

SECTION 2.0

TRITIUM

2.0 TRITIUM

This section provides information on the sources and biokinetics of tritium and summarizes the technical basis used for the internal dosimetry of tritium (^3H) at Hanford. This section is not intended to be an all-encompassing technical basis for any type of tritium exposure, but rather to provide the approach to be used for routinely encountered exposures at Hanford. For additional information, models, and approaches suitable for types of tritium exposures other than those addressed here, refer to the references listed in Section 10.0.

2.1 SOURCES OF TRITIUM

Tritium exists as part of the natural background of environmental radiation (National Council on Radiation Protection and Measurements [NCRP] 1979a). It can be assumed that the tritium concentration of the body water of non-occupationally exposed persons should be reasonably close to that of their drinking water. The Environmental Protection Agency (EPA) has reported that background tritium concentrations in U.S. drinking water range from 100 to 400 pCi/L (EPA 1985), which corresponds to about 0.2 to 1.0 dpm/mL. In addition, the EPA has promulgated a limit for tritium in drinking water of 20 nCi/L, based on 4 mrem/yr (EPA 1976), although an upward revision of this limit seems technically justifiable (Moghissi and Cothern 1986).

It is also worth noting that tritium has been widely distributed in the public domain as a source of luminosity for various "glow-in-the-dark" applications, such as the faces of watches, clocks, instruments, and exit signs. Breakage or other loss of containment in such devices could result in tritium levels in urine being substantially above background without occupational exposure.

Tritium at Hanford is encountered at levels of potential occupational dose concern primarily in research associated with tritium production, research associated with tritium production, the decontamination and decommissioning (D&D) of former tritium production facilities, laboratories associated

with such facilities, radioluminescent lights being developed by PNL, and as a tracer or labeling compound for biological research projects.

Tritium in the human body can be routinely detected at levels well below those of any dosimetric concern. Therefore, in addition to its use for dosimetry, tritium bioassay can be readily used as a workplace monitoring technique supplemental to air sampling or contamination surveys.

2.2 BIOKINETIC BEHAVIOR OF TRITIUM

This section describes the biokinetic models and assumptions used for the behavior of tritium, with the emphasis on tritium in the form of tritiated water.

2.2.1 Chemical Form

Unless otherwise specified, exposure to tritium is assumed to occur as exposure to tritiated water. Routine Hanford dosimetry is based on this form of tritium because it is the typical form encountered. Dosimetrically, tritiated water is also substantially more limiting than exposure to elemental tritium.

Organic compounds containing tritium can be substantially more limiting than tritiated water (by as much as a factor of 50). Dosimetry for exposure to elemental tritium or organic forms of tritium requires further knowledge of the nature of the material and the circumstances of exposure. Because elemental and organic forms are not in widespread use at Hanford, they are not addressed in this technical basis. If special circumstances warrant, this technical basis can be expanded.

2.2.2 Transportability

Tritium in the form of tritiated water or vapor is assumed to be instantaneously and uniformly mixed with body water immediately following intake. Although the NCRP suggests that 2 or more hours may be required for this distribution and mixing to occur (NCRP 1976), from a practical standpoint the process is quite rapid and an approximate equilibrium condition will probably

be reached by the time a sample can be collected. The collection of overnight urine samples provides reasonable assurance that an equilibrium condition in the body has been achieved.

2.2.3 Metabolic Model

The metabolic model used for tritium is described in ICRP 30 (1979). Tritiated water is assumed to be uniformly distributed among all soft tissues at any time following intake. Its retention (r_s^a) is described as a single exponential with an effective clearance half-time of 10 days. Thus, the fraction of tritium taken into the body as tritiated water, which is retained in the body at time t days later, is given by

$$r_s^a(t) = \exp(-0.693/10)t = \exp^{-0.0693t} \quad (2.1)$$

This retention function has been well established and is considered appropriate for exposures to tritiated water. It can be expected that the retention of tritiated water in individuals will vary from this, and if sufficient data are available to establish an alternate model for an individual worker's exposure, they should be used.

In addition to body water, ICRP 30 acknowledges the existence of two organically bound tritium components. However, the ICRP concludes that these could be ignored for radiation protection purposes, and Johnson (1982) estimates that these components would add approximately 10% to the committed dose equivalent. Unless worker data specifically indicate the existence of significantly longer-term components, the Hanford Internal Dosimetry Program will follow the ICRP recommendation of single compartment retention.

The fraction of the initial uptake eliminated on any given day after intake is derived by differentiating the retention function. Thus, the elimination function based on Equation (2.1) is given by

$$e(t) = 0.0693 \exp^{-0.0693t} \quad (2.2)$$

where $e(t)$ is the fraction of uptake excreted on day t and t is the elapsed time (days) post intake.

It must be recognized that Equation (2.2) describes the total tritium eliminated from the body. This elimination occurs via a number of pathways, notably urine, feces, insensible loss (exhalation), and sweat. The ICRP 23 (1974) Reference Man water balance, shown in Table 2.1, indicates that 47% or approximately half of the water loss of the body occurs via urine. In applying the excretion function to uptake estimation based on urine sampling, the fraction of an initial uptake excreted in urine on day (t) post intake is then calculated to be

$$e_u^a(t) = 0.47 e(t) = 0.033 \exp^{-0.0693t} \quad (2.3)$$

The uniform concentration of tritium in body water and its single component clearance rate allow for the estimation of uptake based on concentration rather than total daily excretion. Thus, the excretion functions, Equations (2.2) and (2.3), can be generally ignored, and the retention function, Equation (2.1), can be directly used to estimate the initial body water concentration as follows:

TABLE 2.1. ICRP 23 Reference Man Water Balance

<u>Source</u>	<u>Intakes</u>		<u>Pathway</u>	<u>Losses</u>	
	<u>mL/day</u>	<u>Fraction</u>		<u>mL/day</u>	<u>Fraction</u>
Milk	300	0.10	Urine	1400	0.47
Tap water	150	0.05	Feces	100	0.03
Other	500	0.50	Exhalation	850	0.28
Total fluid	1950	0.65	Sweat	650	0.22
Food	700	0.23			
Oxidation of food	<u>350</u>	<u>0.12</u>			
Total intake	3000	1.00	Total loss	3000	1.00

$$C(t) = C(0) \exp^{-0.0693t} \quad (2.4)$$

where $C(t)$ is body water concentration on day t , $C(0)$ is initial body water concentration, and t is elapsed time (days) post intake.

Once $C(0)$ has been determined, the uptake for an acute exposure can be estimated by multiplying $C(0)$ by the source organ (body water) mass as shown in Equation (2.5):

$$U(0) = C(0) * M(s) \quad (2.5)$$

where $U(0)$ is the uptake in units of activity, $C(0)$ is initial body water concentration, and $M(s)$ is the source organ (body water) mass.

For airborne exposures, ICRP 30 suggests that the uptake rate for tritiated water by inhalation and skin absorption pathways can be approximated by

$$U' = 1.8E+6 * C(\text{air}) \quad (2.6)$$

where U' is the uptake rate in $\mu\text{Ci/h}$, and $C(\text{air})$ is the air concentration in $\mu\text{Ci/cc}$.

2.3 TRITIUM INTERNAL DOSIMETRY FACTORS

The general approach to tritium dosimetry, including basic dose calculations for acute, chronic, and other exposures to tritium, is discussed in the following subsections.

2.3.1 General Approach

Determining the dose from tritium exposures involves calculating the dose to soft tissue from tritium that is assumed to be uniformly distributed throughout the body water. The body water concentration can be determined by the sampling of body fluids (typically urine), followed by direct measurement of tritium using liquid scintillation techniques. For acute exposure situations, the initial body water concentration can be estimated from the retention function, and a total tritium uptake can be calculated using the

Reference Man body water mass from ICRP 23 (1974). From this uptake, the soft tissue dose equivalent can be calculated for any pertinent time period. For chronic exposure situations, an equilibrium body burden of tritium can be estimated from body water concentration, and a dose equivalent can be calculated for any pertinent time period using a dose rate factor.

Historically, the approach to tritium dosimetry used in ICRP 2, ICRP 10, and American National Standards Institute (ANSI) N13.14-1983 was to calculate the dose to body water as the critical organ (ICRP 1959, 1969; ANSI 1983). A body water mass of 42,000 g was assumed for ICRP 23 Reference Man (1974). It was assumed that the dose to body water was essentially the same as the dose to soft tissue. This approach was quite conservative.

In ICRP 30, a more realistic approach to tritium dosimetry is recommended. The body water mass of ICRP 23 Reference Man (42,000 g) is recognized to be essentially uniformly distributed throughout the body mass of soft tissue (63,000 g). Consequently, tritium is considered to be uniformly distributed throughout soft tissue, and it is the soft tissue mass that is irradiated rather than merely the body water. The net effect is to distribute the decay energy over a larger mass of tissue, resulting in a lowered total dose. Although less conservative, this approach is more accurate from a biological and technical point of view and thus provides a better technical basis for the Hanford Internal Dosimetry Program. Internal dosimetry calculations for tritium at Hanford will henceforth use the ICRP 23/30 soft tissue mass of 63,000 g as the target organ mass.

As previously noted, there is evidence for an organically bound component of a tritium oxide intake that might add as much as 10% to the total dose. This factor has been incorporated into Canadian recommendations for dosimetry (EHD 1983; Myers and Johnson 1991) but, due to the relatively low level of doses associated with tritium at Hanford, is not being adopted, pending further national review. If individual worker monitoring data at Hanford show evidence of this organically bound component, it will be factored into the calculations.

Other factors used for tritium dosimetry are shown in Table 2.2.

TABLE 2.2. Tritium Dosimetry Factors

Radiological half-life	12.35 yr
Biological half-life	10 days
Effective half-life	10 days
Effective energy per transformation	5.7 keV (0.0057 MeV)
SEE factor ^(a)	9.0E-08 MeV/g-transformation
Quality factor	1.0
Weighting factor	1.0
Source organ	Body water
Source organ mass	42,000 g
Target organ	Soft tissue
Target organ mass	63,000 g
Intake dose equivalent factor	0.063 mrem/ μ Ci
Dose equivalent per unit concentration factor	0.0664
	2.8 mrem per μ Ci/L
Dose rate per unit concentration factor	0.19 mrem/day per μ Ci/L

(a) SEE = specific effective energy.

2.3.2 Dose Calculation for an Acute Exposure

The dose calculation for acute uptakes of tritium is as follows:

$$H_{H,T} = 51.15 U(0) \text{ SEE } (1 - \exp^{-0.0693t}) / 0.0693 \quad (2.7)$$

where $H_{T,t}$ = the soft tissue dose equivalent in rem

$U(0)$ = the initial uptake in microcuries

SEE = the ICRP 30 specific effective energy per transformation (9.0E-8 MeV/dis-g)

t = the time interval (in days) following uptake over which the dose is calculated.

Because the weighting factor used for total body soft tissue is 1, the soft tissue dose equivalent is equal to the effective dose equivalent, or

$$H_E = H_T(2.8)$$

The 10-day effective half-life of tritium results in the total 50-year committed dose being delivered within about 100 days. Thus, there is no significant difference between the first-year dose and the 50-year committed dose. The 50-year committed dose equivalent from an acute tritium intake can be calculated by solving Equation (2.7) for a period of 18,250 days, giving the following:

$$H_{E,50}^C = \overset{0.0664}{\cancel{0.064}} U(0) \quad (2.9)$$

where $H_{E,50}^C$ is in mrem and $U(0)$ is in microcuries or, alternatively,

$$H_{E,50}^C = 2.8 * C(0) \quad (2.10)$$

where $C(0)$ is in $\mu\text{Ci/L}$.

Because the dose from tritium is delivered in a relatively short time with regard to a calendar year, it may be a reasonable practice for record-keeping purposes to credit the total committed dose from an acute tritium exposure to the year of intake.

2.3.3 Dose Calculation for a Chronic Exposure

For chronic exposure, or a series of continuing acute exposures, an equilibrium concentration in body water is assumed. The dose equivalent rate during the period when the concentration is maintained can be calculated by

$$H' = 51.15 Q(e) \text{ SEE} \quad (2.11)$$

where H' is the dose equivalent rate in rem/day, $Q(e)$ is the equilibrium activity in soft tissue (microcuries), and SEE is the specific effective energy.

Because $Q(e)$ can be calculated as the product of the body water equilibrium concentration, $C(e)$, multiplied by the body water mass, $M(s)$, Equation (2.11) can be transformed to

$$H' = 51.15 C(e) M(s) \text{ SEE} \quad (2.12)$$

Substituting constants for body water mass (42,000 g) and unit conversion factors gives the following relationships for dose equivalent rate to body water concentration:

$$H' = 0.19 * C(e) \quad (2.13)$$

where H' is in mrem/day and $C(e)$ is in $\mu\text{Ci/L}$; and,

$$H' = 8.7E-5 C(e) \quad (2.14)$$

where H' is in mrem/day and $C(e)$ is in dpm/mL (the units in which bioassay results are typically reported by the Hanford bioassay laboratory).

The dose equivalent for the time period during which the equilibrium body water concentration is maintained can then be calculated by

$$H_T = H' * t \quad (2.15)$$

where t is duration of exposure in days.

The total committed dose resulting from a chronic exposure interval consists of the dose incurred during the interval (as calculated by Equation [2.15]) and the dose incurred following the termination of intake. This latter component can be calculated using the equation for an acute exposure (Equation [2.10]) where $C(0)$ is equal to $C(e)$ as follows:

$$H(\text{total}) = (H' * t) + [2.8 C(0)] \quad (2.16)$$

2.3.4 Dosimetry Based on Multiple Sample Results

When data from routine monitoring indicate that multiple acute intakes or combinations of acute and chronic exposure conditions may exist, dosimetry may be performed by integrating the body water concentration over time and multiplying by the dose rate per unit concentration factor listed in Table 2.2 (as shown in Equation [2.17]). This method is particularly useful if samples are obtained frequently enough to provide an accurate estimate of the integral value.

$$H_E^C = 0.19 \int C(t) dt \quad (2.17)$$

where H_E^C is in mrem and $C(t)$ is in $\mu\text{Ci/L}$.

2.3.5 Dosimetry for Other Exposure Conditions

Dosimetry calculations for other exposure conditions, forms of material, or monitoring techniques will be addressed as specific needs arise. The previously cited references, Brodsky (1983), and the Canadian Environmental Health Directorate's Guidelines for Tritium Bioassay (1983) provide useful models and techniques that can supplement or be adapted to the Hanford dosimetry techniques discussed previously. The NCRP has also addressed the issue of dosimetry for tritium-labeled organic compounds incorporated into genetic material in NCRP 63 (NCRP 1979b).

2.4 BIOASSAY MONITORING

The general approaches to routine monitoring, capabilities of bioassay monitoring, and optimum bioassay sampling intervals are discussed in the following subsections.

2.4.1 General Approach to Bioassay Monitoring

Bioassay monitoring for tritiated water is relatively simple and involves sampling body fluid. Any body fluid can be used, but from a practical standpoint urine is the medium of choice. Because dosimetry can be readily performed using concentration data and because the models are quite

simple, a single voiding (spot) urine sample is sufficient to obtain an adequate volume for analysis. Only a few milliliters are actually used in the liquid scintillation analysis procedure. Sufficient time should pass following exposure to allow for uniform distribution throughout body fluids. The NCRP suggests that 2 or more hours may be required for this (NCRP 1976). For this reason, it is usually recommended that tritium samples be collected at home using a multiple voiding sampling protocol to obtain an average concentration.

The Hanford bioassay analysis laboratory's liquid scintillation procedure involves direct mixing of a small quantity (1 mL) of the urine sample with the scintillation cocktail solution. The sample is then counted in a liquid scintillation analyzer. The sensitivities of the available urine procedures are shown in Table 2.3. It should be noted that the sensitivities of all of the analytical procedures are set at levels above the natural background in urine. More sensitive procedures could be established, if needed.

2.4.2 Capability of Routine Bioassay Monitoring for Acute Exposures

The detection capability of a routine tritium bioassay monitoring program for acute exposures has been considered in terms of potentially undetected committed effective dose equivalent per intake and year, using an analytical procedure sensitivity of 10 dpm/mL. In making these calculations, it was assumed that an acute intake occurred on the day immediately following a sample; thus, the time post intake was considered equal to the length of the sample interval. It was also assumed that the pattern of one intake at the

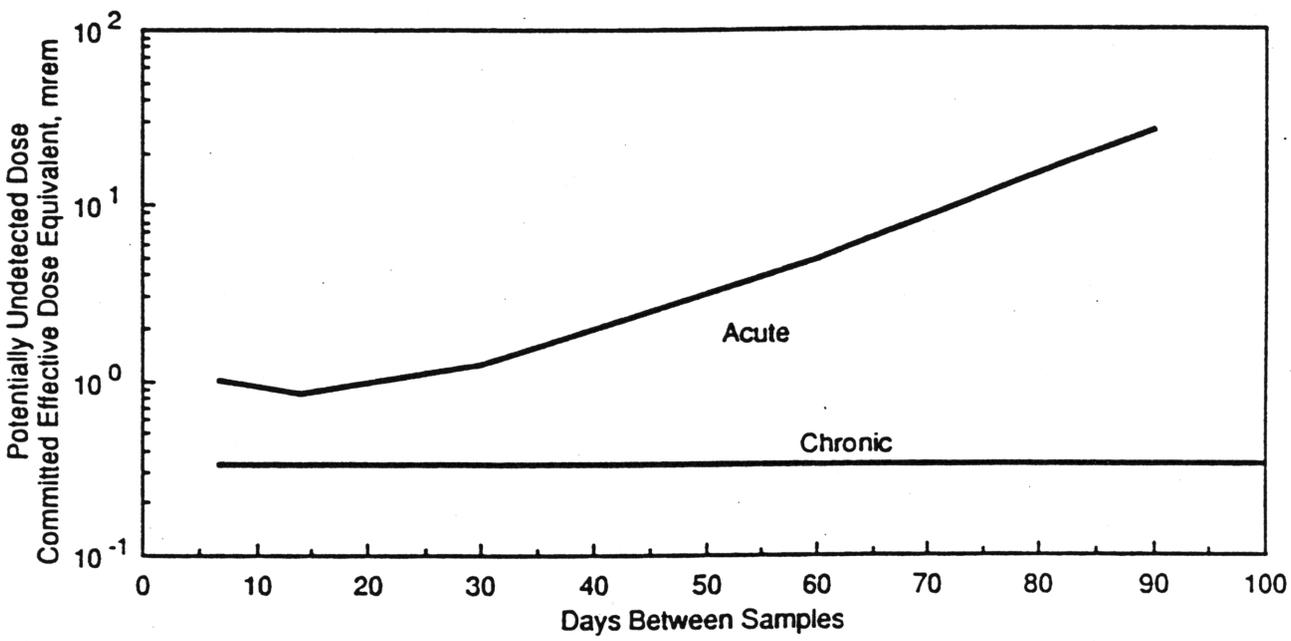
TABLE 2.3. Analytical Sensitivities for Tritium in Urine

<u>Procedure</u>	<u>Detection Level, dpm/mL</u>	<u>Nominal Time for Result (from receipt at lab)</u>
Routine	10	5 working days
Priority	10	3 working days
Expedite	100	1 working day
Rapid	500	1 hour

start of each interval might be maintained for a year. The results of these calculations are listed in Table 2.4 and plotted as the acute intake curve in Figure 2.1.

TABLE 2.4. Detection Capability of Tritium Bioassay Monitoring with a Sensitivity of 10 dpm/mL

Sample Frequency	Days Between Samples	Intakes per Year	Potentially Undetected Dose, mrem	
			per Intake	per Year
Annual	365	1	1.2E+9	1.2E+9
Semiannual	180	2	3300	6600
Quarterly	90	4	6.4	26
Bimonthly	60	6	0.81	4.8
Monthly	30	12	0.10	1.2
Biweekly	14	25	0.033	0.83
Weekly	7	50	0.021	1.0



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FIGURE 2.1. Tritium Bioassay Monitoring Program Detection Capability for Analytical Sensitivity of 10 dpm/mL

From Figure 2.1, it is apparent that a biweekly sampling frequency is optimum for periodic acute intakes of tritium. If the potential exposure to tritium is anticipated only for a very limited interval, starting and ending bioassay samples might be more suitable than participation in a continuing monitoring program.

2.4.3 Capability of Routine Bioassay Monitoring for Chronic Exposures

If the exposure condition is chronic and an equilibrium body water concentration of 10 dpm/mL is assumed (equal to the sensitivity of the analytical procedure and implying a daily intake rate of 14 nCi), then the result- ing committed effective dose equivalent from 365 days of intake would be 0.3 mrem. This estimate is essentially the same as the first-year effective dose equivalent. Because of the assumption of chronic equilibrium condi- tions, this estimate is independent of sample frequency, and is thus shown as a flat line in Figure 2.1.

2.4.4 Optimum Bioassay Sampling Intervals

The optimum routine bioassay sampling frequency for tritium is once every 2 weeks, based on acute exposure conditions. Where exposure conditions are well-established and anticipated exposures are relatively small, longer sampling intervals (e.g., monthly) may be suitable. However, the uncertain- ties with dose estimates associated with longer sampling intervals become much higher. Because of the 10-day effective half-life, sampling intervals greater than 90 days are specifically not recommended.

Based on Table 2.4, a worker monitoring program using screening levels of 110 dpm/mL for biweekly samples or 80 dpm/mL for monthly samples is capable of detecting a 10-mrem annual dose based on a series of acute or chronic intakes. At these screening levels, sampling schedules should be reviewed to assure that workers are on an adequate routine monitoring program consistent with their work. If indications are that annual doses may exceed 100 mrem from ongoing work, then a biweekly sampling program is recommended.

2.4.5 Special Monitoring

Special monitoring may be required after unplanned or unusual exposures. When an unusual exposure has been suspected or reported, arrangements should

be made to collect a urine specimen within a reasonably short period of time following the exposure. For potentially high exposures, this sample might be a single voiding sample collected at the workplace. For less serious exposures, an overnight (simulated 12-hour) or simulated 24-hour sample provides confidence that body equilibrium has been achieved and may be more convenient.

Follow-up sampling should be performed to confirm the initial sample results. Additional follow-up samples may be warranted to verify the applicability of the 10-day retention half-time in the individual, or to assess a more suitable half-time. To adequately determine the degree of agreement between observed and anticipated retention may require only two or three samples over a period of about 3 weeks, or it may involve a more extended sampling program. The evaluator must exercise judgment in determining the number of samples warranted. If the exposed worker is already on a routine (e.g., biweekly) monitoring frequency, additional special sampling for follow-up may not be required.

Once an exposure has been evaluated, elevated urine samples might be expected for some time (several months). If the worker returns to work that involves potential tritium exposure, a more frequent sampling program may be required until normal baselines are re-established. During this time period, consideration may need to be given to the possibility that additional low-level uptakes of tritium might occur, which could be undetectable due to tritium retained from the earlier intake.

2.5 ASSESSMENT OF INTERNAL DOSE

This section provides summary procedures for the assessment of occupational internal dose. As such, it applies the concepts described in Section 2.3 to the Hanford Internal Dosimetry Program.

2.5.1 Simplified Dose Assessments

Simplified dose assessments use the standard models and parameters discussed in the previous sections to provide an estimate of committed effective dose equivalent. Simplified dose assessments may be most suitable when dealing with limited data (e.g., single urine sample results) or when the dose

estimates are low with regard to radiation protection standards or limits (e.g., 100 mrem or less). The simplified dose assessment procedures that follow are based on the discussion contained in Section 2.3, and are adjusted to reflect the units in which Hanford bioassay results are typically reported.

Acute Exposure Simplified Dose Assessment

To calculate the committed effective dose equivalent from an acute intake of tritium based on a single urine sample result, proceed as follows:

1. Calculate the sample concentration, $C(t)$, in dpm/mL

$$C(t) = \frac{\text{Reported Result, dpm}}{\text{Sample Volume, mL}} \quad (2.18)$$

2. Estimate the initial body water concentration, $C(0)$, in dpm/mL

$$C(0) = \frac{C(t)}{\exp(-0.0693 * t)} \quad (t = \text{days post intake}) \quad (2.19)$$

3. Calculate the committed effective dose equivalent, H_E^C , in mrem

$$H_E^C = 1.3E-3 * C(0) \quad (2.20)$$

Because the committed effective dose equivalent is delivered within a relatively short time following the intake, the first-year and committed dose equivalents are considered equal.

Chronic Exposure Simplified Dose Assessment

To calculate the dose equivalent resulting from a chronic exposure to tritium (assuming the equilibrium condition), proceed as follows:

1. Calculate the body water equilibrium concentration, $C(e)$, in dpm/mL:

$$C(e) = \frac{\text{Reported Result, in dpm}}{\text{Sample Volume, in mL}} \quad (2.21)$$

2. Calculate the committed effective dose equivalent, H_E^C , in mrem, for the interval of exposure (t , in days):

$$H_E^C = [(8.7E-5 * t) + 1.3E-3] * C(e) \quad (2.22)$$

Dose Assessment for Periodic Routine Samples

In situations where periodic routine samples are obtained, not associated with specifically identified intakes but rather with ongoing work practices, an average concentration and dose associated with a sampling interval can be calculated. The choice of an arithmetic mean versus a logarithmic mean has little impact on the dose estimates for intervals of 1 month or less. The dose for the interval can be calculated using Equations (2.14) and (2.15) (see Section 2.3.3) and the total annual dose calculated by summing the interval doses for the year.

Individual-Specific Dose Assessments

Individual-specific dose assessments are made when there are significant deviations from the metabolic or dosimetric parameters described above. The assumptions or methods used for these assessments are documented as part of the evaluation.

2.6 MITIGATION OF DOSE FROM TRITIUM

The primary treatment for reducing internal dose from a tritium uptake is to accelerate the turnover of body water. This can be done by substantially increasing the fluid intake rate of an individual through oral or intravenous means, and/or using diuretics (NCRP 1980; IAEA 1978). Dose-mitigating actions should be recommended by the Occupational Medicine Department of the Hanford Environmental Health Foundation (HEHF) with the consultation of Internal Dosimetry.

2.7 TRITIUM MONITORING PROGRAM FOR THE 400 AREA (FFTF)

The 400 Area of Hanford Site, which includes the Fast Flux Test Facility (FFTF), obtains its drinking water from groundwater wells. These wells contain low-levels of tritium (below the EPA drinking water standards) originating from aquifer contamination by the past operation of 200 Area fuel processing and waste management facilities (Jaquish and Bryce 1989). Planned operations supporting fusion materials research were expected to produce large quantities of tritium, resulting in the need for a routine tritium bioassay

program. In FFTF workers, the existence of potentially detectable tritium, which could be attributable to environmental sources rather than occupational exposure, warranted establishing a screening level to use as a basis for initiating investigations and dose assessments of potential occupational exposure.

A baseline bioassay monitoring program was undertaken for FFTF workers prior to the commencement of the tritium operations (Carbaugh, Sula, and McFadden 1990). Forty-seven urine samples were collected from FFTF operations personnel over a five-month period in early 1989. The sample data are plotted in Figure 2.2. Based on the curve fit, it was estimated that the geometric mean was 3 dpm/mL and the tritium concentration corresponding to the 99.9 percentile for environmental exposure at FFTF was 40 dpm/mL. This concentration is similar to the present 20,000 pCi/L (44 dpm/mL) EPA Drinking Water Standard for tritium (EPA 1976).

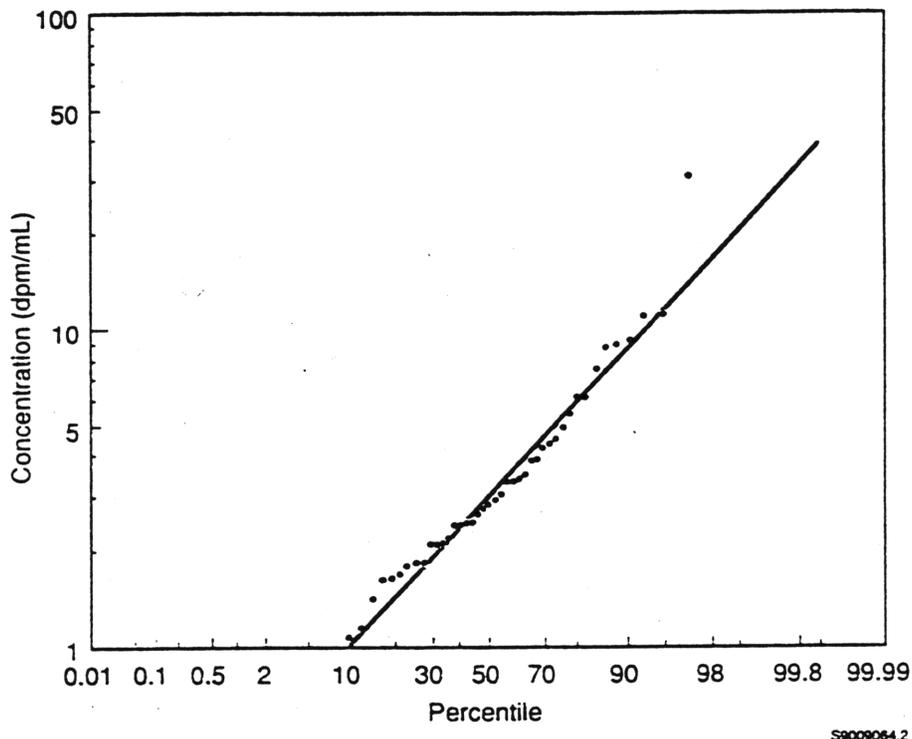


FIGURE 2.2. Tritium Concentration in Urine of Occupationally Unexposed FFTF Workers

The potentially undetected annual (or 50-year committed) effective dose equivalent associated with a 40-dpm/mL tritium screening level was estimated to be 1.2 mrem for chronic equilibrium exposure conditions, 5 mrem for acute intakes with weekly to monthly sample intervals (the anticipated range of sampling intervals), and 100 mrem for quarterly intervals.

Because of the low dose potentially associated with chronic exposure or anticipated sampling intervals, use of the 99.9 percentile is justifiable on a cost-benefit basis. Thus, 40 dpm/mL was selected as a baseline level for tritium in 400 Area workers. Results below 40 dpm/mL are considered normal for persons working in the 400 Area. Results in excess of 40 dpm/mL indicate potential occupational exposure and worker data and sampling schedules should be reviewed in light of the criteria in Section 2.4.4.