NUREG/CR-5631
PNL-7445
Rev. 1
Addendum 1

# Contribution of Maternal Radionuclide Burdens to Prenatal Radiation Doses

## Relationships Between Annual Limits on Intake and Prenatal Doses

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**Prepared for**
**U.S. Nuclear Regulatory Commission**

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Manuscript Completed: September 1993
Date Published: October 1993

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**Prepared for**
**Division of Regulatory Applications**
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**U.S. Nuclear Regulatory Commission**
**Washington, DC 20555-0001**
**NRC FIN B2983**

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

OCT 12 1993

# FOREWORD

The Nuclear Regulatory Commission (NRC) is sponsoring a study designed to improve the understanding of the contribution of maternal radionuclide burdens to prenatal radiation exposure. In March 1992 the NRC published Revision 1 to NUREG/CR-5631, "Contribution of Maternal Radionuclide Burdens to Prenatal Radiation Doses," which provided a method for calculating embryo/fetus dose resulting from radionuclide content in maternal blood.

This addendum is an extension of that report and was developed to facilitate dosimetric assessments in operational radiation protection situations. The addendum provides a method to relate embryo/fetus doses to chronic or repeated intakes, expressed in terms of fractions or multiples of Annual Limits on Intake (ALI), during pregnancy and to preexisting body burdens.

NUREG/CR-5631, Rev. 1, Addendum 1 is not a substitute for NRC regulations, and compliance is not required. The approaches and/or methods described in this NUREG are provided for information only. Publication of this report does not necessarily constitute NRC approval or agreement with the information contained herein.

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## ABSTRACT

This addendum to NUREG/CR-5631, Revision 1, describes approaches to calculating and expressing radiation absorbed doses and dose rates to the embryo/fetus from maternal radionuclide intakes at levels corresponding to Annual Limits on Intake (ALI). To facilitate dosimetric assessments in operational radiation protection, the situations that are addressed include the determination of dose from chronic maternal intakes of radionuclides by inhalation or ingestion during pregnancy and from radionuclide burden in the woman prior to the time at which her pregnancy begins.

These approaches build upon determinations of radiation doses to the conceptus from radionuclides in the woman's transfer compartment that were described in NUREG/CR-5631, Revision 1. However, doses to the embryo/fetus ordinarily would be controlled by maternal intakes, which are restricted in terms of the ALI. The previous dose factors were extended to convert from intakes to activity in the transfer compartment, which allowed use of the tabulated values of gestational-stage-dependent fractional depositions and retentions in the embryo/fetus and the associated dose factors. To simulate chronic exposure, the intake activity was considered as being subdivided into intakes of 1/9 ALI that occurred at the beginning of successive 30-day intervals corresponding to the months of gestation. Separate calculations were performed for ingestion and inhalation and the sums of all increments from the time of exposure through term were obtained by simple addition.

Conventional bioassay and biokinetic modeling approaches can be used to estimate a woman's burden at the beginning of pregnancy from radionuclide intakes prior to her pregnancy. Modeling to estimate the entry of this activity into the embryo/fetus and the resulting dose is not readily accomplished. As a nominal substitute, worst-case scenarios were constructed to develop conservative evaluations of absorbed dose from pre-existing burdens. Calculations assumed ingestion or inhalation intake of an ALI immediately before pregnancy, and initial activity in the transfer compartment was considered to be ALI multiplied by transfer fraction.

The results of the foregoing calculations are tabulated as three complementary dose relationships involving the radiation dose equivalents that correspond to intake of an ALI and the intake levels that would result in a dose of 0.05 rem to the embryo/fetus. These intakes are expressed as fraction of ALI and as activity in $\mu$Ci. It also was desirable to provide approximations of comparable dose factors applicable to radionuclides and forms for which biokinetics in the embryo/fetus have not been established. Values of committed dose equivalent to the uterus per unit intake were used to generate tables of factors to facilitate dose estimates from ingested or inhaled activity. These were tabulated as dose equivalents from intakes of ALI, and placed in formats showing the three complementary intake-dose relationship expressions.

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## EXECUTIVE SUMMARY

NUREG/CR-5631, Revision 1, provides the underlying scientific basis, together with methods and calculations, for determining radiation absorbed doses and dose rates to the embryo/fetus from internal radionuclides in a pregnant woman. This addendum is an extension of that report and was developed to facilitate dosimetric assessments in operational radiation protection situations. Thus, this report relates embryo/fetus dose factors and doses to chronic or repeated intakes, expressed in terms of fractions or multiples of Annual Limits on Intake (ALI), during pregnancy and to pre-existing body burdens.

Dose equivalent limits for the embryo/fetus that are given in 10 CFR Part 20 include the contribution to dose from radionuclides in the embryo/fetus and in tissues of the pregnant woman. Initially, this U.S. Nuclear Regulatory Commission (NRC) project was undertaken to identify, locate, and interpret available information and to make recommendations to the NRC concerning determinations of such radiation doses from internal radionuclides. The previous activities included assembling the available literature, analyzing and tabulating data on placental transfer and concentrations in the embryo/fetus, and developing estimates of radioactivity levels in the embryo/fetus relative to gestational stage and time after exposure. This background information was used to develop approaches to determine activity in the embryo/fetus and the rationale and procedures for calculating radiation absorbed doses to the embryo or fetus from incorporated radionuclides. The recommended approaches to determination of radiation doses to the conceptus from deposited radionuclides were presented in NUREG/CR-5631, Revision 1. The appendix to that document presented a wide array of calculations and tabulations of retained fraction, dose factors, and radiation doses

The approach was based on a simplified scenario that considered a single acute introduction of radioactivity directly into the transfer compartment (blood) of a pregnant woman. Dose factors were calculated relative to the initial activity in her blood and emphasis was directed toward a series of representative ("priority") radionuclides and chemical forms that are of concern for radiation protection. Methods were suggested by which the dosimetrist could use the information for dose assessments relating to exposures in practical or workplace settings. The results of further evaluations, which are described in this addendum, build upon the previous information and methods for the priority radionuclides.

Rationales have been developed that allow relating radiation absorbed dose to levels of maternal radionuclide intakes or to a pre-existing body burden. The specific approaches are predicated on the consideration that internal doses to the embryo/fetus can be related to maternal intake and that these intakes ordinarily are restricted in terms of the ALI as presented in 10 CFR Part 20. Requirements of 10 CFR Part 20 are such that licensee may desire to calculate the cumulative dose to the embryo/fetus that results from an ALI or to the intake that leads to a dose that does not exceed 0.05 rem (5 mSv).

Accordingly, the tables in this addendum facilitate relating maternal intakes with the radiation doses that would be received by her embryo/fetus throughout gestation. Calculations were performed for common physical and chemical forms of the priority radionuclides that were addressed in NUREG/CR-5631, Revision 1. In addition, estimators are suggested for obtaining approximations of comparable dose factors applicable to radionuclides and forms for which biokinetics in the embryo/fetus have not been reported. Results are tabulated as three complementary dose relationships: radiation dose equivalents that correspond to intake of an ALI and intake levels (fraction of ALI and $\mu$Ci), that would result in a dose of 0.05 rem to the embryo/fetus.

One practical situation addressed in this addendum involves embryo/fetus dose relative to chronic maternal intakes of radionuclides by inhalation or ingestion during pregnancy. Multiplication of maternal intake by the relevant transfer fraction or conversion constant, $f_1$ or $TF_1$, translates intake to activity in the transfer compartment. These values were then used to convert the previously tabulated values of gestational-stage-dependent fractional depositions and retentions in the embryo/fetus and associated dose factors to factors that are related to intake. To simulate chronic exposure, the intake activity was considered as being subdivided into intakes of 1/9 ALI that occurred at the beginning of successive 30-day intervals corresponding to each month of gestation. Separate calculations were performed for ingestion and inhalation and the sums of all increments from the time of exposure through term were obtained by simple addition.

Another situation relates to embryo/fetus dose from a radionuclide burden in a woman prior to the time at which her pregnancy begins. Conventional bioassay and biokinetic modeling approaches can be used to estimate a woman's burden at the beginning of pregnancy. Because metabolic modeling to estimate the entry of this activity into the transfer compartment, placental transfer of radioactivity, and the resulting disposition and dose in the embryo/fetus is not readily accomplished, worst-case scenarios were selected to develop conservative evaluations of absorbed dose from pre-existing burdens. It was assumed that the greatest potential dose to the embryo/fetus would result when the total body burden at the beginning of pregnancy was available for uptake to the woman's transfer compartment. Therefore, calculations were based on ingestion or inhalation intake of an ALI immediately before pregnancy, and initial activity in the transfer compartment was taken to be ALI multiplied by transfer fraction. The dose factors presented in Appendix D of NUREG/CR-5631, Revision 1, that corresponded to radionuclide introduction at 0-days or 30-days of gestation were used to calculate dose factors relating to pre-existing burdens of the priority radionuclides.

The foregoing approaches are mainly relevant to situations where dose factors have been determined for the embryo/fetus, such as for the priority radionuclides. An alternative or general surrogate was needed for estimating dose equivalent for other radionuclides for which biokinetic models and dose factors are not yet available. Previously tabulated values of committed dose equivalent to the uterus per unit intake were adjusted by fractional absorption values to generate a table of factors given in NUREG/CR-5631, Revision 1.

Additional calculations were performed to enable the use of these factors for dose estimates relative to ingested or inhaled activity. The results were tabulated as dose equivalents relative to intakes of ALI, and placed in formats showing the same three complementary intake-dose relationship expressions.

Comparisons of results using the surrogate with those directly calculated generally showed reasonable agreement where the biokinetics relating to the embryo/fetus are not dissimilar to that of the uterus (or soft tissue). There are disagreements among the values for other materials. These often are attributable to the difference between the biokinetics of the embryo/fetus as compared to the uterus, which is considered as soft tissue. Another factor contributing to differences between the fetal doses and the uterine doses is the growth and development of the embryo/fetus, which leads to stage-dependent differences in fractional deposition and retention of activity.

# I. INTRODUCTION

This addendum to NUREG/CR-5631, Revision 1 (Sikov et al. 1992) provides methods and calculations to determine radiation absorbed doses to the embryo/fetus from maternal radionuclide intakes, expressed in terms of fraction or multiple of Annual Limits on Intake (ALI). This document is an extension of Revision 1, which provided the underlying basis for estimating radiation absorbed doses and dose rates to the embryo/fetus from internal radionuclides in the transfer compartment of a pregnant woman.

Because of the lack of established methodologies for determining radiation doses to the embryo/fetus from radionuclides in the pregnant woman, research was undertaken for the U.S. Nuclear Regulatory Commission (NRC) to develop procedures. Revision 1 to NUREG/CR-5631 provided recommendations and methods for determining radiation doses to the embryo/fetus from radionuclides in a pregnant woman. The underlying biokinetic information and tabulations of biological and dose factors were provided for a representative selection of "priority" radionuclides and chemical forms that are of concern in radiation protection. The approach in Revision 1 was developed using the simple assumption of a single introduction of unit activity (1 $\mu$Ci) of a radionuclide into the maternal transfer compartment, or blood, for the calculation of dose factors. The resulting series of dose factors (dose rates, doses, and cumulative doses) were tabulated as radiation absorbed dose to the embryo/fetus and separate sets of values were presented for introduction at the start of each 30-day period of pregnancy. These absorbed doses can be multiplied by quality factors to allow expression as radiation dose equivalents for comparisons with the limits.

A similar approach has been used in this addendum to Revision 1, which provides additional dose factors for the priority radionuclides but in formats that are considered to be more amenable to use in operational radiation protection situations. In addition, approaches are suggested for obtaining approximate values of comparable dose factors for a wide range of radionuclides and forms for which biokinetics in the embryo/fetus have not been established. Overall, this addendum aims to relate maternal intakes prior to or during pregnancy with the radiation doses that would be received by her embryo/fetus throughout the remainder of gestation.

One of the practical situations that is addressed in this addendum involves determining radiation dose to an embryo/fetus from chronic maternal intakes of radionuclides by inhalation or ingestion during pregnancy. Another situation relates to radionuclide burden in the woman prior to the time at which her pregnancy begins. It is assumed in both situations that internal doses to the embryo/fetus ordinarily would be controlled by maternal intake. These intakes are restricted in terms of the ALI as presented in 10 CFR Part 20. Accordingly, dose factors have been calculated and are presented in this report relative to fractions or multiples of ALI. These relationships also provide a basis to estimate radiation doses from intakes of radioactivity from the atmosphere or drinking water, which will be useful to epidemiologic evaluations.

It is required by 10 CFR Part 20.1208(d) that if the dose to the embryo/fetus is found to have exceeded 0.5 rem (5 mSv) or is within 0.05 rem (0.5 mSv) of this dose by the time the woman declares pregnancy, the licensee must limit additional doses to the embryo/fetus to 0.05 rem (0.5 mSv) during the remainder of the pregnancy. Thus, a licensee may wish to determine the intake that leads to a cumulative dose to the embryo/fetus that is not likely to exceed the specified 0.05 rem.

Calculations were performed for the most common physical and chemical forms of the priority radionuclides that were addressed in NUREG/CR-5631, Revision 1. Tabulations of results are presented in terms of radiation doses that result from an ALI. Intake levels that would result in a dose of 0.05 rem (0.5 mSv) to the embryo/fetus are also given; these are expressed as fraction of ALI and as activity in $\mu$Ci. Other tables give results of similar calculations to obtain surrogate dose approximations that are based on values of committed dose equivalent to the uterus.

It is commonly accepted that the mammalian embryo or fetus can be adversely affected by radiation at dose levels that are lower than those that produce effects of comparable magnitude in adults. Moreover, prenatal exposures tend to produce unique changes that are related to the gestational stage during which exposure takes place. Gestation-stage-specific effects include induction of lesions such as malformations or congenital deficits of central nervous system function, intrauterine growth retardation, and increased incidence of prenatal or postnatal mortality. In parallel with the stage dependence of radiation response, metabolic and physical characteristics change during prenatal development. These changes in characteristics lead to a close relationship between stage of gestation and the associated biological disposition and dose factors.

Recognition of differences in sensitivity and response has led advisory groups, such as ICRP and NCRP, to recommend that dose from prenatal radiation exposures should be restricted to levels below occupational limits (NCRP 1987, 1993; ICRP 1991). Recently, formal radiation dose limits for the embryo/fetus were specified in 10 CFR Part 20.1208(a). These limits require licensees to ensure that the dose to an embryo/fetus, due to occupational exposure of a declared pregnant woman, does not exceed a total of 0.5 rem (5 mSv) during the pregnancy. The specified radiation dose limit includes the woman's deep-dose equivalent to which is added contributions to dose from internally deposited radionuclides in the embryo/fetus and the woman.

The following sections first address the assumptions and calculational methods used in determining doses in this addendum. Then, doses to the conceptus (embryo/fetus) are calculated for, first, maternal intakes during pregnancy and, then, for burdens of radionuclides that pre-date the pregnancy. These dose factors are calculated for the priority radionuclides identified in Revision 1 and the results are discussed.

## II. DOSIMETRIC CONCEPTS AND CALCULATIONS

Revision 1 to NUREG/CR-5631 provided much of the biological and methodologic information that was used for calculating embryo/fetus doses from maternal intakes (Tables 1-4 of the present addendum). That document recommended methods to estimate radiation doses to the embryo/fetus from many chemical forms of these radionuclides. Results were given as retained fractions of activity in the embryo/fetus and as gestational-stage-dependent dose factors, radiation absorbed dose rates, and doses from a single introduction of unit activity (1 μCi) into the maternal transfer compartment, i.e., the blood. Individual sets of calculations of dose rate and cumulated dose to term were performed to account for the introduction of each radionuclide and chemical form at the start of each 30-day period of gestation.

There are traditional techniques that may be used to calculate absorbed dose rates and doses directly from time-related concentrations in target tissues and surrounding tissues (Quimby and Feitelberg 1963). These calculations combine the number of emissions per unit time, their energies, the time over which emissions are integrated, and accepted physical constants and conversion factors. Not all emissions are absorbed in their tissue of origin, so it is necessary to account for energy loss in the target tissues. For prenatal dosimetry, a time-variant series of factors is needed to adjust for fractional energy absorption, which is a function of path length and target dimensions (i.e., the dimensions of the conceptus). Comparable factors are needed for calculating radiation doses to the conceptus that result from the radioactivity in maternal tissues.

The essential concepts of this traditional process are inherent in the schema described by the Medical Internal Radiation Dose (MIRD) Committee of the Society of Nuclear Medicine (Loevinger et al. 1988). Extending these procedures to prenatal dose calculation involves relatively minor operational differences — chiefly the use of activity instead of concentration. Use of the MIRD schema is particularly attractive because it facilitates incorporation of changing conditions associated with the stage of gestation, such as mass of the conceptus, anatomical dimensions, and placental transfer. In these regards, stage of gestation has several impacts on the biological disposition of radionuclides; these also are accommodated by the MIRD approach to calculation. This methodology also provides a convenient basis to incorporate the changing contribution to prenatal dose of radionuclides in tissues of the pregnant woman.

Previous efforts provided methodology and gestation-stage-dependent dose factors relative to radioactivity that was acutely introduced into the maternal transfer compartment. Additional steps are required to extend the procedures to multiple radionuclide intakes during gestation or to burdens prior to pregnancy. Extending the previous approaches, therefore, involves estimating activity that enters the first transfer compartment from burdens incurred by the woman before pregnancy or from repeated or chronic exposures through all or significant fractions of gestation.

The ALI provides the most convenient nominal value of total maternal intake for use in developing tables that relate intakes to burdens and to radiation dose to the embryo/fetus. Chronic exposures can be approximated by a series of intakes of 1/9 ALI at the beginning of successive 30-day periods of pregnancy. Similar approaches were used as a basis to develop dosimetry for pre-existing body burdens derived from intake of an ALI. The underlying procedure involved multiplying intake or burden by appropriate conversion factors to obtain activity in the transfer compartment.

These previous efforts were extended to encompass the intake phases or pre-existing burdens, and the resulting tabulations (and comparisons of results) are presented here. Calculations were based on stage-related deposition and retention fractions or absorbed dose factors for radionuclides reported in NUREG/CR-5631, Revision 1, when these were available. For other radionuclides, calculations were based on tabulations in Appendix F of that report, which gives embryo/fetus dose factors from nonpregnant uterine doses as surrogates. The limitations to these approximations will be discussed in a later section. It is expected that additional modeling and calculations will be undertaken to provide comparable values for other radionuclides and chemical forms of importance.

## A. FORMALIZATION OF DOSE CALCULATION

Derivation and application of the extensions to the MIRD schema were described in detail in NUREG/CR-5631, Revision 1. Salient features of this approach are repeated in this section to provide the basis for application to their practical implementation.

### 1. Biological Components of the Calculation

Calculation of dose factors can be partitioned into two conceptually separate parts: a biological and a physical component. The biological component involves calculations that determine activity, $A_h(t)$, in the source region, $r_h$, at time t. Values of $A_h(t)$ depend on the properties of the radionuclide that are responsible for its deposition and retention in organs and tissues. These values are derived from biokinetic calculations that include interactions among physicochemical properties of the radionuclide and the physiological processes of the individual and of the conceptus. This calculation requires determination of gestational-stage-related activities in the embryo/fetus, placental structures, and maternal tissues.

The determinations and values in this report are based on available metabolic models such as those given by ICRP 30 (ICRP 1979). Data from NUREG/CR-5631, Revision 1, led to biokinetic models and estimates of initially deposited activity in the conceptus and retained fraction through the remainder of the pregnancy. The derivation involved making specific modifications to the general models to incorporate information concerning placental transfer, distribution, and retention in the embryo/fetus, and ratios of concentration in the embryo/fetus to that in the woman or maternal tissues.

This biological information for several chemical forms of these radionuclides was summarized in Section IV and Appendix B of that report.

2. Physical Considerations in the Calculation

The second component of the calculation, radiation dosimetry, involves the physical properties of the radiations emitted by each specific radionuclide and the absorption of energy in organs or tissues. The composite relationship is given by the S-value or mean absorbed dose rate to a target organ, $r_k$, per unit activity in the source organ. The S-values depend on the physical properties of the emitted radiation, the anatomical characteristics (e.g., physical dimensions), and the elemental composition and density of the mass in which the activity is contained. Therefore, in contrast to the unified MIRD approach, the S-values for the embryo/fetus are dependent on time and stage of gestation.

The mass of the embryo/fetus was calculated from equations given in ICRP 23 (1975) for times greater than 84 days, and values for 30 and 60 days were obtained by extrapolation. These values, together with relevant linear dimensions and maternal masses, were provided as Tables 1 and 2 of NUREG/CR-5631, Revision 1. These parameters were used to derive the values of $A_h(t)$ and $S(r_k \leftarrow r_h, t)$ as well as in other calculations.

The absorbed dose rate in the target region at different stages of gestation, $R(r_k, t)$, is the sum of dose contributions from all source regions:

$$R(r_k,t) = \sum_h A_h(t)\, S(r_k \leftarrow r_h,t) \qquad (1)$$

where t indicates the time-dependence. It is necessary to determine the dose rate to the embryo/fetus at sequential stages of pregnancy and then integrate time-dependent dose rates to determine total dose. The cumulated absorbed dose to the target region, $D(r_k)$, throughout gestation is then given by the integral:

$$D(r_k) = \int_{t_1}^{t_2} R(r_k,t)\, dt \qquad (2)$$

where $t_1$ is the time of intake and $t_2$ is the end of gestation. As was noted above, intake can occur at any time during gestation. Therefore, a series of individual calculations was performed to account for single intakes at times, $t_1$, representing 30-day periods of gestation. Results for other times of intake can be obtained by interpolation.

3. Considerations for Type of Emission

Customarily, radiations are divided into penetrating and nonpenetrating for the determinations of the absorbed fractions that are inherent in the specific S-values. Photons ($\gamma$) of energy higher than 10 keV are considered penetrating radiations. Alpha ($\alpha$) and beta ($\beta$) particles, and photons of energy below 10 keV are usually considered to be nonpenetrating radiations.

a. Alpha particles. Alpha particles, usually not included in MIRD or other dosimetry schemes, must be included in the general approach to maintain consistency. Because of their very short path lengths in tissue, mean absorbed dose in any specific volume may not be a meaningful construct, at least in the theoretical sense. Thus, in situations in which $r_h = r_k$, then $\phi = 1$, but otherwise $\phi = 0$, so that the specific absorbed fraction $\Phi = 1/m_k$ (where $m_k$ is the mass of target organ) or 0, respectively.

b. Beta particles. It is necessary to consider the range of electrons relative to the small sizes of the target region when source regions are maternal tissues (MB) or the embryo/fetus (FB). When maternal tissues are source regions, usual assumptions for nonpenetrating radiations are considered to be adequate and the absorbed fraction $\phi_\beta(FB \leftarrow MB) = 0$. In contrast, in cases where the embryo/fetus is the source region, the value of $\phi_\beta(FB \leftarrow FB)$ may be much less than 1. This is especially relevant at early stages, particularly for higher energy beta particles.

Instead of using the common assumption, $\phi_\beta(FB \leftarrow FB) = 1$, absorbed fractions were calculated under the assumption that the embryo/fetus is an ellipsoid. The dose to the target region from activity contained within the source region was calculated using the Berger (1971) point kernel for beta dose:

$$R_\beta(r) = \frac{k\,y\,E_{ave}\,F_\beta(r/\chi_{90})}{4\pi\rho r^2 \chi_{90}} \qquad (3)$$

where $R_\beta(r)$ is the beta dose rate at the target per unit activity, r is the source-target distance, k is the unit conversion constant, y is the beta yield per disintegration, $E_{ave}$ is the average beta energy per disintegration, $X_{90}$ is the radius of a sphere in which 90% of the beta energy is deposited, $F_\beta(r / X_{90})$ is the scaled absorbed dose distribution, and $\rho$ is the density of the target region. The assumed age-related dimensions of the ellipsoid are given in Table 1 of NUREG/CR-5631, Revision 1.

The sites of deposition of the radionuclides were considered to be point sources for the purpose of dose calculation. The beta dose to a target point is the sum of contributions from all source points within the range of the beta particles. The corresponding beta dose to the target organ, $R_\beta(r_k \leftarrow r_h)$, is given by:

$$R_\beta(r_k \leftarrow r_h) = \frac{\iint A_v(x_h, y_h, z_h)\, R_\beta(r)\, dV_h\, dV_k}{\int dV_k} \quad (4)$$

where $A_v$ is the source activity per unit volume at the source point ($x_h$, $y_h$, $z_h$), $V_h$ is the source volume, and $V_k$ is the target volume. For these dose calculations, the range of beta particles was estimated to be 1.8 times the $X_{90}$ (Berger 1971).

c. Photons. Comprehensive compilations are not currently available to provide values for the specific absorbed fraction $\Phi_\gamma$(FB ← MB) when the embryo/fetus is the target tissue and maternal body is the source region. However, compilations of specific absorbed fractions for the nongravid uterus – the MIRD tables and those presented by Cristy and Eckerman (1987) – serve as a surrogate during early stages of pregnancy. For the 3-month-pregnant female, the data published by Davis et al. (1987) are suggested. Mathematical descriptions of the pregnant woman have also been presented for the third through the ninth month of gestation (Watson et al. 1990). Values of specific absorbed fractions of photons that are applicable to these other stages of gestation may be employed as they become available.

Because appropriate values were not otherwise available for the situation in which the embryo/fetus was the source organ or both the source and target, the computer code MCNP (Briesmeister 1986) was employed to compute specific absorbed fractions, $\Phi_\gamma$(FB ← FB). The embryo/fetus again was assumed to be an ellipsoid with an elemental composition that was the same as the model of a newborn child described by Cristy and Eckerman (1987). It was considered to be entirely soft tissue for times from 30 to 210 days and a combination of newborn soft tissue and skeleton for the 240- and 270-day calculations. Except when noted, the activity was assumed to be uniformly distributed throughout the embryo/fetus. Values of specific absorbed fraction for photons with energies ranging from 10 keV to 4 MeV for every 30-day increment of gestation were given in Table 3 of NUREG/CR-5631, Revision 1.

## B. RADIONUCLIDE INTAKES DURING PREGNANCY

The foregoing sections described general concepts and approaches to practical situations that require determining radiation doses to the embryo/fetus from ingestion or inhalation of radioactivity by a woman during pregnancy. Evaluations for the priority radionuclides were extended by building upon the values of deposited fractions and dose factors from NUREG/CR-5631, Revision 1.

Conventionally, biological disposition is described by the behavior of radionuclides in the transfer compartment, i.e., blood. In practice, therefore, multiplication of maternal intake by the appropriate conversion constant or transfer fraction, $f_1$ or $TF_1$, will translate intake to activity in the transfer compartment. These values were used to convert the previously tabulated values of gestational-stage-dependent fractional depositions and retentions in the embryo/fetus and the associated dose factors to perform the calculation of the present addendum.

Blood uptake factors, $f_1$, for intakes of several forms of the priority radionuclides are included in Tables 1-4 of this addendum.[a] These factors, as adapted from Federal Guidance Report No. 11 (Eckerman et al. 1988), are the numerical equivalent of the transfer fractions, $f_1$, given in ICRP 30 (1979) and ICRP 48 (1986). In most instances, the maximum tabulated value is shown when more than one was available.

1. Routes of Ingestion

The *gastrointestinal absorption* factors that were used to calculate stage-dependent dose factors for ingestion of the priority radionuclides are listed in Tables 1 and 3 of this addendum. Dose equivalent factors for the uterus, as a surrogate for the embryo/fetus, were used to derive estimates for other radionuclides (Table A-1 of the appendix). The results of calculations based on these values provide reasonable estimates in most situations although they are less relevant than directly calculated factors for many radionuclides or chemical forms (see Table 7).

Transfer of *inhaled activity* from lung to blood is ordinarily approached by the use of ICRP lung models that consider incremental movement and clearance class. A less complex method will serve in most situations involving gestational exposure. This approach makes general allowance for the behavior of lung clearance classes, but assumes that uptake into blood is instantaneous. The clearance class of radionuclides in their selected chemical forms was determined from Appendix B to 10 CFR Part 20.1001-20.2401. Appropriate values of the transfer fraction ($TF_1$) were calculated by using the specific equation for that class and the corresponding value of $f_1$. Accordingly, different values of $TF_1$ are used for each of the three inhalation classes to determine activity in blood from activity inhaled:

$TF_1 = 0.48 + 0.15\ f_1$ for class D
$TF_1 = 0.12 + 0.51\ f_1$ for class W
$TF_1 = 0.05 + 0.58\ f_1$ for class Y

These factors were used to calculate stage-dependent dose factors for inhalation of the priority radionuclides. These followed the general scheme that was described for ingestion and yielded the results shown in Tables 2 and 4. Surrogates were likewise calculated; values are given in Table A-2 of the appendix and comparisons are made in Table 8.

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(a) Tables mentioned in this theoretical section of the addendum are found in Section III, close to the more detailed discussions of their derivations.

2. Simulation of Chronic Intakes

Single intakes via injection, ingestion, or inhalation pertain primarily to exposures that result from accidents or medical administration; however, many situations in radiological protection involve repeated or chronic exposures, which require extension of concepts and generalization of exposure scenarios. In particular, the ALI was assumed to be the nominal intake level for each radionuclide and form.

To simulate chronic exposure, the nominal activity was considered as being subdivided into several incremental intakes. It was necessary to obtain a balance between sufficiently small increments of intake and the substantial individual uncertainties that are associated with such situations. As an appropriate compromise, chronic exposure was approximated by intakes of 1/9 ALI that occurred at the beginning of each successive month of gestation.

These values of ALI and the corresponding dose factors (cumulative dose in the period from exposure to term) provided the basis for calculations related to the representative radionuclides reported in NUREG/CR-5631. These dose factors were adjusted by the absorbed fractions from maternal intakes of 1/9 ALI at successive 30-day intervals that correspond to the beginning of months 1, 2, 3...9 of gestation. The sums of all increments from the time of exposure through term were obtained by simple addition and were used for developing Tables 1 and 2.

Similar calculations were performed to derive these complementary intake-dose relationships using uterine dose as a surrogate for other radionuclides for which biokinetic models and dose factors are not yet available (see Tables A-1 and A-2 in the appendix). The values of ALI, from Appendix B to 10 CFR Part 20, usually were taken to be those with the lowest ALI for the selected forms.

a. Ingestion

In applying these parameter values to chronic ingestion, the dose equivalent (rem) resulting from the fractionated ingestion of ALI by the woman was calculated. The list of radionuclides and forms tabulated in NUREG/CR-5631, Revision 1, was expanded to include both soluble and insoluble forms, when applicable. Values of ALI and absorbed fractions for these forms of the radionuclides were multiplied by the previous gestational-stage-dependent dose factors to calculate the cumulated radiation absorbed doses from repeated intakes. Accepted values for quality factor (1 for $\beta$ or $\gamma$; 20 for $\alpha$) were used to convert radiation absorbed doses to dose equivalents (see Table 1).

The inverse relationships - fraction of an ALI and the ingested activity (in $\mu$Ci) that would deliver a cumulated dose equivalent of 50 mrem to the embryo/fetus - also will often be of interest. These complementary values were also calculated and are presented in Table 1. Parallel sets of calculations were performed to derive these three intake-dose relationships - dose equivalent per ALI, fraction of ALI, and ingested activity - for other than the priority radionuclides, using uterine dose as a surrogate (see

Table A-1 in the appendix and Section II.D, below). These calculations were based on the corresponding values of dose equivalent factor, $DF_i$, so that it was not necessary to make adjustments for quality factor.

b. Inhalation

Comparable calculations were performed for chronic inhalations of the radionuclides and forms tabulated in NUREG/CR-5631, Revision 1. The approaches were parallel to those used for ingestion, as above, and the list of selections again was refined on the basis of ALI. As was done for ingestion, three complementary expressions of dose – dose equivalent per ALI, fraction of ALI, and ingested activity (in $\mu$Ci) to deliver a cumulated dose equivalent of 50 mrem to the embryo/fetus – were calculated for these radionuclides and forms (see Table 2).

The corresponding intake-dose relationships were also calculated, as above, for other radionuclides for which biokinetic models and dose factors are not yet available (Table A-2 in the appendix). As discussed in Section II.D, the input values were commitied dose equivalents to the uterus per unit intake and the corresponding fractional absorption values from the gastrointestinal tract or lung. As with ingested activity, these calculations were based on the corresponding values of dose equivalent factor, $DF_i$, so that it was not necessary to adjust for quality factor.

Doses were calculated for all inhalation classes using the ALI values listed in 10 CFR Part 20. The entries for the common inhalation classes of D, W, and Y are identified and segregated in both Tables 2 and 3.

## C. PREGESTATIONAL MATERNAL RADIONUCLIDE INTAKES

Another practical need is to establish the embryo/fetus dose that would result from radionuclide burdens that exist in a woman prior to her pregnancy. Approaches were developed and calculations performed using the concepts and information from NUREG/CR-5631, Revision 1.

Conventional bioassay and biokinetic modeling approaches ordinarily would be used to estimate a woman's burden, which could then be adjusted to the beginning of pregnancy. Metabolic models and information given in ICRP 30, ICRP 54, and other documents and reports could provide quantitative and time-dependent release kinetics from which to estimate the entry of this activity into the transfer compartment. Although it would be complex, such information together with that given in NUREG/CR-5631, Revision 1, sometimes would allow calculating placental transfer of radioactivity and its disposition in the embryo/fetus at subsequent intervals throughout the pregnancy. Adequate information and methodologies are not readily available, however, to evaluate the mobilization of most radionuclides throughout gestation or their availability to the embryo/fetus.

This situation requires nominal substitutes, and worst-case scenarios were selected to develop conservative evaluations of absorbed dose from pre-existing burdens. It was assumed that the greatest potential dose to the embryo/fetus would result when the total body burden at the beginning of pregnancy was available for uptake to the woman's transfer compartment. Therefore, calculations were based on ingestion or inhalation intake of an ALI immediately before pregnancy, and initial activity in the transfer compartment was taken to be ALI multiplied by the transfer fraction.

The dose factors presented in Appendix D of NUREG/CR-5631, Revision 1, are applicable to the priority radionuclides under these conditions. In most instances, the appropriate dose factor would be the cumulated dose that corresponded to radionuclide introduction on the 0-day of gestation. The cumulated doses to the embryo/fetus occasionally were negligible (indicated by N in the tables) for injection at 0 days because of interactions between the biokinetics and time of development of embryonic structures. It would be most convenient to use the entry for cumulative dose from exposure at the start of the second 30-day period in those cases, although a value could be calculated for an intermediate time.

The foregoing provided the basis for calculating dose equivalents to the embryo/fetus that result from intakes of an ALI of the priority radionuclides by ingestion (see Table 3) or by inhalation (Table 4). In addition, the inverse values, fractions or multiples of ALI to deliver 50 mrad during pregnancy (0.5 mSv), were also calculated and are tabulated. Comparable exposure scenarios and dosimetry may be used for other radionuclides through use of the surrogate dose factors that will be discussed in Section III.

D. <u>SURROGATES FOR ESTIMATION</u>

The foregoing approaches are mainly relevant to situations where dose factors have been determined for the embryo/fetus, such as for the priority radionuclides of NUREG/CR-5631. As was implied, alternatives are required to estimate dose equivalent in situations when dose factors are not available. Tabulated values of doses to the uterus from internal radionuclides are considered to provide the most general surrogates for dose to the embryo/fetus, and are particularly relevant to early embryonic stages.

The conversion of uterine committed dose equivalents from activity in the transfer compartment to dose equivalent factors ($DF_i$) for the embryo/fetus was addressed in Section III.C.3 of NUREG/CR-5631, Revision 1. Values of committed dose equivalent to the uterus per unit intake were adjusted by the corresponding fractional absorption values ($f_1$) to generate Table F-1 of Revision 1. These same concepts were employed to generate Tables A-1 and A-2 in the appendix of this report; the procedures will be amplified in Section III.C, below.

Additional calculations were performed to facilitate the use of these factors for dose estimates for ingested or inhaled activity, as well as to provide a basis for examining relationships among parameters and estimators. These were calculated as dose equivalents for intakes of ALI, and placed in formats showing the three complementary intake-dose relationship expressions comparable to those used in Tables 1 through 4. Because calculations of surrogate doses were based on the corresponding values of dose equivalent factor, $DF_i$, adjustments for quality factor were not necessary.

Calculated factors were directly entered into Tables A-1 and A-2 in the appendix for all radionuclides, including those that had been specifically evaluated in NUREG/CR-5631, Revision 1. The tabulated values of cumulated dose for the priority radionuclides (Tables 1 and 2) and the newly calculated values, which were re-expressed as dose equivalents, were used for comparisons with the surrogate values (see Tables 7 and 8).

## III. CALCULATED DOSE FACTORS AND INTERPRETATIONS

This section presents and discusses radiation doses to the embryo/fetus from maternal radionuclide intakes. Dose factors for the series of priority radionuclides described in NUREG/CR-5631, Revision 1, were derived for single direct introductions into maternal blood, and were calculated for each 30-day interval of pregnancy. The contributions of factors such as route of administration, reproductive status, and gestational stage during the exposure period were incorporated into the calculations from which values were determined. Using the approaches described in Section II, the results and values from Revision 1 were incorporated into further calculations to obtain factors relating to exposures by chronic inhalation or ingestion intakes during or before pregnancy.

Committed dose equivalents to the uterus, as surrogate, provided input values to derive dose factors for radionuclides that had not been otherwise evaluated. These surrogate factors were used to generate tables relating to exposures by chronic ingestion or inhalation of these other radionuclides (Tables A-1 and A-2 in the appendix).

### A. INTAKES OF THE PRIORITY RADIONUCLIDES DURING PREGNANCY

#### 1. Ingested Radionuclides

Cumulated radiation doses to the embryo/fetus from maternal ingestion of an ALI were calculated in Table 1 for the expanded series of priority radionuclides. The steps used for calculating such doses, based on the approaches described in foregoing sections, are as follows:

a. Chronic intakes were simulated by assuming ingestion of 1/9 ALI at start of each 30-day interval of gestation that encompasses the exposure period.

b. A cumulative dose factor was selected corresponding to single intravenous injection at each applicable gestational time using values from Appendix D of NUREG/CR-5631, Revision 1.

c. The cumulative dose factor for each interval was multiplied by absorbed fraction, $f_1$, to convert ingestion intake of 1/9 ALI to radiation absorbed dose.

d. Values of cumulative dose for each interval were added to obtain total dose.

e. Radiation absorbed doses were multiplied by quality factor (1 for $\beta$ or $\gamma$; 20 for $\alpha$) to convert to dose equivalent.

The computer files that contained inputs for the original dose factor derivations were available for further calculations. This allowed the use of an operational simplification for many of the further calculations involving ingestion or inhalation of the priority radionuclides. In effect, average stage-related cumulative dose factors may be determined by adding the nine individual cumulative dose values and dividing by nine. Multiplication of ALI by these averages provides values that are mathematically and numerically identical to those obtained by the full calculations for exposure during a[illegible] of gestation. These average dose values and transfer fractions were p[illegible]ammed for direct calculation of the entries to Tables 1 and 2. (The resulting dose factors, applicable to chronic intakes throughout pregnancy, are summarized in Tables 5 and 6.)

2. Inhaled Radionuclides

Table 2 presents cumulated radiation doses to the embryo/fetus from maternal inhalation of the series of representative radionuclides and forms described in NUREG/CR-5631, Revision 1. The entries for the common inhalation classes of D, W, and Y are identified and segregated in this table.

The calculations, parallel those of Table 1, build upon tabulations of dose factors that are based on single direct introductions into maternal blood. An operational simplification, based on average dose factors, also was used with inhalation for calculations leading to Table 2. The following steps for performing direct, or independent, calculation for inhalation of any of the priority radionuclides or forms differ from those for ingestion only in the use of the transfer fraction:

a. Chronic intakes were simulated by assuming inhalation of 1/9 ALI at start of each 30-day interval of gestation that encompasses the period of exposure.

b. From Appendix D of NUREG/CR-5631, Revision 1, a cumulative dose factor was selected corresponding to single intravenous injection at each applicable gestational time.

c. The appropriate value of the transfer fraction ($TF_1$) was calculated from the corresponding value of the absorbed fraction, $f_1$, and the conversion equation for inhalation class.

d. The cumulative dose factor for each interval was multiplied by transfer fraction ($TF_1$) to convert inhalation intake of 1/9 ALI to radiation absorbed dose.

e. The values of cumulative dose for each interval were added to obtain total dose.

f. Radiation absorbed doses were multiplied by quality factor (1 for $\beta$ or $\gamma$; 20 for $\alpha$) to convert to dose equivalent.

3. <u>Use of Tables 1 and 2 for Finding Cumulated Doses from Chronic Intakes</u>

The radionuclides and forms that are characterized in Table 1 are listed in the first and second columns, respectively. Their $f_1$ values are given in the third column and the corresponding values of ALI are shown in the fourth column. A similar arrangement is used in Table 2, but the inhalation classes are interposed as a third column.

To provide information for chemical forms of general interest and potential importance in operational situations, additional radionuclidic compounds were evaluated beyond those in NUREG/CR-5631, Revision 1. Values of oral ingestion ALI were not presented in column one of Table 1, Appendix B, 10 CFR Part 20, for all of the chemical forms that are included in Table 1 of this addendum. Values comparable to the ALI were calculated from information provided in Federal Guidance Report No. 11 (Eckerman et al. 1988). It was considered desirable to use common formats for Tables 1 and 2 to facilitate internal and between-table comparisons. Therefore, all compounds are listed in the body of Table 1 but the secondary entries are shown in italics to indicate that they were not derived from 10 CFR Part 20.

The three right-most columns of Tables 1 and 2 present the results of the calculations designed to facilitate assessment of radionuclide exposures of pregnant women in operational situations. In particular, they provide factors that can be used to determine dose equivalent to the embryo/fetus from chronic radionuclide intakes by a pregnant woman. The third column from the right presents the calculated dose equivalents (rem) that result from ingestion of an ALI under the above conditions.

As noted in Section I (above), 10 CFR Part 20.1208 specifies 0.05 rem as the additional increment that should not be exceeded if the dose to the embryo/fetus had exceeded 0.5 rem at the time the woman declares pregnancy. To facilitate determination of this limiting value, the last two columns of these tables give the values inverse to dose per ALI, i.e., chronic intakes that would deliver a cumulative dose equivalent of 0.05 rem (50 mrem). These are expressed in the second column from the right as fraction of an ALI and in the right-most column as the activity ($\mu$Ci).

4. <u>Explanations and Interactions</u>

The greater number of radionuclidic compounds presented in Table 1 than in the tabulations of NUREG/CR-5631, Revision 1, was noted above, and even more categories are listed in Table 2. The increased numbers of forms of materials reflect the need to account for the fact that many radionuclides may enter the body as a variety of soluble compounds or as insoluble forms that have differing behavior. The inclusion of ingested $^3$H as sugars or amino acids and of cobalt isotopes as vitamin B-12 follows the rationale of Revision 1, while their omission from Table 2 recognizes the underlying practical considerations.

As suggested by entries in both tables, route-related differences pertain to the alkaline earths, strontium and yttrium, ruthenium/rhodium, and the heavy elements, uranium and plutonium. The transfer fractions ($f_1$) of these forms may differ, a fact which is also involved in the differences among the corresponding values of ALI. The solubility differences that pertain for inhaled forms of the heavier radionuclides are more prominent than for ingestion, but the insoluble forms are not considered under oral ingestion in 10 CFR Part 20.

There are other intuitively obvious comparisons and patterns among the results. The existence of similar quantitative behaviors among isotopes of an element leads to similar values of fractional uptake from the gastrointestinal tract or lung but half-life differences may affect differences in biological disposition. Among other prominent factors is the effect that solubility may have on entry into the transfer compartment and, accordingly, on the ALI. Placental transfer is not directly related to transfer fraction, so that the time course of activity in the conceptus may differ from that in the woman.

Differences among half-lives of isotopes of an element also lead to differences in biokinetics, fractional deposition, and retention in the embryo/fetus. Likewise, interplay between the energy of emissions and physical dimensions is responsible for different relationships between the deposited fraction of the energy in the woman and in the conceptus. In turn, the relationships between absorbed activity and radiation dose may vary among isotopes of an element in a given physical or chemical form.

Calculations in Tables 1 and 2 employed the maximum values of $f_1$ derived from Federal Guidance Report 11 (Eckerman et al. 1988) and ICRP 48 (ICRP 1986). Most calculations were based on values of ALI from 10 CFR Part 20 although some employed values comparable to ALI but derived from data in Federal Guidance Report 11. Rounded values of ALI and $f_1$ are tabulated to one significant figure in the original documents. Multiplication of these tabulated numbers by derived factors, such as constants used to obtain $TF_1$ for inhalation or the dose factors given in NUREG/CR-5631, Revision 1, occasionally led to distortions of relative dosimetric values. An analogous uncertainty of ±1 in the single-digit significant figure also occurred through the effect of rounding of values when used for calculating entries to Tables 3 through 6.

These slight inaccuracies in factors can lead to the possibility of confusion due to inconsistencies among entries in these tables. Several of the interactions are conveniently illustrated by the situation with isotopes of cesium, which has an $f_1$ value of 1. The ratio of the tabulated ALI values for $^{134}Cs$ relative to $^{137}Cs$ is 0.5, but it is about 0.7 when unrounded values are used. The initially calculated doses of rem per ALI were 6 and 4 for ingestion of the two isotopes, respectively, but the inverse numerical relationship, 5 and 6 rem, was obtained for inhaled activity. Using the unrounded values, however, doses per ALI are determined to be 5.8 for $^{134}Cs$ by either route and 4.4 for $^{137}Cs$. These values, as rounded to 6 and 4, are given in Tables 1 and 2. When particularly egregious discrepancies were noted, comparable calculations were performed using the underlying data to obtain the values that were tabulated. Adjustment to account for the effect of rounding was not undertaken in cases where resultant differences were a single figure or where there was not a reversal between entries in the two tables.

It might be expected, a priori, that because the ALI is determined from the committed effective dose equivalent limit, the dose to embryo/fetus per ALI should be the same for similar isotopes in a given chemical form. The above-noted differences between the embryo/fetus doses for these two isotopes of cesium do not meet this expectation. The tabular presentations emphasize differences among dose factors for forms and isotopes that evolve from biokinetics and physical constants. Comparable differences in retention and dose factor are inherent in the tables of Appendixes C and D of NUREG/CR-5631, Revision 1; these were rarely apparent because there was not an occasion for direct comparison. Moreover, the apparent discrepancy serves to identify other considerations that deserve explanation.

Because of the impact on biokinetics of the different half-lives of $^{134}$Cs and $^{137}$Cs, the retained fraction of activity in the embryo/fetus decreases more rapidly with $^{134}$Cs than with $^{137}$Cs and results in a greater difference from the maternal pattern (see Tables C-56 and C-58 of NUREG/CR-5631, Revision 1). The disparity between the relative retention of the two isotopes is partially obscured by effects attributable to decay pattern, energy per emission, and absorbed fraction of emissions. The interplay among these several factors leads to the differences between corresponding dose factors that are given in Tables D-24 and D-26 of Revision 1. The indicated differences in Tables 1 and 2 in this addendum result from an almost two-fold difference between the underlying average dose factors, 8.6E-02 and 4.5E-02, that were used for calculations with the two isotopes (see Tables 5 and 6).

Other results in Tables 1 and 2 generally are internally consistent and in accord with descriptions and tabulations of NUREG/CR-5631, Revision 1. Nevertheless, there will be differences among entries for isotopes or forms of elements that may, upon initial inspection, appear to be discrepancies or errors of calculation or tabulation. Reasonable and instructive explanations may be found by examination of the underlying systematics, as is illustrated with cesium.

There is agreement between the complementary dose factors for ingestion and inhalation of tritium or of carbon during pregnancy. There are differences between the dose factors for tritiated water and for organic tritium (only as a sugar or amino acid). As was discussed in Sections IV.B.1 and B.2 and Appendix B of Revision 1, the underlying biokinetic models predict significant retention of organic tritium as persistent compounds in the embryo/fetus compartment. This persistence results in a higher absorbed dose than that for tritiated water, which is cleared with a 10-day half-life.

Agreement may not be as good for sets of entries where emission energy and half-life relationships are complex or where there are differing degrees of placental transfer. Essentially constant values of dose per ALI values are obtained for the three isotopes of cobalt in inorganic form. There is a six-fold difference between the $f_1$ values of $^{57}$Co and $^{60}$Co while the dose factors for their inorganic and organic compounds differ by a factor of

5 to 7. This leads to a 15-fold difference in the amount of intake activity that will give the same doses to the embryo/fetus.

There are marked differences between the doses per ALI to the embryo/fetus from maternal ingestion of the two forms of $^{89}$Sr even though the tabulated ALIs are similar. The ALI value for the insoluble form ($f_1$ = 0.01) is non-stochastic and is based on dose to the woman's intestinal wall. Little of this activity enters the transfer compartment and becomes available for placental transfer. The soluble form ($f_1$ = 0.3) is associated with a stochastic ALI and a substantially greater fraction of the activity is transferred to the embryo/fetus. There are several-fold differences between the inhalation ALI values for the two forms of both $^{89}$Sr and $^{90}$Sr/$^{90}$Y, some of which are stochastic and others non-stochastic. The magnitudes of the differences among the corresponding embryo/fetus doses per ALI are even greater by as much as tenfold. There are comparable differences between the oral ALI values for soluble $^{90}$Sr/$^{90}$Y tabulated in 10 CFR Part 20 and the derived value for the insoluble form. Nevertheless, differences in absorption lead to there being little difference between the doses per ALI.

Finally, the time of the uptake of the radioiodines by the fetal thyroid must be taken into account in interpretation of results. The influence of the temporal factor is significant, and allows for relatively more placental transfer and localization in the thyroid of radioiodines with longer half-lives. This affects the fraction of radioactivity intake in the fetus, but it does not lead to relative doses that are completely monotonic with half-life. The departure from a simple pattern reflects variations among the energies of the beta particles emitted by the several isotopes, as well as the associated gamma energies per decay.

## B. PRE-EXISTING BURDENS OF PRIORITY RADIONUCLIDES

As was discussed in Section II.C, doses to the embryo/fetus also may derive from radionuclide body burdens that remain following ingestion or inhalation intakes of radioactivity by a woman prior to becoming pregnant. Conventional bioassay and biokinetic modeling approaches will serve to estimate the woman's burden at the beginning of pregnancy. Further modeling to account for mobilization of this activity and its entry into blood, placental transfer, and deposition and retention in the embryo/fetus usually will be complex.

The use of substitutes to obviate the need for more sophisticated determinations was also described in Section II.C. The resulting approach, which was used to calculate the values given in Tables 3 and 4, provides conservative estimates of absorbed doses to the embryo/fetus. This worst-case scenario considers the total body burden at the beginning of pregnancy to be available for uptake to the woman's transfer compartment. The radioactivity is assumed to be transferred instantaneously so that initial activity in the transfer compartment is calculated as the ALI multiplied by the transfer fraction relating to ingestion or inhalation intake.

The dose factors in Appendix D of NUREG/CR-5631, Revision 1, are applicable to dosimetry of the priority radionuclides under these conditions. In most instances, therefore, the corresponding dose factor was taken to be the cumulated dose for radionuclide introduction on 0-days of gestation. Because of interactions between the biokinetic model and time of development of structures in the embryo/fetus, in some instances the cumulated doses to the embryo/fetus were negligible following introduction at the start of the first month of gestation. In these cases, the entry for cumulative dose for exposure at the start of the second month can be used instead. Suggestions of the nominal gestational times to be considered as the start of exposure and the corresponding dose factors are provided for the expanded lists of priority radionuclides (see Tables 5 and 6).

1. <u>Ingested Activity</u>

Dose to the embryo/fetus was calculated under the assumption that total body burden at the beginning of pregnancy was available for uptake to the woman's transfer compartment. This situation was simulated using ingestion of an ALI immediately prior to pregnancy. Thus, the resulting burden corresponded to ALI multiplied by the transfer fraction from the gastrointestinal tract; this was taken as being present in the transfer compartment. Radiation absorbed dose was obtained by multiplying this content of radioactivity by the corresponding dose factor.

The dose factor usually was taken to be the cumulated dose associated with introduction of the radionuclide and its form on 0-days of gestation. In some instances, the biokinetics were such that the cumulated dose for the first month was negligible; in these instances the entry for the second month was used instead. Multiplication by values for quality factor (1 for $\beta$ or $\gamma$; 20 for $\alpha$) was used to convert radiation absorbed doses to dose equivalents. The inverse relationships - the fraction of an ALI and the ingested activity (in $\mu$Ci) that would deliver a cumulated dose equivalent of 50 mrem to the embryo/fetus - were also calculated and are presented in Table 3.

The foregoing approach is directly applicable only when dose factors are available, such as those considered in NUREG/CR-5631, Revision 1, for the priority radionuclides. In other situations, dose equivalent to the embryo/fetus would be estimated as the product of maternal burden and a dose equivalent factor, such as those shown in Table A-1 in the appendix.

2. <u>Inhaled Activity</u>

The scenario used to evaluate dose corresponding to a burden from inhalation of an ALI prior to pregnancy paralleled the approach for ingested activity. Inhalation of an ALI immediately prior to pregnancy was assumed so that the resulting burden corresponded to the ALI multiplied by the inhalation transfer fraction. The calculation of dose to the embryo/fetus again assumed that total body burden at the beginning of pregnancy was available for uptake to the woman's transfer compartment. Thus, the resulting burden corresponded to ALI multiplied by the transfer fraction from the lung. This activity was taken as being present in the transfer compartment and absorbed dose was obtained by multiplication by the corresponding dose factor

It also was assumed that intake occurred during the first month of gestation so that the corresponding dose factor was the cumulated dose for radionuclide introduction on 0-days of gestation. In instances in which cumulated dose was negligible for the first month, the entry for the second month was used instead. Values of 1 for β or γ and 20 for α were used to convert radiation absorbed doses to the tabulated values of dose equivalent (Table 4). The corresponding inverse relationships - the fraction of an ALI and the ingested activity (in μCi) that would deliver a cumulated dose equivalent of 50 mrem to the embryo/fetus - were also calculated and are presented in Table 4.

3. Use of Tables 3 and 4 for Finding Cumulated Doses from Pre-Existing Burdens

The results of dosimetric analyses associated with pre-existing burdens of the expanded lists of radionuclides and forms derived from NUREG/CR-5631, Revision 1, are shown in Tables 3 and 4. The resulting dosimetric results for the embryo/fetus are given in the three right-most columns. The value of ALI is shown for each form (compound and class) of each radionuclide to facilitate comparisons with the parallel descriptions given for Tables 1 and 2.

As was noted in Section I to the addendum and in the discussion of Tables 1 and 2 (Section III.A.3), 10 CFR Part 20.1208 specifies 0.05 rem as the additional increment that should not be exceeded if the dose to the embryo/fetus exceeded 0.5 rem at the time the woman declares pregnancy. Based on a dose limit for the embryo/fetus that is 1/10 of the adult limit, together with a monthly limit that is a nominal 1/10 of the total dose limit, 1% of ALI has been suggested as a threshold above which the calculation of dose from a pre-existing maternal burden was warranted (NRC 1992).

The last two columns of Tables 3 and 4 provide complementary information in terms of the inverse values to dose per ALI. These are the full burdens from simulated intakes at the inception of pregnancy that would deliver a cumulative dose equivalent of 0.05 rem (50 mrem). These are shown in the second column from the right as fraction of ALI while the right-most column presents the same values expressed as activity (μCi). The information in these columns should facilitate determination of this limiting value and may be useful in operational situations.

In particular, the column "fraction of ALI for 50 mrem" is useful for evaluating the validity of the approximations that have been suggested for situations in which actual values are not available or to determine the need for more dosimetric assessment (see Section I). Thus, a value of 1E-02 (i.e., 1/100) in this column would represent complete agreement between the suggested "1% ALI approximation" and numerical results from calculations that were based on values from NUREG/CR-5631 Revision 1.

4. Explanations and Interactions

In the discussion of Tables 1 and 2, it was noted that the use of rounded values of ALI from 10 CFR Part 20 could lead to apparent discrepancies in the relationships among the dosimetric values for some radionuclides. Unrounded values of ALI were employed for calculation in these cases to obviate confusion. Analogous perturbations were found to occur through rounding of values that were used for calculating entries in Tables 3 and 4. For consistency, when unrounded values had been employed for Tables 1 and 2, the same values were used for Tables 3 and 4.

The relationships considered for chronic exposure in the preceding section are further illustrated and emphasized by comparisons based on these tabulations. As is to be expected from the basis for estimation, there is reasonable agreement between relative doses from burdens resulting from ingestion and inhalation of tritium, carbon, and cesium isotopes prior to pregnancy. The pattern of calculated doses are in general accord for these materials, all of which are uniformly distributed, have relatively simple biokinetic models, and readily cross the placenta. Moreover, about 1% of ALI or more is required to yield the limiting dose of 0.05 rem.

Agreement is not as good among entries relating to cobalt, strontium, and iodide, where there are more complex differences relating to absorption, biokinetics, placental transfer, half-life, and dosimetry. Other than for $^{57}$Co- and $^{60}$Co-labeled vitamin B-12, where a fraction of about 1E-02 ALI gives 50 mrem, much greater activities of these radionuclides are required to obtain that dose.

There is good correspondence among values for isotopes of uranium and of plutonium after ingestion, but values for inhaled uranium are further affected by the isotope, form, and route. Nevertheless, these prototypic pregestational maternal intakes in excess of a full ALI of these isotopes of uranium, plutonium, or americium should give cumulated doses to the embryo/fetus of less than 0.05 rem.

C. RADIONUCLIDES OTHER THAN PRIORITY LIST OF NUREG/CR-5631

The extension of available values of radiation dose to the uterus will provide surrogate dose factors for radionuclides for which stage-related dose factors have not been determined. The underlying approach, which consisted of dividing committed uterine dose factors by corresponding transfer fractions, had been used in the NUREG/CR-5631, Revision 1 (Table F-1), for radionuclides that had not been otherwise evaluated. Further calculations provided the results relating intake of radioactivity to radiation dose that are tabulated in the present addendum. These were based on committed dose equivalents to the uterus per unit intake that had been generated for Federal Guidance Report No.11 (Eckerman et al. 1988) and are numerically equivalent to values given by ICRP 30 or ICRP 48. The underlying detailed data were obtained from a computer disk that was supplied to the NRC by Dr. Keith F. Eckerman of the Oak Ridge National Laboratory.

1. Calculation of Surrogate Dose Factors for Chronic Intakes During Pregnancy

Surrogate committed dose equivalent factors for the embryo/fetus based on unit activity in blood (NUREG/CR-5631, Revision 1, Table F-1) had been obtained by dividing the uterine committed dose equivalent factors by the corresponding fractional absorption value ($f_1$). This conversion was not required in performing the present evaluations because the underlying ICRP 30 uterine dose values were already available as rem/$\mu$Ci intake. For ingestion, the maximum value of $f_1$ was used to calculate uptake or transfer fraction ($TF_1$) when there was more than one value. For inhalation, ALI values for the inhalation classes D, W, and Y listed in the 10 CFR Part 20 were used. Doses for ingestion and inhalation are shown in Tables A-1 and A-2, respectively, in the Appendix.

2. Calculation of Surrogate Dose Factors for Pre-existing Burdens

It was suggested in Section II.C that a comparable exposure scenario and dosimetric approach might be used in the case of radionuclides for which dose factors are not available. Thus, general estimates would be obtained through the use of surrogate dose factors such as those that were discussed in preceding sections. On these bases, committed dose equivalent to the embryo/fetus would be estimated as the product of maternal burden at the start of pregnancy and the dose factor given in Appendix F of NUREG/CR-5631, Revision 1. These approximations were not calculated and are not among the relationships to be reported in this document.

3. Validity of Uterine Surrogates for Chronic Intakes

The question arises as to how well the approximations afforded by committed dose equivalent to the uterus represent the absorbed doses to the embryo/fetus directly calculated from the biokinetic models. A major factor that can lead to numerical differences was discussed in Section III.C.3 of NUREG/CR-5631, Revision 1. This involves differing time-scale concepts for the underlying committed dose determinations, which form the basis from which the uterine doses are calculated relative to those for absorbed dose from exposure during gestation. The dose equivalent limit specifically is stated as cumulated dose to the embryo/fetus during the 9 months of pregnancy while the committed dose involves total decay in situ and so could extend beyond term. The time periods over which radiation doses are cumulated will be similar when the radionuclides have relatively short physical or biological half-lives, so that differences in expression will not have a detectable impact. For long-lived materials, however, these same factors can lead to overestimates of radiation dose to the embryo/fetus.

The surrogate does not account for uptake into fetal organs; as was clearly illustrated by the radioiodines, this distribution difference leads to higher doses than estimated from the uterus. Another consideration that was also illustrated by the radioiodines is the differing effect that rates of incorporation into and release from the transfer compartment will have for isotopes with either long and short half-lives. This relationship will directly influence relative uterine doses for elements and further allowance must be made for the impact of short half-lives on placental transfer and target-organ distribution.

The differences among the isotopes of chlorine provide a striking illustration of the impact of this situation on the surrogate represented by uterine dose. Although not directly modeled or calculated, it is a logical expectation that these would have an even greater effect on dose to the embryo/fetus. Chorine-36, with a half-life of 3 x $10^5$ years and a 0.27 MeV average β-particle energy, has a stochastic ALI of 2E+03 while the non-stochastic (stomach wall) ALI for the short-lived isotopes of mass 38 and 39, which have more energetic β-particles, are 10-times higher, or 2E+04.

Because of the interactions among factors, intake of an ALI of $^{36}$Cl would yield a committed dose of 6 rem to the uterus. The times required for uptake from the gastrointestinal tract and for tissue deposition lead to a marked contrast with other isotopes. Thus, the committed dose from $^{38}$Cl (1.5 MeV, half-life of 37 min) is 0.6 rem, and from $^{39}$Cl, which has a less energetic particle and slightly longer half-life (0.8 MeV, half-life of 55.6 min) gives a dose of 0.8 rem; both total doses would be delivered within hours after intake. Similar comparisons pertain with inhaled uptakes of these isotopes. Moreover, the comparable differences among isotopes of several other elements that are evident throughout Tables A-1 and A-2 are amenable to similar explanations.

4. Comparison of Results of Direct, Surrogate, and Maximized Dose Calculations

Tables 7 and 8 facilitate the comparison of the direct and surrogate approaches to determining embryo/fetus dose. The embryo/fetus doses listed in columns 3 (Table 7) or 4 (Table 8) of these tables (expressed rem from ingestion or inhalation of 1/9 ALI at the beginning of each 30-day period of gestation) are those also given as dose per ALI in Tables 1 and 2, respectively, of the present addendum. The following columns in Tables 7 and 8 repeat the corresponding values of dose to the uterus given in Tables A-1 or A-2. The following column in Tables 7 and 8 presents the ratio of the directly calculated doses to the embryo/fetus to the uterine dose.

The listings of radionuclides are truncated from those of Tables 1 and 2, being restricted to those for which all three doses were available. This still allows inclusion of separate entries for tritium as water and in organic form, and inhalation of elements with markedly different solubilities and inhalation classes. Where feasible, doses for the maximum value of $DF_1$ were used and their chemical forms are listed.

Radionuclides and forms with reasonable agreement include $^3$H (both as water and organic compounds). As was noted for Tables 1 and 2, organic compounds give a higher dose because their metabolites are retained in the embryo/fetus, while tritiated water is cleared with a 10-day half-life. The differing retentions are a consequence of high rates of structural protein synthesis in the embryo/fetus, which does not apply to organs such as the uterus. Differences among the values for $^{57}$Co and $^{60}$Co in inorganic form and as vitamin B-12 resulted in a wide range of embryo/fetus doses per intake of an ALI. These factors do not affect the relationships among doses to the embryo/fetus and to the uterus, so that there was little difference between values obtained by direct calculation and through use of the surrogate. Likewise, extended discussion was required to explain the interplay between retention and embryo/fetus dosimetry that followed intakes of $^{134}$Cs relative to $^{137}$Cs. These considerations relate equally to the embryo/fetus and to the uterus, so that the ratios are similar (see Section III.A.4).

There are marked differences between dose to the embryo/fetus and the uterus from soluble and insoluble forms of $^{89}$Sr. Dose factors presented in Table D-9 of NUREG/CR-5631, Revision 1, differ by a factor of three, depending on the time of intake resulting from stage-dependent differences in deposited fraction. The dose factors are much higher than for the uterus subsequent to the first two months of gestation. Because each gestational-stage-dependent dose factor contributes equally to the final dose factor, the pattern results in a higher dose to the embryo/fetus than to the uterus.

The ratios are nearly zero for $^{106}$Ru/$^{106}$Rh. As noted in the discussions of Tables 2 and 3, the literature showed that placental transfer was negligible but the initial fetal concentration was assumed to be 5% of that in the pregnant woman to provide a nominal value for activity. Thus, essentially none of the activity was present in the embryo/fetus. This distribution pattern, together with the high energy of the rhodium beta particles, leads to much higher doses to the uterus than to the embryo/fetus.

The radioiodines also yield disparate doses because their high uptake by the fetal thyroid in later gestation leads to substantially higher fetal doses than doses to the uterine surrogate. This interacts with additional time for placental transfer and thyroid localization of isotopes with longer half-lives, but the relative doses are not monotonic with half-life. The departure from a simple pattern reflects variations among the energies of the beta particles and gammas of the several isotopes, and the associated impact on absorbed fractions for direct calculation of doses to the embryo/fetus and the the uterine surrogate.

For uranium, plutonium, and americium, the underlying model does not assume any clearance after the radionuclide has been deposited in the embryo/fetus. Also, initial fetal concentrations are assumed to be 1.5 to 3 times higher when the intakes occur subsequent to two months of pregnancy although this factor is compensated by growth of the embryo/fetus.

The results show a reasonable agreement between uranium doses to both the embryo/fetus and the uterus. For plutonium and americium, the new $f_1$ values of ICRP 48 were used for the prenatal-dose calculations, which leads to disagreement of a factor of 10, as shown for both $^{238}$Pu and $^{239}$Pu. In the model for $^{241}$Am, however, the fetal concentration is assumed to be one-fifth that for plutonium, which led to less disagreement. Similar explanations pertain for the differences with inhalation of these elements (Table 8).

For further comparison, the two columns on the far right of Tables 7 and 8 present a third set of dose estimates, those for the maximized dose to the embryo/fetus, which allow an examination of the impact associated with a simplification in Regulatory Guide 8.36 (NRC 1992). Comparable doses were calculated on the basis of the maximum dose factor for each radionuclide, as tabulated in Appendix D of NUREG/CR-5631. The ratio of the directly calculated dose to this maximum dose is given in the right-most column. In some instances, a ratio of 1 or slightly less is shown, although it is often in the range of 0.5. Such relationships are not unexpected and confirm that the simplification will yield conservative estimates of dose.

Table 1. Cumulated radiation doses to the embryo/fetus from chronic maternal ingestion of important chemical or physical forms of the priority radionuclides[a]

| Nuclide | Compound | $f_1$ | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|---|---|
| H-3 | Water | 1E+00 | 8E+04 | 3E+00 | 1E-02 | 1E+03 |
| *H-3* | *Sugar/amino a.* | *1E+00* | *8E+04* | *7E+00* | *7E-03* | *5E+02* |
| C-14 | Sugar/amino a. | 1E+00 | 2E+03 | 2E+00 | 3E-02 | 7E+01 |
| Co-57 | Inorganic | 5E-02 | 8E+03 | 7E-01 | 7E-02 | 6E+02 |
| Co-58 | Inorganic | 5E-02 | 2E+03 | 8E-01 | 6E-02 | 1E+02 |
| Co-60 | Inorganic | 5E-02 | 5E+02 | 8E-01 | 6E-02 | 3E+01 |
| Co-57 | Vitamin B-12 | 3E-01 | 4E+03 | 5E+00 | 1E-02 | 4E+01 |
| Co-60 | Vitamin B-12 | 3E-01 | 2E+02 | 4E+00 | 1E-02 | 2E+00 |
| Sr-89 | Soluble | 3E-01 | 6E+02 | 2E+00 | 2E-02 | 1E+01 |
| Sr-89 | Insoluble | 1E-02 | 5E+02 | 6E-02 | 8E-01 | 4E+02 |
| Sr/Y-90 | Soluble | 3E-01 | 3E+01 | 3E-01 | 2E-01 | 5E+00 |
| *Sr/Y-90* | *Insoluble* | *1E-02* | *5E+02* | *2E-01* | *3E-01* | *1E+02* |
| Ru/Rh-106 | All | 5E-02 | 2E+02 | 6E-02 | 9E-01 | 2E+02 |
| I-125 | All | 1E+00 | 4E+01 | 3E-02 | 2E+00 | 8E+01 |
| I-131 | All | 1E+00 | 3E+01 | 4E-02 | 1E+00 | 3E+01 |
| I-132 | All | 1E+00 | 4E+03 | 5E-01 | 9E-02 | 4E+02 |
| I-133 | All | 1E+00 | 1E+02 | 7E-02 | 7E-01 | 7E+01 |
| I-134 | All | 1E+00 | 2E+04 | 7E-01 | 7E-02 | 1E+03 |
| I-135 | All | 1E+00 | 8E+02 | 3E-01 | 2E-01 | 2E+02 |
| Cs-134 | All | 1E+00 | 7E+01 | 6E+00 | 8E-03 | 6E-01 |
| Cs-137 | All | 1E+00 | 1E+02 | 4E+00 | 1E-02 | 1E+00 |
| U-233 | Hexavalent | 5E-02 | 1E+01 | 1E-01 | 3E-01 | 3E+00 |
| *U-233* | *Insoluble* | *2E-03* | *2E+02* | *1E-01* | *4E-01* | *9E+01* |
| U-234 | Hexavalent | 5E-02 | 1E+01 | 1E-01 | 3E-01 | 3E+00 |
| *U-234* | *Insoluble* | *2E-03* | *2E+02* | *1E-01* | *4E-01* | *9E+01* |
| U-235 | Hexavalent | 5E-02 | 1E+01 | 1E-01 | 4E-01 | 4E+00 |
| *U-235* | *Insoluble* | *2E-03* | *2E+02* | *1E-01* | *5E-01* | *9E+01* |
| U-238 | Hexavalent | 5E-02 | 1E+01 | 1E-01 | 4E-01 | 4E+00 |
| *U-238* | *Insoluble* | *2E-03* | *2E+02* | *1E-01* | *5E-01* | *1E+02* |

Table 1. (contd)

| Nuclide | Compound | $f_1$ | ALI (μCi) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem (μCi) |
|---|---|---|---|---|---|---|
| Pu-238 | Not $PuO_2$ [(b)] | 1E-03 | 9E-01 | 5E-04 | 1E+02 | 9E+01 |
| *Pu-238* | *$PuO_2$* | *1E-05* | *9E+01* | *5E-04* | *1E+02* | *9E+03* |
| Pu-239 | Not $PuO_2$ | 1E-03 | 8E-01 | 4E-04 | 1E+02 | 1E+02 |
| *Pu-239* | *$PuO_2$* | *1E-05* | *8E+01* | *4E-04* | *1E+02* | *1E+04* |
| Am-241 | All | 1E-03 | 8E-01 | 9E-05 | 6E+02 | 5E+02 |

(a) Entries shown in italics identify compounds for which calculations are not based on values of oral ingestion ALI taken from Table 1, Appendix B, 10 CFR Part 20. Values comparable to ALI were derived independently from Eckerman et al. (1988).

(b) "Not $PuO_2$" is used to signify inclusion of all compounds other than $PuO_2$, while "$PuO_2$" identifies the dioxide form.

Table 2. Cumulated radiation doses to the embryo/fetus from chronic maternal inhalation of chemical or physical forms of the priority radionuclides[a]

| Nuclide | Compound | Class | $f_1$ | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|---|---|---|
| H-3 | Water | - - | 1E+00 | 8E+04 | 3E+00 | 1E-02 | 1E+03 |
| C-14 | $CO_2$ | - - | 1E+00 | 2E+03 | 2E+00 | 3E-02 | 7E+01 |
| Co-57 | Inorganic | Y | 5E-02 | 7E+02 | 1E-01 | 5E-01 | 4E+02 |
| Co-58 | Inorganic | Y | 5E-02 | 7E+02 | 5E-01 | 1E-01 | 7E+01 |
| Co-60 | Inorganic | Y | 5E-02 | 3E+01 | 7E-02 | 7E-01 | 2E+01 |
| Sr-89 | Soluble | D | 3E-01 | 8E+02 | 5E+00 | 9E-03 | 8E+00 |
| Sr-89 | Insoluble | Y | 1E-02 | 1E+02 | 7E-02 | 7E-01 | 7E+01 |
| Sr/Y-90 | Soluble | D | 3E-01 | 2E+01 | 4E-01 | 1E-01 | 3E+00 |
| Sr/Y-90 | Insoluble | Y | 1E-02 | 4E+00 | 8E-03 | 7E+00 | 3E+01 |
| Ru/Rh-106 | Not W or Y[b] | D | 5E-02 | 9E+01 | 2E-01 | 2E-01 | 2E+01 |
| Ru/Rh-106 | Halides | W | 5E-02 | 5E+01 | 4E-02 | 1E+00 | 6E+01 |
| Ru/Rh-106 | Oxides | Y | 5E-02 | 1E+01 | 4E-03 | 1E+01 | 1E+02 |
| I-125 | All | D | 1E+00 | 6E+01 | 2E-02 | 2E+00 | 1E+02 |
| I-131 | All | D | 1E+00 | 5E+01 | 5E-02 | 1E+00 | 5E+01 |
| I-132 | All | D | 1E+00 | 8E+03 | 7E-01 | 7E-02 | 6E+02 |
| I-133 | All | D | 1E+00 | 3E+02 | 1E-01 | 4E-01 | 1E+02 |
| I-134 | All | D | 1E+00 | 5E+04 | 1E+00 | 4E-02 | 2E+03 |
| I-135 | All | D | 1E+00 | 2E+03 | 4E-01 | 1E-01 | 2E+02 |
| Cs-134 | All | D | 1E+00 | 1E+02 | 6E+00 | 8E-03 | 8E-01 |
| Cs-137 | All | D | 1E+00 | 2E+02 | 4E+00 | 1E-02 | 2E+00 |
| U-233 | $UF_6$,....[c] | D | 5E-02 | 1E+00 | 1E-01 | 4E-01 | 4E-01 |
| U-233 | $UO_3$,.... | W | 5E-02 | 7E-01 | 3E-02 | 2E+00 | 1E+00 |
| U-233 | $UO_2$,.... | Y | 2E-03 | 4E-02 | 6E-04 | 8E+01 | 3E+00 |
| U-234 | $UF_6$,.... | D | 5E-02 | 1E+00 | 1E-01 | 4E-01 | 4E-01 |
| U-234 | $UO_3$,.... | W | 5E-02 | 7E-01 | 3E-02 | 2E+00 | 1E+00 |
| U-234 | $UO_2$,.... | Y | 2E-03 | 4E-02 | 6E-04 | 9E+01 | 3E+00 |
| U-235 | $UF_6$,.... | D | 5E-02 | 1E+00 | 1E-01 | 4E-01 | 4E-01 |
| U-235 | $UO_3$,.... | W | 5E-02 | 8E-01 | 3E-02 | 2E+00 | 1E+00 |
| U-235 | $UO_2$,.... | Y | 2E-03 | 4E-02 | 5E-04 | 9E+01 | 4E+00 |
| U-238 | $UF_6$,.... | D | 5E-02 | 1E+00 | 1E-01 | 4E-01 | 4E-01 |
| U-238 | $UO_3$,.... | W | 5E-02 | 8E-01 | 3E-02 | 2E+00 | 1E+00 |
| U-238 | $UO_2$,.... | Y | 2E-03 | 4E-02 | 5E-04 | 1E+02 | 4E+00 |

Table 2. (contd)

| Nuclide | Compound | Class | $f_1$ | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|---|---|---|
| Pu-238 | Not $PuO_2$[d] | W | 1E-03 | 7E-03 | 5E-04 | 1E+02 | 8E-01 |
| Pu-238 | $PuO_2$ | Y | 1E-05 | 2E-02 | 5E-04 | 9E+01 | 2E+00 |
| Pu-239 | Not $PuO_2$ | W | 1E-03 | 6E-03 | 4E-04 | 1E+02 | 8E-01 |
| Pu-239 | $PuO_2$ | Y | 1E-05 | 2E-02 | 5E-04 | 1E+02 | 2E+00 |
| Am-241 | All | W | 1E-03 | 6E-03 | 8E-05 | 6E+02 | 4E+00 |

(a) The entries for the common inhalation classes of D, W and Y are identified.

(b) "Not W or Y" refers to all compounds except those in classes W and Y.

(c) The primary compounds of uranium, as subdivided in Appendix B of 10 CFR Part 20, are shown: $UF_6$... includes $UF_6$, $UO_2F_2$, $UO_2(NO_3)_2$; $UO_3$... includes $UO_3$, $UF_4$, $UCl_4$; and $UO_2$... includes $UO_2$ and $U_3O_8$.

(d) "Not $PuO_2$" is used to signify inclusion of all compounds other than $PuO_2$, while "$PuO_2$" identifies the dioxide form.

Table 3. Cumulated radiation doses to the embryo/fetus from pre-existing maternal burdens derived from ingestion of priority radionuclides[a]

| Nuclide | Compound | $f_1$ | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|---|---|
| H-3 | Water | 1E+00 | 8E+04 | 7E-01 | 7E-02 | 6E+03 |
| *H-3* | *Sugar/amino a.* | *1E+00* | *8E+04* | *2E+00* | *3E-02* | *2E+03* |
| C-14 | Sugar/amino a. | 1E+00 | 2E+03 | 4E-01 | 1E-01 | 3E+02 |
| Co-57 | Inorganic | 5E-02 | 8E+03 | 9E-01 | 6E-02 | 5E+02 |
| Co-58 | Inorganic | 5E-02 | 2E+03 | 9E-01 | 6E-02 | 1E+02 |
| Co-60 | Inorganic | 5E-02 | 5E+02 | 1E+00 | 5E-02 | 2E+01 |
| Co-57 | Vitamin B-12 | 3E-01 | 4E+03 | 6E+00 | 9E-03 | 4E+01 |
| Co-60 | Vitamin B-12 | 3E-01 | 2E+02 | 5E+00 | 1E-02 | 2E+00 |
| Sr-89 | Soluble | 3E-01 | 6E+02 | 9E-01 | 5E-02 | 3E+01 |
| Sr-89 | Insoluble | 1E-02 | 5E+02 | 3E-02 | 2E+00 | 1E+03 |
| Sr/Y-90 | Soluble | 3E-01 | 3E+01 | 2E-01 | 3E-01 | 1E+01 |
| *Sr/Y-90* | *Insoluble* | *1E-02* | *5E+02* | *8E-02* | *6E-01* | *3E+02* |
| Ru/Rh-106 | All | 5E-02 | 2E+02 | 7E-02 | 7E-01 | 1E+02 |
| I-125 | All | 1E+00 | 4E+01 | 3E-03 | 2E+01 | 6E+02 |
| I-131 | All | 1E+00 | 3E+01 | 2E-03 | 3E+01 | 8E+02 |
| I-132 | All | 1E+00 | 4E+03 | 3E-01 | 1E-01 | 6E+02 |
| I-133 | All | 1E+00 | 1E+02 | 3E-02 | 2E+00 | 2E+02 |
| I-134 | All | 1E+00 | 2E+04 | 4E-01 | 1E-01 | 2E+03 |
| I-135 | All | 1E+00 | 8E+02 | 2E-01 | 3E-01 | 3E+02 |
| Cs-134 | All | 1E+00 | 7E+01 | 8E+00 | 6E-03 | 5E-01 |
| Cs-137 | All | 1E+00 | 1E+02 | 6E+00 | 9E-03 | 9E-01 |
| U-233 | Hexavalent | 5E-02 | 1E+01 | 1E-02 | 3E+00 | 3E+01 |
| *U-233* | *Insoluble* | *2E-03* | *2E+02* | *1E-02* | *4E+00* | *9E+02* |
| U-234 | Hexavalent | 5E-02 | 1E+01 | 1E-02 | 3E+00 | 3E+01 |
| *U-234* | *Insoluble* | *2E-03* | *2E+02* | *1E-02* | *4E+00* | *9E+02* |
| U-235 | Hexavalent | 5E-02 | 1E+01 | 1E-02 | 4E+00 | 4E+01 |
| *U-235* | *Insoluble* | *2E-03* | *2E+02* | *1E-02* | *5E+00* | *9E+02* |
| U-238 | Hexavalent | 5E-02 | 1E+01 | 1E-02 | 4E+00 | 4E+01 |
| *U-238* | *Insoluble* | *2E-03* | *2E+02* | *1E-02* | *5E+00* | *1E+03* |

Table 3. (contd)

| Nuclide | Compound | $f_1$ | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|---|---|
| Pu-238 | Not $PuO_2$[b] | 1E-03 | 9E-01 | 5E-05 | 1E+03 | 9E+02 |
| *Pu-238* | *$PuO_2$* | *1E-05* | *9E+01* | *5E-05* | *1E+03* | *9E+04* |
| Pu-239 | Not $PuO_2$ | 1E-03 | 8E-01 | 4E-05 | 1E+03 | 1E+03 |
| *Pu-239* | *$PuO_2$* | *1E-05* | *8E+01* | *4E-05* | *1E+03* | *1E+05* |
| Am-241 | All | 1E-03 | 8E-01 | 9E-06 | 6E+03 | 5E+03 |

(a) Entries shown in italics identify compounds for which calculations are not based on values of oral ingestion ALI taken from Table 1, Appendix B, 10 CFR Part 20. Values comparable to ALI were derived independently from Eckerman et al. (1988).

(b) "Not $PuO_2$" is used to signify inclusion of all compounds other than $PuO_2$, while "$PuO_2$" identifies the dioxide form.

Table 4. Cumulated radiation doses to the embryo/fetus from pre-existing maternal burdens resulting from inhalation of priority radionuclides[a]

| Nuclide | Compound | Class | $f_1$ | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|---|---|---|
| H-3 | Water | - - | 1E+00 | 8E+04 | 7E-01 | 7E-02 | 6E+03 |
| C-14 | $CO_2$ | - - | 1E+00 | 2E+03 | 4E-01 | 1E-01 | 3E+02 |
| Co-57 | Inorganic | Y | 5E-02 | 7E+02 | 1E-01 | 4E-01 | 3E+02 |
| Co-58 | Inorganic | Y | 5E-02 | 7E+02 | 5E-01 | 1E-01 | 7E+01 |
| Co-60 | Inorganic | Y | 5E-02 | 3E+01 | 1E-01 | 5E-01 | 2E+01 |
| Sr-89 | Soluble | D | 3E-01 | 8E+02 | 2E+00 | 2E-02 | 2E+01 |
| Sr-89 | Insoluble | Y | 1E-02 | 1E+02 | 3E-02 | 2E+00 | 2E+02 |
| Sr/Y-90 | Soluble | D | 3E-01 | 2E+01 | 2E-01 | 3E-01 | 6E+00 |
| Sr/Y-90 | Insoluble | Y | 1E-02 | 4E+00 | 4E-03 | 1E+01 | 5E+01 |
| Ru/Rh-106 | Not W or Y[b] | D | 5E-02 | 9E+01 | 3E-01 | 2E-01 | 1E+01 |
| Ru/Rh-106 | Halides | W | 5E-02 | 5E+01 | 5E-02 | 1E+00 | 5E+01 |
| Ru/Rh-106 | Oxides | Y | 5E-02 | 1E+01 | 6E-03 | 9E+00 | 9E+01 |
| I-125 | All | D | 1E+00 | 6E+01 | 3E-03 | 2E+01 | 1E+03 |
| I-131 | All | D | 1E+00 | 5E+01 | 2E-03 | 3E+01 | 1E+03 |
| I-132 | All | D | 1E+00 | 8E+03 | 4E-01 | 1E-01 | 9E+02 |
| I-133 | All | D | 1E+00 | 3E+02 | 5E-02 | 9E-01 | 3E+02 |
| I-134 | All | D | 1E+00 | 5E+04 | 7E-01 | 7E-02 | 4E+03 |
| I-135 | All | D | 1E+00 | 2E+03 | 2E-01 | 2E-01 | 4E+02 |
| Cs-134 | All | D | 1E+00 | 1E+02 | 7E+00 | 7E-03 | 7E-01 |
| Cs-137 | All | D | 1E+00 | 2E+02 | 7E+00 | 7E-03 | 1E+00 |
| U-233 | $UF_6$,...[c] | D | 5E-02 | 1E+00 | 1E-02 | 4E+00 | 4E+00 |
| U-233 | $UO_3$,... | W | 5E-02 | 7E-01 | 3E-03 | 2E+01 | 1E+01 |
| U-233 | $UO_2$,... | Y | 2E-03 | 4E-02 | 6E-05 | 8E+02 | 3E+01 |
| U-234 | $UF_6$,... | D | 5E-02 | 1E+00 | 1E-02 | 4E+00 | 4E+00 |
| U-234 | $UO_3$,... | W | 5E-02 | 7E-01 | 3E-03 | 2E+01 | 1E+01 |
| U-234 | $UO_2$,... | Y | 2E-03 | 4E-02 | 6E-05 | 9E+02 | 3E+01 |
| U-235 | $UF_6$,... | D | 5E-02 | 1E+00 | 1E-02 | 4E+00 | 4E+00 |
| U-235 | $UO_3$,... | W | 5E-02 | 8E-01 | 3E-03 | 2E+01 | 1E+01 |
| U-235 | $UO_2$,... | Y | 2E-03 | 4E-02 | 5E-05 | 9E+02 | 4E+01 |
| U-238 | $UF_6$,... | D | 5E-02 | 1E+00 | 1E-02 | 4E+00 | 4E+00 |
| U-238 | $UO_3$,... | W | 5E-02 | 8E-01 | 3E-03 | 2E+01 | 1E+01 |
| U-238 | $UO_2$,... | Y | 2E-03 | 4E-02 | 5E-05 | 1E+03 | 4E+01 |

Table 4. (contd)

| Nuclide | Compound | Class | $f_1$ | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|---|---|---|
| Pu-238 | Not $PuO_2$[d] | W | 1E-03 | 7E-03 | 5E-05 | 1E+03 | 8E+00 |
| Pu-238 | $PuO_2$ | Y | 1E-05 | 2E-02 | 5E-05 | 9E+02 | 2E+01 |
| Pu-239 | Not $PuO_2$ | W | 1E-03 | 6E-03 | 4E-05 | 1E+03 | 8E+00 |
| Pu-239 | $PuO_2$ | Y | 1E-05 | 2E-02 | 5E-05 | 1E+03 | 2E+01 |
| Am-241 | All | W | 1E-03 | 6E-03 | 8E-06 | 6E+03 | 4E+01 |

(a) The entries for the common inhalation classes of D, W and Y are identified.
(b) "Not W or Y" refers to all compounds except those in classes W and Y.
(c) The primary compounds of uranium, as subdivided in Appendix B of 10 CFR Part 20, are shown: "$UF_6$..." includes $UF_6$, $UO_2F_2$, and $UO_2(NO_3)_2$; "$UO_3$..." includes $UO_3$, $UF_4$, $UCl_4$; and "$UO_2$..." includes $UO_2$, $U_3O_8$.
(d) "Not $PuO_2$" is used to signify inclusion of all compounds other than $PuO_2$. while "$PuO_2$" identifies the dioxide form.

Table 5. Simplified dose factors for calculation of embryo/fetus dose from chronic ingestion of the priority radionuclides throughout gestation or from a maternal burden at the start of pregnancy.

| Nuclide | Compound | Dose Factor for Chronic Exposure (rem/μCi)[a] | Dose Factor for Pre-existing Exposure (rem/μCi)[b] |
|---|---|---|---|
| H-3 | Water | 4E-05 | 9E-06( 0) |
| H-3 | Sugar/amino a. | 9E-05 | 2E-05(30) |
| C-14 | Sugar/amino a. | 8E-04 | 2E-04(30) |
| Co-57 | Inorganic | 9E-05 | 1E-04( 0) |
| Co-58 | Inorganic | 4E-04 | 4E-04( 0) |
| Co-60 | Inorganic | 2E-03 | 2E-03( 0) |
| Co-57 | Vitamin B-12 | 1E-03 | 1E-03( 0) |
| Co-60 | Vitamin B-12 | 2E-02 | 3E-02( 0) |
| Sr-89 | Soluble | 4E-03 | 2E-03( 0) |
| Sr-89 | Insoluble | 1E-04 | 5E-05( 0) |
| Sr/Y-90 | Soluble | 1E-02 | 5E-03( 0) |
| Sr/Y-90 | Insoluble | 3E-04 | 2E-04( 0) |
| Ru/Rh-106 | All | 3E-04 | 3E-04( 0) |
| I-125 | All | 6E-04 | 8E-05( 0) |
| I-131 | All | 1E-03 | 6E-05( 0) |
| I-132 | All | 1E-04 | 8E-05( 0) |
| I-133 | All | 7E-04 | 3E-04( 0) |
| I-134 | All | 4E-05 | 2E-05( 0) |
| I-135 | All | 3E-04 | 2E-04( 0) |
| Cs-134 | All | 9E-02 | 1E-01( 0) |
| Cs-137 | All | 4E-02 | 6E-02( 0) |
| U-233 | Hexavalent | 1E-02 | 1E-03(30) |
| U-233 | Insoluble | 6E-04 | 6E-05(30) |
| U-234 | Hexavalent | 1E-02 | 1E-03(30) |
| U-234 | Insoluble | 6E-04 | 6E-05(30) |
| U-235 | Hexavalent | 1E-02 | 1E-03(30) |
| U-235 | Insoluble | 5E-04 | 5E-05(30) |
| U-238 | Hexavalent | 1E-02 | 1E-03(30) |
| U-238 | Insoluble | 5E-04 | 5E-05(30) |

Table 5. (contd)

| Nuclide | Compound | Dose Factor for Chronic Exposure (rem/$\mu$Ci)[a] | Dose Factor for Pre-existing Exposure (rem/$\mu$Ci)[b] |
|---|---|---|---|
| Pu-238 | Not $PuO_2$[c] | 5E-04 | 5E-05(30) |
| Pu-238 | $PuO_2$ | 5E-06 | 5E-07(30) |
| Pu-239 | Not $PuO_2$ | 5E-04 | 5E-05(30) |
| Pu-239 | $PuO_2$ | 5E-06 | 5E-07(30) |
| Am-241 | All | 1E-04 | 1E-05(30) |

(a) The dose factor for chronic exposure is given as the average stage-related cumulated radiation doses to the embryo/fetus from introduction into the transfer compartment at the start of each 30-day interval of pregnancy.

(b) The dose factor is given as the cumulative dose from introduction into the transfer compartment at the relevant stage for pre-existing burdens. The times of gestation (days) for which the dose factors are pertinent are shown in parentheses.

(c) "Not $PuO_2$" is used to signify inclusion of all compounds other than $PuO_2$, while "$PuO_2$" identifies the dioxide form.

Table 6. Simplified dose factors for calculation of embryo/fetus dose from chronic inhalation of the priority radionuclides throughout gestation or from a maternal burden at the start of pregnancy.

| Nuclide | Compound | Inhalation Class | Dose Factor for Chronic Exposure (rem/μCi)[a] | Dose Factor for Pre-existing Exposure (rem/μCi)[b] |
|---|---|---|---|---|
| H-3 | Water | - - | 4E-05 | 9E-06( 0) |
| C-14 | $CO_2$ | - - | 8E-04 | 2E-04(30) |
| Co-57 | Inorganic | Y | 1E-04 | 2E-04( 0) |
| Co-58 | Inorganic | Y | 7E-04 | 7E-04( 0) |
| Co-60 | Inorganic | Y | 2E-03 | 3E-03( 0) |
| Sr-89 | Soluble | D | 7E-03 | 3E-03( 0) |
| Sr-89 | Insoluble | Y | 7E-04 | 3E-04( 0) |
| Sr/Y-90 | Soluble | D | 2E-02 | 9E-03( 0) |
| Sr/Y-90 | Insoluble | Y | 2E-03 | 9E-04( 0) |
| Ru/Rh-106 | Not W or Y[c] | D | 3E-03 | 3E-03( 0) |
| Ru/Rh-106 | Halides | W | 8E-04 | 1E-03( 0) |
| Ru/Rh-106 | Oxides | Y | 4E-04 | 6E-04( 0) |
| I-125 | All | D | 4E-04 | 5E-05( 0) |
| I-131 | All | D | 9E-04 | 4E-05( 0) |
| I-132 | All | D | 9E-05 | 5E-05( 0) |
| I-133 | All | D | 5E-04 | 2E-04( 0) |
| I-134 | All | D | 2E-05 | 1E-05( 0) |
| I-135 | All | D | 2E-04 | 1E-04( 0) |
| Cs-134 | All | D | 5E-02 | 7E-02( 0) |
| Cs-137 | All | D | 3E-02 | 4E-02( 0) |
| U-233 | $UF_6$,...[d] | D | 1E-01 | 1E-02(30) |
| U-233 | $UO_3$,... | W | 4E-02 | 4E-03(30) |
| U-233 | $UO_2$,... | Y | 1E-02 | 1E-03(30) |
| U-234 | $UF_6$,... | D | 1E-01 | 1E-02(30) |
| U-234 | $UO_3$,... | W | 4E-02 | 4E-03(30) |
| U-234 | $UO_2$,... | Y | 1E-02 | 1E-03(30) |
| U-235 | $UF_6$,... | D | 1E-01 | 1E-02(30) |
| U-235 | $UO_3$,... | W | 4E-02 | 4E-03(30) |
| U-235 | $UO_2$,... | Y | 1E-02 | 1E-03(30) |
| U-238 | $UF_6$,... | D | 1E-01 | 1E-02(30) |
| U-238 | $UO_3$,... | W | 4E-02 | 4E-03(30) |
| U-238 | $UO_2$,... | Y | 1E-02 | 1E-03(30) |

Table 6. (contd)

| Nuclide | Compound | Inhalation Class | Dose Factor for Chronic Exposure (rem/$\mu$Ci)[a] | Dose Factor for Pre-existing Exposure (rem/$\mu$Ci)[b] |
|---|---|---|---|---|
| Pu-238 | Not $PuO_2$[e] | W | 7E-02 | 7E-03(30) |
| Pu-238 | PuO2 | Y | 3E-02 | 3E-03(30) |
| Pu-239 | Not $PuO_2$ | W | 6E-02 | 6E-03(30) |
| Pu-239 | $PuO_2$ | Y | 3E-02 | 3E-03(30) |
| Am-241 | All | W | 1E-02 | 1E-03(30) |

(a) The dose factor for chronic exposure is given as the average stage-related cumulated radiation doses to the embryo/fetus from introduction into the transfer compartment at the start of each 30-day interval of pregnancy.

(b) The dose factor is given as the cumulative dose from introduction into the transfer compartment at the relevant stage for pre-existing burdens. The times of gestation (days) for which the dose factors are pertinent are shown in parentheses.

(c) "Not W or Y" denotes all compounds except those in classes W and Y.

(d) The primary compounds of uranium, as subdivided in Appendix B of 10 CFR Part 20, are shown: "$UF_6$..." includes $UF_6$, $UO_2F_2$, and $UO_2(NO_3)_2$; "$UO_3$..." includes $UO_3$, $UF_4$, $UCl_4$; and "$UO_2$..." includes $UO_2$, $U_3O_8$.

(e) "Not $PuO_2$" is used to signify inclusion of all compounds other than $PuO_2$, while "$PuO_2$" identifies the dioxide form.

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Table 7. Comparisons of the committed uterine dose equivalent surrogate and the maximized dose equivalent to the embryo/fetus with calculated dose equivalents from chronic ingestion of representative radionuclides throughout pregnancy.

| Nuclide | ALI (μCi) | Embryo/Fetus Dose per ALI (rem) | Uterine Dose per ALI (rem) | Ratio of Doses[a] | Maximized Embryo/Fetus Dose per ALI (rem)[b] | Ratio of Doses[c] |
|---|---|---|---|---|---|---|
| H-3[d] | 8E+04 | 3E+00 | 5E+00 | 0.6 | 5E+00 | 0.6 |
| H-3[e] | 8E+04 | 7E+00 | 5E+00 | 1.4 | 1E+01 | 0.6 |
| C-14 | 2E+03 | 2E+00 | 4E+00 | 0.5 | 3E+00 | 0.8 |
| Co-57 | 4E+03 | 5E+00 | 4E+00 | 1.3 | 6E+00 | 0.9 |
| Co-60 | 2E+02 | 4E+00 | 5E+00 | 0.8 | 5E+00 | 0.8 |
| Sr-89 | 6E+02 | 2E+00 | 5E-01 | 4.0 | 3E+00 | 0.6 |
| Sr/Y-90 | 3E+01 | 3E-01 | 2E-01 | 1.5 | 5E-01 | 0.6 |
| Ru/Rh-106 | 2E+02 | 6E-02 | 1E+00 | 0.1 | 7E-02 | 0.8 |
| I-125 | 4E+01 | 3E-02 | 4E-03 | 7.5 | 6E-02 | 0.5 |
| I-131 | 3E+01 | 4E-02 | 5E-03 | 8.0 | 9E-02 | 0.4 |
| I-132 | 4E+03 | 5E-01 | 4E-01 | 1.3 | 6E-01 | 0.8 |
| I-133 | 1E+02 | 7E-02 | 1E-02 | 7.0 | 9E-02 | 0.8 |
| I-134 | 2E+04 | 7E-01 | 9E-01 | 0.8 | 1E+00 | 0.7 |
| I-135 | 8E+02 | 3E-01 | 1E-01 | 3.0 | 3E-01 | 1.0 |
| Cs-134 | 7E+01 | 6E+00 | 6E+00 | 1.0 | 8E+00 | 0.8 |
| Cs-137 | 1E+02 | 4E+00 | 5E+00 | 0.8 | 6E+00 | 0.7 |
| U-233 | 1E+01 | 1E-01 | 1E-01 | 1.0 | 3E-01 | 0.3 |
| U-234 | 1E+01 | 1E-01 | 1E-01 | 1.0 | 3E-01 | 0.3 |
| U-235 | 1E+01 | 1E-01 | 9E-02 | 1.1 | 3E-01 | 0.4 |
| U-238 | 1E+01 | 1E-01 | 9E-02 | 1.1 | 3E-01 | 0.4 |
| Pu-238 | 9E-01 | 5E-04 | 3E-05 | 16.7 | 1E-03 | 0.5 |
| Pu-239 | 8E-01 | 4E-04 | 2E-05 | 20.0 | 8E-04 | 0.5 |
| Am-241 | 8E-01 | 9E-05 | 9E-05 | 1.0 | 2E-04 | 0.5 |

(a) Ratio = embryo/fetus dose divided by uterine dose.
(b) Embryo/fetus dose per ALI calculated using the maximum dose factor during gestation, as done in Regulatory Guide 8.36 (NRC 1992).
(c) Ratio = embryo/fetus dose calculated in this study divided by the maximum embryo/fetus dose.
(d) Tritiated water.
(e) Sugar or amino acid.

Table 8. Comparisons of the committed uterine dose equivalent surrogate and the maximized dose equivalent to the embryo/fetus with calculated dose equivalents from chronic inhalation of representative radionuclides throughout pregnancy.

| Nuclide | Class | ALI (μCi) | Embryo/Fetus Dose per ALI (rem) | Uterine Dose per ALI (rem) | Ratio of Doses[a] | Maximized Embryo/Fetus Dose per ALI (rem)[b] | Ratio of Doses[c] |
|---|---|---|---|---|---|---|---|
| H-3[d] | - | 8E+04 | 3E+00 | 5E+00 | 0.6 | 5E+00 | 0.6 |
| C-14 | - | 2E+03 | 2E+00 | 4E+00 | 0.5 | 3E+00 | 0.8 |
| Co-57 | Y | 7E+02 | 1E-01 | 2E-01 | 0.5 | 1E-01 | 0.8 |
| Co-58 | Y | 7E+02 | 5E-01 | 8E-01 | 0.6 | 5E-01 | 1.0 |
| Co-60 | Y | 3E+01 | 7E-02 | 5E-01 | 0.1 | 1E-01 | 0.7 |
| Sr-89 | D | 8E+02 | 5E+00 | 1E+00 | 5.0 | 8E+00 | 0.6 |
| Sr-89 | Y | 1E+02 | 7E-02 | 3E-03 | 23.3 | 1E-01 | 0.7 |
| Sr/Y-90 | D | 2E+01 | 4E-01 | 2E-01 | 2.0 | 5E-01 | 0.7 |
| Sr/Y-90 | Y | 4E+00 | 8E-03 | 4E-03 | 2.0 | 1E-02 | 0.7 |
| Ru/Rh-106 | D | 9E+01 | 2E-01 | 5E+00 | 0.0 | 3E-01 | 0.6 |
| Ru/Rh-106 | W | 5E+01 | 4E-02 | 7E-01 | 0.1 | 5E-02 | 0.8 |
| Ru/Rh-106 | Y | 1E+01 | 4E-03 | 4E-02 | 0.1 | 6E-03 | 0.7 |
| I-125 | D | 6E+01 | 2E-02 | 4E-03 | 5.0 | 5E-02 | 0.4 |
| I-131 | D | 5E+01 | 5E-02 | 5E-03 | 10.0 | 1E-01 | 0.4 |
| I-132 | D | 8E+03 | 7E-01 | 3E-01 | 2.3 | 8E-01 | 0.9 |
| I-133 | D | 3E+02 | 1E-01 | 2E-02 | 5.0 | 2E-01 | 0.6 |
| I-134 | D | 5E+04 | 1E+00 | 9E-01 | 1.1 | 2E+00 | 0.7 |
| I-135 | D | 2E+03 | 4E-01 | 1E-01 | 4.0 | 5E-01 | 0.9 |
| Cs-134 | D | 1E+02 | 5E+00 | 5E+00 | 1.0 | 7E+00 | 0.7 |
| Cs-137 | D | 2E+02 | 6E+00 | 7E+00 | 0.9 | 7E+00 | 0.8 |
| U-233 | D | 1E+00 | 1E-01 | 9E-02 | 1.1 | 2E-01 | 0.4 |
| U-233 | W | 7E-01 | 3E-02 | 2E-02 | 1.5 | 5E-02 | 0.6 |
| U-233 | Y | 4E-02 | 6E-04 | 4E-04 | 1.5 | 1E-03 | 0.6 |
| U-234 | D | 1E+00 | 1E-01 | 9E-02 | 1.1 | 3E-01 | 0.4 |
| U-234 | W | 7E-01 | 3E-02 | 2E-02 | 1.5 | 6E-02 | 0.5 |
| U-234 | Y | 4E-02 | 6E-04 | 4E-04 | 1.5 | 1E-03 | 0.5 |
| U-235 | D | 1E+00 | 1E-01 | 9E-02 | 1.1 | 3E-01 | 0.4 |
| U-235 | W | 8E-01 | 3E-02 | 2E-02 | 1.5 | 6E-02 | 0.5 |
| U-235 | Y | 4E-02 | 5E-04 | 4E-04 | 1.3 | 1E-03 | 0.5 |
| U-238 | D | 1E+00 | 1E-01 | 8E-02 | 1.3 | 2E-01 | 0.4 |
| U-238 | W | 8E-01 | 3E-02 | 2E-02 | 1.5 | 6E-02 | 0.5 |
| U-238 | Y | 4E-02 | 5E-04 | 4E-04 | 1.3 | 1E-03 | 0.5 |

Table 8. (contd)

| Nuclide | Class | ALI (μCi) | Embryo/Fetus Dose per ALI (rem) | Uterine Dose per ALI (rem) | Ratio of Doses[a] | Maximized Embryo/Fetus Dose per ALI (rem)[b] | Ratio of Doses[c] |
|---|---|---|---|---|---|---|---|
| Pu-238 | W | 7E-03 | 5E-04 | 2E-05 | 25.0 | 9E-04 | 0.5 |
| Pu-238 | Y | 2E-02 | 5E-04 | 3E-05 | 16.7 | 1E-03 | 0.4 |
| Pu-239 | W | 6E-03 | 4E-04 | 2E-05 | 20.0 | 8E-04 | 0.5 |
| Pu-239 | Y | 2E-02 | 5E-04 | 3E-05 | 16.7 | 1E-03 | 0.5 |
| Am-241 | W | 6E-03 | 8E-05 | 3E-05 | 2.7 | 2E-04 | 0.5 |

(a) Ratio = embryo/fetus dose divided by uterine dose.
(b) Embryo/fetus dose per ALI calculated using the maximum dose factor during gestation, as done in Regulatory Guide 8.36 (NRC 1992).
(c) Ratio = embryo/fetus dose calculated in this study divided by the maximum embryo/fetus dose.
(d) Tritiated water

## IV. CONCLUSIONS

It is evident from the evaluations presented in this addendum that the previously used simplified methods and dose factors for the priority radionuclides can be extended to obtain results for more complex practical situations. It was concluded in NUREG/CR-5631, Revision 1, that there are difficulties in accurately determining radionuclide concentrations and activities in the conceptus and surrounding maternal tissues. These difficulties still pertain, but the values obtained from the models used in those analyses have been accepted by the radiation protection community as providing descriptions of adequate accuracy and that they are in a form that is amenable to refinement in the future. The approaches for calculations of gestational stage-related radiation absorbed doses from the radionuclide activities in the embryo/fetus and in maternal tissues also have been accepted by these professionals. Thus, the biological behavior and dose factors for the embryo/fetus relating to activity directly introduced into maternal blood, tabulations of which are available for the priority radionuclides, provides a basis for further evaluations.

Some approaches for calculation of dose in operational situations that were suggested in that report have now been implemented and extended. The prior analyses were used to determine further dose factors that are given in the present addendum. These determinations include conversion of repeated or chronic ingestion or inhalation intakes, expressed in terms of ALI, to stage-related radiation dose equivalents to the embryo/fetus. Analogous approaches, which require simplifying assumptions, have been used to estimate dose to the embryo/fetus from radionuclide burdens in a woman prior to the time she becomes pregnant. Radiation dose equivalent per ALI and relationship of intakes (in fractional ALI or activity) to dose limits (0.5 rem total or an increment of 0.05 rem) clearly are useful tabular values.

Estimators for additional radionuclides that lacked biokinetic models, again relative to ingestion or inhalation of an ALI, were developed through the use of tabulations of committed dose equivalent factors for the uterus. Results using these estimators, when compared with dose obtained through direct calculation, indicate a need for more detailed analysis of some important radionuclides as well as enhancements and amplifications of approach.

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# APPENDIX

## RADIATION DOSES TO THE UTERUS:  INGESTION AND INHALATION

APPENDIX

## RADIATION DOSES TO THE UTERUS: INGESTION AND INHALATION

Sections II.C and III.C discussed the use of uterine surrogate dose factors for situations in which values from evaluations of the radionuclides were not available. Table F-1 of NUREG/CR-5631, Revision 1, provided dose factors using the uterine committed dose equivalent factors as a surrogate for situations in which values from specific evaluations of the radionuclides were not available. To obtain these surrogates for the embryo/fetus based on unit activity in blood, these uterine dose factors were divided by the corresponding fractional absorption value. The maximum value of $f_1$ was used for calculation when there was more than one value. For radionuclides and forms that had been directly evaluated, these entries were multiplied by a quality factor and used to replace the surrogate in that table.

The underlying values for the surrogates (used to prepare Table F-1 of Revision 1) were again used as the input for the calculations in the tables presented in this Appendix, relating intake to radiation dose. Doses were calculated for ingestion classes with the lowest ALI and for all inhalation classes with ALI values listed in 10 CFR Part 20. The entries for inhalation in Table A-2 was segregated for the common inhalation classes of D, W, and Y and are shown as V (vapor) for tritium, and subdivided into c (compound), m (carbon monoxide), and d (carbon dioxide) for carbon.

The dose factors used for calculation were based on uterine doses per activity ingested or inhaled so that it was not necessary to make adjustment for the transfer fraction. These tabulations were available as committed dose equivalent factors so that adjustment for quality factor was not required.

Table A1. Radiation doses to the uterus from ingestion.

| Nuclide | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|
| H-3 | 8E+04 | 5E+00 | 1E-02 | 8E+02 |
| Be-7 | 4E+04 | 3E+00 | 2E-02 | 6E+02 |
| Be-10 | 1E+03 | 9E-02 | 6E-01 | 6E+02 |
| C-11 | 4E+05 | 5E+00 | 1E-02 | 4E+03 |
| C-14 | 2E+03 | 4E+00 | 1E-02 | 2E+01 |
| F-18 | 5E+04 | 7E-01 | 8E-02 | 4E+03 |
| Na-22 | 4E+02 | 4E+00 | 1E-02 | 5E+00 |
| Na-24 | 4E+03 | 5E+00 | 1E-02 | 4E+01 |
| Mg-28 | 7E+02 | 1E+00 | 4E-02 | 3E+01 |
| Al-26 | 4E+02 | 2E+00 | 2E-02 | 9E+00 |
| Si-31 | 9E+03 | 3E-03 | 1E+01 | 1E+05 |
| Si-32 | 2E+03 | 9E-01 | 6E-02 | 1E+02 |
| P-32 | 6E+02 | 1E+00 | 3E-02 | 2E+01 |
| P-33 | 6E+03 | 2E+00 | 2E-02 | 1E+02 |
| S-35 | 1E+04 | 3E+00 | 2E-02 | 2E+02 |
| Cl-36 | 2E+03 | 6E+00 | 8E-03 | 2E+01 |
| Cl-38 | 2E+04 | 6E-01 | 8E-02 | 2E+03 |
| Cl-39 | 2E+04 | 8E-01 | 6E-02 | 1E+03 |
| K-40 | 3E+02 | 6E+00 | 9E-03 | 3E+00 |
| K-42 | 5E+03 | 4E+00 | 1E-02 | 6E+01 |
| K-43 | 6E+03 | 4E+00 | 1E-02 | 7E+01 |
| K-44 | 2E+04 | 4E-01 | 1E-01 | 3E+03 |
| K-45 | 3E+04 | 4E-01 | 1E-01 | 4E+03 |
| Ca-41 | 3E+03 | 3E-02 | 2E+00 | 5E+03 |
| Ca-45 | 2E+03 | 4E-01 | 1E-01 | 3E+02 |
| Ca-47 | 8E+02 | 1E+00 | 4E-02 | 3E+01 |
| Sc-43 | 7E+03 | 2E+00 | 3E-02 | 2E+02 |
| Sc-44 | 4E+03 | 2E+00 | 3E-02 | 1E+02 |
| Sc-44m | 5E+02 | 1E+00 | 4E-02 | 2E+01 |
| Sc-46 | 9E+02 | 3E+00 | 2E-02 | 2E+01 |
| Sc-47 | 2E+03 | 4E-01 | 1E-01 | 3E+02 |
| Sc-48 | 8E+02 | 3E+00 | 2E-02 | 1E+01 |
| Sc-49 | 2E+04 | 8E-04 | 6E+01 | 1E+06 |
| Ti-44 | 3E+02 | 4E+00 | 1E-02 | 4E+00 |
| Ti-45 | 9E+03 | 1E+00 | 4E-02 | 3E+02 |

Table A1. (contd)

| Nuclide | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|
| V-47 | 3E+04 | 7E-01 | 7E-02 | 2E+03 |
| V-48 | 6E+02 | 3E+00 | 2E-02 | 1E+01 |
| V-49 | 7E+04 | 6E-02 | 9E-01 | 6E+04 |
| Cr-48 | 6E+03 | 3E+00 | 1E-02 | 9E+01 |
| Cr-49 | 3E+04 | 1E+00 | 5E-02 | 1E+03 |
| Cr-51 | 4E+04 | 3E+00 | 2E-02 | 7E+02 |
| Mn-51 | 2E+04 | 7E-01 | 7E-02 | 1E+03 |
| Mn-52 | 7E+02 | 3E+00 | 2E-02 | 1E+01 |
| Mn-52m | 3E+04 | 8E-01 | 6E-02 | 2E+03 |
| Mn-53 | 5E+04 | 3E-01 | 2E-01 | 9E+03 |
| Mn-54 | 2E+03 | 4E+00 | 1E-02 | 3E+01 |
| Mn-56 | 5E+03 | 1E+00 | 5E-02 | 2E+02 |
| Fe-52 | 9E+02 | 1E+00 | 4E-02 | 4E+01 |
| Fe-55 | 9E+03 | 3E+00 | 1E-02 | 1E+02 |
| Fe-59 | 8E+02 | 4E+00 | 1E-02 | 1E+01 |
| Fe-60 | 3E+01 | 4E+00 | 1E-02 | 3E-01 |
| Co-55 | 1E+03 | 1E+00 | 4E-02 | 4E+01 |
| Co-56 | 4E+02 | 4E+00 | 1E-02 | 5E+00 |
| Co-57 | 4E+03 | 4E+00 | 1E-02 | 5E+01 |
| Co-58 | 1E+03 | 3E+00 | 2E-02 | 2E+01 |
| Co-58m | 6E+04 | 9E-01 | 5E-02 | 3E+03 |
| Co-60 | 2E+02 | 5E+00 | 9E-03 | 2E+00 |
| Co-60m | 1E+06 | 1E-01 | 4E-01 | 4E+05 |
| Co-61 | 2E+04 | 3E-01 | 2E-01 | 4E+03 |
| Co-62m | 4E+04 | 6E-01 | 8E-02 | 3E+03 |
| Ni-56 | 1E+03 | 3E+00 | 2E-02 | 2E+01 |
| Ni-57 | 2E+03 | 4E+00 | 1E-02 | 3E+01 |
| Ni-59 | 2E+04 | 3E+00 | 2E-02 | 4E+02 |
| Ni-63 | 9E+03 | 3E+00 | 2E-02 | 2E+02 |
| Ni-65 | 8E+03 | 6E-01 | 9E-02 | 7E+02 |
| Ni-66 | 4E+02 | 6E-02 | 9E-01 | 4E+02 |
| Cu-60 | 3E+04 | 1E+00 | 4E-02 | 1E+03 |
| Cu-61 | 1E+04 | 1E+00 | 4E-02 | 4E+02 |
| Cu-64 | 1E+04 | 1E+00 | 5E-02 | 5E+02 |
| Cu-67 | 5E+03 | 2E+00 | 3E-02 | 2E+02 |

Table A1. (contd)

| Nuclide | ALI (μCi) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem (μCi) |
|---|---|---|---|---|
| Zn-62 | 1E+03 | 7E-01 | 7E-02 | 7E+01 |
| Zn-63 | 2E+04 | 6E-01 | 8E-02 | 2E+03 |
| Zn-65 | 4E+02 | 7E+00 | 7E-03 | 3E+00 |
| Zn-69 | 6E+04 | 9E-02 | 5E-01 | 3E+04 |
| Zn-69m | 4E+03 | 1E+00 | 5E-02 | 2E+02 |
| Zn-71m | 6E+03 | 2E+00 | 3E-02 | 2E+02 |
| Zn-72 | 1E+03 | 3E+00 | 2E-02 | 2E+01 |
| Ga-65 | 5E+04 | 5E-01 | 1E-01 | 5E+03 |
| Ga-66 | 1E+03 | 1E+00 | 5E-02 | 5E+01 |
| Ga-67 | 7E+03 | 2E+00 | 3E-02 | 2E+02 |
| Ga-68 | 2E+04 | 1E+00 | 4E-02 | 9E+02 |
| Ga-70 | 5E+04 | 4E-03 | 1E+01 | 6E+05 |
| Ga-72 | 1E+03 | 2E+00 | 3E-02 | 3E+01 |
| Ga-73 | 5E+03 | 5E-01 | 1E-01 | 5E+02 |
| Ge-66 | 2E+04 | 3E+00 | 2E-02 | 4E+02 |
| Ge-67 | 3E+04 | 3E-01 | 2E-01 | 5E+03 |
| Ge-68 | 5E+03 | 4E+00 | 1E-02 | 6E+01 |
| Ge-69 | 1E+04 | 3E+00 | 2E-02 | 2E+02 |
| Ge-71 | 5E+05 | 3E+00 | 1E-02 | 7E+03 |
| Ge-75 | 4E+04 | 6E-01 | 8E-02 | 3E+03 |
| Ge-77 | 9E+03 | 3E+00 | 2E-02 | 1E+02 |
| Ge-78 | 2E+04 | 2E+00 | 2E-02 | 5E+02 |
| As-69 | 3E+04 | 4E-01 | 1E-01 | 4E+03 |
| As-70 | 1E+04 | 1E+00 | 3E-02 | 3E+02 |
| As-71 | 4E+03 | 2E+00 | 2E-02 | 8E+01 |
| As-72 | 9E+02 | 1E+00 | 4E-02 | 4E+01 |
| As-73 | 8E+03 | 1E+00 | 4E-02 | 3E+02 |
| As-74 | 1E+03 | 1E+00 | 3E-02 | 3E+01 |
| As-76 | 1E+03 | 6E-01 | 9E-02 | 9E+01 |
| As-77 | 4E+03 | 4E-01 | 1E-01 | 5E+02 |
| As-78 | 8E+03 | 7E-01 | 7E-02 | 5E+02 |
| Se-70 | 2E+04 | 3E+00 | 2E-02 | 4E+02 |
| Se-73 | 3E+03 | 9E-01 | 6E-02 | 2E+02 |
| Se-73m | 6E+04 | 2E+00 | 3E-02 | 2E+03 |
| Se-75 | 5E+02 | 4E+00 | 1E-02 | 7E+00 |

Table A1. (contd)

| Nuclide | ALI (μCi) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem (μCi) |
|---|---|---|---|---|
| Se-79 | 6E+02 | 2E+00 | 2E-02 | 1E+01 |
| Se-81 | 6E+04 | 5E-02 | 1E+00 | 6E+04 |
| Se-81m | 4E+04 | 5E-01 | 1E-01 | 4E+03 |
| Se-83 | 4E+04 | 1E+00 | 4E-02 | 2E+03 |
| Br-74 | 2E+04 | 7E-01 | 8E-02 | 2E+03 |
| Br-74m | 1E+04 | 6E-01 | 8E-02 | 8E+02 |
| Br-75 | 3E+04 | 2E+00 | 3E-02 | 8E+02 |
| Br-76 | 4E+03 | 5E+00 | 1E-02 | 4E+01 |
| Br-77 | 2E+04 | 7E+00 | 8E-03 | 2E+02 |
| Br-80 | 5E+04 | 2E-01 | 3E-01 | 2E+04 |
| Br-80m | 2E+04 | 3E+00 | 2E-02 | 3E+02 |
| Br-82 | 3E+03 | 6E+00 | 9E-03 | 3E+01 |
| Br-83 | 5E+04 | 1E+00 | 4E-02 | 2E+03 |
| Br-84 | 2E+04 | 5E-01 | 1E-01 | 2E+03 |
| Rb-79 | 4E+04 | 5E-01 | 1E-01 | 4E+03 |
| Rb-81 | 4E+04 | 3E+00 | 2E-02 | 6E+02 |
| Rb-81m | 2E+05 | 2E+00 | 2E-02 | 5E+03 |
| Rb-82m | 1E+04 | 3E+00 | 1E-02 | 1E+02 |
| Rb-83 | 6E+02 | 4E+00 | 1E-02 | 7E+00 |
| Rb-84 | 5E+02 | 5E+00 | 1E-02 | 5E+00 |
| Rb-86 | 5E+02 | 4E+00 | 1E-02 | 6E+00 |
| Rb-87 | 1E+03 | 4E+00 | 1E-02 | 1E+01 |
| Rb-88 | 2E+04 | 2E-01 | 2E-01 | 5E+03 |
| Rb-89 | 4E+04 | 5E-01 | 1E-01 | 4E+03 |
| Sr-80 | 4E+03 | 5E-01 | 1E-01 | 4E+02 |
| Sr-81 | 3E+04 | 1E+00 | 5E-02 | 1E+03 |
| Sr-82 | 3E+02 | 1E+00 | 4E-02 | 1E+01 |
| Sr-83 | 3E+03 | 2E+00 | 2E-02 | 7E+01 |
| Sr-85 | 3E+03 | 4E+00 | 1E-02 | 4E+01 |
| Sr-85m | 2E+05 | 3E+00 | 2E-02 | 3E+03 |
| Sr-87m | 5E+04 | 2E+00 | 2E-02 | 1E+03 |
| Sr-89 | 6E+02 | 5E-01 | 9E-02 | 6E+01 |
| Sr-90 | 3E+01 | 2E-01 | 3E-01 | 9E+00 |
| Sr-91 | 2E+03 | 9E-01 | 6E-02 | 1E+02 |
| Sr-92 | 3E+03 | 7E-01 | 7E-02 | 2E+02 |
| Y-86 | 1E+03 | 2E+00 | 2E-02 | 2E+01 |
| Y-86m | 2E+04 | 3E+00 | 2E-02 | 4E+02 |

Table Al. (contd)

| Nuclide | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|
| Y-87 | 2E+03 | 2E+00 | 2E-02 | 5E+01 |
| Y-88 | 1E+03 | 4E+00 | 1E-02 | 1E+01 |
| Y-90 | 4E+02 | 2E-05 | 3E+03 | 1E+06 |
| Y-90m | 8E+03 | 1E+00 | 5E-02 | 4E+02 |
| Y-91 | 5E+02 | 3E-03 | 2E+01 | 8E+03 |
| Y-91m | 1E+05 | 2E+00 | 2E-02 | 2E+03 |
| Y-92 | 3E+03 | 1E-01 | 3E-01 | 1E+03 |
| Y-93 | 1E+03 | 4E-02 | 1E+00 | 1E+03 |
| Y-94 | 2E+04 | 2E-01 | 2E-01 | 5E+03 |
| Y-95 | 4E+04 | 1E-01 | 4E-01 | 1E+04 |
| Zr-86 | 1E+03 | 2E+00 | 3E-02 | 3E+01 |
| Zr-88 | 4E+03 | 3E+00 | 2E-02 | 6E+01 |
| Zr-89 | 2E+03 | 3E+00 | 2E-02 | 3E+01 |
| Zr-93 | 1E+03 | 2E-04 | 3E+02 | 3E+05 |
| Zr-95 | 1E+03 | 1E+00 | 4E-02 | 4E+01 |
| Zr-97 | 6E+02 | 6E-01 | 8E-02 | 5E+01 |
| Nb-88 | 5E+04 | 6E-01 | 9E-02 | 4E+03 |
| Nb-89 | 5E+03 | 9E-01 | 5E-02 | 3E+02 |
| Nb-89m | 1E+04 | 1E+00 | 4E-02 | 4E+02 |
| Nb-90 | 1E+03 | 2E+00 | 2E-02 | 2E+01 |
| Nb-93m | 9E+03 | 8E-02 | 6E-01 | 5E+03 |
| Nb-94 | 9E+02 | 3E+00 | 2E-02 | 2E+01 |
| Nb-95 | 2E+03 | 2E+00 | 2E-02 | 4E+01 |
| Nb-95m | 2E+03 | 3E-01 | 2E-01 | 4E+02 |
| Nb-96 | 1E+03 | 2E+00 | 2E-02 | 2E+01 |
| Nb-97 | 2E+04 | 8E-01 | 6E-02 | 1E+03 |
| Nb-98 | 1E+04 | 1E+00 | 5E-02 | 5E+02 |
| Mo-90 | 4E+03 | 2E+00 | 2E-02 | 8E+01 |
| Mo-93 | 4E+03 | 1E+00 | 4E-02 | 1E+02 |
| Mo-93m | 9E+03 | 3E+00 | 1E-02 | 1E+02 |
| Mo-99 | 2E+03 | 2E+00 | 3E-02 | 7E+01 |
| Mo-101 | 4E+04 | 5E-01 | 1E-01 | 4E+03 |
| Tc-93 | 3E+04 | 3E+00 | 2E-02 | 5E+02 |
| Tc-93m | 7E+04 | 3E+00 | 2E-02 | 1E+03 |
| Tc-94 | 9E+03 | 3E+00 | 2E-02 | 1E+02 |
| Tc-94m | 2E+04 | 1E+00 | 4E-02 | 9E+02 |

Table A1. (contd)

| Nuclide | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|
| Tc-95 | 1E+04 | 3E+00 | 2E-02 | 2E+02 |
| Tc-95m | 4E+03 | 4E+00 | 1E-02 | 5E+01 |
| Tc-96 | 2E+03 | 4E+00 | 1E-02 | 2E+01 |
| Tc-96m | 2E+05 | 4E+00 | 1E-02 | 3E+03 |
| Tc-97 | 4E+04 | 1E+00 | 3E-02 | 1E+03 |
| Tc-97m | 5E+03 | 1E+00 | 5E-02 | 3E+02 |
| Tc-98 | 1E+03 | 2E+00 | 2E-02 | 2E+01 |
| Tc-99 | 4E+03 | 9E-01 | 6E-02 | 2E+02 |
| Tc-99m | 8E+04 | 2E+00 | 2E-02 | 2E+03 |
| Tc-101 | 9E+04 | 2E-01 | 2E-01 | 2E+04 |
| Tc-104 | 2E+04 | 3E-01 | 2E-01 | 3E+03 |
| Ru-94 | 2E+04 | 2E+00 | 2E-02 | 4E+02 |
| Ru-97 | 8E+03 | 3E+00 | 2E-02 | 1E+02 |
| Ru-103 | 2E+03 | 2E+00 | 3E-02 | 5E+01 |
| Ru-105 | 5E+03 | 1E+00 | 5E-02 | 2E+02 |
| Ru-106 | 2E+02 | 1E+00 | 4E-02 | 9E+00 |
| Rh-99 | 2E+03 | 2E+00 | 2E-02 | 5E+01 |
| Rh-99m | 2E+04 | 4E+00 | 1E-02 | 3E+02 |
| Rh-100 | 2E+03 | 4E+00 | 1E-02 | 3E+01 |
| Rh-101 | 2E+03 | 3E+00 | 2E-02 | 3E+01 |
| Rh-101m | 6E+03 | 3E+00 | 2E-02 | 1E+02 |
| Rh-102 | 6E+02 | 6E+00 | 9E-03 | 5E+00 |
| Rh-102m | 1E+03 | 2E+00 | 3E-02 | 3E+01 |
| Rh-103m | 4E+05 | 2E-02 | 2E+00 | 8E+05 |
| Rh-105 | 4E+03 | 4E-01 | 1E-01 | 5E+02 |
| Rh-106m | 8E+03 | 3E+00 | 2E-02 | 1E+02 |
| Rh-107 | 7E+04 | 3E-01 | 2E-01 | 1E+04 |
| Pd-100 | 1E+03 | 2E+00 | 3E-02 | 3E+01 |
| Pd-101 | 1E+04 | 2E+00 | 3E-02 | 3E+02 |
| Pd-103 | 6E+03 | 4E-02 | 1E+00 | 7E+03 |
| Pd-107 | 3E+04 | 1E-03 | 5E+01 | 1E+06 |
| Pd-109 | 2E+03 | 1E-02 | 4E+00 | 8E+03 |
| Ag-102 | 5E+04 | 9E-01 | 5E-02 | 3E+03 |
| Ag-103 | 4E+04 | 2E+00 | 3E-02 | 1E+03 |
| Ag-104 | 2E+04 | 3E+00 | 2E-02 | 3E+02 |
| Ag-104m | 3E+04 | 2E+00 | 3E-02 | 9E+02 |

Table A1. (contd)

| Nuclide | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|
| Ag-105 | 3E+03 | 3E+00 | 2E-02 | 5E+01 |
| Ag-106 | 6E+04 | 6E-01 | 8E-02 | 5E+03 |
| Ag-106m | 8E+02 | 3E+00 | 2E-02 | 1E+01 |
| Ag-108m | 6E+02 | 2E+00 | 3E-02 | 2E+01 |
| Ag-110m | 5E+02 | 3E+00 | 2E-02 | 1E+01 |
| Ag-111 | 9E+02 | 6E-02 | 8E-01 | 7E+02 |
| Ag-112 | 3E+03 | 3E-01 | 2E-01 | 5E+02 |
| Ag-115 | 3E+04 | 3E-01 | 2E-01 | 5E+03 |
| Cd-104 | 2E+04 | 3E+00 | 2E-02 | 3E+02 |
| Cd-107 | 2E+04 | 2E-01 | 3E-01 | 5E+03 |
| Cd-109 | 3E+02 | 3E-01 | 2E-01 | 5E+01 |
| Cd-113 | 2E+01 | 3E-01 | 2E-01 | 4E+00 |
| Cd-113m | 2E+01 | 3E-01 | 2E-01 | 4E+00 |
| Cd-115 | 9E+02 | 4E-01 | 1E-01 | 1E+02 |
| Cd-115m | 3E+02 | 2E-01 | 3E-01 | 8E+01 |
| Cd-117 | 5E+03 | 1E+00 | 5E-02 | 2E+02 |
| Cd-117m | 5E+03 | 2E+00 | 2E-02 | 1E+02 |
| In-109 | 2E+04 | 3E+00 | 2E-02 | 3E+02 |
| In-110 (4.9 h) | 5E+03 | 4E+00 | 1E-02 | 6E+01 |
| In-110 (69 m) | 2E+04 | 2E+00 | 3E-02 | 6E+02 |
| In-111 | 4E+03 | 2E+00 | 2E-02 | 8E+01 |
| In-112 | 2E+05 | 4E-01 | 1E-01 | 3E+04 |
| In-113m | 5E+04 | 1E+00 | 4E-02 | 2E+03 |
| In-114m | 3E+02 | 2E-01 | 3E-01 | 8E+01 |
| In-115 | 4E+01 | 7E-01 | 7E-02 | 3E+00 |
| In-115m | 1E+04 | 4E-01 | 1E-01 | 1E+03 |
| In-116m | 2E+04 | 2E+00 | 3E-02 | 5E+02 |
| In-117 | 6E+04 | 1E+00 | 3E-02 | 2F+03 |
| In-117m | 1E+04 | 5E-01 | 1E-01 | 1E+03 |
| In-119m | 4E+04 | 1E-02 | 4E+00 | 2E+05 |
| Sn-110 | 4E+03 | 2E+00 | 3E-02 | 1E+02 |
| Sn-111 | 7E+04 | 1E+00 | 4E-02 | 3E+03 |
| Sn-113 | 2E+03 | 1E+00 | 5E-02 | 1E+02 |
| Sn-117m | 2E+03 | 6E-01 | 8E-02 | 2E+02 |
| Sn-119m | 3E+03 | 1E-01 | 4E-01 | 1E+03 |

Table A1. (contd)

| Nuclide | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|
| Sn-121 | 6E+03 | 4E-03 | 1E+01 | 7E+04 |
| Sn-121m | 3E+03 | 3E-01 | 1E-01 | 4E+02 |
| Sn-123 | 5E+02 | 6E-02 | 8E-01 | 4E+02 |
| Sn-123m | 5E+04 | 2E-01 | 2E-01 | 1E+04 |
| Sn-125 | 4E+02 | 2E-01 | 3E-01 | 1E+02 |
| Sn-126 | 3E+02 | 1E+00 | 4E-02 | 1E+01 |
| Sn-127 | 7E+03 | 2E+00 | 3E-02 | 2E+02 |
| Sn-128 | 9E+03 | 1E+00 | 4E-02 | 4E+02 |
| Sb-115 | 8E+04 | 2E+00 | 3E-02 | 2E+03 |
| Sb-116 | 7E+04 | 1E+00 | 4E-02 | 3E+03 |
| Sb-116m | 2E+04 | 3E+00 | 2E-02 | 3E+02 |
| Sb-117 | 7E+04 | 2E+00 | 2E-02 | 1E+03 |
| Sb-118m | 5E+03 | 3E+00 | 2E-02 | 8E+01 |
| Sb-119 | 2E+04 | 4E-01 | 1E-01 | 2E+03 |
| Sb-120 (16 m) | 1E+05 | 4E-01 | 1E-01 | 1E+04 |
| Sb-120 (5.8 d) | 9E+02 | 3E+00 | 2E-02 | 1E+01 |
| Sb-122 | 7E+02 | 4E-01 | 1E-01 | 9E+01 |
| Sb-124 | 5E+02 | 1E+00 | 3E-02 | 2E+01 |
| Sb-124m | 2E+05 | 1E+00 | 5E-02 | 1E+04 |
| Sb-125 | 2E+03 | 2E+00 | 3E-02 | 6E+01 |
| Sb-126 | 5E+02 | 2E+00 | 2E-02 | 1E+01 |
| Sb-126m | 5E+04 | 8E-01 | 6E-02 | 3E+03 |
| Sb-127 | 8E+02 | 8E-01 | 6E-02 | 5E+01 |
| Sb-128 (10.4 m) | 8E+04 | 1E+00 | 5E-02 | 4E+03 |
| Sb-128 (9.0 h) | 1E+03 | 9E-01 | 6E-02 | 6E+01 |
| Sb-129 | 3E+03 | 1E+00 | 5E-02 | 1E+02 |
| Sb-130 | 2E+04 | 2E+00 | 3E-02 | 5E+02 |
| Sb-131 | 1E+04 | 3E-01 | 1E-01 | 1E+03 |
| Te-116 | 8E+03 | 2E+00 | 2E-02 | 2E+02 |
| Te-121 | 3E+03 | 3E+00 | 2E-02 | 5E+01 |
| Te-121m | 5E+02 | 8E-01 | 6E-02 | 3E+01 |
| Te-123 | 5E+02 | 3E-03 | 2E+01 | 8E+03 |
| Te-123m | 6E+02 | 4E-01 | 1E-01 | 8E+01 |
| Te-125m | 1E+03 | 2E-01 | 3E-01 | 3E+02 |
| Te-127 | 7E+03 | 9E-02 | 6E-01 | 4E+03 |

Table A1. (contd)

| Nuclide | ALI (μCi) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem (μCi) |
|---|---|---|---|---|
| Te-127m | 6E+02 | 2E-01 | 2E-01 | 1E+02 |
| Te-129 | 3E+04 | 1E-01 | 4E-01 | 1E+04 |
| Te-129m | 5E+02 | 3E-01 | 1E-01 | 7E+01 |
| Te-131 | 3E+03 | 1E-01 | 4E-01 | 1E+03 |
| Te-131m | 3E+02 | 4E-01 | 1E-01 | 4E+01 |
| Te-132 | 2E+02 | 3E-01 | 1E-01 | 3E+01 |
| Te-133 | 1E+04 | 7E-02 | 8E-01 | 8E+03 |
| Te-133m | 3E+03 | 3E-01 | 2E-01 | 5E+02 |
| Te-134 | 2E+04 | 2E+00 | 3E-02 | 6E+02 |
| I-120 | 4E+03 | 4E-01 | 1E-01 | 5E+02 |
| I-120m | 1E+04 | 9E-01 | 6E-02 | 6E+02 |
| I-121 | 1E+04 | 2E-01 | 3E-01 | 3E+03 |
| I-123 | 3E+03 | 7E-02 | 7E-01 | 2E+03 |
| I-124 | 5E+01 | 1E-02 | 5E+00 | 2E+02 |
| I-125 | 4E+01 | 4E-03 | 1E+01 | 5E+02 |
| I-126 | 2E+01 | 4E-03 | 1E+01 | 2E+02 |
| I-128 | 4E+04 | 2E-01 | 2E-01 | 1E+04 |
| I-129 | 5E+00 | 3E-03 | 2E+01 | 1E+02 |
| I-130 | 4E+02 | 9E-02 | 5E-01 | 2E+02 |
| I-131 | 3E+01 | 5E-03 | 1E+01 | 3E+02 |
| I-132 | 4E+03 | 4E-01 | 1E-01 | 5E+02 |
| I-132m | 4E+03 | 2E-01 | 2E-01 | 8E+02 |
| I-133 | 1E+02 | 1E-02 | 4E+00 | 4E+02 |
| I-134 | 2E+04 | 9E-01 | 5E-02 | 1E+03 |
| I-135 | 8E+02 | 1E-01 | 4E-01 | 4E+02 |
| Cs-125 | 5E+04 | 7E-01 | 8E-02 | 4E+03 |
| Cs-127 | 6E+04 | 4E+00 | 1E-02 | 8E+02 |
| Cs-129 | 2E+04 | 4E+00 | 1E-02 | 2E+02 |
| Cs-130 | 6E+04 | 4E-01 | 1E-01 | 7E+03 |
| Cs-131 | 2E+04 | 5E+00 | 1E-02 | 2E+02 |
| Cs-132 | 3E+03 | 6E+00 | 8E-03 | 2E+01 |
| Cs-134 | 7E+01 | 6E+00 | 9E-03 | 6E-01 |
| Cs-134m | 1E+05 | 3E+00 | 2E-02 | 2E+03 |
| Cs-135 | 7E+02 | 5E+00 | 1E-02 | 7E+00 |
| Cs-135m | 1E+05 | 2E+00 | 2E-02 | 2E+03 |

Table A1. (contd)

| Nuclide | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|
| Cs-136 | 4E+02 | 6E+00 | 9E-03 | 4E+00 |
| Cs-137 | 1E+02 | 5E+00 | 9E-03 | 9E-01 |
| Cs-138 | 2E+04 | 6E-01 | 8E-02 | 2E+03 |
| Ba-126 | 6E+03 | 7E-01 | 7E-02 | 4E+02 |
| Ba-128 | 5E+02 | 6E-01 | 9E-02 | 4E+01 |
| Ba-131 | 3E+03 | 2E+00 | 2E-02 | 7E+01 |
| Ba-131m | 4E+05 | 5E-01 | 9E-02 | 4E+04 |
| Ba-133 | 2E+03 | 3E+00 | 2E-02 | 4E+01 |
| Ba-133m | 2E+03 | 2E-01 | 3E-01 | 6E+02 |
| Ba-135m | 3E+03 | 2E-01 | 2E-01 | 7E+02 |
| Ba-139 | 1E+04 | 5E-02 | 1E+00 | 1E+04 |
| Ba-140 | 5E+02 | 8E-01 | 7E-02 | 3E+01 |
| Ba-141 | 2E+04 | 2E-01 | 3E-01 | 5E+03 |
| Ba-142 | 5E+04 | 1E+00 | 4E-02 | 2E+03 |
| La-131 | 5E+04 | 2E+00 | 3E-02 | 1E+03 |
| La-132 | 3E+03 | 2E+00 | 3E-02 | 1E+02 |
| La-135 | 4E+04 | 1E+00 | 4E-02 | 1E+03 |
| La-137 | 1E+04 | 8E-01 | 7E-02 | 7E+02 |
| La-138 | 9E+02 | 3E+00 | 2E-02 | 2E+01 |
| La-140 | 6E+02 | 1E+00 | 4E-02 | 2E+01 |
| La-141 | 4E+03 | 4E-02 | 1E+00 | 5E+03 |
| La-142 | 8E+03 | 2E+00 | 3E-02 | 3E+02 |
| La-143 | 4E+04 | 1E-01 | 4E-01 | 2E+04 |
| Ce-134 | 5E+02 | 5E-01 | 1E-01 | 5E+01 |
| Ce-135 | 2E+03 | 3E+00 | 2E-02 | 4E+01 |
| Ce-137 | 5E+04 | 1E+00 | 5E-02 | 2E+03 |
| Ce-137m | 2E+03 | 2E-01 | 3E-01 | 5E+02 |
| Ce-139 | 5E+03 | 2E+00 | 3E-02 | 1E+02 |
| Ce-141 | 2E+03 | 3E-01 | 1E-01 | 3E+02 |
| Ce-143 | 1E+03 | 3E-01 | 2E-01 | 2E+02 |
| Ce-144 | 2E+02 | 2E-02 | 2E+00 | 4E+02 |
| Pr-136 | 5E+04 | 6E-01 | 8E-02 | 4E+03 |
| Pr-137 | 4E+04 | 2E+00 | 3E-02 | 1E+03 |
| Pr-138m | 1E+04 | 3E+00 | 2E-02 | 2E+02 |
| Pr-139 | 4E+04 | 1E+00 | 4E-02 | 1E+03 |

Table A1. (contd)

| Nuclide | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|
| Pr-142 | 1E+03 | 4E-02 | 1E+00 | 1E+03 |
| Pr-142m | 8E+04 | 4E-02 | 1E+00 | 1E+05 |
| Pr-143 | 9E+02 | 1E-08 | 4E+06 | 4E+09 |
| Pr-144 | 3E+04 | 8E-03 | 7E+00 | 2E+05 |
| Pr-145 | 3E+03 | 1E-02 | 4E+00 | 1E+04 |
| Pr-147 | 5E+04 | 3E-01 | 2E-01 | 9E+03 |
| Nd-136 | 1E+04 | 1E+00 | 5E-02 | 5E+02 |
| Nd-138 | 2E+03 | 5E-01 | 1E-01 | 2E+02 |
| Nd-139 | 9E+04 | 1E+00 | 5E-02 | 4E+03 |
| Nd-139m | 5E+03 | 3E+00 | 2E-02 | 1E+02 |
| Nd-141 | 2E+05 | 3E+00 | 2E-02 | 4E+03 |
| Nd-147 | 1E+03 | 3E-01 | 2E-01 | 2E+02 |
| Nd-149 | 1E+04 | 4E-01 | 1E-01 | 1E+03 |
| Nd-151 | 7E+04 | 5E-01 | 9E-02 | 7E+03 |
| Pm-141 | 5E+04 | 5E-01 | 9E-02 | 5E+03 |
| Pm-143 | 5E+03 | 3E+00 | 2E-02 | 9E+01 |
| Pm-144 | 1E+03 | 3E+00 | 2E-02 | 2E+01 |
| Pm-145 | 1E+04 | 8E-01 | 6E-02 | 6E+02 |
| Pm-146 | 2E+03 | 3E+00 | 2E-02 | 4E+01 |
| Pm-147 | 4E+03 | 4E-05 | 1E+03 | 5E+06 |
| Pm-148 | 4E+02 | 3E-01 | 2E-01 | 6E+01 |
| Pm-148m | 7E+02 | 2E+00 | 2E-02 | 2E+01 |
| Pm-149 | 1E+03 | 1E-02 | 4E+00 | 4E+03 |
| Pm-150 | 5E+03 | 1E+00 | 5E-02 | 2E+02 |
| Pm-151 | 2E+03 | 7E-01 | 7E-02 | 1E+02 |
| Sm-141 | 5E+04 | 6E-01 | 8E-02 | 4E+03 |
| Sm-141m | 3E+04 | 1E+00 | 4E-02 | 1E+03 |
| Sm-142 | 8E+03 | 5E-01 | 1E-01 | 8E+02 |
| Sm-145 | 6E+03 | 1E+00 | 5E-02 | 3E+02 |
| Sm-151 | 1E+04 | 4E-05 | 1E+03 | 1E+07 |
| Sm-153 | 2E+03 | 2E-01 | 2E-01 | 5E+02 |
| Sm-155 | 6E+04 | 1E-01 | 5E-01 | 3E+04 |
| Sm-156 | 5E+03 | 5E-01 | 9E-02 | 5E+02 |
| Eu-145 | 2E+03 | 4E+00 | 1E-02 | 3E+01 |
| Eu-146 | 1E+03 | 3E+00 | 1E-02 | 1E+01 |

Table A1. (contd)

| Nuclide | ALI (μCi) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem (μCi) |
|---|---|---|---|---|
| Eu-147 | 3E+03 | 3E+00 | 2E-02 | 6E+01 |
| Eu-148 | 1E+03 | 4E+00 | 1E-02 | 1E+01 |
| Eu-149 | 1E+04 | 1E+00 | 4E-02 | 4E+02 |
| Eu-150 (12.6 h) | 3E+03 | 9E-02 | 6E-01 | 2E+03 |
| Eu-150 (34.2 y) | 8E+02 | 2E+00 | 2E-02 | 2E+01 |
| Eu-152 | 8E+02 | 2E+00 | 3E-02 | 2E+01 |
| Eu-152m | 3E+03 | 4E-01 | 1E-01 | 4E+02 |
| Eu-154 | 5E+02 | 1E+00 | 4E-02 | 2E+01 |
| Eu-155 | 4E+03 | 6E-01 | 8E-02 | 3E+02 |
| Eu-156 | 6E+02 | 1E+00 | 4E-02 | 3E+01 |
| Eu-157 | 2E+03 | 4E-01 | 1E-01 | 2E+02 |
| Eu-158 | 2E+04 | 7E-01 | 7E-02 | 1E+03 |
| Gd-145 | 5E+04 | 2E+00 | 3E-02 | 2E+03 |
| Gd-146 | 1E+03 | 1E+00 | 4E-02 | 4E+01 |
| Gd-147 | 2E+03 | 3E+00 | 2E-02 | 3E+01 |
| Gd-149 | 3E+03 | 2E+00 | 2E-02 | 7E+01 |
| Gd-151 | 6E+03 | 9E-01 | 6E-02 | 3E+02 |
| Gd-153 | 5E+03 | 1E+00 | 4E-02 | 2E+02 |
| Gd-159 | 3E+03 | 1E-01 | 4E-01 | 1E+03 |
| Tb-147 | 9E+03 | 2E+00 | 3E-02 | 2E+02 |
| Tb-149 | 5E+03 | 2E+00 | 3E-02 | 1E+02 |
| Tb-150 | 5E+03 | 2E+00 | 3E-02 | 2E+02 |
| Tb-151 | 4E+03 | 3E+00 | 2E-02 | 7E+01 |
| Tb-153 | 5E+03 | 2E+00 | 3E-02 | 1E+02 |
| Tb-154 | 2E+03 | 3E+00 | 1E-02 | 3E+01 |
| Tb-155 | 6E+03 | 2E+00 | 3E-02 | 2E+02 |
| Tb-156 | 1E+03 | 3E+00 | 2E-02 | 2E+01 |
| Tb-156m (24.4 h) | 7E+03 | 2E+00 | 3E-02 | 2E+02 |
| Tb-156m (5.0 h) | 2E+04 | 2E+00 | 3E-02 | 6E+02 |
| Tb-157 | 5E+04 | 4E-01 | 1E-01 | 7E+03 |
| Tb-158 | 1E+03 | 1E+00 | 3E-02 | 3E+01 |
| Tb-160 | 8E+02 | 1E+00 | 3E-02 | 3E+01 |
| Tb-161 | 2E+03 | 2E-01 | 3E-01 | 6E+02 |
| Dy-155 | 9E+03 | 3E+00 | 2E-02 | 2E+02 |
| Dy-157 | 2E+04 | 3E+00 | 1E-02 | 3E+02 |
| Dy-159 | 1E+04 | 1E+00 | 4E-02 | 4E+02 |
| Dy-165 | 1E+04 | 4E-02 | 1E+00 | 1E+04 |

Table A1. (contd)

| Nuclide | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|
| Dy-166 | 6E+02 | 6E-02 | 8E-01 | 5E+02 |
| Ho-155 | 4E+04 | 2E+00 | 3E-02 | 1E+03 |
| Ho-157 | 3E+05 | 2E+00 | 2E-02 | 6E+03 |
| Ho-159 | 2E+05 | 2E+00 | 2E-02 | 5E+03 |
| Ho-161 | 1E+05 | 1E+00 | 4E-02 | 4E+03 |
| Ho-162 | 5E+05 | 7E-01 | 7E-02 | 4E+04 |
| Ho-162m | 5E+04 | 2E+00 | 2E-02 | 1E+03 |
| Ho-164 | 2E+05 | 2E-01 | 3E-01 | 5E+04 |
| Ho-164m | 1E+05 | 4E-01 | 1E-01 | 1E+04 |
| Ho-166 | 9E+02 | 3E-02 | 2E+00 | 2E+03 |
| Ho-166m | 6E+02 | 2E+00 | 3E-02 | 2E+01 |
| Ho-167 | 2E+04 | 1E+00 | 4E-02 | 7E+02 |
| Er-161 | 2E+04 | 4E+00 | 1E-02 | 3E+02 |
| Er-165 | 6E+04 | 2E+00 | 2E-02 | 1E+03 |
| Er-169 | 3E+03 | 1E-04 | 4E+02 | 1E+06 |
| Er-171 | 4E+03 | 7E-01 | 7E-02 | 3E+02 |
| Er-172 | 1E+03 | 8E-01 | 6E-02 | 6E+01 |
| Tm-162 | 7E+04 | 1E+00 | 3E-02 | 2E+03 |
| Tm-166 | 4E+03 | 3E+00 | 2E-02 | 7E+01 |
| Tm-167 | 2E+03 | 6E-01 | 8E-02 | 2E+02 |
| Tm-170 | 8E+02 | 1E-02 | 4E+00 | 3E+03 |
| Tm-171 | 1E+04 | 2E-02 | 2E+00 | 2E+04 |
| Tm-172 | 7E+02 | 4E-01 | 1E-01 | 9E+01 |
| Tm-173 | 4E+03 | 7E-01 | 7E-02 | 3E+02 |
| Tm-175 | 7E+04 | 6E-01 | 9E-02 | 6E+03 |
| Yb-162 | 7E+04 | 2E+00 | 3E-02 | 2E+03 |
| Yb-166 | 1E+03 | 2E+00 | 3E-02 | 3E+01 |
| Yb-167 | 3E+05 | 1E+00 | 5E-02 | 1E+04 |
| Yb-169 | 2E+03 | 1E+00 | 3E-02 | 7E+01 |
| Yb-175 | 3E+03 | 2E-01 | 3E-01 | 8E+02 |
| Yb-177 | 2E+04 | 4E-01 | 1E-01 | 2E+03 |
| Yb-178 | 1E+04 | 1E-01 | 4E-01 | 4E+03 |
| Lu-169 | 3E+03 | 3E+00 | 2E-02 | 5E+01 |
| Lu-170 | 1E+03 | 3E+00 | 2E-02 | 2E+01 |
| Lu-171 | 2E+03 | 2E+00 | 2E-02 | 4E+01 |

Table A1. (contd)

| Nuclide | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|
| Lu-172 | 1E+03 | 3E+00 | 2E-02 | 2E+01 |
| Lu-173 | 5E+03 | 2E+00 | 3E-02 | 2E+02 |
| Lu-174 | 5E+03 | 1E+00 | 4E-02 | 2E+02 |
| Lu-174m | 2E+03 | 3E-01 | 2E-01 | 3E+02 |
| Lu-176 | 7E+02 | 7E-01 | 7E-02 | 5E+01 |
| Lu-176m | 8E+03 | 4E-02 | 1E+00 | 1E+04 |
| Lu-177 | 2E+03 | 1E-01 | 4E-01 | 7E+02 |
| Lu-177m | 7E+02 | 1E+00 | 4E-02 | 2E+01 |
| Lu-178 | 4E+04 | 1E-01 | 5E-01 | 2E+04 |
| Lu-178m | 5E+04 | 8E-01 | 6E-02 | 3E+03 |
| Lu-179 | 6E+03 | 5E-02 | 9E-01 | 5E+03 |
| Hf-170 | 3E+03 | 3E+00 | 2E-02 | 5E+01 |
| Hf-172 | 1E+03 | 9E-01 | 5E-02 | 5E+01 |
| Hf-173 | 5E+03 | 2E+00 | 2E-02 | 1E+02 |
| Hf-175 | 3E+03 | 2E+00 | 2E-02 | 7E+01 |
| Hf-177m | 2E+04 | 2E+00 | 2E-02 | 5E+02 |
| Hf-178m | 3E+02 | 2E+00 | 3E-02 | 8E+00 |
| Hf-179m | 1E+03 | 2E+00 | 3E-02 | 3E+01 |
| Hf-180m | 7E+03 | 2E+00 | 2E-02 | 1E+02 |
| Hf-181 | 1E+03 | 1E+00 | 5E-02 | 5E+01 |
| Hf-182 | 2E+02 | 5E-01 | 1E-01 | 2E+01 |
| Hf-182m | 4E+04 | 2E+00 | 2E-02 | 1E+03 |
| Hf-183 | 2E+04 | 9E-01 | 5E-02 | 1E+03 |
| Hf-184 | 2E+03 | 8E-01 | 6E-02 | 1E+02 |
| Ta-172 | 4E+04 | 2E+00 | 3E-02 | 1E+03 |
| Ta-173 | 7E+03 | 1E+00 | 4E-02 | 3E+02 |
| Ta-174 | 3E+04 | 1E+00 | 4E-02 | 1E+03 |
| Ta-175 | 6E+03 | 3E+00 | 2E-02 | 1E+02 |
| Ta-176 | 4E+03 | 3E+00 | 2E-02 | 6E+01 |
| Ta-177 | 1E+04 | 1E+00 | 4E-02 | 4E+02 |
| Ta-178 | 2E+04 | 3E+00 | 2E-02 | 3E+02 |
| Ta-179 | 2E+04 | 2E+00 | 3E-02 | 5E+02 |
| Ta-180 | 1E+03 | 1E+00 | 4E-02 | 4E+01 |
| Ta-180m | 2E+04 | 7E-01 | 7E-02 | 1E+03 |
| Ta-182 | 8E+02 | 2E+00 | 3E-02 | 2E+01 |

Table A1. (contd)

| Nuclide | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|
| Ta-182m | 2E+05 | 5E-01 | 9E-02 | 2E+04 |
| Ta-183 | 9E+02 | 5E-01 | 1E-01 | 9E+01 |
| Ta-184 | 2E+03 | 1E+00 | 3E-02 | 7E+01 |
| Ta-185 | 3E+04 | 3E-01 | 2E-01 | 5E+03 |
| Ta-186 | 5E+04 | 4E-01 | 1E-01 | 7E+03 |
| W-176 | 1E+04 | 2E+00 | 3E-02 | 3E+02 |
| W-177 | 2E+04 | 2E+00 | 2E-02 | 5E+02 |
| W-178 | 5E+03 | 1E+00 | 5E-02 | 3E+02 |
| W-179 | 5E+05 | 1E+00 | 4E-02 | 2E+04 |
| W-181 | 2E+04 | 2E+00 | 3E-02 | 6E+02 |
| W-185 | 2E+03 | 2E-04 | 2E+02 | 5E+05 |
| W-187 | 2E+03 | 6E-01 | 8E-02 | 2E+02 |
| W-188 | 4E+02 | 2E-02 | 2E+00 | 1E+03 |
| Re-177 | 9E+04 | 1E+00 | 5E-02 | 4E+03 |
| Re-178 | 7E+04 | 5E-01 | 1E-01 | 7E+03 |
| Re-181 | 5E+03 | 2E+00 | 3E-02 | 1E+02 |
| Re-182 (12.7 h) | 7E+03 | 3E+00 | 2E-02 | 1E+02 |
| Re-182 (64.0 h) | 1E+03 | 2E+00 | 3E-02 | 3E+01 |
| Re-184 | 2E+03 | 3E+00 | 2E-02 | 4E+01 |
| Re-184m | 2E+03 | 2E+00 | 2E-02 | 5E+01 |
| Re-186 | 2E+03 | 7E-01 | 7E-02 | 1E+02 |
| Re-186m | 1E+03 | 8E-01 | 7E-02 | 7E+01 |
| Re-187 | 6E+05 | 9E-01 | 6E-02 | 3E+04 |
| Re-188 | 2E+03 | 6E-01 | 8E-02 | 2E+02 |
| Re-188m | 8E+04 | 5E-01 | 1E-01 | 8E+03 |
| Re-189 | 3E+03 | 6E-01 | 8E-02 | 3E+02 |
| Os-180 | 1E+05 | 2E+00 | 3E-02 | 3E+03 |
| Os-181 | 1E+04 | 2E+00 | 3E-02 | 3E+02 |
| Os-182 | 2E+03 | 2E+00 | 2E-02 | 5E+01 |
| Os-185 | 2E+03 | 3E+00 | 2E-02 | 4E+01 |
| Os-189m | 8E+04 | 4E-03 | 1E+01 | 1E+06 |
| Os-191 | 2E+03 | 4E-01 | 1E-01 | 3E+02 |
| Os-191m | 1E+04 | 1E-01 | 4E-01 | 4E+03 |
| Os-193 | 2E+03 | 2E-01 | 3E-01 | 6E+02 |
| Os-194 | 4E+02 | 3E-01 | 1E-01 | 6E+01 |

Table A1. (contd)

| Nuclide | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|
| Ir-182 | 4E+04 | 9E-01 | 6E-02 | 2E+03 |
| Ir-184 | 8E+03 | 3E+00 | 2E-02 | 2E+02 |
| Ir-185 | 5E+03 | 2E+00 | 3E-02 | 1E+02 |
| Ir-186 | 2E+03 | 2E+00 | 2E-02 | 4E+01 |
| Ir-187 | 1E+04 | 2E+00 | 2E-02 | 2E+02 |
| Ir-188 | 2E+03 | 3E+00 | 2E-02 | 3E+01 |
| Ir-189 | 5E+03 | 1E+00 | 5E-02 | 3E+02 |
| Ir-190 | 1E+03 | 3E+00 | 2E-02 | 2E+01 |
| Ir-190m | 2E+05 | 2E+00 | 2E-02 | 5E+03 |
| Ir-192 | 9E+02 | 1E+00 | 3E-02 | 3E+01 |
| Ir-192m | 3E+03 | 3E+00 | 2E-02 | 6E+01 |
| Ir-194 | 1E+03 | 8E-02 | 7E-01 | 7E+02 |
| Ir-194m | 6E+02 | 3E+00 | 2E-02 | 1E+01 |
| Ir-195 | 1E+04 | 1E-01 | 4E-01 | 4E+03 |
| Ir-195m | 8E+03 | 8E-01 | 6E-02 | 5E+02 |
| Pt-186 | 1E+04 | 2E+00 | 2E-02 | 2E+02 |
| Pt-188 | 2E+03 | 2E+00 | 2E-02 | 4E+01 |
| Pt-189 | 1E+04 | 2E+00 | 2E-02 | 2E+02 |
| Pt-191 | 4E+03 | 2E+00 | 3E-02 | 1E+02 |
| Pt-193 | 4E+04 | 4E-02 | 1E+00 | 5E+04 |
| Pt-193m | 3E+03 | 8E-02 | 6E-01 | 2E+03 |
| Pt-195m | 2E+03 | 3E-01 | 2E-01 | 3E+02 |
| Pt-197 | 3E+03 | 8E-02 | 6E-01 | 2E+03 |
| Pt-197m | 2E+04 | 2E-01 | 2E-01 | 4E+03 |
| Pt-199 | 5E+04 | 3E-01 | 2E-01 | 9E+03 |
| Pt-200 | 1E+03 | 2E-01 | 2E-01 | 2E+02 |
| Au-193 | 9E+03 | 1E+00 | 3E-02 | 3E+02 |
| Au-194 | 3E+03 | 3E+00 | 2E-02 | 5E+01 |
| Au-195 | 5E+03 | 1E+00 | 4E-02 | 2E+02 |
| Au-198 | 1E+03 | 6E-01 | 9E-02 | 9E+01 |
| Au-198m | 1E+03 | 1E+00 | 5E-02 | 5E+01 |
| Au-199 | 3E+03 | 5E-01 | 1E-01 | 3E+02 |
| Au-200 | 3E+04 | 3E-01 | 2E-01 | 5E+03 |
| Au-200m | 1E+03 | 2E+00 | 3E-02 | 3E+01 |
| Au-201 | 7E+04 | 8E-02 | 6E-01 | 4E+04 |

Table A1. (contd)

| Nuclide | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|
| Hg-193 | 2E+04 | 1E+00 | 5E-02 | 1E+03 |
| Hg-193m | 4E+03 | 1E+00 | 4E-02 | 2E+02 |
| Hg-194 | 2E+01 | 4E+00 | 1E-02 | 3E-01 |
| Hg-195 | 2E+04 | 1E+00 | 3E-02 | 7E+02 |
| Hg-195m | 3E+03 | 2E+00 | 3E-02 | 9E+01 |
| Hg-197 | 7E+03 | 2E+00 | 3E-02 | 2E+02 |
| Hg-197m | 4E+03 | 1E+00 | 4E-02 | 2E+02 |
| Hg-199m | 6E+04 | 5E-01 | 1E-01 | 7E+03 |
| Hg-203 | 5E+02 | 3E+00 | 2E-02 | 9E+00 |
| Tl-194 | 3E+05 | 2E+00 | 3E-02 | 8E+03 |
| Tl-194m | 5E+04 | 1E+00 | 5E-02 | 2E+03 |
| Tl-195 | 6E+04 | 2E+00 | 2E-02 | 1E+03 |
| Tl-197 | 7E+04 | 3E+00 | 2E-02 | 1E+03 |
| Tl-198 | 2E+04 | 4E+00 | 1E-02 | 3E+02 |
| Tl-198m | 3E+04 | 3E+00 | 2E-02 | 6E+02 |
| Tl-199 | 6E+04 | 3E+00 | 2E-02 | 9E+02 |
| Tl-200 | 8E+03 | 5E+00 | 1E-02 | 8E+01 |
| Tl-201 | 2E+04 | 5E+00 | 1E-02 | 2E+02 |
| Tl-202 | 4E+03 | 6E+00 | 9E-03 | 4E+01 |
| Tl-204 | 2E+03 | 5E+00 | 1E-02 | 2E+01 |
| Pb-195m | 6E+04 | 2E+00 | 3E-02 | 2E+03 |
| Pb-198 | 3E+04 | 2E+00 | 2E-02 | 6E+02 |
| Pb-199 | 2E+04 | 3E+00 | 2E-02 | 4E+02 |
| Pb-200 | 3E+03 | 2E+00 | 2E-02 | 7E+01 |
| Pb-201 | 7E+03 | 2E+00 | 2E-02 | 1E+02 |
| Pb-202 | 1E+02 | 1E+00 | 4E-02 | 4E+00 |
| Pb-202m | 9E+03 | 3E+00 | 1E-02 | 1E+02 |
| Pb-203 | 5E+03 | 2E+00 | 2E-02 | 1E+02 |
| Pb-205 | 4E+03 | 3E-01 | 2E-01 | 7E+02 |
| Pb-209 | 2E+04 | 4E-02 | 1E+00 | 3E+04 |
| Pb-210 | 6E-01 | 3E-01 | 2E-01 | 1E-01 |
| Pb-211 | 1E+04 | 7E-01 | 7E-02 | 7E+02 |
| Pb-212 | 8E+01 | 5E-01 | 9E-02 | 8E+00 |
| Pb-214 | 9E+03 | 1E+00 | 5E-02 | 4E+02 |
| Bi-200 | 3E+04 | 2E+00 | 2E-02 | 6E+02 |

Table A1. (contd)

| Nuclide | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|
| Bi-201 | 1E+04 | 2E+00 | 2E-02 | 2E+02 |
| Bi-202 | 1E+04 | 2E+00 | 2E-02 | 2E+02 |
| Bi-203 | 2E+03 | 3E+00 | 2E-02 | 4E+01 |
| Bi-205 | 1E+03 | 2E+00 | 2E-02 | 2E+01 |
| Bi-206 | 6E+02 | 3E+00 | 2E-02 | 1E+01 |
| Bi-207 | 1E+03 | 2E+00 | 2E-02 | 2E+01 |
| Bi-210 | 8E+02 | 6E-02 | 9E-01 | 7E+02 |
| Bi-210m | 4E+01 | 2E-01 | 3E-01 | 1E+01 |
| Bi-212 | 5E+03 | 4E-01 | 1E-01 | 6E+02 |
| Bi-213 | 7E+03 | 2E-01 | 3E-01 | 2E+03 |
| Bi-214 | 2E+04 | 4E-01 | 1E-01 | 3E+03 |
| Po-203 | 3E+04 | 3E+00 | 2E-02 | 5E+02 |
| Po-205 | 2E+04 | 3E+00 | 2E-02 | 3E+02 |
| Po-207 | 8E+03 | 3E+00 | 2E-02 | 1E+02 |
| Po-210 | 3E+00 | 9E-01 | 5E-02 | 2E-01 |
| At-207 | 6E+03 | 5E+00 | 1E-02 | 6E+01 |
| At-211 | 1E+02 | 4E+00 | 1E-02 | 1E+00 |
| Fr-222 | 2E+03 | 4E+00 | 1E-02 | 2E+01 |
| Fr-223 | 6E+02 | 5E+00 | 1E-02 | 6E+00 |
| Ra-223 | 5E+00 | 8E-01 | 6E-02 | 3E-01 |
| Ra-224 | 8E+00 | 6E-01 | 8E-02 | 6E-01 |
| Ra-225 | 8E+00 | 1E+00 | 5E-02 | 4E-01 |
| Ra-226 | 2E+00 | 7E-01 | 7E-02 | 1E-01 |
| Ra-227 | 2E+04 | 2E-01 | 2E-01 | 4E+03 |
| Ra-228 | 2E+00 | 1E+00 | 4E-02 | 9E-02 |
| Ac-224 | 2E+03 | 2E-01 | 3E-01 | 5E+02 |
| Ac-225 | 5E+01 | 2E-02 | 3E+00 | 1E+02 |
| Ac-226 | 1E+02 | 2E-02 | 3E+00 | 3E+02 |
| Ac-227 | 2E-01 | 5E-05 | 1E+03 | 2E+02 |
| Ac-228 | 2E+03 | 6E-01 | 8E-02 | 2E+02 |
| Th-226 | 5E+03 | 3E-03 | 2E+01 | 8E+04 |
| Th-227 | 1E+02 | 7E-02 | 7E-01 | 7E+01 |
| Th-228 | 6E+00 | 5E-02 | 9E-01 | 6E+00 |
| Th-229 | 6E-01 | 1E-02 | 5E+00 | 3E+00 |
| Th-230 | 4E+00 | 1E-02 | 5E+00 | 2E+01 |
| Th-231 | 4E+03 | 7E-02 | 7E-01 | 3E+03 |

Table A1. (contd)

| Nuclide | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|
| Th-232 | 7E-01 | 3E-03 | 2E+01 | 1E+01 |
| Th-234 | 3E+02 | 1E-02 | 4E+00 | 1E+03 |
| Pa-227 | 4E+03 | 1E-02 | 5E+00 | 2E+04 |
| Pa-228 | 1E+03 | 1E+00 | 5E-02 | 5E+01 |
| Pa-230 | 6E+02 | 6E-01 | 8E-02 | 5E+01 |
| Pa-231 | 2E-01 | 4E-05 | 1E+03 | 2E+02 |
| Pa-232 | 1E+03 | 9E-01 | 6E-02 | 6E+01 |
| Pa-233 | 1E+03 | 4E-01 | 1E-01 | 1E+02 |
| Pa-234 | 2E+03 | 1E+00 | 4E-02 | 7E+01 |
| U-230 | 4E+00 | 1E-01 | 4E-01 | 2E+00 |
| U-231 | 5E+03 | 7E-01 | 8E-02 | 4E+02 |
| U-232 | 2E+00 | 6E-02 | 8E-01 | 2E+00 |
| U-233 | 1E+01 | 1E-01 | 5E-01 | 5E+00 |
| U-234 | 1E+01 | 1E-01 | 5E-01 | 5E+00 |
| U-235 | 1E+01 | 9E-02 | 5E-01 | 5E+00 |
| U-236 | 1E+01 | 9E-02 | 6E-01 | 6E+00 |
| U-237 | 2E+03 | 5E-01 | 9E-02 | 2E+02 |
| U-238 | 1E+01 | 9E-02 | 6E-01 | 6E+00 |
| U-239 | 7E+04 | 2E-01 | 3E-01 | 2E+04 |
| U-240 | 1E+03 | 2E-01 | 2E-01 | 2E+02 |
| Np-232 | 1E+05 | 9E-01 | 6E-02 | 6E+03 |
| Np-233 | 8E+05 | 2E+00 | 2E-02 | 2E+04 |
| Np-234 | 2E+03 | 3E+00 | 2E-02 | 3E+01 |
| Np-235 | 2E+04 | 6E-02 | 8E-01 | 2E+04 |
| Np-236 (1.15E5 y) | 3E+00 | 1E-03 | 4E+01 | 1E+02 |
| Np-236 (22.5 h) | 3E+03 | 2E-01 | 3E-01 | 1E+03 |
| Np-237 | 5E-01 | 2E-04 | 3E+02 | 1E+02 |
| Np-238 | 1E+03 | 6E-01 | 8E-02 | 8E+01 |
| Np-239 | 2E+03 | 5E-01 | 1E-01 | 2E+02 |
| Np-240 | 2E+04 | 1E+00 | 4E-02 | 7E+02 |
| Pu-234 | 8E+03 | 1E+00 | 5E-02 | 4E+02 |
| Pu-235 | 9E+05 | 2E+00 | 3E-02 | 3E+04 |
| Pu-236 | 2E+00 | 1E-04 | 4E+02 | 7E+02 |
| Pu-237 | 1E+04 | 1E+00 | 5E-02 | 5E+02 |
| Pu-238 | 9E-01 | 3E-05 | 2E+03 | 2E+03 |

Table A1. (contd)

| Nuclide | ALI (μCi) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem (μCi) |
|---|---|---|---|---|
| Pu-239 | 8E-01 | 2E-05 | 2E+03 | 2E+03 |
| Pu-240 | 8E-01 | 2E-05 | 2E+03 | 2E+03 |
| Pu-241 | 4E+01 | 1E-05 | 4E+03 | 2E+05 |
| Pu-242 | 8E-01 | 2E-05 | 2E+03 | 2E+03 |
| Pu-243 | 2E+04 | 2E-01 | 3E-01 | 5E+03 |
| Pu-244 | 8E-01 | 9E-04 | 6E+01 | 5E+01 |
| Pu-245 | 2E+03 | 4E-01 | 1E-01 | 2E+02 |
| Pu-246 | 4E+02 | 5E-01 | 9E-02 | 4E+01 |
| Am-237 | 8E+04 | 2E+00 | 2E-02 | 2E+03 |
| Am-238 | 4E+04 | 3E+00 | 2E-02 | 6E+02 |
| Am-239 | 5E+03 | 8E-01 | 6E-02 | 3E+02 |
| Am-240 | 2E+03 | 2E+00 | 2E-02 | 4E+01 |
| Am-241 | 8E-01 | 9E-05 | 6E+02 | 5E+02 |
| Am-242m | 8E-01 | 3E-05 | 2E+03 | 1E+03 |
| Am-242 | 4E+03 | 5E-02 | 9E-01 | 4E+03 |
| Am-243 | 8E-01 | 4E-04 | 1E+02 | 1E+02 |
| Am-244m | 6E+04 | 6E-04 | 8E+01 | 5E+06 |
| Am-244 | 3E+03 | 1E+00 | 4E-02 | 1E+02 |
| Am-245 | 3E+04 | 8E-03 | 6E+00 | 2E+05 |
| Am-246m | 5E+04 | 8E-01 | 7E-02 | 3E+03 |
| Am-246 | 3E+04 | 6E-01 | 8E-02 | 2E+03 |
| Cm-238 | 2E+04 | 3E+00 | 2E-02 | 4E+02 |
| Cm-240 | 6E+01 | 2E-03 | 2E+01 | 1E+03 |
| Cm-241 | 1E+03 | 9E-01 | 6E-02 | 6E+01 |
| Cm-242 | 3E+01 | 1E-03 | 5E+01 | 2E+03 |
| Cm-243 | 1E+00 | 4E-04 | 1E+02 | 1E+02 |
| Cm-244 | 1E+00 | 3E-05 | 2E+03 | 2E+03 |
| Cm-245 | 7E-01 | 2E-04 | 2E+02 | 2E+02 |
| Cm-246 | 7E-01 | 9E-05 | 6E+02 | 4E+02 |
| Cm-247 | 8E-01 | 8E-04 | 7E+01 | 5E+01 |
| Cm-248 | 2E-01 | 7E-03 | 7E+00 | 1E+00 |
| Cm-249 | 5E+04 | 5E-02 | 9E-01 | 5E+04 |
| Cm-250 | 4E-02 | 1E-02 | 5E+00 | 2E-01 |
| Bk-245 | 2E+03 | 8E-01 | 6E-02 | 1E+02 |
| Bk-246 | 3E+03 | 3E+00 | 2E-02 | 5E+01 |

Table A1. (contd)

| Nuclide | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|
| Bk-247 | 5E-01 | 1E-04 | 4E+02 | 2E+02 |
| Bk-249 | 2E+02 | 2E-04 | 3E+02 | 6E+04 |
| Bk-250 | 9E+03 | 1E+00 | 4E-02 | 3E+02 |
| Cf-244 | 3E+04 | 3E-03 | 2E+01 | 5E+05 |
| Cf-246 | 4E+02 | 1E-02 | 4E+00 | 2E+03 |
| Cf-248 | 8E+00 | 3E-04 | 1E+02 | 1E+03 |
| Cf-249 | 5E-01 | 5E-04 | 1E+02 | 5E+01 |
| Cf-250 | 1E+00 | 3E-04 | 2E+02 | 2E+02 |
| Cf-251 | 5E-01 | 2E-04 | 2E+02 | 1E+02 |
| Cf-252 | 2E+00 | 2E-02 | 2E+00 | 4E+00 |
| Cf-253 | 2E+02 | 2E-04 | 3E+02 | 6E+04 |
| Cf-254 | 2E+00 | 7E-01 | 7E-02 | 1E-01 |
| Es-250 | 4E+04 | 2E+00 | 3E-02 | 1E+03 |
| Es-251 | 7E+03 | 9E-01 | 6E-02 | 4E+02 |
| Es-253 | 2E+02 | 7E-03 | 7E+00 | 1E+03 |
| Es-254 | 8E+00 | 1E-02 | 5E+00 | 4E+01 |
| Fm-252 | 5E+02 | 1E-02 | 4E+00 | 2E+03 |
| Fm-253 | 1E+03 | 1E-01 | 4E-01 | 4E+02 |
| Fm-254 | 3E+03 | 2E-02 | 3E+00 | 8E+03 |
| Fm-255 | 5E+02 | 1E-02 | 4E+00 | 2E+03 |
| Fm-257 | 2E+01 | 5E-03 | 1E+01 | 2E+02 |
| Md-257 | 7E+03 | 3E-01 | 2E-01 | 1E+03 |
| Md-258 | 3E+01 | 2E-03 | 3E+01 | 8E+02 |

Table A2. Radiation doses to the uterus from inhalation.

| Nuclide | Class | ALI (μCi) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem (μCi) |
|---|---|---|---|---|---|
| H-3 | V | 8E+04 | 5E+00 | 1E-02 | 8E+02 |
| Be-7 | W | 2E+04 | 1E+00 | 4E-02 | 8E+02 |
| | Y | 2E+04 | 1E+00 | 5E-02 | 1E+03 |
| Be-10 | W | 2E+02 | 4E-01 | 1E-01 | 2E+01 |
| | Y | 1E+01 | 9E-03 | 5E+00 | 5E+01 |
| C-11 | c | 4E+05 | 5E+00 | 1E-02 | 4E+03 |
| | m | 1E+06 | 4E+00 | 1E-02 | 1E+04 |
| | d | 6E+05 | 5E+00 | 1E-02 | 6E+03 |
| C-14 | c | 2E+03 | 4E+00 | 1E-02 | 2E+01 |
| | m | 2E+06 | 6E+00 | 9E-03 | 2E+04 |
| | d | 2E+05 | 5E+00 | 1E-02 | 2E+03 |
| F-18 | D | 7E+04 | 3E-01 | 1E-01 | 1E+04 |
| | W | 9E+04 | 2E-01 | 3E-01 | 3E+04 |
| | Y | 8E+04 | 1E-01 | 4E-01 | 3E+04 |
| Na-22 | D | 6E+02 | 4E+00 | 1E-02 | 7E+00 |
| Na-24 | D | 5E+03 | 3E+00 | 2E-02 | 8E+01 |
| Mg-28 | D | 2E+03 | 2E+00 | 3E-02 | 6E+01 |
| | W | 1E+03 | 6E-01 | 8E-02 | 8E+01 |
| Al-26 | D | 6E+01 | 4E+00 | 1E-02 | 8E-01 |
| | W | 9E+01 | 2E+00 | 3E-02 | 3E+00 |
| Si-31 | D | 3E+04 | 5E-01 | 1E-01 | 3E+03 |
| | W | 3E+04 | 1E-01 | 4E-01 | 1E+04 |
| | Y | 3E+04 | 8E-03 | 6E+00 | 2E+05 |
| Si-32 | D | 2E+02 | 4E+00 | 1E-02 | 2E+00 |
| | W | 1E+02 | 6E-01 | 9E-02 | 9E+00 |
| | Y | 5E+00 | 1E-02 | 4E+00 | 2E+01 |
| P-32 | D | 9E+02 | 2E+00 | 3E-02 | 3E+01 |
| | W | 4E+02 | 5E-01 | 1E-01 | 4E+01 |
| P-33 | D | 8E+03 | 2E+00 | 2E-02 | 2E+02 |
| | W | 3E+03 | 6E-01 | 9E-02 | 3E+02 |
| S-35 | D | 2E+04 | 4E+00 | 1E-02 | 2E+02 |
| | W | 2E+03 | 3E-01 | 1E-01 | 3E+02 |
| | V | 1E+04 | 4E+00 | 1E-02 | 1E+02 |
| Cl-36 | D | 2E+03 | 4E+00 | 1E-02 | 3E+01 |
| | W | 2E+02 | 4E-01 | 1E-01 | 3E+01 |
| Cl-38 | D | 4E+04 | 6E-01 | 9E-02 | 4E+03 |
| | W | 5E+04 | 2E-01 | 2E-01 | 1E+04 |
| Cl-39 | D | 5E+04 | 8E-01 | 6E-02 | 3E+03 |
| | W | 6E+04 | 3E-01 | 2E-01 | 9E+03 |
| K-40 | D | 4E+02 | 5E+00 | 1E-02 | 4E+00 |
| K-42 | D | 5E+03 | 2E+00 | 3E-02 | 1E+02 |
| K-43 | D | 9E+03 | 3E+00 | 1E-02 | 1E+02 |
| K-44 | D | 7E+04 | 6E-01 | 9E-02 | 6E+03 |
| K-45 | D | 1E+05 | 5E-01 | 1E-01 | 1E+04 |

Table A2. (contd)

| Nuclide | Class | ALI (μCi) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem (μCi) |
|---|---|---|---|---|---|
| Ca-41 | W | 4E+03 | 3E-02 | 1E+00 | 6E+03 |
| Ca-45 | W | 3E+02 | 1E-01 | 4E-01 | 3E+02 |
| Ca-47 | W | 9E+02 | 7E-01 | 7E-02 | 7E+01 |
| Sc-43 | Y | 2E+04 | 7E-01 | 8E-02 | 2E+03 |
| Sc-44 | Y | 1E+04 | 6E-01 | 8E-02 | 8E+02 |
| Sc-44m | Y | 7E+02 | 8E-01 | 6E-02 | 4E+01 |
| Sc-46 | Y | 2E+02 | 5E-01 | 1E-01 | 2E+01 |
| Sc-47 | Y | 3E+03 | 2E-01 | 2E-01 | 6E+02 |
| Sc-48 | Y | 1E+03 | 1E+00 | 4E-02 | 4E+01 |
| Sc-49 | Y | 5E+04 | 5E-03 | 1E+01 | 5E+05 |
| Ti-44 | D | 1E+01 | 5E+00 | 1E-02 | 1E-01 |
| | W | 3E+01 | 4E+00 | 1E-02 | 4E-01 |
| | Y | 6E+00 | 4E-01 | 1E-01 | 8E-01 |
| Ti-45 | D | 3E+04 | 1E+00 | 3E-02 | 1E+03 |
| | W | 4E+04 | 8E-01 | 6E-02 | 2E+03 |
| | Y | 3E+04 | 5E-01 | 9E-02 | 3E+03 |
| V-47 | D | 8E+04 | 6E-01 | 9E-02 | 7E+03 |
| | W | 1E+05 | 2E-01 | 3E-01 | 3E+04 |
| V-48 | D | 1E+03 | 3E+00 | 2E-02 | 2E+01 |
| | W | 6E+02 | 1E+00 | 3E-02 | 2E+01 |
| V-49 | D | 3E+04 | 1E+00 | 4E-02 | 1E+03 |
| | W | 2E+04 | 2E-01 | 3E-01 | 5E+03 |
| Cr-48 | D | 1E+04 | 4E+00 | 1E-02 | 1E+02 |
| | W | 7E+03 | 2E+00 | 3E-02 | 2E+02 |
| | Y | 7E+03 | 2E+00 | 3E-02 | 2E+02 |
| Cr-49 | D | 8E+04 | 8E-01 | 6E-02 | 5E+03 |
| | W | 1E+05 | 3E-01 | 2E-01 | 2E+04 |
| | Y | 9E+04 | 1E-01 | 4E-01 | 4E+04 |
| Cr-51 | D | 5E+04 | 5E+00 | 1F-02 | 5E+02 |
| | W | 2E+04 | 9E-01 | 5E-02 | 1E+03 |
| | Y | 2E+04 | 7E-01 | 7E-02 | 1E+03 |
| Mn-51 | D | 5E+04 | 6E-01 | 8E-02 | 4E+03 |
| | W | 6E+04 | 2E-01 | 2E-01 | 1E+04 |
| Mn-52 | D | 9E+04 | 2E+02 | 2E-04 | 2E+01 |
| | W | 1E+05 | 2E+02 | 2E-04 | 2E+01 |
| Mn-52m | D | 1E+03 | 7E-03 | 7E+00 | 7E+03 |
| | W | 9E+02 | 2E-03 | 2E+01 | 2E+04 |
| Mn-53 | D | 1E+04 | 3E-01 | 2E-01 | 2E+03 |
| | W | 1E+04 | 1E-01 | 5E-01 | 5E+03 |
| Mn-54 | D | 9E+02 | 3E+00 | 2E-02 | 1E+01 |
| | W | 8E+02 | 1E+00 | 3E-02 | 3E+01 |
| Mn-56 | D | 2E+04 | 1E+00 | 4E-02 | 7E+02 |
| | W | 2E+04 | 6E-01 | 9E-02 | 2E+03 |

Table A2. (contd)

| Nuclide | Class | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|---|
| Fe-52 | D | 3E+03 | 1E+00 | 3E-02 | 1E+02 |
| | W | 2E+03 | 6E-01 | 8E-02 | 2E+02 |
| Fe-55 | D | 2E+03 | 4E+00 | 1E-02 | 3E+01 |
| | W | 4E+03 | 3E+00 | 2E-02 | 8E+01 |
| Fe-59 | D | 3E+02 | 4E+00 | 1E-02 | 3E+00 |
| | W | 5E+02 | 2E+00 | 2E-02 | 1E+01 |
| Fe-60 | D | 6E+00 | 4E+00 | 1E-02 | 7E-02 |
| | W | 2E+01 | 5E+00 | 1E-02 | 2E-01 |
| Co-55 | W | 3E+03 | 1E+00 | 4E-02 | 1E+02 |
| | Y | 3E+03 | 1E+00 | 4E-02 | 1E+02 |
| Co-56 | W | 3E+02 | 2E+00 | 3E-02 | 9E+00 |
| | Y | 2E+02 | 9E-01 | 5E-02 | 1E+01 |
| Co-57 | W | 3E+03 | 1E+00 | 4E-02 | 1E+02 |
| | Y | 7E+02 | 2E-01 | 2E-01 | 2E+02 |
| Co-58 | W | 1E+03 | 2E+00 | 3E-02 | 3E+01 |
| | Y | 7E+02 | 8E-01 | 6E-02 | 4E+01 |
| Co-58m | W | 9E+04 | 8E-01 | 7E-02 | 6E+03 |
| | Y | 6E+04 | 4E-01 | 1E-01 | 9E+03 |
| Co-60 | W | 2E+02 | 3E+00 | 2E-02 | 4E+00 |
| | Y | 3E+01 | 5E-01 | 1E-01 | 3E+00 |
| Co-60m | W | 4E+06 | 3E-01 | 2E-01 | 7E+05 |
| | Y | 3E+06 | 2E-01 | 3E-01 | 8E+05 |
| Co-61 | W | 6E+04 | 2E-01 | 3E-01 | 2E+04 |
| | Y | 6E+04 | 6E-02 | 9E-01 | 5E+04 |
| Co-62m | W | 2E+05 | 3E-01 | 2E-01 | 4E+04 |
| | Y | 2E+05 | 1E-01 | 4E-01 | 9E+04 |
| Ni-56 | D | 2E+03 | 5E+00 | 9E-03 | 2E+01 |
| | W | 1E+03 | 2E+00 | 3E-02 | 3E+01 |
| | V | 1E+03 | 5E+00 | 1E-02 | 1E+01 |
| Ni-57 | D | 5E+03 | 3E+00 | 2E-02 | 9E+01 |
| | W | 3E+03 | 2E+00 | 3E-02 | 8E+01 |
| | V | 6E+03 | 4E+00 | 1E-02 | 8E+01 |
| Ni-59 | D | 4E+03 | 5E+00 | 1E-02 | 4E+01 |
| | W | 7E+03 | 3E+00 | 2E-02 | 1E+02 |
| | V | 2E+03 | 5E+00 | 9E-03 | 2E+01 |
| Ni-63 | D | 2E+03 | 6E+00 | 8E-03 | 2E+01 |
| | W | 3E+03 | 3E+00 | 2E-02 | 5E+01 |
| | V | 8E+02 | 5E+00 | 1E-02 | 8E+00 |
| Ni-65 | D | 2E+04 | 6E-01 | 9E-02 | 2E+03 |
| | W | 3E+04 | 3E-01 | 2E-01 | 5E+03 |
| | V | 2E+04 | 8E-01 | 6E-02 | 1E+03 |
| Ni-66 | D | 2E+03 | 9E-01 | 5E-02 | 1E+02 |
| | W | 6E+02 | 7E-02 | 7E-01 | 4E+02 |
| | V | 3E+03 | 3E+00 | 2E-02 | 5E+01 |

Table A2. (contd)

| Nuclide | Class | ALI (μCi) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem (μCi) |
|---|---|---|---|---|---|
| Cu-60 | D | 9E+04 | 1E+00 | 5E-02 | 4E+03 |
| | W | 1E+05 | 3E-01 | 2E-01 | 2E+04 |
| | Y | 1E+05 | 2E-01 | 3E-01 | 3E+04 |
| Cu-61 | D | 3E+04 | 1E+00 | 4E-02 | 1E+03 |
| | W | 4E+04 | 8E-01 | 6E-02 | 3E+03 |
| | Y | 4E+04 | 7E-01 | 7E-02 | 3E+03 |
| Cu-64 | D | 3E+04 | 1E+00 | 3E-02 | 1E+03 |
| | W | 2E+04 | 6E-01 | 8E-02 | 2E+03 |
| | Y | 2E+04 | 5E-01 | 9E-02 | 2E+03 |
| Cu-67 | D | 8E+03 | 2E+00 | 2E-02 | 2E+02 |
| | W | 5E+03 | 7E-01 | 7E-02 | 3E+02 |
| | Y | 5E+03 | 7E-01 | 8E-02 | 4E+02 |
| Zn-62 | Y | 3E+03 | 5E-01 | 1E-01 | 3E+02 |
| Zn-63 | Y | 7E+04 | 8E-02 | 6E-01 | 4E+04 |
| Zn-65 | Y | 3E+02 | 3E+00 | 2E-02 | 5E+00 |
| Zn-69 | Y | 1E+05 | 1E-02 | 5E+00 | 5E+05 |
| Zn-69m | Y | 7E+03 | 5E-01 | 1E-01 | 7E+02 |
| Zn-71m | Y | 2E+04 | 8E-01 | 6E-02 | 1E+03 |
| Zn-72 | Y | 1E+03 | 1E+00 | 4E-02 | 4E+01 |
| Ga-65 | D | 2E+05 | 5E-01 | 9E-02 | 2E+04 |
| | W | 2E+05 | 2E-01 | 3E-01 | 6E+04 |
| Ga-66 | D | 4E+03 | 1E+00 | 3E-02 | 1E+02 |
| | W | 3E+03 | 7E-01 | 7E-02 | 2E+02 |
| Ga-67 | D | 1E+04 | 1E+00 | 4E-02 | 4E+02 |
| | W | 1E+04 | 1E+00 | 5E-02 | 5E+02 |
| Ga-68 | D | 4E+04 | 7E-01 | 7E-02 | 3E+03 |
| | W | 5E+04 | 3E-01 | 2E-01 | 9E+03 |
| Ga-70 | D | 2E+05 | 3E-01 | 2E-01 | 4E+04 |
| | W | 2E+05 | 8E-02 | 6E-01 | 1E+05 |
| Ga-72 | D | 4E+03 | 2E+00 | 2E-02 | 1E+02 |
| | W | 3E+03 | 1E+00 | 4E-02 | 1E+02 |
| Ga-73 | D | 2E+04 | 9E-01 | 5E-02 | 1E+03 |
| | W | 2E+04 | 4E-01 | 1E-01 | 3E+03 |
| Ge-66 | D | 3E+44 | 2E+40 | 2E-42 | 7E+02 |
| | W | 2E+04 | 8E-01 | 6E-02 | 1E+03 |
| Ge-67 | D | 9E+04 | 4E-01 | 1E-01 | 1E+04 |
| | W | 1E+05 | 1E-01 | 4E-01 | 4E+04 |
| Ge-68 | D | 4E+03 | 2E+00 | 2E-02 | 9E+01 |
| | W | 1E+02 | 7E-02 | 7E-01 | 7E+01 |
| Ge-69 | D | 2E+04 | 3E+00 | 1E-02 | 3E+02 |
| | W | 8E+03 | 1E+00 | 5E-02 | 4E+02 |
| Ge-71 | D | 4E+05 | 2E+00 | 3E-02 | 1E+04 |
| | W | 4E+04 | 1E-01 | 4E-01 | 1E+04 |
| Ge-75 | D | 8E+04 | 6E-01 | 9E-02 | 7E+03 |
| | W | 8E+04 | 2E-01 | 3E-01 | 2E+04 |

Table A2. (contd)

| Nuclide | Class | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|---|
| Ge-77 | D | 1E+04 | 2E+00 | 3E-02 | 3E+02 |
| | W | 6E+03 | 6E-01 | 8E-02 | 5E+02 |
| Ge-78 | D | 2E+04 | 1E+00 | 5E-02 | 1E+03 |
| | W | 2E+04 | 3E-01 | 1E-01 | 3E+03 |
| As-69 | W | 1E+05 | 3E-01 | 2E-01 | 2E+04 |
| As-70 | W | 5E+04 | 6E-01 | 9E-02 | 4E+03 |
| As-71 | W | 5E+02 | 1E-01 | 4E-01 | 2E+02 |
| As-72 | W | 1E+03 | 5E-01 | 1E-01 | 1E+02 |
| As-73 | W | 2E+03 | 2E-01 | 3E-01 | 5E+02 |
| As-74 | W | 8E+02 | 6E-01 | 8E-02 | 6E+01 |
| As-76 | W | 1E+03 | 2E-01 | 2E-01 | 2E+02 |
| As-77 | W | 5E+03 | 2E-01 | 2E-01 | 1E+03 |
| As-78 | W | 2E+04 | 2E-01 | 2E-01 | 4E+03 |
| Se-70 | D | 4E+04 | 2E+00 | 3E-02 | 1E+03 |
| | W | 4E+04 | 5E-01 | 9E-02 | 4E+03 |
| Se-73 | D | 1E+04 | 1E+00 | 4E-02 | 4E+02 |
| | W | 2E+04 | 1E+00 | 4E-02 | 7E+02 |
| Se-73m | D | 2E+05 | 2E+00 | 2E-02 | 5E+03 |
| | W | 1E+05 | 5E-01 | 9E-02 | 9E+03 |
| Se-75 | D | 7E+02 | 4E+00 | 1E-02 | 1E+01 |
| | W | 6E+02 | 3E+00 | 2E-02 | 1E+01 |
| Se-79 | D | 8E+02 | 2E+00 | 2E-02 | 2E+01 |
| | W | 6E+02 | 1E+00 | 4E-02 | 2E+01 |
| Se-81 | D | 2E+05 | 2E-01 | 2E-01 | 4E+04 |
| | W | 2E+05 | 7E-02 | 7E-01 | 1E+05 |
| Se-81m | D | 7E+04 | 6E-01 | 9E-02 | 6E+03 |
| | W | 7E+04 | 2E-01 | 3E-01 | 2E+04 |
| Se-83 | D | 1E+05 | 9E-01 | 6E-02 | 6E+03 |
| | W | 1E+05 | 3E-01 | 2E-01 | 2E+04 |
| Br-74 | D | 7E+04 | 9E-01 | 6E-02 | 4E+03 |
| | W | 8E+04 | 3E-01 | 2E-01 | 1E+04 |
| Br-74m | D | 4E+04 | 1E+00 | 5E-02 | 2E+03 |
| | W | 4E+04 | 3E-01 | 2E-01 | 6E+03 |
| Br-75 | D | 5E+04 | 1E+00 | 4E-02 | 2E+03 |
| | W | 5E+04 | 5E-01 | 1E-01 | 6E+03 |
| Br-76 | D | 5E+03 | 3E+00 | 2E-02 | 9E+01 |
| | W | 4E+03 | 2E+00 | 3E-02 | 1E+02 |
| Br-77 | D | 2E+04 | 4E+00 | 1E-02 | 3E+02 |
| | W | 2E+04 | 3E+00 | 2E-02 | 4E+02 |
| Br-80 | D | 2E+05 | 3E-01 | 2E-01 | 3E+04 |
| | W | 2E+05 | 8E-02 | 6E-01 | 1E+05 |
| Br-80m | D | 2E+04 | 1E+00 | 4E-02 | 7E+02 |
| | W | 1E+04 | 3E-01 | 2E-01 | 2E+03 |

Table A2. (contd)

| Nuclide | Class | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|---|
| Br-82 | D | 4E+03 | 4E+00 | 1E-02 | 5E+01 |
| | W | 4E+03 | 3E+00 | 2E-02 | 7E+01 |
| Br-83 | D | 6E+04 | 7E-01 | 7E-02 | 4E+03 |
| | W | 6E+04 | 3E-01 | 2E-01 | 1E+04 |
| Br-84 | D | 6E+04 | 7E-01 | 8E-02 | 5E+03 |
| | W | 6E+04 | 2E-01 | 3E-01 | 2E+04 |
| Rb-79 | D | 1E+05 | 5E-01 | 1E-01 | 1E+04 |
| Rb-81 | D | 5E+04 | 2E+00 | 3E-02 | 1E+03 |
| Rb-81m | D | 3E+05 | 1E+00 | 3E-02 | 1E+04 |
| Rb-82m | D | 2E+04 | 3E+00 | 2E-02 | 3E+02 |
| Rb-83 | D | 1E+03 | 4E+00 | 1E-02 | 1E+01 |
| Rb-84 | D | 8E+02 | 5E+00 | 9E-03 | 8E+00 |
| Rb-86 | D | 8E+02 | 4E+00 | 1E-02 | 1E+01 |
| Rb-87 | D | 2E+03 | 5E+00 | 9E-03 | 2E+01 |
| Rb-88 | D | 6E+04 | 3E-01 | 2E-01 | 1E+04 |
| Rb-89 | D | 1E+05 | 5E-01 | 1E-01 | 1E+04 |
| Sr-80 | D | 1E+04 | 6E-01 | 9E-02 | 9E+02 |
| | Y | 1E+04 | 9E-02 | 6E-01 | 6E+03 |
| Sr-81 | D | 8E+04 | 9E-01 | 5E-02 | 4E+03 |
| | Y | 8E+04 | 3E-01 | 2E-01 | 2E+04 |
| Sr-82 | D | 4E+02 | 2E+00 | 3E-02 | 1E+01 |
| | Y | 9E+01 | 9E-02 | 6E-01 | 5E+01 |
| Sr-83 | D | 7E+03 | 2E+00 | 2E-02 | 2E+02 |
| | Y | 4E+03 | 1E+00 | 4E-02 | 2E+02 |
| Sr-85 | D | 3E+03 | 4E+00 | 1E-02 | 4E+01 |
| | Y | 2E+03 | 1E+00 | 5E-02 | 9E+01 |
| Sr-85m | D | 6E+05 | 2E+00 | 2E-02 | 1E+04 |
| | Y | 8E+05 | 9E-01 | 5E-02 | 4E+04 |
| Sr-87m | D | 1E+05 | 1E+00 | 4E-02 | 4E+03 |
| | Y | 2E+05 | 1E+00 | 4E-02 | 9E+03 |
| Sr-89 | D | 8E+02 | 1E+00 | 4E-02 | 3E+01 |
| | Y | 1E+02 | 3E-03 | 2E+01 | 2E+03 |
| Sr-90 | D | 2E+01 | 2E-01 | 3E-01 | 5E+00 |
| | Y | 4E+00 | 4E-03 | 1E+01 | 5E+01 |
| Sr-91 | D | 6E+03 | 1E+00 | 4E-02 | 2E+02 |
| | Y | 4E+03 | 4E-01 | 1E-01 | 5E+02 |
| Sr-92 | D | 9E+03 | 9E-01 | 5E-02 | 5E+02 |
| | Y | 7E+03 | 2E-01 | 2E-01 | 2E+03 |
| Y-86 | W | 3E+03 | 2E+00 | 3E-02 | 9E+01 |
| | Y | 3E+03 | 2E+00 | 3E-02 | 8E+01 |
| Y-86m | W | 6E+04 | 2E+00 | 3E-02 | 2E+03 |
| | Y | 5E+04 | 2E+00 | 3E-02 | 1E+03 |
| Y-87 | W | 3E+03 | 1E+00 | 4E-02 | 1E+02 |
| | Y | 3E+03 | 1E+00 | 4E-02 | 1E+02 |

Table A2. (contd)

| Nuclide | Class | ALI (μCi) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem (μCi) |
|---|---|---|---|---|---|
| Y-88 | W | 3E+02 | 2E+00 | 2E-02 | 7E+00 |
| | Y | 2E+02 | 8E-01 | 6E-02 | 1E+01 |
| Y-90 | W | 7E+02 | 2E-02 | 2E+00 | 1E+03 |
| | Y | 6E+02 | 1E-03 | 4E+01 | 3E+04 |
| Y-90m | W | 1E+04 | 2E-01 | 3E-01 | 3E+03 |
| | Y | 1E+04 | 1E-01 | 4E-01 | 4E+03 |
| Y-91 | W | 2E+02 | 8E-02 | 6E-01 | 1E+02 |
| | Y | 1E+02 | 3E-03 | 2E+01 | 2E+03 |
| Y-91m | W | 2E+05 | 3E-01 | 2E-01 | 3E+04 |
| | Y | 2E+05 | 2E-01 | 3E-01 | 5E+04 |
| Y-92 | W | 9E+03 | 1E-01 | 4E-01 | 3E+03 |
| | Y | 8E+03 | 5E-02 | 9E-01 | 7E+03 |
| Y-93 | W | 3E+03 | 7E-02 | 7E-01 | 2E+03 |
| | Y | 2E+03 | 2E-02 | 2E+00 | 5E+03 |
| Y-94 | W | 8E+04 | 1E-01 | 4E-01 | 3E+04 |
| | Y | 8E+04 | 3E-02 | 2E+00 | 1E+05 |
| Y-95 | W | 2E+05 | 2E-01 | 3E-01 | 6E+04 |
| | Y | 1E+05 | 3E-02 | 2E+00 | 2E+05 |
| Zr-86 | D | 4E+03 | 3E+00 | 2E-02 | 7E+01 |
| | W | 3E+03 | 2E+00 | 2E-02 | 7E+01 |
| | Y | 2E+03 | 2E+00 | 3E-02 | 7E+01 |
| Zr-88 | D | 2E+02 | 2E+00 | 3E-02 | 5E+00 |
| | W | 5E+02 | 1E+00 | 3E-02 | 2E+01 |
| | Y | 3E+02 | 6E-01 | 9E-02 | 3E+01 |
| Zr-89 | D | 4E+03 | 3E+00 | 2E-02 | 6E+01 |
| | W | 2E+03 | 1E+00 | 4E-02 | 8E+01 |
| | Y | 2E+03 | 1E+00 | 4E-02 | 8E+01 |
| Zr-93 | D | 6E+00 | 3E-04 | 2E+02 | 1E+03 |
| | W | 2E+01 | 2E-04 | 2E+02 | 5E+03 |
| | Y | 6E+01 | 3E-04 | 1E+02 | 9E+03 |
| Zr-95 | D | 1E+02 | 5E-01 | 9E-02 | 9E+00 |
| | W | 4E+02 | 8E-01 | 7E-02 | 3E+01 |
| | Y | 3E+02 | 3E-01 | 2E-01 | 5E+01 |
| Zr-97 | D | 2E+03 | 1E+00 | 5E-02 | 1E+02 |
| | W | 1E+03 | 3E-01 | 2E-01 | 2E+02 |
| | Y | 1E+03 | 3E-01 | 2E-01 | 2E+02 |
| Nb-88 | W | 2E+05 | 2E-01 | 3E-01 | 6E+04 |
| | Y | 2E+05 | 9E-02 | 6E-01 | 1E+05 |
| Nb-89 | W | 2E+04 | 7E-01 | 7E-02 | 1E+03 |
| | Y | 2E+04 | 6E-01 | 8E-02 | 2E+03 |
| Nb-89 | W | 4E+04 | 7E-01 | 7E-02 | 3E+03 |
| | Y | 4E+04 | 6E-01 | 8E-02 | 3E+03 |
| Nb-90 | W | 3E+03 | 2E+00 | 3E-02 | 8E+01 |
| | Y | 2E+03 | 1E+00 | 4E-02 | 7E+01 |

Table A2. (contd)

| Nuclide | Class | ALI (μCi) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem (μCi) |
|---|---|---|---|---|---|
| Nb-93m | W | 2E+03 | 2E-01 | 2E-01 | 4E+02 |
| | Y | 2E+02 | 8E-03 | 6E+00 | 1E+03 |
| Nb-94 | W | 2E+02 | 2E+00 | 3E-02 | 6E+00 |
| | Y | 2E+01 | 2E-01 | 2E-01 | 5E+00 |
| Nb-95 | W | 1E+03 | 1E+00 | 5E-02 | 5E+01 |
| | Y | 1E+03 | 7E-01 | 7E-02 | 7E+01 |
| Nb-95m | W | 3E+03 | 4E-01 | 1E-01 | 4E+02 |
| | Y | 2E+03 | 2E-01 | 3E-01 | 7E+02 |
| Nb-96 | W | 3E+03 | 2E+00 | 3E-02 | 8E+01 |
| | Y | 2E+03 | 1E+00 | 4E-02 | 8E+01 |
| Nb-97 | W | 8E+04 | 3E-01 | 2E-01 | 1E+04 |
| | Y | 7E+04 | 2E-01 | 3E-01 | 2E+04 |
| Nb-98 | W | 5E+04 | 4E-01 | 1E-01 | 7E+03 |
| | Y | 5E+04 | 2E-01 | 2E-01 | 1E+04 |
| Mo-90 | D | 7E+03 | 2E+00 | 2E-02 | 2E+02 |
| | Y | 5E+03 | 2E+00 | 3E-02 | 1E+02 |
| Mo-93 | D | 5E+03 | 1E+00 | 4E-02 | 2E+02 |
| | Y | 2E+02 | 9E-03 | 6E+00 | 1E+03 |
| Mo-93m | D | 2E+04 | 3E+00 | 2E-02 | 4E+02 |
| | Y | 1E+04 | 1E+00 | 3E-02 | 3E+02 |
| Mo-99 | D | 3E+03 | 1E+00 | 3E-02 | 1E+02 |
| | Y | 1E+0[illegible] | 2E-01 | 3E-01 | 3E+02 |
| Mo-101 | D | 1E+[illegible] | 4E-01 | 1E-01 | 1E+04 |
| | Y | 1E+[illegible] | 4E-02 | 1E+00 | 1E+05 |
| Tc-93 | D | 7E+[illegible] | 2E+00 | 2E-02 | 2E+03 |
| | W | 1E+05 | 2E+00 | 3E-02 | 3E+03 |
| Tc-93m | D | 2E+05 | 2E+00 | 2E-02 | 4E+03 |
| | W | 3E+05 | 1E+00 | 3E-02 | 1E+04 |
| Tc-94 | D | 2E+04 | 2E+00 | 2E-02 | 4E+02 |
| | W | 2E+04 | 1E+00 | 4E-02 | 8E+02 |
| Tc-94m | D | 4E+04 | 7E-01 | 7E-02 | 3E+03 |
| | W | 6E+04 | 3E-01 | 2E-01 | 9E+03 |
| Tc-95 | D | 2E+04 | 3E+00 | 2E-02 | 4E+02 |
| | W | 2E+04 | 2E+00 | 3E-02 | 5E+02 |
| Tc-95m | D | 5E+03 | 3E+00 | 2E-02 | 8E+01 |
| | W | 2E+03 | 1E+00 | 4E-02 | 8E+01 |
| Tc-96 | D | 3E+03 | 3E+00 | 1E-02 | 4E+01 |
| | W | 2E+03 | 2E+00 | 3E-02 | 5E+01 |
| Tc-96m | D | 3E+05 | 3E+00 | 2E-02 | 5E+03 |
| | W | 2E+05 | 2E+00 | 3E-02 | 6E+03 |
| Tc-97 | D | 5E+04 | 1E+00 | 4E-02 | 2E+03 |
| | W | 6E+03 | 1E-01 | 3E-01 | 2E+03 |
| Tc-97m | D | 7E+03 | 1E+00 | 5E-02 | 3E+02 |
| | W | 1E+03 | 1E-01 | 4E-01 | 4E+02 |

Table A2. (contd)

| Nuclide | Class | ALI (μCi) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem (μCi) |
|---|---|---|---|---|---|
| Tc-98 | D | 2E+03 | 3E+00 | 2E-02 | 3E+01 |
| | W | 3E+02 | 5E-01 | 9E-02 | 3E+01 |
| Tc-99 | D | 5E+03 | 8E-01 | 6E-02 | 3E+02 |
| | W | 7E+02 | 1E-01 | 5E-01 | 3E+02 |
| Tc-99m | D | 2E+05 | 2E+00 | 3E-02 | 5E+03 |
| | W | 2E+05 | 1E+00 | 5E-02 | 1E+04 |
| Tc-101 | D | 3E+05 | 3E-01 | 2E-01 | 5E+04 |
| | W | 4E+05 | 1E-01 | 5E-01 | 2E+05 |
| Tc-104 | D | 7E+04 | 4E-01 | 1E-01 | 9E+03 |
| | W | 9E+04 | 2E-01 | 3E-01 | 3E+04 |
| Ru-94 | D | 4E+04 | 1E+00 | 4E-02 | 2E+03 |
| | W | 6E+04 | 6E-01 | 8E-02 | 5E+03 |
| | Y | 6E+04 | 5E-01 | 1E-01 | 6E+03 |
| Ru-97 | D | 2E+04 | 4E+00 | 1E-02 | 3E+02 |
| | W | 1E+04 | 1E+00 | 3E-02 | 3E+02 |
| | Y | 1E+04 | 1E+00 | 3E-02 | 3E+02 |
| Ru-103 | D | 2E+03 | 5E+00 | 1E-02 | 2E+01 |
| | W | 1E+03 | 9E-01 | 5E-02 | 5E+01 |
| | Y | 6E+02 | 3E-01 | 1E-01 | 9E+01 |
| Ru-105 | D | 1E+04 | 8E-01 | 6E-02 | 6E+02 |
| | W | 1E+04 | 4E-01 | 1E-01 | 1E+03 |
| | Y | 1E+04 | 3E-01 | 1E-01 | 1E+03 |
| Ru-106 | D | 9E+01 | 5E+00 | 1E-02 | 1E+00 |
| | W | 5E+01 | 7E-01 | 7E-02 | 3E+00 |
| | Y | 1E+01 | 4E-02 | 1E+00 | 1E+01 |
| Rh-99 | D | 3E+03 | 5E+00 | 1E-02 | 3E+01 |
| | W | 2E+03 | 1E+00 | 3E-02 | 7E+01 |
| | Y | 2E+03 | 1E+00 | 4E-02 | 9E+01 |
| Rh-99m | D | 6E+04 | 3E+00 | 2E-02 | 1E+03 |
| | W | 8E+04 | 2E+00 | 2E-02 | 2E+03 |
| | Y | 7E+04 | 2E+00 | 3E-02 | 2E+03 |
| Rh-100 | D | 5E+03 | 3E+00 | 1E-02 | 7E+01 |
| | W | 4E+03 | 2E+00 | 2E-02 | 9E+01 |
| | Y | 4E+03 | 2E+00 | 2E-02 | 8E+01 |
| Rh-101 | D | 5E+02 | 6E+00 | 9E-03 | 4E+00 |
| | W | 8E+02 | 3E+00 | 2E-02 | 1E+01 |
| | Y | 2E+02 | 4E-01 | 1E-01 | 3E+01 |
| Rh-101m | D | 1E+04 | 3E+00 | 2E-02 | 2E+02 |
| | W | 8E+03 | 2E+00 | 3E-02 | 2E+02 |
| | Y | 8E+03 | 2E+00 | 3E-02 | 2E+02 |
| Rh-102 | D | 9E+01 | 6E+00 | 9E-03 | 8E-01 |
| | W | 2E+02 | 4E+00 | 1E-02 | 2E+00 |
| | Y | 6E+01 | 7E-01 | 7E-02 | 4E+00 |

Table A2. (contd)

| Nuclide | Class | ALI (μCi) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem (μCi) |
|---|---|---|---|---|---|
| Rh-102m | D | 5E+02 | 5E+00 | 1E-02 | 5E+00 |
| | W | 4E+02 | 1E+00 | 4E-02 | 2E+01 |
| | Y | 1E+02 | 1E-01 | 4E-01 | 4E+01 |
| Rh-103m | D | 1E+06 | 3E-01 | 2E-01 | 2E+05 |
| | W | 1E+06 | 9E-02 | 5E-01 | 5E+05 |
| | Y | 1E+06 | 7E-03 | 7E+00 | 7E+06 |
| Rh-105 | D | 1E+04 | 1E+00 | 4E-02 | 4E+02 |
| | W | 6E+03 | 3E-01 | 2E-01 | 1E+03 |
| | Y | 6E+03 | 2E-01 | 2E-01 | 1E+03 |
| Rh-106m | D | 3E+04 | 3E+00 | 2E-02 | 6E+02 |
| | W | 4E+04 | 1E+00 | 4E-02 | 1E+03 |
| | Y | 4E+04 | 1E+00 | 4E-02 | 2E+03 |
| Rh-107 | D | 2E+05 | 3E-01 | 1E-01 | 3E+04 |
| | W | 3E+05 | 1E-01 | 3E-01 | 1E+05 |
| | Y | 3E+05 | 4E-02 | 1E+00 | 4E+05 |
| Pd-100 | D | 1E+03 | 8E-01 | 6E-02 | 6E+01 |
| | W | 1E+03 | 1E+00 | 4E-02 | 4E+01 |
| | Y | 1E+03 | 1E+00 | 4E-02 | 4E+01 |
| Pd-101 | D | 3E+04 | 1E+00 | 4E-02 | 1E+03 |
| | W | 3E+04 | 1E+00 | 4E-02 | 1E+03 |
| | Y | 3E+04 | 1E+00 | 4E-02 | 1E+03 |
| Pd-103 | D | 6E+03 | 1E-01 | 5E-01 | 3E+03 |
| | W | 4E+03 | 2E-02 | 2E+00 | 9E+03 |
| | Y | 4E+03 | 1E-02 | 4E+00 | 1E+04 |
| Pd-107 | D | 2E+04 | 7E-02 | 7E-01 | 1E+04 |
| | W | 7E+03 | 6E-03 | 8E+00 | 6E+04 |
| | Y | 4E+02 | 2E-04 | 3E+02 | 1E+05 |
| Pd-109 | D | 6E+03 | 2E-01 | 3E-01 | 2E+03 |
| | [illegible] | 5E+03 | 4E-02 | 1E+00 | 7E+03 |
| | [illegible] | 5E+03 | 1E-02 | 5E+00 | 3E+04 |
| Ag-102 | D | 2E+05 | 8E-01 | 6E-02 | 1E+04 |
| | W | 2E+05 | 2E-01 | 2E-01 | 4E+04 |
| | Y | 2E+05 | 1E-01 | 4E-01 | 8E+04 |
| Ag-103 | D | 1E+05 | 1E+00 | 5E-02 | 5E+03 |
| | W | 1E+05 | 3E-01 | 1E-01 | 1E+04 |
| | Y | 1E+05 | 2E-01 | 2E-01 | 2E+04 |
| Ag-104 | D | 7E+04 | 2E+00 | 2E-02 | 2E+03 |
| | W | 1E+05 | 1E+00 | 5E-02 | 5E+03 |
| | Y | 1E+05 | 9E-01 | 6E-02 | 6E+03 |
| Ag-104m | D | 9E+04 | 1E+00 | 4E-02 | 4E+03 |
| | W | 1E+05 | 4E-01 | 1E-01 | 1E+04 |
| | Y | 1E+05 | 3E-01 | 2E-01 | 2E+04 |
| Ag-105 | D | 1E+03 | 1E+00 | 4E-02 | 4E+01 |
| | W | 2E+03 | 1E+00 | 4E-02 | 7E+01 |
| | Y | 2E+03 | 1E+00 | 5E-02 | 9E+01 |

Table A2. (contd)

| Nuclide | Class | ALI (μCi) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem (μCi) |
|---|---|---|---|---|---|
| Ag-106 | D | 2E+05 | 6E-01 | 8E-02 | 2E+04 |
| | W | 2E+05 | 2E-01 | 3E-01 | 6E+04 |
| | Y | 2E+05 | 6E-02 | 8E-01 | 2E+05 |
| Ag-106m | D | 7E+02 | 2E+00 | 3E-02 | 2E+01 |
| | W | 9E+02 | 2E+00 | 3E-02 | 2E+01 |
| | Y | 9E+02 | 2E+00 | 3E-02 | 3E+01 |
| Ag-108m | D | 2E+02 | 1E+00 | 3E-02 | 7E+00 |
| | W | 3E+02 | 1E+00 | 4E-02 | 1E+01 |
| | Y | 2E+01 | 2E-01 | 3E-01 | 6E+00 |
| Ag-110m | D | 1E+02 | 1E+00 | 5E-02 | 5E+00 |
| | W | 2E+02 | 1E+00 | 5E-02 | 9E+00 |
| | Y | 9E+01 | 5E-01 | 1E-01 | 9E+00 |
| Ag-111 | D | 2E+03 | 5E-01 | 9E-02 | 2E+02 |
| | W | 9E+02 | 6E-02 | 8E-01 | 7E+02 |
| | Y | 9E+02 | 3E-02 | 2E+00 | 1E+03 |
| Ag-112 | D | 8E+03 | 5E-01 | [illegible]E-01 | 8E+02 |
| | W | 1E+04 | 2E-01 | 2E-01 | 2E+03 |
| | Y | 9E+03 | 1E-01 | 4E-01 | 4E+03 |
| Ag-115 | D | 9E+04 | 4E-01 | 1E-01 | 1E+04 |
| | W | 9E+04 | 2E-01 | 3E-01 | 2E+04 |
| | Y | 8E+04 | 1E-01 | 4E-01 | 4E+04 |
| Cd-104 | D | 7E+04 | 3E+00 | 2E-02 | 1E+03 |
| | W | 1E+05 | 1E+00 | 3E-02 | 3E+03 |
| | Y | 1E+05 | 1E+00 | 4E-02 | 4E+03 |
| Cd-107 | D | 5E+04 | 4E-01 | 1E-01 | 6E+03 |
| | W | 6E+04 | 2E-01 | 3E-01 | 2E+04 |
| | Y | 5E+04 | 9E-02 | 5E-01 | 3E+04 |
| Cd-109 | D | 4E+01 | 4E-01 | 1E-01 | 5E+00 |
| | W | 1E+02 | 3E-01 | 2E-01 | 2E+01 |
| | Y | 1E+02 | 9E-02 | 6E-01 | 6E+01 |
| Cd-113 | D | 2E+00 | 3E-01 | 2E-01 | 4E-01 |
| | W | 8E+00 | 3E-01 | 2E-01 | 1E+00 |
| | Y | 1E+01 | 2E-01 | 2E-01 | 2E+00 |
| Cd-113m | D | 2E+00 | 2E-01 | 2E-01 | 4E-01 |
| | W | 8E+00 | 3E-01 | 2E-01 | 1E+00 |
| | Y | 1E+01 | 2E-01 | 3E-01 | 3E+00 |
| Cd-115 | D | 1E+03 | 4E-01 | 1E-01 | 1E+02 |
| | W | 1E+03 | 2E-01 | 2E-01 | 2E+02 |
| | Y | 1E+03 | 2E-01 | 2E-01 | 2E+02 |
| Cd-115m | D | 5E+01 | 3E-01 | 2E-01 | 9E+00 |
| | W | 1E+02 | 1E-01 | 4E-01 | 4E+01 |
| | Y | 1E+02 | 4E-02 | 1E+00 | 1E+02 |
| Cd-117 | D | 1E+04 | 7E-01 | 7E-02 | 7E+02 |
| | W | 2E+04 | 6E-01 | 8E-02 | 2E+03 |
| | Y | 1E+04 | 3E-01 | 2E-01 | 2E+03 |

Table A2. (contd)

| Nuclide | Class | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|---|
| Cd-117m | D | 1E+04 | 1E+00 | 4E-02 | 4E+02 |
| | W | 2E+04 | 1E+00 | 4E-02 | 8E+02 |
| | Y | 1E+04 | 6E-01 | 8E-02 | 8E+02 |
| In-109 | D | 4E+04 | 2E+00 | 3E-02 | 1E+03 |
| | W | 6E+04 | 1E+00 | 4E-02 | 2E+03 |
| In-110 (4.9 h) | D | 2E+04 | 4E+00 | 1E-02 | 2E+02 |
| | W | 2E+04 | 2E+00 | 2E-02 | 4E+02 |
| In-110 (69 m) | D | 4E+04 | 1E+00 | 5E-02 | 2E+03 |
| | W | 6E+04 | 5E-01 | 1E-01 | 7E+03 |
| In-111 | D | 6E+03 | 2E+00 | 2E-02 | 1E+02 |
| | W | 6E+03 | 2E+00 | 3E-02 | 2E+02 |
| In-112 | D | 6E+05 | 4E-01 | 1E-01 | 8E+04 |
| | W | 7E+05 | 1E-01 | 4E-01 | 3E+05 |
| In-113m | D | 1E+05 | 7E-01 | 7E-02 | 7E+03 |
| | W | 2E+05 | 5E-01 | 1E-01 | 2E+04 |
| In-114m | D | 6E+01 | 6E-01 | 8E-02 | 5E+00 |
| | W | 1E+02 | 2E-01 | 2E-01 | 2E+01 |
| In-115 | D | 1E+00 | 4E-01 | 1E-01 | 1E-01 |
| | W | 5E+00 | 6E-01 | 9E-02 | 4E-01 |
| In-115m | D | 4E+04 | 7E-01 | 7E-02 | 3E+03 |
| | W | 5E+04 | 4E-01 | 1E-01 | 6E+03 |
| In-116m | D | 8E+04 | 2E+00 | 3E-02 | 2E+03 |
| | W | 1E+05 | 7E-01 | 7E-02 | 7E+03 |
| In-117 | D | 2E+05 | 1E+00 | 4E-02 | 8E+03 |
| | W | 2E+05 | 3E-01 | 1E-01 | 3E+04 |
| In-117m | D | 3E+04 | 6E-01 | 8E-02 | 2E+03 |
| | W | 4E+04 | 3E-01 | 2E-01 | 7E+03 |
| In-119m | D | 1E+05 | 2E-01 | 3E-01 | 3E+04 |
| | W | 1E+05 | 5E-02 | 9E-01 | 9E+04 |
| Sn-110 | D | 1E+04 | 1E+00 | 4E-02 | 4E+02 |
| | W | 1E+04 | 7E-01 | 8E-02 | 8E+02 |
| Sn-111 | D | 2E+05 | 1E+00 | 5E-02 | 1E+04 |
| | W | 3E+05 | 9E-01 | 6E-02 | 2E+04 |
| Sn-113 | D | 1E+03 | 2E+00 | 3E-02 | 3E+01 |
| | W | 5E+02 | 3E-01 | 1E-01 | 7E+01 |
| Sn-117m | D | 1E+03 | 3E-01 | 2E-01 | 2E+02 |
| | W | 1E+03 | 2E-01 | 3E-01 | 3E+02 |
| Sn-119m | D | 2E+03 | 2E+00 | 3E-02 | 6E+01 |
| | W | 1E+03 | 2E-01 | 2E-01 | 2E+02 |
| Sn-121 | D | 2E+04 | 3E-01 | 2E-01 | 3E+03 |
| | W | 1E+04 | 3E-02 | 2E+00 | 2E+04 |
| Sn-121m | D | 9E+02 | 2E+00 | 2E-02 | 2E+01 |
| | W | 5E+02 | 3E-01 | 1E-01 | 7E+01 |

Table A2. (contd)

| Nuclide | Class | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|---|
| Sn-123 | D | 6E+02 | 2E+00 | 3E-02 | 2E+01 |
| | W | 2E+02 | 1E-01 | 4E-01 | 8E+01 |
| Sn-123m | D | 1E+05 | 3E-01 | 2E-01 | 2E+04 |
| | W | 1E+05 | 9E-02 | 6E-01 | 6E+04 |
| Sn-125 | D | 9E+02 | 8E-01 | 6E-02 | 6E+01 |
| | W | 4E+02 | 1E-01 | 4E-01 | 1E+02 |
| Sn-126 | D | 6E+01 | 3E+00 | 2E-02 | 1E+00 |
| | W | 7E+01 | 1E+00 | 5E-02 | 3E+00 |
| Sn-127 | D | 2E+04 | 1E+00 | 4E-02 | 8E+02 |
| | W | 2E+04 | 6E-01 | 8E-02 | 2E+03 |
| Sn-128 | D | 3E+04 | 1E+00 | 4E-02 | 1E+03 |
| | W | 4E+04 | 5E-01 | 1E-01 | 4E+03 |
| Sb-115 | D | 2E+05 | 9E-01 | 6E-02 | 1E+04 |
| | W | 3E+05 | 4E-01 | 1E-01 | 4E+04 |
| Sb-116 | D | 3E+05 | 1E+00 | 5E-02 | 1E+04 |
| | W | 3E+05 | 3E-01 | 2E-01 | 5E+04 |
| Sb-116m | D | 7E+04 | 2E+00 | 2E-02 | 2E+03 |
| | W | 1E+05 | 1E+00 | 5E-02 | 5E+03 |
| Sb-117 | D | 2E+05 | 2E+00 | 3E-02 | 6E+03 |
| | W | 3E+05 | 1E+00 | 4E-02 | 1E+04 |
| Sb-118m | D | 2E+04 | 3E+00 | 1E-02 | 3E+02 |
| | W | 2E+04 | 2E+00 | 2E-02 | 5E+02 |
| Sb-119 | D | 5E+04 | 1E+00 | 5E-02 | 3E+03 |
| | W | 3E+04 | 3E-01 | 2E-01 | 6E+03 |
| Sb-120 (16 m) | D | 4E+05 | 4E-01 | 1E-01 | 5E+04 |
| | W | 5E+05 | 1E-01 | 4E-01 | 2E+05 |
| Sb-120 (5.8 d) | D | 2E+03 | 4E+00 | 1E-02 | 3E+01 |
| | W | 1E+03 | 2E+00 | 3E-02 | 3E+01 |
| Sb-122 | D | 2E+03 | 1E+00 | 5E-02 | 1E+02 |
| | W | 1E+03 | 3E-01 | 2E-01 | 2E+02 |
| Sb-124 | D | 9E+02 | 3E+00 | 2E-02 | 2E+01 |
| | W | 2E+02 | 4E-01 | 1E-01 | 2E+01 |
| Sb-124m | D | 8E+05 | 1E+00 | 4E-02 | 3E+04 |
| | W | 6E+05 | 4E-01 | 1E-01 | 8E+04 |
| Sb-125 | D | 2E+03 | 2E+00 | 2E-02 | 5E+01 |
| | W | 5E+02 | 3E-01 | 1E-01 | 7E+01 |
| Sb-126 | D | 1E+03 | 3E+00 | 2E-02 | 2E+01 |
| | W | 5E+02 | 1E+00 | 4E-02 | 2E+01 |
| Sb-126m | D | 2E+05 | 9E-01 | 6E-02 | 1E+04 |
| | W | 2E+05 | 3E-01 | 2E-01 | 4E+04 |
| Sb-127 | D | 2E+03 | 1E+00 | 4E-02 | 7E+01 |
| | W | 9E+02 | 4E-01 | 1E-01 | 1E+02 |
| Sb-128 (10.4 m) | D | 4E+05 | 1E+00 | 5E-02 | 2E+04 |
| | W | 4E+05 | 3E-01 | 2E-01 | 7E+04 |

Table A2. (contd)

| Nuclide | Class | ALI (μCi) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem (μCi) |
|---|---|---|---|---|---|
| Sb-128 (9.0 h) | D | 4E+03 | 1E+00 | 4E-02 | 2E+02 |
| | W | 3E+03 | 6E-01 | 8E-02 | 2E+02 |
| Sb-129 | D | 9E+03 | 1E+00 | 5E-02 | 4E+02 |
| | W | 9E+03 | 5E-01 | 1E-01 | 9E+02 |
| Sb-130 | D | 6E+04 | 1E+00 | 4E-02 | 2E+03 |
| | W | 8E+04 | 5E-01 | 1E-01 | 8E+03 |
| Sb-131 | D | 2E+04 | 2E-01 | 2E-01 | 5E+03 |
| | W | 2E+04 | 7E-02 | 7E-01 | 1E+04 |
| Te-116 | D | 2E+04 | 2E+00 | 3E-02 | 6E+02 |
| | W | 3E+04 | 1E+00 | 5E-02 | 1E+03 |
| Te-121 | D | 4E+03 | 3E+00 | 2E-02 | 7E+01 |
| | W | 3E+03 | 2E+00 | 3E-02 | 9E+01 |
| Te-121m | D | 2E+02 | 6E-01 | 8E-02 | 2E+01 |
| | W | 4E+02 | 6E-01 | 8E-02 | 3E+01 |
| Te-123 | D | 2E+02 | 3E-03 | 2E+01 | 3E+03 |
| | W | 4E+02 | 3E-03 | 2E+01 | 7E+03 |
| Te-123m | D | 2E+02 | 2E-01 | 3E-01 | 6E+01 |
| | W | 5E+02 | 2E-01 | 2E-01 | 1E+02 |
| Te-125m | D | 4E+02 | 2E-01 | 3E-01 | 1E+02 |
| | W | 7E+02 | 1E-01 | 5E-01 | 3E+02 |
| Te-127 | D | 2E+04 | 5E-01 | 1E-01 | 2E+03 |
| | W | 2E+04 | 1E-01 | 4E-01 | 7E+03 |
| Te-127m | D | 3E+02 | 3E-01 | 2E-01 | 6E+01 |
| | W | 3E+02 | 1E-01 | 5E-01 | 1E+02 |
| Te-129 | D | 6E+04 | 4E-01 | 1E-01 | 8E+03 |
| | W | 7E+04 | 1E-01 | 4E-01 | 3E+04 |
| Te-129m | D | 6E+02 | 9E-01 | 6E-02 | 3E+01 |
| | W | 2E+02 | 1E-01 | 4E-01 | 9E+01 |
| Te-131 | D | 5E+03 | 1E-01 | 5E-01 | 2E+03 |
| | W | 5E+03 | 4E-02 | 1E+00 | 7E+03 |
| Te-131m | D | 4E+02 | 2E-01 | 2E-01 | 9E+01 |
| | W | 4E+02 | 2E-01 | 3E-01 | 1E+02 |
| Te-132 | D | 2E+02 | 3E-01 | 2E-01 | 3E+01 |
| | W | 2E+02 | 3E-01 | 2E-01 | 3E+01 |
| Te-133 | D | 2E+04 | 5E-02 | 1E+00 | 2E+04 |
| | W | 2E+04 | 3E-02 | 2E+00 | 4E+04 |
| Te-133m | D | 5E+03 | 2E-01 | 3E-01 | 2E+03 |
| | W | 5E+03 | 6E-02 | 8E-01 | 4E+03 |
| Te-134 | D | 2E+04 | 8E-01 | 6E-02 | 1E+03 |
| | W | 2E+04 | 7E-01 | 7E-02 | 1E+03 |
| I-120 | D | 9E+03 | 4E-01 | 1E-01 | 1E+03 |
| I-120m | D | 2E+04 | 7E-01 | 7E-02 | 1E+03 |
| I-121 | D | 2E+04 | 2E-01 | 3E-01 | 6E+03 |
| I-123 | D | 6E+03 | 7E-02 | 7E-01 | 4E+03 |

Table A2. (contd)

| Nuclide | Class | ALI (µCi) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem (µCi) |
|---|---|---|---|---|---|
| I-124 | D | 8E+01 | 1E-02 | 5E+00 | 4E+02 |
| I-125 | D | 6E+01 | 4E-03 | 1E+01 | 7E+02 |
| I-126 | D | 4E+01 | 6E-03 | 9E+00 | 4E+02 |
| I-128 | D | 1E+05 | 3E-01 | 2E-01 | 2E+04 |
| I-129 | D | 9E+00 | 3E-03 | 2E+01 | 2E+02 |
| I-130 | D | 7E+02 | 8E-02 | 6E-01 | 4E+02 |
| I-131 | D | 5E+01 | 5E-03 | 1E+01 | 5E+02 |
| I-132 | D | 8E+03 | 3E-01 | 1E-01 | 1E+03 |
| I-132m | D | 8E+03 | 2E-01 | 2E-01 | 2E+03 |
| I-133 | D | 3E+02 | 2E-02 | 2E+00 | 7E+02 |
| I-134 | D | 5E+04 | 9E-01 | 5E-02 | 3E+03 |
| I-135 | D | 2E+03 | 1E-01 | 4E-01 | 7E+02 |
| Cs-125 | D | 1E+05 | 6E-01 | 9E-02 | 9E+03 |
| Cs-127 | D | 9E+04 | 3E+00 | 2E-02 | 2E+03 |
| Cs-129 | D | 3E+04 | 4E+00 | 1E-02 | 4E+02 |
| Cs-130 | D | 2E+05 | 6E-01 | 8E-02 | 2E+04 |
| Cs-131 | D | 3E+04 | 4E+00 | 1E-02 | 4E+02 |
| Cs-132 | D | 4E+03 | 5E+00 | 1E-02 | 4E+01 |
| Cs-134 | D | 1E+02 | 5E+00 | 1E-02 | 1E+00 |
| Cs-134m | D | 1E+05 | 1E+00 | 3E-02 | 3E+03 |
| Cs-135 | D | 1E+03 | 4E+00 | 1E-02 | 1E+01 |
| Cs-135m | D | 2E+05 | 2E+00 | 3E-02 | 5E+03 |
| Cs-136 | D | 7E+02 | 6E+00 | 8E-03 | 6E+00 |
| Cs-137 | D | 2E+02 | 7E+00 | 7E-03 | 1E+00 |
| Cs-138 | D | 6E+04 | 7E-01 | 7E-02 | 4E+03 |
| Ba-126 | D | 2E+04 | 8E-01 | 6E-02 | 1E+03 |
| Ba-128 | D | 2E+03 | 1E+00 | 5E-02 | 1E+02 |
| Ba-131 | D | 8E+03 | 2E+00 | 2E-02 | 2E+02 |
| Ba-131m | D | 1E+06 | 5E-01 | 1E-01 | 1E+05 |
| Ba-133 | D | 7E+02 | 2E+00 | 3E-02 | 2E+01 |
| Ba-133m | D | 9E+03 | 6E-01 | 9E-02 | 8E+02 |
| Ba-135m | D | 1E+04 | 5E-01 | 1E-01 | 1E+03 |
| Ba-139 | D | 3E+04 | 3E-01 | 2E-01 | 5E+03 |
| Ba-140 | D | 1E+03 | 1E+00 | 4E-02 | 4E+01 |
| Ba-141 | D | 7E+04 | 4E-01 | 1E-01 | 1E+04 |
| Ba-142 | D | 1E+05 | 7E-01 | 7E-02 | 7E+03 |
| La-131 | D | 1E+05 | 1E+00 | 5E-02 | 5E+03 |
| | W | 2E+05 | 8E-01 | 6E-02 | 1E+04 |
| La-132 | D | 1E+04 | 1E+00 | 4E-02 | 4E+02 |
| | W | 1E+04 | 8E-01 | 6E-02 | 6E+02 |
| La-135 | D | 1E+05 | 1E+00 | 5E-02 | 5E+03 |
| | W | 9E+04 | 9E-01 | 6E-02 | 5E+03 |
| La-137 | D | 6E+01 | 7E-01 | 7E-02 | 4E+00 |
| | W | 3E+02 | 9E-01 | 6E-02 | 2E+01 |

Table A2. (contd)

| Nuclide | Class | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|---|
| La-138 | D | 4E+00 | 2E+00 | 3E-02 | 1E-01 |
| | W | 1E+01 | 1E+00 | 5E-02 | 5E-01 |
| La-140 | D | 1E+03 | 9E-01 | 6E-02 | 6E+01 |
| | W | 1E+03 | 9E-01 | 6E-02 | 6E+01 |
| La-141 | D | 9E+03 | 3E-01 | 2E-01 | 1E+03 |
| | W | 1E+04 | 1E-01 | 5E-01 | 5E+03 |
| La-142 | D | 2E+04 | 1E+00 | 5E-02 | 9E+02 |
| | W | 3E+04 | 6E-01 | 9E-02 | 3E+03 |
| La-143 | D | 1E+05 | 3E-01 | 2E-01 | 2E+04 |
| | W | 9E+04 | 1E-01 | 4E-01 | 4E+04 |
| Ce-134 | W | 7E+02 | 3E-01 | 2E-01 | 1E+02 |
| | Y | 7E+02 | 3E-01 | 2E-01 | 1E+02 |
| Ce-135 | W | 4E+03 | 1E+00 | 3E-02 | 1E+02 |
| | Y | 4E+03 | 2E+00 | 3E-02 | 1E+02 |
| Ce-137 | W | 1E+05 | 4E-01 | 1E-01 | 1E+04 |
| | Y | 1E+05 | 5E-01 | 1E-01 | 1E+04 |
| Ce-137m | W | 4E+03 | 2E-01 | 3E-01 | 1E+03 |
| | Y | 4E+03 | 2E-01 | 3E-01 | 1E+03 |
| Ce-139 | W | 8E+02 | 6E-01 | 9E-02 | 7E+01 |
| | Y | 7E+02 | 2E-01 | 3E-01 | 2E+02 |
| Ce-141 | W | 7E+02 | 1E-01 | 3E-01 | 2E+02 |
| | Y | 6E+02 | 6E-02 | 9E-01 | 5E+02 |
| Ce-143 | W | 2E+03 | 2E-01 | 2E-01 | 4E+02 |
| | Y | 2E+03 | 2E-01 | 2E-01 | 4E+02 |
| Ce-144 | W | 3E+01 | 2E-01 | 2E-01 | 7E+00 |
| | Y | 1E+01 | 8E-03 | 6E+00 | 6E+01 |
| Pr-136 | W | 2E+05 | 6E-02 | 8E-01 | 2E+05 |
| | Y | 2E+05 | 7E-02 | 8E-01 | 2E+05 |
| Pr-137 | W | 2E+05 | 5E-01 | 1E-01 | 2E+04 |
| | Y | 1E+05 | 3E-01 | 2E-01 | 2E+04 |
| Pr-138m | W | 5E+04 | 1E+00 | 5E-02 | 2E+03 |
| | Y | 4E+04 | 1E+00 | 5E-02 | 2E+03 |
| Pr-139 | W | 1E+05 | 5E-01 | 1E-01 | 1E+04 |
| | Y | 1E+05 | 5E-01 | 9E-02 | 9E+03 |
| Pr-142 | W | 2E+03 | 2E-02 | 2E+00 | 5E+03 |
| | Y | 2E+03 | 3E-02 | 2E+00 | 4E+03 |
| Pr-142m | W | 2E+05 | 3E-02 | 2E+00 | 4E+05 |
| | Y | 1E+05 | 2E-02 | 3E+00 | 3E+05 |
| Pr-143 | W | 8E+02 | 6E-09 | 9E+06 | 7E+09 |
| | Y | 7E+02 | 5E-09 | 1E+07 | 7E+09 |
| Pr-144 | W | 1E+05 | 8E-04 | 6E+01 | 6E+06 |
| | Y | 1E+05 | 9E-04 | 6E+01 | 6E+06 |
| Pr-145 | W | 9E+03 | 6E-03 | 9E+00 | 8E+04 |
| | Y | 8E+03 | 6E-03 | 8E+00 | 7E+04 |

Table A2. (contd)

| Nuclide | Class | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|---|
| Pr-147 | W | 2E+05 | 5E-02 | 1E+00 | 2E+05 |
| | Y | 2E+05 | 5E-02 | 1E+00 | 2E+05 |
| Nd-136 | W | 6E+04 | 3E-01 | 2E-01 | 1E+04 |
| | Y | 5E+04 | 3E-01 | 2E-01 | 1E+04 |
| Nd-138 | W | 6E+03 | 2E-01 | 3E-01 | 2E+03 |
| | Y | 5E+03 | 2E-01 | 3E-01 | 1E+03 |
| Nd-139 | W | 3E+05 | 2E-01 | 2E-01 | 6E+04 |
| | Y | 3E+05 | 3E-01 | 2E-01 | 6E+04 |
| Nd-139m | W | 2E+04 | 2E+00 | 3E-02 | 7E+02 |
| | Y | 1E+04 | 9E-01 | 5E-02 | 5E+02 |
| Nd-141 | W | 7E+05 | 7E-01 | 7E-02 | 5E+04 |
| | Y | 6E+05 | 7E-01 | 7E-02 | 4E+04 |
| Nd-147 | W | 9E+02 | 1E-01 | 5E-01 | 4E+02 |
| | Y | 8E+02 | 1E-01 | 5E-01 | 4E+02 |
| Nd-149 | W | 3E+04 | 8E-02 | 6E-01 | 2E+04 |
| | Y | 2E+04 | 6E-02 | 8E-01 | 2E+04 |
| Nd-151 | W | 2E+05 | 2E-01 | 3E-01 | 6E+04 |
| | Y | 2E+05 | 2E-01 | 3E-01 | 5E+04 |
| Pm-141 | W | 2E+05 | 8E-02 | 7E-01 | 1E+05 |
| | Y | 2E+05 | 9E-02 | 6E-01 | 1E+05 |
| Pm-143 | W | 6E+02 | 8E-01 | 6E-02 | 4E+01 |
| | Y | 7E+02 | 4E-01 | 1E-01 | 8E+01 |
| Pm-144 | W | 1E+02 | 9E-01 | 6E-02 | 6E+00 |
| | Y | 1E+02 | 4E-01 | 1E-01 | 1E+01 |
| Pm-145 | W | 2E+02 | 1E-01 | 4E-01 | 9E+01 |
| | Y | 2E+02 | 5E-02 | 1E+00 | 2E+02 |
| Pm-146 | W | 5E+01 | 7E-01 | 7E-02 | 3E+00 |
| | Y | 4E+01 | 2E-01 | 2E-01 | 8E+00 |
| Pm-147 | W | 1E+02 | 5E-06 | 1E+04 | 1E+06 |
| | Y | 1E+02 | 2E-06 | 3E+04 | 3E+06 |
| Pm-148 | W | 5E+02 | 2E-01 | 3E-01 | 1E+02 |
| | Y | 5E+02 | 2E-01 | 3E-01 | 1E+02 |
| Pm-148m | W | 3E+02 | 8E-01 | 6E-02 | 2E+01 |
| | Y | 3E+02 | 6E-01 | 9E-02 | 3E+01 |
| Pm-149 | W | 2E+03 | 1E-02 | 5E+00 | 1E+04 |
| | Y | 2E+03 | 1E-02 | 4E+00 | 9E+03 |
| Pm-150 | W | 2E+04 | 4E-01 | 1E-01 | 3E+03 |
| | Y | 2E+04 | 4E-01 | 1E-01 | 2E+03 |
| Pm-151 | W | 4E+03 | 4E-01 | 1E-01 | 5E+02 |
| | Y | 3E+03 | 3E-01 | 1E-01 | 4E+02 |
| Sm-141 | W | 2E+05 | 7E-02 | 7E-01 | 1E+05 |
| Sm-141m | W | 1E+05 | 1E-01 | 4E-01 | 4E+04 |
| Sm-142 | W | 3E+04 | 9E-02 | 6E-01 | 2E+04 |
| Sm-145 | W | 5E+02 | 1E-01 | 4E-01 | 2E+02 |

Table A2. (contd)

| Nuclide | Class | ALI (μCi) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem (μCi) |
|---|---|---|---|---|---|
| Sm-151 | W | 1E+02 | 2E-06 | 2E+04 | 2E+06 |
| Sm-153 | W | 3E+03 | 1E-01 | 5E-01 | 1E+03 |
| Sm-155 | W | 2E+05 | 8E-03 | 6E+00 | 1E+06 |
| Sm-156 | W | 9E+03 | 4E-01 | 1E-01 | 1E+03 |
| Eu-145 | W | 2E+03 | 2E+00 | 3E-02 | 6E+01 |
| Eu-146 | W | 1E+03 | 1E+00 | 4E-02 | 4E+01 |
| Eu-147 | W | 2E+03 | 1E+00 | 5E-02 | 1E+02 |
| Eu-148 | W | 4E+02 | 1E+00 | 4E-02 | 2E+01 |
| Eu-149 | W | 3E+03 | 4E-01 | 1E-01 | 4E+02 |
| Eu-150 (12.6 h) | W | 8E+03 | 5E-02 | 1E+00 | 8E+03 |
| Eu-150 (34.2 y) | W | 2E+01 | 1E+00 | 5E-02 | 9E-01 |
| Eu-152 | W | 2E+01 | 7E-01 | 7E-02 | 1E+00 |
| Eu-152m | W | 6E+03 | 2E-01 | 3E-01 | 2E+03 |
| Eu-154 | W | 2E+01 | 6E-01 | 8E-02 | 2E+00 |
| Eu-155 | W | 9E+01 | 8E-02 | 6E-01 | 6E+01 |
| Eu-156 | W | 5E+02 | 5E-01 | 9E-02 | 5E+01 |
| Eu-157 | W | 5E+03 | 2E-01 | 2E-01 | 1E+03 |
| Eu-158 | W | 6E+04 | 8E-02 | 6E-01 | 4E+04 |
| Gd-145 | D | 2E+05 | 1E+00 | 5E-02 | 1E+04 |
| | W | 2E+05 | 7E-01 | 8E-02 | 2E+04 |
| Gd-146 | D | 1E+02 | 7E-01 | 7E-02 | 7E+00 |
| | W | 3E+02 | 8E-01 | 7E-02 | 2E+01 |
| Gd-147 | D | 4E+03 | 1E+00 | 3E-02 | 1E+02 |
| | W | 4E+03 | 2E+00 | 3E-02 | 1E+02 |
| Gd-149 | D | 2E+03 | 7E-01 | 8E-02 | 2E+02 |
| | W | 2E+03 | 7E-01 | 7E-02 | 1E+02 |
| Gd-151 | D | 4E+02 | 1E-01 | 4E-01 | 2E+02 |
| | W | 1E+03 | 1E-01 | 4E-01 | 4E+02 |
| Gd-153 | D | 1E+02 | 1E-01 | 5E-01 | 5E+01 |
| | W | 6E+02 | 2E-01 | 2E-01 | 1E+02 |
| Gd-159 | D | 8E+03 | 6E-02 | 8E-01 | 6E+03 |
| | W | 6E+03 | 7E-02 | 7E-01 | 4E+03 |
| Tb-147 | W | 3E+04 | 9E-01 | 5E-02 | 2E+03 |
| Tb-149 | W | 7E+02 | 4E-02 | 1E+00 | 9E+02 |
| Tb-150 | W | 2E+04 | 6E-01 | 8E-02 | 2E+03 |
| Tb-151 | W | 9E+03 | 2E+00 | 3E-02 | 3E+02 |
| Tb-153 | W | 7E+03 | 9E-01 | 6E-02 | 4E+02 |
| Tb-154 | W | 4E+03 | 2E+00 | 3E-02 | 1E+02 |
| Tb-155 | W | 8E+03 | 9E-01 | 5E-02 | 4E+02 |
| Tb-156 | W | 1E+03 | 1E+00 | 4E-02 | 4E+01 |
| Tb-156m (24.4 h) | W | 8E+03 | 1E+00 | 4E-02 | 3E+02 |
| Tb-156m (5.0 h) | W | 3E+04 | 1E+00 | 4E-02 | 1E+03 |
| Tb-157 | W | 3E+02 | 2E-02 | 2E+00 | 7E+02 |
| Tb-158 | W | 2E+01 | 8E-01 | 6E-02 | 1E+00 |

Table A2. (contd)

| Nuclide | Class | ALI (μCi) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem (μCi) |
|---|---|---|---|---|---|
| Tb-160 | W | 2E+02 | 4E-01 | 1E-01 | 2E+01 |
| Tb-161 | W | 2E+03 | 7E-02 | 8E-01 | 2E+03 |
| Dy-155 | W | 3E+04 | 2E+00 | 2E-02 | 7E+02 |
| Dy-157 | W | 6E+04 | 2E+00 | 3E-02 | 2E+03 |
| Dy-159 | W | 2E+03 | 2E-01 | 2E-01 | 5E+02 |
| Dy-165 | W | 5E+04 | 2E-02 | 3E+00 | 2E+05 |
| Dy-166 | W | 7E+02 | 3E-02 | 2E+00 | 1E+03 |
| Ho-155 | W | 2E+05 | 1E+00 | 4E-02 | 8E+03 |
| Ho-157 | W | 1E+06 | 9E-01 | 6E-02 | 6E+04 |
| Ho-159 | W | 1E+06 | 3E-01 | 2E-01 | 2E+05 |
| Ho-161 | W | 4E+05 | 4E-01 | 1E-01 | 5E+04 |
| Ho-162 | W | 2E+06 | 6E-02 | 8E-01 | 2E+06 |
| Ho-162m | W | 3E+05 | 6E-01 | 8E-02 | 2E+04 |
| Ho-164 | W | 6E+05 | 1E-02 | 5E+00 | 3E+06 |
| Ho-164m | W | 3E+05 | 3E-02 | 1E+00 | 4E+05 |
| Ho-166 | W | 2E+03 | 2E-02 | 3E+00 | 5E+03 |
| Ho-166m | W | 7E+00 | 6E-01 | 8E-02 | 6E-01 |
| Ho-167 | W | 6E+04 | 4E-01 | 1E-01 | 8E+03 |
| Er-161 | W | 6E+04 | 1E+00 | 4E-02 | 2E+03 |
| Er-165 | W | 2E+05 | 1E+00 | 4E-02 | 7E+03 |
| Er-169 | W | 3E+03 | 3E-02 | 2E+00 | 5E+03 |
| Er-171 | W | 1E+04 | 4E-01 | 1E-01 | 1E+03 |
| Er-172 | W | 1E+03 | 3E-01 | 1E-01 | 1E+02 |
| Tm-162 | W | 3E+05 | 4E-01 | 1E-01 | 4E+04 |
| Tm-166 | W | 1E+04 | 1E+00 | 4E-02 | 4E+02 |
| Tm-167 | W | 2E+03 | 3E-01 | 2E-01 | 3E+02 |
| Tm-170 | W | 2E+02 | 1E-01 | 5E-01 | 1E+02 |
| Tm-171 | W | 3E+02 | 6E-02 | 8E-01 | 2E+02 |
| Tm-172 | W | 1E+03 | 2E-01 | 2E-01 | 2E+02 |
| Tm-173 | W | 1E+04 | 4E-01 | 1E-01 | 1E+03 |
| Tm-175 | W | 3E+05 | 2E-01 | 3E-01 | 8E+04 |
| Yb-162 | W | 3E+05 | 3E-01 | 2E-01 | 6E+04 |
|  | Y | 3E+05 | 3E-01 | 2E-01 | 5E+04 |
| Yb-166 | W | 2E+03 | 2E+00 | 3E-02 | 6E+01 |
|  | Y | 2E+03 | 2E+00 | 3E-02 | 5E+01 |
| Yb-167 | W | 8E+05 | 2E-01 | 3E-01 | 2E+05 |
|  | Y | 7E+05 | 2E-01 | 3E-01 | 2E+05 |
| Yb-169 | W | 8E+02 | 3E-01 | 2E-01 | 1E+02 |
|  | Y | 7E+02 | 3E-01 | 2E-01 | 1E+02 |
| Yb-175 | W | 4E+03 | 1E-01 | 5E-01 | 2E+03 |
|  | Y | 3E+03 | 8E-02 | 6E-01 | 2E+03 |
| Yb-177 | W | 5E+04 | 8E-02 | 6E-01 | 3E+04 |
|  | Y | 5E+04 | 1E-01 | 5E-01 | 2E+04 |

Table A2. (contd)

| Nuclide | Class | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|---|
| Yb-178 | W | 4E+04 | 3E-02 | 2E+00 | 7E+04 |
| | Y | 4E+04 | 4E-02 | 1E+00 | 6E+04 |
| Lu-169 | W | 4E+03 | 1E+00 | 4E-02 | 1E+02 |
| | Y | 4E+03 | 2E+00 | 3E-02 | 1E+02 |
| Lu-170 | W | 2E+03 | 2E+00 | 3E-02 | 6E+01 |
| | Y | 2E+03 | 2E+00 | 2E-02 | 5E+01 |
| Lu-171 | W | 2E+03 | 1E+00 | 5E-02 | 1E+02 |
| | Y | 2E+03 | 1E+00 | 5E-02 | 9E+01 |
| Lu-172 | W | 1E+03 | 1E+00 | 4E-02 | 4E+01 |
| | Y | 1E+03 | 1E+00 | 4E-02 | 4E+01 |
| Lu-173 | W | 3E+02 | 2E-01 | 2E-01 | 7E+01 |
| | Y | 3E+02 | 1E-01 | 5E-01 | 1E+02 |
| Lu-174 | W | 1E+02 | 1E-01 | 3E-01 | 3E+01 |
| | Y | 2E+02 | 1E-01 | 3E-01 | 7E+01 |
| Lu-174m | W | 2E+02 | 6E-02 | 8E-01 | 2E+02 |
| | Y | 2E+02 | 3E-02 | 1E+00 | 3E+02 |
| Lu-176 | W | 5E+00 | 1E-01 | 5E-01 | 2E+00 |
| | Y | 8E+00 | 8E-02 | 6E-01 | 5E+00 |
| Lu-176m | W | 3E+04 | 1E-02 | 4E+00 | 1E+05 |
| | Y | 2E+04 | 1E-02 | 4E+00 | 9E+04 |
| Lu-177 | W | 2E+03 | 6E-02 | 9E-01 | 2E+03 |
| | Y | 2E+03 | 6E-02 | 8E-01 | 2E+03 |
| Lu-177m | W | 1E+02 | 3E-01 | 2E-01 | 2E+01 |
| | Y | 8E+01 | 1E-01 | 4E-01 | 3E+01 |
| Lu-178 | W | 1E+05 | 9E-03 | 6E+00 | 6E+05 |
| | Y | 1E+05 | 1E-02 | 5E+00 | 5E+05 |
| Lu-178m | W | 2E+05 | 7E-02 | 7E-01 | 1E+05 |
| | Y | 2E+05 | 8E-02 | 6E-01 | 1E+05 |
| Lu-179 | W | 2E+04 | 2E-02 | 2E+00 | 5E+04 |
| | Y | 2E+04 | 3E-02 | 2E+00 | 4E+04 |
| Hf-170 | D | 6E+03 | 3E+00 | 2E-02 | 1E+02 |
| | W | 5E+03 | 2E+00 | 3E-02 | 1E+02 |
| Hf-172 | D | 9E+00 | 5E-01 | 9E-02 | 8E-01 |
| | W | 4E+01 | 6E-01 | 8E-02 | 3E+00 |
| Hf-173 | D | 1E+04 | 1E+00 | 3E-02 | 3E+02 |
| | W | 1E+04 | 1E+00 | 4E-02 | 4E+02 |
| Hf-175 | D | 9E+02 | 1E+00 | 4E-02 | 3E+01 |
| | W | 1E+03 | 7E-01 | 8E-02 | 8E+01 |
| Hf-177m | D | 6E+04 | 1E+00 | 3E-02 | 2E+03 |
| | W | 9E+04 | 6E-01 | 8E-02 | 7E+03 |
| Hf-178m | D | 1E+00 | 4E-01 | 1E-01 | 1E-01 |
| | W | 5E+00 | 5E-01 | 1E-01 | 5E-01 |
| Hf-179m | D | 3E+02 | 6E-01 | 8E-02 | 2E+01 |
| | W | 6E+02 | 7E-01 | 7E-02 | 4E+01 |

Table A2. (contd)

| Nuclide | Class | ALI (μCi) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem (μCi) |
|---|---|---|---|---|---|
| Hf-180m | D | 2E+04 | 2E+00 | 3E-02 | 6E+02 |
| | W | 3E+04 | 2E+00 | 3E-02 | 9E+02 |
| Hf-181 | D | 2E+02 | 3E-01 | 1E-01 | 3E+01 |
| | W | 4E+02 | 3E-01 | 2E-01 | 6E+01 |
| Hf-182 | D | 8E-01 | 3E-01 | 1E-01 | 1E-01 |
| | W | 3E+00 | 3E-01 | 1E-01 | 4E-01 |
| Hf-182m | D | 9E+04 | 1E+00 | 4E-02 | 3E+03 |
| | W | 1E+05 | 4E-01 | 1E-01 | 1E+04 |
| Hf-183 | D | 5E+04 | 9E-01 | 6E-02 | 3E+03 |
| | W | 6E+04 | 4E-01 | 1E-01 | 8E+03 |
| Hf-184 | D | 8E+03 | 1E+00 | 4E-02 | 3E+02 |
| | W | 6E+03 | 6E-01 | 8E-02 | 5E+02 |
| Ta-172 | W | 1E+05 | 3E-01 | 2E-01 | 2E+04 |
| | Y | 1E+05 | 2E-01 | 3E-01 | 3E+04 |
| Ta-173 | W | 2E+04 | 8E-01 | 6E-02 | 1E+03 |
| | Y | 2E+04 | 8E-01 | 6E-02 | 1E+03 |
| Ta-174 | W | 1E+05 | 4E-01 | 1E-01 | 1E+04 |
| | Y | 9E+04 | 2E-01 | 2E-01 | 2E+04 |
| Ta-175 | W | 2E+04 | 2E+00 | 2E-02 | 4E+02 |
| | Y | 1E+04 | 1E+00 | 4E-02 | 4E+02 |
| Ta-176 | W | 1E+04 | 2E+00 | 3E-02 | 3E+02 |
| | Y | 1E+04 | 2E+00 | 3E-02 | 3E+02 |
| Ta-177 | W | 2E+04 | 1E+00 | 5E-02 | 1E+03 |
| | Y | 2E+04 | 1E+00 | 5E-02 | 1E+03 |
| Ta-178 | W | 9E+04 | 1E+00 | 4E-02 | 4E+03 |
| | Y | 7E+04 | 9E-01 | 5E-02 | 4E+03 |
| Ta-179 | W | 5E+03 | 9E-01 | 5E-02 | 3E+02 |
| | Y | 9E+02 | 9E-02 | 6E-01 | 5E+02 |
| Ta-180 | W | 4E+02 | 1E+00 | 4E-02 | 2E+01 |
| | Y | 2E+01 | 7E-02 | 7E-01 | 1E+01 |
| Ta-180m | W | 7E+04 | 5E-01 | 9E-02 | 7E+03 |
| | Y | 6E+04 | 4E-01 | 1E-01 | 7E+03 |
| Ta-182 | W | 3E+02 | 1E+00 | 5E-02 | 1E+01 |
| | Y | 1E+02 | 2E-01 | 2E-01 | 2E+01 |
| Ta-182m | W | 5E+05 | 3E-01 | 2E-01 | 9E+04 |
| | Y | 4E+05 | 1E-01 | 5E-01 | 2E+05 |
| Ta-183 | W | 1E+03 | 3E-01 | 2E-01 | 2E+02 |
| | Y | 1E+03 | 2E-01 | 2E-01 | 2E+02 |
| Ta-184 | W | 5E+03 | 8E-01 | 6E-02 | 3E+02 |
| | Y | 5E+03 | 8E-01 | 6E-02 | 3E+02 |
| Ta-185 | W | 7E+04 | 1E-01 | 4E-01 | 3E+04 |
| | Y | 6E+04 | 3E-02 | 2E+00 | 1E+05 |
| Ta-186 | W | 2E+05 | 1E-01 | 5E-01 | 9E+04 |
| | Y | 2E+05 | 4E-02 | 1E+00 | 3E+05 |

Table A2. (contd)

| Nuclide | Class | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|---|
| W-176 | D | 5E+04 | 2E+00 | 3E-02 | 2E+03 |
| W-177 | D | 9E+04 | 1E+00 | 3E-02 | 3E+03 |
| W-178 | D | 2E+04 | 7E-01 | 7E-02 | 1E+03 |
| W-179 | D | 2E+06 | 5E-01 | 9E-02 | 2E+05 |
| W-181 | D | 3E+04 | 6E-01 | 9E-02 | 3E+03 |
| W-185 | D | 7E+03 | 2E-04 | 3E+02 | 2E+06 |
| W-187 | D | 9E+03 | 4E-01 | 1E-01 | 1E+03 |
| W-188 | D | 1E+03 | 2E-02 | 3E+00 | 3E+03 |
| Re-177 | D | 3E+05 | 1E+00 | 5E-02 | 1E+04 |
| | W | 4E+05 | 6E-01 | 9E-02 | 4E+04 |
| Re-178 | D | 3E+05 | 6E-01 | 9E-02 | 3E+04 |
| | W | 3E+05 | 2E-01 | 3E-01 | 8E+04 |
| Re-181 | D | 9E+03 | 1E+00 | 3E-02 | 3E+02 |
| | W | 9E+03 | 1E+00 | 5E-02 | 4E+02 |
| Re-182 (12.7 h) | D | 1E+04 | 1E+00 | 3E-02 | 3E+02 |
| | W | 2E+04 | 2E+00 | 2E-02 | 5E+02 |
| Re-182 (64.0 h) | D | 2E+03 | 2E+00 | 3E-02 | 6E+01 |
| | W | 2E+03 | 1E+00 | 4E-02 | 8E+01 |
| Re-184 | D | 4E+03 | 3E+00 | 2E-02 | 6E+01 |
| | W | 1E+03 | 8E-01 | 6E-02 | 6E+01 |
| Re-184m | D | 3E+03 | 2E+00 | 2E-02 | 7E+01 |
| | W | 4E+02 | 3E-01 | 2E-01 | 6E+01 |
| Re-186 | D | 3E+03 | 8E-01 | 7E-02 | 2E+02 |
| | W | 2E+03 | 3E-01 | 2E-01 | 3E+02 |
| Re-186m | D | 2E+03 | 1E+00 | 4E-02 | 9E+01 |
| | W | 2E+02 | 1E-01 | 4E-01 | 9E+01 |
| Re-187 | D | 8E+05 | 9E-01 | 6E-02 | 5E+04 |
| | W | 1E+05 | 1E-01 | 5E-01 | 5E+04 |
| Re-188 | D | 3E+03 | 5E-01 | 9E-02 | 3E+02 |
| | W | 3E+03 | 3E-01 | 2E-01 | 5E+02 |
| Re-188m | D | 1E+05 | 4E-01 | 1E-01 | 1E+04 |
| | W | 1E+05 | 2E-01 | 3E-01 | 3E+04 |
| Re-189 | D | 5E+03 | 6E-01 | 8E-02 | 4E+02 |
| | W | 4E+03 | 3E-01 | 2E-01 | 7E+02 |
| Os-180 | D | 4E+05 | 2E+00 | 3E-02 | 1E+04 |
| | W | 5E+05 | 5E-01 | 1E-01 | 5E+04 |
| | Y | 5E+05 | 3E-01 | 2E-01 | 1E+05 |
| Os-181 | D | 4E+04 | 2E+00 | 3E-02 | 1E+03 |
| | W | 5E+04 | 1E+00 | 4E-02 | 2E+03 |
| | Y | 4E+04 | 1E+00 | 4E-02 | 2E+03 |
| Os-182 | D | 6E+03 | 2E+00 | 2E-02 | 1E+02 |
| | W | 4E+03 | 2E+00 | 3E-02 | 1E+02 |
| | Y | 4E+03 | 2E+00 | 3E-02 | 1E+02 |

Table A2. (contd)

| Nuclide | Class | ALI (μCi) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem (μCi) |
|---|---|---|---|---|---|
| Os-185 | D | 5E+02 | 3E+00 | 2E-02 | 8E+00 |
| | W | 8E+02 | 2E+00 | 3E-02 | 3E+01 |
| | Y | 8E+02 | 8E-01 | 6E-02 | 5E+01 |
| Os-189m | D | 2E+05 | 4E-01 | 1E-01 | 3E+04 |
| | W | 2E+05 | 9E-02 | 6E-01 | 1E+05 |
| | Y | 2E+05 | 6E-03 | 8E+00 | 2E+06 |
| Os-191 | D | 2E+03 | 1E+00 | 4E-02 | 7E+01 |
| | W | 2E+03 | 4E-01 | 1E-01 | 3E+02 |
| | Y | 1E+03 | 1E-01 | 5E-01 | 5E+02 |
| Os-191m | D | 3E+04 | 1E+00 | 5E-02 | 1E+03 |
| | W | 2E+04 | 2E-01 | 3E-01 | 5E+03 |
| | Y | 2E+04 | 1E-01 | 5E-01 | 1E+04 |
| Os-193 | D | 5E+03 | 7E-01 | 7E-02 | 3E+02 |
| | W | 3E+03 | 1E-01 | 3E-01 | 1E+03 |
| | Y | 3E+03 | 9E-02 | 5E-01 | 2E+03 |
| Os-194 | D | 4E+01 | 1E+00 | 3E-02 | 1E+00 |
| | W | 6E+01 | 6E-01 | 9E-02 | 5E+00 |
| | Y | 8E+00 | 3E-02 | 2E+00 | 2E+01 |
| Ir-182 | D | 1E+05 | 8E-01 | 7E-02 | 7E+03 |
| | W | 2E+05 | 1E+00 | 4E-02 | 9E+03 |
| | Y | 1E+05 | 5E-01 | 9E-02 | 9E+03 |
| Ir-184 | D | 2E+04 | 2E+00 | 3E-02 | 6E+02 |
| | W | 3E+04 | 1E+00 | 4E-02 | 1E+03 |
| | Y | 3E+04 | 1E+00 | 4E-02 | 1E+03 |
| Ir-185 | D | 1E+04 | 2E+00 | 3E-02 | 3E+02 |
| | W | 1E+04 | 1E+00 | 5E-02 | 5E+02 |
| | Y | 1E+04 | 1E+00 | 5E-02 | 5E+02 |
| Ir-186 | D | 8E+03 | 3E+00 | 2E-02 | 2E+02 |
| | W | 6E+03 | 2E+00 | 3E-02 | 2E+02 |
| | Y | 6E+03 | 2E+00 | 3E-02 | 2E+02 |
| Ir-187 | D | 3E+04 | 2E+00 | 3E-02 | 8E+02 |
| | W | 3E+04 | 1E+00 | 4E-02 | 1E+03 |
| | Y | 3E+04 | 1E+00 | 3E-02 | 1E+03 |
| Ir-188 | D | 5E+03 | 3E+00 | 2E-02 | 8E+01 |
| | W | 4E+03 | 2E+00 | 2E-02 | 8E+01 |
| | Y | 3E+03 | 2E+00 | 3E-02 | 8E+01 |
| Ir-189 | D | 5E+03 | 2E+00 | 3E-02 | 1E+02 |
| | W | 4E+03 | 6E-01 | 9E-02 | 4E+02 |
| | Y | 4E+03 | 4E-01 | 1E-01 | 5E+02 |
| Ir-190 | D | 9E+02 | 3E+00 | 2E-02 | 2E+01 |
| | W | 1E+03 | 2E+00 | 3E-02 | 3E+01 |
| | Y | 9E+02 | 1E+00 | 4E-02 | 4E+01 |

Table A2. (contd)

| Nuclide | Class | ALI (μCi) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem (μCi) |
|---|---|---|---|---|---|
| Ir-190m | D | 2E+05 | 2E+00 | 2E-02 | 4E+03 |
| | W | 2E+05 | 1E+00 | 4E-02 | 8E+03 |
| | Y | 2E+05 | 1E+00 | 5E-02 | 1E+04 |
| Ir-192 | D | 3E+02 | 2E+00 | 2E-02 | 6E+00 |
| | W | 4E+02 | 1E+00 | 5E-02 | 2E+01 |
| | Y | 2E+02 | 2E-01 | 2E-01 | 5E+01 |
| Ir-192m | D | 9E+01 | 2E+00 | 2E-02 | 2E+00 |
| | W | 2E+02 | 1E+00 | 3E-02 | 7E+00 |
| | Y | 2E+01 | 1E-01 | 3E-01 | 7E+00 |
| Ir-194 | D | 3E+03 | 6E-01 | 9E-02 | 3E+02 |
| | W | 2E+03 | 1E-01 | 5E-01 | 1E+03 |
| | Y | 2E+03 | 5E-02 | 1E+00 | 2E+03 |
| Ir-194m | D | 9E+01 | 3E+00 | 2E-02 | 2E+00 |
| | W | 2E+02 | 2E+00 | 3E-02 | 6E+00 |
| | Y | 1E+02 | 4E-01 | 1E-01 | 1E+01 |
| Ir-195 | D | 4E+04 | 5E-01 | 1E-01 | 4E+03 |
| | W | 5E+04 | 2E-01 | 3E-01 | 1E+04 |
| | Y | 4E+04 | 5E-02 | 1E+00 | 4E+04 |
| Ir-195m | D | 2E+04 | 7E-01 | 7E-02 | 1E+03 |
| | W | 3E+04 | 5E-01 | 1E-01 | 3E+03 |
| | Y | 2E+04 | 3E-01 | 2E-01 | 4E+03 |
| Pt-186 | D | 4E+04 | 2E+00 | 2E-02 | 1E+03 |
| Pt-188 | D | 2E+03 | 3E+00 | 2E-02 | 3E+01 |
| Pt-189 | D | 3E+04 | 2E+00 | 3E-02 | 8E+02 |
| Pt-191 | D | 8E+03 | 2E+00 | 3E-02 | 2E+02 |
| Pt-193 | D | 2E+04 | 1E+00 | 5E-02 | 1E+03 |
| Pt-193m | D | 6E+03 | 8E-01 | 6E-02 | 4E+02 |
| Pt-195m | D | 4E+03 | 9E-01 | 6E-02 | 2E+02 |
| Pt-197 | D | 1E+04 | 6E-01 | 9E-02 | 9E+02 |
| Pt-197m | D | 4E+04 | 4E-01 | 1E-01 | 4E+03 |
| Pt-199 | D | 1E+05 | 4E-01 | 1E-01 | 1E+04 |
| Pt-200 | D | 3E+03 | 6E-01 | 9E-02 | 3E+02 |
| Au-193 | D | 3E+04 | 2E+00 | 3E-02 | 8E+02 |
| | W | 2E+04 | 1E+00 | 5E-02 | 1E+03 |
| | Y | 2E+04 | 1E+00 | 5E-02 | 1E+03 |
| Au-194 | D | 8E+03 | 4E+00 | 1E-02 | 1E+02 |
| | W | 5E+03 | 2E+00 | 2E-02 | 1E+02 |
| | Y | 5E+03 | 2E+00 | 2E-02 | 1E+02 |
| Au-195 | D | 1E+04 | 2E+00 | 2E-02 | 2E+02 |
| | W | 1E+03 | 2E-01 | 3E-01 | 3E+02 |
| | Y | 4E+02 | 6E-02 | 8E-01 | 3E+02 |
| Au-198 | D | 4E+03 | 2E+00 | 3E-02 | 1E+02 |
| | W | 2E+03 | 5E-01 | 1E-01 | 2E+02 |
| | Y | 2E+03 | 5E-01 | 1E-01 | 2E+02 |

Table A2. (contd)

| Nuclide | Class | ALI ($\mu$Ci) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem ($\mu$Ci) |
|---|---|---|---|---|---|
| Au-198m | D | 3E+03 | 2E+00 | 2E-02 | 7E+01 |
| | W | 1E+03 | 5E-01 | 1E-01 | 1E+02 |
| | Y | 1E+03 | 5E-01 | 1E-01 | 1E+02 |
| Au-199 | D | 9E+03 | 2E+00 | 3E-02 | 3E+02 |
| | W | 4E+03 | 3E-01 | 1E-01 | 6E+02 |
| | Y | 4E+03 | 3E-01 | 2E-01 | 7E+02 |
| Au-200 | D | 6E+04 | 4E-01 | 1E-01 | 7E+03 |
| | W | 8E+04 | 2E-01 | 3E-01 | 2E+04 |
| | Y | 7E+04 | 4E-02 | 1E+00 | 9E+04 |
| Au-200m | D | 4E+03 | 3E+00 | 2E-02 | 8E+01 |
| | W | 3E+03 | 1E+00 | 3E-02 | 1E+02 |
| | Y | 2E+04 | 1E+01 | 5E-03 | 1E+02 |
| Au-201 | D | 2E+05 | 3E-01 | 2E-01 | 3E+04 |
| | W | 2E+05 | 9E-02 | 6E-01 | 1E+05 |
| | Y | 2E+05 | 1E-02 | 5E+00 | 9E+05 |
| Hg-193 | D | 4E+04 | 1E+00 | 4E-02 | 2E+03 |
| | W | 4E+04 | 7E-01 | 7E-02 | 3E+03 |
| | D | 3E+04 | 7E-01 | 7E-02 | 2E+03 |
| | V | 6E+04 | 5E-01 | 1E-01 | 6E+03 |
| Hg-193m | D | 9E+03 | 2E+00 | 2E-02 | 2E+02 |
| | W | 8E+03 | 1E+00 | 4E-02 | 3E+02 |
| | D | 8E+03 | 1E+00 | 4E-02 | 3E+02 |
| | V | 1E+04 | 8E-01 | 6E-02 | 6E+02 |
| Hg-194 | D | 4E+01 | 4E+00 | 1E-02 | 5E-01 |
| | W | 1E+02 | 3E+00 | 2E-02 | 2E+00 |
| | D | 3E+01 | 3E+00 | 1E-02 | 4E-01 |
| | V | 3E+01 | 4E+00 | 1E-02 | 4E-01 |
| Hg-195 | D | 4E+04 | 2E+00 | 3E-02 | 1E+03 |
| | W | 3E+04 | 9E-01 | 6E-02 | 2E+03 |
| | D | 3E+04 | 1E+00 | 4E-02 | 1E+03 |
| | V | 5E+04 | 9E-01 | 6E-02 | 3E+03 |
| Hg-195m | D | 5E+03 | 2E+00 | 3E-02 | 2E+02 |
| | W | 4E+03 | 7E-01 | 7E-02 | 3E+02 |
| | D | 4E+03 | 1E+00 | 4E-02 | 2E+02 |
| | V | 6E+03 | 2E+00 | 3E-02 | 2E+02 |
| Hg-197 | D | 1E+04 | 1E+00 | 3E-02 | 3E+02 |
| | W | 9E+03 | 6E-01 | 8E-02 | 7E+02 |
| | D | 8E+03 | 1E+00 | 4E-02 | 4E+02 |
| | V | 1E+04 | 1E+00 | 4E-02 | 4E+02 |
| Hg-197m | D | 7E+03 | 1E+00 | 4E-02 | 3E+02 |
| | W | 5E+03 | 3E-01 | 1E-01 | 7E+02 |
| | D | 5E+03 | 8E-01 | 6E-02 | 3E+02 |
| | V | 9E+03 | 1E+00 | 5E-02 | 4E+02 |

Table A2. (contd)

| Nuclide | Class | ALI (μCi) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem (μCi) |
|---|---|---|---|---|---|
| Hg-199m | D | 1E+05 | 3E-01 | 1E-01 | 1E+04 |
| | W | 2E+05 | 2E-01 | 3E-01 | 5E+04 |
| | D | 8E+04 | 3E-01 | 2E-01 | 1E+04 |
| | V | 2E+05 | 5E-02 | 1E+00 | 2E+05 |
| Hg-203 | D | 1E+03 | 2E+00 | 2E-02 | 2E+01 |
| | W | 1E+03 | 7E-01 | 7E-02 | 7E+01 |
| | D | 8E+02 | 3E+00 | 2E-02 | 1E+01 |
| | V | 8E+02 | 3E+00 | 2E-02 | 1E+01 |
| Tl-194 | D | 6E+05 | 1E+00 | 3E-02 | 2E+04 |
| Tl-194m | D | 2E+05 | 2E+00 | 3E-02 | 6E+03 |
| Tl-195 | D | 1E+05 | 2E+00 | 3E-02 | 3E+03 |
| Tl-197 | D | 1E+05 | 2E+00 | 3E-02 | 3E+03 |
| Tl-198 | D | 3E+04 | 3E+00 | 2E-02 | 6E+02 |
| Tl-198m | D | 5E+04 | 2E+00 | 3E-02 | 1E+03 |
| Tl-199 | D | 8E+04 | 2E+00 | 2E-02 | 2E+03 |
| Tl-200 | D | 1E+04 | 4E+00 | 1E-02 | 1E+02 |
| Tl-201 | D | 2E+04 | 3E+00 | 2E-02 | 3E+02 |
| Tl-202 | D | 5E+03 | 4E+00 | 1E-02 | 6E+01 |
| Tl-204 | D | 2E+03 | 3E+00 | 2E-02 | 3E+01 |
| Pb-195m | D | 2E+05 | 2E+00 | 3E-02 | 7E+03 |
| Pb-198 | D | 6E+04 | 2E+00 | 3E-02 | 2E+03 |
| Pb-199 | D | 7E+04 | 2E+00 | 2E-02 | 2E+03 |
| Pb-200 | D | 6E+03 | 2E+00 | 3E-02 | 2E+02 |
| Pb-201 | D | 2E+04 | 2E+00 | 3E-02 | 5E+02 |
| Pb-202 | D | 5E+01 | 2E+00 | 3E-02 | 1E+00 |
| Pb-202m | D | 3E+04 | 3E+00 | 2E-02 | 5E+02 |
| Pb-203 | D | 9E+03 | 1E+00 | 4E-02 | 3E+02 |
| Pb-205 | D | 1E+03 | 2E-01 | 3E-01 | 3E+02 |
| Pb-209 | D | 6E+04 | 3E-01 | 2E-01 | 9E+03 |
| Pb-210 | D | 2E-01 | 2E-01 | 2E-01 | 4E-02 |
| Pb-211 | D | 6E+02 | 4E-01 | 1E-01 | 8E+01 |
| Pb-212 | D | 3E+01 | 4E-01 | 1E-01 | 4E+00 |
| Pb-214 | D | 8E+02 | 5E-01 | 1E-01 | 8E+01 |
| Bi-200 | D | 8E+04 | 1E+00 | 4E-02 | 3E+03 |
| | W | 1E+05 | 1E+00 | 4E-02 | 4E+03 |
| Bi-201 | D | 3E+04 | 1E+00 | 4E-02 | 1E+03 |
| | W | 4E+04 | 1E+00 | 5E-02 | 2E+03 |
| Bi-202 | D | 4E+04 | 2E+00 | 3E-02 | 1E+03 |
| | W | 8E+04 | 1E+00 | 4E-02 | 3E+03 |
| Bi-203 | D | 7E+03 | 2E+00 | 3E-02 | 2E+02 |
| | W | 6E+03 | 2E+00 | 3E-02 | 2E+02 |
| Bi-205 | D | 3E+03 | 2E+00 | 2E-02 | 7E+01 |
| | W | 1E+03 | 1E+00 | 4E-02 | 4E+01 |

Table A2. (contd)

| Nuclide | Class | ALI (µCi) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem (µCi) |
|---|---|---|---|---|---|
| Bi-206 | D | 1E+03 | 1E+00 | 4E-02 | 4E+01 |
| | W | 9E+02 | 2E+00 | 3E-02 | 3E+01 |
| Bi-207 | D | 2E+03 | 2E+00 | 3E-02 | 6E+01 |
| | W | 4E+02 | 7E-01 | 7E-02 | 3E+01 |
| Bi-210 | D | 2E+02 | 1E-01 | 3E-01 | 7E+01 |
| | W | 3E+01 | 7E-03 | 7E+00 | 2E+02 |
| Bi-210m | D | 5E+00 | 2E-01 | 3E-01 | 1E+00 |
| | W | 7E-01 | 8E-03 | 6E+00 | 4E+00 |
| Bi-212 | D | 2E+02 | 1E-01 | 4E-01 | 8E+01 |
| | W | 3E+02 | 5E-02 | 1E+00 | 3E+02 |
| Bi-213 | D | 3E+02 | 1E-01 | 3E-01 | 1E+02 |
| | W | 4E+02 | 6E-02 | 9E-01 | 4E+02 |
| Bi-214 | D | 8E+02 | 2E-01 | 3E-01 | 3E+02 |
| | W | 9E-02 | 5E-06 | 1E+04 | 9E+02 |
| Po-203 | D | 6E+04 | 2E+00 | 3E-02 | 2E+03 |
| | W | 9E+04 | 2E+00 | 3E-02 | 2E+03 |
| Po-205 | D | 4E+04 | 2E+00 | 2E-02 | 9E+02 |
| | W | 7E+04 | 2E+00 | 3E-02 | 2E+03 |
| Po-207 | D | 3E+04 | 3E+00 | 2E-02 | 5E+02 |
| | W | 3E+04 | 2E+00 | 2E-02 | 7E+02 |
| Po-210 | D | 6E-01 | 9E-01 | 6E-02 | 3E-02 |
| | W | 6E-01 | 3E-01 | 2E-01 | 1E-01 |
| At-207 | D | 3E+03 | 1E+00 | 4E-02 | 1E+02 |
| | W | 2E+03 | 3E-01 | 2E-01 | 4E+02 |
| At-211 | D | 8E+01 | 2E+00 | 3E-02 | 3E+00 |
| | W | 5E+01 | 4E-01 | 1E-01 | 6E+00 |
| Fr-222 | D | 5E+02 | 6E-01 | 8E-02 | 4E+01 |
| Fr-223 | D | 8E+02 | 4E+00 | 1E-02 | 9E+00 |
| Ra-223 | W | 7E-01 | 9E-02 | 6E-01 | 4E-01 |
| Ra-224 | W | 2E+00 | 1E-01 | 4E-01 | 9E-01 |
| Ra-225 | W | 7E-01 | 8E-02 | 6E-01 | 4E-01 |
| Ra-226 | W | 6E-01 | 2E-01 | 2E-01 | 1E-01 |
| Ra-227 | W | 1E+04 | 8E-02 | 6E-01 | 6E+03 |
| Ra-228 | W | 1E+00 | 7E-01 | 7E-02 | 7E-02 |
| Ac-224 | D | 3E+01 | 7E-04 | 7E+01 | 2E+03 |
| | W | 5E+01 | 1E-03 | 4E+01 | 2E+03 |
| | Y | 5E+01 | 1E-03 | 4E+01 | 2E+03 |
| Ac-225 | D | 3E-01 | 5E-05 | 9E+02 | 3E+02 |
| | W | 6E-01 | 1E-04 | 5E+02 | 3E+02 |
| | Y | 6E-01 | 1E-04 | 5E+02 | 3E+02 |
| Ac-226 | D | 3E+00 | 1E-04 | 5E+02 | 2E+03 |
| | W | 5E+00 | 2E-04 | 2E+02 | 1E+03 |
| | Y | 5E+00 | 3E-04 | 2E+02 | 9E+02 |

Table A2. (contd)

| Nuclide | Class | ALI (μCi) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem (μCi) |
|---|---|---|---|---|---|
| Ac-227 | D | 4E-04 | 5E-05 | 1E+03 | 4E-01 |
| | W | 2E-03 | 6E-05 | 8E+02 | 2E+00 |
| | Y | 4E-03 | 5E-05 | 1E+03 | 4E+00 |
| Ac-228 | D | 9E+00 | 7E-04 | 8E+01 | 7E+02 |
| | W | 4E+01 | 2E-03 | 2E+01 | 1E+03 |
| | Y | 4E+01 | 2E-03 | 2E+01 | 9E+02 |
| Th-226 | W | 2E+02 | 1E-01 | 4E-01 | 8E+01 |
| | Y | 1E+02 | 3E-03 | 1E+01 | 1E+03 |
| Th-227 | W | 3E-01 | 6E-02 | 8E-01 | 3E-01 |
| | Y | 3E-01 | 3E-03 | 2E+01 | 5E+00 |
| Th-228 | W | 1E-02 | 5E-02 | 1E+00 | 1E-02 |
| | Y | 2E-02 | 2E-02 | 3E+00 | 6E-02 |
| Th-229 | W | 9E-04 | 9E-03 | 5E+00 | 5E-03 |
| | Y | 2E-03 | 9E-03 | 6E+00 | 1E-02 |
| Th-230 | W | 6E-03 | 9E-03 | 6E+00 | 3E-02 |
| | Y | 2E-02 | 1E-02 | 4E+00 | 8E-02 |
| Th-231 | W | 6E+03 | 7E-02 | 7E-01 | 4E+03 |
| | Y | 6E+03 | 4E-02 | 1E+00 | 8E+03 |
| Th-232 | W | 1E-03 | 3E-03 | 2E+01 | 2E-02 |
| | Y | 3E-03 | 7E-03 | 8E+00 | 2E-02 |
| Th-234 | W | 2E+02 | 8E-02 | 6E-01 | 1E+02 |
| | Y | 2E+02 | 9E-03 | 6E+00 | 1E+03 |
| Pa-227 | W | 1E+02 | 1E-05 | 5E+03 | 5E+05 |
| | Y | 1E+02 | 1E-05 | 4E+03 | 4E+05 |
| Pa-228 | W | 1E+01 | 3E-03 | 2E+01 | 2E+02 |
| | Y | 1E+01 | 3E-03 | 2E+01 | 2E+02 |
| Pa-230 | W | 5E+00 | 3E-03 | 2E+01 | 9E+01 |
| | Y | 4E+00 | 2E-03 | 2E+01 | 9E+01 |
| Pa-231 | W | 2E-03 | 4E-05 | 1E+03 | 3E+00 |
| | Y | 4E-03 | 3E-05 | 2E+03 | 6E+00 |
| Pa-232 | W | 2E+01 | 6E-03 | 9E+00 | 2E+02 |
| | Y | 6E+01 | 2E-02 | 3E+00 | 2E+02 |
| Pa-233 | W | 7E+02 | 1E-01 | 3E-01 | 2E+02 |
| | Y | 6E+02 | 1E-01 | 4E-01 | 2E+02 |
| Pa-234 | W | 8E+03 | 8E-01 | 6E-02 | 5E+02 |
| | Y | 7E+03 | 9E-01 | 6E-02 | 4E+02 |
| U-230 | D | 4E-01 | 1E-01 | 4E-01 | 2E-01 |
| | W | 4E-01 | 3E-02 | 2E+00 | 8E-01 |
| | Y | 3E-01 | 1E-03 | 5E+01 | 2E+01 |
| U-231 | D | 8E+03 | 5E-01 | 1E-01 | 9E+02 |
| | W | 6E+03 | 3E-01 | 2E-01 | 9E+02 |
| | Y | 5E+03 | 3E-01 | 2E-01 | 9E+02 |

Table A2. (contd)

| Nuclide | Class | ALI (μCi) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem (μCi) |
|---|---|---|---|---|---|
| U-232 | D | 2E-01 | 6E-02 | 9E-01 | 2E-01 |
| | W | 4E-01 | 4E-02 | 1E+00 | 5E-01 |
| | Y | 8E-03 | 5E-04 | 1E+02 | 8E-01 |
| U-233 | D | 1E+00 | 9E-02 | 5E-01 | 5E-01 |
| | W | 7E-01 | 2E-02 | 3E+00 | 2E+00 |
| | Y | 4E-02 | 4E-04 | 1E+02 | 5E+00 |
| U-234 | D | 1E+00 | 9E-02 | 5E-01 | 5E-01 |
| | W | 7E-01 | 2E-02 | 3E+00 | 2E+00 |
| | Y | 4E-02 | 4E-04 | 1E+02 | 5E+00 |
| U-235 | D | 1E+00 | 9E-02 | 6E-01 | 6E-01 |
| | W | 8E-01 | 2E-02 | 2E+00 | 2E+00 |
| | Y | 4E-02 | 4E-04 | 1E+02 | 5E+00 |
| U-236 | D | 1E+00 | 9E-02 | 6E-01 | 6E-01 |
| | W | 8E-01 | 2E-02 | 2E+00 | 2E+00 |
| | Y | 4E-02 | 4E-04 | 1E+02 | 5E+00 |
| U-237 | D | 3E+03 | 4E-01 | 1E-01 | 3E+02 |
| | W | 2E+03 | 3E-01 | 2E-01 | 4E+02 |
| | Y | 2E+03 | 3E-01 | 2E-01 | 4E+02 |
| U-238 | D | 1E+00 | 8E-02 | 6E-01 | 6E-01 |
| | W | 8E-01 | 2E-02 | 3E+00 | 2E+00 |
| | Y | 4E-02 | 4E-04 | 1E+02 | 6E+00 |
| U-239 | D | 2E+05 | 4E-01 | 1E-01 | 3E+04 |
| | W | 2E+05 | 2E-01 | 2E-01 | 5E+04 |
| | Y | 2E+05 | 2E-01 | 3E-01 | 7E+04 |
| U-240 | D | 4E+03 | 5E-01 | 1E-01 | 4E+02 |
| | W | 3E+03 | 2E-01 | 3E-01 | 8E+02 |
| | Y | 2E+03 | 1E-01 | 4E-01 | 9E+02 |
| Np-232 | W | 2E+03 | 1E-03 | 5E+01 | 1E+05 |
| Np-233 | W | 3E+06 | 5E-01 | 1E-01 | 3E+05 |
| Np-234 | W | 3E+03 | 2E+00 | 3E-02 | 8E+01 |
| Np-235 | W | 8E+02 | 6E-03 | 8E+00 | 7E+03 |
| Np-236 (1.15E5 y) | W | 2E-02 | 4E-04 | 1E+02 | 3E+00 |
| Np-236 (22.4 h) | W | 3E+01 | 6E-04 | 9E+01 | 3E+03 |
| Np-237 | W | 4E-03 | 1E-04 | 4E+02 | 1E+00 |
| Np-238 | W | 6E+01 | 1E-02 | 4E+00 | 2E+02 |
| Np-239 | W | 2E+03 | 2E-01 | 3E-01 | 5E+02 |
| Np-240 | W | 8E+04 | 4E-01 | 1E-01 | 9E+03 |
| Pu-234 | W | 2E+02 | 3E-02 | 2E+00 | 4E+02 |
| | Y | 2E+02 | 1E-02 | 4E+00 | 8E+02 |
| Pu-235 | W | 3E+06 | 3E-01 | 2E-01 | 5E+05 |
| | Y | 3E+06 | 1E-01 | 4E-01 | 1E+06 |
| Pu-236 | W | 2E-02 | 2E-04 | 3E+02 | 6E+00 |
| | Y | 4E-02 | 1E-04 | 4E+02 | 2E+01 |

Table A2. (contd)

| Nuclide | Class | ALI (μCi) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem (μCi) |
|---|---|---|---|---|---|
| Pu-237 | W | 3E+03 | 2E-01 | 2E-01 | 7E+02 |
| | Y | 3E+03 | 2E-01 | 3E-01 | 9E+02 |
| Pu-238 | W | 7E-03 | 2E-05 | 2E+03 | 1E+01 |
| | Y | 2E-02 | 3E-05 | 2E+03 | 4E+01 |
| Pu-239 | W | 6E-03 | 2E-05 | 2E+03 | 1E+01 |
| | Y | 2E-02 | 3E-05 | 2E+03 | 4E+01 |
| Pu-240 | W | 6E-03 | 2E-05 | 2E+03 | 1E+01 |
| | Y | 2E-02 | 3E-05 | 2E+03 | 4E+01 |
| Pu-241 | W | 3E-01 | 1E-05 | 5E+03 | 1E+03 |
| | Y | 8E-01 | 2E-05 | 3E+03 | 2E+03 |
| Pu-242 | W | 7E-03 | 2E-05 | 2E+03 | 2E+01 |
| | Y | 2E-02 | 3E-05 | 2E+03 | 4E+01 |
| Pu-243 | W | 4E+04 | 1E-01 | 5E-01 | 2E+04 |
| | Y | 4E+04 | 6E-02 | 8E-01 | 3E+04 |
| Pu-244 | W | 7E-03 | 4E-04 | 1E+02 | 9E-01 |
| | Y | 2E-02 | 5E-04 | 1E+02 | 2E+00 |
| Pu-245 | W | 5E+03 | 3E-01 | 2E-01 | 9E+02 |
| | Y | 4E+03 | 2E-01 | 2E-01 | 9E+02 |
| Pu-246 | W | 3E+02 | 2E-01 | 2E-01 | 7E+01 |
| | Y | 3E+02 | 2E-01 | 3E-01 | 8E+01 |
| Am-237 | W | 3E+05 | 6E-01 | 8E-02 | 2E+04 |
| Am-238 | W | 3E+03 | 2E-02 | 3E+00 | 8E+03 |
| Am-239 | W | 1E+04 | 4E-01 | 1E-01 | 1E+03 |
| Am-240 | W | 3E+03 | 1E+00 | 4E-02 | 1E+02 |
| Am-241 | W | 6E-03 | 3E-05 | 2E+03 | 9E+00 |
| Am-242m | W | 6E-03 | 1E-05 | 4E+03 | 2E+01 |
| Am-242 | W | 8E+01 | 1E-03 | 5E+01 | 4E+03 |
| Am-243 | W | 6E-03 | 2E-04 | 3E+02 | 2E+00 |
| Am-244m | W | 4E+03 | 2E-03 | 3E+01 | 1E+05 |
| Am-244 | W | 2E+02 | 2E-02 | 3E+00 | 6E+02 |
| Am-245 | W | 8E+04 | 9E-02 | 6E-01 | 4E+04 |
| Am-246m | W | 2E+05 | 2E-01 | 2E-01 | 4E+04 |
| Am-246 | W | 1E+05 | 2E-01 | 3E-01 | 3E+04 |
| Cm-238 | W | 1E+03 | 8E-02 | 6E-01 | 6E+02 |
| Cm-240 | W | 6E-01 | 2E-03 | 3E+01 | 2E+01 |
| Cm-241 | W | 3E+01 | 2E-02 | 3E+00 | 8E+01 |
| Cm-242 | W | 3E-01 | 1E-03 | 5E+01 | 1E+01 |
| Cm-243 | W | 9E-03 | 1E-04 | 4E+02 | 4E+00 |
| Cm-244 | W | 1E-02 | 4E-05 | 1E+03 | 1E+01 |
| Cm-245 | W | 6E-03 | 8E-05 | 6E+02 | 4E+00 |
| Cm-246 | W | 6E-03 | 4E-05 | 1E+03 | 7E+00 |
| Cm-247 | W | 6E-03 | 2E-04 | 2E+02 | 1E+00 |
| Cm-248 | W | 2E-03 | 3E-03 | 2E+01 | 4E-02 |
| Cm-249 | W | 2E+04 | 1E-02 | 3E+00 | 7E+04 |

Table A2. (contd)

| Nuclide | Class | ALI (μCi) | Dose per ALI (rem) | Fraction ALI for 50 mrem | Activity for 50 mrem (μCi) |
|---|---|---|---|---|---|
| Cm-250 | W | 3E-04 | 3E-03 | 2E+01 | 5E-03 |
| Bk-245 | W | 1E+03 | 2E-01 | 3E-01 | 3E+02 |
| Bk-246 | W | 3E+03 | 1E+00 | 5E-02 | 1E+02 |
| Bk-247 | W | 4E-03 | 6E-05 | 9E+02 | 4E+00 |
| Bk-249 | W | 2E+00 | 2E-04 | 2E+02 | 5E+02 |
| Bk-250 | W | 3E+02 | 6E-03 | 8E+00 | 2E+03 |
| Cf-244 | W | 6E+02 | 5E-02 | 1E+00 | 6E+02 |
| | Y | 6E+02 | 3E-03 | 2E+01 | 1E+04 |
| Cf-246 | W | 9E+00 | 2E-02 | 3E+00 | 2E+01 |
| | Y | 9E+00 | 1E-03 | 4E+01 | 4E+02 |
| Cf-248 | W | 6E-02 | 2E-04 | 2E+02 | 1E+01 |
| | Y | 1E-01 | 5E-05 | 1E+03 | 1E+02 |
| Cf-249 | W | 4E-03 | 2E-04 | 3E+02 | 1E+00 |
| | Y | 1E-02 | 2E-04 | 3E+02 | 3E+00 |
| Cf-250 | W | 9E-03 | 9E-05 | 6E+02 | 5E+00 |
| | Y | 3E-02 | 1E-04 | 4E+02 | 1E+01 |
| Cf-251 | W | 4E-03 | 8E-05 | 6E+02 | 3E+00 |
| | Y | 1E-02 | 8E-05 | 6E+02 | 6E+00 |
| Cf-252 | W | 2E-02 | 2E-03 | 3E+01 | 6E-01 |
| | Y | 3E-02 | 9E-04 | 6E+01 | 2E+00 |
| Cf-253 | W | 2E+00 | 7E-04 | 7E+01 | 1E+02 |
| | Y | 2E+00 | 4E-05 | 1E+03 | 2E+03 |
| Cf-254 | W | 2E-02 | 8E-03 | 6E+00 | 1E-01 |
| | Y | 2E-02 | 5E-03 | 1E+01 | 2E-01 |
| Es-250 | W | 5E+02 | 2E-03 | 2E+01 | 1E+04 |
| Es-251 | W | 9E+02 | 5E-02 | 1E+00 | 1E+03 |
| Es-253 | W | 1E+00 | 3E-03 | 2E+01 | 2E+01 |
| Es-254m | W | 1E+01 | 2E-02 | 3E+00 | 3E+01 |
| Es-254 | W | 7E-02 | 7E-04 | 7E+01 | 5E+00 |
| Fm-252 | W | 1E+01 | 2E-02 | 2E+00 | 2E+01 |
| Fm-253 | W | 1E+01 | 4E-03 | 1E+01 | 1E+02 |
| Fm-254 | W | 9E+01 | 8E-02 | 6E-01 | 6E+01 |
| Fm-255 | W | 2E+01 | 4E-02 | 1E+00 | 2E+01 |
| Fm-257 | W | 2E-01 | 9E-04 | 6E+01 | 1E+01 |
| Md-257 | W | 8E+01 | 1E-02 | 5E+00 | 4E+02 |
| Md-258 | W | 2E-01 | 1E-03 | 5E+01 | 1E+01 |

NRC FORM 335 (2-89) NRCM 1102, 3201, 3202

U.S. NUCLEAR REGULATORY COMMISSION

# BIBLIOGRAPHIC DATA SHEET

(See instructions on the reverse)

1. REPORT NUMBER (Assigned by NRC, Add Vol., Supp., Rev., and Addendum Numbers, if any.)

NUREG/CR-5631
PNL-7745
Rev. 1
Addendum 1

2. TITLE AND SUBTITLE

Contribution of Maternal Radionuclide Burdens to Prenatal Radiation Doses

Relationships Between Annual Limits on Intake and Prenatal Doses

3. DATE REPORT PUBLISHED

MONTH: October YEAR: 1993

4. FIN OR GRANT NUMBER

B2923

5. AUTHOR(S)

M. R. Sikov, T. E. Hui

6. TYPE OF REPORT

Technical

7. PERIOD COVERED (Inclusive Dates)

8. PERFORMING ORGANIZATION — NAME AND ADDRESS (If NRC, provide Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address; if contractor, provide name and mailing address.)

Pacific Northwest Laboratory
Richland, WA 99352

9. SPONSORING ORGANIZATION — NAME AND ADDRESS (If NRC, type "Same as above"; if contractor, provide NRC Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address.)

Division of Regulatory Applications
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

10. SUPPLEMENTARY NOTES

11. ABSTRACT (200 words or less)

This addendum describes approaches for calculating and expressing radiation doses to the embryo/fetus from maternal intakes of radionuclides at levels corresponding to fractions or multiples of the Annual Limits on Intake (ALI). Information concerning metabolic or dosimetric characteristics and the placental transfer of selected, occupationally significant radionuclides was presented in NUREG/CR-5631, Revision 1. That information was used to estimate levels of radioactivity in the embryo/fetus as a function of stage of pregnancy and time after entry. Extension of MIRD methodology to accommodate gestational-stage-dependent characteristics allowed dose calculations for the simplified situation based on introduction of 1 $\mu$Ci into the woman's transfer compartment (blood). The expanded scenarios in this addendum include repeated or chronic ingestion or inhalation intakes by a woman during pregnancy and body burdens at the beginning of pregnancy. Tables present dose equivalent to the embryo/fetus relative to intakes of these radionuclides in various chemical or physical forms and from pre-existing maternal burdens corresponding to ALI; complementary intake values (fraction of an ALI and $\mu$Ci) that yield a dose equivalent of 0.05 rem are included. Similar tables give these measures of dose equivalency to the uterus from intakes of radionuclides for use as surrogates for embryo/fetus dose when biokinetic information is not available.

12. KEY WORDS/DESCRIPTORS (List words or phrases that will assist researchers in locating the report.)

radionuclides intakes by pregnant women
radiation doses to embryo/fetus
placental transfer of radionuclides
prenatal dose calculations
radionuclide metabolism in pregnancy

13. AVAILABILITY STATEMENT

Unlimited

14. SECURITY CLASSIFICATION

(This Page) Unclassified

(This Report) Unclassified

15. NUMBER OF PAGES

16. PRICE

NRC FORM 335 (2-89)

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