.C.. (Nonsto-chastic ALIs are those in which the organ is identified underneath the ALI in "State of Florida Bureau of Radiation Control ALIs, DACs, and Effluent Concentrations," July 1993.) The equation is:

Equation 6

$$H_{i,T} = \frac{50\ I_i}{ALI_{i,T}}$$

$H_{i,T}$ = CEDE to tissue or organ T from radionuclide i (rem)

I_i = Intake of radionuclide i by inhalation during the calendar year

$ALI_{i,T}$ = Value of the nonstochastic inhalation ALI for radionuclide i (based on the organ-specific CDE) from Column 2 of Table 1 in "State of Florida Bureau of Radiation Control ALIs, DACs, and Effluent Concentrations," July 1993

50 = CDE to maximum-exposed organ from inhalation of 2000 DAC hours (rem)

5.3 Use of DACs from "State of Florida Bureau of Radiation Control ALIs, DACs, and Effluent Concentrations," July 1993.

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

Equation 7

$$H_{i,T} = \frac{50\ C_i t}{2000\ DAC_i}$$

$H_{i,T}$ = CEDE to tissue or organ T from radionuclide i (rem)

C_i = The concentration of radionuclide i (μCi/ml)

DAC_i = The nonstochastic DAC for radionuclide i (μCi/ml)

t = The duration of the exposure (hours)

2000 = The number of hours in a work year

50 = CDE to maximum-exposed organ from annual intake of 1 ALI or 2000 DAC hours (rem)

If intakes during the monitoring period are from more than one radionuclide and the organs 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 of ICRP Publication 30

The supplements to ICRP Publication 30 (Ref. 2) list "committed dose equivalent in target organs or tissues per intake of unit activity," in sieverts per becquerel, to significantly exposed organs. These values may be used to calculate organ-specific CDEs after converting the units from Sv/Bq to rem/μCi.

5.5 Use of Individual or Material Specific Information

Department regulations [subsection 64E-5.307(3), F.A.C.] state that the CEDE may be calculated based on specific information on the physical and biochemical properties of radionuclides taken into the body. Although not explicitly stated, the organ-specific CDE may also be calculated based on specific information.

In general, if specific information is used to calculate the CEDE, 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 Skin

According to subsection 64E-5.305(4), F.A.C., 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 "State of Florida Bureau of Radiation Control ALIs, DACs, and Effluent Concentrations," July 1993.) As a practical matter, the intake by skin absorption of airborne radioactive materials 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 solutions 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 section 64E-5.339, F.A.C., which requires that the recording be done on DOH Form DH 1622 or equivalent. DOH Form DH 1622 is used to record, on an annual basis, doses received. Thus, for workers who work for the same licensee 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 DOH Form DH 1622 and instructions for filling it out are contained in Regulatory Guide 6.7, "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 section 64E-5.305, F.A.C., when both external monitoring and internal monitoring of an individual are required to meet subsections 64E-5.315(1) and (2), F.A.C. 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 subsection 64E-5.305(1), F.A.C., 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 evaluating the shallow dose equivalent to the skin and the extremities and the eye dose equivalent.

TEDE is calculated by summing the external component (DDE) and the internal component (CEDE). Likewise, the TODE is calculated by summing the external component (DDE) and the internal component to the organ or tissue (CDE to any organ or tissue).

7.2 Preferred Units

The preferred unit for dose is the "rem." The use of "millirem" on DOH Form DH 1622 is permitted but is discouraged. The preferred unit for intakes is the "microcurie."

7.3 Round-off of Doses

Licensees should avoid entering doses on DOH Form DH 1622 with more significant figures than justified by the precision of the basic measured values. In general, it is appropriate to enter dose values with two significant figures on DOH Form DH 1622 using the standard rules for round-off. Thus, a computer-generated calculated dose of "1.726931 rem" should be entered on DOH Form DH 1622 as "1.7 rem." However, licensees should generally carry at least three significant figures in calculations to avoid loss of accuracy due to multiple round-off.

In addition, licensees should not enter doses smaller than 0.001 rem on DOH Form DH 1622 because smaller values are insignificant relative to the dose limits. Therefore, a calculated CEDE of "0.006192 rem" should be entered as "0.006 rem," and a value of "0.000291 rem" should be entered as "0 rem."

The rounding recommended in this section is illustrated in the appendix to this guide.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the department's 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 department's regulations, the methods described in this guide will be used in the evaluation of applications for new licenses, license renewals, and license amendments and for evaluating compliance with Chapter 64E-5, F.A.C.

REFERENCES

1. K. F. Eckerman, A. B. Wolbarst, and A. C. B. Richardson, "Limiting Values of Radionuclide Intake and Air 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. The report is also available on the Internet at <http://www.epa.gov/rpdweb00/federal/docs/>.

2. International Commission on Radiological Protection, "Limits for Intakes of Radionuclides by Workers," ICRP Publication 30 (seven volume set, including supplements), Pergamon Press Inc., 1982.

APPENDIX

EXAMPLE OF THE CALCULATION OF OCCUPATIONAL DOSES

This example illustrates the calculation of dose information needed for DOH Form DH 1622, "Occupational Exposure Record for a Monitoring Period." A form with the sample data and calculations is provided to illustrate how to fill out the form. In this example, it is assumed that the individual was exposed to external radiation and received an intake by inhalation of five airborne radionuclides.

Deep Dose Equivalent (Whole Body)

The licensee provided individual monitoring for the DDE (1 cm depth) based on the likelihood of exceeding 0.5 rem DDE. In this example, the sum of the PM badge reading for the year is assumed to be 1.435 rem of low LET radiation (gamma), which in the licensee's calculations is rounded to 1.44 rem, maintaining three significant figures for calculational purposes, but entered as 1.4 rem on the form.

Eye Dose Equivalent

The licensee provided monitoring for eye dose equivalent because the dose to the eye was likely to exceed 1.5 rem. The total annual dose measured at a depth of 0.3 cm by a PM badge worn on the trunk was 1.720 rem. The rounded value of 1.7 is entered on DOH Form DH 1622.

Shallow Dose Equivalent

The shallow dose equivalent to the skin or extremities must be monitored if the shallow dose equivalent is likely to exceed 5 rem in the year. In this example, the licensee concluded at the start of the year that the shallow dose equivalent was not likely to exceed 5 rem, and, therefore, monitoring of the shallow dose equivalent was not required by section 64E-5.315, F.A.C. Nevertheless, the licensee provided shallow dose equivalent monitoring because the dosimeter supplier automatically provided a shallow dose equivalent reading on all badges. The annual monitored total of the shallow dose equivalent was 1.85 rem, confirming that monitoring of the shallow dose equivalent was not necessary. The licensee could enter "NR," meaning not required, on DOH Form DH 1622 because monitoring the shallow dose equivalent was not required by section 64E-5.315, F.A.C. However, in this case the licensee decided, for the sake of completeness, to enter the rounded value of 1.9 rem as the shallow dose equivalent, whole body column, but he entered "NR" under shallow dose equivalent to the extremities because no extremity monitoring was required or provided. The licensee also could have entered 1.9 rem on the basis that the extremities received about the same dose as the PM badges located on the trunk. Either of those entries is acceptable. A value of zero should not be entered if no monitoring was provided. Any numerical value, including zero, should signify a measured or estimated dose.

Radionuclide Intakes

The intake of each radionuclide must be entered separately. The solubility class of each radionuclide must be specified. The intake mode, inhalation (H) in this case, must also be entered. Based on air sampling data, worker stay times, and respirator protection factors when applicable, the licensee calculated the intakes from inhalation (H), which are shown in Table A.1 using this equation:

Equation A.1

$$I_i = \frac{C_i}{APF}$$

I_i = Intake of radionuclide i in microcuries (μCi)

C_i = Concentration of radionuclide i in micocuries/ml

B = Worker's breathing rate of 20,000 ml/min

t = Duration of the worker's exposure in minutes

APF = Assigned respiratory protection factor (dimensionless)

All the data in Table A.1 must be entered on DOH Form DH 1622.

Committed Effective Dose Equivalent

The CEDE from each radionuclide is calculated by using Equation 1. The data used in Equation 1 are shown in Table A.2.

The sum (1.3 rem) in Table A.2 must be entered on DOH Form DH 1622.

Total Effective Dose Equivalent

The TEDE is the sum of the DDE and the sum of the CEDE from all radionuclides. In this case, the TEDE is 1.44 + 1.30 rem = 2.74 rem, which is rounded to 2.7 rem for entry onto DOH Form DH 1622.

Organ-Specific Committed Dose Equivalent

The organ-specific CDEs should be calculated because the CEDE exceeds 1 rem. The organ dose factors in Federal Guidance Report No. 11* may be used. The organ dose factors from Table 2.1 of that report are reproduced in Table A.3. The dose factor for the "remainder" listed in Federal Guidance Report No. 11 is not listed here or used to calculate organ-specific CDEs because it does not represent a dose to a particular individual organ.

To calculate the organ-specific CDE, multiply the intake by the organ dose factor and a conversion factor to convert from Sv/Bq to rem/μCi. The equation is:

Equation A.2

$$H_{T,i} = I_i \times DCF_{T,i} \times 3.7 \times 10^6$$

$H_{T,i}$ = 50 year committed dose to organ or tissue T from radionuclide i, in rem

I_i = Intake of radionuclide i (æCi)

$DCF_{T,i}$ = Dose conversion factor for organ or tissue T from radionuclide i (Sv/Bq)

3.7×10^6 = Conversion factor to convert from Sv/Bq to rem/μCi

The results are shown in Table A.4.

The doses in Table A.4 were calculated using the rounding method described in this guide.

Table A.1
Worker Intakes

Radionuclide	Solubility Class	Intake Mode	Intake (microcuries)
U-238	D	H	0.022
U-235	D	H	0.0031
U-234	D	H	0.060
Cs-137	D	H	1.87
Ce-144	Y	H	2.07

* K.F. Eckerman, A.B. Wolbarst, and A.C.B. Richardson, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion," Environmental Protection Agency, Federal Guidance Report No. 11 (EPA 520/1-88-020), 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. The report is also available on the Internet at http://www.epa.gov/rpdweb00/federal/docs/.

Table A.2
Calculation of Committed Effective Dose Equivalent

Radionuclide and Class	Intake I_i (μCi)	$ALI_{i,E}$ (μCi)	CEDE (rem)
U-238 (D)	D	H	0.055
U-235 (D)	D	H	0.008
U-234 (D)	D	H	0.15
Cs-137 (D)	D	H	0.047
Ce-144 (Y)	Y	H	1.04
Sum			1.30

Organ Dose

The organ dose to the most exposed organ is the sum of the DDE and the CEDE to the organ with the largest dose. In this case, the deep dose equivalent is 1.44 rem. The lung is the organ with the highest CDE (6.22 rem). The organ dose is the sum, 7.66 rem, which is rounded to 7.7 rem and entered on DOH Form DH 1622.

Table A.3
Organ Dose Factors from Federal Guidance Report No. 11

	Dose per Unit Intake (Sv/Bq)					
Radionuclide	Gonad	Breast	Lung	R Marrow	B Surface	Thyroid
U-238 (D)	2.23×10^{-8}	2.23×10^{-8}	2.80×10^{-7}	6.58×10^{-7}	9.78×10^{-6}	2.22×10^{-8}
U-235 (D)	2.27×10^{-8}	2.28×10^{-8}	2.95×10^{-7}	6.58×10^{-7}	1.018×10^{-5}	2.37×10^{-8}
U234 (D)	2.50×10^{-8}	2.50×10^{-8}	3.18×10^{-7}	6.98×10^{-7}	1.09×10^{-5}	2.50×10^{-8}
Cs-137 (D)	8.76×10^{-9}	7.80×10^{-9}	8.82×10^{-9}	8.30×10^{-9}	7.94×10^{-9}	7.93×10^{-8}
Ce-144 (Y)	2.396×10^{-10}	3.48×10^{-10}	7.91×10^{-7}	2.88×10^{-9}	4.72×10^{-9}	2.92×10^{-10}

Table A.4
Calculated Organ-Specific Committed Dose Equivalents

		Dose Per Unit Intake (Sv/Bq)					
Radionuclide	(μCi)	Gonad	Breast	Lung	R Marrow	B Surface	Thyroid
U-238 (D)	0.022	0.002	0.002	0.023	0.054	0.796	0.002
U-235 (D)	0.0031	0	0	0.003	0.008	0.116	0
U234 (D)	0.060	0.006	0.006	0.071	0.155	2.42	0.006
Cs-137 (D)	1.87	0.061	0.054	0.061	0.057	0.055	0.055
Ce-144 (Y)	2.07	0.002	0.003	6.06	0.022	0.036	0.002
Sum		0.071	0.065	6.22	0.296	3.42	0.065

FLORIDA DEPARTMENT OF HEALTH

OCCUPATIONAL EXPOSURE RECORD FOR A MONITORING PERIOD

SAMPLE

1. NAME (Last, First, M.I.)	2. IDENTIFICATION NUMBER	3. ID TYPE	4. SEX	5. DATE OF BIRTH
McGuire, Stephen A.	113-34-8964	SSN	■ MALE ☐ FEMALE	11/18/1942

6. MONITORING PERIOD	7. LICENSEE OR REGISTRANT NAME	8. LICENSE OR REGISTRATION NO(S).	9A.	9B.
01/01/1994 – 12/31/1994	**XYZ Corporation**	**555-5**	■ RECORD ☐ ESTIMATE	■ ROUTINE ☐ PSE

INTAKES

10A. RADIONUCLIDE	10B. CLASS	10C. MODE	10D. INTAKE IN µCi
U-238	D	H	0.022
U-235	D	H	0.0031
U-234	D	H	0.060
Cs-137	D	H	1.87
Ce-144	Y	H	2.07

DOSES (in rem)

DEEP DOSE EQUIVALENT	(DDE)	11.	1.4
EYE DOSE EQUIVALENT TO THE LENS OF THE EYE	(LDE)	12.	1.7
SHALLOW DOSE EQUIVALENT, WHOLE BODY	(SDE, WB)	13.	1.9
COMMITTED DOSE EQUIVALENT, MAX EXTREMITY	(SDE, ME)	14.	NR
COMMITTED DOSE EQUIVALENT	(CEDE)	15.	1.3
COMMITTED DOSE EQUIVALENT MAXIMALLY EXPOSED ORGAN	(CDE)	16.	6.2
TOTAL EFFECTIVE DOSE EQUIVALENT	(11+15) (TEDE)	17.	2.7
TOTAL ORGAN DOSE EQUIVALENT, MAXIMALLY EXPOSED ORGAN	(11+16) (TODE)	18.	7.7

19. COMMENTS

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.

20. SIGNATURE – LICENSEE OR REGISTRANT

Stephen A. McGuire

21. DATE PREPARED

01/31/1995

DH-1622, Edition 05/1997 (replaces HRS form 1622 which may also be used)

Instructions for Completing DOH Form 1622 "Occupational Exposure Record for a Monitoring Period"

1. Type or print the full name of the monitored individual in the order of last name (include "Jr.", "Sr.", III", etc.), first name, middle name, middle initial (if applicable).
2. Enter the individual's identification number, including punctuation. this number should be the 9-digit social security number if at all possible. If the individual has no social security number, enter the number from another official identification such as a passport or work permit.
3. Enter the code for the type of identification used as shown below:

CODE	ID TYPE
SSN	U.S. Social Security Number
PPN	Passport Number
CSI	Canadian Social Insurance Number
WPN	Work Permit Number
IND	INDEX Identification Number
OTH	Other

4. Check the box that denotes the sex of the individual being monitored.
5. Enter the date of birth of the individual being monitored in the format MM/DD/YYYY.
6. Enter the monitoring period for which this report is filed. The format should be MM/DD/YYYY - MM/DD/YYYY.
7. Enter the name of the licensee or registrant.
8. Enter the Agency license or registration number or numbers.

9A. Place an "X" in Record or Estimate. Choose "record" if the dose data listed represents a final determination of the dose received to the best of the licensee's or registrants knowledge. Choose "Estimate" only if the listed dose data are preliminary and will be superseded by a final determination resulting in subsequent report. An example of such an instance would be dose data based on self-reading dosimeter results and the licensee intends to assign the record dose on the basis of the TLD results that are yet available.

9B. Place an "X" in either Routine or PSE. Choose "Routine" if the data represents the results of monitoring for routine exposures. Choose "PSE" if the dose data represents the results of monitoring of planned special exposures received during the monitoring period. If more than one PSE was received in a single year, the licensee or registrant should sum them and report the total of all PSEs.

10A. Enter the symbol for each radionuclide that resulted in an inter exposure recorded for the individual in the format "Xx-###x"; for instance, Cs-137 or Tc-99m.

10B. Enter the lung clearance class as listed in Appendix B to Part D (D, W, Y, V, or O for other) for all intakes by inhalation.

10C. Enter the mode of intake. For inhalation, enter "H." For absorption through the skin, enter "B." For oral ingestion, enter "G." For injection, enter "J."

10D. Enter the intake of each radionuclied in µCi.

11. Enter the deep dose equivalent (DDE) to the whole body.
12. Enter the lens dose equivalent (LDE) recorded for the lens of the eye.
13. Enter the shallow dose equivalent recorded for the skin of the whole body (SDE, WB).
14. Enter the shallow dose equivalent recorded for the skin of the extremity receiving the maximum dose (SDE, ME).
15. Enter the committed effective dose equivalent (CEDE) or "NR" for "Not Required" or "NC" for "Not Calculated."
16. Enter the committed dose equivalent (CDE) recorded for the maximally exposed organ or "NR" for "Not Required" or "NC" for "Not Calculated."
17. Enter the total effective dose equivalent (TEDE). The TEDE is the sum of Items 11 and 15.
18. Enter the total organ dose equivalent (TODE) for maximally exposed organ. The TODE is the sum of Items 11 and 16.
19. Signature of the person designated to represent the licensee or registrant.
20. Enter the date this form was prepared.
21. COMMENTS. In the space provided, enter additional information that might be needed to determine compliance with limits. An example might be to enter the note that the SDE, ME was the result of exposure from a discrete hot particle. Another possibility would be to indicate that an overexposed report has been sent to the Agency in reference to the exposure report.