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A Directory of Parameters Used in a Series of Assessment Applications of the AIRDOS-EPA and DARTAB Computer Codes

C. F. Baes III
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FOR THE UNITED STATES
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HEALTH AND SAFETY RESEARCH DIVISION
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Health and Safety Research Division

A DIRECTORY OF PARAMETERS USED IN A SERIES OF ASSESSMENT APPLICATIONS OF THE AIRDOS-EPA AND DARTAB COMPUTER CODES

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ABSTRACT

Between January and September 1980, the Health and Safety Research Division (HASRD) of the Oak Ridge National Laboratory (ORNL) performed a series of radiological dose and risk assessments for the U. S. Environmental Protection Agency (EPA) of 79 facilities in the United States which release radionuclides to the atmosphere on a routine basis. The AIRDOS-EPA computer code was used to simulate atmospheric and terrestrial transport and to calculate resulting environmental exposures of individuals and populations to contaminated ground surfaces, air, meat, milk, and vegetables. Doses and risks from these exposures were calculated separately in the computer code DARTAB using dose and risk factors developed through the RADRISK and INREM II computer codes. Because of the importance of these assessments in determining EPA actions concerning these facilities and the possibility of conflict of interest (ORNL was one of the facilities assessed), Teknekron Research, Inc., was given responsibility for providing site-specific information, including facility code name, location, surrounding population, meteorological information, etc. The Oak Ridge National Laboratory was given responsibility for supplying nuclide-specific information and for running the assessment codes. This report describes and lists the nuclide-specific parameters supplied by ORNL, and for reader convenience, some of the site-specific parameters used in running the codes. A report detailing the site-specific parameters used in AIRDOS-EPA and the results of the radiological risk assessments will be available from Teknekron Research, Inc. Thus, the results of these assessments and the impact on surrounding populations and individuals from the facilities is not and cannot be discussed here.

ACKNOWLEDGEMENT

The authors would like to stress that the assessment runs were the product of a group effort. AIRDOS-EPA production runs were carried out by R. D. Sharp, and DARTAB production runs were carried out by S. Y. Ohr. However, many additional tests and refinements of the computer codes AIRDOS-EPA and DARTAB were carried out by R. E. Moore and C. L. Begovich, respectively. The authors would like to cite C. B. Nelson of the EPA for his advice, support, and guidance during the production runs. We would like to recognize C. L. Begovich, S. Y. Ohr, and D. E. Dunning, Jr., for their mammoth efforts in updating and completing the RADRISK data file. We wish to thank M. T. Ryan for providing dose factors which were necessary for running the AIRDOS-EPA code, and S. J. Cotter for calculating ingrowth factors used in AIRDOS-EPA. We also wish to recognize K. F. Eckerman, D. E. Dunning, Jr., and M. T. Ryan for their assistance in reviewing input data, scrutinizing the assessments, and eliminating inconsistencies in the running of the codes. Finally, we extend our thanks to W. C. Minor who typed this report.

NOMENCLATURE OF THE ASSESSMENT RUNS

The site names and locations were not revealed to ORNL staff by Teknekron Research, Inc. Instead, a system of coded facility names was given. Each facility was designated with a name from one of five series, GOLD, NARM, NUFE, LICE, or PART and a number (e.g., "GOLD-09") or a number-letter (e.g., "NARM-90A"). If there was more than one location of nuclide releases for a facility, then each release location was designated by a stack number, S1, S2, or S3. These stack numbers are given in parenthesis following the facility code name (e.g., "GOLD-05 [S3]"). Doses and risks were calculated for each release location, separately; and thus, a facility with more than one release location was assessed an according number of times. Some stack designations actually represent area sources (such as tailings piles).

Each assessment of a nuclide source term was made for the population surrounding the release and for an individual at the location of maximum dose or risk. In referring to a particular assessment run a "P" or "I" designation after the code name indicates a population or individual assessment, respectively. For example, "NARM-33 (S1)P" indicates a facility of the NARM classification or series, coded number 33, and assessment specific for release location "stack 1" for the surrounding population. These facility code names are used in this manner to describe cases listed in Tables 6-44.

DEFINITIONS OF PARAMETERS LISTED IN THIS REPORT

Parameter	Units	Definition
Plant pathway parameters		
BSUBV1 (B_{iv1})	$\frac{Ci/kg(dry)plant}{Ci/kg(dry)soil}$	Soil-to-plant bioaccumulation factor for a given nuclide in pasture forage.
BSUBV2 (B_{iv2})	$\frac{Ci/kg(wet)plant}{Ci/kg(dry)soil}$	Soil-to-plant bioaccumulation factor for a given nuclide in vegetables consumed by man.
LAMW (λ_w)	hr^{-1}	Weathering loss constant for material deposited on plant surfaces.
P	kg/m^2	Surface density of root-zone soil.
R1 (R_1)	--	Interception fraction for pasture forage
R2 (R_2)	--	Interception fraction for vegetables consumed by man.
YSUBV1 (Y_{v1})	kg/m^2	Productivity of pasture grass.
YSUBV2 (Y_{v2})	kg/m^2	Productivity of vegetables consumed by man.
Animal pathway parameters		
FSUBF (F_f)	day/kg	Ingestion-to-meat transfer coefficient for a given nuclide.
FSUBM (F_m)	day/liter	Ingestion-to-milk transfer coefficient for a given nuclide.
FSUBP (f_p)	--	Fraction of the year that cattle are grazing pasture.
FSUBS (f_s)	--	Fraction of cattle's daily diet which is fresh pasture forage when they are grazing pasture.
MSUBB	kg	Muscle mass of a steer.

Parameter	Units	Definition
QSUBF (Q_f)	(dry)kg/day	Quantity of feed or feed-equivalent ingested by a mature cow per day.
TAUBEF	dry^{-1}	Fraction of cattle herd slaughtered per day.
VSUBM	liters/day	Daily milk production of a milk cow.
<u>Time parameters</u>		
TSUBB (t_B)	yr	Period of long-term buildup of all nuclides in the soil (equal to the facility lifetime in this assessment application).
TSUBE1 (t_{e1})	hr	Period of exposure to atmospherically depositing nuclides for pasture forage.
TSUBE2 (t_{e2})	hr	Period of exposure to atmospherically depositing nuclides for vegetables consumed by man.
TSUBF (t_f)	day	Transport time from ingestion of feed by milk cow to ingestion of milk by man.
TSUBH1 (t_{h1})	hr	Time between harvest and consumption of pasture forage by cattle.
TSUBH2 (t_{h2})	hr	Time between harvest and consumption of stored feeds by cattle.
TSUBH3 (t_{h3})	hr	Time between harvest and consumption of vegetables by the general population.
TSUBH4 (t_{h4})	hr	Time between harvest and consumption of vegetables by the maximum individual.
TSUBS (t_s)	day	Time between slaughter of steer and consumption of meat.

Parameter	Units	Definition
Intake parameters		
BRTHRT (B_r)	cm^3/hr	Breathing rate of man.
UF (U_{ap}^F)	kg/yr	Consumption rate of beef by man.
UL (U_{ap}^L)	kg/yr	Consumption rate of leafy vegetables by man.
UM (U_{ap}^M)	liter/yr	Consumption rate of milk by man.
UV (U_{ap}^V)	kg/yr	Consumption rate of non-leafy vegetables by man.
Site characteristic parameters		
DD1	--	Fraction of nuclide remaining on food after washing and preparation.
DILFAC (d)	cm	Depth of water used in estimation of swimming doses.
F3BEFM	--	Minimum fraction of ingested meat imported from outside of the assessment area.
F3MLKM	--	Minimum fraction of ingested milk imported from outside of the assessment area.
F3VEGM	--	Minimum fraction of ingested vegetables imported from outside of the assessment area.
FSUBG (f_g)	--	Fraction of ingested produce grown in assessment area.
FSUBL (f_l)	--	Fraction of ingested leafy vegetables grown in assessment area.
RBEF	--	Fraction equal to the quantity of ingested beef produced at an environmental location divided by the total produced within the assessment area.

Parameter	Units	Definition
RMLK	--	Fraction equal to the quantity of ingested milk produced at an environmental location divided by the total produced within the assessment area.
RVEG	--	Fraction equal to the quantity of ingested vegetable produced at an environmental location divided by the total produced within the assessment area.
USEFAC	--	Fraction of time spent swimming.

1. INTRODUCTION

Under Task I of contract EPA-78-D-X0394, the Health and Safety Research Division prepared the AIRDOS-EPA (Moore et al., 1979) and DARTAB (Begovich et al., in press) computer codes to provide the Environmental Protection Agency (EPA) with an integrated set of codes and data bases to simulate atmospheric and terrestrial transport of radionuclides routinely released to the atmosphere and to calculate resulting health impacts to man consequent from these releases. The AIRDOS-EPA computer code employs a Gaussian plume model and an implementation of the U. S. Nuclear Regulatory Commission (NRC) Regulatory Guide 1.109 terrestrial transport models to calculate dispersion of radionuclide pollutants from point or area source releases through the surrounding atmospheric and terrestrial environment. The code uses meteorological and agricultural information to calculate concentrations in air, water, surface soil, meat, milk, and vegetables at several downwind receptor sites from the release point. Exposures to individuals and populations from immersion in air and water; standing on the ground surface; ingestion of meat, milk, and vegetables; and inhalation of air are calculated from the environmental concentrations using various parameters and scenarios pertaining to human activities and intake rates. The code also calculates doses to 11 target organs from the various exposure pathways via user input of appropriate internal and external dose conversion factors. It is necessary to input these dose conversion factors in order to run the AIRDOS-EPA code; however, the doses calculated in AIRDOS-EPA were not incorporated into the assessment done for EPA.

Instead, doses and resulting health risks were calculated separately in the DARTAB computer code from the external exposures and intake rates output by AIRDOS-EPA. This procedure was adopted because the health effects data used by EPA are based on considerations of the age distribution of the cohort population and the dose factors used in AIRDOS-EPA are not. The computer code DARTAB reads a dosimetric data file, compiled through numerous runs of the RADRISK computer code

(Dunning, Leggett, and Yalcintas, 1980), and combines the dose and risk factors for a particular nuclide with exposure and intake rate estimates from AIRDOS-EPA. DARTAB tabulates doses and health risks by cancer, exposure pathway, or nuclide. It is beyond the scope of this document to detail the RADRISK methodology in generating the dosimetric data file. Briefly, however, RADRISK combines nuclide decay data (Kocher, 1979), internal exposure dosimetric data (Killough et al., 1978a; Dunning et al., 1979) generated through the INREM II computer code (Killough, Dunning, and Pleasant, 1978b), and health effects estimates supplied by EPA.

This report is intended as a complete documentation of Oak Ridge National Laboratory (ORNL) participation in the radiological dose and risk assessments by providing a comprehensive key to all nuclide-specific input parameters used by ORNL staff in running AIRDOS-EPA. Additionally, for reader convenience in understanding the nuclide-specific input data some of the site-specific input parameters supplied by Teknekron Research are also included. However, Teknekron Research retains responsibility for documentation of all site-specific input parameters, including meteorological parameters, input to AIRDOS-EPA and final documentation of the results of the DARTAB runs. The EPA currently has a listing of the dosimetric and health risk data generated through the RADRISK code. The RADRISK data file, this report, and Teknekron Research's documentation—all serve as a computer documentation of the assessment methodology.

A brief description of the nuclide-specific input parameters to AIRDOS-EPA is given for reader convenience in interpretation of their use in the code. An effort has been made to clarify the procedures used to generate input parameters from literature reviews. Also, some parameters listed in this report, but not discussed in the documentation of AIRDOS-EPA, are briefly discussed. However, this report should not be interpreted as a supplement or update of the AIRDOS-EPA documentation. Likewise, it is beyond the scope of this report to detail the methodology of AIRDOS-EPA, DARTAB, or RADRISK. The reader is referred to the documentation of the computer codes AIRDOS-EPA (Moore et al., 1979), DARTAB (Begovich et al., in press), and RADRISK (Dunning, Leggett, and Yalcintas, 1980) for further details of these assessment codes.

The parameter values given in this document should not be interpreted as being recommended by either ORNL, Teknekron Research, Inc., or EPA for use in generic or site-specific radionuclide assessments. They are merely values agreed upon by the three organizations as acceptable for the intended intercomparison between the facilities assessed. The inherent uncertainty in their "correctness" or their "appropriateness" as used in the models is the subject of much discussion and study. Many of the terrestrial transport parameters are recommended by the NRC in their Regulatory Guide 1.109. Others were used in sample runs of the AIRDOS-II (Moore, 1977) and AIRDOS-EPA computer codes. Some may be traced back to the computer code TERMOD (Booth et al., 1971), while others were based on recent analyses of the statistical distributions of terrestrial transport model input parameters (Hoffman and Baes, 1979). Current work at ORNL concerns analysis of many of these parameters and the variation with location of many agricultural parameters. Thus, the incorporation of the parameter values into the models which make up the computer codes represents a photograph in time of our understanding of them and their use in assessment models.

2. PARAMETERS COMMON FOR ALL AIRDOS-EPA RUNS

In this assessment application of the AIRDOS-EPA and DARTAB computer codes, all parameters pertaining to transport of nuclides through the environment and their impact on man were constant over all computer runs. Such parameters include B_{iv}, F_m, F_f, dose factors, and risk factors. Additionally, many parameters pertaining to agricultural practices including productivity and time constants were also constant over all computer runs. The following discussion pertains to these parameters. The reader is referred to the documentation of AIRDOS-EPA (Moore et al., 1979) and DARTAB (Begovich et al., in press) for discussion of how the parameters were determined and their use in the codes.

2.1 Terrestrial Transport Parameters

The soil-plant bioaccumulation factors B_{iv1} for pasture grass and B_{iv2} for vegetables consumed by man were derived from available literature references. The factors used are a product of the references available at the time the computer codes were run and the progress of the ongoing review of these literature values. Therefore, the values presented (Tables 1 and 2) are neither the most recent values, nor are they recommended by ORNL for use in AIRDOS-EPA. The values incorporated into assessments using AIRDOS-EPA should be chosen within the framework, aims, and the limitations of the assessment application.

The procedure for deriving the parameters B_{iv1} and B_{iv2} is that of Moore et al. (1979). However, a brief description is given here. Whenever available, original literature sources describing experimental results were used, and bioaccumulation factors are element-specific. If the reported experiment was judged to be appropriate to the parameter as used in the model and all necessary corrollary information was given, the plant species reported in the reference were divided into "animal feeds" and "direct consumption by man" categories, corresponding to B_{iv1} and B_{iv2}, respectively. Thus, a literature reference could be used for B_{iv1} or B_{iv2} or both. Conversely, B_{iv1} and B_{iv2} for an element might consist of two sets of references which could be equal, intersect, or be disjoint.

B_{iv1} values were calculated from dry plant/dry soil concentration ratios. B_{iv2} values were calculated from fresh weight plant/dry soil concentration ratios. The arithmetic mean of all reported values in a literature source was used as a value for that source. The element-specific B_{iv}'s used in AIRDOS-EPA are an arithmetic mean of the source values, rounded to two significant digits. Since nearly all experimental results for plant concentrations are reported in dry weight, appropriate conversion factors were used to obtain fresh weight concentrations. In studies where specific species and specific plant parts were reported, appropriate wet-to-dry weight conversion factors were taken from Morrison (1956) and Spector (1956). When reviews were the only available reference for a particular element, a generic assumption of

25% dry matter was assumed. In most cases, $B_{iv2} \leqq B_{iv1}$ was observed. This is logical because the concentration of a finite quantity of material decreases as the weight of the plant increases. However, if two disjoint sets of references were used, $B_{iv2} \geqq B_{iv1}$ could occur. Future work at ORNL will be directed toward improving the method and logic of determining soil-plant bioaccumulation factors and eliminating procedures which may result in inconsistencies of logic.

B_{iv2} for radium was based on an abstract of the Mordberg et al. (1976) paper. Unfortunately, the abstract contained an error, reporting the values 10^3 greater than actually reported in the original. Consideration of this error in the estimate of B_{iv2}, based on the Moore et al. (1979) methodology, gives a revised B_{iv2} value of 2.0×10^{-2}. This revised estimate of B_{iv2} is a factor of approximately 4 less than actually used in the assessment runs. Caution should be exercised when interpretation of doses and risks from Radium in vegetables consumed by man are made. However, careful evaluation of all doses and risks must be made in the light of our present knowledge of default parameters and the methods used to determine them.

The ingestion-to-milk transfer factors (Table 3) were taken largely from Ng et al. (1977). A reevaluation of values included in Moore et al. (1979) necessitated a revision of the values for lead and uranium. An additional reference for strontium was included in the evaluation of F_m for that element. Inadvertantly, an older reference (Ng et al., 1968) was used for the thallium F_m, although a more recent reference was available (Ng et al., 1977). This more recent value is more than an order of magnitude higher than the older value and may necessitate a reevaluation of thallium milk ingestion doses and risks where they are significant.

The beef-transfer coefficients for elements not included in Moore et al. (1979) (Table 4) were largely taken from Ng et al. (1968) with the assumption that the average cow ingests 50 kg of fresh feed or pasture equivalent a day (equal to a Q_F of 12.5 kg/day assuming 25% dry matter). The value of F_f was determined from information given by Ng et al. (1968),

$$F_f = C_M \text{ (Table 10B)}/[C_p \text{ (Table 10A)} \cdot 50] \; , \qquad (1)$$

where

C_M = concentration of an element per kg of meat,

C_p = concentration of the same element per kg of plant, and Tables 10A and 10B are from Ng et al. (1968).

When original literature references were used for F_f values, the procedures outlined by Moore et al. (1979) were used.

2.2 Other Parameters

In order to facilitate an unbiased comparison among facilities with respect to site-specific variations, many parameters concerning agricultural management practices, human intake rates, and time constants were constant for all runs. Many of these parameters (Table 5) were taken from Moore et al. (1979) and the U.S. NRC Regulatory Guide 1.109. For a detailed explanation of these parameters, including the interception fraction for pasture grass, R_1, interception fraction for fresh vegetables, R_2, pasture productivity, Y_{v1}, and fresh vegetable productivity, Y_{v2}, the reader is referred to Moore et al., 1979.

Some parameters, not discussed in Moore et al., 1979, were derived from the TERMOD computer code and later adopted into the AIRDOS-II computer code. These parameters, namely the input variables, MSUBB, TAUBEF, and VSUBM concern beef and milk production. Because these factors are not discussed in the documentation of AIRDOS-EPA, they are briefly discussed below.

The parameters MSUBB, which is the muscle mass of a steer, and TAUBEF, the fraction of the herd slaughtered per day, are used in the following equation to estimate beef production,

$$\text{Beef (kg/yr)} = \text{number of beef cattle} \cdot \text{TAUBEF} \cdot 365 \cdot \text{MSUBB} \qquad (2)$$

The value for TAUBEF chosen for the assessment runs was taken directly from the TERMOD computer code. The implication of this value (3.80 E-03) is that the standing herd represents less (72%) than the actual number of cattle slaughtered each year. That is, a feedlot type of operation is assumed with cattle being added and removed from the herd over a short time period. If a user of AIRDOS-EPA wishes the standing herd to be the actual number of beef cattle slaughtered, then TAUBEF should be set equal to 2.74 E-03. The input variable MSUBB was also taken from the TERMOD computer code and is equal to the weight of beef supplied from each slaughtered steer. The number of beef cattle is an input parameter supplied by Teknekron Research, Inc.

The input variable VSUBM is multiplied by the number of milk cows to determine the quantity of milk in liters supplied by the milk cow herd each day. This parameter was also adopted into the AIRDOS-II computer code. The number of milk cows is supplied by Teknekron Research, Inc. The inherent assumption here is that the grazing herd is the total population giving milk each year.

3. PARAMETERS SPECIFIC FOR EACH AIRDOS-EPA RUN

Many parameters specific for a given site or facility were used in this assessment application of the AIRDOS-EPA and DARTAB codes. Collectively, these site-specific parameters were the responsibility of Teknekron Research. These parameters, including source term, buildup time, local meteorology, and surrounding human and cattle populations are not discussed in this section (although some of them are listed for reader convenience). However, the composition of the source term and period of long-term buildup in soil of all nuclides was used to determine the value and number of ingrowth factors input by ORNL staff. Therefore, a discussion of ORNL methodology in determining these ingrowth factors is given below.

3.1 Ingrowth Factors

The AIRDOS-EPA computer code does not model parent decay and ingrowth of daughters explicitly, but will simulate daughter ingrowth at a given time subsequent to a release of the parent with the input of ingrowth factors (F1-F5) and the addition of the daughter products to the original source term. The ingrowth factor for a particular daughter is the ratio of the ingrowth rate of the daughter via decay to the deposition rate of the parent at a given time after the parent is released. If the daughter product is the parent of a second daughter, then a second ingrowth factor for the second daughter must be added corresponding to decay from the first daughter. Thus, incorporation of decay chains in AIRDOS-EPA is limited to chains of five. In most assessments this limitation is acceptable as long as the five most important (in terms of contribution to doses and risks) daughters are used. The computer code HARAD (Moore, 1980) was written to calculate the ingrowth factors used in AIRDOS-EPA.

Upon submission of source term data by Teknekron Research, the nuclide lists were scrutinized by ORNL staff. If daughter products, which could significantly contribute to doses and risks over the period of long-term buildup in soil following release (t_b) were not included in the original nuclide list, they were added by ORNL staff. The criteria for adding daughters depended on release rates of the parents, period of long-term buildup, and the other nuclides in the source term. Therefore, each assessment case was treated individually. Generally, the daughters Ba-137m from decay of Cs-137, Rh-106 from decay of Ru-106, and Pr-144 from decay of Ce-144 (Table 6) were always added to the original source term. Also, various important daughters for the U-238 (Table 7), U-235 (Table 8), and Th-232 (Table 9) decay series chains were also added when deemed necessary.

Essentially two protocols were used in adding daughter products to the source term supplied by Teknekron Research. If the parent and its daughters (already in the source term) had equal release rates, then it was assumed by ORNL staff that the chain was in equilibrium, and new daughters added by ORNL staff were added with a release rate equal to that of the parent. In these cases, ingrowth factors were not used. If the parent had daughters in the source term with different release rates, then equilibrium was not assumed and new daughters were added with zero release rates and ingrowth factors pointing back to the nearest long-lived parent in the source term. Some cases did not conveniently fit into the above two categories. For example, in a situation where both parent and daughter were in the original source term supplied to ORNL, but ORNL staff felt that daughter ingrowth would significantly add to the daughter already released, an ingrowth factor pointing back to the parent was added. The above procedure was instituted when the ingrowing daughter became a significant fraction (>10%) of the released daughter over the period of long-term buildup in the soil.

3.2 Site Characteristics

Source terms, local meteorology, and other site-specific parameters (Table 10) were the responsibility of Teknekron Research, Inc. However, the number nuclides released, the period of long-term buildup, the type of release (point or area source), the fraction of the year cattle are on pasture (f_p), the population, and the number of beef and milk cattle are given in this directory for reader convenience and to assist in interpretation of the assessment strategy. For a description of their use in AIRDOS-EPA the reader is referred to Moore et al. (1979).

3.3 Nuclide Data

The nuclide data (Tables 11-44) were supplied by ORNL staff. The parameters include ingrowth factors, clearance class, and gastrointestinal (GI) absorption fraction for ingestion. The GI absorption fractions used as input to AIRDOS-EPA were not necessarily the GI absorption fractions contained in the RADRISK data file used with DARTAB. Therefore, the GI adsorption fractions used in the DARTAB runs are included with the GI adsorption fractions used in AIRDOS-EPA in Tables 11 through 44. For interpretation of their use in AIRDOS-EPA, the reader is referred to Moore et al. (1979).

4. CONSIDERATIONS FOR THE DARTAB RUNS

It is beyond the scope of this document to describe the methodology of calculation of doses and risks via the DARTAB code and nuclide-specific dose and risk factors generated through the INREM II and RADRISK computer codes. The reader is referred to the DARTAB documentation (Begovich et al., in press) and the RADRISK documentation (Dunning et al., 1980) for details of the methodology. However, of user interest is the version of the RADRISK data file used in the runs (Table 45). The additions, deletions, and corrections given in Table 45 are cumulative. That is, the second version of the file contains all changes made in the first version, the third version all changes made in the first and second, etc.

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Table 1. Soil-plant bioaccumulation factors, B_{iv1} and B_{iv2}

Element	B_{iv1}	B_{iv2}	Reference[a]	Element	B_{iv1}	B_{iv2}	Reference[a]
Be	1.7E-03	4.2E-04	a	I	2.0E-01	5.5E-02	g
Na	2.1E-01	5.2E-02	b	Cs	1.4E-01	9.1E-03	h
P	4.4E00	1.1E00	b	Ba	6.1E-02	2.0E-01	i
S	2.4E00	5.9E-01	a	La	4.2E-03	1.1E-03	c
Cr	2.4E-02	6.0E-03	c	Ce	2.9E-02	2.2E-03	j
Mn	3.9E-02	9.8E-03	c	Pr	1.0E-02	2.5E-03	b
Fe	9.3E-03	2.3E-03	c	Pm	1.0E-02	2.5E-03	a
Co	3.7E-02	9.3E-03	c	Eu	1.0E-02	2.5E-03	a
Zn	3.9E-01	9.8E-02	c	Tb	1.0E-02	2.6E-03	a
Ga	1.0E-03	2.5E-04	a	Ir	5.2E01	1.3E01	a
As	3.9E-03	1.7E-02	d	Hg	1.5E00	3.8E-01	a
Rb	2.5E-01	6.3E-02	c	Tl	1.0E00	2.5E-01	a
Sr	2.4E00	2.2E-01	e	Pb	1.4E-01	4.8E-03	k
Y	1.1E-02	4.3E-03	f	Bi	6.0E-01	1.5E-01	a
Zr	6.8E-04	1.7E-04	b	Po	4.2E-03	2.6E-04	g
Nb	3.8E-02	9.4E-03	b	Ra	1.0E-01	7.2E-02	l
Mo	3.4E00	2.2E-01	d	Ac	1.0E-02	2.5E-03	a
Tc	2.2E02	1.1E00	g	Th	6.3E-03	3.5E-04	m
Ru	1.7E-01	1.6E-02	f	Pa	1.0E-02	2.5E-03	a
Ag	6.0E-01	1.5E-01	b	U	2.1E-02	4.2E-03	n
Sn	2.0E-02	5.0E-03	c	Pu	6.7E-03	1.1E-03	o
Sb	1.1E-01	2.8E-02	c	Am	9.8E-03	1.5E-03	p
Te	5.2E00	1.3E00	b	Cm	1.3E-03	1.7E-03	q

[a] References for Table 1 are given in Table 2.

Table 2. References for soil-plant bioaccumulation factors

Code	References
a	Ng et al., 1968: Cp (Table 10A)/Cs (Table 4)[a]
b	US NRC Reg. Guide 1.109 (Table E-1)[a]
c	Furr et al., 1978[b]
d	B_{iv1}: Furr et al., 1978
	B_{iv2}: Furr et al., 1977 (Spector, 1956)[c]
e	B_{iv1}: References listed in Moore et al., 1979. Additionally, Milbourn et al., 1959; Morgan, 1959; Vose and Koontz, 1959; Furr et al., 1978; Rediske et al., 1955; Andersen, 1971
	B_{iv2}: References listed in Moore et al., 1979; Milbourn et al., 1959 (Spector, 1956); Furr et al., 1978 (Spector, 1956); Ralls et al., 1967; Andersen, 1965
f	B_{iv1}: Romney et al., 1957; Rediske et al., 1955
	B_{iv2}: Romney et al., 1957 (Spector, 1956)
g	Moore et al., 1979
h	B_{iv1}: References listed in Moore et al., 1979. Additionally, Furr et al., 1978
	B_{iv2}: References listed in Moore et al., 1979. Additionally, Fedorov and Romanov, 1969 (Spector, 1956)
i	B_{iv1}: Furr et al., 1978
	B_{iv2}: Rediske et al., 1955 (Spector, 1956)
j	B_{iv1}: Romney et al., 1957; Rediske et al., 1955; Furr et al., 1978
	B_{iv2}: Cummings and Bankert, 1971 (Spector, 1956); Romney et al., 1957 (Spector, 1956); Essington et al., 1963 (Spector, 1956)
k	B_{iv1}: Cox and Rains, 1972; Zimdahl et al., 1978; Rabinowitz, 1972; Dedolph et al., 1970
	B_{iv2}: Ter Haar, 1970 (Spector, 1956); John and Van Laerhoven, 1972 (Spector, 1956); Rabinowitz, 1972 (Spector, 1956); Dedolph et al., 1970 (Spector, 1956)
l	B_{iv1}: Whitehead and Brooks, 1971; Kirchmann et al., 1968; Taskayev et al., 1977; DeBortoli and Gaglione, 1972

Table 2. (continued)

Code		References
	B_{iv2}:	Vavilov et al., 1964 (Spector, 1956); Mordberg et al., 1976 (Morrison, 1956; Spector, 1956); Kirchmann et al., 1968 (Spector, 1956); DeBortoli and Gaglione, 1972 (Spector, 1956)
m	B_{iv1}:	Bondietti et al., 1978; Furr et al., 1978
	B_{iv2}:	Bondietti et al., in preparation (Spector, 1956)
n	B_{iv1}:	Furr et al., 1978; Prister, 1970; Bondietti et al., 1978; Adams et al., 1975
	B_{iv2}:	Prister, 1970 (Morrison, 1956, Spector, 1956) Bondietti and Sweeton, 1976 (Spector, 1956); Adams et al., 1975
o	B_{iv1}:	Romney et al., 1970; Price, 1972; Rediske et al., 1955; Au et al., 1977; Cline, 1968; Brown and McFarlane, 1978; Hardy et al., 1977; Adams et al., 1975
	B_{iv2}:	Dahlman and McLeod, 1977 (Spector, 1956) Schulz et al., 1975 (Spector, 1956); Au et al., 1977 (Spector, 1956); Brown and McFarlane, 1978 (Spector, 1956); Hardy et al., 1977 (Spector, 1956); Adams et al., 1975 (Spector, 1956)
p	B_{iv1}:	Price, 1972; Bondietti et al., 1978; Au et al., 1977; Wallace et al., 1979
	B_{iv2}:	Bondietti et al., 1978 (25% dry matter assumed); Cline, 1968 (Spector, 1956); Schulz et al., 1975 (Spector, 1956); Au et al., 1977 (Spector, 1956)
q	B_{iv1}:	Price, 1972
	B_{iv2}:	Ng et al., 1978 (Spector, 1956)

[a] The value given in the reference is in fresh weight and, therefore corresponds to B_{iv2}. B_{iv1} is derived by multiplying B_{iv2} by a factor of 4, based on an assumption of 25% dry matter. Tables 10A and 4 are from Ng et al., 1968.

[b] The value given in the reference is in dry weight and, therefore, corresponds to B_{iv1}, $B_{iv2} = 0.25\ B_{iv1}$. Table E-1 is from Reg. Guide 1.109.

[c] References in parentheses indicate source of appropriate dry-to-fresh weight conversion factors for preceding reference.

Table 3. Ingestion-to-milk transfer factors, F_m

Element	F_m	Reference	Element	F_m	Reference
Be	9.1E-07	Ng et al., 1977	I	9.9E-03	Ng et al., 1977
Na	3.5E-02	Ng et al., 1977	Cs	5.6E-03	Moore et al., 1979
P	1.6E-02	Ng et al., 1977	Ba	3.5E-04	Ng et al., 1977
S	1.6E-02	Ng et al., 1977	La	2.0E-05	Ng et al., 1977
Cr	2.0E-03	Ng et al., 1977	Ce	2.0E-05	Ng et al., 1977
Mn	8.4E-05	Ng et al., 1977	Pr	2.0E-05	Ng et al., 1977
Fe	5.9E-05	Ng et al., 1977	Pm	2.0E-05	Ng et al., 1977
Co	2.0E-03	Ng et al., 1977	Eu	2.0E-05	Ng et al., 1977
Za	1.0E-02	Ng et al., 1977	Tb	2.0E-05	Ng et al., 1977
Ga	5.0E-05	Ng et al., 1977	Ir	2.0E-06	Ng et al., 1977
As	6.2E-05	Ng et al., 1977	Hg	9.7E-06	Ng et al., 1977
Rb	1.2E-02	Ng et al., 1977	Tl	2.2E-02	Ng et al., 1968
Sr	1.1E-03	Moore et al., 1979; Squire et al., 1958	Pb	8.7E-05	Moore et al., 1979 (estimate revised)
Y	2.0E-05	Ng et al., 1977	Bi	5.0E-04	Ng et al., 1977
Zr	8.0E-02	Ng et al., 1977	Po	1.2E-04	Moore et al., 1979
Nb	2.0E-02	Ng et al., 1977	Ra	5.9E-04	Moore et al., 1979
Mo	1.4E-03	Ng et al., 1977	Ac	2.0E-05	Ng et al., 1977
Tc	9.9E-03	Ng et al., 1977	Th	5.0E-06	Ng et al., 1977
Ru	6.1E-07	Ng et al., 1977	Pa	5.0E-06	Ng et al., 1977
Ag	3.0E-02	Ng et al., 1977	U	1.4E-04 (estimate	Moore et al., 1979 revised)
Sn	1.2E-03	Ng et al., 1977	Pu	5.3E-08	Sansom, 1964
Sb	2.0E-05	Ng et al., 1977	Am	3.6E-05	Sutton et al., 1978
Te	2.0E-04	Ng et al., 1977	Cm	2.0E-05	Ng et al., 1977

Table 4. Ingestion-to-meat transfer coefficients for beef, F_f

Element	F_f	Reference	Element	F_f	Reference
Be	1.0E-03	Ng et al., 1968	I	7.0E-03	Moore et al., 1979
Na	3.0E-02	Ng et al., 1968	Cs	1.4E-02	Moore et al., 1979
P	4.6E-02	U.S. NRC Reg. Guide 1.109	Ba	3.2E-03	U.S. NRC Reg. Guide 1.109
S	1.0E-01	Ng et al., 1968	La	2.0E-04	U.S. NRC Reg. Guide 1.109
Cr	2.4E-03	U.S. NRC Reg. Guide 1.109	Ce	1.2E-03	U.S. NRC Reg. Guide 1.109
Mn	8.0E-04	U.S. NRC Reg. Guide 1.109	Pr	4.7E-03	U.S. NRC Reg. Guide 1.109
Fe	4.0E-02	U.S. NRC Reg. Guide 1.109	Pm	4.8E-03	Ng et al., 1968
Co	1.3E-02	U.S. NRC Reg. Guide 1.109	Eu	4.8E-03	Ng et al., 1968
Zn	3.0E-02	U.S. NRC Reg. Guide 1.109	Tb	4.4E-03	Ng et al., 1968
Ga	1.4E00	Ng et al., 1968	Ir	1.5E-03	Ng et al., 1968
As	2.0E-03	Ng et al., 1968	Hg	2.6E-01	Ng et al., 1968
Rb	3.1E-02	U.S. NRC Reg. Guide 1.109	Tl	4.0E-02	Ng et al., 1968
Sr	3.0E-04	Moore et al., 1979	Pb	9.1E-04	Moore et al., 1979
Y	4.6E-03	U.S. NRC Reg. Guide 1.109	Bi	1.3E-02	Ng et al., 1968
Zr	3.4E-02	U.S. NRC Reg. Guide 1.109	Po	8.7E-03	Moore et al., 1979 (revised estimate)
Nb	2.8E-01	U.S. NRC Reg. Guide 1.109	Ra	3.0E-03	Moore et al., 1979
Mo	8.0E-03	U.S. NRC Reg. Guide 1.109	Ac	1.6E-06	Moore et al., 1979
Tc	8.7E-03	Moore et al., 1979	Th	1.6E-06	Moore et al., 1979
Ru	1.8E-03	Ng et al., 1978	Pa	1.6E-06	Moore et al., 1979
Ag	1.7E-02	Ng et al., 1968	U	1.6E-06	Moore et al., 1979
Sn	8.0E-02	Ng et al., 1968	Pu	1.9E-08	Garten, 1978
Sb	4.0E-03	Ng et al., 1968	Am	1.6E-06	Ng et al., 1978
Te	7.7E-02	Ng et al., 1968	Cm	1.6E-06	Ng et al., 1978

Table 5. Parameters used in all cases

Parameter		Value	Units	Reference
<u>Plant-pathway parameters</u>				
LAMW	(λ_w)	2.10E-03	hr^{-1}	Table 14; Moore et al., 1979
P		2.15E02	kg/m^2	Table 14; Moore et al., 1979
R1	(R_1)	6.30E-01		Supplied by Teknekron Research
R2	(R_2)	2.00E-01		U.S. NRC Reg. Guide 1.109
YSUBV1	(Y_{v1})	2.80E-01	kg/m^2	Table 8; Moore et al., 1979
YSUBV2	(Y_{v2})	1.90E00	kg/m^2	Table 8; Moore et al., 1979
<u>Animal-pathway parameters</u>				
FSUBS	(f_s)	4.30E-01		Table 14; Moore et al., 1979
MSUBB		2.00E02	kg	Appendix, Booth et al., 1971
QSUBF	(Q_F)	1.56E01	kg/day	Table 14; Moore et al., 1979
TAUBEF		3.8E-03	day^{-1}	Appendix, Booth et al., 1971
VSUBM		1.10E01	liters/day	Appendix B, Moore, 1977
<u>Time parameters</u>				
TSUBE1	(t_{e1})	7.20E02	hr	Table 14; Moore et al., 1979
TSUBE2	(t_{e2})	1.44E03	hr	Table 14; Moore et al., 1979
TSUBF	(t_f)	4.00E00	day	Table 14; Moore et al., 1979
TSUBH1	(t_{h1})	0	hr	Table 14; Moore et al., 1979
TSUBH2	(t_{h2})	2.16E03	hr	Table 14; Moore et al., 1979
TSUBH3	(t_{h3})	3.36E02	hr	Table 14; Moore et al., 1979
TSUBH4	(t_{h4})	3.36E02	hr	Table 14; Moore et al., 1979
TSUBS	(t_s)	2.00E01	day	Table 14; Moore et al., 1979

Table 5. (continued)

Parameter		Value	Units	Reference
Intake parameters				
BRTHRT	(B_r)	8.30E05	cm^3/hr	Supplied by Teknekron Research
UF	($U_{ap}{}^F$)	9.40E01	kg/yr	Table 15; Moore et al., 1979
UL	($U_{ap}{}^L$)	1.80E01	kg/yr	Table 15; Moore et al., 1979
UM	($U_{ap}{}^M$)	1.12E02	liter/yr	Table 15; Moore et al., 1979
UV	($U_{ap}{}^V$)	1.76E02	kg/yr	Table 15; Moore et al., 1979
Site characteristic parameters				
DD1		1.00E00		d[a]
DILFAC	(d)	1.50E02	cm	Supplied by Teknekron Research
F3BEFM		0		d
F3MLKM		0		d
F3VEGM		0		d
FSUBG	(f_g)	1.00E00		d
FSUBL	(f_l)	1.00E00		d
RBEF		0		d
RMLK		0		d
RVEG		0		d
USEFAC		1.00E-02		Appendix B, Moore, 1977

[a]d = default value designed to give a conservative estimate.

Table 6. Ingrowth factors for short-series decay chains

Daughter	Ingrowth factor, 100 years
Cs-137 parent	
Ba-137m	5.59E06
Used in cases:	GOLD 09 I & P
Ru-106 parent	
Rh-106	1.06E06
Used in cases:	GOLD 25 I & P
Ce-144 parent	
Pr-144	2.37E04
Used in cases:	GOLD 25 I & P

Table 7. Ingrowth factors for U-238 decay series nuclides

Daughters of U-238	Ingrowth factors					
	100 years		30 years		20 years	15 years
U-238 parent						
Th-234		1.05E03	3.14E02			
Pa-234m		3.11E07	9.32E06			
Used in cases:		a	b			
U-234 parent						
Th-230		4.50E-04			9.00E-05	
Used in cases:		c			d	
Th-230 parent						
Ra-226		2.18E-02			3.25E-03	
Used in cases:		c,e			d,f	
Ra-226 parent						
Pb-210		2.21E00	5.34E-01			2.50E-01
Po-210	1.24E02	1.24E02	1.85E01	1.85E01		5.11E00
Used in cases:	g	h	i	j		k
Pb-210 parent						
Po-210		5.62E01	3.53E01			2.13E01
Used in cases:		g,h	i,j			k

Cases:
a = GOLD 12, 13, 15, 17, 18, 20, 21, 22, 23, 83 I & P.
b = GOLD 04 I & P.
c = NUFE 13 (S1, S2) P.
d = NUFE 13 (S1, S2) I.
e = NARM 32 (S1), 33 (S1) P.
f = NARM 32 (S1), 33 (S1) I.
g = NARM 80B P.
h = NARM 33 (S1), 90A, 90B, 100A, 100B P.
i = NARM 90A, 90B, 100A, 100B I.
j = NARM 80B I.
k = NARM 33 (S1) I.

Table 8. Ingrowth factors for U-235 decay series nuclides

Daughters of U-235	Ingrowth factor		
	10 years	30 years	
Th-231	2.38E04	7.14E03	7.14E03
Pa-231	1.07E-01	3.20E-04	3.20E-04
Ac-227	1.99E-03	1.27-04	1.27E-04
Th-227			3.24E-02
Ra-223			5.28E-02
Used in cases:	a	b	c

Cases: a = GOLD 03, 13, 15, 16, 17, 20, 21, 23, 83, 101 I & P.

b = NUFE 21, 22, 40A, 40B I & P.

c = NUFE 30 I & P.

Table 9. Ingrowth factors for Th-232 decay series nuclides

Daughters of Th-232	Ingrowth factor, 100 years
Ra-228	1.11E01
Ac-228	9.09E04
Th-228	3.22E01
Ra-224	6.15E03
Pb-212	5.08E04
Bi-212	5.35E05
Tl-208	3.79E06
Used in cases: GOLD 04, 101 I & P	

Table 10. Site-specific parameters

Run	Number of nuclides released	Buildup time (years)		Source[a]	f_p	Total population	Total number cattle	
		Population run	Individual run				Beef	Milk
GOLD								
01	18	100	100	Pt.	0.50	626,079	1,029,392	52,672
02	5	100	100	Pt.	0.50	8,024,652	377,904	32,368
03	35	100	100	Pt.	0.50	1,895,523	307,600	75,376
04	13	100	100	Pt.	0.50	3,248,787	207,088	121,456
05 (S1)	2	100	100	Pt.	0.4167	5,370,586	137,104	148,352
05 (S2)	1	100	100	Pt.	0.4167	5,370,586	137,104	148,352
05 (S3)	6	100	100	Pt.	0.4167	5,370,586	137,104	148,352
06	8	100	100	Pt.	0.50	2,064,574	307,600	75,376
07	3	100	100	Pt.	0.50	7,506,460	377,728	32,352
09	26	100	100	Pt.	0.50	241,665	138,304	12,944
11	7	100	100	Pt.	1.0	4,401,851	177,904	42,016
12	8	100	100	Pt.	1.0	46,251	177,904	42,016
13	19	100	100	Pt.	0.75	109,936	97,104	1,968
14	2	100	100	Pt.	0.50	2,887,738	307,600	75,376
15	14	100	100	Pt.	1.0	1,131	39,056	10,624
16	20	100	100	Pt.	0.5833	681,528	468,432	38,592
17	10	100	100	Pt.	0.50	444,451	556,896	54,288
18	4	100	100	Pt.	1.0	185,920	420,128	9,248
19	2	100	100	Pt.	1.0	1,331,351	309,552	28,352
20	10	100	100	Pt.	0.50	587,131	307,600	75,376
21	8	100	100	Pt.	0.50	1,456,580	307,600	75,376
22	4	100	100	Pt.	1.0	7,121,175	177,904	42,016
23	9	100	100	Pt.	0.3333	1,624,996	233,200	5,312
24	2	100	100	Pt.	1.0	345,039	97,104	1,968
25	20	100	100	Pt.	0.80	465,333	160,304	14,144
26 (S1)	18	100	100	Pt.	0.50	3,659,764	207,088	121,456
26 (S2)	19	100	100	Pt.	0.50	3,659,764	207,088	121,456
27	1	100	100	Pt.	1.0	4,381,663	177,904	42,016

Table 10. (continued)

Run	Number of nuclides released	Buildup time (years)		Source[a]	f_p	Total population	Total number cattle	
		Population run	Individual run				Beef	Milk
28	12	100	100	Pt.	0.50	2,036,873	128,080	20,496
29	1	100	100	Pt.	1.0	96,841	96,720	1,968
81	27	100	100	Pt.	0.60	222,728	126,080	20,176
82	2	100	100	Pt.	0.60	243,619	126,080	20,176
83	13	100	100	Pt.	0.60	140,802	128,080	20,496
101	28	100	100	Pt.	0.4167	1,219,842	137,120	148,368
102	11	100	100	Pt.	0.4167	3,112,931	89,456	86,272
NARM								
10A	1	15	15	Pt.	1.0	981,811	309,584	28,352
10B	1	15	15	Pt.	0.833	2,120,533	420,176	9,248
20	1	15	15	Pt.	1.0	364,271	177,904	42,016
31 (S1)	20	100	24	Pt.	1.0	981,811	309,584	28,352
31 (S2)	1	100	24	A	1.0	981,811	309,584	28,352
32 (S1)	11	100	15	Pt.	1.0	981,811	309,584	28,352
32 (S2)	1	100	15	A	1.0	981,811	309,584	28,352
33 (S1)	11	100	15	A	1.0	981,811	309,584	28,352
33 (S2)	1	100	15	A	1.0	981,811	309,584	28,352
41 (S1)	8	50	50	Pt.	0.625	36,004	97,104	1,968
41 (S2)	8	50	50	A	0.625	36,004	97,104	1,968
42 (S1)	10	100	50	A	0.625	36,004	97,088	1,968
42 (S2)	10	100	50	A	0.625	36,004	97,088	1,968
43 (S1)	8	50	50	Pt.	0.625	36,004	97,104	1,968
43 (S2)	8	50	50	A	0.625	36,004	97,104	1,968
50 (S1)	5	20	20	A	0.833	2,120,533	420,176	9,248
50 (S2)	7	20	20	Pt.	0.833	2,120,533	420,176	9,248
62	18	100	15	A	0.583	3,244,008	207,088	121,456
80A	17	100	30	Pt.	0.583	3,244,008	207,088	121,456
80B	17	100	30	Pt.	0.625	449,953	468,432	43,424

Table 10. (continued)

Run	Number of nuclides released	Buildup time (years) Population run	Buildup time (years) Individual run	Source[a]	f_p	Total population	Total number cattle Beef	Total number cattle Milk
90A	24	100	30	Pt.	0.625	2,486,049	120,064	45,408
90B	24	100	30	Pt.	0.667	460,581	162,832	14,368
100A	18	100	30	Pt.	0.583	3,244,008	207,088	121,456
100B	18	100	30	Pt.	0.625	449,953	468,432	43,424
NUFE								
11	1	17	17	A	0.625	36,004	97,104	1,968
12	1	20	10	A	0.625	36,004	97,088	1,968
13 (S1)	11	100	20	A	0.625	36,004	97,104	1,968
13 (S2)	11	100	20	A	0.625	36,004	97,104	1,968
21	16	30	30	Pt.	0.625	449,953	468,432	43,424
22	26	30	30	Pt.	0.625	449,953	468,432	43,424
30	12	30	30	A	0.625	449,741	468,384	43,424
40A	18	30	30	Pt.	0.583	175,851	128,080	20,496
40B	18	30	30	Pt.	0.667	460,581	162,832	14,368
51A	25	100	30	Pt.	0.667	460,581	162,832	14,368
51B	25	100	30	Pt.	0.583	7,477,427	377,952	32,368
52A	28	100	30	Pt.	0.667	460,581	162,832	14,368
52B	28	100	30	Pt.	0.583	7,477,427	377,952	32,368
61 (S1)	8	100	30	A	0.667	460,581	162,832	14,368
61 (S2)	2	30	30	A	0.667	460,581	162,832	14,368
62	6	30	30	Pt.	0.667	460,581	162,832	14,368
LICE								
10	6	30	30	Pt.	0.583	3,099,024	207,088	121,456
31	11	15	15	Pt.	0.583	16,259,831	137,120	148,368
32	2	30	20	Pt.	0.833	2,161,351	420,176	9,248

Table 10. (continued)

Run	Number of nuclides released	Buildup time (years)		Source[a]	f_p	Total population	Total number cattle	
		Population run	Individual run				Beef	Milk
PART								
70	6	20	20	Pt.	0.583	7,753,572	377,952	32,368

[a]Pt. = point source, A = area source.

Table 11. Nuclides and release rates for GOLD-1 and GOLD-2

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
		GOLD-1		
Pu-239	8.3E-6	Y	3.0E-5	1.0E-4
Ce-144	1.5E-5	Y	1.0E-4	3.0E-4
Pr-144[a]	1.5E-5	Y	1.0E-4	3.0E-4
Ce-141	2.9E-6	Y	1.0E-4	3.0E-4
Cs-137	9.1E-7	D	9.5E-1	9.5E-1
Ba-137m[a]	9.1E-7	D	1.0E-1	1.0E-1
I-131	6.4E-7	D	9.5E-1	9.5E-1
Ru-106	3.2E-6	W	4.0E-2	5.0E-2
Rh-106[a]	3.2E-6	Y	4.0E-2	5.0E-2
Ru-103	2.1E-5	W	4.0E-2	5.0E-2
Zr-95	1.3E-5	W	2.0E-3	2.0E-3
Nb-95	4.2E-5	W	1.0E-2	1.0E-2
Sr-90	2.8E-5	D	2.0E-1	3.0E-1
Co-60	1.1E-5	W	5.0E-2	5.0E-2
Ar-41	1.3E+4	-	-	-
Na-22	3.0E-7	D	9.5E-1	9.5E-1
Be-7	9.0E+5	W	2.0E-3	2.0E-3
H-3	1.0E+3	-	9.5E-1	9.5E-1
		GOLD-2		
Kr-85	4.2E+1	-	-	-
Ar-41	3.0E+4	-	-	-
N-13	1.0E-1	-	-	9.5E-1
C-11	1.3E+0	-	-	9.5E-1
H-3	8.5E+2	-	9.5E-1	9.5E-1

[a]Nuclide added to original list by ORNL staff.

Table 12. Nuclides and release rates for GOLD-3

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
Pu-239	7.9E-8	Y	3.0E-5	1.0E-4
U-235	1.96E-7	Y	2.0E-3	2.0E-3
Th-231[a,b]	0	Y	1.0E-3	2.0E-4
Pa-231[a,b]	0	Y	1.0E-3	1.0E-3
Ac-227[a,b]	0	Y	1.0E-3	1.0E-3
Hg-203	4.2E-7	W	2.0E-2	2.0E-2
Ir-192	4.0E-9	Y	1.0E-2	1.0E-2
Tb-160	3.17E-7	Y	1.0E-4	1.0E-4
Eu-154	4.5E-7	Y	1.0E-4	1.0E-4
Eu-152	7.9E-7	Y	1.0E-4	1.0E-4
Ce-144	5.3E-7	Y	1.0E-4	3.0E-4
Pr-144[b]	5.3E-7	Y	1.0E-4	3.0E-4
La-140	2.94E-5	Y	1.0E-4	3.0E-4
Cs-137	1.29E-6	D	9.5E-1	9.5E-1
Ba-137m[b]	1.29E-6	D	1.0E-1	1.0E-1
Cs-134	1.3E-7	D	9.5E-1	9.5E-1
Xe-133m	2.9E-7	-	-	-
Ba-133	6.0E-9	D	1.0E-1	1.0E-1
I-131	1.5E-7	D	9.5E-1	9.5E-1
Sb-125	3.49E-5	W	5.0E-2	2.0E-1
Sb-124	2.6E-7	W	5.0E-2	2.0E-1
Sn-113	6.0E-8	W	5.0E-2	5.0E-2
Ru-106	1.0E-7	Y	4.0E-2	5.0E-2
Rh-106[b]	1.0E-7	Y	4.0E-2	5.0E-2
Ru-97	1.4E-7	D	4.0E-2	5.0E-2
Zr-95	2.14E-7	W	2.0E-3	2.0E-3
Nb-95	4.0E-8	W	1.0E-2	1.0E-2
Sr-90	7.83E-6	D	2.0E-1	3.0E-1
Kr-85	5.24E-6	-	-	-
Zn-65	9.0E-8	W	5.0E-1	5.0E-1
Co-60	1.393E-4	Y	5.0E-2	5.0E-2
Co-58	9.0E-8	Y	5.0E-2	5.0E-2
Co-57	3.3E-8	Y	5.0E-2	5.0E-2
Mn-54	1.6E-7	W	1.0E-1	1.0E-1
Cr-51	1.3E-8	D	1.0E-1	1.0E-1

[a]Nuclide is added to source term with a zero release rate and an appropriate ingrowth factor.

[b]Nuclide added to original list by ORNL staff.

Table 13. Nuclides and release rates for GOLD-4

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
Th-232	2.2E-5	Y	1.0E-3	2.0E-4
Ra-228[a,b]	0	W	2.0E-1	2.0E-1
Ac-228[a,b]	0	W	1.0E-3	1.0E-3
Th-228[a,b]	0	W	1.0E-3	2.0E-4
Ra-224[a,b]	0	W	2.0E-1	2.0E-1
Pb-212[a,b]	0	W	8.0E-2	2.0E-1
Bi-212[a,b]	0	W	5.0E-2	5.0E-2
Tl-208[a,b]	0	W	9.5E-1	9.5E-1
I-131	1.1E-1	D	9.5E-1	9.5E-1
Sb-125	1.4E-4	W	5.0E-2	2.0E-1
Sr-90	2.9E-4	D	2.0E-1	3.0E-1
Kr-85	8.2E-1	-	-	-
H-3	4.8E-5	-	9.5E-1	9.5E-1

[a]Nuclide is added to source term with a zero release rate and an appropriate ingrowth factor.

[b]Nuclide added to original list by ORNL staff.

Table 14. Nuclides and release rates for GOLD-5, stacks 1, 2, and 3

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
		GOLD-5 (S1)		
O-15	6.7E-14	-	9.5E-1	9.5E-1
H-3	1.07E+3	-	-	9.5E-1
		GOLD-5 (S2)		
Ar-41	3.6E+2	-	-	-
		GOLD-5 (S3)		
I-131	1.1E-5	D	9.5E-1	9.5E-1
Xe-127	1.6E+0	-	-	-
Xe-125	2.0E-1	-	-	-
Xe-123	1.2E+1	-	-	-
Xe-122	1.0E-1	-	-	-
H-3	1.2E+2	-	9.5E-1	9.5E-1

Table 15. Nuclides and release rates for GOLD-6 and GOLD-7

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
		GOLD-6		
U-238	3.0E-2	Y	2.0E-3	2.0E-3
Th-234[a,b]	0	Y	1.0E-3	2.0E-4
Pa-234m[a,b]	0	Y	1.0E-3	1.0E-3
U-234	3.0E-2	Y	2.0E-3	2.0E-3
U-235	1.35E-3	Y	2.0E-3	2.0E-3
Th-231[a,b]	0	Y	1.0E-3	2.0E-4
Pa-231[a,b]	0	Y	1.0E-3	1.0E-3
Ac-227[a,b]	0	Y	1.0E-3	1.0E-3
		GOLD-7		
C-11	2.5E+3	-	-	9.5E-1
Be-7	9.4E-1	W	2.0E-3	2.0E-3
H-3	1.5E-1	-	9.5E-1	9.5E-1

[a]Nuclide is added to source term with a zero release rate and an appropriate ingrowth factor.

[b]Nuclide added to original list by ORNL staff.

Table 16. Nuclides and release rates for GOLD-9

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
Pu-240	6.3E-5	Y	3.0E-5	1.0E-4
Pu-239	3.6E-4	Y	3.0E-5	1.0E-4
Pu-238	9.9E-4	Y	3.0E-5	1.0E-3
Ba-139	5.0E+2	D	1.0E-2	1.0E-1
Xe-138	1.0E+4	-	-	-
Cs-138	7.2E+1	D	9.5E-1	9.5E-1
Cs-137	2.0E-1	D	9.5E-1	9.5E-1
Ba-137m[a,b]	0	D	1.0E-1	1.0E-1
Xe-135m	3.6E+3	-	-	-
Xe-135	2.3E+2	-	-	-
Cs-134	1.1E-1	D	9.5E-1	9.5E-1
Xe-133m	1.5E-1	-	-	-
Xe-133	6.5E+2	-	-	-
I-131	1.7E-3	D	9.5E-1	9.5E-1
Sb-125	3.4E-2	W	5.0E-2	2.0E-1
Ru-106	1.3E-1	Y	4.0E-2	5.0E-2
Rh-106[b]	1.3E-1	Y	4.0E-2	5.0E-2
Sr-90	6.2E-2	D	2.0E-1	1.0E-2
Y-90	6.2E-2	W	1.0E-4	1.0E-4
Rb-88	4.2E+1	D	9.5E-1	9.5E-1
Kr-88	3.4E+3	-	-	-
Kr-87	4.7E+3	-	-	-
Kr-85m	1.1E+3	-	-	-
Kr-85	1.1E+5	-	-	-
Ar-41	3.5E+3	-	-	-
H-3	3.1E+3	-	9.5E-1	9.5E-1

[a]Nuclide is added to source term with a zero release rate and an appropriate ingrowth factor.

[b]Nuclide added to original list by ORNL staff.

Table 17. Nuclides and release rates for GOLD-11 and GOLD-12

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
		GOLD-11		
Pu-239	1.4E-7	Y	3.0E-5	1.0E-4
I-131	6.0E-7	D	9.5E-1	9.5E-1
I-125	4.6E-4	D	9.5E-1	9.5E-1
Sr-90	8.4E-6	D	2.0E-1	3.0E-1
Ga-67	1.3E-3	W	1.0E-3	1.0E-3
C-14	2.2E-2	-	9.5E-1	9.5E-1
H-3	7.8E+1	-	9.5E-1	9.5E-1
		GOLD-12		
U-238	2.6E-9	Y	2.0E-3	2.0E-3
Th-234[a,b]	0	Y	1.0E-3	2.0E-4
Pa-234m[a,b]	0	Y	1.0E-3	1.0E-3
Kr-85	2.2E+0	-	-	-
Ar-41	3.9E+2	-	-	-
O-15	4.0E+2	-	-	9.5E-1
N-13	5.9E+2	-	-	9.5E-1
H-3	5.201E+3	-	9.5E-1	9.5E-1

[a]Nuclide is added to source term with a zero release rate and an appropriate ingrowth factor.

[b]Nuclide added to original list by ORNL staff.

Table 18. Nuclides and release rates for GOLD-13

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
Pu-239	1.17E-4	Y	3.0E-5	1.0E-4
Pu-238	2.03E-5	Y	3.0E-5	1.0E-3
U-238	4.52E-4	Y	2.0E-3	2.0E-3
Th-234	5.2E-3	Y	1.0E-3	2.0E-3
Pa-234m [a,b]	0	Y	1.0E-3	1.0E-3
U-235	3.78E-4	Y	2.0E-3	2.0E-3
Th-231[a,b]	0	Y	1.0E-3	2.0E-4
Pa-231[a,b]	0	Y	1.0E-3	1.0E-3
Ac-227[a,b]	0	Y	1.0E-3	1.0E-3
I-131	8.8E-5	D	9.5E-1	9.5E-1
Sr-90	2.8E-3	D	2.0E-1	3.0E-1
Co-60	5.0E-9	Y	5.0E-2	5.0E-2
Ar-41	7.9E+2	-	-	-
P-32	3.0E-4	D	8.0E-1	8.0E-1
O-15	3.2E+4	-	-	9.5E-1
N-13	1.4E+3	-	-	9.5E-1
C-11	1.4E+4	-	-	9.5E-1
Be-7	2.8E-7	W	2.0E-3	2.0E-3
H-3	3.9E+4	-	9.5E-1	9.5E-1

[a]Nuclide is added to source term with a zero release rate and an appropriate ingrowth factor.

[b]Nuclide added to original list by ORNL staff.

Table 19. Nuclides and release rates for GOLD-14 and GOLD-15

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
		GOLD-14		
Pu-238	1.1E-5	Y	3.0E-5	1.0E-3
H-3	4.9E+3	-	9.5E-1	9.5E-1
		GOLD-15		
U-238	3.5E-5	Y	2.0E-3	2.0E-3
Th-234[a,b]	0	Y	1.0E-3	2.0E-4
Pa-234m[a,b]	0	Y	1.0E-3	1.0E-3
U-235	2.4E-5	Y	2.0E-3	2.0E-3
Th-231[a,b]	0	Y	1.0E-3	2.0E-4
Pa-231[a,b]	0	Y	1.0E-3	1.0E-3
Ac-227[a,b]	0	Y	1.0E-3	1.0E-3
Xe-135	8.5E-1	-	-	-
I-135	2.5E-9	D	9.5E-1	9.5E-1
Xe-133m	6.3E-1	-	-	-
Xe-133	4.5E+1	-	-	-
I-133	8.6E-7	D	9.5E-1	9.5E-1
I-131	2.6E-6	D	9.5E-1	9.5E-1
H-3	4.1E+0	-	9.5E-1	9.5E-1

[a]Nuclide is added to source term with a zero release rate and an appropriate ingrowth factor.

[b]Nuclide added to original list by ORNL staff.

Table 20. Nuclides and release rates for GOLD-16

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
Pu-239	2.0E-1	Y	3.0E-5	1.0E-4
U-238	4.1E-4	Y	2.0E-3	2.0E-3
Th-234[a,b]	0	Y	1.0E-3	2.0E-4
Pa-234m[a,b]	0	Y	1.0E-3	1.0E-3
U-234	6.1E-2	Y	2.0E-3	2.0E-3
U-236	2.1E-5	Y	2.0E-3	2.0E-3
U-235	3.7E-5	Y	2.0E-3	2.0E-3
Th-231[a,b]	0	Y	1.0E-3	2.0E-4
Pa-231[a,b]	0	Y	1.0E-3	1.0E-3
Ac-227[a,b]	0	Y	1.0E-3	1.0E-3
U-233	1.0E-6	Y	2.0E-3	2.0E-3
Hg-203	5.0E-5	W	2.0E-2	2.0E-2
Xe-133	4.2E+4	-	-	-
I-131	1.4E+0	D	9.5E-1	9.5E-1
I-125	9.5E-5	D	9.5E-1	9.5E-1
Tc-99	1.0E-6	W	8.0E-1	8.0E-1
Kr-85	8.6E+3	-	-	-
S-35	2.0E-4	D	9.5E-1	9.5E-1
C-14	2.5E-4	-	9.5E-1	9.5E-1
H-3	2.5E+3	-	9.5E-1	9.5E-1

[a]Nuclide is added to source term with a zero release rate and an appropriate ingrowth factor.

[b]Nuclide added to original list by ORNL staff.

Table 21. Nuclides and release rates for GOLD-17, GOLD-18, and GOLD-19

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
		GOLD-17		
U-238	2.0E-1	W	2.0E-3	2.0E-1
Th-234[a,b]	0	Y	1.0E-3	2.0E-4
Pa-234m[a,b]	0	Y	1.0E-3	1.0E-3
U-234	2.0E-1	W	2.0E-3	2.0E-1
U-236	3.6E-4	W	2.0E-3	2.0E-1
U-235	1.0E-2	W	2.0E-3	2.0E-1
Th-231[a,b]	0	Y	1.0E-3	2.0E-4
Pa-231[a,b]	0	Y	1.0E-3	1.0E-3
Ac-227[a,b]	0	Y	1.0E-3	1.0E-3
Tc-99	7.4E-2	W	8.0E-1	8.0E-1
		GOLD-18		
U-238	1.0E-4	Y	2.0E-3	2.0E-3
Th-234[a,b]	0	Y	1.0E-3	2.0E-4
Pa-234m[a,b]	0	Y	1.0E-3	1.0E-3
H-3	1.0E-2	-	9.5E-1	9.5E-1
		GOLD-19		
Kr-85	2.8E+1	-	-	-
H-3	2.9E+2	-	9.5E-1	9.5E-1

[a]Nuclide is added to source term with a zero release rate and an appropriate ingrowth factor.

[b]Nuclide added to original list by ORNL staff.

Table 22. Nuclides and release rates for GOLD-20 and GOLD-21

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
		GOLD-20		
U-238	4.7E-3	W	2.0E-3	2.0E-3
Th-234	4.6E-2	Y	1.0E-3	2.0E-4
Pa-234m	4.6E-2	Y	1.0E-3	1.0E-3
U-234	1.0E-2	W	2.0E-3	2.0E-3
U-236	1.1E-4	W	2.0E-3	2.0E-3
U-235	3.5E-3	W	2.0E-3	2.0E-3
Th-231[a,b]	0	Y	1.0E-3	2.0E-4
Pa-231[a,b]	0	Y	1.0E-3	1.0E-3
Ac-227[a,b]	0	Y	1.0E-3	1.0E-3
Tc-99	4.4E+0	W	8.0E-1	8.0E-1
		GOLD-21		
U-238	2.1E-2	Y	2.0E-3	2.0E-3
Th-234[a,b]	0	Y	1.0E-3	2.0E-4
Pa-234m[a,b]	0	Y	1.0E-3	1.0E-3
U-234	2.1E-2	Y	2.0E-3	2.0E-3
U-235	1.0E-3	Y	2.0E-3	2.0E-3
Th-231[a,b]	0	Y	1.0E-3	2.0E-4
Pa-231[a,b]	0	Y	1.0E-3	1.0E-3
Ac-227[a,b]	0	Y	1.0E-3	1.0E-3

[a] Nuclide is added to source term with a zero release rate and an appropriate ingrowth factor.

[b] Nuclide added to original list by ORNL staff.

Table 23. Nuclides and release rates for GOLD-22, GOLD-23, and GOLD-24

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
		GOLD-22		
U-238	1.12E-5	Y	2.0E-3	2.0E-3
Th-234[a,b]	0	Y	1.0E-3	2.0E-4
Pa-234m[a,b]	0	Y	1.0E-3	1.0E-3
Sr-90	2.76E-5	D	2.0E-1	3.0E-1
		GOLD-23		
Pu-239	4.1E-6	Y	3.0E-5	1.0E-4
U-238	1.8E-5	Y	2.0E-3	2.0E-3
Th-234[a,b]	0	Y	1.0E-3	2.0E-4
Pa-234m[a,b]	0	Y	1.0E-3	1.0E-3
U-235	2.1E-5	Y	2.0E-3	2.0E-3
Th-231[a,b]	0	Y	1.0E-3	2.0E-4
Pa-231[a,b]	0	Y	1.0E-3	1.0E-3
Ac-227[a,b]	0	Y	1.0E-3	1.0E-3
H-3	5.1E-1	-	9.5E-1	9.5E-1
		GOLD-24		
Ar-41	4.9E+0	-	-	-
H-3	1.0E-2	-	9.5E-1	9.5E-1

[a]Nuclide is added to source term with a zero release rate and an appropriate ingrowth factor.

[b]Nuclide added to original list by ORNL staff.

Table 24. Nuclides and release rates for GOLD-25

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
Cm-244	3.4E-4	Y	1.0E-3	1.0E-3
Am-241	3.4E-4	Y	1.0E-3	1.0E-3
Pu-239	1.0E-4	Y	3.0E-5	1.0E-4
Pu-238	5.0E-3	Y	3.0E-5	1.0E-3
Ce-144	1.5E-2	Y	1.0E-4	3.0E-4
Pr-144[a,b]	0	Y	1.0E-4	3.0E-4
Xe-135	1.6E+3	-	-	-
Xe-133	2.3E+3	-	-	-
Xe-131m	1.2E+1	-	-	-
I-131	6.1E-2	D	9.5E-1	9.5E-1
I-129	1.4E-1	D	9.5E-1	9.5E-1
Ru-106[a,b]	1.4E-1	Y	4.0E-2	5.0E-2
Rh-106	0	Y	4.0E-2	5.0E-2
Kr-88	6.7E+2	-	-	-
Kr-87	6.0E+2	-	-	-
Kr-85m	8.4E+2	-	-	-
Kr-85	4.4E+5	-	-	-
Ar-41	6.5E+4	-	-	-
C-14	6.3E+1	-	9.5E-1	9.5E-1
H-3	3.6E+5	-	9.5E-1	9.5E-1

[a] Nuclide is added to source term with a zero release rate and an appropriate ingrowth factor.

[b] Nuclide added to original list by ORNL staff.

Table 25. Nuclides and release rates for GOLD-26, stacks 1 and 2

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction AIRDOS and DARTAB
		GOLD-26(S1)	
Xe-138	1.5E-2	-	-
Xe-137	1.8E-1	-	-
Xe-135m	4.9E-2	-	-
Xe-135	1.9E-1	-	-
I-135	2.4E-3	D	9.5E-1
I-134	1.1E-2	D	9.5E-1
Xe-133m	6.1E-4	-	-
Xe-133	6.0E-2	-	-
I-133	1.0E-3	D	9.5E-1
I-132	4.6E-3	D	9.5E-1
Xe-131m	3.0E-8	-	-
I-131	6.4E-5	D	9.5E-1
I-130	7.0E-7	D	9.5E-1
Kr-88	5.7E-2	-	-
Kr-87	3.3E-2	-	-
Kr-85m	1.8E-2	-	-
Kr-85	2.5E-6	-	-
Ar-41	2.4E+0	-	-
		GOLD-26(S2)	
Xe-138	3.2E-3	-	-
Xe-137	3.8E-2	-	-
Xe-135m	1.1E-2	-	-
Xe-135	4.0E-2	-	-
I-135	1.5E-5	D	9.5E-1
I-134	8.8E-6	D	9.5E-1
Xe-133m	1.3E-4	-	-
Xe-133	1.7E-1	-	-
I-133	1.7E-5	D	9.5E-1
I-132	9.8E-6	D	9.5E-1
Xe-131m	7.1E-7	-	-
I-131	4.2E-6	D	9.5E-1
I-130	7.4E-9	D	9.5E-1
Kr-88	1.2E-2	-	-
Kr-87	7.1E-3	-	-
Kr-85m	3.9E-3	-	-
Kr-85	3.4E-4	-	-
Ar-41	5.2E-1	-	-
C-14	5.7E-1	-	9.5E-1

Table 26. Nuclides and release rates for GOLD-27, GOLD-28, and GOLD-29

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction AIRDOS and DARTAB
		GOLD-27	
Ar-41	9.1E+0	-	-
		GOLD-28	
X-135	2.5E-1	-	-
Xe-133m	1.0E-2	-	-
Xe-133	1.1E-1	-	-
Xe-131m	5.0E-3	-	-
Kr-88	2.0E-2	-	-
Kr-87	5.0E-2	-	-
Kr-85m	2.4E-2	-	-
Kr-85	1.0E-3	-	-
Co-60	1.0E-3	Y	5.0E-2
Ar-41	4.1E-1	-	-
C-14	1.0E-1	-	9.5E-1
H-3	1.0E-3	-	9.5E-1
		GOLD-29	
Ar-41	1.8E+1	-	-

Table 27. Nuclides and release rates for GOLD-81

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
Am-241	4.0E-3	Y	1.0E-3	1.0E-3
Pu-239	4.6E-6	Y	3.0E-5	1.0E-4
Pu-238	1.1E-6	Y	3.0E-5	1.0E-3
Ce-144	2.4E-2	Y	1.0E-4	3.0E-4
Pr-144	2.4E-2	Y	1.0E-4	3.0E-4
La-140	6.04E-1	W	1.0E-4	3.0E-4
Ba-140	6.0E-1	D	1.0E-1	1.0E-1
Cs-138	2.7E+3	D	9.5E-1	9.5E-1
Xe-135	3.4E+3	-	-	-
I-135	8.7E+0	D	9.5E-1	9.5E-1
Xe-133	6.8E+2	-	-	-
I-133	4.0E+0	D	9.5E-1	9.5E-1
I-132	5.8E+0	D	9.5E-1	9.5E-1
I-131	5.5E-1	D	9.5E-1	9.5E-1
Sr-90	1.9E-4	D	2.0E-1	3.0E-1
Sr-89	7.7E-3	D	2.0E-1	3.0E-1
Kr-88	2.0E+3	-	-	-
Kr-87	2.5E+3	-	-	-
Kr-85m	8.3E+2	-	-	-
As-76	5.5E-1	W	3.0E-2	3.0E-2
Co-60	3.0E-2	Y	5.0E-2	5.0E-2
Fe-59	1.8E-2	W	1.0E-1	1.0E-1
Co-58	2.6E-3	Y	5.0E-2	5.0E-2
Mn-56	2.4E+0	W	1.0E-1	1.0E-1
Mn-54	1.6E-2	W	1.0E-1	1.0E-1
Ar-41	1.3E+5	-	-	-
H-3	1.8E+1	-	9.5E-1	9.5E-1

Table 28. Nuclides and release rates for GOLD-82 and GOLD-83

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
		GOLD-82		
Pu-239	2.1E-3	Y	3.0E-5	1.0E-4
Sr-90	2.9E-2	D	2.0E-1	3.0E-1
		GOLD-83		
Cm-244	8.4E-8	Y	1.0E-3	1.0E-3
Pu-239	3.2E-7	Y	3.0E-5	1.0E-4
U-238	1.3E-4	Y	2.0E-3	2.0E-3
Th-234[a,b]	0	Y	1.0E-3	2.0E-4
Pa-234m[a,b]	0	Y	1.0E-3	1.0E-3
U-234	1.3E-4	Y	2.0E-3	2.0E-3
U-235	5.9E-6	Y	2.0E-3	2.0E-3
Th-231[a,b]	0	Y	1.0E-3	2.0E-4
Pa-231[a,b]	0	Y	1.0E-3	1.0E-3
Ac-227[a,b]	0	Y	1.0E-3	1.0E-3
I-131	4.5E-4	D	9.5E-1	9.5E-1
Sr-90	2.4E-4	D	2.0E-1	3.0E-1
Co-60	6.0E-5	Y	5.0E-2	5.0E-2

[a]Nuclide is added to source term with a zero release rate and an appropriate ingrowth factor.

[b]Nuclide added to original list by ORNL staff.

Table 29. Nuclides and release rates for GOLD-101 and GOLD-102

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
		GOLD-101		
Pu-239	1.3E-8	Y	3.0E-5	1.0E-4
U-235	2.9E-6	Y	2.0E-3	2.0E-3
Th-231[a,b]	0	Y	1.0E-3	2.0E-4
Pa-231[a,b]	0	Y	1.0E-3	1.0E-3
Ac-227[a,b]	0	Y	1.0E-3	1.0E-3
Th-232	1.4E-6	Y	1.0E-3	2.0E-4
Ra-228[a,b]	0	W	2.0E-1	2.0E-1
Ac-228[a,b]	0	W	1.0E-3	1.0E-3
Th-228[a,b]	0	W	1.0E-3	2.0E-4
Ra-224[a,b]	0	W	2.0E-1	2.0E-1
Pb-212[a,b]	0	W	8.0E-2	2.0E-1
Bi-212[a,b]	0	W	5.0E-2	5.0E-2
Tl-208[a,b]	0	W	9.5E-1	9.5E-1
Xe-138	2.8E-3	-	-	-
Xe-135	1.097E-1	-	-	-
Xe-133m	3.6E-3	-	-	-
Xe-133	1.112E-1	-	-	-
Xe-131m	8.0E-4	-	-	-
I-131	1.7E-5	D	9.5E-1	9.5E-1
Sb-125	3.6E-4	W	5.0E-2	2.0E-1
Sr-90	1.7E-4	D	2.0E-1	3.0E-1
Kr-88	3.6E-2	-	-	-
Kr-87	1.96E-2	-	-	-
Kr-85m	1.52E-2	-	-	-
Kr-85	4.3E-1	-	-	-
Co-60	3.5E-5	Y	5.0E-2	5.0E-2
Ar-41	1.26E+1	-	-	-
C-14	1.0E-1	-	9.5E-1	9.5E-1
		GOLD-102		
Xe-135	2.5E-2	-	-	-
Xe-133m	3.9E-4	-	-	-
Xe-133	1.2E-2	-	-	-
Xe-131m	5.7E-5	-	-	-
Kr-88	3.2E-3	-	-	-
Kr-87	1.6E-3	-	-	-
Kr-85m	2.8E-3	-	-	-
Kr-85	2.9E-6	-	-	-
Co-60	3.8E-6	Y	5.0E-2	5.0E-2
Ar-41	6.8E-1	-	-	-
C-14	6.3	-	9.5E-1	9.5E-1

[a]Nuclide is added to source term with a zero release rate and an appropriate ingrowth factor.

[b]Nuclide added to original list by ORNL staff.

Table 30. Nuclides and release rates for NARM-10A, NARM-10B, NARM-20, and NARM-31, stacks 1 and 2

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
		NARM-10A		
Rn-222	8.1E+0	-	-	-
		NARM-10B		
Rn-222	8.1E+0	-	-	-
		NARM-20		
RN-222	5.47E+2	-	-	-
		NARM-31(S1)		
U-238	3.8E-2	Y	2.0E-3	2.0E-3
Th-234	3.8E-2	Y	1.0E-3	2.0E-4
Pa-234m	3.8E-2	Y	1.0E-3	1.0E-3
U-234	3.8E-2	Y	2.0E-3	2.0E-3
Th-230	3.8E-2	Y	1.0E-3	2.0E-4
Ra-226	3.8E-2	W	2.0E-1	2.0E-1
Rn-222	4.98E+1	-	-	-
Pb-214[a]	3.8E-2	W	8.0E-2	2.0E-1
Bi-214[a]	3.8E-2	W	5.0E-2	5.0E-2
Pb-210	3.8E-2	W	8.0E-2	2.0E-1
Bi-210	3.8E-2	W	5.0E-2	5.0E-2
Po-210	3.8E-2	W	1.0E-1	1.0E-1
Th-232	3.2E-4	Y	1.0E-3	2.0E-4
Ra-228	3.2E-4	W	2.0E-1	2.0E-1
Ac-228	3.2E-4	W	1.0E-3	1.0E-3
Th-228	3.2E-4	W	1.0E-3	1.0E-4
Ra-224	3.2E-4	W	2.0E-1	2.0E-1
Pb-212	3.2E-4	W	8.0E-2	2.0E-1
Bi-212	3.2E-4	W	5.0E-2	5.0E-2
Tl-208	1.1E-4	W	9.5E-1	9.5E-1
		NARM-31A(S2)		
Rn-222	1.37E+3	-	-	-

[a]Nuclide added to original list by ORNL staff.

Table 31. Nuclides and release rates for NARM-32, stacks 1 and 2, and NARM-33, stacks 1 and 2

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
		NARM-32(S1)		
U-238	2.9E-2	Y	2.0E-3	2.0E-3
Th-234	2.9E-2	Y	1.0E-3	2.0E-4
Pa-234m	2.9E-2	Y	1.0E-3	1.0E-3
U-234	2.9E-2	Y	2.0E-3	2.0E-3
Th-230	2.7E-2	Y	1.0E-3	2.0E-4
Ra-226	1.1E-2	W	2.0E-1	2.0E-1
Rn-222	6.7E+1	-	-	-
Pb-214[a]	1.1E-2	W	8.0E-2	2.0E-1
Bi-214[a]	1.1E-2	W	5.0E-2	5.0E-2
Pb-210	1.1E-2	W	8.0E-2	2.0E-1
Po-210	1.1E-2	W	1.0E-1	1.0E-1
		NARM-32(S2)		
Rn-222	4.17E+2	-	-	-
		NARM-33(S1)		
U-238	7.1E-2	Y	2.0E-3	2.0E-3
Th-234	7.1E-2	Y	1.0E-3	2.0E-4
Pa-234m	7.1E-2	Y	1.0E-3	1.0E-3
U-234	7.1E-2	Y	2.0E-3	2.0E-3
Th-230	7.1E-2	Y	1.0E-3	2.0E-4
Ra-226	1.3E-2	W	2.0E-1	2.0E-1
Rn-222	6.7E+1	-	-	-
Pb-214[a]	1.3E-2	W	8.0E-2	2.0E-1
Bi-214[a]	1.3E-2	W	5.0E-2	5.0E-2
Pb-210	2.0E-2	W	8.0E-2	2.0E-1
Po-210	1.21E+1	W	1.0E-1	1.0E-1
		NARM-33(S2)		
Rn-222	8.19E+2	-	-	-

[a] Nuclide added to original list by ORNL staff.

Table 32. Nuclides and release rates for NARM-41, stacks 1 and 2, and NARM-42, stacks 1 and 2

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
		NARM-41(S1)		
U-238	2.3E-5	Y	2.0E-3	2.0E-3
Th-234	2.3E-5	Y	1.0E-3	2.0E-4
U-234	2.3E-5	Y	2.0E-3	2.0E-3
Th-230	2.3E-5	Y	1.0E-3	2.0E-4
Ra-226	2.3E-5	W	2.0E-1	2.0E-1
Rn-222	2.1E+2	-	-	-
Pb-210	2.3E-5	W	8.0E-2	2.0E-1
Po-210	2.3E-5	W	1.0E-1	1.0E-1
		NARM-41(S2)		
U-238	1.0E-2	Y	2.0E-3	2.0E-3
Th-234	1.0E-2	Y	1.0E-3	2.0E-4
U-234	1.0E-2	Y	2.0E-3	2.0E-3
Th-230	1.0E-2	Y	1.0E-3	2.0E-4
Ra-226	1.0E-2	W	2.0E-1	2.0E-1
Rn-222	2.3E+2	-	-	-
Pb-210	1.0E-2	W	8.0E-2	2.0E-1
Po-210	1.0E-2	W	1.0E-1	1.0E-1
		NARM-42(S1)		
U-238	2.0E-2	Y	2.0E-3	2.0E-3
Th-234	2.0E-2	Y	1.0E-3	2.0E-4
U-234	2.0E-2	Y	2.0E-3	2.0E-3
Th-230	2.0E-2	Y	1.0E-3	2.0E-4
Ra-226	2.0E-2	W	2.0E-1	2.0E-1
Rn-222	1.7E+3	-	-	-
Pb-214[a]	2.0E-2	W	8.0E-2	2.0E-1
Bi-214[a]	2.0E-2	W	5.0E-2	5.0E-2
Pb-210	2.0E-2	W	8.0E-2	2.0E-1
Po-210	2.0E-2	W	1.0E-1	1.0E-1
		NARM-42(S2)		
U-238	5.0E-2	Y	2.0E-3	2.0E-3
Th-234	5.0E-2	Y	1.0E-3	2.0E-4
U-234	5.0E-2	Y	2.0E-3	2.0E-3
Th-230	5.0E-2	Y	1.0E-3	2.0E-4
Ra-226	5.0E-2	W	2.0E-1	2.0E-1

Table 32. (continued)

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
Rn-222	4.5E+3	-	-	-
Pb-214[a]	5.0E-2	W	8.0E-2	2.0E-1
Bi-214[a]	5.0E-2	W	5.0E-2	5.0E-2
Pb-210	5.0E-2	W	8.0E-2	2.0E-1
Po-210	5.0E-2	W	1.0E-1	1.0E-1

[a]Nuclide added to original list by ORNL staff.

Table 33. Nuclides and release rates for NARM-43, stacks 1 and 2, and NARM-50, stacks 1 and 2

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction AIRDOS	GI absorption fraction DARTAB
		NARM-43(S1)		
U-238	4.5E-2	Y	2.0E-3	2.0E-3
Th-234	4.5E-2	Y	1.0E-3	2.0E-4
U-234	4.5E-2	Y	2.0E-3	2.0E-3
Th-230	4.5E-2	Y	1.0E-3	2.0E-4
Ra-226	4.5E-2	W	2.0E-1	2.0E-1
Rn-222	8.0E+0	-	-	-
Pb-210	1.0E+1	W	8.0E-2	2.0E-1
Po-210	1.0E+1	W	1.0E-1	1.0E-1
		NARM-43(S2)		
U-238	5.3E-2	Y	2.0E-3	2.0E-3
Th-234	5.3E-2	Y	1.0E-3	2.0E-4
U-234	5.3E-2	Y	2.0E-3	2.0E-3
Th-230	5.3E-2	Y	1.0E-3	2.0E-4
Ra-226	5.3E-2	W	2.0E-1	2.0E-1
Rn-222	1.66E+2	-	-	-
Pb-210	5.3E-2	W	8.0E-2	2.0E-1
Po-210	5.3E-2	W	1.0E-1	1.0E-1
		NARM-50(S1)		
U-238	8.0E-4	Y	2.0E-3	2.0E-3
Th-234	8.0E-4	Y	1.0E-3	2.0E-4
Pa-234m	8.0E-4	Y	1.0E-3	1.0E-3
Ra-226	8.0E-4	W	2.0E-1	2.0E-1
Rn-222	6.0E-1	-	-	-
		NARM-50(S2)		
U-238	4.0E-4	Y	2.0E-3	2.0E-3
Th-234	4.0E-4	Y	1.0E-3	2.0E-4
Pa-234m	4.0E-4	Y	1.0E-3	1.0E-3
Ra-226	4.0E-4	W	2.0E-1	2.0E-1
Rn-222	2.0E-1	-	-	-
Pb-210	2.0E-1	W	8.0E-2	2.0E-1
Po-210	2.0E-1	W	1.0E-1	1.0E-1

Table 34. Nuclides and release rates for NARM-62

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
U-238	3.6E-4	Y	2.0E-3	2.0E-3
Th-234	3.6E-4	Y	1.0E-3	2.0E-4
Pa-234m [a]	3.6E-4	Y	1.0E-3	1.0E-3
U-234	3.6E-4	Y	2.0E-3	2.0E-3
Th-230	3.6E-4	Y	1.0E-3	2.0E-4
Ra-226	3.6E-4	W	2.0E-1	2.0E-1
Rn-222	1.4E+0	-	-	-
Pb-214 [a]	3.6E-4	W	8.0E-2	2.0E-1
Bi-214 [a]	3.6E-4	W	5.0E-2	5.0E-2
Pb-210	3.6E-4	W	8.0E-2	2.0E-1
Po-210	3.6E-4	W	1.0E-1	1.0E-1
Th-232	2.8E-4	Y	1.0E-3	2.0E-4
Ra-228	2.8E-4	W	2.0E-1	2.0E-1
Ac-228	2.8E-4	W	1.0E-3	1.0E-3
Th-228	2.8E-4	W	1.0E-3	1.0E-4
Ra-224 [a]	2.8E-4	W	2.0E-1	2.0E-1
Pb-212 [a]	2.8E-4	W	8.0E-2	2.0E-1
Tl-208	9.0E-5	W	9.5E-1	9.5E-1

[a] Nuclide added to original list by ORNL staff.

Table 35. Nuclides and release rates for NARM-80A and NARM-80B

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
		NARM-80A		
U-238	9.1E-4	Y	2.0E-3	2.0E-3
Th-234	9.1E-4	Y	1.0E-3	2.0E-4
U-234	9.1E-4	Y	2.0E-3	2.0E-3
Th-230	9.1E-4	Y	1.0E-3	2.0E-4
Ra-226	9.1E-4	W	2.0E-1	2.0E-1
Rn-222	6.1E-1	-	-	-
Pb-214	9.1E-4	W	8.0E-2	2.0E-1
Bi-214	9.1E-4	W	5.0E-2	5.0E-2
Pb-210[a]	9.1E-4	W	8.0E-2	2.0E-1
Po-210	6.1E-1	W	1.0E-1	1.0E-1
Th-232	6.9E-4	Y	1.0E-3	2.0E-4
Ra-228	6.9E-4	W	2.0E-1	2.0E-1
Ac-228	6.9E-4	W	1.0E-3	1.0E-3
Th-228	6.9E-4	W	1.0E-3	1.0E-4
Ra-224[a]	6.9E-4	W	2.0E-1	2.0E-1
Pb-212[a]	6.9E-4	W	8.0E-2	2.0E-1
Tl-208	2.3E-4	W	9.5E-1	9.5E-1
		NARM-80B		
U-238	9.1E-4	Y	2.0E-3	2.0E-3
Th-234	9.1E-4	Y	1.0E-3	2.0E-4
U-234	9.1E-4	Y	2.0E-3	2.0E-3
Th-230	9.1E-4	Y	1.0E-3	2.0E-4
Ra-226	9.1E-4	W	2.0E-1	2.0E-1
Rn-222	6.1E-1	-	-	-
Pb-214	9.1E-1	W	8.0E-2	2.0E-1
Bi-214	9.1E-4	W	5.0E-2	5.0E-2
Pb-210[a]	9.1E-4	W	8.0E-2	2.0E-1
Po-210	6.1E-1	W	1.0E-1	1.0E-1
Th-232	6.9E-4	Y	1.0E-3	2.0E-4
Ra-228	6.9E-4	W	2.0E-1	2.0E-1
Ac-228	6.9E-4	W	1.0E-3	1.0E-3
Th-228	6.9E-4	W	1.0E-3	1.0E-4
Ra-224[a]	6.9E-4	W	2.0E-1	2.0E-1
Pb-212[a]	6.9E-4	W	8.0E-2	2.0E-1
Tl-208	2.3E-4	W	9.5E-1	9.5E-1

[a] Nuclide added to original list by ORNL staff.

Table 36. Nuclides and release rates for NARM-90A and NARM-90B

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
U-238	2.9E-2	Y	2.0E-3	2.0E-3
Th-234	2.9E-2	Y	1.0E-3	2.0E-4
Pa-234m[a]	2.9E-2	Y	1.0E-3	1.0E-3
U-234	2.9E-2	Y	2.0E-3	2.0E-3
Th-230	2.9E-2	Y	1.0E-3	2.0E-4
Ra-226	2.9E-2	W	2.0E-1	2.0E-1
Rn-222	3.9E-1	-	-	-
Pb-214	2.9E-2	W	8.0E-2	2.0E-1
Bi-214	2.9E-2	W	5.0E-2	5.0E-2
Pb-210	5.7E-2	W	8.0E-2	2.0E-1
Po-210	5.7E-2	W	1.0E-1	1.0E-1
U-235	1.6E-3	Y	2.0E-3	2.0E-3
Th-231	1.6E-3	Y	1.0E-3	2.0E-4
Pa-231	1.6E-3	Y	1.0E-3	1.0E-3
Ac-227[a]	1.6E-3	Y	1.0E-3	1.0E-3
Th-227[a]	1.6E-3	W	1.0E-3	2.0E-4
Ra-223	1.6E-3	W	2.0E-1	2.0E-1
Th-232	2.1E-2	Y	1.0E-3	2.0E-4
Ra-228	2.1E-2	W	2.0E-1	2.0E-1
Ac-228	2.1E-2	W	1.0E-3	1.0E-3
Th-228	2.1E-2	W	1.0E-3	1.0E-4
Ra-224[a]	2.1E-2	W	2.0E-1	2.0E-1
Pb-212[a]	2.1E-2	W	8.0E-2	2.0E-1
Tl-208	7.0E-3	W	9.5E-1	9.5E-1

[a]Nuclide added to original list by ORNL staff.

Table 37. Nuclides and release rates for NARM-100A and NARM-100B

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
U-238	4.5E-3	Y	2.0E-3	2.0E-3
Th-234	4.5E-3	Y	1.0E-3	2.0E-4
Pa-234m[a]	4.5E-3	Y	1.0E-3	1.0E-3
U-234	4.5E-3	Y	2.0E-3	2.0E-3
Th-230	4.5E-3	Y	1.0E-3	2.0E-4
Ra-226	4.5E-3	W	2.0E-1	2.0E-1
Rn-222	2.48E-2	-	-	-
Pb-214	4.5E-3	W	8.0E-2	2.0E-1
Bi-214	4.5E-3	W	5.0E-2	5.0E-2
Pb-210	9.0E-3	W	8.0E-2	2.0E-1
Po-210	9.0E-3	W	1.0E-1	1.0E-1
Th-232	3.3E-3	Y	1.0E-3	2.0E-4
Ra-228	3.3E-3	W	2.0E-1	2.0E-1
Ac-228	3.3E-3	W	1.0E-3	1.0E-3
Th-228	3.3E-3	W	1.0E-3	1.0E-4
Ra-224	3.3E-3	W	2.0E-1	2.0E-1
Pb-212	3.3E-3	W	8.0E-2	2.0E-1
Tl-208	1.1E-3	W	9.5E-1	9.5E-1

[a]Nuclide added to original list by ORNL staff.

Table 38. Nuclides and release rates for NUFE-11, NUFE-12, and NUFE-13, stacks 1 and 2

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
		NUFE-11		
Rn-222	1.997E+3	-	-	-
		NUFE-12		
RN-222	7.3E+3	-	-	-
		NUFE-13(S1)		
U-238	7.3E-2	Y	2.0E-3	2.0E-3
Th-234	7.3E-2	Y	1.0E-3	2.0E-4
Pa-234m	7.3E-2	Y	1.0E-3	1.0E-3
U-234	7.3E-2	Y	2.0E-3	2.0E-3
Th-230	5.0E-3	Y	1.0E-3	2.0E-4
Ra-226	2.0E-3	W	2.0E-1	2.0E-1
Rn-222	1.07E+2	-	-	-
Pb-214[a]	2.0E-3	W	8.0E-2	2.0E-1
Bi-214[a]	2.0E-3	W	5.0E-2	5.0E-2
Pb-210	2.0E-3	W	8.0E-2	2.0E-1
Po-210	2.0E-3	W	1.0E-1	1.0E-1
		NUFE-13(S2)		
U-238	1.4E-2	Y	2.0E-3	2.0E-3
Th-234	1.4E-2	Y	1.0E-3	2.0E-4
Pa-234m	1.4E-2	Y	1.0E-3	1.0E-3
U-234	1.4E-2	Y	2.0E-3	2.0E-3
Th-230	1.9E-1	Y	1.0E-3	2.0E-4
Ra-226	2.0E-1	W	2.0E-1	2.0E-1
Rn-222	7.0E+3	-	-	-
Pb-214[a]	2.0E-1	W	8.0E-2	2.0E-1
Bi-214[a]	2.0E-1	W	5.0E-2	5.0E-2
Pb-210	2.0E-1	W	8.0E-2	2.0E-1
Po-210	2.0E-1	W	1.0E-1	1.0E-1

[a] Nuclide added to original list by ORNL staff.

Table 39. Nuclides and release rates for NUFE-21 and NUFE-22

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
		NUFE-21		
U-238	2.3E-3	D	2.0E-3	2.0E-3
Th-234[a,b]	0	Y	1.0E-3	2.0E-4
Pa-234m[a,b]	0	Y	1.0E-3	1.0E-3
U-234	2.3E-3	D	2.0E-3	2.0E-3
U-238	2.03E-2	Y	2.0E-3	2.0E-3
Th-234[a,b]	0	Y	1.0E-3	2.0E-4
Pa-234m[a,b]	0	Y	1.0E-3	1.0E-3
U-234	2.03E-2	Y	2.0E-3	2.0E-3
U-235	1.1E-4	D	2.0E-3	2.0E-3
Th-231[a,b]	0	Y	1.0E-3	2.0E-1
Pa-231[a,b]	0	Y	1.0E-3	1.0E-3
Ac-227[a,b]	0	Y	1.0E-3	1.0E-3
U-235	9.9E-4	Y	2.0E-3	2.0E-3
Th-231[a,b]	0	Y	1.0E-3	2.0E-4
Pa-231[a,b]	0	Y	1.0E-3	1.0E-3
Ac-227[a,b]	0	Y	1.0E-3	1.0E-3
		NUFE-22		
U-238	2.08E-2	D	2.0E-3	2.0E-3
Th-234[a,b]	0	Y	1.0E-3	2.0E-4
Pa-234m[a,b]	0	Y	1.0E-3	1.0E-3
U-234	2.08E-2	D	2.0E-3	2.0E-3
U-238	7.68E-2	W	2.0E-3	2.0E-3
Th-234[a,b]	0	Y	1.0E-3	2.0E-4
Pa-234m[a,b]	0	Y	1.0E-3	1.0E-3
U-234	7.68E-2	W	2.0E-3	2.0E-3
U-238	6.24E-2	Y	2.0E-3	2.0E-3
Th-234[a,b]	0	Y	1.0E-3	2.0E-4
Pa-234m[a,b]	0	Y	1.0E-3	1.0E-3
U-234	6.24E-2	Y	2.0E-3	2.0E-3
U-235	1.0E-3	D	2.0E-3	2.0E-3
Th-231[a,b]	0	Y	1.0E-3	2.0E-4
Pa-231[a,b]	0	Y	1.0E-3	1.0E-3
Ac-227[a,b]	0	Y	1.0E-3	1.0E-3
U-235	3.6E-3	W	2.0E-3	2.0E-3
Th-231[a,b]	0	Y	1.0E-3	2.0E-4
Pa-231[a,b]	0	Y	1.0E-3	1.0E-3
Ac-227[a,b]	0	Y	1.0E-3	1.0E-3
U-235	3.6E-3	Y	2.0E-3	2.0E-3

Table 39. (continued)

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
Th-231[a,b]	0	Y	1.0E-3	2.0E-4
Pa-231[a,b]	0	Y	1.0E-3	1.0E-3
Ac-227[a,b]	0	Y	1.0E-3	1.0E-3
Th-230	1.4E-3	Y	1.0E-3	2.0E-4
Ra-226	8.3E-5	W	2.0E-1	2.0E-1

[a]Nuclide is added to source term with a zero release rate and an appropriate ingrowth factor.

[b]Nuclide added to original list by ORNL staff.

Table 40. Nuclides and release rates for NUFE-30, NUFE-40A, and NUFE-40B

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
		NUFE-30		
U-238	6.8E-2	W	2.0E-3	2.0E-3
Th-234	4.6E-2	Y	1.0E-3	2.0E-4
Pa-234m	4.6E-2	Y	1.0E-3	1.0E-3
U-234	1.0E-1	W	2.0E-3	2.0E-3
U-236	1.64E-4	W	2.0E-3	2.0E-3
U-235	4.3E-3	W	2.0E-3	2.0E-3
Th-231[a,b]	0	Y	1.0E-3	2.0E-4
Pa-231[a,b]	0	Y	1.0E-3	1.0E-3
Ac-227[a,b]	0	Y	1.0E-3	1.0E-3
Th-227[a,b]	0	W	1.0E-3	2.0E-4
Ra-223[a,b]	0	W	2.0E-1	2.0E-1
Tc-99	1.5E+0	W	8.0E-1	8.0E-1
		NUFE-40A and NUFE-40B		
U-238	2.5E-4	W	2.0E-3	2.0E-3
Th-234	0	Y	1.0E-3	2.0E-4
Pa-234m	0	Y	1.0E-3	1.0E-3
U-234	5.6E-5	W	2.0E-3	2.0E-3
U-238	1.4E-4	Y	2.0E-3	2.0E-3
Th-234[a,b]	0	Y	1.0E-3	2.0E-4
Pa-234m[a,b]	0	Y	1.0E-3	1.0E-3
U-234	3.0E-4	Y	2.0E-3	2.0E-3
U-236	4.2E-6	W	2.0E-3	2.0E-3
U-236	2.3E-6	Y	2.0E-3	2.0E-3
U-235	3.0E-5	W	2.0E-3	2.0E-3
Th-231[a,b]	0	Y	1.0E-3	2.0E-4
Pa-231[a,b]	0	Y	1.0E-3	1.0E-3
Ac-227[a,b]	0	Y	1.0E-3	1.0E-3
U-235	1.6E-5	Y	2.0E-3	2.0E-3
Th-231[a,b]	0	Y	1.0E-3	2.0E-4
Pa-231[a,b]	0	Y	1.0E-3	1.0E-3
Ac-227[a,b]	0	Y	1.0E-3	1.0E-3

[a]Nuclide is added to source term with a zero release rate and an appropriate ingrowth factor.

[b]Nuclide added to original list by ORNL staff.

Table 41. Nuclides and release rates for NUFE-51A and NUFE-51B

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
La-140	3.9E-6	W	1.0E-4	3.0E-4
Ba-140	1.3E-5	D	1.0E-1	1.0E-1
Xe-138	2.4E-1	-	-	-
Cs-137	4.4E-6	D	9.5E-1	9.5E-1
Ba-137m[a]	4.4E-6	D	1.0E-1	1.0E-1
Xe-135m	1.05E+0	-	-	-
Xe-135	8.96E+1	-	-	-
I-135	1.08E-1	D	9.5E-1	9.5E-1
Cs-134	4.8E-6	D	9.5E-1	9.5E-1
Xe-133m	2.3E+1	-	-	-
Xe-133	3.57E+3	-	-	-
I-133	3.3E-3	D	9.5E-1	9.5E-1
I-131	1.33E-2	D	9.5E-1	9.5E-1
Sr-90	1.8E-7	D	2.0E-1	1.0E-2
Sr-89	2.4E-7	D	2.0E-1	1.0E-2
Kr-88	1.58E+1	-	-	-
Kr-87	6.14E+0	-	-	-
Kr-85m	1.56E+1	-	-	-
Kr-85	8.88E+2	-	-	-
Co-60	1.6E-6	Y	5.0E-2	5.0E-2
Co-58	9.9E-6	Y	5.0E-2	5.0E-2
Mn-54	2.1E-6	W	1.0E-1	1.0E-1
Ar-41	2.27E+0	-	-	-
C-14	1.1E+1	-	9.5E-1	9.5E-1
H-3	2.98E+0	-	9.5E-1	9.5E-1

[a]Nuclide added to original list by ORNL staff.

Table 42. Nuclides and release rates for NUFE-52A and NUFE-52B

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
Ce-141	1.01E-3	Y	1.0E-4	3.0E-4
La-140	6.48E-1	W	1.0E-4	3.0E-4
Ba-140	5.58E-2	D	1.0E-1	1.0E-1
Cs-137	1.06E-2	D	9.5E-1	9.5E-1
Ba-137m[a]	1.06E-2	D	1.0E-1	1.0E-1
Cs-136	3.75E-4	D	9.5E-1	9.5E-1
Xe-135m	6.99E+0	-	-	-
Xe-135	1.14E+4	-	-	-
I-135	2.69E+0	D	9.5E-1	9.5E-1
Cs-134	6.11E-3	D	9.5E-1	9.5E-1
Xe-133	1.16E+4	-	-	-
I-133	2.96E+0	D	9.5E-1	9.5E-1
I-131	7.16E-1	D	9.5E-1	9.5E-1
Ag-110m	1.5E-4	Y	5.0E-2	5.0E-2
Zr-95	3.1E-5	W	2.0E-3	2.0E-3
Nb-95	1.63E-4	W	1.0E-2	1.0E-2
Sr-90	4.5E-4	D	2.0E-1	1.0E-2
Sr-89	6.94E-2	D	2.0E-1	1.0E-2
Kr-88	9.94E+2	-	-	-
Kr-87	7.02E+1	-	-	-
Kr-85m	1.45E+3	-	-	-
Zn-65	2.42E-4	W	5.0E-1	5.0E-1
Co-60	8.22E-3	Y	5.0E-2	5.0E-2
Co-58	1.73E-4	Y	5.0E-2	5.0E-2
Mn-54	8.34E-4	W	1.0E-1	1.0E-1
Cr-51	6.84E-3	D	1.0E-1	1.0E-1
C-14	2.5E+1	-	9.5E-1	9.5E-1
H-3	4.03E+1	-	9.5E-1	9.5E-1

[a]Nuclide added to original list by ORNL staff.

Table 43. Nuclides and release rates for NUFE-61, stacks 1 and 2, and NUFE-62

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
		NUFE-61(S1)		
Pu-239	2.0E-6	Y	3.0E-5	1.0E-4
Pu-238	1.1E-4	Y	3.0E-5	1.0E-3
Cs-137	8.3E-3	D	9.5E-1	9.5E-1
Ba-137m[a]	8.3E-3	D	1.0E-1	1.0E-1
Cs-137	2.1E-4	D	9.5E-1	9.5E-1
Sr-90	4.60E-4	D	2.0E-1	1.0E-2
Co-60	5.8E-4	W	5.0E-2	5.0E-2
Co-58	1.9E-4	W	5.0E-2	5.0E-2
H-3	5.9E+3	-	9.5E-1	9.5E-1
		NUFE-61(S2)		
C-14	5.0E+0	-	9.5E-1	9.5E-1
H-3	8.0E+1	-	9.5E-1	9.5E-1
		NUFE-62		
Pu-239	5.4E-5	Y	3.0E-5	1.0E-4
I-131	8.4E-2	D	9.5E-1	9.5E-1
I-129	1.2E-2	D	9.5E-1	9.5E-1
Sr-90	1.9E-5	D	2.0E-1	1.0E-2
Kr-85	1.1E+4	-	-	-
H-3	4.2E+2	-	9.5E-1	9.5E-1

[a]Nuclide added to original list by ORNL staff.

Table 44. Nuclides and release rates for LICE-10, LICE-31, LICE-32, and PART-70

Nuclide	Release rate (curies/year)	Clearance class	GI absorption fraction	
			AIRDOS	DARTAB
		LICE-10		
Pu-242[a]	1.5E-7	Y	3.0E-5	1.0E-3
Am-241	1.6E-5	Y	1.0E-3	1.0E-3
Pu-241[a]	8.6E-3	Y	3.0E-5	1.0E-3
Pu-240[a]	3.9E-5	Y	3.0E-5	1.0E-4
Pu-239[a]	2.6E-5	Y	3.0E-5	1.0E-4
Pu-238[a]	3.2E-4	Y	3.0E-5	1.0E-3
		LICE-31		
Xe-135	8.0E+3	-	-	-
Xe-133	1.0E+4	-	-	-
I-131[a]	6.0E-1	D	9.5E-1	9.5E-1
I-125[a]	5.0E-2	D	9.5E-1	9.5E-1
Mo-99[a]	3.0E+0	D	9.5E-1	5.0E-2
Tc-99m[a]	3.0E+0	W	8.0E-1	8.0E-1
Kr-85m	8.0E+2	-	-	-
Kr-88	1.4E+3	-	-	-
Ar-41	8.0E+2	-	-	-
C-14	1.0E-4	-	9.5E-1	9.5E-1
H-3	1.6E+2	-	9.5E-1	9.5E-1
		LICE-32		
Xe-133	5.0E+0	-	-	-
I-131	2.3E-3	D	9.5E-1	9.5E-1
		PART-70		
Ar-41	1.0E-4	-	-	-
O-15	1.0E+0	-	-	9.5E-1
C-14	1.0E-9	-	9.5E-1	9.5E-1
N-13	4.0E-2	-	-	9.5E-1
C-11	2.0E-3	-	-	9.5E-1
H-3	1.0E+0	-	9.5E-1	9.5E-1

[a] Particle size is 0.3 micron.

Table 45. Versions of RADRISK data file used in DARTAB runs

GOLD	NARM	NUFE	LICE	PART

Runs made on original RADRISK data file:

25 P

Runs made after the following additions were made to the RADRISK data file: *N-P*, *PUL*, *T-B* factors set equal to LUNGS (5-9-80),; Rn-222, Rn-220, Rn-219, IND = 2, 12, 99 deleted (5-12-80); risk factors for H-3, IND = 2 corrected (5-13-80); internal dose conversion factors for C-14, Sc-46, Hf-181, W-181, and K-40, IND = 2, 3, 13, 99 added (5-19-80) risk factors for Rn-222, IND = 33 corrected (5-26-80); and respiratory classification 00000000 set equal to 40404040 to obtain correct sorting order (5-28-80):

01 P
02 P
03 P
04 P
05 (S1) P
05 (S2) P
05 (S3) P
06 P
07 P
09 P
11 P
12 P
13 P
14 P
15 P
16 P
17 P
18 P
19 P
22 P
24 P
26 (S1) P
26 (S2) P
27 P
28 P
31 (S2) P
32 (S2) P
33 (S2) P
43 (S1) P
43 (S2) P

Table 45. (continued)

GOLD	NARM	NUFE	LICE	PART
29 P				
81 P				
82 P				
83 P				
101 P				
102 P				
Runs made after the following additions were made to the RADRISK file: years of life lost set equal to 23.80 for Rn-222, IND = 33 (6-11-80):				
01 I	10A P & I	11 P & I	10 P & I	70 P & I
02 I	10B P & I	12 P & I	31 P & I	
03 I	20 P & I	21 P & I	32 P & I	
04 I	31 (S2) I	22 P & I		
05 (S1) I	32 (S2) I	30 P & I		
05 (S2) I	33 (S2) I	40A P & I		
05 (S3) I	41 (S1) P & I	40B P & I		
06 I	41 (S2) P & I	51A P & I		
07 I	42 (S1) P & I	51B P & I		
09 I	42 (S2) P & I	52A P & I		
11 I	43 (S1) I	52B P & I		
12 I	43 (S2) I	61 (S1) P & I		
13 I	50 (S1) P & I	61 (S2) P & I		
14 I	50 (S2) P & I	62 P & I		
15 I	62 I			
16 I	90A I			
17 I	90B I			
18 I	100A I			
19 I	100B I			
20 P & I				
21 P & I				
22 I				
23 P & I				
24 I				
25 I				
26 (S1) I				
26 (S2) I				
27 I				
28 I				
29 I				
81 I				
82 I				
83 I				
101 I				
102 I				

Table 45. (continued)

GOLD	NARM	NUFE	LICE	PART
Runs made after the following additions were made to the RADRISK file: particle sizes 0.3 and 3.0 added for Ac-228; Bi-210, 212, 214; Pa-234m; Pb-210, 212, 214; Po-210, 212, 214, 216, 218, 234; Ra-224, 226, 228; Rn-222; Th-228, 230, 232, 234; Tl-208; and U-234, 238 (6-27-80); external dose conversion factors for Ra-228 changed (7-18-80):				
	31 (S1) I & P	13 (S1) I & P		
	32 (S1) I & P	13 (S2) I & P		
	33 (S1) I & P			
	62 P			
	80A I & P			
	80B I & P			
	90A P			
	90B P			
	100A P			
	100B P			

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