**Three Questions from NRC.**

5. In accordance with 10 CFR 32.23(a), you must demonstrate that, in normal handling/storage of either a single device or of multiple devices, it is unlikely that the external radiation dose in any 1 year, or the dose commitment resulting from the intake of radioactive material in any 1 year, will exceed, for a given individual, the doses specified in either Column I or Column II, respectively, of the table in 10 CFR 32.24. In Attachment J, "Dose Calculations," you indicate in the "Conclusion" section on Page 2 that "….[i]nternal dose, at a leak rate of 10 ppb/h, should be negligible and certainly less than [these limits]." Please explain how you arrived at this conclusion.

**From Part 32.24:**

| Part of body | Column 1 (rem) | Column II (rem) | Column III (rem) | Column IV (rem) |
|---|---|---|---|---|
| Whole body; head and trunk; active blood-forming organs; gonads; or lens of eye | 0.001 | 0.01 | 0.5 | 15 |
| Hands and forearms; feet and ankles; localized areas of skin averaged over areas no larger than 1 square centimeter | 0.015 | 0.15 | 7.5 | 200 |
| Other organs | 0.003 | 0.03 | 1.5 | 50 |

**From the report:**

**Conclusion**

External radiation dose to all exposed individuals and groups is zero. Internal doses, at a leak rate of 10 ppb/h, should be negligible and certainly less than 1 mrem per year for an individual and less than 10 mrem per year to handlers and distributors of these devices. This fulfills the requirements of 10CFR 32.23 and 10 CFR 32.24.

**Response:**

An examination of the appropriate portions of NUREG 1717, Tables 2.14.3 and 2.14.4 (pp. 2-213 and 2-214) were considered. Since these dose projections are based on a 50mCi $^{3}H$ activity, and the Hi-Viz gun sights contain 150 mCi each, the table values were multiplied by 3. All applicable table values were still less than 1 mrem. This shows that (using NRC estimates) potential individual doses "In normal use and disposal of a single exempt unit or the dose commitment resulting from the intake of radioactive material in any one year" and "In normal handling and storage of the quantities of exempt units likely to accumulate in one location during marketing, distribution, installation, and servicing of the product" are less than the dose limits in 10 CFR 32.23 and 10 CFR 32.24.

6. In accordance with 10 CFR 32.23(c), you must demonstrate that in the use and disposal of a single device, or in the handling and storage of typical quantities of multiple devices, the probability is low that the containment, shielding, or other safety features of the product would fail under such circumstances that a person would receive an external radiation dose or dose commitment in excess of the doses specified in Column III of the table in 10 CFR 32.24, and the probability is negligible that a person would receive an external radiation dose or dose commitment in excess of the doses specified in Column IV of that table.

a. In Attachment J, "Dose Calculations," Selection D, "Accident Scenarios Considered," for Scenarios 1 and 2, you assume that 5 percent and 1 percent of devices, respectively, are destroyed in the conceived fire conditions. Please explain why these particular percentages were selected and why the probability of these scenarios is considered to be "low." Furthermore, please explain why the probability of Scenarios 4 and 5 are considered to be "low," and why the probabilities of Scenarios 3 and 6 are considered to be "negligible."

**From the report:**

"For purposes of these calculations, six scenarios are considered.

1. Dose to a warehouse worker and to a firefighter extinguishing a fire in a manufacturer's warehouse containing 1,000 devices (1.5E+5 mCi). This scenario assumes that 5% (50) of the sights are destroyed in the fire, releasing 7.5E+3 mCi or **7.5E+6 µCi = A**;
2. Dose to firefighters extinguishing a tractor trailer fire containing 5,000 devices. This scenario assumes that 1% (50) of these sets are destroyed in the fire, releasing 7.5E+3 mCi or **7.5E+6 µCi = A**;
3. Dose to a worker (resident) during a fire, and to a firefighter extinguishing a fire in an end use facility, assumed to be an armory equivalent in size to a private residence and containing 1,000 gun sights (1.5 E+8 µCi). Two thirds (670) of the gun sights are assumed to be destroyed in the fire releasing 1E+5 mCi or **1E+8 µCi = A**. {Probability negligible.}
4. A catastrophic release from crushing of a sight in a repair shop, releasing **1.5E+5 µCi = A**. (Room volume = 18 $m^3$; 1 air change/h) {Probability low.}
5. An accident involving the crushing of a rifle scope in a home releasing **1.5E+5 µCi = A**. (Room volume = 450 $m^3$; 1 air change/h) {Probability low.}
6. A shipping accident in a storeroom or cargo-handling area involving the crushing of a shipment of 1000 gun sights, releasing **1.5E+8 µCi = A**. (Room volume = 300 $m^3$; 4 air changes/h). {Probability negligible.}

Please explain why these particular percentages (5 percent and 1 percent of devices for Scenarios 1 and 2, respectively) were selected and why the probability of these scenarios is considered to be 'low.'"

## Response:

These devices consist of gaseous $^{3}H$ (tritium) sealed into a protective base (Fig. 1) that is constructed of borosilicate glass. Borosilicate glass is high-temperature resistant and is used for laboratory glassware (e.g., beakers and flasks) which is subjected to quite high temperatures. Borosilicate glass (sold under such trade names as Pyrex, Endural and Schott) is highly temperature resistant. The softening point of Pyrex is 820 °C (1,510 °F). It is also used in implantable medical devices and devices used in space applications, where ruggedness and a very high degree of reliability are essential. Additionally, the glass cylinder containing the tritium source is well protected within a metal mounting bracket (Fig. 1, 2 and 3).

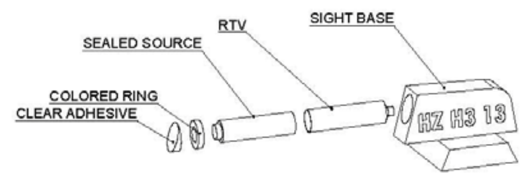


Figure 1. Exploded view of the tritium source, protective borosilicate sleeve and metal protective base in a front sight. Rear sight is similar.

Borosilicate glass is known for having very low coefficients of thermal expansion, making it resistant to thermal shock, which reduces material stresses caused by temperature gradients. All of these attributes make borosilicate an excellent material for use in tritium gun sights.


Figure 2. A Hi-Viz $^{3}H$ front sight.

During an internet search I was unable to find ***any*** mention of incidents or accidents involving tritium gun sights in manufacturing, in warehouse storage or in transport[1]. While history provides no protection against future events, no significant incidents since these devices were first introduced in the mid-1980s must count for something.


Figure 3. A Hi-Viz rear sight.

Notwithstanding speculative scenarios in NUREG 1717 and possibly other documents, involving hundreds or a thousand of these sights, the fact of the matter is that we know of no such incidents occurring. Also, given the excellent design and robust construction of these sights, I believe that my breakage/destruction estimates in Scenarios 1 and 2 are realistic but conservative based on existing evidence.

Additionally, my judgment of low and negligible likelihood is also supported by the evidence we have, which indicates that the likelihood of destruction or breakage of large quantities of these devices in a single incident is extremely small.

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[1] A letter dated August 3, 2001 (Sturz to Mattia, pbadupws.nrc.gov/docs/ML0122/ML012210061.pdf - 77k - 2012-11-18) stated that "We searched our Nuclear Materials Events Database (NMED) and other historical files and are able to provide you with the following…" but no incidents involving gun sights were reported. Nothing else was found.

b. In Attachment J, "Dose Calculations," Section E, "Internal Dose Potential," Subsection 2, "Inhalation Intake and Dose" (Page 6), you have calculated the individual intake for the scenarios considered using Equation 4 from Appendix A of NUREG-1717 (Page A.1-2). However, instead of considering the average concentration during the period of individual exposure, you have used the values for instantaneous air concentration at the time t=1 h in your calculations. Please provide corrected calculations, incorporating the time-averaged value for air concentration over the period of time in which each considered individual is exposed.

**Response:**

In Equation 4 under the definition of terms, the definition of C was erroneously labeled "Instantaneous air concentration" when it should have been Average air concentration. The values used for the calculations were the average values. The intake calculations were re-done and resulted in a few very minor corrections having to do with rounding. The three tables involved, along with the associated example calculations have been corrected and are included below. The changed data have been highlighted.

*2. Inhalation Intake and Dose*

During a fire, an individual's intake from inhalation of airborne radioactive material (µCi) is given by

$I_{Inh.} = C \times BR \times t,$ **(4)**

Where: C = Average air concentration (µCi/m$^3$)

t = time of exposure (h),

BR = breathing rate (m$^3$/h) = 1.2 m$^3$/h[9]

C = average concentration of airborne radioactive material (µCi/m$^3$) over time, t.

| Scenario | Type of Enclosure | Avg. Concentration (C) (µCi/m$^3$) | (BR) (m$^3$/h) | Intake (µCi) t = 0.083 h (5 min) Worker (Resident) | Intake (µCi) t = 2 h Firefighter | Intake (µCi) t = 0.5 h Firefighter[10] | Intake (µCi) t = 1 h Firefighter[10] |
|---|---|---|---|---|---|---|---|
| **1** | Warehouse | 1.6E+3 | 1.2 | 160 | 3840 (1280) | -- | -- |
| **2** | Tractor trailer | 5.4E+4 | 1.2 | 5.4E+3 | -- | 32,400 (10,800) | -- |
| **3** | Residence | 1.4E+5 | 1.2 | 1.4E+4 | -- | -- | 168,000 (56,000) |

[9] NUREG-1717, section A.1.5, last paragraph.

[10] Fire fighters are presumed to be wearing self-contained breathing apparatus (SCBA) that provides an assigned protection factor (APF) of 3 against tritium. Refer to 10 CFR 20 Appendix A footnote f.

| Scenario | Type of Enclosure | Avg. Concentration (C) ($\mu$Ci/m$^3$) | Breathing Rate (BR) (m$^3$/h) | t = 0.083 hour (5 min) Worker (Resident) | Intake ($\mu$Ci) $I_{Inh.}$ |
|---|---|---|---|---|---|
| 4 | Repair shop | 5.3E+3 | 1.2 | 0.083 | 530 |
| 5 | Home | 2.1E+2 | 1.2 | 0.083 | 21 |
| 6 | Cargo area | 3.2E+5 | 1.2 | 0.083 | 32,000 |

***Table 2. Calculated intakes due to fires for the various enclosure types, for workers as well as firefighters. Firefighter intakes account for SCBA use (APF = 3)[10].***

Internal dose is calculated by comparing the calculated intake to the stochastic ALI for tritium in Appendix B to 10 CFR 20. This ALI is 8E+4 µCi. Using proportionalities, e.g.,

$$\frac{5000 \text{ mrem}}{8\text{E} + 4\ \mu\text{Ci}} = \frac{x \text{ mrem}}{160\ \mu\text{Ci}}$$

$$x = \frac{(160\ \mu\text{Ci})(5000 \text{ mrem})}{8\text{E} + 4\ \mu\text{Ci}} = \mathbf{10\ mrem}$$

| Scenario | Type of Enclosure | Intake (µCi) t = 0.083 hour Worker (Resident) | Worker (Resident) Dose (mrem) | Intake (µCi) t = {hour} Firefighter | Firefighter Dose (mrem) |
|---|---|---|---|---|---|
| 1 | Warehouse | 160 | **10** | {2} 1,280 | 80 |
| 2 | Tractor trailer | 5.4E+3 | **338** | {0.5} 10,800 | 675 |
| 3 | Residence | 1.4E+4 | **875** | {1} 56,000 | 3,500 |
| 4 | Repair shop | 530 | **33** | -- | -- |
| 5 | Home | 21 | **1.3** | -- | -- |
| 6 | Cargo area | 3.2E+4 | **2000** | -- | -- |

*Table 3. Calculated internal doses to workers (residents) and firefighters using SCBA due to inhalation.*

Respectfully submitted,

March 26, 2014

K. Paul Steinmeyer, RRPT