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Recommended ALIs and DACs for 10 CFR Part 20: A Consistent Numerical Set

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RECOMMENDED ALIs and DACs FOR 10 CFR PART 20: A Consistent Numerical Set

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ABSTRACT

Appendix B to 10 CFR Part 20 contains numerical data for controlling the intake of radionuclides in the workplace or in the environment. These data, derived from the recommendations of the International Commission on Radiological Protection (ICRP), do not provide a numerically consistent basis for demonstrating compliance with the limitation on dose stated in the regulation. This situation is largely a consequence of the numerical procedures used by the ICRP which did not maintain, in a strict numerical sense, the hierarchial relationship among the radiation protection quantities. In this work recommended values of the quantities in Appendix B to CFR Part 20 are developed using the dose coefficients of the applicable ICRP publications and a numerical procedure which ensures that the tabulated quantities are numerically consistent.

1. INTRODUCTION

Radiation protection standards for workers and the general public are based, in the United States, on a hierarchy of recommendations including those of the International Commission on Radiological Protection (ICRP), the National Council on Radiation Protection and Measurements (NCRP) and the responsible Federal agencies. The current standards in the United States were signed into law by President Ronald Reagan in 1987 (EPA 1987). The Nuclear Regulatory Commission (NRC) revised its radiation protection standards for protection against ionizing radiation in an amendment to 10 CFR Part 20 (NRC 1992a). That amendment serves as the basis for NRC's regulation of ionizing radiation. The numerical data for controlling exposure to and intake of specific radionuclides in the workplace and in the environment are contained in Appendix B of 10 CFR Part 20.

The data of Appendix B of 10 CFR Part 20 were derived from Publication 30, Parts 1-4 (ICRP 1979, 1980, 1981a, 1988) of the ICRP. Further guidance regarding acceptable use of these data in demonstrating compliance with the occupational limits was provided in Regulatory Guide 8.34 (NRC 1992b). The utility of that guidance is impacted by the failure of the data of Appendix B to fully preserve the hierarchical relationships among the various radiation protection quantities. The purpose of this report is to recommend a set of data for controlling radionuclides in the workplace and the environment that adheres to the principles and dose limits of 10 CFR Part 20 and preserves the hierarchical relationships among the various radiation protection quantities.

A cursory examination of Appendix B of 10 CFR Part 20 reveals a number of deficiencies. For example, the presentation implies a relationship between the clearance classes assigned to chemical forms of the radionuclide that may be inhaled and the limit on intake by ingestion. Even for radionuclides where chemical form is well known to influence the magnitude of the radiation dose, the limits on the activity that might be ingested are specified without reference to chemical form. In tabulating the data from the recommendation documents, the NRC apparently chose to ignore these known differences in radiation dose based on chemical form and hence tabulated only the most restrictive value for ingestion of each radionuclide. This decision can have a substantial impact since, for example, the uptake to blood of various chemical forms of plutonium considered in Part 4 of Publication 30 (ICRP 1988) varied more than two orders of magnitude.

Many examples of numerical values of questionable origin can be seen in Appendix B. For example, the entries for ingestion of Be-10 and F-18 indicate that the intakes of these radionuclides are limited by the constraint on organ dose (non-stochastic health effects), yet identical values are tabulated for the constraint on the effective dose (associated with stochastic health effects). The data for inhalation of Os-189m provides another interesting example. The annual limits on intake of Os-189m in chemical forms corresponding to all three clearance classes were assigned the same value, yet when those values were divided by the volume of air breathed in a year — a constant, three different answers were obtained. Additional numerical artifacts are evident in the tabulations. The artifacts arise, in part, as a consequence of an excessive rounding procedure used by the ICRP in Publication 30 — excessive in that it fails to preserve the numerical relationship between the various quantities. Unfortunately these artifacts are amplified when, as set forth in Regulatory Guide 8.34, compliance with the dose limits of 10 CFR Part 20 is demonstrated using various protection quantities. That is, a situation demonstrated to be in compliance based on one protection quantity may be found to be in non-compliance by a mathematically equivalent analysis using a different protection quantity. Furthermore, one does not know *a priori* which analysis would be conservative. These matters were first called to the author's attention by M. W. Lantz in 1991 and have been discussed in the open literature (Poston and Poston 1992, Windham *et al.* 1994) although no solution nor basis for a recommendation was presented.

In this report, a computational procedure is established to derive numerical values of the radiation protection quantities which are consistent with their hierarchical relationships. The procedure is used to tabulate the numerical data in the manner of Appendix B to 10 CFR Part 20. We begin with a brief discussion of the radiation protection guidance set forth in 10 CFR Part 20 to define the relationship between the primary and secondary limits and to identify the origins of the numerical difficulties noted above. We then illustrate the impact of these numerical data in demonstrating regulatory compliance and define a computational procedure which yields numerical values for the radiation protection quantities that are consistent with their hierarchical relationship. Finally, a full set of internally consistent numerical data is presented in an appendix in the manner of Appendix B to 10 CFR Part 20.

2. RADIATION PROTECTION GUIDANCE

Radiological control of the workplace can be demonstrated by comparison of the estimated radiation dose with the primary dose limits (numerical constraints on dose). In the case of intakes of radionuclides into the body either through ingestion, inhalation, or wounds, the dose must be calculated from knowledge of the intake or the time-integrated activity concentration of the radionuclides in air or water. Committee 2 of the ICRP, in Publication 30 (ICRP 1979), translated the primary dose limits stated in Publication 26 (ICRP 1977) into secondary limits representing the quantity of the radionuclide which if inhaled or ingested by a reference individual would irradiate the body to levels corresponding to the primary limits. The secondary limits were computed assuming the anatomical and physiological characterization of Reference Man (ICRP 1975) and the dosimetric and biokinetic models of Publication 30 (ICRP 1979).

Primary Limits

Paragraph 10 CFR 20.1201 of the revised 10 CFR Part 20, states the primary limits (dose limits) for occupationally exposed adults. The limits apply to the sum of the dose received from external exposure and the dose from internally deposited radionuclides. Paragraph 20.1201(a) states the limits as:

a. the annual effective dose equivalent is limited to 5 ***rem*** (0.05 ***Sv***),

b. the annual dose equivalent to any organ or tissue (other than lens of the eye) is limited to 50 ***rem*** (0.5 ***Sv***).

The occupational dose limits for minors, stated in paragraph 20.1207, are 10% of the dose limits for adult workers — paragraph 210.1208 establishes a dose limit for the embryo/fetus of 0.5 ***rem*** (5 ***mSv***). In the discussions below, the limits on the effective dose equivalent and dose equivalent in organ or tissue T are represented by the symbols $H_{Limit,E}$ and $H_{Limit,T}$, respectively, to enable presenting equations without reference to a particular system of units.

The effective dose equivalent, H_E, is defined as

$$H_E = \sum_T w_T H_T \qquad (1)$$

where w_T is the weighting factor for organ or tissue T, and H_T is the corresponding dose equivalent for organ or tissue T. The summation in Eq. 1 extends over all irradiated tissues. The weighting factor for an organ or tissue represents the contribution of that tissue to the risk of cancer (genetic effects if the organ is the gonads) when the body is irradiated in a uniform manner. The weighting factors are given in Table 1.

Table 1. Tissue Weighting Factors

Organ/Tissue	w_T
Gonads	0.25
Breast	0.12
Lung	0.12
Red Marrow	0.12
Bone Surface	0.03
Thyroid	0.03
Remainder*	0.30

* A value of 0.06 is to be applied to the five most highly irradiated tissues not explicitly named, excluding skin.

For the various radionuclides, ICRP Committee 2 translated the annual dose limits into annual limits on intake and/or air concentrations which, if experienced by Reference Man (ICRP 1975), would result in radiation doses corresponding to the annual dose limits. The starting point in the translation is the computation of the committed dose equivalent in the various organs and tissues of the body per unit intake. The committed dose equivalent is the total dose equivalent that organs or tissues will experience in the 50-year period following the intake of a radionuclide and is denoted by $H_{50,T}$; the dose coefficient (the committed dose equivalent per unit intake) is denoted as $h_{50,T}$. In a similar manner, we denote the committed effective dose equivalent as $H_{50,E}$ and the corresponding dose coefficient as $h_{50,E}$. Committee 2 published dose coefficients for those tissues of the body that contributed substantially in determination of the annual limit on intake but they did not publish the effective dose equivalent coefficients (ICRP 1979). The coefficients were published in Federal Guidance Report No. 11 (Eckerman *et al.* 1988) and a full set of dose coefficients is available from Eckerman and Ryman (1993).

Secondary Limits

The annual intake I of a radionuclide, by ingestion or inhalation, must satisfy the constraint on the effective dose equivalent, $H_{Limit,E}$, and the constraint on organ dose, $H_{Limit,T}$. That is, the product of the activity inhaled or ingested (the intake) and the dose coefficient must be less than the applicable dose limit; i.e.,

$$I\, h_{50,E} \le H_{Limit,E} \quad and \tag{3a}$$

$$I\, h_{50,T} \le H_{Limit,T} \quad for\ all\ T \ . \tag{3b}$$

The constraint of Eq. 3a is frequently referred to as the stochastic constraint since the effective dose equivalent is a measure of the risk of cancer and genetic effects suitable for radiation protection purposes, i.e., a linear function of dose without threshold. The annual intake permitted by this constraint, ALI_S, is

$$ALI_S = \frac{H_{Limit,E}}{h_{50,E}} \ . \tag{4a}$$

The constraint of Eq. 3b, the "non-stochastic" or "deterministic" constraint, was formulated to avoid impairing the functioning of organs and tissues of the body. The annual intake permitted by this constraint, ALI_{NS}, is

$$ALI_{NS} = MIN(\frac{H_{limit,T}}{h_{50,T}} \ ; \ T = 1, 2, ..., M) \tag{4b}$$

where the function MIN denotes the minimum value of the M arguments. The annual limit on intake, ALI, must satisfy both constraints and thus is

$$ALI = MIN(ALI_S, ALI_{NS}) \ . \tag{4c}$$

The ALI is the minimum activity of the radionuclide that can be taken into the body and satisfy the constraint on the effective dose equivalent, ALI_S, and the constraint on the dose equivalent in the individual organs and tissues of the body, ALI_{NS}.

In Appendix B of 10 CFR Part 20, if the ALI for a radionuclide was based on the non-stochastic constraint, the intake corresponding to the stochastic constraint, ALI_S, was also tabulated along with the identity of the organ or tissue involving the non-stochastic constraint. It has become common practice to speak of the "*nonstochastic ALI (NALI)*" and the "*stochastic ALI (SALI)*" although only a single *ALI* satisfies the dose limits.

The concentration of a radionuclide in air, which if breathed by Reference Man during a working year, that results in the intake of an *ALI* is referred to as the Derived Air Concentration (*DAC*). The *DAC* is given by

$$DAC = \frac{ALI}{q} \tag{5}$$

where q is the annual intake of the radionuclide per unit airborne concentration. For all radionuclides, other than tritiated water vapor and radon - which are discussed later, q is simply the annual occupational intake of air, 2.4 10^3 m^3 (the product of 2000 h x 0.02 m^3/min x 60 min/h). In the case of tritiated water vapor, the intake occurs through two routes: inhalation and dermal (skin) absorption. The total intake of tritiated water through these two routes is 1.5 times that due only to inhalation; i.e., q is 3.6 10^3 m^3 for tritiated water vapor.

Some airborne radionuclides, in particular isotopes of the noble gas elements, do not deposit within the lung when inhaled and they are not metabolized by the body to any appreciable extent. The secondary limits for these radionuclides are based, therefore, on consideration of the external dose due to submersion in air containing the radionuclide. For such situations, the DAC may be derived directly from the primary limits. The annual average airborne concentration $\bar{C}$ of the radionuclide must satisfy the constraints:

$$2000\ \dot{h}_{E,Sub}\ \bar{C} \le H_{Limit,E} \tag{6a}$$

$$2000\ \dot{h}_{Lens,Sub}\ \bar{C} \le H_{Limit,Lens} \tag{6b}$$

$$2000\ \dot{h}_{T,Sub}\ \bar{C} \le H_{Limit,T}\ \ for\ all\ T, \tag{6c}$$

where $\dot{h}_{E,Sub}$, $\dot{h}_{Lens,Sub}$, and $\dot{h}_{T,Sub}$ are dose rate coefficients for the effective dose equivalent, the lens of the eye, and tissue T, respectively, due to submersion exposure per unit activity concentration of the radionuclide in air. The factor 2000 denotes the number of working hours in a year. The dose rate coefficients are thus assumed to have time units of inverse hours. The DAC is the maximum value of $\bar{C}$ that satisfies the above inequalities.

3. CALCULATION OF SECONDARY LIMITS

Establishing a limit on intake of a radionuclide begins with a calculation of the committed dose equivalent in the various organs and tissues of the body per unit intake of the radionuclide. Such factors depend on the chemical form of the radionuclide and are referred to as dose factors or dose coefficients. For exposures to airborne noble gas radionuclides, referred to as submersion, the activity concentration corresponding to the dose limits, the derived air concentrations (*DAC*), are calculated from dose coefficients relating the organ dose rate to the airborne concentration. In the Supplements to Publication 30, the ICRP published the coefficients for those organs and tissues necessary to reproduce the calculations of the *ALI* and *DAC*. At the time Publication 30 was prepared, the ICRP had not used the term "effective dose equivalent" but referred to the "sum of the weighted dose equivalent." ICRP Committee 2 devised a procedure, the so-called 10% rule, to restrict the published coefficients to only those tissues which were numerically significant in establishing the *ALI*. In addition, the ICRP continued its earlier practice of rounding the secondary limits to a single digit. As shown below, the 10% rule and the rounding procedure disrupts the numerical relationships among the quantities.

ICRP Publication 30's 10% Rule

ICRP Committee 2 formulated and used the 10% rule to limit the numerical data presented in the Supplements to Publication 30. Those organs or tissues *T* for which the product of the applicable tissue weighting factor and committed dose equivalent per unit intake, $w_T\, h_{50,T}$, was less than 10% of the maximum value of $w_T\, h_{50,T}$ were not considered in the computation of the *ALIs* and *DACs* and thus data for these tissues do not appear in the Supplements. This procedure was very effective in reducing the size of the Supplements; e.g., only data for the thyroid gland are found in the Supplements for radioiodines. In computations of dose, however, the 10% rule should not be used and was not used in the computations of the effective dose equivalent coefficients given in Federal Guidance Report No.11 (Eckerman *et al.* 1988). Furthermore, ICRP Committee 2 has not used the 10% rule in any publications following Publication 30. An illustrative example is presented below for which the contributions to the effective dose equivalent by tissue retained with the 10% rule accounts for slightly more than half of the effective dose equivalent.

Rounding Procedures

Committee 2 rounded the calculated *ALI* and *DAC* values to a single digit for publication. The rounding procedure employed was consistent with usual numerical rounding; i.e., values between 0.5 and 1.4 round to 1, values between 1.5 and 2.4 round to 2, and so on. Under this procedure some values are rounded upward and other values downward. Since some *ALI* values were rounded upward, the rounding procedure fails to ensure that an intake of one *ALI* will not result in a dose numerically in excess of the dose limit.

Other Considerations

In Publication 30, Committee 2's decision as to whether the annual limit on intake was limited by nonstochastic or stochastic constraints was based on a comparison of the numerical values of ALI_S and ALI_{NS} as represented within the computer, not the rounded values that were published. This procedure resulted in the situation noted in the introduction in which the ***ALIs*** for ingestion of Be-10 and F-18 were listed as being based on the nonstochastic constraint and yet the exact same numerical value of intake was tabulated for the stochastic constraint.

In addition, ICRP Committee 2 computed the ***DACs*** from the computer's representation of the ***ALIs***, not from the rounded or published values of the ***ALIs***. The ***DACs*** were then rounded to a single digit. This explains the situation noted in the introduction for Os-189m. Again, the rounding procedure makes it possible for an annual occupational exposure (2000 h) to an airborne activity concentration corresponding to the ***DAC*** to result in an intake numerically in excess of the ***ALI*** and a dose in excess of the limit.

The computational procedures used by the ICRP can not be relied upon to preserve the numerical relationships between the primary and secondary limits. Note that while the maximum error of the rounding procedure is 50%, this is a varying multiplicative factor which can be as much as two. Furthermore, deriving the ***DAC*** from a value of the ***ALI*** that might vary by a factor of two from the published value jeopardizes the relationship between these two secondary quantities.

Illustrative Example

To illustrate the details in the calculation of the secondary limits, consider the data for the inhalation of *Class Y* compounds of Sr-85 in Table 2. Column one of the table lists the organs and tissues for which dose coefficients, $h_{50,T}$, were computed in Publication 30. The numerical values of the coefficients are given in column two. The product of the coefficients (column two) and the applicable tissue weighting factors (column three) is tabulated in column four. The maximum value in column four, the maximum weighted dose equivalent, is 8.58 10^{-10} $Sv\ Bq^{-1}$ for the lung; the entry is highlighted by a double underline. Using the 10% rule, only organs and tissues with weighted dose equivalents larger than 10% of the maximum weighted dose equivalent, or 8.58 10^{-11} $Sv\ Bq^{-1}$, are retained in the computations. Inspection of column four indicates that the lung is the only tissue surviving the 10% rule. Thus, if one approximates the committed effective dose equivalent by the sum of the weighted committed dose equivalent of the tissues surviving the 10% rule then the committed effective dose equivalent for inhalation of *Class Y* compounds of Sr-85 is 8.6 10^{-10} $Sv\ Bq^{-1}$ (this value is found in the Supplement to Publication 30).

If the 10% rule is not used, as in Federal Guidance Report 11, the committed effective dose equivalent is the sum of the underlined values of weighted committed dose equivalent in column four or 1.36 10^{-9} $Sv\ Bq^{-1}$. In Federal Guidance Report 11, dose coefficients are given to three digits of which only two were apparently considered significant by the ICRP. The additional digit can be viewed as a "guard" and the result of subsequent calculations using these data should be rounded to no more than two digits.

The *ALI* and *DAC* for inhalation of *Class Y* forms of Sr-85 calculated in the manner of ICRP Publication 30, (i.e., with the 10% rule and rounding to a single digit), are

$$ALI = \frac{0.05\ Sv}{8.58\ x\ 10^{-10}\ Sv\ Bq^{-1}}$$

$$= 6\ x\ 10^{7}\ Bq$$

$$DAC = \frac{0.05\ Sv}{8.58\ x\ 10^{-10}\ Sv\ Bq^{-1}\ 2400\ m^{3}}$$

$$= 2\ x\ 10^{4}\ Bq\ m^{-3}.$$

The corresponding values calculated without the 10% rule and with the *DAC* calculated from the rounded *ALI*, rounded to 2 digits, are

$$ALI = \frac{0.05\ Sv}{1.36\ x\ 10^{-9}\ Sv\ Bq^{-1}}$$

$$= 3.6\ x\ 10^{7}\ Bq$$

$$DAC = \frac{3.6\ x\ 10^{7}\ Bq}{2400\ m^{3}}$$

$$= 1.5\ x\ 10^{4}\ Bq\ m^{-3}.$$

The combination of the 10% rule and the rounding procedure were responsible for almost a factor of two numerical uncertainty in the *ALI* (6 10^{7} vs 3.6 10^{7} *Bq*). This example was selected because of the large effect of the 10% rule on the *ALI*. Other examples could be presented that would illustrate an even greater impact of the rounding procedure.

Table 2. Committed Effective Dose Equivalent Coefficient for Inhalation of Class *Y* Forms of Sr-85

Organ/Tissue	$h_{50,T}$ (Sv Bq^{-1})	w_T	$w_T\, h_{50,T}$ (Sv Bq^{-1})
Gonads	3.34E-10	0.25	8.35E-11
Breast	4.65E-10	0.15	6.97E-11
Lung	7.15E-09	0.12	8.58E-10
R. Marrow	4.65E-10	0.12	5.58E-11
B. Surface	3.50E-10	0.03	1.05E-11
Thyroid	3.85E-10	0.03	1.15E-11
Remainder Tissues[1]			
Adrenals	7.87E-10	0.06	4.72E-11
Bladder Wall	1.11E-10	0.06	6.66E-12
St Wall	6.59E-10	0.06	3.95E-11
SI Wall	3.78E-10	0.06	2.27E-11
ULI Wall	5.87E-10	0.06	3.52E-11
LLI Wall	9.12E-10	0.06	5.47E-11
Kidneys	3.67E-10	0.06	2.20E-11
Liver	7.71E-10	0.06	4.63E-11
Pancreas	9.03E-10	0.06	5.42E-11
Spleen	6.95E-10	0.06	4.17E-11
Thymus	1.15E-09	0.06	6.90E-11
Uterus	1.43E-10	0.06	8.58E-12
		$h_{50,E}$ *with* 10% *rule*	8.58E-10
		$h_{50,E}$ *without* 10% *rule*	1.36E-09

[1] Only the five tissues with the highest dose equivalent coefficient are retained.

4. REGULATORY ISSUES

Regulatory Guide 8.34 (NRC 1992b) provides guidance on procedures considered acceptable in demonstrating compliance with the dose limits for the effective dose equivalent and the dose equivalent. The Guide defines the "total effective dose equivalent" as the sum of the "deep-dose equivalent" (from radiation sources external to the body) and the "committed effective dose equivalent" (from radionuclide intakes). The total dose equivalent to an organ is similarly defined as the sum of the "deep-dose equivalent" and the "committed dose equivalent" from the intake of radionuclides in a year. The guide lists various procedures that the NRC finds acceptable for calculation of the committed effective dose equivalent from inhalation and ingestion intakes. Four of the procedures use tabulated dosimetric information to serve as estimates of the committed effective dose equivalent per unit intake, $h_{50,E}$, and thus are of interest here. The procedures include:

1. Use dose coefficient, $h_{50,E}$, from Federal Guidance Report No. 11 (Eckerman *et al.*, 1988). That report lists the committed effective dose and the committed dose equivalent coefficients for both inhalation and ingestion intakes of radionuclides. The effective dose equivalent $H_{50,E}$ is computed from knowledge of the intake I of the radionuclide as

$$H_{50,E} = I\, h_{50,E} \tag{7a}$$

   where $h_{50,E}$ is the effective dose equivalent coefficient for the radionuclide.

2. Use the stochastic *ALI* of Appendix B to 10 CFR Part 20 and knowledge of the intake I of the radionuclide to compute the effective dose equivalent. The effective dose equivalent is

$$H_{50,E} = I\, \frac{H_{Limit,E}}{ALI_S} \tag{7b}$$

   where I is the intake and $H_{Limit,E}$ is the annual limit on effective dose equivalent.

3. Use the *DAC* of Appendix B to 10 CFR Part 20, if the *ALI* is based on the stochastic constraint, and express the intake in terms of the time-integrated airborne concentration. The effective dose equivalent is

$$H_{50,E} = \left[\frac{q}{2000}\int_0^{2000} C(t)\,dt\right]\left[\frac{H_{Limit,E}}{q\,DAC}\right]$$

$$= q\,\bar{C}\,\frac{H_{Limit,E}}{q\,DAC} \tag{7c}$$

$$= I\,\frac{H_{Limit,E}}{q\,DAC}$$

where t is in hours, $C(t)$ is the airborne concentration, DAC is the derived air concentration corresponding to the ALI, q is the annual intake per unit airborne activity concentration (see Eq. 5), $\bar{C}$ is the annual average activity concentration, and $H_{Limit,E}$ is the annual limit on the effective dose equivalent.

4. Approximate the effective dose equivalent coefficient as the sum of the "weighted committed dose equivalents" listed in the Supplements of ICRP Publication 30. As discussed above, Committee 2 tabulated the "weighted committed dose equivalent to target organs or tissues per intake of unit activity" which were not eliminated by the 10% rule. These values can be summed to approximate the committed effective dose equivalent per unit intake. The effective dose equivalent $H_{50,E}$ is computed from the intake I as

$$H_{50,E} = I \sum_T w_T\, H_{50,T} \tag{7d}$$

where $w_T\, H_{50,T}$ is the weighted committed dose equivalent tabulated in the Supplements. Since the tabulations were limited by the 10% rule, the summation can only extend over tabulated values.

All four procedures are mathematically equivalent. However, the 10% rule and the rounding procedure used in tabulating the numerical values results in the procedures yielding different numerical values. Procedures one and four differ in that the former utilizes dose coefficients not based on the 10% rule and given to three digits while the latter is based only on the tissues surviving the 10% rule and is limited to two digits. Procedures two and three are the least desirable, from a numerical perspective, since the ALI and DAC were only given to a single digit — the extensive rounding limits the utility of these quantities in estimating effective dose equivalent.

Considering the manner in which the numerical values of the secondary quantities were derived, one cannot expect the procedures suggested in Regulatory Guide 8.34 to yield the same estimates of the effective dose equivalent. It is instructive to examine the extent to which the procedures approximate the effective dose equivalent coefficient. Table 3 compares, for a selected number of radionuclides, the values of the committed effective dose equivalent per unit intake as estimated by these procedures with the value from Federal Guidance Report 11. Examination of the table confirms that the suggested procedures are numerically inconsistent. The estimates based on the data from the Supplements of ICRP Publication 30, tabulated in column four, nearly always underestimate the actual value (column three) since the former includes the 10% rule. Estimates based on the secondary limits ALI and DAC, the last two columns, may over- or underestimate the committed effective dose equivalent. Thus, the procedures recommended in Regulatory Guide 8.34 are of questionable utility in demonstration of regulatory compliance since they, in fact, result in numerically different values.

Table 3. Values of the Committed Effective Equivalent per Unit Inhaled Activity ($Sv\ Bq^{-1}$) per Regulatory Guide 8.34

Nuclide	Class	FGR 11[1]	ICRP 30[2]	Computed from *ALI*[3]	Computed from *DAC*[4]
H-3	Vapor	1.73E-11	1.7E-11	2E-11	2E-11
Co-60	W	8.94E-09	8.0E-09	8E-09	7E-09
	Y	5.91E-08	4.1E-08	5E-08	4E-08
Fe-59	D	4.00E-09	4.0E-09	5E-09	4E-09
	W	3.30E-09	2.7E-09	2E-09	3E-09
Sr-85	D	5.18E-10	5.2E-10	5E-10	5E-10
	Y	1.36E-09	8.6E-10	8E-10	1E-09
Sr-90	D	6.47E-08	6.2E-08	6E-08	-----[5]
	Y	3.51E-07	3.4E-07	5E-07	3E-07
Zr-95	D	6.39E-09	5.2E-09	5E-09	-----
	W	4.29E-09	3.5E-09	5E-09	3E-09
	Y	6.32E-09	4.9E-09	5E-09	5E-09
Mo-99	D	5.42E-10	5.2E-10	5E-10	5E-10
	W	1.07E-09	9.9E-10	1E-09	1E-09
I-131	D	8.89E-09	8.8E-09	8E-09	-----
Cs-137	D	8.63E-09	8.7E-09	8E-09	1E-08
Ce-144	W	5.84E-08	5.3E-08	6E-08	5E-08
	Y	1.01E-07	9.5E-08	1E-07	1E-07
Ra-226	W	2.32E-06	2.1E-06	2E-06	2E-06
Th-232	W	4.43E-04	4.4E-04	5E-04	-----
	Y	3.11E-04	3.1E-04	2E-04	-----
U-234	D	7.37E-07	7.2E-07	7E-07	-----
	W	2.13E-06	1.9E-06	2E-06	2E-06
	Y	3.58E-05	3.6E-05	5E-05	3E-05
Pu-239	W	1.16E-04	1.1E-04	1E-04	-----
	Y	8.33E-05	8.1E-05	8E-05	-----
Am-241	W	1.20E-04	1.2E-04	1E-04	-----

[1] From Table 2.1 of Eckerman, *et al.* (1988).
[2] Computed from Supplements to ICRP Publication 30.
[3] Computed as 0.05/*ALIs* using the *ALI* from Publication 30.
[4] Computed as 0.05/2400 *DAC*, if the *ALI* is based on stochastic considerations.
[5] *DAC* not based on stochastic consideration.

5. RADON DECAY PRODUCTS

Because of difficulties in calculating the dose to lung tissues from inhalation of the short-lived decay products of radon, a different type of secondary limit has been used for controlling such exposures (FRC 1967). The quantity, Working Level Month (***WLM***) — developed for use in regulating the exposure of underground uranium miners, has gradually gained application to other workers as well. In 1969, the previous 12 ***WLM*** guidance for annual exposures to the short-lived decay products of Rn-222 was reduced, for a trial period, to 4 ***WLM***. There apparently was not adequate basis for less stringent protection and the recommended 4 ***WLM*** limit remains in effect (EPA 1971a, 1971b).

The ICRP reviewed the epidemiological and dosimetric data for the two radon isotopes of concern. It recommended guidance for Rn-222 that is comparable to the 4 ***WLM*** value in use in the United States. It also concluded that the risk from inhalation of the short-lived decay products of Rn-220 is about one-third that associated with Rn-222 decay products (ICRP 1981b). This relationship was used in Federal Guidance Report No. 11 (Eckerman *et al.* 1988) to establish 12 ***WLM*** as the guidance for Rn-220. The secondary quantities presented here are based on these guidelines.

The relationship between ***WLM*** and Rn-222 equilibrium-equivalent concentration in the workplace is 0.00126 ***WLM per*** $Bq\ m^{-3}$, assuming 2000 ***h*** per year at work and an equilibrium factor ***F*** of 40% (ICRP 1987)[1]. Thus 4 ***WLM*** corresponds to a Rn-222 concentration of 3200 $Bq\ m^{-3}$ or 8.6 10^{-8} $\mu Ci\ ml^{-1}$. For Rn-220 the relationship between ***WLM*** and Rn-220 equilibrium-equivalent concentration is 0.017 ***WLM per*** $Bq\ m^{-3}$ and thus the 12 ***WLM*** corresponds to an Rn-220 concentration of 700 $Bq\ m^{-3}$ or 1.9 10^{-8} $\mu Ci\ ml^{-1}$. The ***DAC*** values as a function of equilibrium factor ***F*** are given in Table 4 and shown graphically in Fig. 1. Note that Table 4 contains an entry for pure radon (***F*** equal zero) although such exposure conditions are not typical of the workplace or the environment.

For public exposures and Rn-222, the relationship between ***WLM*** and Rn-222 concentration is 0.0044 ***WLM per*** $Bq\ m^{-3}$, assuming continuous exposure and an equilibrium factor of 0.4. Thus 0.3 ***WLM*** corresponds to an Rn-222 concentration of 68 $Bq\ m^{-3}$ or 1.8 10^{-9} $\mu Ci\ ml^{-1}$. For Rn-220, the relationship 0.059 ***WLM per*** $Bq\ m^{-3}$ and the 1 ***WLM*** exposure limit yields Rn-220 air concentration of 16 $Bq\ m^{-3}$ or 4.6 10^{-10} $\mu Ci\ ml^{-1}$.

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[1] The equilibrium-equivalent radon concentration of a non-equilibrium mixture of short-lived Rn-daughters in air is that activity concentration of radon in radioactive equilibrium with its short-lived daughters that has the same potential α-energy concentration as the non-equilibrium mixture. The "equilibrium factor F" is the ratio, often expressed as a percent, of the actual radon activity concentration to the equilibrium-equivalent radon concentration of the non-equilibrium mixture.

Table 4. Equilibrium-equivalent radon derived air concentrations (*DAC*) as a function of equilibrium.

	Rn-220		Rn-222	
F(%)	*DAC* (*Bq m*$^{-3}$)	*DAC* (μ*Ci ml*$^{-1}$)	*DAC* (*Bq m*$^{-3}$)	*DAC* (μ*Ci ml*$^{-1}$)
0.0	2.3E+05	6.2E-06	1.4E+05	3.8E-06
1.0	3.1E+04	8.4E-07	1.2E+05	3.1E-06
2.0	2.3E+04	6.3E-07	8.5E+04	2.3E-06
4.0	1.2E+04	3.2E-07	3.8E+04	1.0E-06
6.0	6.1E+03	1.6E-07	2.1E+04	5.7E-07
8.0	3.6E+03	9.6E-08	1.6E+04	4.2E-07
10.0	2.8E+03	7.4E-08	1.3E+04	3.4E-07
20.0	1.4E+03	3.8E-08	6.3E+03	1.7E-07
40.0	7.0E+02	1.9E-08	3.2E+03	8.6E-08
60.0	4.6E+02	1.2E-08	2.1E+03	5.7E-08
80.0	3.5E+02	9.4E-09	1.6E+03	4.3E-08
100.0	2.8E+02	7.5E-09	1.3E+03	3.4E-08

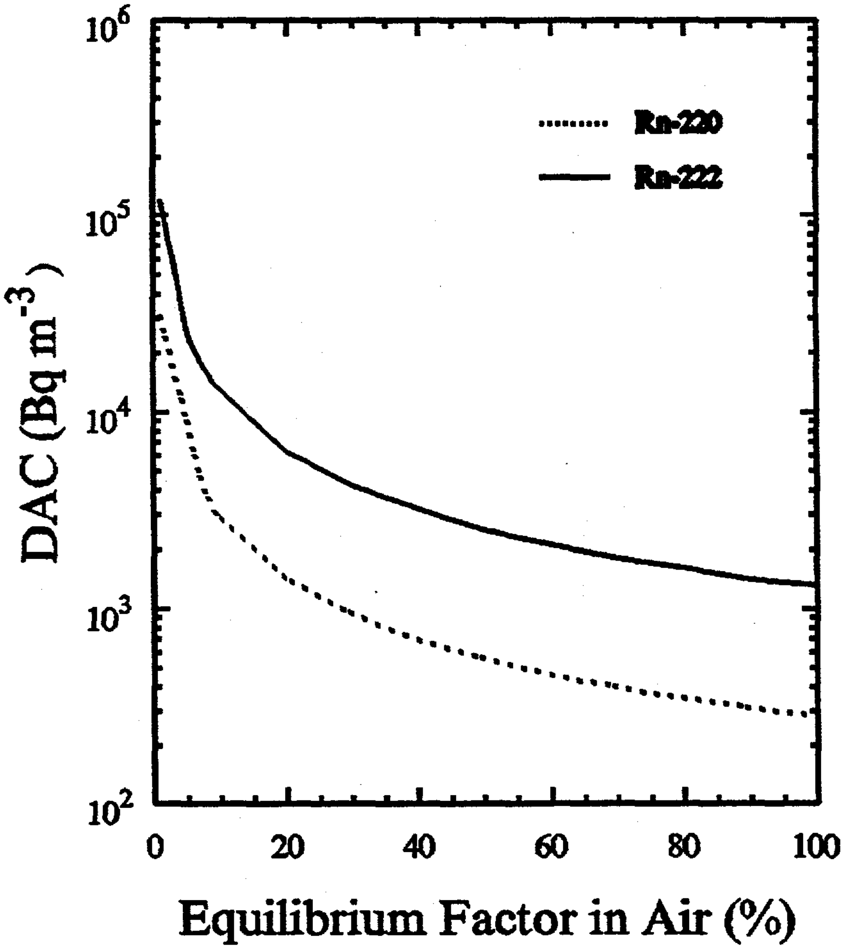

Figure 1. The equilibrium-equivalent DAC of radon for a non-equilibrium mixture of its short-lived daughters as a function of equilibrium.

6. RECOMMENDED VALUES FOR RADIONUCLIDE *ALIs* and *DACs*

A computational procedure was formulated to derive the radiation protection quantities in a manner that preserves their hierarchial relationships. The hierarchial relationship establishes the dose coefficients as the primary basis for estimation of dose with the ***ALI*** and ***DAC*** being of secondary importance. To establish the numerical relationship it was required that the secondary limits be derived without use of the 10% rule and that numerical rounding of values for publication must be performed in a manner consistent with the hierarchial relationships among the quantities. The computational procedure is briefly outlined below.

1. The dose coefficients for inhalation and ingestion intakes used in the calculations are those derived during preparation of Publication 30. Coefficients for selected radionuclides were published by Eckerman *et al.* (1981) and the coefficients determining the committed effective dose equivalent, including the committed dose equivalent for the organ or tissue encountering the nonstochastic constraint were published in Federal Guidance Report No. 11 (Eckerman *et al.* 1988), for inhalation and ingestion intakes, respectively. These data were retained in data files at Oak Ridge National Laboratory with an additional digit beyond the published data in the Supplements to Publication 30 and the 10% rule was not used in the computation of the committed effective dose equivalent.

   The dose rate coefficients for submersion used in the calculations of this report are those contained in Federal Guidance Report 12 (Eckerman and Ryman 1993). These data are very similar to the data of Publication 30 but represent more extensive calculations of the organ doses from photons emitted within a semi-infinite cloud.

2. The intakes corresponding to the stochastic and non-stochastic constraints were computed using the above noted dose coefficients and applicable equations. The numerical values of the intakes corresponding to the two constraints on dose were truncated, by algorithm, to two digits[2]. The ***ALI*** is the lesser of the two truncated values. If the two truncated values are equal then the ***ALI*** is considered to be based on the stochastic constraint. When the ***ALI*** is based on the non-stochastic constraint the intake corresponding to the stochastic constraint, $\boldsymbol{ALI_S}$, is tabulated in parentheses followed by the identity of the organ associated with the non-stochastic constraint. The algorithm truncates the numerical values; thus, if the ***ALI*** is used to estimate dose it will not result in an underestimate.

3. For inhalation and ingestion, the ***DAC*** is computed from the tabulated (truncated) value of the ***ALI*** and is truncated, by algorithm, to two digits. The truncation ensures that the intake resulting from an exposure to a time-integrated airborne activity concentration of 2000 ***DAC-h*** will be less than the ***ALI***.

   For submersion, the annual average air concentrations corresponding to the stochastic and non-stochastic constraints are computed. These values are truncated to two digits and the ***DAC*** is the lesser of the two values. If the ***DAC*** is based on the non-stochastic constraint on either the lens of the eye or any other tissue, then the air concentration corresponding to the stochastic constraint is tabulated in parentheses followed by the identity of the organ associated with the non-stochastic constraint.

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[2] The truncation operation retains only two nonzero digits. For example 1.416 becomes 1.4 and 1.993 becomes 1.9. The truncated value is always less than or equal to the original value.

The dose coefficients of Federal Guidance Reports No. 11 and 12 were tabulated in SI units. The secondary quantities tabulated in this report were expressed in traditional units as in Appendix B to 10 CFR Part 20. The computations proceeded by first converting the dose coefficients to traditional units, within the software, and the calculations then continued with the dose limits also expressed in traditional units.

Appendix B of 10 CFR Part 20 contains guidance regarding the concentrations of radionuclides in effluent and sewage streams which was derived from the secondary quantities. As the numerical values of the secondary quantities have been revised here for completeness, the concentration data for the effluent and sewage streams have also been updated. The revised values are also given in Appendix A of this report.

7. DISCUSSION AND CONCLUSIONS

A revised set of numerical guides, tabulated in Appendix A, has been established in a manner that preserves, in a numerical sense, the hierarchial relationship among the quantities and is consistent in content with Appendix B of 10 CFR Part 20. This was accomplished by not using the 10% rule of ICRP Publication 30 and by using a rounding (truncating) procedure that preserves the relationships among the quantities. Below are some observations regarding the new tabulations together with recommendations regarding the use of the revised data.

Hierarchial Relationships:

It was illustrated in Table 3 that the numerical data tabulated in Appendix B to 10 CFR Part 20 could not be used as suggested in Regulatory Guide 8.34 to estimate a unique value of the effective dose equivalent. That table illustrates the nature of the "numerical noise" in the existing Appendix B and shows that it is not possible to determine which of the procedures recommended in Regulatory Guide 8.34 might be more conservative. Thus, the user does not know *a priori* which procedure will provide a conservative determination of compliance. In Table 5 we show that the revised numerical values presented in Appendix A of this report provide a consistent basis for assessing compliance. In Table 5, the column headed "ICRP 30" is simply the data of the corresponding column of Table 3, expressed, however, in conventional units. Ignoring that column for the moment, examination of the numerical values of the effective dose equivalent derived from the ***ALI*** and the ***DAC***, the data contained in the columns headed by "ALI_S" and "***DAC***", are equal to or greater than the corresponding value in the column headed "FGR 11." Thus, use of the ***ALI*** or ***DAC*** from the tabulations of Appendix A of this report with the procedures suggested in Regulatory Guide 8.34 will not underestimate the effective dose equivalent. That is, use of the ***ALI*** and ***DAC*** will not indicate compliance when use of the committed effective dose equivalent of Federal Guidance 11 would suggest non-compliance. The data reflect a hierarchial relationship among the committed effective dose equivalent coefficient $h_{50,E}$, the ***ALI***, and the ***DAC*** for the radionuclide. The ***ALI*** and ***DAC*** provide a biased estimate of $h_{50,E}$, biased in a conservative manner with the ***DAC*** potentially reflecting a slightly greater degree of conservatism.

The data of Appendix A are given to two digits to preserve the hierarchial relationship among the quantities without the excessive conservatism one would introduce if the data were rounded to a single digit. Since the data from Supplements to Publication 30, column headed "ICRP 30", nearly always underestimate the effective dose equivalent, they should not be used to demonstrate regulatory compliance.

Chemical Form Considerations:

The tabulation of Appendix A includes information on the dependence of the ***ALI*** and ***DAC*** on the chemical form of the inhaled or ingested radionuclide. In the case of inhalation intakes, the chemical forms for particulate matter are specified by the clearance classes ***D***, ***W***, and ***Y***, while vapor forms are denoted by ***V***. For ingested material, the chemical form considerations are represented by the numerical value assigned to the f_1 parameter. This parameter represents the fraction of the radioelement entering the stomach that is transferred to blood in the absence of radioactive decay. Since inhalation also results in the ingestion of material mechanically cleared from the respiratory tract, the tabulations of Appendix A indicate the value of f_1 used with each clearance class. In Appendix B to 10 CFR Part 20 the chemical form consideration for ingested materials was not included in the tabulation.

It is important to note that the classification of materials with respect to inhalation (clearance classes and f_1 value) is a separate consideration from that for an ingestion intake. Considering the different physiological conditions within the respiratory tract and the gastrointestinal tract, it may be reasonable that the same value of f_1 is assigned to all three clearance classes despite the implication that *Class D* materials are more soluble than *Class Y* materials. Furthermore, it should be noted that for many situations little or no information is available to assign values to f_1 for inhalation intakes.

Care must also be taken in applying the rule of thumb that dose increases with increasing solubility as measured by clearance class and f_1 value; e.g., considering *Class D* compounds to be more soluble than *Class W*. The biodistribution of the radionuclide depends, in part, upon its route of intake and its physical half-life while the dose to any organ or tissue depends upon the biodistribution and the nature of the emitted radiations; the effective dose equivalent depends on the organ/tissue dose equivalent as well as the assigned weighting factors. The ***ALIs*** for various chemical forms of a radionuclide may be independent of the chemical form if the radionuclide has a short physical half-life (see the inhalation ***ALIs*** for *Class D, W,* and *Y* forms of Si-31). Three chemical forms were considered for ingestion of Pu with the f_1 values ranging from 10^{-5} to 10^{-3}. For Pu-235, the ***ALI*** is the same for the three chemical forms because its short half-life results in the stochastic constraint limiting the intake based on the dose to the segments of the gastrointestinal tract. For longer-lived plutonium forms, the ingestion ***ALI*** will exhibit the full dependence on f_1 and range over two orders of magnitude. An additional consideration that can further complicate the considerations is the ingrowth of decay products which contribute significantly to dose.

Recommendations:

The tabulated data of Appendix A form a consistent set of numerical data within the context of the radiation protection guidance of 10 CFR Part 20 and are presented in the format of Appendix B to 10 CFR Part 20. Furthermore, these data preserve in a numerical sense the hierarchial relationships of the secondary radiation protection quantities such that they are consistent with the recommendations of Regulatory Guide 8.34.

The extraction of dosimetric data from the Supplements to Publication 30 should not be recommended as currently indicated in Regulatory Guide 8.34. This approach results in a consistent underestimate of the effective dose and thus, even in a screening type calculation, is hardly a useful estimator. With this exception, the other approaches recommended in the guide are valid when used with the data of Appendix A.

Table 5. Values of the Committed Effective Equivalent per Unit Inhaled Activity (*rem* μCi^{-1}) per Regulatory Guide 8.3

				Computed from	
Nuclide	Class	FGR 11[1]	ICRP 30[2]	*ALIs*[3]	*DAC*[4]
H-3	Vapor	6.40E-05	6.3E-05	6.4E-05	6.6E-05
Co-60	W	3.31E-02	3.0E-02	3.3E-02	3.4E-02
	Y	2.19E-01	1.5E-01	2.2E-01	2.3E-01
Fe-59	D	1.48E-02	1.5E-02	1.5E-02	1.6E-02
	W	1.22E-02	1.0E-02	1.3E-02	1.3E-02
Sr-85	D	1.91E-03	1.9E-03	1.9E-03	2.1E-03
	Y	5.03E-02	3.2E-03	5.1E-03	5.1E-03
Sr-90	D	2.39E-01	2.3E-01	2.5E-01	-----
	Y	1.30E+00	1.3E+00	1.3E+00	1.4E+00
Zr-95	D	2.37E-02	1.9E-02	2.4E-02	-----
	W	1.59E-02	1.3E-02	1.6E-02	1.7E-02
	Y	2.33E-02	1.8E-02	2.4E-02	2.4E-02
Mo-99	D	2.00E-03	1.9E-03	2.1E-03	2.1E-03
	W	3.97E-03	3.7E-03	4.2E-03	4.2E-03
I-131	D	3.29E-02	3.3E-02	3.3E-02	-----
Cs-137	D	3.19E-02	3.2E-02	3.3E-02	3.4E-02
Ce-144	W	2.16E-01	2.0E-01	2.2E-01	2.2E-01
	Y	3.75E-01	3.5E-01	3.8E-01	3.9E-01
Ra-226	W	8.57E+00	7.8E+00	8.6E+00	8.7E+00
Th-232	W	1.64E+03	1.6E+03	1.7E+03	-----
	Y	1.15E+03	1.1E+03	1.2E+03	-----
U-234	D	2.73E+00	2.7E+00	2.8E+00	-----
	W	7.89E+00	7.0E+00	7.9E+00	8.0E+00
	Y	1.33E+02	1.3E+00	1.4E+02	1.4E+02
Pu-239	W	4.30E+02	4.1E+02	4.5E+02	-----
	Y	3.08E+02	3.0E+02	3.1E+02	-----
Am-241	W	4.43E+02	4.4E+02	4.5E+02	-----

[1] From Table 2.1 of Eckerman, *et al.* (1988).
[2] Computed from Supplements to ICRP Publication 30.
[3] Computed as 5.0/*ALIs* using the *ALI* from Appendix A.
[4] Computed as 5.0/2.4 x 10^9 *DAC*, if the *ALI* is based on stochastic considerations.

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APPENDIX A
Recommended Values for the Quantities in Appendix B of 10 CFR Part 20

Introduction

This appendix presents values for the radiation protection quantities in the format of Appendix B to 10 CFR Part 20. As such, the discussion here follows that of 10 CFR Part 20; in particular, we retain the structure of Appendix B with respect to data tabulations, including the use of traditional units. The data are presented in three tables numbered in the manner of Appendix B to 10 CFR Part 20. We include an additional table, Table IV, which lists for each radionuclide the chemical form corresponding to the clearance class and f_1 value for which *ALI* or *DAC* values are given in Table I. The *ALIs* and *DACs* for inhalation are given for an aerosol with an activity median aerodynamic diameter (*AMAD*) of 1 µm and for four classes (*D*, *W*, *Y*, and *V*) of radioactive material. The first three classes refer to the retention time within the pulmonary region of the lung of the deposited aerosol. Class *V* refers to the vapor form of selected radioelements. The classification by pulmonary retention applies to clearance half-times ranges of less than 10 days for *D*, of 10 to 100 days for *W*, and of greater than 100 days for *Y*. The class (*D*, *W*, *Y*, or *V*) given in the column headed "Class/f_1" applies only to the inhalation *ALIs* and *DACs* given in Table I. The f_1 parameter denotes the fraction of the material entering the gastrointestinal tract that would be transferred to body fluids in the absence of radioactive decay. The *ALIs* for ingestion are characterized by the value of the f_1 parameter that are seen in Table IV and Table I.

Numerical Notation

The numerical values in Tables I, II, III, and IV are presented in the computer "E" notation when necessary. In this notation the entry 8.1E-05 represents the number 8.1×10^{-5} and similarly 2.9E+04 represents 2.9×10^{4}.

Table I

Note that the entries in the columns of Table I, captioned "Inhalation" and "Ingestion," are applicable to occupational exposure to radioactive material.

The *ALIs* in Table I are the annual intakes of the radionuclides by an adult male reference individual, hereafter designated "Reference Man," that would result in either (1) a committed effective dose equivalent of 5 *rem* (stochastic *ALI*) or (2) a committed dose equivalent of 50 *rem* to an organ or tissue (non-stochastic *ALI*). Due to irradiation of the organs and tissues of the body, an intake of a quantity of a radionuclide corresponding to the stochastic *ALI* is considered comparable to the risk associated with deep dose equivalent to the whole body of 5 *rem*. The derivation includes multiplying the committed dose equivalent to an organ or tissue by a weighting factor, w_T. This weighting factor is the proportion of the risk of stochastic effects resulting from irradiation of the organ or tissue *T* to the total risk of stochastic effects when the whole body is irradiated uniformly. The values of w_T are listed in Table 1; see also §20.1003 of 10 CFR Part 20. The non-stochastic *ALIs* were derived to avoid non-stochastic effects, such as prompt damage to tissue or reduction in organ function.

A value of $w_T = 0.06$ is applicable to each of the five organs or tissues in the "remainder" category receiving the highest dose equivalents, and the dose equivalents of all other remaining tissues may be disregarded. The following parts of the GI tract — stomach, small intestine, upper large intestine, and lower large intestine — are treated as separate organs.

Note that the dose equivalent for extremities (hands and forearms, feet and lower legs), skin, and lens of the eye are not considered in computing the committed effective dose equivalent, but are subject to limits that must be met separately.

When an *ALI* is defined by the stochastic dose limit, this value alone is given. When an *ALI* is determined by the non-stochastic dose limit, the *ALI* for the stochastic limit is shown in parentheses followed by name of the organ or tissue for which the non-stochastic limit applies. (Abbreviated organ or tissue designations are: ***LLI wall*** denotes the wall of the lower large intestine; ***St wall*** is the wall of the stomach; and ***BSurface*** denotes bone surface.)

Use of the *ALI* (first value listed) will ensure that non-stochastic effects are avoided and that the risk of stochastic effects is limited to an acceptably low value. If a situation involves a radionuclide for which the non-stochastic *ALI* is limiting and its use is considered unduly conservative, then the stochastic *ALI* can be used to determine the committed effective dose equivalent. However, it will be necessary also to ensure that the 50-rem dose equivalent limit for any organ or tissue is not exceeded by the sum of the external deep dose equivalent plus the internal committed dose to that organ (not the effective dose). For the case where there is no external dose contribution, this would be demonstrated if the sum of the fractions of the nonstochastic *ALIs* (ALI_{NS}) that contribute to the committed dose equivalent to the organ receiving the highest dose does not exceed unity; i.e.,

$$\sum \frac{intake\ (\mu Ci)\ of\ radionuclide}{ALI_{NS}\ for\ radionuclide} \leq 1 \ .$$

If there is an external deep dose equivalent contribution of H_d then the above sum must be less than $1 - (H_d / 50)$ instead of 1.0.

The derived air concentration (*DAC*) values are intended to control chronic occupational exposures. The relationship between the *DAC* and the *ALI* is given by

$$DAC = \frac{ALI}{2000\ hour\ 60\ minutes/hour\ 2 \times 10^4\ ml/minute}$$

$$= \frac{ALI}{2.4 \times 10^9}\ \mu Ci/ml \ ,$$

where 2×10^4 ***ml*** is the volume of air breathed per minute at work by "Reference Man" under working conditions of "light work." In the case of tritiated water vapor, considerations are given to the intakes via both dermal (skin) absorption and inhalation. The total intake is assumed to be 1.5 times that due to inhalation alone. Thus, for tritiated water vapor, the *DAC* is the quotient of the *ALI* and 3.6×10^9.

The *DAC* values relate to one of the two modes of exposure: either external submersion or the internal committed dose equivalent resulting from inhalation of radioactive materials. Derived air concentrations based upon submersion are for immersion in a semi-infinite cloud of uniform concentration and apply to each radionuclide separately.

The *ALI* and *DAC* values relate to exposure to the single radionuclide named, but also include contributions for the ingrowth of any daughter radionuclide produced in the body by the decay of the parent. However, intakes that include both the parent and daughter radionuclides should be treated by the general method appropriate for mixtures.

Table II

The columns in Table II of this appendix captioned "Effluent" are applicable to the assessment and control of dose to the public, particularly in the implementation of the provisions of §20.1303 of 10 CFR Part 20. The concentration values given in Table II are equivalent to the radionuclide concentration which, if inhaled or ingested continuously over the course of a year, would produce a total effective dose equivalent of 0.05 *rem*.

Consideration of the non-stochastic limits has not been included in deriving the air and water effluent concentration limits because non-stochastic effects are presumed not to occur at the dose levels established for individual members of the public. In the case of radionuclide for which the non-stochastic limit governed the occupational *DAC*, the stochastic *ALI* was used in deriving the corresponding airborne effluent limit in Table II.

The air concentration values listed in Table II were derived by one of two methods as outlined in Appendix B to 10 CFR Part 20. For those radionuclides for which the stochastic limit governs, the occupational stochastic inhalation *ALI* was divided by 2.4 10^9 *ml*, relating the inhalation *ALI* to the *DAC*, as explained above, and then divided by a factor of 300. The factor of 300 includes the following components: a factor of 50 to relate the 5-rem annual occupational dose limit to the 0.1-rem limit for members of the public; a factor of 3 to adjust for the difference in exposure time and the inhalation rate for a worker or for members of the public; and a factor of 2 to adjust the occupational values (derived for adults) so that they are applicable to children.

For radionuclides for which submersion (external dose) is limiting, air concentration values in Table II were obtained by dividing the occupational *DAC* of Table I by 219. The factor 219 is composed of a factor of 50, as noted above, and a factor of 4.38 relating an annual occupational exposure for 2000 hours to a continuous annual exposure of 8760 hours. Note that an additional factor of 2 for age considerations was not consider warranted for submersion case in Appendix B to 10 CFR Part 20.

The concentrations in water listed in Table II were derived by taking the most restrictive value of the stochastic *ALI* for ingestion listed in Table I and dividing by 7.3 10^7. The factor 7.3 10^7 *ml* includes the following components: the factors of 50 and 2 described above and a factor of 7.3 10^5 *ml* which is the annual water intake of "Reference Man."

Note 5 of this appendix provides groupings of radionuclides that are applicable to unknown mixtures of radionuclides. These groupings (including occupational inhalation *ALIs* and *DACs*, air and water effluent concentrations and sewerage) require demonstrating that the most limiting radionuclides in successive classes are absent. The limit for the unknown mixture is defined when the presence of one of the listed radionculides cannot be definitely excluded either from knowledge of the radionuclide composition of the source or from actual measurements.

Table III

The monthly average concentration for release to sanitary sewers is applicable to the provisions in §20.2003 of Appendix B to 10 CFR Part 20. The concentration values were derived by taking the most restrictive value of the stochastic ***ALI*** for ingestion intakes in Table I and dividing by 7.3 10^6 ***ml***. This factor is composed of a factor of 7.3 10^5 ***ml***, the annual water intake by "Reference Man," and a factor of 10, such that the concentrations, if the sewage released by the licensee were the only source of water ingested by "Reference Man' during a year, would result in a committed effective dose equivalent of 0.5 ***rem***.

	Table I Occupational Values					Table II		Table III
	Inhalation			Ingestion		Effluent		Sewer
Nuclide	Class/f_1	ALI (μCi)	DAC (μCi/ml)	f_1	ALI (μCi)	Air (μCi/ml)	Water (μCi/ml)	Discharge (μCi/ml)
Hydrogen								
H-3	V 1	7.8E+04	2.1E-05	1	7.8E+04	7.2E-08	0.0010	1.0E-02
12.35 y	Submersion		0.56					
Beryllium								
Be-7	W 0.005	2.1E+04	8.7E-06	0.005	3.9E+04	2.1E-08	5.3E-04	5.3E-03
53.3 d	Y 0.005	1.5E+04	6.2E-06					
Be-10	W 0.005	130	5.4E-08	0.005	1000	1.9E-11	1.4E-05	1.4E-04
1.6E6 y	Y 0.005	14	5.8E-09					
Carbon								
C-11	cmpds* 1	4.1E+05	1.7E-04	1	4.1E+05	5.7E-07	0.0056	5.6E-02
20.38 m	CO 1	1.1E+06	4.5E-04					
	CO_2 1	6.3E+05	2.6E-04					
C-14	cmpds* 1	2300	9.5E-07	1	2300	3.3E-09	3.2E-05	3.2E-04
5730 y	CO 1	1.7E+06	7.0E-04					
	CO_2 1	2.1E+05	8.7E-05					
Fluorine								
F-18	D 1	5.9E+04	2.4E-05	1	4.0E+04	8.3E-08	5.5E-04	5.5E-03
109.77 m	W 1	6.7E+04	2.7E-05					
	Y 1	6.3E+04	2.6E-05					
Sodium								
Na-22	D 1	650	2.7E-07	1	430	9.0E-10	5.9E-06	5.9E-05
2.602 y								
Na-24	D 1	4100	1.7E-06	1	3500	5.7E-09	4.8E-05	4.8E-04
15.00 h								
Magnesium								
Mg-28	D 0.5	1400	5.8E-07	0.5	620	1.4E-09	8.5E-06	8.5E-05
20.91 h	W 0.5	1000	4.1E-07					
Aluminum								
Al-26	D 0.01	62	2.5E-08	0.01	340	8.7E-11	4.7E-06	4.7E-05
7.16E5 y	W 0.01	69	2.8E-08					
Silicon								
Si-31	D 0.01	2.2E+04	9.1E-06	0.01	9200	3.1E-08	1.2E-04	1.2E-03
157.3 m	W 0.01	2.4E+04	10E-06					
	Y 0.01	2.2E+04	9.1E-06					
Si-32	D 0.01	230	9.5E-08	0.01	2100	6.8E-12	3.1E-05	3.1E-04
450 y	W 0.01	95	3.9E-08		(2200)			
	Y 0.01	4.9	2.0E-09		LLI wall			
Phosphorus								
P-32	D 0.8	820	3.4E-07	0.8	570	4.4E-10	7.8E-06	7.8E-05
14.29 d	W 0.8	320	1.3E-07					
P-33	D 0.8	7900	3.2E-06	0.8	5400	2.9E-09	7.4E-05	7.4E-04
25.4 d	W 0.8	2100	8.7E-07					
Sulfur								
S-35	D 0.8	1.6E+04	6.6E-06	0.8	1.1E+04	2.8E-09	9.3E-05	9.3E-04
87.44 d	W 0.8	2000	8.3E-07	0.1	6000			
	V 1	1.4E+04	5.8E-06		(6800)			
					LLI wall			
Chlorine								
Cl-36	D 1	2200	9.1E-07	1	1600	3.1E-10	2.2E-05	2.2E-04
3.01E5 y	W 1	220	9.1E-08					
Cl-38	D 1	3.7E+04	1.5E-05	1	1.5E+04	5.1E-08	2.9E-04	2.9E-03
37.21 m	W 1	4.2E+04	1.7E-05		(2.1E+04)			
					St wall			
Cl-39	D 1	4.4E+04	1.8E-05	1	2.1E+04	6.1E-08	3.7E-04	3.7E-03
55.6 m	W 1	4.9E+04	2.0E-05		(2.7E+04)			
					St wall			
Argon								
Ar-37	Submersion		1.4			0.0067		
35.02 d								
Ar-39	Submersion		1.7E-04			9.4E-05		
269 y			(0.020)					
			Skin					
Ar-41	Submersion		2.8E-06			1.3E-08		
1.827 h								
Potassium								
K-40	D 1	400	1.6E-07	1	260	5.6E-10	3.6E-06	3.6E-05
1.28E9 y								
K-42	D 1	3600	1.5E-06	1	4400	5.1E-09	6.0E-05	6.0E-04
12.36 h								

* Labelled organic compounds

	Table I Occupational Values					Table II Effluent		Table III Sewer
	Inhalation			Ingestion				
Nuclide	Class/f_1	ALI (μCi)	DAC (μCi/ml)	f_1	ALI (μCi)	Air (μCi/ml)	Water (μCi/ml)	Discharge (μCi/ml)
Potassium,	cont'd.							
K-43	D 1	7200	3.0E-06	1	6400	1.0E-08	8.8E-05	8.8E-04
22.6 h								
K-44	D 1	6.0E+04	2.5E-05	1	2.0E+04	8.3E-08	3.9E-04	3.9E-03
22.13 m					(2.8E+04)			
					St wall			
K-45	D 1	9.7E+04	4.0E-05	1	3.2E+04	1.3E-07	6.1E-04	6.1E-03
20 m					(4.4E+04)			
					St wall			
Calcium								
Ca-41	W 0.3	3700	1.5E-06	0.3	3300	5.1E-09	5.3E-05	5.3E-04
1.4E5 y					(3900)			
					BSurface			
Ca-45	W 0.3	750	3.1E-07	0.3	1500	1.0E-09	2.1E-05	2.1E-04
163 d								
Ca-47	W 0.3	760	3.1E-07	0.3	760	1.0E-09	1.0E-05	1.0E-04
4.53 d								
Scandium								
Sc-43	Y 1.0E-04	1.9E+04	7.9E-06	1.0E-04	6500	2.6E-08	8.9E-05	8.9E-04
3.891 h								
Sc-44	Y 1.0E-04	1.0E+04	4.1E-06	1.0E-04	3400	1.4E-08	4.7E-05	4.7E-04
3.927 h								
Sc-44m	Y 1.0E-04	660	2.7E-07	1.0E-04	480	9.1E-10	6.6E-06	6.6E-05
58.6 h								
Sc-46	Y 1.0E-04	160	6.6E-08	1.0E-04	770	2.3E-10	1.0E-05	1.0E-04
83.83 d								
Sc-47	Y 1.0E-04	2700	1.1E-06	1.0E-04	2200	3.7E-09	3.0E-05	3.0E-04
3.351 d								
Sc-48	Y 1.0E-04	1200	5.0E-07	1.0E-04	690	1.6E-09	9.4E-06	9.4E-05
43.7 h								
Sc-49	Y 1.0E-04	4.9E+04	2.0E-05	1.0E-04	1.9E+04	6.8E-08	2.7E-04	2.7E-03
57.4 m								
Titanium								
Ti-44	D 0.01	11	4.5E-09	0.01	210	6.8E-12	2.9E-06	2.9E-05
47.3 y	W 0.01	27	1.1E-08					
	Y 0.01	4.9	2.0E-09					
Ti-45	D 0.01	2.3E+04	9.5E-06	0.01	8300	3.2E-08	1.1E-04	1.1E-03
3.08 h	W 0.01	2.5E+04	1.0E-05					
	Y 0.01	2.3E+04	9.5E-06					
Vanadium								
V-47	D 0.01	7.1E+04	2.9E-05	0.01	2.8E+04	9.8E-08	3.9E-04	3.9E-03
32.6 m	W 0.01	8.7E+04	3.6E-05					
V-48	D 0.01	1000	4.1E-07	0.01	580	6.8E-10	7.9E-06	7.9E-05
16.238 d	W 0.01	490	2.0E-07					
V-49	D 0.01	2.9E+04	1.2E-05	0.01	7.3E+04	2.0E-08	0.0011	1.1E-02
330 d	W 0.01	1.4E+04	5.8E-06		(8.1E+04)			
					LLI wall			
Chromium								
Cr-48	D 0.1	1.1E+04	4.5E-06	0.1	5600	7.9E-09	7.4E-05	7.4E-04
22.96 h	W 0.1	6300	2.6E-06	0.01	5400			
	Y 0.1	5600	2.3E-06					
Cr-49	D 0.1	6.8E+04	2.8E-05	0.1	2.7E+04	9.5E-08	3.7E-04	3.7E-03
42.09 m	W 0.1	8.5E+04	3.5E-05	0.01	2.7E+04			
	Y 0.1	8.0E+04	3.3E-05					
Cr-51	D 0.1	4.5E+04	1.8E-05	0.1	3.3E+04	2.0E-08	4.6E-04	4.6E-03
27.704 d	W 0.1	1.9E+04	7.9E-06	0.01	3.4E+04			
	Y 0.1	1.4E+04	5.8E-06					
Manganese								
Mn-51	D 0.1	4.3E+04	1.7E-05	0.1	1.7E+04	6.0E-08	2.4E-04	2.4E-03
46.2 m	W 0.1	5.3E+04	2.2E-05					
Mn-52	D 0.1	1000	4.1E-07	0.1	660	1.2E-09	9.0E-06	9.0E-05
5.591 d	W 0.1	870	3.6E-07					
Mn-52m	D 0.1	7.3E+04	3.0E-05	0.1	2.6E+04	1.0E-07	3.7E-04	3.7E-03
21.1 m	W 0.1	9.0E+04	3.7E-05		(2.7E+04)			
					St wall			
Mn-53	D 0.1	1.2E+04	5.0E-06	0.1	4.6E+04	1.3E-08	6.3E-04	6.3E-03
3.7E6 y		(1.9E+04)						
		BSurface						
	W 0.1	1.0E+04	4.1E-06					
Mn-54	D 0.1	950	3.9E-07	0.1	1800	1.0E-09	2.4E-05	2.4E-04
312.5 d	W 0.1	740	3.0E-07					
Mn-56	D 0.1	1.3E+04	5.4E-06	0.1	5100	1.8E-08	7.0E-05	7.0E-04
2.5785 h	W 0.1	1.5E+04	6.2E-06					

	Table I Occupational Values					Table II		Table III
	Inhalation			Ingestion		Effluent		Sewer
Nuclide	Class/f_1	ALI (μCi)	DAC (μCi/ml)	f_1	ALI (μCi)	Air (μCi/ml)	Water (μCi/ml)	Discharge (μCi/ml)
Iron								
Fe-52	D 0.1	2600	1.0E-06	0.1	890	3.1E-09	1.2E-05	1.2E-04
8.275 h	W 0.1	2200	9.1E-07					
Fe-55	D 0.1	1800	7.5E-07	0.1	8200	2.5E-09	1.1E-04	1.1E-03
2.7 y	W 0.1	3700	1.5E-06					
Fe-59	D 0.1	330	1.3E-07	0.1	740	4.6E-10	1.0E-05	1.0E-04
44.529 d	W 0.1	400	1.6E-07					
Fe-60	D 0.1	6.7	2.7E-09	0.1	32	9.3E-12	4.4E-07	4.4E-06
1E5 y	W 0.1	18	7.5E-09					
Cobalt								
Co-55	W 0.05	2600	1.0E-06	0.05	1100	3.3E-09	1.5E-05	1.5E-04
17.54 h	Y 0.05	2300	9.5E-07	0.3	1400			
Co-56	W 0.05	220	9.1E-08	0.05	490	1.7E-10	5.4E-06	5.4E-05
78.76 d	Y 0.05	120	5.0E-08	0.3	390			
Co-57	W 0.05	1800	7.5E-07	0.05	6700	7.6E-10	5.7E-05	5.7E-04
270.9 d	Y 0.05	550	2.2E-07	0.3	4200			
Co-58	W 0.05	780	3.2E-07	0.05	1600	6.3E-10	1.9E-05	1.9E-04
70.80 d	Y 0.05	450	1.8E-07	0.3	1300			
Co-58m	W 0.05	7.4E+04	3.0E-05	0.05	5.4E+04	7.3E-08	7.5E-04	7.5E-03
9.15 h	Y 0.05	5.3E+04	2.2E-05	0.3	6.2E+04			
Co-60	W 0.05	150	6.2E-08	0.05	480	3.1E-11	2.5E-06	2.5E-05
5.271 y	Y 0.05	22	9.1E-09	0.3	180			
Co-60m	W 0.05	3.6E+06	0.0015	0.05	9.9E+05	3.2E-06	0.018	0.18
10.47 m	Y 0.05	2.3E+06	9.5E-04		(1.3E+06)			
					St wall			
				0.3	9.9E+05			
					(1.3E+06)			
					St wall			
Co-61	W 0.05	5.1E+04	2.1E-05	0.05	1.9E+04	6.5E-08	2.6E-04	2.6E-03
1.65 h	Y 0.05	4.7E+04	1.9E-05	0.3	2.0E+04			
Co-62m	W 0.05	1.4E+05	5.8E-05	0.05	3.7E+04	1.9E-07	5.9E-04	5.9E-03
13.91 m	Y 0.05	1.4E+05	5.8E-05		(4.3E+04)			
					St wall			
				0.3	3.7E+04			
					(4.3E+04)			
					St wall			
Nickel								
Ni-56	D 0.05	1900	7.9E-07	0.05	1200	1.6E-09	1.7E-05	1.7E-04
6.10 d	W 0.05	1200	5.0E-07					
	V 10	1200	5.0E-07					
Ni-57	D 0.05	4700	1.9E-06	0.05	1300	3.6E-09	1.8E-05	1.8E-04
36.08 h	W 0.05	2600	1.0E-06					
	V 10	6200	2.5E-06					
Ni-59	D 0.05	3700	1.5E-06	0.05	2.3E+04	2.5E-09	3.2E-04	3.2E-03
7.5E4 y	W 0.05	5400	2.2E-06					
	V 10	1800	7.5E-07					
Ni-63	D 0.05	1600	6.6E-07	0.05	8600	1.1E-09	1.1E-04	1.1E-03
96 y	W 0.05	2100	8.7E-07					
	V 10	790	3.2E-07					
Ni-65	D 0.05	2.0E+04	8.3E-06	0.05	8000	2.0E-08	1.1E-04	1.1E-03
2.520 h	W 0.05	2.2E+04	9.1E-06					
	V 10	1.4E+04	5.8E-06					
Ni-66	D 0.05	1400	5.8E-07	0.05	390	8.3E-10	5.7E-06	5.7E-05
54.6 h	W 0.05	600	2.5E-07		(410)			
	V 10	2500	1.0E-06		LLI wall			
Copper								
Cu-60	D 0.5	7.2E+04	3.0E-05	0.5	2.5E+04	1.0E-07	3.5E-04	3.5E-03
23.2 m	W 0.5	9.0E+04	3.7E-05					
	Y 0.5	8.6E+04	3.5E-05					
Cu-61	D 0.5	2.7E+04	1.1E-05	0.5	1.1E+04	3.7E-08	1.5E-04	1.5E-03
3.408 h	W 0.5	2.8E+04	1.1E-05					
	Y 0.5	2.6E+04	1.0E-05					
Cu-64	D 0.5	2.5E+04	1.0E-05	0.5	1.0E+04	2.5E-08	1.4E-04	1.4E-03
12.701 h	W 0.5	1.9E+04	7.9E-06					
	Y 0.5	1.8E+04	7.5E-06					
Cu-67	D 0.5	7300	3.0E-06	0.5	3800	5.6E-09	5.2E-05	5.2E-04
61.86 h	W 0.5	4200	1.7E-06					
	Y 0.5	4000	1.6E-06					
Zinc								
Zn-62	Y 0.5	2400	10E-07	0.5	1300	3.3E-09	1.8E-05	1.8E-04
9.26 h								
Zn-63	Y 0.5	6.1E+04	2.5E-05	0.5	2.2E+04	8.5E-08	3.1E-04	3.1E-03
38.1 m								

Nuclide	Class/f_1	Table I Occupational Values: Inhalation ALI (μCi)	Inhalation DAC (μCi/ml)	Ingestion f_1	Ingestion ALI (μCi)	Table II Effluent: Air (μCi/ml)	Table II Effluent: Water (μCi/ml)	Table III Sewer Discharge (μCi/ml)
Zinc, cont'd.								
Zn-65	Y 0.5	240	1.0E-07	0.5	340	3.4E-10	4.7E-06	4.7E-05
243.9 d								
Zn-69	Y 0.5	1.2E+05	5.0E-05	0.5	5.6E+04	1.7E-07	7.7E-04	7.7E-03
57 m								
Zn-69m	Y 0.5	6100	2.5E-06	0.5	3800	8.5E-09	5.2E-05	5.2E-04
13.76 h								
Zn-71m	Y 0.5	1.2E+04	5.0E-06	0.5	5500	1.7E-08	7.6E-05	7.6E-04
3.92 h								
Zn-72	Y 0.5	990	4.1E-07	0.5	900	1.3E-09	1.2E-05	1.2E-04
46.5 h								
Gallium								
Ga-65	D 0.001	1.4E+05	5.8E-05	0.001	4.6E+04	2.0E-07	7.6E-04	7.6E-03
15.2 m	W 0.001	1.7E+05	7.0E-05		(5.5E+04) St wall			
Ga-66	D 0.001	3100	1.2E-06	0.001	1000	3.7E-09	1.4E-05	1.4E-04
9.40 h	W 0.001	2600	1.0E-06					
Ga-67	D 0.001	1.4E+04	5.8E-06	0.001	6300	1.2E-08	8.7E-05	8.7E-04
78.26 h	W 0.001	8900	3.7E-06					
Ga-68	D 0.001	3.6E+04	1.5E-05	0.001	1.4E+04	5.0E-08	2.0E-04	2.0E-03
68.0 m	W 0.001	4.3E+04	1.7E-05					
Ga-70	D 0.001	1.5E+05	6.2E-05	0.001	5.4E+04	2.2E-07	9.1E-04	9.1E-03
21.15 m	W 0.001	1.8E+05	7.5E-05		(6.6E+04) St wall			
Ga-72	D 0.001	3400	1.4E-06	0.001	1000	3.7E-09	1.4E-05	1.4E-04
14.1 h	W 0.001	2600	1.0E-06					
Ga-73	D 0.001	1.3E+04	5.4E-06	0.001	4800	1.8E-08	6.6E-05	6.6E-04
4.91 h	W 0.001	1.3E+04	5.4E-06					
Germanium								
Ge-66	D 1	2.0E+04	8.3E-06	1	2.3E+04	2.1E-08	3.2E-04	3.2E-03
2.27 h	W 1	1.5E+04	6.2E-06					
Ge-67	D 1	8.2E+04	3.4E-05	1	2.6E+04	1.1E-07	5.2E-04	5.2E-03
18.7 m	W 1	9.4E+04	3.9E-05		(3.8E+04) St wall			
Ge-68	D 1	3000	1.2E-06	1	4600	1.3E-10	6.4E-05	6.4E-04
288 d	W 1	96	4.0E-08					
Ge-69	D 1	1.1E+04	4.5E-06	1	1.3E+04	8.2E-09	1.8E-04	1.8E-03
39.05 h	W 1	5900	2.4E-06					
Ge-71	D 1	3.1E+05	1.2E-04	1	5.1E+05	5.6E-08	0.0071	0.071
11.8 d	W 1	4.0E+04	1.6E-05					
Ge-75	D 1	7.0E+04	2.9E-05	1	4.1E+04	9.7E-08	7.2E-04	7.2E-03
82.78 m	W 1	7.3E+04	3.0E-05		(5.3E+04) St wall			
Ge-77	D 1	7100	2.9E-06	1	8600	6.5E-09	1.1E-04	1.1E-03
11.30 h	W 1	4700	1.9E-06					
Ge-78	D 1	1.8E+04	7.5E-06	1	1.8E+04	2.4E-08	2.5E-04	2.5E-03
87 m	W 1	1.7E+04	7.0E-06					
Arsenic								
As-69	W 0.5	1.0E+05	4.1E-05	0.5	3.1E+04	1.4E-07	5.1E-04	5.1E-03
15.2 m					(3.7E+04) St wall			
As-70	W 0.5	3.9E+04	1.6E-05	0.5	1.1E+04	5.4E-08	1.6E-04	1.6E-03
52.6 m								
As-71	W 0.5	3900	1.6E-06	0.5	3300	5.4E-09	4.5E-05	4.5E-04
64.8 h								
As-72	W 0.5	1200	5.0E-07	0.5	820	1.7E-09	1.1E-05	1.1E-04
26.0 h								
As-73	W 0.5	1400	5.8E-07	0.5	7000	2.0E-09	9.6E-05	9.6E-04
80.30 d								
As-74	W 0.5	620	2.5E-07	0.5	1200	8.7E-10	1.7E-05	1.7E-04
17.76 d								
As-76	W 0.5	1300	5.4E-07	0.5	960	1.8E-09	1.3E-05	1.3E-04
26.32 h								
As-77	W 0.5	4700	1.9E-06	0.5	3900	6.5E-09	5.3E-05	5.3E-04
38.8 h								
As-78	W 0.5	1.8E+04	7.5E-06	0.5	7400	2.5E-08	1.0E-04	1.0E-03
90.7 m								
Selenium								
Se-70	D 0.8	2.8E+04	1.1E-05	0.8	1.3E+04	3.9E-08	1.3E-04	1.3E-03
41.0 m	W 0.8	3.4E+04	1.4E-05	0.05	9700			
Se-73	D 0.8	1.1E+04	4.5E-06	0.8	6800	1.5E-08	4.2E-05	4.2E-04
7.15 h	W 0.8	1.0E+04	4.1E-06	0.05	3100			

	Table I Occupational Values					Table II Effluent		Table III Sewer
	Inhalation			Ingestion				
Nuclide	Class/f_1	ALI (μCi)	DAC (μCi/ml)	f_1	ALI (μCi)	Air (μCi/ml)	Water (μCi/ml)	Discharge (μCi/ml)
Selenium, cont'd.								
Se-73m	D 0.8	1.1E+05	4.5E-05	0.8	5.8E+04	1.4E-07	4.4E-04	4.4E-03
39 m	W 0.8	1.0E+05	4.1E-05	0.05	3.2E+04			
Se-75	D 0.8	690	2.8E-07	0.8	510	8.2E-10	7.1E-06	7.1E-05
119.8 d	W 0.8	590	2.4E-07	0.05	2800			
Se-79	D 0.8	760	3.1E-07	0.8	570	7.0E-10	7.8E-06	7.8E-05
65000 y	W 0.8	500	2.0E-07	0.05	3800			
Se-81	D 0.8	1.9E+05	7.9E-05	0.8	6.2E+04	2.6E-07	0.0010	0.010
18.5 m	W 0.8	2.2E+05	9.1E-05		(8.4E+04)			
					St wall			
				0.05	6.2E+04			
					(7.9E+04)			
					St wall			
Se-81m	D 0.8	5.6E+04	2.3E-05	0.8	3.3E+04	7.8E-08	3.2E-04	3.2E-03
57.25 m	W 0.8	6.3E+04	2.6E-05	0.05	2.3E+04			
Se-83	D 0.8	9.1E+04	3.7E-05	0.8	3.8E+04	1.2E-07	4.2E-04	4.2E-03
22.5 m	W 0.8	1.0E+05	4.1E-05	0.05	3.1E+04			
Bromine								
Br-74	D 1	5.8E+04	2.4E-05	1	2.1E+04	8.0E-08	3.6E-04	3.6E-03
25.3 m	W 1	6.9E+04	2.8E-05		(2.6E+04)			
					St wall			
Br-74m	D 1	3.0E+04	1.2E-05	1	1.3E+04	4.2E-08	2.2E-04	2.2E-03
41.5 m	W 1	3.5E+04	1.4E-05		(1.6E+04)			
					St wall			
Br-75	D 1	3.8E+04	1.5E-05	1	2.5E+04	5.3E-08	3.7E-04	3.7E-03
98 m	W 1	4.0E+04	1.6E-05		(2.7E+04)			
					St wall			
Br-76	D 1	4000	1.6E-06	1	3600	4.3E-09	5.0E-05	5.0E-04
16.2 h	W 1	3100	1.2E-06					
Br-77	D 1	2.3E+04	9.5E-06	1	1.6E+04	2.5E-08	2.2E-04	2.2E-03
56 h	W 1	1.8E+04	7.5E-06					
Br-80	D 1	1.7E+05	7.0E-05	1	5.4E+04	2.4E-07	0.0011	0.011
17.4 m	W 1	2.0E+05	8.3E-05		(8.5E+04)			
					St wall			
Br-80m	D 1	1.4E+04	5.8E-06	1	1.8E+04	1.7E-08	2.4E-04	2.4E-03
4.42 h	W 1	1.2E+04	5.0E-06					
Br-82	D 1	4000	1.6E-06	1	2900	4.5E-09	4.0E-05	4.0E-04
35.30 h	W 1	3200	1.3E-06					
Br-83	D 1	5.7E+04	2.3E-05	1	4.5E+04	7.7E-08	7.4E-04	7.4E-03
2.39 h	W 1	5.6E+04	2.3E-05		(5.4E+04)			
					St wall			
Br-84	D 1	5.1E+04	2.1E-05	1	1.9E+04	7.1E-08	3.7E-04	3.7E-03
31.80 m	W 1	5.9E+04	2.4E-05		(2.7E+04)			
					St wall			
Krypton								
Kr-74	Submersion		3.3E-06			1.5E-08		
11.50 m								
Kr-76	Submersion		9.2E-06			4.2E-08		
14.8 h								
Kr-77	Submersion		3.8E-06			1.7E-08		
74.7 m								
Kr-79	Submersion		1.5E-05			7.0E-08		
35.04 h								
Kr-81m	Submersion		3.0E-05			1.3E-07		
13 s								
Kr-81	Submersion		7.0E-04			3.2E-06		
2.1E5 y								
Kr-83m	Submersion		0.052			5.7E-04		
1.83 h			(0.12)					
			Skin					
Kr-85m	Submersion		2.5E-05			1.1E-07		
4.48 h								
Kr-85	Submersion		1.4E-04			7.2E-06		
10.72 y			(0.0015)					
			Skin					
Kr-87	Submersion		4.5E-06			2.0E-08		
76.3 m								
Kr-88	Submersion		1.8E-06			8.4E-09		
2.84 h								
Rubidium								
Rb-79	D 1	1.0E+05	4.1E-05	1	3.4E+04	1.4E-07	6.6E-04	6.6E-03
22.9 m					(4.8E+04)			
					St wall			

	Table I Occupational Values					Table II Effluent		Table III Sewer Discharge
	Inhalation			Ingestion				
Nuclide	Class/f_1	ALI (µCi)	DAC (µCi/ml)	f_1	ALI (µCi)	Air (µCi/ml)	Water (µCi/ml)	(µCi/ml)
Rubidium, cont'd.								
Rb-81	D 1	3.8E+04	1.5E-05	1	3.4E+04	5.3E-08	4.7E-04	4.7E-03
4.58 h								
Rb-81m	D 1	2.4E+05	10E-05	1	2.1E+05	3.4E-07	0.0029	0.029
32 m								
Rb-82m	D 1	1.7E+04	7.0E-06	1	1.2E+04	2.3E-08	1.6E-04	1.6E-03
6.2 h								
Rb-83	D 1	1000	4.1E-07	1	650	1.4E-09	8.9E-06	8.9E-05
86.2 d								
Rb-84	D 1	760	3.1E-07	1	500	1.0E-09	6.8E-06	6.8E-05
32.77 d								
Rb-86	D 1	750	3.1E-07	1	530	1.0E-09	7.3E-06	7.3E-05
18.66 d								
Rb-87	D 1	1500	6.2E-07	1	1000	2.1E-09	1.3E-05	1.3E-04
4.7E10 y								
Rb-88	D 1	5.9E+04	2.4E-05	1	1.8E+04	8.3E-08	3.9E-04	3.9E-03
17.8 m					(2.8E+04)			
					St wall			
Rb-89	D 1	1.1E+05	4.5E-05	1	3.7E+04	1.6E-07	6.9E-04	6.9E-03
15.2 m					(5.0E+04)			
					St wall			
Strontium								
Sr-80	D 0.3	9900	4.1E-06	0.3	4300	1.3E-08	5.4E-05	5.4E-04
100 m	Y 0.01	1.0E+04	4.1E-06	0.01	3900			
Sr-81	D 0.3	5.9E+04	2.4E-05	0.3	2.3E+04	8.2E-08	3.0E-04	3.0E-03
25.5 m	Y 0.01	6.4E+04	2.6E-05	0.01	2.2E+04			
Sr-82	D 0.3	370	1.5E-07	0.3	220	1.1E-10	2.8E-06	2.8E-05
25.0 d	Y 0.01	81	3.3E-08	0.01	190			
					(200)			
					LLI wall			
Sr-83	D 0.3	6700	2.7E-06	0.3	2500	4.5E-09	2.7E-05	2.7E-04
32.4 h	Y 0.01	3200	1.3E-06	0.01	2000			
Sr-85	D 0.3	2600	1.0E-06	0.3	2500	1.3E-09	3.4E-05	3.4E-04
64.84 d	Y 0.01	990	4.1E-07	0.01	3300			
Sr-85m	D 0.3	6.0E+05	2.5E-04	0.3	2.1E+05	8.1E-07	0.0028	0.028
69.5 m	Y 0.01	5.8E+05	2.4E-04	0.01	2.0E+05			
Sr-87m	D 0.3	1.1E+05	4.5E-05	0.3	4.2E+04	1.6E-07	5.1E-04	5.1E-03
2.805 h	Y 0.01	1.2E+05	5.0E-05	0.01	3.7E+04			
Sr-89	D 0.3	760	3.1E-07	0.3	540	1.6E-10	7.4E-06	7.4E-05
50.5 d	Y 0.01	120	5.0E-08	0.01	460			
					(540)			
					LLI wall			
Sr-90	D 0.3	18	7.5E-09	0.3	32	5.3E-12	4.8E-07	4.8E-06
29.12 y		(20)			(35)			
		BSurface			BSurface			
	Y 0.01	3.8	1.5E-09	0.01	410			
Sr-91	D 0.3	5300	2.2E-06	0.3	2000	4.1E-09	2.2E-05	2.2E-04
9.5 h	Y 0.01	3000	1.2E-06	0.01	1600			
Sr-92	D 0.3	7900	3.2E-06	0.3	3000	8.6E-09	3.4E-05	3.4E-04
2.71 h	Y 0.01	6200	2.5E-06	0.01	2400			
Yttrium								
Y-86	W 1.0E-04	3200	1.3E-06	1.0E-04	1100	4.0E-09	1.6E-05	1.6E-04
14.74 h	Y 1.0E-04	2900	1.2E-06					
Y-86m	W 1.0E-04	5.5E+04	2.2E-05	1.0E-04	2.0E+04	6.9E-08	2.8E-04	2.8E-03
48 m	Y 1.0E-04	5.0E+04	2.0E-05					
Y-87	W 1.0E-04	3000	1.2E-06	1.0E-04	2000	3.9E-09	2.8E-05	2.8E-04
80.3 h	Y 1.0E-04	2800	1.1E-06					
Y-88	W 1.0E-04	240	1.0E-07	1.0E-04	830	2.4E-10	1.1E-05	1.1E-04
106.64 d	Y 1.0E-04	170	7.0E-08					
Y-90	W 1.0E-04	630	2.6E-07	1.0E-04	420	8.2E-10	6.3E-06	6.3E-05
64.0 h	Y 1.0E-04	590	2.4E-07		(460)			
					LLI wall			
Y-90m	W 1.0E-04	1.1E+04	4.5E-06	1.0E-04	7000	1.4E-08	9.6E-05	9.6E-04
3.19 h	Y 1.0E-04	1.0E+04	4.1E-06					
Y-91	W 1.0E-04	150	6.2E-08	1.0E-04	440	1.4E-10	7.1E-06	7.1E-05
58.51 d	Y 1.0E-04	100	4.1E-08		(520)			
					LLI wall			
Y-91m	W 1.0E-04	1.9E+05	7.9E-05	1.0E-04	1.2E+05	1.9E-07	0.0016	0.016
49.71 m	Y 1.0E-04	1.3E+05	5.4E-05					
Y-92	W 1.0E-04	6900	2.8E-06	1.0E-04	2600	8.8E-09	3.5E-05	3.5E-04
3.54 h	Y 1.0E-04	6400	2.6E-06					
Y-93	W 1.0E-04	2500	1.0E-06	1.0E-04	1000	3.2E-09	1.5E-05	1.5E-04
10.1 h	Y 1.0E-04	2300	9.5E-07					

Nuclide	Class/f_1		Table I Occupational Values: Inhalation ALI (μCi)	Inhalation DAC (μCi/ml)	Ingestion f_1	Ingestion ALI (μCi)	Table II Effluent: Air (μCi/ml)	Table II Effluent: Water (μCi/ml)	Table III Sewer Discharge (μCi/ml)
Yttrium, cont'd.									
Y-94	W	1.0E-04	7.5E+04	3.1E-05	1.0E-04	2.1E+04	9.9E-08	3.4E-04	3.4E-03
19.1 m	Y	1.0E-04	7.1E+04	2.9E-05		(2.5E+04)			
						St wall			
Y-95	W	1.0E-04	1.4E+05	5.8E-05	1.0E-04	3.6E+04	1.8E-07	6.7E-04	6.7E-03
10.7 m	Y	1.0E-04	1.3E+05	5.4E-05		(4.9E+04)			
						St wall			
Zirconium									
Zr-86	D	0.002	3900	1.6E-06	0.002	1300	3.1E-09	1.7E-05	1.7E-04
16.5 h	W	0.002	2400	10E-07					
	Y	0.002	2200	9.1E-07					
Zr-88	D	0.002	230	9.5E-08	0.002	3300	2.8E-10	4.5E-05	4.5E-04
83.4 d	W	0.002	450	1.8E-07					
	Y	0.002	200	8.3E-08					
Zr-89	D	0.002	3400	1.4E-06	0.002	1400	2.9E-09	2.0E-05	2.0E-04
78.43 h	W	0.002	2200	9.1E-07					
	Y	0.002	2100	8.7E-07					
Zr-93	D	0.002	6.1	2.5E-09	0.002	1400	2.1E-11	4.1E-05	4.1E-04
1.53E6 y			(15)			(3000)			
			BSurface			BSurface			
	W	0.002	24	10E-09					
			(60)						
			BSurface						
	Y	0.002	56	2.3E-08					
			(67)						
			BSurface						
Zr-95	D	0.002	130	5.4E-08	0.002	1300	2.9E-10	1.8E-05	1.8E-04
63.98 d			(210)						
			BSurface						
	W	0.002	310	1.2E-07					
	Y	0.002	210	8.7E-08					
Zr-97	D	0.002	1800	7.5E-07	0.002	590	1.6E-09	8.1E-06	8.1E-05
16.90 h	W	0.002	1200	5.0E-07					
	Y	0.002	1100	4.5E-07					
Niobium									
Nb-88	W	0.01	1.9E+05	7.9E-05	0.01	4.6E+04	2.5E-07	7.7E-04	7.7E-03
14.3 m	Y	0.01	1.8E+05	7.5E-05		(5.6E+04)			
						St wall			
Nb-89	W	0.01	1.3E+04	5.4E-06	0.01	4800	1.6E-08	6.6E-05	6.6E-04
122 m	Y	0.01	1.2E+04	5.0E-06					
Nb-89	W	0.01	2.9E+04	1.2E-05	0.01	1.0E+04	3.8E-08	1.4E-04	1.4E-03
66 m	Y	0.01	2.7E+04	1.1E-05					
Nb-90	W	0.01	2300	9.5E-07	0.01	920	3.0E-09	1.2E-05	1.2E-04
14.60 h	Y	0.01	2100	8.7E-07					
Nb-93m	W	0.01	1500	6.2E-07	0.01	9100	2.3E-10	1.3E-04	1.3E-03
13.6 y	Y	0.01	170	7.0E-08		(9500)			
						LLI wall			
Nb-94	W	0.01	130	5.4E-08	0.01	700	1.6E-11	9.5E-06	9.5E-05
2.03E4 y	Y	0.01	12	5.0E-09					
Nb-95	W	0.01	1000	4.1E-07	0.01	1900	1.1E-09	2.6E-05	2.6E-04
35.15 d	Y	0.01	860	3.5E-07					
Nb-95m	W	0.01	2200	9.1E-07	0.01	2000	2.8E-09	2.9E-05	2.9E-04
86.6 h	Y	0.01	2000	8.3E-07		(2100)			
						LLI wall			
Nb-96	W	0.01	2300	9.5E-07	0.01	1000	3.0E-09	1.4E-05	1.4E-04
23.35 h	Y	0.01	2100	8.7E-07					
Nb-97	W	0.01	6.4E+04	2.6E-05	0.01	2.1E+04	8.3E-08	2.9E-04	2.9E-03
72.1 m	Y	0.01	6.0E+04	2.5E-05					
Nb-98	W	0.01	4.3E+04	1.7E-05	0.01	1.3E+04	5.6E-08	1.8E-04	1.8E-03
51.5 m	Y	0.01	4.0E+04	1.6E-05					
Molybdenum									
Mo-90	D	0.8	7000	2.9E-06	0.8	4100	5.6E-09	2.5E-05	2.5E-04
5.67 h	Y	0.05	4000	1.6E-06	0.05	1800			
Mo-93	D	0.8	4900	2.0E-06	0.8	3700	2.4E-10	5.0E-05	5.0E-04
3.5E3 y	Y	0.05	170	7.0E-08	0.05	2.0E+04			
Mo-93m	D	0.8	1.7E+04	7.0E-06	0.8	8600	1.8E-08	5.7E-05	5.7E-04
6.85 h	Y	0.05	1.3E+04	5.4E-06	0.05	4100			
Mo-99	D	0.8	2400	10E-07	0.8	1600	1.7E-09	1.3E-05	1.3E-04
66.0 h	Y	0.05	1200	5.0E-07	0.05	980			
						(990)			
						LLI wall			

Nuclide	Table I Occupational Values: Inhalation Class/f_1	Inhalation ALI (μCi)	Inhalation DAC (μCi/ml)	Ingestion f_1	Ingestion ALI (μCi)	Table II Effluent Air (μCi/ml)	Table II Effluent Water (μCi/ml)	Table III Sewer Discharge (μCi/ml)
Molybdenum, cont'd.								
Mo-101	D 0.8	1.2E+05	5.0E-05	0.8	4.1E+04	1.6E-07	6.2E-04	6.2E-03
14.62 m	Y 0.05	1.3E+05	5.4E-05		(4.8E+04)			
					St wall			
				0.05	4.1E+04			
					(4.5E+04)			
					St wall			
Technetium								
Tc-93	D 0.8	7.0E+04	2.9E-05	0.8	3.0E+04	9.7E-08	4.2E-04	4.2E-03
2.75 h	W 0.8	9.9E+04	4.1E-05					
Tc-93m	D 0.8	1.4E+05	5.8E-05	0.8	6.7E+04	2.0E-07	9.2E-04	9.2E-03
43.5 m	W 0.8	2.0E+05	8.3E-05					
Tc-94	D 0.8	1.8E+04	7.5E-06	0.8	8600	2.5E-08	1.1E-04	1.1E-03
293 m	W 0.8	2.3E+04	9.5E-06					
Tc-94m	D 0.8	3.5E+04	1.4E-05	0.8	1.7E+04	4.9E-08	2.4E-04	2.4E-03
52 m	W 0.8	4.9E+04	2.0E-05					
Tc-95	D 0.8	2.0E+04	8.3E-06	0.8	1.0E+04	2.7E-08	1.4E-04	1.4E-03
20.0 h	W 0.8	1.9E+04	7.9E-06					
Tc-95m	D 0.8	5300	2.2E-06	0.8	3400	1.7E-09	4.7E-05	4.7E-04
61 d	W 0.8	1200	5.0E-07					
Tc-96	D 0.8	3100	1.2E-06	0.8	1800	2.9E-09	2.4E-05	2.4E-04
4.28 d	W 0.8	2100	8.7E-07					
Tc-96m	D 0.8	2.7E+05	1.1E-04	0.8	1.5E+05	2.9E-07	0.0021	0.021
51.5 m	W 0.8	2.1E+05	8.7E-05					
Tc-97	D 0.8	4.0E+04	1.6E-05	0.8	2.9E+04	6.9E-09	3.9E-04	3.9E-03
2.6E6 y	W 0.8	5000	2.0E-06					
Tc-97m	D 0.8	5700	2.3E-06	0.8	4000	1.4E-09	5.5E-05	5.5E-04
87 d	W 0.8	1000	4.1E-07					
Tc-98	D 0.8	1500	6.2E-07	0.8	1000	3.0E-10	1.4E-05	1.4E-04
4.2E6 y	W 0.8	210	8.7E-08					
Tc-99	D 0.8	4800	2.0E-06	0.8	3400	8.3E-10	4.6E-05	4.6E-04
2.13E5 y	W 0.8	600	2.5E-07					
Tc-99m	D 0.8	1.5E+05	6.2E-05	0.8	8.0E+04	2.1E-07	0.0011	0.011
6.02 h	W 0.8	1.8E+05	7.5E-05					
Tc-101	D 0.8	2.7E+05	1.1E-04	0.8	9.0E+04	3.8E-07	0.0016	0.016
14.2 m	W 0.8	3.4E+05	1.4E-04		(1.1E+05)			
					St wall			
Tc-104	D 0.8	6.0E+04	2.5E-05	0.8	2.1E+04	8.4E-08	3.6E-04	3.6E-03
18.2 m	W 0.8	7.6E+04	3.1E-05		(2.6E+04)			
					St wall			
Ruthenium								
Ru-94	D 0.05	3.7E+04	1.5E-05	0.05	1.4E+04	5.2E-08	1.9E-04	1.9E-03
51.8 m	W 0.05	4.7E+04	1.9E-05					
	Y 0.05	4.3E+04	1.7E-05					
Ru-97	D 0.05	1.8E+04	7.5E-06	0.05	7100	1.5E-08	9.8E-05	9.8E-04
2.9 d	W 0.05	1.1E+04	4.5E-06					
	Y 0.05	1.1E+04	4.5E-06					
Ru-103	D 0.05	1600	6.6E-07	0.05	1600	7.7E-10	2.2E-05	2.2E-04
39.28 d	W 0.05	770	3.2E-07					
	Y 0.05	550	2.2E-07					
Ru-105	D 0.05	1.3E+04	5.4E-06	0.05	4700	1.5E-08	6.4E-05	6.4E-04
4.44 h	W 0.05	1.2E+04	5.0E-06					
	Y 0.05	1.0E+04	4.1E-06					
Ru-106	D 0.05	88	3.6E-08	0.05	180	1.4E-11	2.5E-06	2.5E-05
368.2 d	W 0.05	42	1.7E-08					
	Y 0.05	10	4.1E-09					
Rhodium								
Rh-99	D 0.05	2900	1.2E-06	0.05	2200	2.2E-09	3.0E-05	3.0E-04
16 d	W 0.05	1700	7.0E-07					
	Y 0.05	1600	6.6E-07					
Rh-99m	D 0.05	5.7E+04	2.3E-05	0.05	1.7E+04	8.0E-08	2.3E-04	2.3E-03
4.7 h	W 0.05	6.5E+04	2.7E-05					
	Y 0.05	6.0E+04	2.5E-05					
Rh-100	D 0.05	5000	2.0E-06	0.05	1500	4.9E-09	2.1E-05	2.1E-04
20.8 h	W 0.05	3900	1.6E-06					
	Y 0.05	3500	1.4E-06					
Rh-101	D 0.05	490	2.0E-07	0.05	2100	1.7E-10	2.9E-05	2.9E-04
3.2 y	W 0.05	640	2.6E-07					
	Y 0.05	120	5.0E-08					
Rh-101m	D 0.05	1.1E+04	4.5E-06	0.05	5000	9.2E-09	6.9E-05	6.9E-04
4.34 d	W 0.05	7100	2.9E-06					
	Y 0.05	6600	2.7E-06					

	Table I Occupational Values					Table II Effluent		Table III Sewer
	Inhalation			Ingestion				
Nuclide	Class/f_1	ALI (μCi)	DAC (μCi/ml)	f_1	ALI (μCi)	Air (μCi/ml)	Water (μCi/ml)	Discharge (μCi/ml)
Rhodium, cont'd.								
Rh-102	D 0.05	94	3.9E-08	0.05	470	5.7E-11	6.5E-06	6.5E-05
2.9 y	W 0.05	160	6.6E-08					
	Y 0.05	41	1.7E-08					
Rh-102m	D 0.05	500	2.0E-07	0.05	1000	1.4E-10	1.4E-05	1.4E-04
207 d	W 0.05	300	1.2E-07					
	Y 0.05	100	4.1E-08					
Rh-103m	D 0.05	9.7E+05	4.0E-04	0.05	4.3E+05	1.3E-06	0.0058	0.058
56.12 m	W 0.05	1.1E+06	4.5E-04					
	Y 0.05	1.0E+06	4.1E-04					
Rh-105	D 0.05	1.0E+04	4.1E-06	0.05	3300	7.2E-09	4.6E-05	4.6E-04
35.36 h	W 0.05	5700	2.3E-06					
	Y 0.05	5200	2.1E-06					
Rh-106m	D 0.05	2.3E+04	9.5E-06	0.05	7700	3.2E-08	1.0E-04	1.0E-03
132 m	W 0.05	2.9E+04	1.2E-05					
	Y 0.05	2.7E+04	1.1E-05					
Rh-107	D 0.05	2.0E+05	8.3E-05	0.05	7.2E+04	2.8E-07	0.0011	0.011
21.7 m	W 0.05	2.4E+05	10E-05		(8.3E+04)			
	Y 0.05	2.3E+05	9.5E-05		St wall			
Palladium								
Pd-100	D 0.005	1400	5.8E-07	0.005	1100	1.7E-09	1.5E-05	1.5E-04
3.63 d	W 0.005	1200	5.0E-07					
	Y 0.005	1200	5.0E-07					
Pd-101	D 0.005	3.1E+04	1.2E-05	0.005	1.2E+04	3.7E-08	1.6E-04	1.6E-03
8.27 h	W 0.005	2.9E+04	1.2E-05					
	Y 0.005	2.6E+04	1.0E-05					
Pd-103	D 0.005	5700	2.3E-06	0.005	5800	4.4E-09	8.6E-05	8.6E-04
16.96 d	W 0.005	3500	1.4E-06		(6300)			
	Y 0.005	3100	1.2E-06		LLI wall			
Pd-107	D 0.005	1.9E+04	7.9E-06	0.005	2.8E+04	5.4E-10	4.5E-04	4.5E-03
6.5E6 y	W 0.005	6100	2.5E-06		(3.3E+04)			
	Y 0.005	390	1.6E-07		LLI wall			
Pd-109	D 0.005	6000	2.5E-06	0.005	2300	6.3E-09	3.1E-05	3.1E-04
13.427 h	W 0.005	4900	2.0E-06					
	Y 0.005	4500	1.8E-06					
Silver								
Ag-102	D 0.05	1.4E+05	5.8E-05	0.05	4.5E+04	2.0E-07	6.7E-04	6.7E-03
12.9 m	W 0.05	1.7E+05	7.0E-05		(4.9E+04)			
	Y 0.05	1.7E+05	7.0E-05		St wall			
Ag-103	D 0.05	8.5E+04	3.5E-05	0.05	3.3E+04	1.1E-07	4.6E-04	4.6E-03
65.7 m	W 0.05	1.0E+05	4.1E-05					
	Y 0.05	9.7E+04	4.0E-05					
Ag-104	D 0.05	7.0E+04	2.9E-05	0.05	2.1E+04	9.7E-08	2.9E-04	2.9E-03
69.2 m	W 0.05	1.0E+05	4.1E-05					
	Y 0.05	9.9E+04	4.1E-05					
Ag-104m	D 0.05	7.9E+04	3.2E-05	0.05	2.9E+04	1.1E-07	4.0E-04	4.0E-03
33.5 m	W 0.05	1.0E+05	4.1E-05					
	Y 0.05	9.7E+04	4.0E-05					
Ag-105	D 0.05	1000	4.1E-07	0.05	2400	1.4E-09	3.3E-05	3.3E-04
41.0 d	W 0.05	1300	5.4E-07					
	Y 0.05	1100	4.5E-07					
Ag-106	D 0.05	1.5E+05	6.2E-05	0.05	5.5E+04	2.1E-07	8.1E-04	8.1E-03
23.96 m	W 0.05	1.8E+05	7.5E-05		(5.9E+04)			
	Y 0.05	1.7E+05	7.0E-05		St wall			
Ag-106m	D 0.05	690	2.8E-07	0.05	770	9.7E-10	1.0E-05	1.0E-04
8.41 d	W 0.05	870	3.6E-07					
	Y 0.05	900	3.7E-07					
Ag-108m	D 0.05	160	6.6E-08	0.05	650	2.4E-11	8.9E-06	8.9E-05
127 y	W 0.05	190	7.9E-08					
	Y 0.05	17	7.0E-09					
Ag-110m	D 0.05	120	5.0E-08	0.05	460	8.6E-11	6.3E-06	6.3E-05
249.9 d	W 0.05	160	6.6E-08					
	Y 0.05	62	2.5E-08					
Ag-111	D 0.05	1400	5.8E-07	0.05	910	1.1E-09	1.3E-05	1.3E-04
7.45 d	W 0.05	860	3.5E-07		(980)			
	Y 0.05	810	3.3E-07		LLI wall			
Ag-112	D 0.05	7600	3.1E-06	0.05	3000	1.0E-08	4.1E-05	4.1E-04
3.12 h	W 0.05	8200	3.4E-06					
	Y 0.05	7500	3.1E-06					
Ag-115	D 0.05	7.6E+04	3.1E-05	0.05	3.1E+04	9.8E-08	4.2E-04	4.2E-03
20.0 m	W 0.05	7.5E+04	3.1E-05					
	Y 0.05	7.1E+04	2.9E-05					

	Table I Occupational Values					Table II Effluent		Table III Sewer
	Inhalation			Ingestion				
Nuclide	Class/f_1	ALI (µCi)	DAC (µCi/ml)	f_1	ALI (µCi)	Air (µCi/ml)	Water (µCi/ml)	Discharge (µCi/ml)
Cadmium								
Cd-104	D 0.05	6.6E+04	2.7E-05	0.05	2.1E+04	9.1E-08	2.9E-04	2.9E-03
57.7 m	W 0.05	9.6E+04	4.0E-05					
	Y 0.05	9.0E+04	3.7E-05					
Cd-107	D 0.05	4.8E+04	2.0E-05	0.05	1.9E+04	6.3E-08	2.7E-04	2.7E-03
6.49 h	W 0.05	4.9E+04	2.0E-05					
	Y 0.05	4.6E+04	1.9E-05					
Cd-109 464 d	D 0.05	34 (43) Kidneys	1.4E-08	0.05	330 (380) Kidneys	6.0E-11	5.2E-06	5.2E-05
	W 0.05	110 (120) Kidneys	4.5E-08					
	Y 0.05	110	4.5E-08					
Cd-113 9.3E15 y	D 0.05	2.2 (2.9) Kidneys	9.1E-10	0.05	21 (28) Kidneys	4.1E-12	3.9E-07	3.9E-06
	W 0.05	7.5 (9.8) Kidneys	3.1E-09					
	Y 0.05	12	5.0E-09					
Cd-113m 13.6 y	D 0.05	2.4 (3.2) Kidneys	10E-10	0.05	23 (31) Kidneys	4.5E-12	4.2E-07	4.2E-06
	W 0.05	8.2 (10) Kidneys	3.4E-09					
	Y 0.05	12	5.0E-09					
Cd-115	D 0.05	1200	5.0E-07	0.05	870	1.6E-09	1.2E-05	1.2E-04
53.46 h	W 0.05	1100	4.5E-07					
	Y 0.05	1100	4.5E-07					
Cd-115m 44.6 d	D 0.05	54 (69) Kidneys	2.2E-08	0.05	300	9.6E-11	4.2E-06	4.2E-05
	W 0.05	120	5.0E-08					
	Y 0.05	110	4.5E-08					
Cd-117	D 0.05	1.1E+04	4.5E-06	0.05	4400	1.5E-08	6.1E-05	6.1E-04
2.49 h	W 0.05	1.2E+04	5.0E-06					
	Y 0.05	1.1E+04	4.5E-06					
Cd-117m	D 0.05	1.1E+04	4.5E-06	0.05	4200	1.5E-08	5.7E-05	5.7E-04
3.36 h	W 0.05	1.3E+04	5.4E-06					
	Y 0.05	1.2E+04	5.0E-06					
Indium								
In-109	D 0.02	4.2E+04	1.7E-05	0.02	1.7E+04	5.8E-08	2.4E-04	2.4E-03
4.2 h	W 0.02	5.9E+04	2.4E-05					
In-110	D 0.02	1.6E+04	6.6E-06	0.02	4700	2.2E-08	6.4E-05	6.4E-04
4.9 h	W 0.02	1.9E+04	7.9E-06					
In-110	D 0.02	3.6E+04	1.5E-05	0.02	1.4E+04	5.1E-08	1.9E-04	1.9E-03
69.1 m	W 0.02	4.6E+04	1.9E-05					
In-111	D 0.02	6400	2.6E-06	0.02	3700	8.2E-09	5.1E-05	5.1E-04
2.83 d	W 0.02	5900	2.4E-06					
In-112	D 0.02	5.5E+05	2.2E-04	0.02	1.6E+05 (2.0E+05) St wall	7.6E-07	0.0028	0.028
14.4 m	W 0.02	6.5E+05	2.7E-04					
In-113m	D 0.02	1.2E+05	5.0E-05	0.02	4.7E+04	1.6E-07	6.5E-04	6.5E-03
1.658 h	W 0.02	1.4E+05	5.8E-05					
In-114m	D 0.02	56	2.3E-08	0.02	290	7.8E-11	4.0E-06	4.0E-05
49.51 d	W 0.02	89	3.7E-08					
In-115	D 0.02	1.3	5.4E-10	0.02	31	1.8E-12	4.3E-07	4.3E-06
5.1E15 y	W 0.02	4.8	2.0E-09					
In-115m	D 0.02	3.7E+04	1.5E-05	0.02	1.4E+04	5.2E-08	1.9E-04	1.9E-03
4.486 h	W 0.02	3.9E+04	1.6E-05					
In-116m	D 0.02	6.5E+04	2.7E-05	0.02	2.2E+04	9.1E-08	3.1E-04	3.1E-03
54.15 m	W 0.02	8.8E+04	3.6E-05					
In-117	D 0.02	1.3E+05	5.4E-05	0.02	5.2E+04	1.8E-07	7.1E-04	7.1E-03
43.8 m	W 0.02	1.7E+05	7.0E-05					
In-117m	D 0.02	2.8E+04	1.1E-05	0.02	1.1E+04	3.9E-08	1.6E-04	1.6E-03
116.5 m	W 0.02	3.3E+04	1.3E-05					
In-119m	D 0.02	1.1E+05	4.5E-05	0.02	3.6E+04 (4.6E+04) St wall	1.5E-07	6.4E-04	6.4E-03
18.0 m	W 0.02	1.3E+05	5.4E-05					

	Table I Occupational Values						Table II Effluent		Table III Sewer Discharge
	Inhalation				Ingestion				
Nuclide	Class/f_1		ALI (μCi)	DAC (μCi/ml)	f_1	ALI (μCi)	Air (μCi/ml)	Water (μCi/ml)	(μCi/ml)
Tin									
Sn-110	D	0.02	1.0E+04	4.1E-06	0.02	3200	1.3E-08	4.4E-05	4.4E-04
4.0 h	W	0.02	9900	4.1E-06					
Sn-111	D	0.02	1.8E+05	7.5E-05	0.02	6.9E+04	2.5E-07	9.4E-04	9.4E-03
35.3 m	W	0.02	1.9E+05	7.9E-05					
Sn-113	D	0.02	1200	5.0E-07	0.02	1600	6.5E-10	2.2E-05	2.2E-04
115.1 d	W	0.02	460	1.9E-07					
Sn-117m	D	0.02	1200	5.0E-07	0.02	1600	1.6E-09	2.3E-05	2.3E-04
13.61 d			(1900)						
			BSurface						
	W	0.02	1100	4.5E-07					
Sn-119m	D	0.02	2200	9.1E-07	0.02	3300	1.1E-09	4.9E-05	4.9E-04
293.0 d	W	0.02	800	3.3E-07		(3500)			
						LLI wall			
Sn-121	D	0.02	1.4E+04	5.8E-06	0.02	5500	1.3E-08	7.5E-05	7.5E-04
27.06 h	W	0.02	9800	4.0E-06					
Sn-121m	D	0.02	760	3.1E-07	0.02	3000	6.0E-10	4.4E-05	4.4E-04
55 y	W	0.02	430	1.7E-07		(3200)			
						LLI wall			
Sn-123	D	0.02	580	2.4E-07	0.02	520	2.1E-10	8.1E-06	8.1E-05
129.2 d	W	0.02	150	6.2E-08		(590)			
						LLI wall			
Sn-123m	D	0.02	1.0E+05	4.1E-05	0.02	4.6E+04	1.5E-07	6.3E-04	6.3E-03
40.08 m	W	0.02	1.2E+05	5.0E-05					
Sn-125	D	0.02	860	3.5E-07	0.02	360	4.4E-10	5.5E-06	5.5E-05
9.64 d	W	0.02	320	1.3E-07		(400)			
						LLI wall			
Sn-126	D	0.02	57	2.3E-08	0.02	250	6.9E-11	3.5E-06	3.5E-05
1.0E5 y	W	0.02	50	2.0E-08					
Sn-127	D	0.02	1.7E+04	7.0E-06	0.02	6400	2.1E-08	8.8E-05	8.8E-04
2.10 h	W	0.02	1.5E+04	6.2E-06					
Sn-128	D	0.02	2.3E+04	9.5E-06	0.02	9000	3.2E-08	1.2E-04	1.2E-03
59.1 m	W	0.02	2.9E+04	1.2E-05					
Antimony									
Sb-115	D	0.1	1.9E+05	7.9E-05	0.1	6.9E+04	2.6E-07	9.4E-04	9.4E-03
31.8 m	W	0.01	2.4E+05	10E-05	0.01	6.9E+04			
Sb-116	D	0.1	2.1E+05	8.7E-05	0.1	7.0E+04	2.9E-07	9.7E-04	9.7E-03
15.8 m	W	0.01	2.6E+05	1.0E-04		(7.1E+04)			
						St wall			
					0.01	7.0E+04			
						(7.1E+04)			
						St wall			
Sb-116m	D	0.1	6.5E+04	2.7E-05	0.1	2.0E+04	9.0E-08	2.7E-04	2.7E-03
60.3 m	W	0.01	9.3E+04	3.8E-05	0.01	2.0E+04			
Sb-117	D	0.1	1.9E+05	7.9E-05	0.1	6.7E+04	2.7E-07	8.8E-04	8.8E-03
2.80 h	W	0.01	2.3E+05	9.5E-05	0.01	6.4E+04			
Sb-118m	D	0.1	1.9E+04	7.9E-06	0.1	5500	2.6E-08	7.2E-05	7.2E-04
5.00 h	W	0.01	2.1E+04	8.7E-06	0.01	5200			
Sb-119	D	0.1	4.2E+04	1.7E-05	0.1	1.5E+04	3.2E-08	1.9E-04	1.9E-03
38.1 h	W	0.01	2.3E+04	9.5E-06	0.01	1.4E+04			
Sb-120	D	0.1	3.8E+05	1.5E-04	0.1	1.2E+05	5.2E-07	0.0019	0.019
15.89 m	W	0.01	4.5E+05	1.8E-04		(1.4E+05)			
						St wall			
					0.01	1.2E+05			
						(1.4E+05)			
						St wall			
Sb-120	D	0.1	2200	9.1E-07	0.1	920	1.7E-09	1.2E-05	1.2E-04
5.76 d	W	0.01	1200	5.0E-07	0.01	870			
Sb-122	D	0.1	2100	8.7E-07	0.1	730	1.3E-09	9.4E-06	9.4E-05
2.70 d	W	0.01	970	4.0E-07	0.01	680			
Sb-124	D	0.1	890	3.7E-07	0.1	510	2.7E-10	6.7E-06	6.7E-05
60.20 d	W	0.01	190	7.9E-08	0.01	490			
Sb-124m	D	0.1	6.1E+05	2.5E-04	0.1	2.2E+05	6.6E-07	0.0031	0.031
93 s	W	0.01	4.8E+05	2.0E-04	0.01	2.2E+05			
Sb-125	D	0.1	2300	9.5E-07	0.1	1700	5.6E-10	2.4E-05	2.4E-04
2.77 y	W	0.01	410	1.7E-07	0.01	1700			
Sb-126	D	0.1	1000	4.1E-07	0.1	490	5.9E-10	6.4E-06	6.4E-05
12.4 d	W	0.01	420	1.7E-07	0.01	460			

	Table I Occupational Values						Table II Effluent		Table III Sewer
	Inhalation				Ingestion				
Nuclide	Class/f_1		ALI (μCi)	DAC (μCi/ml)	f_1	ALI (μCi)	Air (μCi/ml)	Water (μCi/ml)	Discharge (μCi/ml)
Antimony									
Sb-126m	D	0.1	1.4E+05	5.8E-05	0.1	5.1E+04	2.0E-07	7.2E-04	7.2E-03
19.0 m	W	0.01	1.7E+05	7.0E-05		(5.3E+04)			
						St wall			
					0.01	5.1E+04			
						(5.3E+04)			
						St wall			
Sb-127	D	0.1	2000	8.3E-07	0.1	740	1.1E-09	9.5E-06	9.5E-05
3.85 d	W	0.01	820	3.4E-07	0.01	680			
						(690)			
						LLI wall			
Sb-128	D	0.1	2.8E+05	1.1E-04	0.1	8.2E+04	3.9E-07	0.0011	0.011
10.4 m	W	0.01	3.4E+05	1.4E-04		(8.4E+04)			
						St wall			
					0.01	8.2E+04			
						(8.4E+04)			
						St wall			
Sb-128	D	0.1	3600	1.5E-06	0.1	1200	4.1E-09	1.5E-05	1.5E-04
9.01 h	W	0.01	2900	1.2E-06	0.01	1100			
Sb-129	D	0.1	8200	3.4E-06	0.1	2900	1.0E-08	3.8E-05	3.8E-04
4.32 h	W	0.01	7700	3.2E-06	0.01	2700			
Sb-130	D	0.1	4.8E+04	2.0E-05	0.1	1.7E+04	6.6E-08	2.3E-04	2.3E-03
40 m	W	0.01	6.2E+04	2.5E-05	0.01	1.7E+04			
Sb-131	D	0.1	2.3E+04	9.5E-06	0.1	1.4E+04	4.8E-08	2.2E-04	2.2E-03
23 m			(3.4E+04)			(1.6E+04)			
			Thyroid			Thyroid			
	W	0.01	2.3E+04	9.5E-06	0.01	1.4E+04			
			(3.8E+04)			(1.6E+04)			
			Thyroid			Thyroid			
Tellurium									
Te-116	D	0.2	1.8E+04	7.5E-06	0.2	6900	2.6E-08	9.4E-05	9.4E-04
2.49 h	W	0.2	2.2E+04	9.1E-06					
Te-121	D	0.2	4200	1.7E-06	0.2	2900	3.6E-09	4.0E-05	4.0E-04
17 d	W	0.2	2600	1.0E-06					
Te-121m	D	0.2	190	7.9E-08	0.2	490	4.3E-10	8.8E-06	8.8E-05
154 d			(310)			(640)			
			BSurface			BSurface			
	W	0.2	330	1.3E-07					
Te-123	D	0.2	180	7.5E-08	0.2	480	6.5E-10	1.6E-05	1.6E-04
1E13 y			(470)			(1100)			
			BSurface			BSurface			
	W	0.2	430	1.7E-07					
			(1000)						
			BSurface						
Te-123m	D	0.2	220	9.1E-08	0.2	560	6.5E-10	1.2E-05	1.2E-04
119.7 d			(470)			(880)			
			BSurface			BSurface			
	W	0.2	470	1.9E-07					
Te-125m	D	0.2	420	1.7E-07	0.2	1000	9.5E-10	1.8E-05	1.8E-04
58 d			(880)			(1300)			
			BSurface			BSurface			
	W	0.2	680	2.8E-07					
Te-127	D	0.2	2.0E+04	8.3E-06	0.2	7200	2.1E-08	9.9E-05	9.9E-04
9.35 h	W	0.2	1.5E+04	6.2E-06					
Te-127m	D	0.2	250	1.0E-07	0.2	600	3.2E-10	8.3E-06	8.3E-05
109 d			(370)						
			BSurface						
	W	0.2	230	9.5E-08					
Te-129	D	0.2	5.5E+04	2.2E-05	0.2	2.4E+04	7.7E-08	3.3E-04	3.3E-03
69.6 m	W	0.2	6.4E+04	2.6E-05					
Te-129m	D	0.2	530	2.2E-07	0.2	460	2.8E-10	6.4E-06	6.4E-05
33.6 d	W	0.2	200	8.3E-08					
Te-131	D	0.2	5100	2.1E-06	0.2	3200	1.4E-08	7.5E-05	7.5E-04
25.0 m			(1.0E+04)			(5500)			
			Thyroid			Thyroid			
	W	0.2	5000	2.0E-06					
			(1.0E+04)						
			Thyroid						

	Table I Occupational Values					Table II Effluent		Table III Sewer Discharge
	Inhalation			Ingestion				
Nuclide	Class/f_1	ALI (µCi)	DAC (µCi/ml)	f_1	ALI (µCi)	Air (µCi/ml)	Water (µCi/ml)	(µCi/ml)
Tellurium, cont'd.								
Te-131m 30 h	D 0.2	410 (970) Thyroid	1.7E-07	0.2	310 (540) Thyroid	1.0E-09	7.5E-06	7.5E-05
	W 0.2	370 (780) Thyroid	1.5E-07					
Te-132 78.2 h	D 0.2	230 (590) Thyroid	9.5E-08	0.2	220 (530) Thyroid	7.3E-10	7.2E-06	7.2E-05
	W 0.2	210 (520) Thyroid	8.7E-08					
Te-133 12.45 m	D 0.2	2.2E+04 (5.4E+04) Thyroid	9.1E-06	0.2	1.4E+04 (2.8E+04) Thyroid	7.5E-08	3.9E-04	3.9E-03
	W 0.2	2.2E+04 (5.6E+04) Thyroid	9.1E-06					
Te-133m 55.4 m	D 0.2	5100 (1.1E+04) Thyroid	2.1E-06	0.2	3200 (5900) Thyroid	1.6E-08	8.2E-05	8.2E-04
	W 0.2	5100 (1.2E+04) Thyroid	2.1E-06					
Te-134 41.8 m	D 0.2	2.4E+04 (3.9E+04) Thyroid	10E-06	0.2	1.5E+04 (2.0E+04) Thyroid	5.4E-08	2.7E-04	2.7E-03
	W 0.2	2.4E+04 (4.1E+04) Thyroid	10E-06					
Iodine								
I-120 81.0 m	D 1	8700 (1.1E+04) Thyroid	3.6E-06	1	3900 (6500) Thyroid	1.5E-08	8.9E-05	8.9E-04
I-120m 53 m	D 1	1.8E+04	7.5E-06	1	1.0E+04	2.6E-08	1.3E-04	1.3E-03
I-121 2.12 h	D 1	1.7E+04 (4.2E+04) Thyroid	7.0E-06	1	9800 (2.5E+04) Thyroid	5.8E-08	3.4E-04	3.4E-03
I-123 13.2 h	D 1	6000 (1.6E+04) Thyroid	2.5E-06	1	3000 (9400) Thyroid	2.3E-08	1.2E-04	1.2E-03
I-124 4.18 d	D 1	79 (250) Thyroid	3.2E-08	1	47 (150) Thyroid	3.5E-10	2.1E-06	2.1E-05
I-125 60.14 d	D 1	62 (200) Thyroid	2.5E-08	1	39 (130) Thyroid	2.8E-10	1.7E-06	1.7E-05
I-126 13.02 d	D 1	34 (110) Thyroid	1.4E-08	1	21 (70) Thyroid	1.5E-10	9.6E-07	9.6E-06
I-128 24.99 m	D 1	1.0E+05	4.1E-05	1	4.1E+04 (5.5E+04) St wall	1.4E-07	7.6E-04	7.6E-03
I-129 1.57E7 y	D 1	8.6 (28) Thyroid	3.5E-09	1	5.4 (18) Thyroid	3.9E-11	2.4E-07	2.4E-06
I-130 12.36 h	D 1	670 (1800) Thyroid	2.7E-07	1	340 (1000) Thyroid	2.6E-09	1.4E-05	1.4E-04
I-131 8.04 d	D 1	46 (150) Thyroid	1.9E-08	1	28 (93) Thyroid	2.1E-10	1.2E-06	1.2E-05
I-132 2.30 h	D 1	7700 (1.3E+04) Thyroid	3.2E-06	1	3400 (7400) Thyroid	1.8E-08	1.0E-04	1.0E-03
I-132m 83.6 m	D 1	8100 (1.6E+04) Thyroid	3.3E-06	1	3600 (9500) Thyroid	2.3E-08	1.3E-04	1.3E-03

	Table I Occupational Values					Table II Effluent		Table III Sewer Discharge
	Inhalation			Ingestion				
Nuclide	Class/f_1	ALI (μCi)	DAC (μCi/ml)	f_1	ALI (μCi)	Air (μCi/ml)	Water (μCi/ml)	(μCi/ml)
Iodine, cont'd.								
I-133 20.8 h	D 1	270 (850) Thyroid	1.1E-07	1	140 (480) Thyroid	1.1E-09	6.6E-06	6.6E-05
I-134 52.6 m	D 1	3.8E+04	1.5E-05	1	2.0E+04	5.2E-08	2.7E-04	2.7E-03
I-135 6.61 h	D 1	1500 (4000) Thyroid	6.2E-07	1	750 (2200) Thyroid	5.6E-09	3.0E-05	3.0E-04
Xenon								
Xe-120 40 m	Submersion		9.6E-06			4.4E-08		
Xe-121 40.1 m	Submersion		2.0E-06			9.3E-09		
Xe-122 20.1 h	Submersion		7.6E-05			3.4E-07		
Xe-123 2.08 h	Submersion		6.1E-06			2.8E-08		
Xe-125 17.0 h	Submersion		1.5E-05			7.2E-08		
Xe-127 36.41 d	Submersion		1.5E-05			6.8E-08		
Xe-129m 8.0 d	Submersion		1.7E-04			8.0E-07		
Xe-131m 11.9 d	Submersion		3.8E-04 (4.8E-04) Skin			2.2E-06		
Xe-133m 2.188 d	Submersion		1.3E-04			6.2E-07		
Xe-133 5.245 d	Submersion		1.2E-04			5.4E-07		
Xe-135m 15.29 m	Submersion		9.2E-06			4.2E-08		
Xe-135 9.09 h	Submersion		1.5E-05			7.2E-08		
Xe-138 14.17 m	Submersion		3.2E-06			1.4E-08		
Cesium								
Cs-125 45 m	D 1	1.2E+05	5.0E-05	1	5.4E+04 (6.9E+04) St wall	1.6E-07	9.4E-04	9.4E-03
Cs-127 6.25 h	D 1	8.4E+04	3.5E-05	1	6.3E+04	1.1E-07	8.7E-04	8.7E-03
Cs-129 32.06 h	D 1	3.1E+04	1.2E-05	1	2.2E+04	4.3E-08	3.1E-04	3.1E-03
Cs-130 29.9 m	D 1	1.6E+05	6.6E-05	1	6.2E+04 (8.7E+04) St wall	2.3E-07	0.0011	0.011
Cs-131 9.69 d	D 1	3.0E+04	1.2E-05	1	2.0E+04	4.1E-08	2.7E-04	2.7E-03
Cs-132 6.475 d	D 1	4000	1.6E-06	1	2600	5.6E-09	3.6E-05	3.6E-04
Cs-134 2.062 y	D 1	100	4.1E-08	1	68	1.4E-10	9.3E-07	9.3E-06
Cs-134m 2.90 h	D 1	1.1E+05	4.5E-05	1	1.0E+05	1.5E-07	0.0013	0.013
Cs-135 2.3E6 y	D 1	1100	4.5E-07	1	700	1.5E-09	9.6E-06	9.6E-05
Cs-135m 53 m	D 1	2.0E+05	8.3E-05	1	8.9E+04	2.8E-07	0.0012	0.012
Cs-136 13.1 d	D 1	680	2.8E-07	1	440	9.4E-10	6.0E-06	6.0E-05
Cs-137 30.0 y	D 1	150	6.2E-08	1	99	2.1E-10	1.3E-06	1.3E-05
Cs-138 32.2 m	D 1	4.9E+04	2.0E-05	1	1.9E+04 (2.5E+04) St wall	6.8E-08	3.5E-04	3.5E-03
Barium								
Ba-126 96.5 m	D 0.1	1.3E+04	5.4E-06	0.1	5500	1.8E-08	7.5E-05	7.5E-04
Ba-128 2.43 d	D 0.1	1600	6.6E-07	0.1	470	2.2E-09	6.5E-06	6.5E-05

Nuclide	Table I Occupational Values: Inhalation Class/f_1	Inhalation ALI (μCi)	Inhalation DAC (μCi/ml)	Ingestion f_1	Ingestion ALI (μCi)	Table II Effluent Air (μCi/ml)	Table II Effluent Water (μCi/ml)	Table III Sewer Discharge (μCi/ml)
Barium, cont'd.								
Ba-131	D 0.1	7400	3.0E-06	0.1	2700	1.0E-08	3.7E-05	3.7E-04
11.8 d								
Ba-131m	D 0.1	1.0E+06	4.1E-04	0.1	3.7E+05	1.5E-06	0.0056	0.056
14.6 m					(4.1E+05)			
					St wall			
Ba-133	D 0.1	630	2.6E-07	0.1	1400	8.8E-10	2.0E-05	2.0E-04
10.74 y								
Ba-133m	D 0.1	8000	3.3E-06	0.1	2300	1.1E-08	3.2E-05	3.2E-04
38.9 h								
Ba-135m	D 0.1	9900	4.1E-06	0.1	2900	1.3E-08	4.0E-05	4.0E-04
28.7 h								
Ba-139	D 0.1	2.9E+04	1.2E-05	0.1	1.2E+04	4.0E-08	1.7E-04	1.7E-03
82.7 m								
Ba-140	D 0.1	1300	5.4E-07	0.1	510	1.8E-09	7.2E-06	7.2E-05
12.74 d					(520)			
					LLI wall			
Ba-141	D 0.1	6.2E+04	2.5E-05	0.1	2.3E+04	8.6E-08	3.2E-04	3.2E-03
18.27 m								
Ba-142	D 0.1	1.2E+05	5.0E-05	0.1	4.4E+04	1.6E-07	6.1E-04	6.1E-03
10.6 m								
Lanthanum								
La-131	D 0.001	9.6E+04	4.0E-05	0.001	4.1E+04	1.3E-07	5.7E-04	5.7E-03
59 m	W 0.001	1.2E+05	5.0E-05					
La-132	D 0.001	9100	3.7E-06	0.001	3100	1.2E-08	4.3E-05	4.3E-04
4.8 h	W 0.001	9700	4.0E-06					
La-135	D 0.001	1.0E+05	4.1E-05	0.001	3.6E+04	1.1E-07	5.0E-04	5.0E-03
19.5 h	W 0.001	8.4E+04	3.5E-05					
La-137	D 0.001	57	2.3E-08	0.001	1.1E+04	7.9E-11	1.5E-04	1.5E-03
6E4 y	W 0.001	210	8.7E-08					
La-138	D 0.001	3.6	1.5E-09	0.001	840	5.0E-12	1.1E-05	1.1E-04
1.35E11	W 0.001	14	5.8E-09					
La-140	D 0.001	1400	5.8E-07	0.001	590	1.4E-09	8.1E-06	8.1E-05
40.272 h	W 0.001	1000	4.1E-07					
La-141	D 0.001	8500	3.5E-06	0.001	3600	1.1E-08	4.9E-05	4.9E-04
3.93 h	W 0.001	8800	3.6E-06					
La-142	D 0.001	1.9E+04	7.9E-06	0.001	7500	2.7E-08	1.0E-04	1.0E-03
92.5 m	W 0.001	2.4E+04	10E-06					
La-143	D 0.001	8.5E+04	3.5E-05	0.001	3.4E+04	1.1E-07	4.9E-04	4.9E-03
14.23 m	W 0.001	8.3E+04	3.4E-05		(3.5E+04)			
					St wall			
Cerium								
Ce-134	W 3.0E-04	630	2.6E-07	3.0E-04	480	8.5E-10	6.5E-06	6.5E-05
72.0 h	Y 3.0E-04	610	2.5E-07					
Ce-135	W 3.0E-04	3400	1.4E-06	3.0E-04	1400	4.3E-09	1.9E-05	1.9E-04
17.6 h	Y 3.0E-04	3100	1.2E-06					
Ce-137	W 3.0E-04	1.2E+05	5.0E-05	3.0E-04	4.8E+04	1.6E-07	6.6E-04	6.6E-03
9.0 h	Y 3.0E-04	1.1E+05	4.5E-05					
Ce-137m	W 3.0E-04	3700	1.5E-06	3.0E-04	2200	4.9E-09	3.1E-05	3.1E-04
34.4 h	Y 3.0E-04	3500	1.4E-06					
Ce-139	W 3.0E-04	690	2.8E-07	3.0E-04	4300	7.6E-10	5.9E-05	5.9E-04
137.66 d	Y 3.0E-04	550	2.2E-07					
Ce-141	W 3.0E-04	600	2.5E-07	3.0E-04	1500	7.7E-10	2.3E-05	2.3E-04
32.501 d	Y 3.0E-04	550	2.2E-07		(1700)			
					LLI wall			
Ce-143	W 3.0E-04	1500	6.2E-07	3.0E-04	1000	2.0E-09	1.5E-05	1.5E-04
33.0 h	Y 3.0E-04	1400	5.8E-07					
Ce-144	W 3.0E-04	23	9.5E-09	3.0E-04	200	1.8E-11	3.2E-06	3.2E-05
284.3 d	Y 3.0E-04	13	5.4E-09		(230)			
					LLI wall			
Praseodymium								
Pr-136	W 3.0E-04	2.1E+05	8.7E-05	3.0E-04	5.2E+04	2.8E-07	8.2E-04	8.2E-03
13.1 m	Y 3.0E-04	2.0E+05	8.3E-05		(6.0E+04)			
					St wall			
Pr-137	W 3.0E-04	1.1E+05	4.5E-05	3.0E-04	3.5E+04	1.4E-07	4.8E-04	4.8E-03
76.6 m	Y 3.0E-04	1.0E+05	4.1E-05					
Pr-138m	W 3.0E-04	4.1E+04	1.7E-05	3.0E-04	9700	5.1E-08	1.3E-04	1.3E-03
2.1 h	Y 3.0E-04	3.7E+04	1.5E-05					
Pr-139	W 3.0E-04	1.0E+05	4.1E-05	3.0E-04	3.8E+04	1.2E-07	5.2E-04	5.2E-03
4.51 h	Y 3.0E-04	8.6E+04	3.5E-05					
Pr-142	W 3.0E-04	1800	7.5E-07	3.0E-04	950	2.4E-09	1.3E-05	1.3E-04
19.13 h	Y 3.0E-04	1700	7.0E-07					

	Table I Occupational Values						Table II Effluent		Table III Sewer Discharge
	Inhalation				Ingestion				
Nuclide	Class/f_1		ALI (μCi)	DAC (μCi/ml)	f_1	ALI (μCi)	Air (μCi/ml)	Water (μCi/ml)	(μCi/ml)
Praseodymium, cont'd.									
Pr-142m	W	3.0E-04	1.4E+05	5.8E-05	3.0E-04	7.4E+04	1.8E-07	0.0010	0.010
14.6 m	Y	3.0E-04	1.3E+05	5.4E-05					
Pr-143	W	3.0E-04	660	2.7E-07	3.0E-04	910	8.5E-10	1.4E-05	1.4E-04
13.56 d	Y	3.0E-04	610	2.5E-07		(1000)			
						LLI wall			
Pr-144	W	3.0E-04	1.2E+05	5.0E-05	3.0E-04	3.3E+04	1.6E-07	5.8E-04	5.8E-03
17.28 m	Y	3.0E-04	1.1E+05	4.5E-05		(4.2E+04)			
						St wall			
Pr-145	W	3.0E-04	8100	3.3E-06	3.0E-04	3200	1.0E-08	4.4E-05	4.4E-04
5.98 h	Y	3.0E-04	7400	3.0E-06					
Pr-147	W	3.0E-04	1.7E+05	7.0E-05	3.0E-04	5.3E+04	2.2E-07	8.8E-04	8.8E-03
13.6 m	Y	3.0E-04	1.6E+05	6.6E-05		(6.4E+04)			
						St wall			
Neodymium									
Nd-136	W	3.0E-04	4.7E+04	1.9E-05	3.0E-04	1.4E+04	6.0E-08	1.9E-04	1.9E-03
50.65 m	Y	3.0E-04	4.3E+04	1.7E-05					
Nd-138	W	3.0E-04	5300	2.2E-06	3.0E-04	1900	6.7E-09	2.6E-05	2.6E-04
5.04 h	Y	3.0E-04	4800	2.0E-06					
Nd-139	W	3.0E-04	2.6E+05	1.0E-04	3.0E-04	8.3E+04	3.2E-07	0.0011	0.011
29.7 m	Y	3.0E-04	2.3E+05	9.5E-05					
Nd-139m	W	3.0E-04	1.4E+04	5.8E-06	3.0E-04	4500	1.8E-08	6.2E-05	6.2E-04
5.5 h	Y	3.0E-04	1.3E+04	5.4E-06					
Nd-141	W	3.0E-04	5.3E+05	2.2E-04	3.0E-04	1.4E+05	6.7E-07	0.0020	0.020
2.49 h	Y	3.0E-04	4.8E+05	2.0E-04					
Nd-147	W	3.0E-04	780	3.2E-07	3.0E-04	1000	1.0E-09	1.5E-05	1.5E-04
10.98 d	Y	3.0E-04	730	3.0E-07		(1100)			
						LLI wall			
Nd-149	W	3.0E-04	2.4E+04	10E-06	3.0E-04	1.0E+04	3.1E-08	1.4E-04	1.4E-03
1.73 h	Y	3.0E-04	2.2E+04	9.1E-06					
Nd-151	W	3.0E-04	1.7E+05	7.0E-05	3.0E-04	6.3E+04	2.2E-07	8.6E-04	8.6E-03
12.44 m	Y	3.0E-04	1.6E+05	6.6E-05					
Promethium									
Pm-141	W	3.0E-04	1.6E+05	6.6E-05	3.0E-04	4.9E+04	2.1E-07	7.3E-04	7.3E-03
20.90 m	Y	3.0E-04	1.5E+05	6.2E-05		(5.3E+04)			
						St wall			
Pm-143	W	3.0E-04	610	2.5E-07	3.0E-04	4800	6.3E-10	6.6E-05	6.6E-04
265 d	Y	3.0E-04	450	1.8E-07					
Pm-144	W	3.0E-04	110	4.5E-08	3.0E-04	1100	1.2E-10	1.5E-05	1.5E-04
363 d	Y	3.0E-04	93	3.8E-08					
Pm-145	W	3.0E-04	170	7.0E-08	3.0E-04	1.0E+04	2.2E-10	1.4E-04	1.4E-03
17.7 y			(190)						
			BSurface						
	Y	3.0E-04	160	6.6E-08					
Pm-146	W	3.0E-04	48	2.0E-08	3.0E-04	1300	4.7E-11	1.8E-05	1.8E-04
2020 d	Y	3.0E-04	34	1.4E-08					
Pm-147	W	3.0E-04	130	5.4E-08	3.0E-04	4200	1.7E-10	6.5E-05	6.5E-04
2.6234 y			(190)			(4700)			
			BSurface			LLI wall			
	Y	3.0E-04	120	5.0E-08					
Pm-148	W	3.0E-04	480	2.0E-07	3.0E-04	430	6.3E-10	6.3E-06	6.3E-05
5.37 d	Y	3.0E-04	450	1.8E-07		(450)			
						LLI wall			
Pm-148m	W	3.0E-04	240	1.0E-07	3.0E-04	650	3.0E-10	8.9E-06	8.9E-05
41.3 d	Y	3.0E-04	220	9.1E-08					
Pm-149	W	3.0E-04	1800	7.5E-07	3.0E-04	1100	2.3E-09	1.7E-05	1.7E-04
53.08 h	Y	3.0E-04	1700	7.0E-07		(1200)			
						LLI wall			
Pm-150	W	3.0E-04	1.5E+04	6.2E-06	3.0E-04	5000	1.9E-08	6.8E-05	6.8E-04
2.68 h	Y	3.0E-04	1.3E+04	5.4E-06					
Pm-151	W	3.0E-04	3000	1.2E-06	3.0E-04	1600	3.9E-09	2.2E-05	2.2E-04
28.40 h	Y	3.0E-04	2800	1.1E-06					
Samarium									
Sm-141	W	3.0E-04	1.6E+05	6.6E-05	3.0E-04	4.5E+04	2.2E-07	6.8E-04	6.8E-03
10.2 m						(5.0E+04)			
						St wall			
Sm-141m	W	3.0E-04	8.5E+04	3.5E-05	3.0E-04	2.5E+04	1.1E-07	3.4E-04	3.4E-03
22.6 m									
Sm-142	W	3.0E-04	2.3E+04	9.5E-06	3.0E-04	7900	3.2E-08	1.0E-04	1.0E-03
72.49 m									
Sm-145	W	3.0E-04	450	1.8E-07	3.0E-04	5400	6.2E-10	7.5E-05	7.5E-04
340 d									

	Table I Occupational Values						Table II Effluent		Table III Sewer Discharge
	Inhalation				Ingestion				
Nuclide	Class/f_1		ALI (μCi)	DAC (μCi/ml)	f_1	ALI (μCi)	Air (μCi/ml)	Water (μCi/ml)	(μCi/ml)
Samarium, cont'd.									
Sm-146 1.03E8 y	W	3.0E-04	0.035 (0.060) BSurface	1.4E-11	3.0E-04	14 (24) BSurface	8.4E-14	3.3E-07	3.3E-06
Sm-147 1.06E11	W	3.0E-04	0.039 (0.066) BSurface	1.6E-11	3.0E-04	15 (26) BSurface	9.2E-14	3.6E-07	3.6E-06
Sm-151 90 y	W	3.0E-04	97 (160) BSurface	4.0E-08	3.0E-04	1.2E+04	2.3E-10	1.7E-04	1.7E-03
Sm-153 46.7 h	W	3.0E-04	2500	1.0E-06	3.0E-04	1600	3.5E-09	2.2E-05	2.2E-04
Sm-155 22.1 m	W	3.0E-04	1.9E+05	7.9E-05	3.0E-04	5.8E+04 (6.9E+04) St wall	2.7E-07	9.5E-04	9.5E-03
Sm-156 9.4 h	W	3.0E-04	7100	2.9E-06	3.0E-04	4900	9.9E-09	6.7E-05	6.7E-04
Europium									
Eu-145 5.94 d	W	0.001	1800	7.5E-07	0.001	1400	2.5E-09	2.0E-05	2.0E-04
Eu-146 4.61 d	W	0.001	1200	5.0E-07	0.001	870	1.7E-09	1.2E-05	1.2E-04
Eu-147 24 d	W	0.001	1400	5.8E-07	0.001	2500	1.9E-09	3.4E-05	3.4E-04
Eu-148 54.5 d	W	0.001	340	1.4E-07	0.001	870	4.8E-10	1.1E-05	1.1E-04
Eu-149 93.1 d	W	0.001	2600	1.0E-06	0.001	1.0E+04	3.6E-09	1.4E-04	1.4E-03
Eu-150 12.62 h	W	0.001	7400	3.0E-06	0.001	3300	1.0E-08	4.5E-05	4.5E-04
Eu-150 34.2 y	W	0.001	18	7.5E-09	0.001	780	2.5E-11	1.0E-05	1.0E-04
Eu-152 13.33 y	W	0.001	22	9.1E-09	0.001	770	3.1E-11	1.0E-05	1.0E-04
Eu-152m 9.32 h	W	0.001	6100	2.5E-06	0.001	2500	8.4E-09	3.4E-05	3.4E-04
Eu-154 8.8 y	W	0.001	17	7.0E-09	0.001	520	2.4E-11	7.1E-06	7.1E-05
Eu-155 4.96 y	W	0.001	88 (120) BSurface	3.6E-08	0.001	3200	1.6E-10	4.4E-05	4.4E-04
Eu-156 15.19 d	W	0.001	350	1.4E-07	0.001	540	4.9E-10	7.4E-06	7.4E-05
Eu-157 15.15 h	W	0.001	4400	1.8E-06	0.001	2000	6.2E-09	2.8E-05	2.8E-04
Eu-158 45.9 m	W	0.001	5.3E+04	2.2E-05	0.001	1.7E+04	7.3E-08	2.4E-04	2.4E-03
Gadolinium									
Gd-145 22.9 m	D	3.0E-04	1.1E+05	4.5E-05	3.0E-04	4.0E+04	1.5E-07	5.5E-04	5.5E-03
	W	3.0E-04	1.2E+05	5.0E-05					
Gd-146 48.3 d	D	3.0E-04	130	5.4E-08	3.0E-04	1200	1.8E-10	1.6E-05	1.6E-04
	W	3.0E-04	220	9.1E-08					
Gd-147 38.1 h	D	3.0E-04	4100	1.7E-06	3.0E-04	1800	4.6E-09	2.4E-05	2.4E-04
	W	3.0E-04	3300	1.3E-06					
Gd-148 93 y	D	3.0E-04	0.0076 (0.015) BSurface	3.1E-12	3.0E-04	12 (22) BSurface	2.1E-14	3.1E-07	3.1E-06
	W	3.0E-04	0.030 (0.056) BSurface	1.2E-11					
Gd-149 9.4 d	D	3.0E-04	2100	8.7E-07	3.0E-04	2400	3.0E-09	3.4E-05	3.4E-04
	W	3.0E-04	2100	8.7E-07					
Gd-151 120 d	D	3.0E-04	370 (560) BSurface	1.5E-07	3.0E-04	6000	7.8E-10	8.3E-05	8.3E-04
	W	3.0E-04	1100	4.5E-07					
Gd-152 1.08E14	D	3.0E-04	0.010 (0.020) BSurface	4.1E-12	3.0E-04	16 (31) BSurface	2.8E-14	4.2E-07	4.2E-06
	W	3.0E-04	0.041 (0.077) BSurface	1.7E-11					

Nuclide	Class/f_1	Inhalation ALI (μCi)	Inhalation DAC (μCi/ml)	Ingestion f_1	Ingestion ALI (μCi)	Table II Effluent Air (μCi/ml)	Table II Effluent Water (μCi/ml)	Table III Sewer Discharge (μCi/ml)
	Table I Occupational Values							
Gadolinium, cont'd.								
Gd-153 242 d	D 3.0E-04	140 (210) BSurface	5.8E-08	3.0E-04	4200	2.9E-10	5.8E-05	5.8E-04
	W 3.0E-04	520	2.1E-07					
Gd-159 18.56 h	D 3.0E-04	7400	3.0E-06	3.0E-04	2500	7.1E-09	3.4E-05	3.4E-04
	W 3.0E-04	5100	2.1E-06					
Terbium								
Tb-147 1.65 h	W 3.0E-04	2.4E+04	10E-06	3.0E-04	8400	3.3E-08	1.1E-04	1.1E-03
Tb-149 4.15 h	W 3.0E-04	680	2.8E-07	3.0E-04	4900	9.4E-10	6.7E-05	6.7E-04
Tb-150 3.27 h	W 3.0E-04	1.6E+04	6.6E-06	3.0E-04	4900	2.2E-08	6.7E-05	6.7E-04
Tb-151 17.6 h	W 3.0E-04	7900	3.2E-06	3.0E-04	3300	1.1E-08	4.5E-05	4.5E-04
Tb-153 2.34 d	W 3.0E-04	6600	2.7E-06	3.0E-04	4600	9.1E-09	6.3E-05	6.3E-04
Tb-154 21.4 h	W 3.0E-04	4200	1.7E-06	3.0E-04	1600	5.8E-09	2.3E-05	2.3E-04
Tb-155 5.32 d	W 3.0E-04	6400	2.6E-06	3.0E-04	5500	8.9E-09	7.5E-05	7.5E-04
Tb-156 5.34 d	W 3.0E-04	1200	5.0E-07	3.0E-04	960	1.7E-09	1.3E-05	1.3E-04
Tb-156m 24.4 h	W 3.0E-04	6500	2.7E-06	3.0E-04	6600	9.0E-09	9.0E-05	9.0E-04
Tb-156m 5.0 h	W 3.0E-04	2.3E+04	9.5E-06	3.0E-04	1.4E+04	3.2E-08	2.0E-04	2.0E-03
Tb-157 150 y	W 3.0E-04	300 (540) BSurface	1.2E-07	3.0E-04	4.0E+04	7.5E-10	5.5E-04	5.5E-03
Tb-158 150 y	W 3.0E-04	19	7.9E-09	3.0E-04	1100	2.7E-11	1.5E-05	1.5E-04
Tb-160 72.3 d	W 3.0E-04	200	8.3E-08	3.0E-04	740	2.7E-10	1.0E-05	1.0E-04
Tb-161 6.91 d	W 3.0E-04	1400	5.8E-07	3.0E-04	1500 (1700) LLI wall	2.0E-09	2.3E-05	2.3E-04
Dysprosium								
Dy-155 10.0 h	W 3.0E-04	2.2E+04	9.1E-06	3.0E-04	8600	3.1E-08	1.1E-04	1.1E-03
Dy-157 8.1 h	W 3.0E-04	6.2E+04	2.5E-05	3.0E-04	1.7E+04	8.6E-08	2.4E-04	2.4E-03
Dy-159 144.4 d	W 3.0E-04	2000	8.3E-07	3.0E-04	1.1E+04	2.8E-09	1.5E-04	1.5E-03
Dy-165 2.334 h	W 3.0E-04	3.7E+04	1.5E-05	3.0E-04	1.3E+04	5.1E-08	1.8E-04	1.8E-03
Dy-166 81.6 h	W 3.0E-04	660	2.7E-07	3.0E-04	600 (750) LLI wall	9.2E-10	1.0E-05	1.0E-04
Holmium								
Ho-155 48 m	W 3.0E-04	1.1E+05	4.5E-05	3.0E-04	3.8E+04	1.5E-07	5.2E-04	5.2E-03
Ho-157 12.6 m	W 3.0E-04	9.6E+05	4.0E-04	3.0E-04	2.4E+05	1.3E-06	0.0034	0.034
Ho-159 33 m	W 3.0E-04	7.6E+05	3.1E-04	3.0E-04	1.9E+05	1.0E-06	0.0026	0.026
Ho-161 2.5 h	W 3.0E-04	3.2E+05	1.3E-04	3.0E-04	9.9E+04	4.4E-07	0.0013	0.013
Ho-162 15 m	W 3.0E-04	2.1E+06	8.7E-04	3.0E-04	5.4E+05 (5.9E+05) St wall	2.9E-06	0.0081	0.081
Ho-162m 68 m	W 3.0E-04	1.9E+05	7.9E-05	3.0E-04	5.1E+04	2.7E-07	7.0E-04	7.0E-03
Ho-164 29 m	W 3.0E-04	5.7E+05	2.3E-04	3.0E-04	1.8E+05 (2.0E+05) St wall	7.9E-07	0.0027	0.027
Ho-164m 37.5 m	W 3.0E-04	2.6E+05	1.0E-04	3.0E-04	9.3E+04	3.6E-07	0.0012	0.012
Ho-166 26.80 h	W 3.0E-04	1500	6.2E-07	3.0E-04	890	2.2E-09	1.2E-05	1.2E-04
Ho-166m 1.20E3 y	W 3.0E-04	6.4	2.6E-09	3.0E-04	610	8.9E-12	8.4E-06	8.4E-05

	Table I Occupational Values						Table II Effluent		Table III Sewer
	Inhalation				Ingestion				
Nuclide	Class/f_1		ALI (µCi)	DAC (µCi/ml)	f_1	ALI (µCi)	Air (µCi/ml)	Water (µCi/ml)	Discharge (µCi/ml)
Holmium, cont'd.									
Ho-167	W	3.0E-04	4.5E+04	1.8E-05	3.0E-04	1.5E+04	6.3E-08	2.0E-04	2.0E-03
3.1 h									
Erbium									
Er-161	W	3.0E-04	5.5E+04	2.2E-05	3.0E-04	1.4E+04	7.6E-08	1.9E-04	1.9E-03
3.24 h									
Er-165	W	3.0E-04	1.6E+05	6.6E-05	3.0E-04	6.0E+04	2.3E-07	8.2E-04	8.2E-03
10.36 h									
Er-169	W	3.0E-04	2300	9.5E-07	3.0E-04	2800	3.3E-09	4.5E-05	4.5E-04
9.3 d						(3300)			
						LLI wall			
Er-171	W	3.0E-04	8800	3.6E-06	3.0E-04	3400	1.2E-08	4.7E-05	4.7E-04
7.52 h									
Er-172	W	3.0E-04	1200	5.0E-07	3.0E-04	1100	1.6E-09	1.6E-05	1.6E-04
49.3 h									
Thulium									
Tm-162	W	3.0E-04	2.2E+05	9.1E-05	3.0E-04	6.1E+04	3.1E-07	8.4E-04	8.4E-03
21.7 m									
Tm-166	W	3.0E-04	1.3E+04	5.4E-06	3.0E-04	4000	1.8E-08	5.5E-05	5.5E-04
7.70 h									
Tm-167	W	3.0E-04	1600	6.6E-07	3.0E-04	2100	2.3E-09	2.9E-05	2.9E-04
9.24 d									
Tm-170	W	3.0E-04	190	7.9E-08	3.0E-04	800	2.6E-10	1.2E-05	1.2E-04
128.6 d						(940)			
						LLI wall			
Tm-171	W	3.0E-04	290	1.2E-07	3.0E-04	1.0E+04	7.6E-10	1.5E-04	1.5E-03
1.92 y			(540)			(1.1E+04)			
			BSurface			LLI wall			
Tm-172	W	3.0E-04	1000	4.1E-07	3.0E-04	720	1.4E-09	9.9E-06	9.9E-05
63.6 h									
Tm-173	W	3.0E-04	1.0E+04	4.1E-06	3.0E-04	4000	1.4E-08	5.4E-05	5.4E-04
8.24 h									
Tm-175	W	3.0E-04	2.1E+05	8.7E-05	3.0E-04	6.7E+04	2.9E-07	0.0010	0.010
15.2 m						(7.4E+04)			
						St wall			
Ytterbium									
Yb-162	W	3.0E-04	2.4E+05	10E-05	3.0E-04	6.6E+04	3.1E-07	9.0E-04	9.0E-03
18.9 m	Y	3.0E-04	2.2E+05	9.1E-05					
Yb-166	W	3.0E-04	1700	7.0E-07	3.0E-04	1100	2.3E-09	1.6E-05	1.6E-04
56.7 h	Y	3.0E-04	1600	6.6E-07					
Yb-167	W	3.0E-04	6.2E+05	2.5E-04	3.0E-04	2.6E+05	8.3E-07	0.0036	0.036
17.5 m	Y	3.0E-04	5.9E+05	2.4E-04					
Yb-169	W	3.0E-04	710	2.9E-07	3.0E-04	1600	8.6E-10	2.2E-05	2.2E-04
32.01 d	Y	3.0E-04	620	2.5E-07					
Yb-175	W	3.0E-04	3100	1.2E-06	3.0E-04	2600	4.2E-09	3.8E-05	3.8E-04
4.19 d	Y	3.0E-04	3000	1.2E-06		(2800)			
						LLI wall			
Yb-177	W	3.0E-04	3.7E+04	1.5E-05	3.0E-04	1.5E+04	4.7E-08	2.1E-04	2.1E-03
1.9 h	Y	3.0E-04	3.4E+04	1.4E-05					
Yb-178	W	3.0E-04	3.4E+04	1.4E-05	3.0E-04	1.2E+04	4.2E-08	1.7E-04	1.7E-03
74 m	Y	3.0E-04	3.0E+04	1.2E-05					
Lutetium									
Lu-169	W	3.0E-04	4000	1.6E-06	3.0E-04	2400	5.1E-09	3.3E-05	3.3E-04
34.06 h	Y	3.0E-04	3700	1.5E-06					
Lu-170	W	3.0E-04	2100	8.7E-07	3.0E-04	1000	2.6E-09	1.5E-05	1.5E-04
2.00 d	Y	3.0E-04	1900	7.9E-07					
Lu-171	W	3.0E-04	1700	7.0E-07	3.0E-04	1700	2.3E-09	2.3E-05	2.3E-04
8.22 d	Y	3.0E-04	1600	6.6E-07					
Lu-172	W	3.0E-04	1000	4.1E-07	3.0E-04	880	1.3E-09	1.2E-05	1.2E-04
6.70 d	Y	3.0E-04	1000	4.1E-07					
Lu-173	W	3.0E-04	280	1.1E-07	3.0E-04	4500	3.0E-10	6.2E-05	6.2E-04
1.37 y			(390)						
			BSurface						
	Y	3.0E-04	220	9.1E-08					
Lu-174	W	3.0E-04	110	4.5E-08	3.0E-04	4400	1.7E-10	6.1E-05	6.1E-04
3.31 y			(200)						
			BSurface						
	Y	3.0E-04	120	5.0E-08					
Lu-174m	W	3.0E-04	240	1.0E-07	3.0E-04	2100	2.7E-10	3.2E-05	3.2E-04
142 d			(300)			(2300)			
			BSurface			LLI wall			
	Y	3.0E-04	190	7.9E-08					

	Table I Occupational Values						Table II Effluent		Table III Sewer Discharge
	Inhalation				Ingestion				
Nuclide	Class	f_1	ALI (μCi)	DAC (μCi/ml)	f_1	ALI (μCi)	Air (μCi/ml)	Water (μCi/ml)	(μCi/ml)
Lutetium, cont'd.									
Lu-176	W	3.0E-04	4.6	1.9E-09	3.0E-04	680	1.0E-11	9.3E-06	9.3E-05
3.60E10			(9.9)						
			BSurface						
	Y	3.0E-04	7.5	3.1E-09					
Lu-176m	W	3.0E-04	2.0E+04	8.3E-06	3.0E-04	7800	2.6E-08	1.0E-04	1.0E-03
3.68 h	Y	3.0E-04	1.8E+04	7.5E-06					
Lu-177	W	3.0E-04	2000	8.3E-07	3.0E-04	2100	2.8E-09	3.1E-05	3.1E-04
6.71 d	Y	3.0E-04	2000	8.3E-07		(2300)			
						LLI wall			
Lu-177m	W	3.0E-04	100	4.1E-08	3.0E-04	680	9.4E-11	9.3E-06	9.3E-05
160.9 d	Y	3.0E-04	68	2.8E-08					
Lu-178	W	3.0E-04	1.1E+05	4.5E-05	3.0E-04	3.6E+04	1.4E-07	5.5E-04	5.5E-03
28.4 m	Y	3.0E-04	1.0E+05	4.1E-05		(4.0E+04)			
						St wall			
Lu-178m	W	3.0E-04	1.6E+05	6.6E-05	3.0E-04	4.7E+04	2.1E-07	6.7E-04	6.7E-03
22.7 m	Y	3.0E-04	1.5E+05	6.2E-05		(4.8E+04)			
						St wall			
Lu-179	W	3.0E-04	1.6E+04	6.6E-06	3.0E-04	6200	2.0E-08	8.5E-05	8.5E-04
4.59 h	Y	3.0E-04	1.4E+04	5.8E-06					
Hafnium									
Hf-170	D	0.002	5800	2.4E-06	0.002	2300	5.8E-09	3.2E-05	3.2E-04
16.01 h	W	0.002	4100	1.7E-06					
Hf-172	D	0.002	9.3	3.8E-09	0.002	1100	2.1E-11	1.5E-05	1.5E-04
1.87 y			(15)						
			BSurface						
	W	0.002	37	1.5E-08					
			(47)						
			BSurface						
Hf-173	D	0.002	1.2E+04	5.0E-06	0.002	4900	1.4E-08	6.8E-05	6.8E-04
24.0 h	W	0.002	1.0E+04	4.1E-06					
Hf-175	D	0.002	890	3.7E-07	0.002	2700	1.2E-09	3.7E-05	3.7E-04
70 d	W	0.002	970	4.0E-07					
Hf-177m	D	0.002	5.0E+04	2.0E-05	0.002	1.8E+04	7.0E-08	2.4E-04	2.4E-03
51.4 m	W	0.002	6.7E+04	2.7E-05					
Hf-178m	D	0.002	1.2	5.0E-10	0.002	230	2.8E-12	3.2E-06	3.2E-05
31 y			(2.0)						
			BSurface						
	W	0.002	5.1	2.1E-09					
			(7.5)						
			BSurface						
Hf-179m	D	0.002	330	1.3E-07	0.002	920	6.8E-10	1.2E-05	1.2E-04
25.1 d			(500)						
			BSurface						
	W	0.002	490	2.0E-07					
Hf-180m	D	0.002	2.1E+04	8.7E-06	0.002	6800	2.9E-08	9.3E-05	9.3E-04
5.5 h	W	0.002	2.2E+04	9.1E-06					
Hf-181	D	0.002	160	6.6E-08	0.002	1000	4.4E-10	1.4E-05	1.4E-04
42.4 d			(320)						
			BSurface						
	W	0.002	380	1.5E-07					
Hf-182	D	0.002	0.78	3.2E-10	0.002	180	2.0E-12	4.3E-06	4.3E-05
9E6 y			(1.5)			(310)			
			BSurface			BSurface			
	W	0.002	3.0	1.2E-09					
			(5.8)						
			BSurface						
Hf-182m	D	0.002	8.0E+04	3.3E-05	0.002	3.4E+04	1.1E-07	4.7E-04	4.7E-03
61.5 m	W	0.002	1.0E+05	4.1E-05					
Hf-183	D	0.002	4.2E+04	1.7E-05	0.002	1.9E+04	5.9E-08	2.6E-04	2.6E-03
64 m	W	0.002	4.4E+04	1.8E-05					
Hf-184	D	0.002	6800	2.8E-06	0.002	2300	8.1E-09	3.1E-05	3.1E-04
4.12 h	W	0.002	5800	2.4E-06					
Tantalum									
Ta-172	W	0.001	1.0E+05	4.1E-05	0.001	3.1E+04	1.2E-07	4.3E-04	4.3E-03
36.8 m	Y	0.001	8.8E+04	3.6E-05					
Ta-173	W	0.001	1.7E+04	7.0E-06	0.001	6300	2.1E-08	8.7E-05	8.7E-04
3.65 h	Y	0.001	1.5E+04	6.2E-06					
Ta-174	W	0.001	7.9E+04	3.2E-05	0.001	2.5E+04	1.0E-07	3.5E-04	3.5E-03
1.2 h	Y	0.001	7.4E+04	3.0E-05					
Ta-175	W	0.001	1.4E+04	5.8E-06	0.001	5500	1.8E-08	7.5E-05	7.5E-04
10.5 h	Y	0.001	1.3E+04	5.4E-06					

Nuclide	Class/f_1	Table I Occupational Values: Inhalation ALI (μCi)	Inhalation DAC (μCi/ml)	Ingestion f_1	Ingestion ALI (μCi)	Table II Effluent: Air (μCi/ml)	Water (μCi/ml)	Table III Sewer Discharge (μCi/ml)
Tantalum, cont'd.								
Ta-176	W 0.001	1.1E+04	4.5E-06	0.001	3600	1.4E-08	4.9E-05	4.9E-04
8.08 h	Y 0.001	1.0E+04	4.1E-06					
Ta-177	W 0.001	1.7E+04	7.0E-06	0.001	1.1E+04	2.2E-08	1.5E-04	1.5E-03
56.6 h	Y 0.001	1.6E+04	6.6E-06					
Ta-178	W 0.001	6.5E+04	2.7E-05	0.001	1.7E+04	8.3E-08	2.3E-04	2.3E-03
2.2 h	Y 0.001	6.0E+04	2.5E-05					
Ta-179	W 0.001	3800	1.5E-06	0.001	1.8E+04	1.0E-09	2.5E-04	2.5E-03
664.9 d	Y 0.001	760	3.1E-07					
Ta-180	W 0.001	270	1.1E-07	0.001	1300	2.8E-11	1.8E-05	1.8E-04
1.0E13 y	Y 0.001	20	8.3E-09					
Ta-180m	W 0.001	5.8E+04	2.4E-05	0.001	2.2E+04	7.4E-08	3.1E-04	3.1E-03
8.1 h	Y 0.001	5.3E+04	2.2E-05					
Ta-182	W 0.001	220	9.1E-08	0.001	760	1.5E-10	1.0E-05	1.0E-04
115.0 d	Y 0.001	110	4.5E-08					
Ta-182m	W 0.001	4.5E+05	1.8E-04	0.001	1.5E+05	5.1E-07	0.0024	0.024
15.84 m	Y 0.001	3.7E+05	1.5E-04		(1.8E+05)			
					St wall			
Ta-183	W 0.001	980	4.0E-07	0.001	910	1.3E-09	1.2E-05	1.2E-04
5.1 d	Y 0.001	950	3.9E-07		(920)			
					LLI wall			
Ta-184	W 0.001	4800	2.0E-06	0.001	1700	6.0E-09	2.4E-05	2.4E-04
8.7 h	Y 0.001	4300	1.7E-06					
Ta-185	W 0.001	6.5E+04	2.7E-05	0.001	2.4E+04	8.2E-08	3.3E-04	3.3E-03
49 m	Y 0.001	5.9E+04	2.4E-05					
Ta-186	W 0.001	2.1E+05	8.7E-05	0.001	5.1E+04	2.8E-07	8.9E-04	8.9E-03
10.5 m	Y 0.001	2.0E+05	8.3E-05		(6.5E+04)			
					St wall			
Tungsten (Wolfram)								
W-176	D 0.3	4.6E+04	1.9E-05	0.01	1.0E+04	6.5E-08	1.3E-04	1.3E-03
				0.3	1.3E+04			
2.3 h								
W-177	D 0.3	7.6E+04	3.1E-05	0.01	2.0E+04	1.0E-07	2.7E-04	2.7E-03
				0.3	2.3E+04			
135 m								
W-178	D 0.3	1.8E+04	7.5E-06	0.01	4900	2.5E-08	6.7E-05	6.7E-04
				0.3	6600			
21.7 d								
W-179	D 0.3	1.4E+06	5.8E-04	0.01	4.9E+05	1.9E-06	0.0067	0.067
				0.3	5.1E+05			
37.5 m								
W-181	D 0.3	3.3E+04	1.3E-05	0.01	1.4E+04	4.5E-08	1.9E-04	1.9E-03
				0.3	1.7E+04			
121.2 d								
W-185	D 0.3	6600	2.7E-06	0.01	2100	9.2E-09	3.4E-05	3.4E-04
75.1 d					(2500)			
					LLI wall			
				0.3	3000			
					(3100)			
					LLI wall			
W-187	D 0.3	8000	3.3E-06	0.01	1800	1.1E-08	2.4E-05	2.4E-04
				0.3	2400			
23.9 h								
W-188	D 0.3	1200	5.0E-07	0.01	400	1.6E-09	7.2E-06	7.2E-05
69.4 d					(530)			
					LLI wall			
				0.3	570			
					(640)			
					LLI wall			
Rhenium								
Re-177	D 0.8	2.0E+05	8.3E-05	0.8	9.2E+04	2.9E-07	0.0012	0.012
14.0 m	W 0.8	2.6E+05	1.0E-04					
Re-178	D 0.8	2.2E+05	9.1E-05	0.8	7.0E+04	3.0E-07	0.0011	0.011
13.2 m	W 0.8	2.6E+05	1.0E-04		(8.6E+04)			
					St wall			
Re-181	D 0.8	8300	3.4E-06	0.8	4800	1.0E-08	6.5E-05	6.5E-04
20 h	W 0.8	7700	3.2E-06					
Re-182	D 0.8	1.2E+04	5.0E-06	0.8	6700	1.7E-08	9.2E-05	9.2E-04
12.7 h	W 0.8	1.3E+04	5.4E-06					
Re-182	D 0.8	2400	10E-07	0.8	1400	2.4E-09	2.0E-05	2.0E-04
64.0 h	W 0.8	1700	7.0E-07					
Re-184	D 0.8	3500	1.4E-06	0.8	2200	1.3E-09	3.1E-05	3.1E-04
38.0 d	W 0.8	970	4.0E-07					

	Table I Occupational Values						Table II		Table III
	Inhalation				Ingestion		Effluent		Sewer
Nuclide	Class/f_1		ALI (μCi)	DAC (μCi/ml)	f_1	ALI (μCi)	Air (μCi/ml)	Water (μCi/ml)	Discharge (μCi/ml)
Rhenium, cont'd.									
Re-184m	D	0.8	2400	10E-07	0.8	1600	4.7E-10	2.3E-05	2.3E-04
165 d	W	0.8	330	1.3E-07					
Re-186	D	0.8	2500	1.0E-06	0.8	1600	2.1E-09	2.3E-05	2.3E-04
90.64 h	W	0.8	1500	6.2E-07					
Re-186m	D	0.8	1600	6.6E-07	0.8	1200	1.9E-10	1.7E-05	1.7E-04
2.0E5 y			(1700)						
			St wall						
	W	0.8	130	5.4E-08					
Re-187	D	0.8	7.4E+05	3.0E-04	0.8	5.2E+05	1.2E-07	0.0071	0.071
5E10 y	W	0.8	9.2E+04	3.8E-05					
Re-188	D	0.8	2500	1.0E-06	0.8	1600	3.4E-09	2.2E-05	2.2E-04
16.98 h	W	0.8	2400	10E-07					
Re-188m	D	0.8	1.2E+05	5.0E-05	0.8	7.3E+04	1.6E-07	0.0010	0.010
18.6 m	W	0.8	1.2E+05	5.0E-05					
Re-189	D	0.8	4500	1.8E-06	0.8	2800	5.5E-09	3.9E-05	3.9E-04
24.3 h	W	0.8	4000	1.6E-06					
Osmium									
Os-180	D	0.01	2.8E+05	1.1E-04	0.01	9.5E+04	3.9E-07	0.0013	0.013
22 m	W	0.01	3.7E+05	1.5E-04					
	Y	0.01	3.6E+05	1.5E-04					
Os-181	D	0.01	4.3E+04	1.7E-05	0.01	1.3E+04	5.1E-08	1.8E-04	1.8E-03
105 m	W	0.01	4.0E+04	1.6E-05					
	Y	0.01	3.7E+04	1.5E-05					
Os-182	D	0.01	5800	2.4E-06	0.01	2000	5.0E-09	2.8E-05	2.8E-04
22 h	W	0.01	3900	1.6E-06					
	Y	0.01	3600	1.5E-06					
Os-185	D	0.01	480	2.0E-07	0.01	2200	6.6E-10	3.0E-05	3.0E-04
94 d	W	0.01	760	3.1E-07					
	Y	0.01	500	2.0E-07					
Os-189m	D	0.01	2.0E+05	8.3E-05	0.01	7.4E+04	2.3E-07	0.0010	0.010
6.0 h	W	0.01	1.8E+05	7.5E-05					
	Y	0.01	1.6E+05	6.6E-05					
Os-191	D	0.01	2000	8.3E-07	0.01	2000	1.6E-09	2.9E-05	2.9E-04
15.4 d	W	0.01	1300	5.4E-07		(2100)			
	Y	0.01	1200	5.0E-07		LLI wall			
Os-191m	D	0.01	2.6E+04	1.0E-05	0.01	1.3E+04	2.2E-08	1.7E-04	1.7E-03
13.03 h	W	0.01	1.8E+04	7.5E-06					
	Y	0.01	1.6E+04	6.6E-06					
Os-193	D	0.01	4300	1.7E-06	0.01	1500	3.4E-09	2.1E-05	2.1E-04
30.0 h	W	0.01	2700	1.1E-06					
	Y	0.01	2400	10E-07					
Os-194	D	0.01	39	1.6E-08	0.01	440	1.0E-11	6.3E-06	6.3E-05
6.0 y	W	0.01	51	2.1E-08		(460)			
	Y	0.01	7.4	3.0E-09		LLI wall			
Iridium									
Ir-182	D	0.01	1.0E+05	4.1E-05	0.01	3.9E+04	1.4E-07	5.3E-04	5.3E-03
15 m	W	0.01	1.0E+05	4.1E-05					
	Y	0.01	1.0E+05	4.1E-05					
Ir-184	D	0.01	2.1E+04	8.7E-06	0.01	7100	3.0E-08	9.8E-05	9.8E-04
3.02 h	W	0.01	2.5E+04	1.0E-05					
	Y	0.01	2.3E+04	9.5E-06					
Ir-185	D	0.01	1.2E+04	5.0E-06	0.01	4500	1.2E-08	6.1E-05	6.1E-04
14.0 h	W	0.01	1.0E+04	4.1E-06					
	Y	0.01	9100	3.7E-06					
Ir-186	D	0.01	7500	3.1E-06	0.01	2300	7.6E-09	3.1E-05	3.1E-04
15.8 h	W	0.01	6000	2.5E-06					
	Y	0.01	5400	2.2E-06					
Ir-187	D	0.01	3.0E+04	1.2E-05	0.01	9500	3.3E-08	1.3E-04	1.3E-03
10.5 h	W	0.01	2.6E+04	1.0E-05					
	Y	0.01	2.3E+04	9.5E-06					
Ir-188	D	0.01	4600	1.9E-06	0.01	1700	4.4E-09	2.3E-05	2.3E-04
41.5 h	W	0.01	3400	1.4E-06					
	Y	0.01	3200	1.3E-06					
Ir-189	D	0.01	4700	1.9E-06	0.01	4700	4.2E-09	6.5E-05	6.5E-04
13.3 d	W	0.01	3300	1.3E-06					
	Y	0.01	3000	1.2E-06					
Ir-190	D	0.01	900	3.7E-07	0.01	910	1.0E-09	1.2E-05	1.2E-04
12.1 d	W	0.01	810	3.3E-07					
	Y	0.01	770	3.2E-07					
Ir-190m	D	0.01	1.9E+05	7.9E-05	0.01	1.5E+05	2.2E-07	0.0021	0.021
1.2 h	W	0.01	1.7E+05	7.0E-05					
	Y	0.01	1.6E+05	6.6E-05					

	Table I Occupational Values						Table II Effluent		Table III Sewer Discharge
	Inhalation				Ingestion				
Nuclide	Class/f_1		ALI (μCi)	DAC (μCi/ml)	f_1	ALI (μCi)	Air (μCi/ml)	Water (μCi/ml)	(μCi/ml)
Iridium, cont'd.									
Ir-192	D	0.01	260	1.0E-07	0.01	870	2.4E-10	1.1E-05	1.1E-04
74.02 d	W	0.01	270	1.1E-07					
	Y	0.01	170	7.0E-08					
Ir-192m	D	0.01	91	3.7E-08	0.01	3100	1.8E-11	4.3E-05	4.3E-04
241. y	W	0.01	190	7.9E-08					
	Y	0.01	12	5.0E-09					
Ir-194	D	0.01	2800	1.1E-06	0.01	940	2.3E-09	1.2E-05	1.2E-04
19.15 h	W	0.01	1800	7.5E-07					
	Y	0.01	1700	7.0E-07					
Ir-194m	D	0.01	91	3.7E-08	0.01	550	1.0E-10	7.5E-06	7.5E-05
171 d	W	0.01	140	5.8E-08					
	Y	0.01	73	3.0E-08					
Ir-195	D	0.01	3.6E+04	1.5E-05	0.01	1.4E+04	5.0E-08	2.0E-04	2.0E-03
2.5 h	W	0.01	3.9E+04	1.6E-05					
	Y	0.01	3.6E+04	1.5E-05					
Ir-195m	D	0.01	2.1E+04	8.7E-06	0.01	7600	2.7E-08	1.0E-04	1.0E-03
3.8 h	W	0.01	2.1E+04	8.7E-06					
	Y	0.01	2.0E+04	8.3E-06					
Platinum									
Pt-186	D	0.01	3.7E+04	1.5E-05	0.01	1.2E+04	5.2E-08	1.6E-04	1.6E-03
2.0 h									
Pt-188	D	0.01	1500	6.2E-07	0.01	1500	2.2E-09	2.0E-05	2.0E-04
10.2 d									
Pt-189	D	0.01	2.7E+04	1.1E-05	0.01	9400	3.8E-08	1.2E-04	1.2E-03
10.87 h									
Pt-191	D	0.01	8100	3.3E-06	0.01	3400	1.1E-08	4.6E-05	4.6E-04
2.8 d									
Pt-193	D	0.01	2.2E+04	9.1E-06	0.01	3.7E+04	3.0E-08	5.7E-04	5.7E-03
50 y						(4.2E+04)			
						LLI wall			
Pt-193m	D	0.01	5600	2.3E-06	0.01	2500	7.9E-09	3.7E-05	3.7E-04
4.33 d						(2700)			
						LLI wall			
Pt-195m	D	0.01	4100	1.7E-06	0.01	1800	5.6E-09	2.6E-05	2.6E-04
4.02 d						(1900)			
						LLI wall			
Pt-197	D	0.01	8800	3.6E-06	0.01	3100	1.2E-08	4.2E-05	4.2E-04
18.3 h									
Pt-197m	D	0.01	4.0E+04	1.6E-05	0.01	1.5E+04	5.6E-08	2.1E-04	2.1E-03
94.4 m									
Pt-199	D	0.01	1.0E+05	4.1E-05	0.01	4.6E+04	1.5E-07	6.3E-04	6.3E-03
30.8 m									
Pt-200	D	0.01	3000	1.2E-06	0.01	1000	4.1E-09	1.4E-05	1.4E-04
12.5 h									
Gold									
Au-193	D	0.1	2.6E+04	1.0E-05	0.1	8600	2.3E-08	1.1E-04	1.1E-03
17.65 h	W	0.1	1.8E+04	7.5E-06					
	Y	0.1	1.7E+04	7.0E-06					
Au-194	D	0.1	7800	3.2E-06	0.1	2600	6.7E-09	3.6E-05	3.6E-04
39.5 h	W	0.1	5200	2.1E-06					
	Y	0.1	4800	2.0E-06					
Au-195	D	0.1	1.1E+04	4.5E-06	0.1	4700	5.3E-10	6.4E-05	6.4E-04
183 d	W	0.1	1100	4.5E-07					
	Y	0.1	380	1.5E-07					
Au-198	D	0.1	3400	1.4E-06	0.1	1100	2.1E-09	1.6E-05	1.6E-04
2.696 d	W	0.1	1600	6.6E-07					
	Y	0.1	1500	6.2E-07					
Au-198m	D	0.1	2600	1.0E-06	0.1	930	1.4E-09	1.2E-05	1.2E-04
2.30 d	W	0.1	1100	4.5E-07					
	Y	0.1	1000	4.1E-07					
Au-199	D	0.1	8200	3.4E-06	0.1	2800	4.6E-09	3.8E-05	3.8E-04
3.139 d	W	0.1	3600	1.5E-06					
	Y	0.1	3300	1.3E-06					
Au-200	D	0.1	5.6E+04	2.3E-05	0.1	2.4E+04	7.8E-08	3.3E-04	3.3E-03
48.4 m	W	0.1	6.8E+04	2.8E-05					
	Y	0.1	6.3E+04	2.6E-05					
Au-200m	D	0.1	3400	1.4E-06	0.1	1100	3.1E-09	1.5E-05	1.5E-04
18.7 h	W	0.1	2400	10E-07					
	Y	0.1	2200	9.1E-07					
Au-201	D	0.1	1.8E+05	7.5E-05	0.1	7.0E+04	2.5E-07	0.0011	0.011
26.4 m	W	0.1	2.2E+05	9.1E-05		(8.0E+04)			
	Y	0.1	2.1E+05	8.7E-05		St wall			

	Table I Occupational Values					Table II Effluent		Table III Sewer
	Inhalation			Ingestion				
Nuclide	Class/f_1	ALI (μCi)	DAC (μCi/ml)	f_1	ALI (μCi)	Air (μCi/ml)	Water (μCi/ml)	Discharge (μCi/ml)
Mercury								
Hg-193	D 0.02	4.0E+04	1.6E-05	0.02	1.4E+04	3.7E-08	2.0E-04	2.0E-03
3.5 h	W 0.02	3.7E+04	1.5E-05	1	4.4E+04			
	D* 1	5.4E+04	2.2E-05	0.4	1.8E+04			
	V 1	2.6E+04	1.0E-05					
Hg-193m	D 0.02	8700	3.6E-06	0.02	2900	9.0E-09	3.9E-05	3.9E-04
11.1 h	W 0.02	7100	2.9E-06	1	9000			
	D* 1	1.1E+04	4.5E-06	0.4	3900			
	V 1	6500	2.7E-06					
Hg-194	D 0.02	42	1.7E-08	0.02	810	3.8E-11	2.3E-07	2.3E-06
260 y	W 0.02	110	4.5E-08	1	17			
	D* 1	27	1.1E-08	0.4	43			
	V 1	28	1.1E-08					
Hg-195	D 0.02	3.4E+04	1.4E-05	0.02	1.2E+04	3.3E-08	1.6E-04	1.6E-03
9.9 h	W 0.02	3.0E+04	1.2E-05	1	3.4E+04			
	D* 1	4.3E+04	1.7E-05	0.4	1.6E+04			
	V 1	2.4E+04	10E-06					
Hg-195m	D 0.02	5100	2.1E-06	0.02	2100	4.5E-09	2.9E-05	2.9E-04
41.6 h	W 0.02	3300	1.3E-06	1	4000			
	D* 1	5600	2.3E-06	0.4	2700			
	V 1	3200	1.3E-06					
Hg-197	D 0.02	1.1E+04	4.5E-06	0.02	5200	9.7E-09	7.1E-05	7.1E-04
64.1 h	W 0.02	7200	3.0E-06	1	8600			
	D* 1	1.2E+04	5.0E-06	0.4	6300			
	V 1	7000	2.9E-06					
Hg-197m	D 0.02	6700	2.7E-06	0.02	2600	5.8E-09	3.6E-05	3.6E-04
23.8 h	W 0.02	4400	1.8E-06	1	6500			
	D* 1	8200	3.4E-06	0.4	3400			
	V 1	4100	1.7E-06					
Hg-199m	D 0.02	1.3E+05	5.4E-05	0.02	5.5E+04	1.0E-07	7.5E-04	7.5E-03
42.6 m	W 0.02	1.5E+05	6.2E-05	1	6.1E+04			
	D* 1	1.4E+05	5.8E-05		(8.6E+04) St wall			
	V 1	7.4E+04	3.0E-05					
Hg-203	D 0.02	1200	5.0E-07	0.02	2100	9.4E-10	5.9E-06	5.9E-05
46.60 d	W 0.02	860	3.5E-07	1	430			
	D* 1	680	2.8E-07	0.4	860			
	V 1	780	3.2E-07					
Thallium								
Tl-194 33 m	D 1	5.4E+05	2.2E-04	1	2.1E+05	7.5E-07	0.0030	0.030
Tl-194m 32.8 m	D 1	1.1E+05	4.5E-05	1	4.7E+04 (5.1E+04) St wall	1.5E-07	6.9E-04	6.9E-03
Tl-195 1.16 h	D 1	1.0E+05	4.1E-05	1	6.3E+04	1.4E-07	8.7E-04	8.7E-03
Tl-197 2.84 h	D 1	1.0E+05	4.1E-05	1	7.4E+04	1.4E-07	0.0010	0.010
Tl-198 5.3 h	D 1	3.0E+04	1.2E-05	1	1.9E+04	4.2E-08	2.6E-04	2.6E-03
Tl-198m 1.87 h	D 1	4.6E+04	1.9E-05	1	3.1E+04	6.5E-08	4.3E-04	4.3E-03
Tl-199 7.42 h	D 1	7.2E+04	3.0E-05	1	6.1E+04	1.0E-07	8.3E-04	8.3E-03
Tl-200 26.1 h	D 1	1.0E+04	4.1E-06	1	7400	1.4E-08	1.0E-04	1.0E-03
Tl-201 3.044 d	D 1	2.1E+04	8.7E-06	1	1.6E+04	2.9E-08	2.2E-04	2.2E-03
Tl-202 12.23 d	D 1	5000	2.0E-06	1	3300	7.0E-09	4.6E-05	4.6E-04
Tl-204 3.779 y	D 1	2000	8.3E-07	1	1400	2.8E-09	2.0E-05	2.0E-04
Lead								
Pb-195m 15.8 m	D 0.2	1.6E+05	6.6E-05	0.2	5.5E+04	2.2E-07	7.5E-04	7.5E-03
Pb-198 2.4 h	D 0.2	6.4E+04	2.6E-05	0.2	3.0E+04	9.0E-08	4.1E-04	4.1E-03
Pb-199 90 m	D 0.2	6.8E+04	2.8E-05	0.2	2.2E+04	9.5E-08	3.0E-04	3.0E-03
Pb-200 21.5 h	D 0.2	6300	2.6E-06	0.2	2800	8.7E-09	3.9E-05	3.9E-04

* Organic mercury

	Table I Occupational Values					Table II Effluent		Table III Sewer Discharge
	Inhalation			Ingestion				
Nuclide	Class/f_1	ALI (µCi)	DAC (µCi/ml)	f_1	ALI (µCi)	Air (µCi/ml)	Water (µCi/ml)	(µCi/ml)
Lead, cont'd.								
Pb-201	D 0.2	1.9E+04	7.9E-06	0.2	7000	2.6E-08	9.6E-05	9.6E-04
9.4 h								
Pb-202	D 0.2	50	2.0E-08	0.2	120	7.0E-11	1.7E-06	1.7E-05
3E5 y								
Pb-202m	D 0.2	2.7E+04	1.1E-05	0.2	8800	3.8E-08	1.2E-04	1.2E-03
3.62 h								
Pb-203	D 0.2	9400	3.9E-06	0.2	4600	1.3E-08	6.3E-05	6.3E-04
52.05 h								
Pb-205	D 0.2	1200	5.0E-07	0.2	3000	1.7E-09	4.1E-05	4.1E-04
1.43E7 y								
Pb-209	D 0.2	5.2E+04	2.1E-05	0.2	2.3E+04	7.3E-08	3.2E-04	3.2E-03
3.253 h								
Pb-210	D 0.2	0.24	1.0E-10	0.2	0.62	5.1E-13	1.2E-08	1.2E-07
22.3 y		(0.36)			(0.93)			
		BSurface			BSurface			
Pb-211	D 0.2	570	2.3E-07	0.2	9500	7.9E-10	1.3E-04	1.3E-03
36.1 m								
Pb-212	D 0.2	29	1.2E-08	0.2	81	4.1E-11	1.5E-06	1.5E-05
10.64 h					(100)			
					BSurface			
Pb-214	D 0.2	640	2.6E-07	0.2	7900	8.9E-10	1.0E-04	1.0E-03
26.8 m								
Bismuth								
Bi-200	D 0.05	7.5E+04	3.1E-05	0.05	2.7E+04	1.0E-07	3.7E-04	3.7E-03
36.4 m	W 0.05	8.3E+04	3.4E-05					
Bi-201	D 0.05	2.6E+04	1.0E-05	0.05	1.0E+04	3.6E-08	1.4E-04	1.4E-03
108 m	W 0.05	3.1E+04	1.2E-05					
Bi-202	D 0.05	3.9E+04	1.6E-05	0.05	1.3E+04	5.4E-08	1.9E-04	1.9E-03
1.67 h	W 0.05	6.1E+04	2.5E-05					
Bi-203	D 0.05	6600	2.7E-06	0.05	2300	8.3E-09	3.1E-05	3.1E-04
11.76 h	W 0.05	6000	2.5E-06					
Bi-205	D 0.05	2400	10E-07	0.05	1200	1.6E-09	1.7E-05	1.7E-04
15.31 d	W 0.05	1100	4.5E-07					
Bi-206	D 0.05	1300	5.4E-07	0.05	590	1.0E-09	8.1E-06	8.1E-05
6.243 d	W 0.05	760	3.1E-07					
Bi-207	D 0.05	1500	6.2E-07	0.05	910	3.4E-10	1.2E-05	1.2E-04
38 y	W 0.05	240	1.0E-07					
Bi-210	D 0.05	230	9.5E-08	0.05	780	3.5E-11	1.0E-05	1.0E-04
5.012 d		(320)						
		Kidneys						
	W 0.05	25	1.0E-08					
Bi-210m	D 0.05	4.5	1.8E-09	0.05	44	9.1E-13	7.1E-07	7.1E-06
3.0E6 y		(6.0)			(52)			
		Kidneys			Kidneys			
	W 0.05	0.65	2.7E-10					
Bi-212	D 0.05	230	9.5E-08	0.05	4700	3.2E-10	6.4E-05	6.4E-04
60.55 m	W 0.05	260	1.0E-07					
Bi-213	D 0.05	290	1.2E-07	0.05	6900	4.0E-10	9.4E-05	9.4E-04
45.65 m	W 0.05	320	1.3E-07					
Bi-214	D 0.05	760	3.1E-07	0.05	1.5E+04	1.0E-09	2.4E-04	2.4E-03
19.9 m	W 0.05	800	3.3E-07		(1.7E+04)			
					St wall			
Polonium								
Po-203	D 0.1	6.3E+04	2.6E-05	0.1	2.4E+04	8.7E-08	3.4E-04	3.4E-03
36.7 m	W 0.1	6.7E+04	2.7E-05					
Po-205	D 0.1	3.7E+04	1.5E-05	0.1	2.0E+04	5.1E-08	2.8E-04	2.8E-03
1.80 h	W 0.1	4.8E+04	2.0E-05					
Po-207	D 0.1	2.4E+04	10E-06	0.1	8000	3.4E-08	1.1E-04	1.1E-03
350 m	W 0.1	2.8E+04	1.1E-05					
Po-210	D 0.1	0.53	2.2E-10	0.1	2.6	7.3E-13	3.6E-08	3.6E-07
138.38 d	W 0.1	0.58	2.4E-10					
Astatine								
At-207	D 1	2200	9.1E-07	1	5700	2.8E-09	7.8E-05	7.8E-04
1.80 h	W 1	2000	8.3E-07					
At-211	D 1	60	2.5E-08	1	120	6.8E-11	1.7E-06	1.7E-05
7.214 h	W 1	48	2.0E-08					

	Table I Occupational Values					Table II Effluent		Table III Sewer
	Inhalation			Ingestion				
Nuclide	Class/f_1	ALI (μCi)	DAC (μCi/ml)	f_1	ALI (μCi)	Air (μCi/ml)	Water (μCi/ml)	Discharge (μCi/ml)
Radon (See Section 5 for details)								
Rn-220	Pure		6.2E-06			2.8E-08		
55.6 s	40% Equ.		1.9E-08			4.6E-10		
Rn-222	Pure		3.8E-06			1.7E-08		
3.823 d	40% Equ.		8.6E-08			1.8E-09		
Francium								
Fr-222 14.4 m	D 1	400	1.6E-07	1	2000	5.6E-10	2.7E-05	2.7E-04
Fr-223 21.8 m	D 1	800	3.3E-07	1	570	1.1E-09	7.9E-06	7.9E-05
Radium								
Ra-223 11.434 d	W 0.2	0.63	2.6E-10	0.2	4.6 (7.6) BSurface	8.8E-13	1.0E-07	1.0E-06
Ra-224 3.66 d	W 0.2	1.5	6.2E-10	0.2	8.4 (13) BSurface	2.1E-12	1.8E-07	1.8E-06
Ra-225 14.8 d	W 0.2	0.64	2.6E-10	0.2	7.5 (12) BSurface	8.9E-13	1.7E-07	1.7E-06
Ra-226 1600 y	W 0.2	0.58	2.4E-10	0.2	1.9 (3.7) BSurface	8.1E-13	5.1E-08	5.1E-07
Ra-227 42.2 m	W 0.2	1.4E+04 (1.7E+04) BSurface	5.8E-06	0.2	1.5E+04 (2.2E+04) BSurface	2.4E-08	3.0E-04	3.0E-03
Ra-228 5.75 y	W 0.2	1.0	4.1E-10	0.2	2.3 (3.4) BSurface	1.4E-12	4.7E-08	4.7E-07
Actinium								
Ac-224 2.9 h	D 0.001	27 (37) BSurface	1.1E-08	0.001	1600	5.2E-11	2.3E-05	2.3E-04
	W 0.001	41	1.7E-08					
	Y 0.001	45	1.8E-08					
Ac-225 10.0 d	D 0.001	0.29 (0.46) BSurface	1.2E-10	0.001	45	6.4E-13	6.1E-07	6.1E-06
	W 0.001	0.58	2.4E-10					
	Y 0.001	0.61	2.5E-10					
Ac-226 29 h	D 0.001	3.2 (3.7) BSurface	1.3E-09	0.001	110	5.2E-12	1.6E-06	1.6E-05
	W 0.001	4.1	1.7E-09					
	Y 0.001	4.5	1.8E-09					
Ac-227 21.773 y	D 0.001	4.2E-04 (7.4E-04) BSurface	1.7E-13	0.001	0.20 (0.35) BSurface	1.0E-15	4.8E-09	4.8E-08
	W 0.001	0.0016 (0.0029) BSurface	6.6E-13					
	Y 0.001	0.0038	1.5E-12					
Ac-228 6.13 h	D 0.001	9.4 (16) BSurface	3.9E-09	0.001	2300	2.2E-11	3.1E-05	3.1E-04
	W 0.001	38 (55) BSurface	1.5E-08					
	Y 0.001	39	1.6E-08					
Thorium								
Th-226 30.9 m	W 2.0E-04	150	6.2E-08	2.0E-04	5000 (5400) St wall	1.9E-10	7.4E-05	7.4E-04
	Y 2.0E-04	140	5.8E-08					
Th-227 18.718 d	W 2.0E-04	0.32	1.3E-10	2.0E-04	130	4.2E-13	1.8E-06	1.8E-05
	Y 2.0E-04	0.30	1.2E-10					
Th-228 1.9131 y	W 2.0E-04	0.0098 (0.020) BSurface	4.0E-12	2.0E-04	5.7 (12) BSurface	2.0E-14	1.7E-07	1.7E-06
	Y 2.0E-04	0.014	5.8E-12					

	Table I Occupational Values						Table II Effluent		Table III Sewer Discharge
	Inhalation				Ingestion				
Nuclide	Class	f_1	ALI (µCi)	DAC (µCi/ml)	f_1	ALI (µCi)	Air (µCi/ml)	Water (µCi/ml)	(µCi/ml)
Thorium, cont'd.									
Th-229 7340 y	W	2.0E-04	9.4E-04 (0.0023) BSurface	3.9E-13	2.0E-04	0.56 (1.4) BSurface	3.2E-15	1.9E-08	1.9E-07
	Y	2.0E-04	0.0023 (0.0028) BSurface	9.5E-13					
Th-230 7.7E4 y	W	2.0E-04	0.0062 (0.015) BSurface	2.5E-12	2.0E-04	3.7 (9.1) BSurface	2.1E-14	1.2E-07	1.2E-06
	Y	2.0E-04	0.015 (0.019) BSurface	6.2E-12					
Th-231 25.52 h	W	2.0E-04	5800	2.4E-06	2.0E-04	3700	7.9E-09	5.0E-05	5.0E-04
	Y	2.0E-04	5700	2.3E-06					
Th-232 1.405E10	W	2.0E-04	0.0012 (0.0030) BSurface	5.0E-13	2.0E-04	0.73 (1.8) BSurface	4.2E-15	2.5E-08	2.5E-07
	Y	2.0E-04	0.0027 (0.0043) BSurface	1.1E-12					
Th-234 24.10 d	W	2.0E-04	160	6.6E-08	2.0E-04	310 (360) LLI wall	1.9E-10	5.0E-06	5.0E-05
	Y	2.0E-04	140	5.8E-08					
Protactinium									
Pa-227 38.3 m	W	0.001	110	4.5E-08	0.001	3800	1.4E-10	5.2E-05	5.2E-04
	Y	0.001	100	4.1E-08					
Pa-228 22 h	W	0.001	12 (21) BSurface	5.0E-09	0.001	1100	1.5E-11	1.6E-05	1.6E-04
	Y	0.001	11	4.5E-09					
Pa-230 17.4 d	W	0.001	4.3	1.7E-09	0.001	650 (800) BSurface	4.7E-12	1.1E-05	1.1E-04
	Y	0.001	3.3	1.3E-09					
Pa-231 3.276E4	W	0.001	0.0015 (0.0038) BSurface	6.2E-13	0.001	0.18 (0.47) BSurface	5.4E-15	6.4E-09	6.4E-08
	Y	0.001	0.0037 (0.0058) BSurface	1.5E-12					
Pa-232 1.31 d	W	0.001	22 (54) BSurface	9.1E-09	0.001	1400	7.6E-11	1.9E-05	1.9E-04
	Y	0.001	56 (71) BSurface	2.3E-08					
Pa-233 27.0 d	W	0.001	600	2.5E-07	0.001	1300	7.2E-10	1.8E-05	1.8E-04
	Y	0.001	520	2.1E-07					
Pa-234 6.70 h	W	0.001	6800	2.8E-06	0.001	2300	8.5E-09	3.1E-05	3.1E-04
	Y	0.001	6100	2.5E-06					
Uranium									
U-230 20.8 d	D	0.05	0.41 (0.58) BSurface	1.7E-10	0.05	3.9 (5.5) BSurface	3.5E-13	7.5E-08	7.5E-07
	W	0.05	0.30	1.2E-10	0.002	37			
	Y	0.002	0.25	1.0E-10					
U-231 4.2 d	D	0.05	7500	3.1E-06	0.05	4200	5.8E-09	5.7E-05	5.7E-04
	W	0.05	4800	2.0E-06	0.002	4200			
	Y	0.002	4100	1.7E-06					
U-232 72 y	D	0.05	0.21 (0.39) BSurface	8.7E-11	0.05	2.0 (3.8) BSurface	1.0E-14	5.2E-08	5.2E-07
	W	0.05	0.33	1.3E-10	0.002	50 (72) BSurface			
	Y	0.002	0.0075	3.1E-12					
U-233 1.585E5	D	0.05	1.2 (1.7) BSurface	5.0E-10	0.05	11 (17) BSurface	5.1E-14	2.3E-07	2.3E-06
	W	0.05	0.62	2.5E-10	0.002	180			
	Y	0.002	0.036	1.5E-11					

	Table I Occupational Values					Table II Effluent		Table III Sewer
	Inhalation			Ingestion				
Nuclide	Class/f_1	ALI (μCi)	DAC (μCi/ml)	f_1	ALI (μCi)	Air (μCi/ml)	Water (μCi/ml)	Discharge (μCi/ml)
Uranium, cont'd.								
U-234	D 0.05	1.2	5.0E-10	0.05	11	5.2E-14	2.4E-07	2.4E-06
2.445E5		(1.8)			(17)			
		BSurface			BSurface			
	W 0.05	0.63	2.6E-10	0.002	190			
	Y 0.002	0.037	1.5E-11					
U-235	D 0.05	1.3	5.4E-10	0.05	12	5.6E-14	2.5E-07	2.5E-06
703.8E6		(1.9)			(18)			
		BSurface			BSurface			
	W 0.05	0.68	2.8E-10	0.002	180			
	Y 0.002	0.040	1.6E-11					
U-236	D 0.05	1.2	5.0E-10	0.05	12	5.5E-14	2.5E-07	2.5E-06
2.3415E7		(1.9)			(18)			
		BSurface			BSurface			
	W 0.05	0.67	2.7E-10	0.002	200			
	Y 0.002	0.039	1.6E-11					
U-237	D 0.05	2500	1.0E-06	0.05	1500	1.9E-09	2.1E-05	2.1E-04
6.75 d	W 0.05	1400	5.8E-07	0.002	1500			
	Y 0.002	1400	5.8E-07					
U-238	D 0.05	1.3	5.4E-10	0.05	13	5.8E-14	2.6E-07	2.6E-06
4.468E9		(2.0)			(19)			
		BSurface			BSurface			
	W 0.05	0.71	2.9E-10	0.002	210			
	Y 0.002	0.042	1.7E-11					
U-239	D 0.05	1.5E+05	6.2E-05	0.05	6.5E+04	1.8E-07	8.8E-04	8.8E-03
23.54 m	W 0.05	1.4E+05	5.8E-05	0.002	6.4E+04			
	Y 0.002	1.3E+05	5.4E-05					
U-240	D 0.05	3200	1.3E-06	0.05	1100	3.0E-09	1.5E-05	1.5E-04
14.1 h	W 0.05	2400	10E-07	0.002	1100			
	Y 0.002	2200	9.1E-07					
Neptunium								
Np-232	W 0.001	1700	7.0E-07	0.001	1.3E+05	5.5E-09	0.0018	0.018
14.7 m		(3900)						
		BSurface						
Np-233	W 0.001	2.3E+06	9.5E-04	0.001	6.7E+05	3.1E-06	0.0092	0.092
36.2 m								
Np-234	W 0.001	2400	10E-07	0.001	1800	3.4E-09	2.4E-05	2.4E-04
4.4 d								
Np-235	W 0.001	800	3.3E-07	0.001	2.0E+04	1.6E-09	2.8E-04	2.8E-03
396.1 d		(1200)						
		BSurface						
Np-236	W 0.001	0.021	8.7E-12	0.001	2.5	6.6E-14	7.9E-08	7.9E-07
115E3 y		(0.048)			(5.7)			
		BSurface			BSurface			
Np-236	W 0.001	27	1.1E-08	0.001	3300	8.4E-11	5.0E-05	5.0E-04
22.5 h		(60)			(3600)			
		BSurface			BSurface			
Np-237	W 0.001	0.0041	1.7E-12	0.001	0.49	1.2E-14	1.5E-08	1.5E-07
2.14E6 y		(0.0092)			(1.1)			
		BSurface			BSurface			
Np-238	W 0.001	64	2.6E-08	0.001	1200	1.8E-10	1.7E-05	1.7E-04
2.117 d		(130)						
		BSurface						
Np-239	W 0.001	1900	7.9E-07	0.001	1500	2.7E-09	2.0E-05	2.0E-04
2.355 d								
Np-240	W 0.001	6.1E+04	2.5E-05	0.001	2.1E+04	8.5E-08	2.8E-04	2.8E-03
65 m								
Plutonium								
Pu-234	W 0.001	180	7.5E-08	0.001	7500	2.5E-10	1.0E-04	1.0E-03
8.8 h	Y 1.0E-05	180	7.5E-08	1.0E-04	8300			
				1.0E-05	8300			
Pu-235	W 0.001	2.3E+06	9.5E-04	0.001	7.8E+05	3.0E-06	0.010	0.10
25.3 m	Y 1.0E-05	2.1E+06	8.7E-04	1.0E-04	7.8E+05			
				1.0E-05	7.8E+05			
Pu-236	W 0.001	0.020	8.3E-12	0.001	2.4	4.7E-14	5.8E-08	5.8E-07
2.851 y		(0.034)			(4.2)			
		BSurface			BSurface			
	Y 1.0E-05	0.038	1.5E-11	1.0E-04	24			
					(37)			
					BSurface			
				1.0E-05	160			

	Table I Occupational Values					Table II Effluent		Table III Sewer Discharge
	Inhalation			Ingestion				
Nuclide	Class/f_1	ALI (μCi)	DAC (μCi/ml)	f_1	ALI (μCi)	Air (μCi/ml)	Water (μCi/ml)	(μCi/ml)
Plutonium, cont'd.								
Pu-237 45.3 d	W 0.001	2800	1.1E-06	0.001	1.1E+04	3.5E-09	1.5E-04	1.5E-03
	Y 1.0E-05	2500	1.0E-06	1.0E-04	1.1E+04			
				1.0E-05	1.1E+04			
Pu-238 87.74 y	W 0.001	0.0071 (0.012) BSurface	2.9E-12	0.001	0.85 (1.5) BSurface	1.7E-14	2.1E-08	2.1E-07
	Y 1.0E-05	0.017	7.0E-12	1.0E-04	8.5 (14) BSurface			
				1.0E-05	85 (100) BSurface			
Pu-239 24065 y	W 0.001	0.0064 (0.011) BSurface	2.6E-12	0.001	0.76 (1.4) BSurface	1.6E-14	1.9E-08	1.9E-07
	Y 1.0E-05	0.016	6.6E-12	1.0E-04	7.6 (13) BSurface			
				1.0E-05	76 (96) BSurface			
Pu-240 6537 y	W 0.001	0.0064 (0.011) BSurface	2.6E-12	0.001	0.76 (1.4) BSurface	1.6E-14	1.9E-08	1.9E-07
	Y 1.0E-05	0.016	6.6E-12	1.0E-04	7.6 (13) BSurface			
				1.0E-05	76 (96) BSurface			
Pu-241 14.4 y	W 0.001	0.32 (0.60) BSurface	1.3E-10	0.001	38 (73) BSurface	8.4E-13	1.0E-06	1.0E-05
	Y 1.0E-05	0.75 (1.0) BSurface	3.1E-10	1.0E-04	380 (720) BSurface			
				1.0E-05	3800 (6500) BSurface			
Pu-242 3.763E5	W 0.001	0.0067 (0.012) BSurface	2.7E-12	0.001	0.80 (1.4) BSurface	1.6E-14	2.0E-08	2.0E-07
	Y 1.0E-05	0.017	7.0E-12	1.0E-04	8.0 (14) BSurface			
				1.0E-05	80 (100) BSurface			
Pu-243 4.956 h	W 0.001	3.0E+04	1.2E-05	0.001	1.4E+04	4.2E-08	2.0E-04	2.0E-03
	Y 1.0E-05	3.0E+04	1.2E-05	1.0E-04	1.4E+04			
				1.0E-05	1.4E+04			
Pu-244 8.26E7 y	W 0.001	0.0068 (0.012) BSurface	2.8E-12	0.001	0.82 (1.5) BSurface	1.7E-14	2.0E-08	2.0E-07
	Y 1.0E-05	0.017	7.0E-12	1.0E-04	8.2 (14) BSurface			
				1.0E-05	81 (85) BSurface			
Pu-245 10.5 h	W 0.001	4000	1.6E-06	0.001	1800	5.2E-09	2.5E-05	2.5E-04
	Y 1.0E-05	3800	1.5E-06	1.0E-04	1800			
				1.0E-05	1800			
Pu-246 10.85 d	W 0.001	220	9.1E-08	0.001	350 (360) LLI wall	3.1E-10	5.0E-06	5.0E-05
	Y 1.0E-05	230	9.5E-08	1.0E-05	350 (360) LLI wall			
Americium								
Am-237 73.0 m	W 0.001	2.0E+05	8.3E-05	0.001	7.6E+04	2.9E-07	0.0010	0.010

	Table I Occupational Values						Table II Effluent		Table III Sewer Discharge
	Inhalation				Ingestion				
Nuclide	Class/f_1		ALI (μCi)	DAC (μCi/ml)	f_1	ALI (μCi)	Air (μCi/ml)	Water (μCi/ml)	(μCi/ml)
Americium, cont'd.									
Am-238 98 m	W	0.001	3300 (5800) BSurface	1.3E-06	0.001	3.8E+04	8.0E-09	5.2E-04	5.2E-03
Am-239 11.9 h	W	0.001	1.0E+04	4.1E-06	0.001	5000	1.5E-08	6.9E-05	6.9E-04
Am-240 50.8 h	W	0.001	2700	1.1E-06	0.001	1900	3.7E-09	2.7E-05	2.7E-04
Am-241 432.2 y	W	0.001	0.0062 (0.011) BSurface	2.5E-12	0.001	0.74 (1.3) BSurface	1.5E-14	1.8E-08	1.8E-07
Am-242m 152 y	W	0.001	0.0063 (0.011) BSurface	2.6E-12	0.001	0.76 (1.4) BSurface	1.6E-14	1.9E-08	1.9E-07
Am-242 16.02 h	W	0.001	81 (85) BSurface	3.3E-08	0.001	3500	1.1E-10	4.8E-05	4.8E-04
Am-243 7380 y	W	0.001	0.0062 (0.011) BSurface	2.5E-12	0.001	0.75 (1.3) BSurface	1.5E-14	1.8E-08	1.8E-07
Am-244m 26 m	W	0.001	4200 (7100) BSurface	1.7E-06	0.001	5.9E+04 (6.4E+04) St wall	9.8E-09	8.8E-04	8.8E-03
Am-244 10.1 h	W	0.001	180 (300) BSurface	7.5E-08	0.001	2500	4.1E-10	3.4E-05	3.4E-04
Am-245 2.05 h	W	0.001	6.2E+04	2.5E-05	0.001	2.7E+04	8.6E-08	3.7E-04	3.7E-03
Am-246m 25.0 m	W	0.001	1.4E+05	5.8E-05	0.001	5.2E+04 (5.3E+04) St wall	2.0E-07	7.2E-04	7.2E-03
Am-246 39 m	W	0.001	7.9E+04	3.2E-05	0.001	2.9E+04	1.1E-07	4.0E-04	4.0E-03
Curium									
Cm-238 2.4 h	W	0.001	940	3.9E-07	0.001	1.4E+04	1.3E-09	2.0E-04	2.0E-03
Cm-240 27 d	W	0.001	0.59 (0.62) BSurface	2.4E-10	0.001	65 (80) BSurface	8.6E-13	1.0E-06	1.0E-05
Cm-241 32.8 d	W	0.001	26 (34) BSurface	1.0E-08	0.001	1100	4.7E-11	1.5E-05	1.5E-04
Cm-242 162.8 d	W	0.001	0.27 (0.28) BSurface	1.1E-10	0.001	30 (43) BSurface	4.0E-13	5.9E-07	5.9E-06
Cm-243 28.5 y	W	0.001	0.0091 (0.016) BSurface	3.7E-12	0.001	1.0 (1.9) BSurface	2.2E-14	2.7E-08	2.7E-07
Cm-244 18.11 y	W	0.001	0.011 (0.020) BSurface	4.5E-12	0.001	1.3 (2.4) BSurface	2.8E-14	3.3E-08	3.3E-07
Cm-245 8500 y	W	0.001	0.0060 (0.010) BSurface	2.5E-12	0.001	0.72 (1.3) BSurface	1.5E-14	1.8E-08	1.8E-07
Cm-246 4730 y	W	0.001	0.0060 (0.011) BSurface	2.5E-12	0.001	0.73 (1.3) BSurface	1.5E-14	1.8E-08	1.8E-07
Cm-247 1.56E7 y	W	0.001	0.0066 (0.012) BSurface	2.7E-12	0.001	0.79 (1.4) BSurface	1.6E-14	2.0E-08	2.0E-07
Cm-248 3.39E5 y	W	0.001	0.0016 (0.0030) BSurface	6.6E-13	0.001	0.20 (0.36) BSurface	4.1E-15	5.0E-09	5.0E-08
Cm-249 64.15 m	W	0.001	1.7E+04 (2.5E+04) BSurface	7.0E-06	0.001	4.9E+04	3.5E-08	6.8E-04	6.8E-03
Cm-250 6900 y	W	0.001	2.9E-04 (5.3E-04) BSurface	1.2E-13	0.001	0.035 (0.064) BSurface	7.3E-16	8.8E-10	8.8E-09
Berkelium									
Bk-245 4.94 d	W	0.001	1100	4.5E-07	0.001	2000	1.5E-09	2.8E-05	2.8E-04

Nuclide	Table I Occupational Values: Inhalation Class/f_1		Inhalation ALI (μCi)	Inhalation DAC (μCi/ml)	Ingestion f_1	Ingestion ALI (μCi)	Table II Effluent Air (μCi/ml)	Table II Effluent Water (μCi/ml)	Table III Sewer Discharge (μCi/ml)
Berkelium, cont'd.									
Bk-246 1.83 d	W	0.001	2900	1.2E-06	0.001	2300	4.0E-09	3.2E-05	3.2E-04
Bk-247 1380 y	W	0.001	0.0040 (0.0087) BSurface	1.6E-12	0.001	0.49 (1.0) BSurface	1.2E-14	1.4E-08	1.4E-07
Bk-249 320 d	W	0.001	1.6 (3.6) BSurface	6.6E-10	0.001	200 (410) BSurface	5.0E-12	5.7E-06	5.7E-05
Bk-250 3.222 h	W	0.001	320 (660) BSurface	1.3E-07	0.001	8600	9.2E-10	1.1E-04	1.1E-03
Californium									
Cf-244 19.4 m	W	0.001	500	2.0E-07	0.001	2.5E+04 (2.6E+04) St wall	7.0E-10	3.5E-04	3.5E-03
	Y	0.001	510	2.1E-07					
Cf-246 35.7 h	W	0.001	8.3	3.4E-09	0.001	340	1.1E-11	4.7E-06	4.7E-05
	Y	0.001	8.3	3.4E-09					
Cf-248 333.5 d	W	0.001	0.064 (0.11) BSurface	2.6E-11	0.001	7.5 (14) BSurface	1.3E-13	2.0E-07	2.0E-06
	Y	0.001	0.098	4.0E-11					
Cf-249 350.6 y	W	0.001	0.0040 (0.0086) BSurface	1.6E-12	0.001	0.48 (1.0) BSurface	1.2E-14	1.4E-08	1.4E-07
	Y	0.001	0.010 (0.013) BSurface	4.1E-12					
Cf-250 13.08 y	W	0.001	0.0092 (0.019) BSurface	3.8E-12	0.001	1.1 (2.3) BSurface	2.6E-14	3.2E-08	3.2E-07
	Y	0.001	0.024	10E-12					
Cf-251 898 y	W	0.001	0.0039 (0.0085) BSurface	1.6E-12	0.001	0.48 (1.0) BSurface	1.1E-14	1.4E-08	1.4E-07
	Y	0.001	0.010 (0.012) BSurface	4.1E-12					
Cf-252 2.638 y	W	0.001	0.019 (0.036) BSurface	7.9E-12	0.001	2.3 (4.6) BSurface	4.4E-14	6.3E-08	6.3E-07
	Y	0.001	0.031	1.2E-11					
Cf-253 17.81 d	W	0.001	1.7	7.0E-10	0.001	200 (350) BSurface	2.2E-12	4.8E-06	4.8E-05
	Y	0.001	1.6	6.6E-10					
Cf-254 60.5 d	W	0.001	0.019	7.9E-12	0.001	2.0	2.3E-14	2.8E-08	2.8E-07
	Y	0.001	0.017	7.0E-12					
Einsteinium									
Es-250 2.1 h	W	0.001	500 (1000) BSurface	2.0E-07	0.001	4.2E+04	1.4E-09	5.7E-04	5.7E-03
Es-251 33 h	W	0.001	860 (1000) BSurface	3.5E-07	0.001	6700	1.4E-09	9.2E-05	9.2E-04
Es-253 20.47 d	W	0.001	1.2	5.0E-10	0.001	140	1.7E-12	2.0E-06	2.0E-05
Es-254m 39.3 h	W	0.001	° °	3.7E-09	0.001	270	1.2E-11	3.8E-06	3.8E-05
Es-254 275.7 d	W	0.001	0.071 (0.12) BSurface	2.9E-11	0.001	8.2 (15) BSurface	1.6E-13	2.1E-07	2.1E-06
Fermium									
Fm-252 22.7 h	W	0.001	11	4.5E-09	0.001	430	1.6E-11	5.9E-06	5.9E-05
Fm-253 3.00 d	W	0.001	8.6	3.5E-09	0.001	980	1.2E-11	1.3E-05	1.3E-04
Fm-254 3.240 h	W	0.001	85	3.5E-08	0.001	2800	1.1E-10	3.9E-05	3.9E-04
Fm-255 20.07 h	W	0.001	18	7.5E-09	0.001	480	2.6E-11	6.6E-06	6.6E-05
Fm-257 100.5 d	W	0.001	0.17 (0.21) BSurface	7.0E-11	0.001	18 (33) BSurface	2.9E-13	4.5E-07	4.5E-06

Nuclide	Class/f_1	Inhalation ALI (μCi)	Inhalation DAC (μCi/ml)	Ingestion f_1	Ingestion ALI (μCi)	Table II Effluent Air (μCi/ml)	Table II Effluent Water (μCi/ml)	Table III Sewer Discharge (μCi/ml)
Mendelevium								
Md-257 5.2 h	W 0.001	84 (87) BSurface	3.5E-08	0.001	7100	1.2E-10	9.8E-05	9.8E-04
Md-258 55 d	W 0.001	0.23 (0.30) BSurface	9.5E-11	0.001	25 (42) BSurface	4.2E-13	5.8E-07	5.8E-06

Notes:

1. Submersion refers to the external irradiation of the body while in a semi-infinite cloud of the airborne material.

2. The total effective dose equivalent received during operations with radionuclides of radiological half-lives less than two hours might include a significant contribution from external exposure. The *DAC* values for these radionuclides, other than those designated by Class "Submersion," are based upon the intake by inhalation of the radionuclide into the body and do not include potentially significant contributions to dose equivalent from external exposures. The licensee may substitute a *DAC* of 1.0E-07 μCi/ml for the listed *DAC* or derive an appropriate value from Federal Guidance Report 12 to account for the submersion dose prospectively, but should use individual monitoring devices or other radiation measuring instruments that measure external exposure to demonstrate compliance with the limits.

3. For soluble mixtures of U-238, U-234, and U-235 in air, chemical toxicity may be the limiting factors. If the percent by weight (enrichment) of U-235 is not greater that 5, the average concentration value for a 40-hour workweek is 0.2 mg/m^3. For any enrichment, the product of the average concentration and time of exposure during a 40-hour workweek shall not exceed 8.0E-03 *SA* μCi-hr/ml, where *SA* is the specific activity of the uranium inhaled. The specific activity for natural uranium is 6.77E-07 Ci/g-U. The specific activity for other mixtures of U-238, U-235, and U-234, if not known, shall be:

$$SA\ Ci/g{-}U = 3.67 \times 10^{-7} \ \textit{for depleted uranium}$$

$$= \left[0.4 + 0.38\ \%U{-}235 + 0.0034\ (\%U{-}235)^2\right] \times 10^{-6},\ \%U{-}235 > 0.72\ ,$$

   where $\%U{-}235$ is the enrichment as a percentage, by weight, of U-235 in the mixture.

4. Mixtures
   If a mixture of radionuclides consists of uranium and its daughters in ore dust (10 μm *AMAD* particle distribution assumed) prior to chemical separation of the uranium from the ore, the following values may be used for the *DAC* of the mixture: 6.0E-11 μCi/ml gross alpha activity from U-238, U-234, Th-230, and Ra-226; 3.0E-11 μCi/ml of natural uranium; or 45 μg/m^3 of natural uranium.

   If the identities and concentrations of each radionuclide in a mixture are known, the limiting values should be derived as follows: determine, for each radionuclide in the mixture, the ratio between the concentration present in the mixture and the *DAC* for the specific radionuclide when not in a mixture. The sum of such ratios for all radionuclides in the mixture may not exceed 1.

Example: If radionuclides A, B, and C are present in concentrations C_A, C_B, and C_C and if the applicable *DACs* are DAC_A, DAC_B, and DAC_C, respectively, then mixture shall be limited so that the following relationship exists:

$$\frac{C_A}{DAC_A} + \frac{C_B}{DAC_B} + \frac{C_C}{DAC_C} \leq 1 \ .$$

5. Unidentified radionuclides
   If the identity of each radionuclide in a mixture is known but the concentration of one or more of the radionuclides in the mixture is not known, the *DAC* for the mixture shall be the most restrictive *DAC* of any radionuclide in the mixture.

   If the identity of each radionuclide in the mixture is not known, but it is known that certain radionuclides specified in the appendix are not present in the mixture, the inhalation *ALI*, *DAC*, and effluent and sewage concentrations for the mixture are the lowest value specified in this appendix for any radionuclide that is not known to be absent from the mixture, or

Airborne Activity:	*ALI* (*μCi*)	*DAC* (*μCi/ml*)
If it is know that Ac-227:D and Cm-250 are not present	7.0E-04	3.0E-13
If, in addition, it is known that Ac-227: W & Y, Th-229, Th-230: W, Th-232, Pa-231, Np-237, Pu-239:W, Pu-240:W, Pu-242:W, Am-241, Am-242m, Am-243, Cm-245, Cm-246, Cm-247 are not present	7.0E-03	3.0E-12
If, in addition, it is known that Sm-146, Sm-147, Gd-148, Gd-152, Th-228, Th-230:Y, U-232:Y, U-235:Y, U-236:Y, U-238:Y, Np-236, Pu-236, Pu-238, Pu-239, Pu-240:Y, Pu-242, Pu-242, Cm-243, Cm-244, Cf-248:W, Cf-249:Y, Cf-250, Cf-251:Y, Cf-251 and Cf-252 are not present	0.07	3.0E-11
If, in addition, it is known that Pb-210, Bi-210m:W, Po-210, Ra-226, Ac-225, Th-227, U-230, U-232:D & W, Pu-241:W, Cm-240, Cm-242, Cf-248:Y, Es-254, Fm-257 and Md-258 are not present	0.7	3.0E-10
If, in addition, it is known that Si-32:Y, Ti-44:Y, Fe-60:D, Sr-90:Y, Zr-93:D, Cd-113m:D, Cd-113:D, In-115, La-138:D, Lu-176:W, Hf-178m, Hf-182:D & W, Bi-210m:D, Ra-224, Ra-228, Ac-226, Pa-230, U-233:D & W, U-234:D & W, U-235:D & W, U-236:D & W, U-238:D & W, Pu-241:Y, Bk-249, Cf-253 and Es-253 are not present	7.0	3.0E-09

Table IV. Gastrointestinal Absorption Fractions (f_1) and Lung Clearance Classes for Chemical Compounds

Element	Inhalation			Ingestion	
	Compound	f_1	Class	Compound	f_1
Actinium (Ac)	Oxides & hydroxides	$1\ 10^{-3}$	Y	All forms	$1\ 10^{-3}$
	Halides & nitrates	$1\ 10^{-3}$	W		
	All others	$1\ 10^{-3}$	D		
Aluminum (Al)	Oxides, hydroxides, carbides, halides, nitrates & elemental	0.01	W	All forms	0.01
	All others	0.01	D		
Americium (Am)	All forms	$1\ 10^{-3}$	W	All forms	$1\ 10^{-3}$
Antimony (Sb)	Oxides, hydroxides, halides, sulfides, sulfates & nitrates	0.1	W	Tartar emetic	0.1
				All others	0.01
	All others	0.01	D		
Arsenic (As)	All forms	0.5	W	All forms	0.5
Astatine (At)	See halide assignment	1	D	All forms	1
	of associated element	1	W		
Barium (Ba)	All forms	0.1	D	All forms	0.1
Berkelium (Bk)	All forms	$1\ 10^{-3}$	W	All forms	$1\ 10^{-3}$
Beryllium (Be)	Oxides, halides & nitrates	$5\ 10^{-3}$	Y	All forms	$5\ 10^{-3}$
	All others	$5\ 10^{-3}$	W		

Table IV. Cont'd

Element	Inhalation Compound	Inhalation f_1	Inhalation Class	Ingestion Compound	Ingestion f_1
Calcium (Ca)	All forms	0.3	W	All forms	0.03
Californium (Cf)	Oxides, hydroxides	$1\ 10^{-3}$	Y	All forms	$1\ 10^{-3}$
	All others	$1\ 10^{-3}$	W		
Carbon (C)	Monoxides Dioxide Organic forms	Special models		Organic forms	1
Cerium (Ce)	Oxides, hydroxides & fluorides	$3\ 10^{-4}$	Y	All forms	$3\ 10^{-4}$
	All others	$3\ 10^{-4}$	W		
Cesium (Cs)	All forms	1	D	All forms	1
Chlorine (Cl)	See assignment of associated element	1 1	D W	All forms	1
Chromium (Cr)	Oxides & hydroxides	0.1	Y	Trivalent state	0.01
	Halides & nitrates	0.1	W	Hexavalent state	0.1
	All others	0.1	D		
Cobalt (Co)	Oxides, hydroxides, halides & nitrates	0.05	Y	Oxides, hydroxides & trace inorganic	0.05
	All others	0.05	W	Organic complexes & other inorganics	0.3
Copper (Cu)	Oxides & hydroxides	0.5	Y	All forms	0.5
	Sulfites, halides & nitrates	0.5	W		
	All others	0.5	D		
Curium (Cm)	All forms	$1\ 10^{-3}$	W	All forms	$1\ 10^{-3}$
Dysprosium (Dy)	All forms	$3\ 10^{-4}$	W	All forms	$3\ 10^{-4}$

Table IV. Cont'd

Element	Inhalation Compound	Inhalation f_1	Inhalation Class	Ingestion Compound	Ingestion f_1
Einsteinium (Es)	All forms	$1\ 10^{-3}$	W	All forms	$1\ 10^{-3}$
Erbium (Er)	All forms	$3\ 10^{-4}$	W	All forms	$3\ 10^{-4}$
Europium (Eu)	All forms	$1\ 10^{-3}$	W	All forms	$1\ 10^{-3}$
Fermium (Fm)	All forms	$1\ 10^{-3}$	W	All forms	$1\ 10^{-3}$
Fluorine (F)	See assignment of associated element	1	D	All forms	1
		1	W		
		1	Y		
Francium (Fr)	All forms	1	D	All forms	1
Gadolinium (Gd)	Oxides, hydroxides & fluorides	$3\ 10^{-4}$	W	All forms	$3\ 10^{-4}$
	All others	$3\ 10^{-4}$	D		
Gallium (Ga)	Oxides, hydroxides, carbides, halides & nitrates	$1\ 10^{-3}$	W	All forms	$1\ 10^{-3}$
	All others	$1\ 10^{-3}$	D		
Germanium (Ge)	Oxides, sulfides & halides	1	W	All forms	1
	All others	1	D		
Gold (Au)	Oxides & hydroxides	0.1	Y	All forms	0.1
	Halides & nitrates	0.1	W		
	All others	0.1	D		

Table IV. Cont'd

Element	Inhalation Compound	Inhalation f_1	Inhalation Class	Ingestion Compound	Ingestion f_1
Hafnium (Hf)	Oxides, hydroxides halides, carbides & nitrates	$2\ 10^{-3}$	W	All forms	$2\ 10^{-3}$
	All other	$2\ 10^{-3}$	D		
Holmium (Ho)	All forms	$3\ 10^{-4}$	W	All forms	$3\ 10^{-4}$
Hydrogen (H)	Water vapor	1		All forms	1
	Elemental	Special model			
Indium (In)	Oxides, hydroxides, halides & nitrates	0.02	W	All forms	0.02
	All others	0.02	D		
Iodine (I)	All forms	1	D	All forms	1
Iridium (Ir)	Oxides & hydroxides	0.01	Y	All forms	0.01
	Halides, nitrates & metallic form	0.01	W		
	All others	0.01	D		
Iron (Fe)	Oxides, hydroxides & halides	0.1	W	All forms	0.1
	All others	0.1	D		
Lanthanum (La)	Oxides & hydroxides	$1\ 10^{-3}$	W	All forms	$1\ 10^{-3}$
	All others	$1\ 10^{-3}$	D		
Lead (Pb)	All forms	0.2	D	All forms	0.2
Lutetium (Lu)	Oxides, hydroxides & fluorides	$3\ 10^{-4}$	Y	All forms	$3\ 10^{-4}$
	All others	$3\ 10^{-4}$	W		

Table IV. Cont'd

Element	Inhalation Compound	Inhalation f_1	Inhalation Class	Ingestion Compound	Ingestion f_1
Magnesium (Mg)	Oxides, hydroxides, carbides, halides & nitrates	0.5	W	All forms	0.5
	All others	0.5	D		
Manganese (Mn)	Oxides, hydroxides, halides & nitrates	0.1	W	All forms	0.1
	All others	0.1	D		
Mendelevium (Md)	All forms	$1\ 10^{-3}$	W	All forms	$1\ 10^{-3}$
Mercury (Hg)	Oxides, hydroxides, halides, nitrates & sulfides	0.02	W	All inorganic forms	0.02
				Methyl mercury	1
				Other organic forms	0.4
	Sulfates	0.02	D		
	Organic forms	1	D		
	Vapors	Special model			
Molybdenum (Mo)	Oxides, hydroxides & MoS_2	0.05	Y	MoS_2	0.05
				All others	0.8
	All others	0.8	D		
Neodymium (Nd)	Oxides, hydroxides, carbides & fluorides	$3\ 10^{-4}$	Y	All forms	$3\ 10^{-4}$
	All others	$3\ 10^{-4}$	W		
Neptunium (Np)	All forms	$1\ 10^{-3}$	W	All forms	$1\ 10^{-3}$
Nickel (Ni)	Oxides, hydroxides & carbides	0.05	W	All forms	0.05
	All others				
		0.05	D		
	Vapors	Special model			
Niobium (Nb)	Oxides & hydroxides	0.01	Y	All forms	0.01
	All others	0.01	W		

Table IV. Cont'd

Element	Inhalation			Ingestion	
	Compound	f_1	Class	Compound	f_1
Osmium (Os)	Oxides & hydroxides	0.01	Y	All forms	0.01
	Halides & nitrates	0.01	W		
	All others	0.01	D		
Palladium (Pd)	Oxides & hydroxides	$5\ 10^{-3}$	Y	All forms	$5\ 10^{-3}$
	Nitrates	$5\ 10^{-3}$	W		
	All others	$5\ 10^{-3}$	D		
Phosphorus (P)	Phosphates of particular element	0.8	W	All forms	0.8
	All others	0.8	D		
Platinum (Pt)	All forms	0.01	D	All forms	0.01
Plutonium (Pu)	Oxides	$1\ 10^{-5}$	Y	Oxides	$1\ 10^{-5}$
	All others	$1\ 10^{-3}$	W	Nitrates	$1\ 10^{-4}$
				Others	$1\ 10^{-3}$
Polonium (Po)	Oxides, hydroxides & nitrates	0.1	W	All forms	0.1
	All others	0.1	D		
Potassium (K)	All forms	1	D	All forms	1
Praseodymium (Pr)	Oxides, hydroxides, carbides, & fluorides	$3\ 10^{-4}$	Y	All forms	$3\ 10^{-4}$
	All others	$3\ 10^{-4}$	W		
Promethium (Pm)	Oxides, hydroxides, carbides, & fluorides	$3\ 10^{-4}$	Y	All forms	$3\ 10^{-4}$
	All others	$3\ 10^{-4}$	W		
Protactinium (Pa)	Oxides & hydroxides	$1\ 10^{-3}$	Y	All forms	$1\ 10^{-3}$
	All others	$1\ 10^{-3}$	W		

Table IV. Cont'd

Element	Inhalation			Ingestion	
	Compound	f_1	Class	Compound	f_1
Radium (Ra)	All forms	0.2	W	All forms	0.2
Rhenium (Re)	Oxides, hydroxides, halides & nitrates	0.8	W	All forms	0.8
	All others	0.8	D		
Rhodium (Rh)	Oxides & hydroxides	0.05	Y	All forms	0.05
	Halides	0.05	W		
	All others	0.05	D		
Rubidium (Rb)	All forms	1	D	All forms	1
Ruthenium (Ru)	Oxides & hydroxides	0.05	Y	All forms	0.05
	Halides	0.05	W		
	All others	0.05	D		
Samarium (Sm)	All forms	$3\ 10^{-4}$	W	All forms	$3\ 10^{-4}$
Scandium (Sc)	All forms	$1\ 10^{-4}$	Y	All forms	$1\ 10^{-4}$
Selenium (Se)	Oxides, hydroxides, carbides & elemental	0.8	W	Elemental	0.05
				All others	0.8
	All others	0.8	D		
Silicon (Si)	Ceramic forms	0.01	Y	All compounds	0.01
	Oxides, hydroxides, carbides, & nitrates	0.01	W		
	All others	0.01	D		
Silver (Ag)	Oxides & hydroxides	0.05	Y	All forms	0.05
	Nitrates & sulfides	0.05	W		
	All others	0.05	D		
Sodium (Na)	All forms	1	D	All forms	1

Table IV. Cont'd

Element	Inhalation Compound	Inhalation f_1	Inhalation Class	Ingestion Compound	Ingestion f_1
Strontium (Sr)	$SrTiO_3$	0.01	Y	Soluble salts	0.3
	All others	0.3	D	$SrTiO_3$	0.01
Sulfur (S)	Sulfates & sulfides of associated elements	0.8	D W	All inorganic forms	0.8
				Elemental	
	Elemental	0.8	W		0.1
	Gases	Special model			
Tantalum (Ta)	Oxides, hydroxides, halides, carbides, nitrates & nitrides	$1\ 10^{-3}$	Y	All forms	$1\ 10^{-3}$
	All others	$1\ 10^{-3}$	W		
Technetium (Tc)	Oxides, hydroxides, halides & nitrates	0.8	W	All forms	0.8
	All others	0.8	D		
Tellurium (Te)	Oxides, hydroxides & nitrates	0.2	W	All forms	0.2
	All others	0.2	D		
Terbium (Tb)	All forms	$3\ 10^{-4}$	W	All forms	$3\ 10^{-4}$
Thallium (Tl)	All forms	1	D	All forms	1
Thorium (Th)	Oxides & hydroxides	$2\ 10^{-4}$	Y	All forms	$2\ 10^{-4}$
	All others	$2\ 10^{-4}$	W		
Thulium (Tm)	All forms	$3\ 10^{-4}$	W	All forms	$3\ 10^{-4}$
Tin (Sn)	Oxides, hydroxides, halides, nitrates, sulfides & $Sn_3(PO_4)_4$	0.02	W	All forms	0.02
	All others	0.02	D		

Table IV. Cont'd

Element	Inhalation			Ingestion	
	Compound	f_1	Class	Compound	f_1
Titanium (Ti)	$SrTiO_3$	0.01	Y	All forms	0.01
	Oxides, hydroxides, carbides, halides & nitrates	0.01	W		
	All others	0.01	D		
Tungsten (W)	All forms	0.3	D	Tungstic acid	0.01
				All others	0.3
Uranium (U)	UO_2, U_3O_8	$2\ 10^{-3}$	Y	Hexavalent	0.05
	UO_3, UF_4 & UCl_4	0.05	W	Insoluble forms	$2\ 10^{-3}$
	UF_6, UO_2F_2 & $UO_2(NO_3)_2$	0.05	D		
Vanadium (V)	Oxides, hydroxides, carbides, & halides	0.01	W	All forms	0.01
	All others	0.01	D		
Ytterbium (Yb)	Oxides, hydroxides & fluorides	$3\ 10^{-4}$	Y	All forms	$3\ 10^{-4}$
	All others	$3\ 10^{-4}$	W		
Yttrium (Y)	Oxides & hydroxides	$1\ 10^{-4}$	Y	All forms	$1\ 10^{-4}$
	All others	$1\ 10^{-4}$	W		
Zinc (Zn)	All forms	0.5	Y	All forms	0.5
Zirconium (Zr)	Carbides	$2\ 10^{-3}$	Y	All forms	$2\ 10^{-3}$
	Oxides, hydroxides, halides, & nitrates	$2\ 10^{-3}$	W		
	All others	$2\ 10^{-3}$	D		

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