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Normalized Tritium Quantification Approach (NoTQA) a Method for Quantifying Tritium Contaminated Trash and Debris at LLNL

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Disclaimer

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Introduction

Several facilities and many projects at LLNL work exclusively with tritium. These operations have the potential to generate large quantities of Low-Level Radioactive Waste (LLW) with the same or similar radiological characteristics. A standardized documented approach to characterizing these waste materials for disposal as radioactive waste will enhance the ability of the Laboratory to manage them in an efficient and timely manner while ensuring compliance with all applicable regulatory requirements. This standardized characterization approach couples documented process knowledge with analytical verification and is very conservative, over-estimating the radioactivity concentration of the waste. The characterization approach documented here is the Normalized Tritium Quantification Approach (NoTQA). This document will serve as a Technical Basis Document which can be referenced in radioactive waste characterization documentation packages such as the Information Gathering Document.

Discussion

In general, radiological characterization of waste consists of both developing an isotopic breakdown (distribution) of radionuclides contaminating the waste and using an appropriate method to quantify the radionuclides in the waste. Characterization approaches require varying degrees of rigor depending upon the radionuclides contaminating the waste and the concentration of the radionuclide contaminants as related to regulatory thresholds. Generally, as activity levels in the waste approach a regulatory or disposal facility threshold the degree of required precision and accuracy, and therefore the level of rigor, increases.

In the case of tritium, thresholds of concern for control, contamination, transportation, and waste acceptance are relatively high. Due to the benign nature of tritium and the resulting higher regulatory thresholds, this less rigorous yet conservative characterization approach is appropriate.

Scope

The scope of this document is to define an appropriate and acceptable characterization method for quantification of tritium contaminated trash and debris. The characterization technique is applicable to surface and subsurface tritium contaminated materials with surfaces amenable to swiping. Some limitations of this characterization technique are identified below.

Limitations

1. The quantification method is intended to be used for dry solid materials associated with handling tritium such as trash and debris.
2. The characterization method is only to be used to quantify materials with residual tritium contamination.

3. The quantification methodology is NOT intended to be used to characterize components of pressurized tritium handling systems.
4. The quantification method is NOT to be used for concentrated tritium, tritium sources, targets, tritium (hydrogen) concentrating or storage materials such as metallic tritides, tritium storage beds, boules, mole sieves, sponges or vessels.
5. The quantification method is NOT intended for tritiated oils or organic liquids requiring solidification.

Waste Radiological Characterization

The characterization technique employs generator Process Knowledge (PK) for isotopic identification. The waste generator must certify that tritium is the only radionuclide present in the waste for this method to be used as the sole means of quantifying the radioactivity in a waste. However, this method may be used to quantify tritium in waste with other radionuclide contaminants when coupled with other characterization techniques that are specifically tailored to quantify the other radionuclide contaminants. When quantifying tritium using this method the tritium value obtained shall not be used as a scaling nuclide to quantify other radionuclides in the waste. When not used as a stand alone characterization approach, details of the other characterization techniques employed must be included in the waste specific characterization documentation package.

Assumptions:

1. For purposes of bounding calculation, the waste material is considered to be uniformly contaminated and the contamination is assumed to be equally distributed at this level. All waste is contaminated at or below the established swipe value. The established swipe value is $1E^6$ dpm/100 cm^2.
2. The surface contamination is in equilibrium with and representative of subsurface tritium contamination (Ref 2).
3. The waste has the same surface area per unit weight as 6 mil plastic. 6 mil plastic sheet has a surface density of 12mg/cm^2 (Table 1).
4. The swipe results are corrected for counting efficiency and reported in dpm/100 cm^2.
5. A 10% swipe removal efficiency is added into the equation for an additional level of conservatism.

Assumption 1 establishes a swipe value $1E^6$ dpm/100 cm^2. This is the highest removable tritium swipe value for materials characterized through this method. The mass to curie conversion is established assuming all the surface areas of the waste are contaminated at this level. The waste generator must document

their PK by certifying on the NoTQA quantification worksheet (See Attachment 1) that the highest removable tritium value for materials characterized by NoTQA do not exceed $1E^6$ dpm/100 cm^2. The swipe used must be a damp swipe or material that will readily absorb tritium, such as polystyrene foam (Ref. 2).

Assumption 2 is that material surface is amenable for swiping using dampened swipes or equivalent as described in Assumption 1, and potential volumetric tritium contamination is adequately characterized by swiping techniques (Ref. 2).

Assumption 3 provides a method to convert surface area to weight. Six-mil plastic was chosen because it is one of the lighter items frequently disposed of as low level waste and therefore provides a conservative (over) estimate of the activity in the waste. Low surface density values are conservative because they equate to higher activity per a given weight. The table below provides some of the surface density of items that are frequently found in the low level waste generated at LLNL.

Table 1 (Ref. 1)

Item	Surface Density (mg/cm^2)
Six-mil Plastic Sheet	12
20# Copier Paper	10
Powderless Gloves	20
Heavy Rubber Gloves	48
Plastic and Launderable Shoe Covers	120
Coverall Material	19-28
Twelve-mil Plastic	24

Although metal and other solid items (e.g. plastic parts, glassware) are not specifically identified on the table, they are acceptable for characterization using this method as they will have a very low surface area per unit weight compared to lighter materials and they are not as susceptible to tritium absorption and infiltration.

Assumption 4 requires efficiency corrected data to be used for comparison against the characterization threshold of $1E^6$ dpm/100 cm^2.

Assumption 5 accounts for varying or poor swipe efficiency by applying a 10% swipe efficiency. This will help ensure that tritium activity is not under estimated.

Activity Concentration Calculation:

By converting surface area contaminated at $1E^6$ dpm/100 cm^2 to activity concentration using a surface density of 12 mg/cm^2 it is determined that the waste will contain approximately $3.75E^{-6}$ Ci per gram (see Attachment 2).

$$\frac{\left(\frac{1E6dpm}{100cm^2}\right)\left(\frac{1Ci}{2.22E12dpm}\right)}{(0.1)\left(\frac{1g}{1000mg}\right)\left(\frac{12mg}{cm^2}\right)} = 3.753754E-6\,\tfrac{Ci}{g} \approx 3.75E-6\,\tfrac{Ci}{g}$$

Maximum allowable removable swipe activity is $1E^6$ dpm/swipe.
Swipe area is assumed to be 100 cm^2.
Conversion from dpm to nCi; 2.22 x 10^3 dpm = 1 nCi.
Swipe efficiency is 10%.

Justification for using NoTQA:

Waste will undergo swipe analysis as described in assumption 1 by the generator. Waste with contamination greater than $1E^6$ dpm/100 cm^2 will be segregated from waste that is less than $1E^6$ dpm/100 cm^2. Segregation of contaminated waste from greater than $1E^6$ dpm/100 cm^2 waste will be conducted prior to waste being packaged.

Conclusions:

By using an overly conservative activity per unit mass estimate combined with the generators documented PK, this method will ensure that tritium activity in suitable waste streams does not exceed regulatory and disposal site threshold values.

Attachments:

1. Normalized Tritium Quantification Approach (NoTQA) Requisition Quantification Worksheet, 7/21/08.
2. Normalized Tritium Quantification Approach Supporting Calculations, 7/21/08.

References:

1. Dominick, J.L., *Building 251 Radioactive Waste Characterization by Process Knowledge*, UCRL-ID-148571, May 29 2002.

2. DOE G 441.1-XX, *Control and Release of Property with Residual Radioactive Material*, Issued by Andy Lawrence, May 1, 2002.
3. DOE Order 5400.5, Chg 2, *Radiation Protection of the Public and the Environment*, latest revision.

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Normalized Tritium Quantification Approach (NoTQA)
Requisition Quantification Worksheet

PACKAGE INFORMATION

WDR# :	W223	
Container # (Q#) :	Q00	
Tare Weight if Drum :	1	Pounds
Gross Weight of Drum :	2	Pounds
Waste Net Weight :	1	Pounds

SCALE INFORMATION

Tare Weight

WCP Critical Equipment Scale (Serial #):	99999
Calibration Due Date:	03/12/07

Gross Weight

WCP Critical Equipment Scale (Serial #):	25
Calibration Due Date:	01/04/03

RADIONUCLIDE INFORMATION

Radionuclide to Report		Total Package Activity to Report (Ci)
H-3	---------->	1.70E-03

Notes:

GENERATOR CERTIFICATION

By signing below, I am certifying that waste material was swiped for removable tritium contamination and that the highest swipe results do not exceed 1E6 dpm/100 cm^2.

Generator (Print) : _____

Generator Signature : _____

Date : _____

Notes:

	Fields to be completed electronically.
	Nuclide and total package activity to report.
3.75E-06	Ci per gram of waste @1E+06 dpm/100cm^2.
1.70E-03	Ci per pound of waste @1E+06 dpm/100cm^2 and 454 grams per pound.

Ref. UCRL-TR-230857.

JLD 07/21/08

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Reviewed By:
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Normalized Tritium Quantification Approach (NoTQA)
Supporting Calculations

ORIGINAL Revised JLD 07/21/08

H-3 Maximum dpm/swipe	H-3 Activity Conc. (Ci/g)
1.00E+06	3.7538E-06
1.00E+07	3.7538E-05
1.00E+08	3.7538E-04

100	cm^2/swipe
0.1	Swipe removal efficiency
12	mg/cm^2 is the areal density of 6 mil plastic sheeting.
2.22E+12	dpm/Ci
454	grams/pound

Container size		1.5 ft^3	1.5 ft^3	30 gal	55 gal	85 gal	4X4X6	8X8X20
Waste Mass (lb)		1	20	400	600	800	4000	40000
Waste Mass (g)	1	454	9080	181600	272400	363200	1816000	18160000
H-3 Activity (Ci) @ 1E6 dpm/swipe	3.7538E-06	1.7042E-03	3.4084E-02	6.8168E-01	1.0225E+00	1.3634E+00	6.8168E+00	6.8168E+01
H-3 Activity (Ci) @ 1E7 dpm/swipe	3.7538E-05	1.7042E-02	3.4084E-01	6.8168E+00	1.0225E+01	1.3634E+01	6.8168E+01	6.8168E+02
H-3 Activity (Ci) @ 1E8 dpm/swipe	3.7538E-04	1.7042E-01	3.4084E+00	6.8168E+01	1.0225E+02	1.3634E+02	6.8168E+02	6.8168E+03

$$\frac{\left(\frac{Swipedpm}{100\ cm^2}\right)\left(\frac{1\,Ci}{2.22\ E12\ dpm}\right)}{(0.1)\left(\frac{1\,g}{1000\ mg}\right)\left(\frac{12\ mg}{cm^2}\right)} = Activity\ \frac{Ci}{g}$$

Notes:
- Swipes must be damp or made of a material which readily absorbs tritium such as polystyrene foam.
- Estimated weights for various containers were used to bound likely package loading.
- Removable H-3 swipe values of 1E6, 1E7, and 1E8 dpm/100 cm^2 were evaluated with the estimated weights to estimate potential package total H-3 activity.
- A 10% swipe efficiency was included for additional conservatism.
- The areal density for 6 mil plastic (12 mg/cm^2) was used as the surface area per unit mass is very high and conservatively bounds other waste materials.
- Revised 07/21/08 to add calculations for 1 lb of waste for revision of field worksheet.

Prepared by: J. Aldrich Date: 07/21/08

Reviewed by: G. M. Aldrich Date: 7/21/08