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10CFR 32.23 SAFETY CRITERIA

1. General Discussion
Tritium H-3 does not present an external radiation hazard because it emits no x-rays or gamma rays and the beta particle emitted has very low energy. The major hazard is from internal uptake. Inhalation and percutaneous absorption (absorption through the skin) are by far the most significant intake mechanisms for the user of RL devices (vials). The intake rate of absorption through the skin and the intake rate of inhalation is included in the following basic equation.

2. Basic Equation
The basic equation, to calculate dose in rem, is shown below. (Reference: Tritium Radiolminescent Devices Health and Safety Manual, Pacific Northwest Laboratory, Richland, WA) (Battelle Report). Using generally accepted principals of calculating dose effectiveness based on tritiated water vapor, we shall use a default factor of 1% with the equation below.

$$H = (Q) \, 2 \, (C) \, (T) \text{ rem}$$

Where: H= the committed dose equivalent (rem)
Q= the quality factor (no dimension)
C= the activity conc. of H-3 in air (uCi/ml)
T= the exposure time in minutes

We shall use a quality factor (Q) of 1 and simplify the equation to the following:

$$H = .02 \, (C) \, (T) \text{ rem}$$

This equation shall be used in the following examples.

3. **Examples**

    A. Normal use of a Single Exempt Unit (10CFR32.23 (a))

For this example, a single unit is defined as one knife containing 4 tritium filled vials, 60mCi maximum activity. The worker assembles an estimated annual quantity of 2,000 knives. Assume an average assembly of 30 knives per hour at an individual workstation; a worker would spend approximately 67 hours (4,000 minutes) assembling knives per year. The maximum diffusion rate for each knife is 6E-2 uCi/hr. The volume of each workstation is approximately 100 cu. ft. and is equipped with exhaust ventilation such that the estimated air volume dilution per workstation is estimated at 1,300 cu. ft./hour.

Estimated H-3
Activity Conc
In Workstation

$$\text{Activity Conc In Workstation} = \frac{(30 \text{ knives}) (6E\text{-}2 \text{ uCi/hr/knife})}{(1,300 \text{ cu ft/hr})} \quad X \quad \frac{1 \text{ cu. ft.}}{2.83E4 \text{ ml}} = 4.9E\text{-}8 \text{ uCi/ml}$$

(Where [2.83E4 ml] is the ml/cu. ft.)

Estimated Dose
To Worker/Year   H = .02 C T
From Assembling   H = .02 (4.9E-8 uCi/ml) (4E3 mins/yr)
Knives   H = 3.9E-6

This value is below the .001 rem limit of 10CFR 32.24, Column I

B. Normal Handling/Storage of Quantities of Exempt Units Likely to Accumulate in
One Location (10CFR 32.23 (b))

For the purposes of this example, we will assume that the maximum number of knives in
storage is 2,000 (estimated annual production). Therefore a total of 8,000 H-3 vials, or
120Ci total activity. The worker occupies the knife storage area for a maximum of two
hours/day, 250 days/year, 30,000 minutes/year. The maximum H-3 diffusion rate in the
storage area is 120 uCi/hour (2,000 x .06 uCi/hr.). The volume of the storage room is
approximately 9,200 cu. ft. and is exhausted by an area exhaust fan such that the dilution air
in the storage room is estimated at 24,000 cu. ft./hour.

Estimated H-3
Activity Conc   = $\dfrac{120 \text{ uCi/hour}}{24{,}000 \text{ cu. ft./hour}}$ x $\dfrac{1 \text{ cu. ft.}}{2.83\text{E}4 \text{ ml}}$ =   1.77E-7 uCi/ml
In Storage Room

(Where [2.83E4 ml] is the ml/cu. ft.)

Estimated Dose
To Worker/Year $H = .02 \, C \, T$
From Working In $H = (.02)(1.77\text{E-}7 \text{ uCi/ml})(3.0\text{E}4 \text{ mins/yr})$
The Storage Room $H = 1.06\text{E-}4 \text{ rem}$

This value is below the .01 rem limit of 10CFR 32.24, Column II.

C. Use/Disposal of a Single Exempt Unit(s) Likely to Accumulate in One Location
(10CFR 32.23 (d))

For the purposes of this example, we will assume that 500 knives in storage are severely
damaged such that all of the largest vials, 25mCi each, are broken and the H-3 is released
into the storage room. We will assume that the area exhaust ventilation is not working. A
reasonable assumption is that the H-3 will be contained within a volume of 200 cu. ft. and the
worker is able to vacate the area within one minute.

Estimated H-3
Activity Conc   = $\underline{25{,}000 \text{ mCi}}$ x $\underline{1 \text{ cu. Ft.}}$ = 4.4 uCi/ml
In Storage Room   200 cu. Ft.   2.83E4 ml

(Where [2.83E4 ml] is the ml/cu. ft.)

Estimated Dose   H = .02 C T
To Worker From   H = (.02) (4.4 uCi/ml) (1 min)
This Event   H = .09 rem

This value is below the 0.5 rem limit of 10CFR 32.24, Column III.

D. Handling/Storage of Quantities of Exempt Units Likely to Accumulate in One
    Location During Marketing/Distribution (10CFR 32.23 (d))

For the purpose of this example, we will assume a transportation accident occurs to a
shipment of 500 knives. We will also assume that the accident severely damages 50% of the
vials, releasing 15E3 mCi. A reasonable assumption is that the H-3 will be concentrated
within a volume of 200 cu. ft. and the worker is able to vacate the area within one minute.

Estimated H-3
Activity Conc   =   15E3 mCi   x   1 cu. Ft.   =   2.65 uCi/ml
In Affected Area   200 cu. Ft.   2.83E4 ml

(Where [2.83E4 ml] is the ml/cu. ft.)

Estimated Dose   H = .02 C T
To Worker From   H = (.02) (2.65 uCi/ml) (1 min)
This Event   H = .05 rem

This value is below the 0.5 rem limit of 10CFR 32.24, Column III.