

## **Reportable Nuclide Criteria for ORNL Radioactive Waste Management Activities – 13005**

Kip McDowell\*, Tim Forrester\* and Mark Saunders\*\*

\* Oak Ridge National Laboratory, PO Box 2008 MS-6322, Oak Ridge, TN 37831  
[www.ornl.gov](http://www.ornl.gov)

\*\* Fairfield Services Group, PO Box 31468, Knoxville, TN 37930  
<http://fairfieldsg.com/Blog/>

### **ABSTRACT**

The U.S. Department of Energy's Oak Ridge National Laboratory (ORNL) in Oak Ridge, Tennessee generates numerous radioactive waste streams. Many of those streams contain a large number of radionuclides with an extremely broad range of concentrations. To feasibly manage the radionuclide information, ORNL developed reportable nuclide criteria to distinguish between those nuclides in a waste stream that require waste tracking versus those nuclides of such minimal activity that do not require tracking. The criteria include tracking thresholds drawn from ORNL onsite management requirements, transportation requirements, and relevant treatment and disposal facility acceptance criteria. As a management practice, ORNL maintains waste tracking on a nuclide in a specific waste stream if it exceeds any of the reportable nuclide criteria. Nuclides in a specific waste stream that screen out as non-reportable under all these criteria may be dropped from ORNL waste tracking. The benefit of these criteria is to ensure that nuclides in a waste stream with activities which meaningfully affect safety and compliance are tracked, while documenting the basis for removing certain isotopes from further consideration.

### **INTRODUCTION**

The ORNL mission to advance the scientific basis for breakthrough nuclear technologies and systems involves work with varying quantities of a very large and diverse set of radionuclides. In some cases, radiological waste characterization methods result in the identification of nuclides present at minimal levels with regard to waste tracking and reporting requirements for onsite management, through transportation, and to offsite treatment/disposal.

Waste characterization modeling of accelerator produced waste at the Spallation Neutron Source (SNS), for instance, may include literally hundreds of nuclides. The minimal activity levels of some nuclides can only be calculated theoretically using computer models and cannot be detected through other characterization methods such as non-destructive assay or radiochemical analysis. Many of these nuclides are calculated at activity quantities orders of magnitude lower than one percent of the total activity. It is not practical or prudent to track in waste databases, list on shipping papers, and report to treatment, storage, and disposal facilities (TSDF) minimal quantities of nuclides that have no regulatory or programmatic requirement for reporting.

While acknowledging that there is no universally recognized criteria below which minimal activity nuclides can be excluded from waste tracking, a reasonable framework for nuclide tracking balances the need for capturing essential nuclide information with the need for being pragmatic. This framework ensures that nuclides with activities that meaningfully affect waste calculations get reported, while allowing for the elimination of tracking on those minimal activity nuclides that do not.

This paper documents reportable nuclide criteria for ORNL radioactive waste management activities in order to provide a technical basis for determining when it may be appropriate to drop certain nuclides from waste tracking. Any additional criteria used to drop waste tracking on nuclides will be documented in a Laboratory Waste Services approved radiological characterization calculation. The approved radiological calculation could, for example, document that the criteria related to Nevada National Security Site (NNSS) Waste Acceptance Criteria (WAC) (Reference 1) Table E-1 action levels does not apply for a waste stream not destined for NNSS.

It is important to note that this reportable nuclide criteria is specifically intended to apply only to those waste that will be managed as radioactive waste. The process for evaluating materials for release from radiological control is outside the scope of this document and must be performed under applicable procedures and DOE Orders.

## **METHODOLOGY**

### **Review of ORNL Onsite Nuclide Tracking Requirements**

#### Facility Hazard Categorization

Requirements for ORNL onsite tracking of nuclide activity are found in Standards Based Management System (SBMS) Subject Area “Facility Hazard Categorization” (Reference 2). The procedure, “Establishing and Maintaining Facility Hazard Categorization Documents” of Reference 2, requires that facility managers collect isotope and activity information for radiological material, including waste. A conservative factor of one order of magnitude below the referenced SBMS requirements is used for the Reportable Nuclide Criteria for ORNL Radioactive Waste Management Activities. Waste with nuclides exceeding any of the following criteria will be considered ORNL reportable nuclides:

- Equal to or Exceeds .0005% Hazard Category 3 Sum of Fractions (SOF)
- Equal to or Exceeds 0.0035 g U-235 Fissionable Equivalent Mass (FEM)
- Exceeds 1.5e-1 microcuries

### Nuclear Criticality Safety

Requirements for onsite tracking of fissionable material are found in SBMS Subject Area “Nuclear Criticality Safety” (Reference 3). This SBMS subject area refers to the SBMS Facility Hazard Categorization subject area for requirements for the safety evaluation and control of the fissionable material inventory of less-than-DOE Hazard Category 3 facilities and activities. No unique reportable nuclide criteria were identified.

### Nuclear Material Control & Accountability

Requirements for onsite tracking of accountable nuclear material are found in SBMS Subject Area “Nuclear Materials Control and Accountability” (Reference 4). The subject area points to the ORNL Nuclear Material Control and Accountability (NMC&A) Plan for the definition of reportable quantities of accountable material. The accountable quantity definition found in Appendix I of the NMC&A plan includes what is termed at ORNL as “asterisk” quantities. A conservative factor of one order of magnitude below the referenced SBMS requirements is used for the Reportable Nuclide Criteria for ORNL Radioactive Waste Management Activities.

The reporting of uranium nuclides merits additional consideration due to the importance of uranium enrichment information. Since the ORNL NMC&A Plan has different tracking requirements for enriched versus natural or depleted uranium, and since most offsite TSDF’s desire enrichment information on any uranium bearing waste they receive, then all uranium nuclides present in a waste will be reported if any uranium nuclide is present that requires reporting under any other ORNL reportable nuclide criteria. These criteria will ensure that uranium enrichment percentage integrity is maintained through the waste management lifecycle.

Waste with nuclides exceeding any of the following criteria will be considered ORNL reportable nuclides:

- Exceeds 10% of an accountable quantity under ORNL NMC&A Plan
- Report all uranium nuclides present if any U nuclide is reportable under any criteria.

## **Review of Nuclide Tracking Requirements for Transportation**

### 49 CFR Transportation

The shipment of radioactive waste is performed in accordance with 49 CFR transportation regulations. Requirements for the listing of specific nuclides on shipping papers and labels (Reference 5) include those nuclides that contribute to 95% of the total A1/A2s. A conservative factor of including nuclides that contribute to 99% of the total A1/A2s is used for the Reportable Nuclide Criteria for ORNL Radioactive Waste Management Activities. Waste with nuclides exceeding any of the following criteria will be considered ORNL reportable nuclides:

- Contributes to 99% of the total A1/A2's per 49 CFR 173.433.

#### NRC Uniform Low-Level Radioactive Waste Manifest (540/541 forms)

Reference 6, page 20, includes a description of what is considered a “significant” nuclide for Nuclear Regulatory Commission (NRC) 540/541 manifest form purposes. A conservative factor of one order of magnitude below the referenced NRC requirements is used for the Reportable Nuclide Criteria for ORNL Radioactive Waste Management Activities. Waste with nuclides exceeding any of the following criteria will be considered ORNL reportable nuclides:

- Exceeds 0.001 times the concentration of that nuclide listed in Table 1 of 10 CFR 61.55
- Exceeds 0.001 times the smallest concentration of that nuclide listed in Table 2 of 10 CFR 61.55
- Exceeds 0.026 megabecquerels/cm<sup>3</sup>
- Any radionuclide whose activity represents 10% of a Reportable Quantity under Department of Transportation (DOT) regulations

#### **Review of Nuclide Tracking Requirements for Offsite Treatment and/or Disposal**

ORNL ships radioactive waste to a number of offsite facilities for treatment and/or disposal. The acceptance criteria for these various TSDF's were reviewed as described below to determine if there are any unique reportable nuclide criteria requirements.

#### Nevada Nuclear Security Site (NNSS)

The NNSS WAC (Reference 1) has three primary reporting requirements. The NNSS definition of TRU includes radionuclides that are alpha-emitting and transuranic with a half-life greater than 20 years. A conservative factor of one order of magnitude below the referenced NNSS requirements is used for the Reportable Nuclide Criteria for ORNL Radioactive Waste Management Activities. Waste with nuclides exceeding any of the following criteria will be considered ORNL reportable nuclides:

- Exceeds 1 pCi/g TRU nuclides
- Exceeds 0.1 % of NNSS Action Level (Table E-1)
- Exceeds 0.1 % of the total activity.

EnergySolutions Clive, Utah

The Clive Bulk Waste Facility Waste Acceptance Criteria (Reference 7) was reviewed and no unique reportable nuclide criteria were identified.

EnergySolutions Bear Creek, TN

The Bear Creek Waste Acceptance Guideline (WAG) (Reference 8) was reviewed and no unique reportable nuclide criteria were identified.

Perma-Fix

The Perma-Fix WAC (Reference 9) was reviewed and no unique reportable nuclide criteria were identified.

## **RESULTS**

A list of reportable nuclide criteria for ORNL waste management activities was developed based on a thorough review of nuclide tracking requirements for onsite management, transportation, and offsite treatment and/or disposal. The list is included as Attachment A. An example of the application of the criteria is included as Attachment B.

## **CONCLUSION**

This reportable nuclide criteria provides a documented basis for identifying those nuclides that must be tracked throughout the waste management lifecycle for ORNL radioactive waste. ORNL will maintain waste tracking on a nuclide in a specific waste stream or container if it exceeds any of the reportable nuclide criteria. Nuclides in a specific waste stream or container that screen out as non-reportable under all these criteria may be dropped from ORNL waste tracking.

## **REFERENCES**

1. NNSS WAC
2. SBMS, Subject Area “Facility Hazard Categorization”
3. SBMS, Subject Area, “Nuclear Criticality Safety”
4. SBMS, Subject Area “Nuclear Materials Control & Accountability”
5. 49 CFR 173.433
6. NUREG/BR-0204, Revision 2, Instructions for Completing NRC’s Low-Level Radioactive Waste Manifest
7. Clive WAC
8. Bear Creek WAG
9. Perma-Fix WAC

## **ATTACHMENTS**

- Attachment A: Reportable Nuclide Criteria List
- Attachment B: Reportable Nuclide Evaluation (Example Only)

• **ATTACHMENT A - REPORTABLE NUCLIDE CRITERIA LIST**

<b>CRITERIA</b>	<b>Ref.</b>
Exceeds 0.1 % of the total activity	1
Exceeds 1 pCi/g TRU nuclides	1
Exceeds 0.1 % of NNSS Action Level (Table E-1)	1
Equal to or Exceeds .0005% HazCat3 SOF	2
Equal to or Exceeds 0.0035 g U-235 FEM	2
Exceeds 1.5e-1 microcuries	2
Report all uranium nuclides present if any U nuclide is reportable under any criteria	4
Exceeds 10 % of an accountable quantity under ORNL NMCA Plan	4
Contributes to 99% of the total A1/A2's per 49 CFR 173.433	5
Exceeds 10 % of a DOT reportable quantity	6
Exceeds 0.026 MBq/cm <sup>3</sup>	6
Exceeds 0.001 times the 10 CFR 61.55 Table 1 concentration	6
Exceeds 0.001 times the smallest concentration of nuclide in 10 CFR 61.55 Table 2	6

• **ATTACHMENT B - REPORTABLE NUCLIDE EVALUATION (Example Only)**

Nuclide	Ci	>99% A2	> 0.1 % activity	>1 pCi/G TRU	>0.1% NNSA Action Level	>10% RQ?	>10% Accounta ble quantity?	>0.026 MBq/c m3?	>.001 x Waste Class Table 1?	>.001 Waste Class Table 2?	>.0005 % HazCat3	>.0035 g U235 FEM?	>1.5e-1 uCi?	Reportable Uranium?
Mn54	1.58E+03	yes	yes			yes		yes		yes	yes		yes	
Fe55	1.56E+03		yes			yes		yes		yes	yes		yes	
Co57	4.67E+02		yes			yes		yes		yes	yes		yes	
V49	4.18E+02		yes			yes		yes		yes	yes		yes	
Co58	3.20E+02		yes			yes		yes		yes	yes		yes	
Co60	1.85E+02		yes		yes	yes		yes		yes	yes		yes	
Co56	5.88E+01		yes			yes		yes		yes	yes		yes	
Sc46	2.98E+01		yes			yes		yes		yes	yes		yes	
H3	2.84E+01		yes		yes	yes	yes	yes		yes	yes		yes	
Ta179	2.84E+01		yes					yes		yes	yes		yes	
Lu173	2.16E+01		yes			yes		yes		yes	yes		yes	
Cr51	1.90E+01		yes					yes		yes	yes		yes	
W181	1.76E+01		yes			yes		yes		yes	yes		yes	
Os185	1.73E+01		yes			yes		yes		yes	yes		yes	
Lu172	1.65E+01		yes			yes		yes		yes	yes		yes	
Hf172	1.64E+01		yes			yes		yes		yes	yes		yes	
Y88	1.24E+01		yes			yes		yes		yes	yes		yes	
Ca45	1.09E+01		yes			yes		yes		yes	yes		yes	
Re183	9.35E+00	yes	yes			yes		yes		yes	yes		yes	
Ni63	6.62E+00		yes					yes		yes	yes		yes	
Dy159	5.38E+00		yes					yes		yes	yes		yes	
Hf175	5.29E+00		yes					yes		yes	yes		yes	
S35	5.26E+00		yes			yes		yes		yes	yes		yes	
Pt193	5.19E+00		yes					yes		yes	yes		yes	
Gd153	4.28E+00					yes		yes		yes	yes		yes	
Zr88	3.88E+00					yes		yes		yes	yes		yes	
Na22	3.86E+00					yes		yes		yes	yes		yes	
Fe59	2.90E+00					yes		yes		yes	yes		yes	
Sm145	2.73E+00							yes		yes	yes		yes	
Gd151	2.18E+00	yes						yes		yes	yes		yes	
Nb91m	2.01E+00					yes		yes		yes	yes		yes	
Pm143	1.89E+00									yes	yes		yes	
Rb83	1.60E+00					yes				yes	yes		yes	
Eu149	1.46E+00									yes	yes		yes	
Ar37	1.22E+00					yes				yes	yes		yes	
Sr85	1.12E+00					yes				yes	yes		yes	
Se75	1.00E+00					yes				yes	yes		yes	
Ce139	8.71E-01									yes	yes		yes	
Ge68	4.63E-01									yes	yes		yes	
Zr95	2.45E-01									yes	yes		yes	
Pm144	2.05E-01									yes	yes		yes	
Ru106	1.54E-01					yes				yes	yes		yes	
In113m	1.12E-01										yes		yes	
P33	7.42E-02									yes	yes		yes	

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Nuclide	Ci	>99% A2	> 0.1 % activity	>1 pCi/G TRU	>0.1% NNSS Action Level	>10% RQ?	>10% Accounta ble quantity?	>0.026 MBq/c m3?	>.001 x Waste Class Table 1?	>.001 Waste Class Table 2?	>.0005 % HazCat3	>.0035 g U235 FEM?	>1.5e-1 uCi?	Reportable Uranium?
Ir194m	4.19E-02										yes		yes	
W178	3.77E-02										yes		yes	
Pm147	2.99E-02										yes		yes	
K42	2.12E-02												yes	
Ru103	1.29E-02										yes		yes	
Hg203	1.03E-02										yes		yes	
Eu150	8.48E-03				yes						yes		yes	
Te127m	6.02E-03										yes		yes	
Sb124	3.93E-03										yes		yes	
Tc99	2.64E-03				yes			yes					yes	
W188	9.81E-04										yes		yes	
Sn121	7.46E-04												yes	
Tb158	4.29E-04												yes	
As74	1.83E-04												yes	
Pd103	5.70E-05												yes	
Lu177	3.74E-05												yes	
Dy154	6.58E-06										yes		yes	
Zr93	2.97E-06												yes	
Sn117m	5.01E-07												yes	
Sn126	2.50E-07												yes	
La140	5.92E-08 **													
Sn125	4.48E-10													
Ni56	5.58E-11													
Tb161	4.92E-13													
Pt193m	5.69E-16													
Y87	1.09E-20													
Ga67	3.24E-22													
Tc99m	9.91E-24													
Cu67	1.58E-28													
Br77	4.33E-30													
Ba133m	1.43E-46													
Re189	8.58E-73													
I122	4.88E-91													
Xe122	4.86E-91													
Pr142	1.06E-92													
Gd159	2.17E-96													
Co55	1.56E-97													
	2 significant digits			10 Significant digits										
Totals (Ci)	4.88E+03		Totals (Ci)	4.8774695997E+03										
Reportable	4.88E+03		Reportable	4.8774695996E+03										
Non-reportable	5.97E-08		Non-reportable	5.9717607081E-08										
**	Highlighted cells are determined to be non-reportable nuclides													