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Derived Intervention and Response Levels for Tritium Oxide at the Savannah River Site

Tim Jannik

Principal Technical Advisor

Environmental Radiological Assistance Directory Working Group

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Outline

- Introduction
- FDA Derived Intervention Levels (DILs) Methodology
- SRS Developed DIL Methodology for Tritium Oxide (HTO)
- SRS Derived Response Level (DRL) Methodology for HTO
- Conclusions and DOE-EH Guidance from 2006
- Acknowledgement – Patricia Lee and Ali Simpkins did most of the work on this, I am the only left to take the credit!

Introduction

- **SRNL (Lee 2013) recently updated the SRS Derived Intervention Levels (DILs) and Derived Response Levels (DRLs) used for emergency response**
  – Dose Coefficients (DCs) from DOE Technical Standard DOE-STD-1196-2011
  – Elemental Transfer Factors from IAEA Report #472 (IAEA 2010)
- **Most DILs/DRLs changed**
  – DILs for HTO and Sr went down, but most alpha-emitters went up
    - *Update from ICRP 56 to ICRP 72 DCs*
  – Many DRLs changed even more because of updated transfer factors
- **SRNL advised DOE-SR and DOE-EH of these changes**
  – Confirmed that the methodology is still valid, especially for the unique case of HTO
- **DOE-HSS (formally DOE-EH) requested this presentation**
  – Highlight the 2006 DOE-HSS formal guidance to DOE Operations and Field Offices

Updated Derived Response Level Comparison – 2013/2006 Ratios

	Derived Intervention Level (DIL)	Derived Response Level (DRL)					
		Produce		Beef	Milk	Fish	Beverage
		External	Internal				
H-3	0.73	N/A	0.86	0.84	0.57	N/A	N/A
Sr-89	0.84	0.92	0.12	0.15	0.20	8.64	0.84
Sr-90	0.67	0.73	0.09	0.12	0.16	7.06	0.67
Nb-95	1.12	1.24	4.86	462055.47	2716.79	112.33	1.12
I 129	1.00	1.10	1.52	0.17	0.42	0.50	1.00
I-131	1.01	1.12	1.54	0.18	0.43	0.51	1.01
I-133	0.98	1.08	1.48	0.17	0.44	0.48	0.98
Cs-134	0.99	1.09	1.44	0.07	0.99	0.63	0.99
Cs-137	0.95	1.04	1.38	0.07	0.97	0.62	0.95
Ru-103	1.12	1.23	8.87	52.31	0.05	0.20	1.12
Ru-106	1.07	1.18	8.46	50.50	0.04	0.19	1.07
Ce-144	1.09	1.20	1.75	26.32	2.14	0.04	1.09
Np-237	1.99	2.18	1.22	0.16	0.78	0.95	1.99
Np-239	0.97	1.07	0.62	0.08	0.39	0.46	0.97
Pu-238	2.37	2.61	29.89	11.72	0.18	0.28	2.37
Pu-239	2.41	2.65	30.48	11.97	0.19	0.28	2.41
Pu-241	2.75	3.02	2.72	1.08	1.09	2.76	2.75
Am-241	2.42	2.66	2.41	0.93	0.97	2.37	2.42
Cm 244	4.26	4.68	4.29	1.65	1.60	4.31	4.26
Cs-Group	0.97	1.06	0.97	0.39	0.37	0.94	0.97
Pu+Am Group	2.41	2.66	2.40	0.94	0.94	2.43	2.41

Introduction - DRL Estimation Process

Protective Action Guide (PAG)
EPA (1982)

Dose Limit (i.e. 5 mSv ingestion). Recommended by the Environmental Protection Agency (EPA)

↓

Derived Intervention Level (DIL)
FDA (1998)

Concentration in food (Bq kg^{-1}). Equivalent to the PAG Food and Drug Administration (FDA)

↓

Derived Response Level (DRL)
FRMAC (2012)

Concentration on ground surface (Bq m^{-2}) equivalent to the DIL. Computed by Federal Radiological Monitoring and Assessment Center (FRMAC)

FDA DIL Methodology

- **Derived Intervention Levels (DILs)**
  - Computed and promulgated as Federal Guidance
  - Concentration in food that equates to a radiation dose equal to the PAG
- **FDA issued DIL technical guidance for determining appropriate action levels for food in 1998**
  - Considers only radiological half-life
  - Does not consider very short tritium environmental half-life
- **SRS first estimated DILs in 2002 (Simpkins)**
  - Followed FDA Guidance
  - ICRP 56 Dose Coefficients
  - Essentially the same as FDA published DILs

FDA DIL Methodology

$$DIL = \frac{PAG}{f \times FI \times DC}$$

DIL	derived intervention level (Bq kg^{-1})
PAG	protective action guide (mSv)
f	fraction of food or water assumed to be contaminated (unitless)
FI	quantity of food or water consumed in an appropriate period of time (kg/y) (allowing only for radioactive decay)
DC	dose coefficient–radiation dose received per unit activity ingested (mSv Bq^{-1})

$$FI_t = FI\,\frac{\mathrm{t}(\text{time to decay to 1\% of total activity})}{365\ \text{days}}$$

SRS HTO DIL Methodology

- **SRS March 2004 emergency response exercise illustrated conservative nature of HTO DILs**

- **SRNL task team develops alternative HTO DIL methodology in 2005/2006**

- **DOE Office of Health, Safety and Security (HSS, formally EH) champions SRS methodology**
  – Coordinated concurrence with FDA
  – Issued formal guidance to DOE operations and field offices in April 2006
  – EPA and NRC copied

SRS DIL Methodology for HTO

- **DILs for tritium oxide (HTO) are not specifically estimated in FDA or FRMAC guidance**

- **Because of the unique environmental fate of HTO, using the exact method supplied for particulate radionuclides not appropriate**
  - Assumes a constant concentration in the produce for 1 year
  - Provides an overly-conservative HTO DIL
  - Could result in unnecessary food embargoes

- **The method developed for HTO considers environmental decay along with radioactive decay**

- **This method is consistent with FDA objectives and is still reasonably conservative**
  - More realistic, for HTO than considering radioactive decay alone

SRS HTO DIL Methodology

- **HTO in air readily exchanges with moisture in plants**
  – Uptake is rapid - equilibrium reached in less than 30 minutes
  – 0.5 uptake factor -HTO present in each g of water in the plant is 50% of tritium present in each g of water in the air
  – Concentration of HTO in air more representative than deposition

- **HTO environmental half-life is short**
  – 1 day in plant matter (Anspaugh 1973)
  – NCRP Report 62 confirms this value (NCRP 1979)

- **HTO converts to organic bound tritium (OBT) (Diabate and Strack 1993)**
  – <0.3% (Murphy 1990)
  – Average environmental half-life for OBT is 27 days (Smith et al. 1995)

Derived Response Level for HTO

- **Per FDA (1998), the time period for the dietary intake is the time required for a nuclide to decay to less than 1% of the initial activity**

- **The time it would take for the HTO/OBT concentration to decay to 1% is estimated with the following equation for different time increments**

$$0.01A_0 = A_0\left[0.997e^{-\lambda_{E-HTO}t} + 0.003e^{-\lambda_{E-OBT}t}\right]$$

where

A_0	initial activity in the plant
t	time after exposure (d)
$\lambda_{E\text{-}HTO}$	environmental decay constant for HTO (0.693 d^{-1})
$\lambda_{E\text{-}OBT}$	environmental decay constant for OBT (0.026 d^{-1})

- **Using the equation, on day 8 the activity is reduced below 1%**

Vegetable Derived Response Level for HTO (most limiting)

$$DRL_{veg\text{-}HTO} = (DIL*H*CF)/(f*CR)$$

$DRL_{veg\text{-}HTO}$	derived response level (Bq m^{-3})
DIL	derived intervention level (Bq kg^{-2})
H	absolute humidity – 12.9 g m^{-3}
CF	conversion factor 1 kg / 1000 g
f	fraction of plant mass that is water (0.75)
CR	concentration ratio of plant HTO to air HTO (0.54)

DIL and Vegetable DRL Comparison for HTO

- **Using the current methods and input parameters, without using environmental decay, the DIL for tritium is 4.3E+06 pCi/kg**
- **Considering the environmental decay of tritium from the plant surface the DIL would be increased to 2.0E+08 pCi/kg**
- **The DRL for produce would have a similar increase with the new value being 6.2E+06 pCi/m^3**
  - HTO DRL for produce is the bounding DRL

Derived Levels	FDA Guidance	Environmental Decay, HTO	Environmental Decay, HTO+OBT
DIL, pCi/kg	4.3E+06	2.2E+08	2.0E+08
DRL, pCi/m^3	1.2E+05	7.1E+06	6.2E+06

Conclusions

- DRL's represent the deposition concentration upon a given environmental media (i.e. soil)—or for the special case of tritium, the air concentration—that would lead to exceeding the DIL and the PAG

- DRLs are compared with emergency response computer model output to provide decision-makers with an additional tool for early actions

- Site-specific DRLs are developed for ingestion pathways pertinent to SRS: milk, meat, fish, grain, produce, and beverage (water)

- DRL for tritium is unique because of its short environmental half-life

DOE-EH Guidance – April 11, 2006

Guidance on Deriving Intervention Levels for Tritium Contaminated Crops and Animal Feed for DOE Emergency Planning and Response Activities

- EH recommends that sites with the potential for accidents involving tritium utilize the approach outlined above and described in the attachment for developing tritium intervention levels, and where appropriate, that they use the DOE/SRS intervention level for tritium
- However, sites considering use of this level should confirm that the SRS assumptions regarding the fractional content of HTO and OBT in food and feed in their areas are appropriate
- Otherwise, site-specific data should be used to develop a site specific intervention level for tritium
- The methodology outlined in this guidance is appropriate for use in DOE emergency planning and response activities and is consistent with the FDA guidance
- FDA reviewed this methodology and found it to be consistent with its guidance for deriving intervention and response levels for planning and responding to events involving the release of other radionuclides