TECHNICAL EVALUATIONS OF PROPOSED REMOTE-HANDLED TRANSURANIC WASTE CHARACTERIZATION REQUIREMENTS AT WIPP

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ABSTRACT

Characterization, packaging, transport, handling and disposal of remotely handled transuranic (RH TRU) waste at WIPP will be different than similar operations with contact handled transuranic (CH TRU) waste. This paper presents results of technical evaluations associated with the planned disposal of remotely handled transuranic waste at the Waste Isolation Pilot Plant (WIPP).

PRELUDE

The New Mexico Environmental Evaluation Group (EEG) is an interdisciplinary group of scientists and engineers who provide independent technical evaluations of the WIPP to ensure the protection of public health and safety, and the environment of New Mexico. The WIPP Project, located in southeastern New Mexico, became operational in March 1999 for the disposal of transuranic (TRU) radioactive wastes generated by the national defense programs. For 22 years EEG has reviewed the planning, design, construction and now operation of the WIPP. Recent evaluations by EEG regarding RH TRU are the genesis of this paper (1).

INTRODUCTION

The purpose of the WIPP is to safely dispose of TRU waste generated by the United States defense activities relating to the production of nuclear and thermonuclear weapons, the operation of naval nuclear reactors and associated activities such as research, development and demonstration (2). TRU waste means waste materials containing more than 100 nanocuries (3.7×10^3 Bq) of alpha-emitting transuranic isotopes with half lives greater than 20 years per gram of waste (3). TRU isotopes, in the context of WIPP, include: all nuclides with an atomic number greater than that of Uranium (with an atomic number of 92)(4). However, other long half life isotopes, such as Uranium-233 (U-233), Uranium-235 (U-235) and Uranium 238 (U-238), may also be present in TRU (5). The waste materials may include: regular laboratory waste, glove box components, machine parts, machine cuttings, rags, paper, respirators, debris, homogeneous solids, soils and gravel, respirator cartridges, all contaminated with TRU (4a).

Contact handled (CH) TRU is packaged TRU which exhibits a dose rate, at any accessible point on the surface of the package, of less than 200 millirem per hour (3a).

Remotely handled (RH) TRU is packaged TRU which exhibits a dose rate, at any accessible point on the surface of the package, greater than 200 millirem per hour and less than 1,000 rem per hour (3b).

The distinguishing difference between CH and RH TRU mixed wastes is the level of radiation doses at the surface of the package (6).

Table I summarizes several of the salient features of TRU destined for WIPP.

Table I. Salient Features of Transuranic Waste Generated from Defense Operations and Destined to WIPP (3c, 4, 7, 8)

TRU	Million cubic feet	Cubic Meters	Drum Equivalents (X 10^3)	Maximum Dose Rate at Surface of Container rem/hr	Number of Curies per liter
CH	5.95	168,485	810	≤0.200	
RH	0.250	7,079			<23
95% of RH	0.2375	6725		0.200≤100	
5% of RH *	0.0125	354		100≤1,000 **	
Total	6.2	175,564			

* No more than 5% of the RH TRU can exceed 100 rem/hr.
** No RH TRU with a dose rate in excess of 1,000 rem/hr can be placed at WIPP.

Figure I is a bar chart graphically showing the differences in surface dose rate for CH and RH TRU containers in accordance with the LWA (3c).

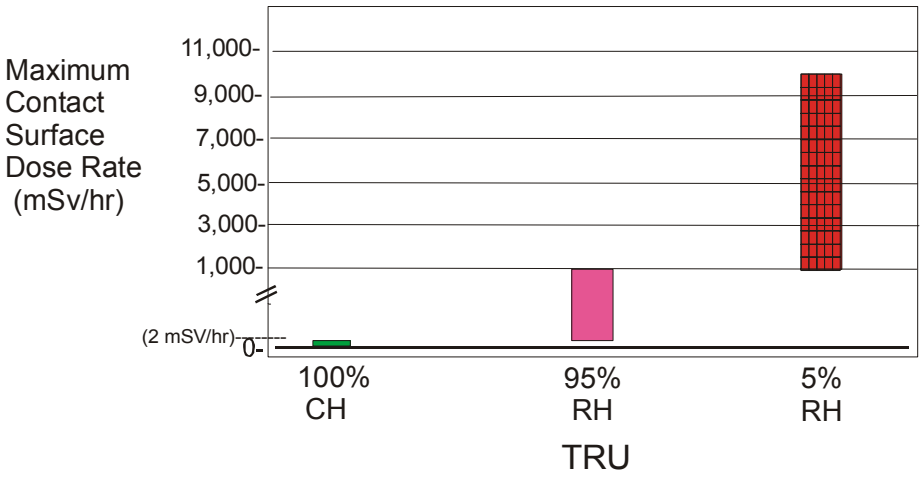

Fig. 1. TRU Container Surface Dose Rate

Note: 2 mSv/hr = 0.2rem/hr = 200 mrem/hr

RH TRU

The predominant isotopes in RH TRU for the next several hundred years are Sr-90 and its daughter isotope Y-90, CS-137 and its daughter isotope Ba-137m, Am-241, Pu-238, Pu-239 and Pu-240. Table II summarizes the characteristics of the predominant isotopes contained in RH TRU (8a).

Table II: Characteristics of Isotopes in RH TRU (9,10)

Isotope	Half life	Principle Emissions and Energy (β E_{MAX}), keV	Daughter Product
Sr-90	28.6 y	β 546	Y-90
Y-90	64.1 h	β 2280	None
Cs-137	30.0 y	β 511	Ba-137m
Ba-137m	2.55 m	γ 661	None
Am-241	432.0 y	γ 14, 59, others	Np-237
Np-237	2.1E6 y	γ 13, 29, 86, others	Pa-233
Pa-233	27.0 d	γ 13, 94, 98, 311 others	U-233
Pu-238	88.0 y	γ 13	U-234
U-234	244500 y	γ 13	Th-230
Pu-239	24000 y	γ 13	U-235
U-235	7E8 y	γ 13, 143, 184	
Pu-240	6500y	γ 13	U-236
U-236	3.4E6	γ 13	Th-232

Clearly, after several hundred years, Sr-90 (and Y-90) and Cs-137 (and Ba-137m) will decay to relatively low levels and the isotopes of concern for long term repository performance are Pu-238, Pu-239, Pu-240 and Am-241.

RH TRU was and is generated in a number of locations. Table III presents a brief overview of sites with current (October 2001) estimated quantities of RH TRU.

Table III: Locations and Estimated Quantities of RH TRU (11a,12)

Location	Volume of RH TRU (m^3)				Estimated Stored Activity (Curies)	Estimated Dose Rate (rem/hr)
	Stored	Projected	Total	Planned Disposal		
Large Quantity Sites						
Hanford	207.0	938.0	1145.0	1048.0	36000	0.2-1000
INEEL	84.0	101.3	185.3	275.2	6360	0.2-100
Los Alamos	99.5	24.0	123.5	120.0	10700	
Oak Ridge	1306.0	288.6	1594.6	453.4	587000	0.2-1000
Total LQS	1696.5	1351.9	3048.4	1896.6	640060	
Small-Quantity Sites						
Argonne-East	2.0	8.0	10.0	10.0		0.2-10
Argonne-West	1.1	5.0	6.1	6.1		1.0-100
Battelle-Columbus	0.0	20.8	20.8	20.8	5800	0.2-125
Bettis	3.0	0.0	3.0	3.0	16300	1.0-100
ETAC	8.7	0.0	8.7	5.5	8	0.2-10
Vallecitos	11.8	0.0	11.8	11.8		1.0-100
KAPL	3.7	6.8	10.5	10.5	118	1.0-100
Sandia	1.5	24.0	25.5			NA
West Valley	470.5	8.4	478.9			NA
SRS*	0.0	0.0	0.0			NA
Total SQS	502.3	73	575.3	67.7	22226	
Total of LQS and SQS	2198.8	1424.9	3623.7	1964.3	662286	

LQS means Large Quantity Sites
SQS mean Small Quantity Sites
* The Savannah River Site has not indicated that it possesses any TRU.

BACKGROUND

In May 1998 the Environmental Protection Agency (EPA) certified that WIPP met the radioactive waste disposal requirements and criteria contained in 40 CFR Parts191 and 194 (13,14,15) . This certification allowed DOE to ship and dispose of CH TRU waste at WIPP. DOE began to accept CH TRU waste beginning in March 1999 and as of November 2001 DOE has disposed of approximately 2800 m^3 of CH TRU at WIPP (18).

One of the limitations in the EPA certification was that DOE can not receive nor dispose of RH TRU waste until such time as the EPA accepts the DOE waste characterization program (11).

The New Mexico Environmental Department, consistent with its mandate under the New Mexico Hazardous Waste Act, NMSA section 74-4-1 *et seq*. (HWA) and the Resource Conservation and Recovery Act, 42 USC section 6901 et seq. (RCRA), determined to impose a permit condition prohibiting the disposal of remote handled waste at WIPP. Part of the basis for this permit condition was that the Applicants failed to provide an

approvable waste analysis plan for RH waste as required by regulation and that the Applicants had not prepared any characterization procedures for RH waste (16,17).

OCCUPATIONAL RADIOLOGICAL CONSIDERATIONS

In evaluating operational radiation safety, the type of the radioactivity anticipated in the major constituents in RH TRU waste is far different than the type of radioactivity anticipated in and received in the major constituents of the CH TRU waste. From the 1996 Baseline Inventory Report (19), approximately 98.9 percent of the total CH TRU activity (curies) results from Pu-238, Pu-239, Pu-240, Pu-241, and Am-241. In contrast, 96.5 percent of the total RH TRU activity (curies) result from Cs-137, Ba-137m, Sr-90, Y-90, and Pu-241. The occupational radiation safety concern associated with CH TRU is predominately inhalation and, to a lesser extent, ingestion. The occupational radiation safety concern with RH TRU is both inhalation **AND** external dose rate.

As is pointed out earlier, containers of RH TRU are anticipated to exhibit dose rates substantially in excess of the dose rates exhibited by containers of CH TRU. For example, Hanford has indicated that some of its RH TRU would exhibit unshielded dose rates up to 20,000 R/hr (20). In addition, the packaging, offloading, handling, and disposal of RH TRU are substantially different than for packaging, offloading, handling, and disposal for CH TRU. Compared to CH TRU, RH TRU provides at least several new important dimensions to occupational safety, environmental protection, public health and safety, and process safety. WIPP has an array of sturdy facilities and robust equipment to handle RH TRU: a shipping cask receiving area, a cask unloading room, a transfer cell, a large hot cell, a cask loading room, hoists, shield doors, and so on. However, it would appear worthwhile to evaluate the potential for contact maintenance and repair of remote handling devices and remotely operated conveyances of RH TRU containers under malfunction/breakdown/jammed equipment/contact repair conditions. The evaluation should include scenarios for variable container radioactivity and at several different container locations. Personnel doses should be estimated in connection with ALARA considerations consistent with the WIPP Radiation Safety Program.

RH TRU WASTE ACCEPTANCE CRITERIA –Technical Justifications Deleted

EEG has a long and rich history of correspondence and reviews on the Waste Acceptance Criteria (WAC) for CH TRU and RH TRU waste dating back 22 years. Further, the requirements were not self-imposed by DOE. The criteria were built on information and rationale provided by the Department of Energy, Westinghouse Electric Corporation, and Sandia National Laboratories, with reviews by the Environmental Evaluation Group (21). The first revision of the WAC for CH TRU and RH TRU waste was published 20 years ago (22). Consistent with the stated objectives of the document, revisions through the first ten years included technical justification for each criterion (e.g. WIPP-DOE-069, Revision 4.0, December 1991). However, in later versions of the Waste Acceptance Criteria, each Technical Justification was deleted by DOE (e.g.

DOE/WIPP-069, Revision 5, April 1996). Hence, the later revisions make it difficult to revisit the underlying need for each requirement.

It is Important that all major assumptions, calculations and justifications are documented and carried forward to assure traceability of the information, the design basis and the technical basis of each RH TRU WAC criteria and/or requirement.

EEG has strongly encouraged DOE to return to the practice of including a Technical Justification for each RH TRU WAC criteria/requirement. Such Technical Justification should be supported with a reference, calculations or other scientific foundation.

INVENTORY

An important consideration regarding RH TRU disposal at WIPP is the quantity and activity of the RH TRU contained in the DOE complex and destined for WIPP. There are a number of EEG and DOE reports and correspondence regarding this matter. The most current DOE data available are contained in Chapter 5 (Transuranic Waste) in the April 2001 DOE Report titled "Summary Data on the Radioactive Waste, Spent Nuclear Fuel, and Contaminated Media Managed by the U.S. Department of Energy" (which can be accessed at http://cid.em.doe.gov) (23). These data are based upon the 1996 Integrated Data Base Report (IDB). On page 3-2 the IDB states "the radionuclide inventory is based on the stored TRU inventory at EOCY 1995 that was provided in response to the January 1996 data call" (7). [EOCY End Of Calendar Year]

While the 1995 data are acceptable for 1995, it would be worthwhile to obtain a more recent assessment of the quantity and activity of RH TRU for planning purposes as we near the time when RH TRU may be emplaced at WIPP.

Hanford and Oak Ridge inventory of RH TRU, based upon 1995 data, are as shown in Table IV (28).

Table IV. Summary of RH TRU at Hanford, Oak Ridge and All Other Sites

Site	Number of Stored Curies	% of Total		Estimated Disposal Volume (M^3)	% of Total
Hanford	36,000	5		1048	**53**
Oak Ridge	587,000	88		453.4	**23**
All Others (approximate)	39,286	6		432.9	**22**
Total	**662,286**	**~ 100**		**1964.3**	**~100**

ACCEPTABLE KNOWLEDGE

RH TRU acceptable knowledge (AK) is essentially a process under which RH TRU can be characterized. Based upon problems with records and other historical information (1), records and historical information may not suffice as AK for RH TRU. DOE may have to rely on RH TRU waste characterization or confirmatory testing. There are essentially two reasons for this assertion.

For CH TRU, AK is used to determine hazardous waste numbers, waste matrix, presence of prohibited items, and to establish isotopic ratios. For non-radionuclide characteristics, AK is confirmed by real time radiography and visual examination. For radionuclides, there is 100% non-destructive assay for quantification and confirmation of isotopic ratios. This approach is acceptable and appears to be working.

In September 2001 DOE requested EPA to review proposed revisions to the CH TRU Waste Acceptance Criteria (WAC) (24) and the Technical Basis for Appendix A of the CH WAC (25). One of the items in the DOE request is that a statistical approach be allowed to confirm radionuclide isotopic ratios in lieu of the present requirement for confirmation on each waste container. Upon review of the submittal, EPA was unable to concur on the proposed revision to the CH TRU WAC (26). DOE is planning to use the same basic approach for RH TRU.

DOE documentation has long recognized the need for the construction of RH TRU waste characterization and packaging facilities at Hanford and Oak Ridge (27). For example, at Oak Ridge DOE entered into a $224 million fixed price contract with Foster Wheeler Environmental Corporation to license, permit, construct, test, operate and decontaminate and decommission a facility to treat, process and characterize:

- 900 M^3 of RH TRU sludge
- 1600 M^3 of RH low level waste supernate
- 550 M^3 RH TRU/alpha low level waste solids
- 1000M^3 of CH TRU/alpha low level waste solids.

This project is planned to meet the Waste Isolation Pilot Plant Waste Acceptance Criteria and to meet the Resource Conservation and Recovery Act Land Disposal Requirements (29). With the waste characterization and packaging facilities it would be possible to provide adequate visual examination for about 95% of the RH TRU wastes. This should minimize the need to use historical records and notes as part of the AK process.

DATA QUALITY OBJECTIVES

The DOE has proposed that the only data quality objective (DQO) for any of the RH TRU waste characterization objectives is that quantification of total activity for a unit

(waste stream or individual container) must be within a factor of five of the true value with a confidence level of 95%. This may be expressed as:

0.2 Value (True) < Value (Data) <5.0 Value (True) (at the 95% confidence level) (11b).

The current DQOs for CH TRU waste require an accuracy of 70%-130%.

The rationale behind the factor of five DQO for total activity is:

a. The Land Withdrawal Act limits the total RH TRU radioactivity (from all radionuclides, including short-lived daughters) to 5.1 million curies (3c);

b. Data from the TRU Waste Base Line Inventory Report (TWBIR) estimated that the RH TRU inventory contained about one million curies (30);

c. Therefore, a factor of five was all the accuracy needed to comply with the LWA limit.

The reasoning behind this rationale is questionable. The TWBIR is only a survey and it is in need of being updated. Yet the 1 million curie estimate is treated as a precise number. It is not reasonable to assume that the estimated total activity is much more accurate than is obtainable by a certified nondestructive assay (NDA) system for individual containers.

DOE plans to assay the quantity of Cs-137 by gamma ray analysis and use ratios of Cs-137 to transuranic isotopes determined elsewhere to quantify the transuranic content of a container. These ratios vary significantly (e.g. at Battelle Columbus only 83% of 69 samples had TRU fractions between 1% and 7% and at Oak Ridge 90% of the samples fell between 3% and 12%). This spread in the ratios results in a several fold additional uncertainty in obtaining the TRU activity in an individual container when using this approach.

A reasonable case can perhaps be made that the proposed radio-assay procedure is adequate to ensure long term compliance. However, there are several other reasons why the transuranic radioactivity needs to be known rather accurately:

a. To ensure that only transuranic waste (greater than 100 nanocuries per gram of waste) is disposed at WIPP. The proposed assay procedure would determine the TRU alpha concentration on a waste stream basis, rather than on each container. This has never been allowed with CH TRU waste and seems to be inconsistent with the Consultation and Cooperation (C&C) Agreement and the LWA.

b. To ensure that the RH-72B cask limit of 325 FGE (Fissile Gram Equivalent) can be met for each RH TRU canister;

c. The decay heat limits in the RH TRU TRAMPAC (31) (to control hydrogen gas generation) are calculated from the radionuclide concentrations on each waste container.

It is not clear how the proposed DQOs can lead to the accuracy in the transuranic waste concentrations and ratios necessary to comply with the above three items for all of the RH TRU canisters.

SUMMARY

This paper identified a number of technical considerations which, if provided due consideration, should improve the likelihood of RH TRU disposal at WIPP.

Safety analyses should anticipate the need for maintenance and repair of remote handling equipment under conditions of malfunction, breakdown, and jamming. The evaluations should include scenarios for variable container radioactivity and at different container locations in the handling process.

The DOE should reinstate the technical justification for each waste acceptance criteria with supporting references, calculations, or other scientific justification.

Estimates of the RH TRU inventory rely upon a 1995 survey. The Project is in need of an up-to-date assessment.

The DOE should critically evaluate the propriety of abandoning the current CH TRU NDA process for RH TRU.

The proposed data quality objective for estimating isotopic content of individual RH TRU containers is questionable. And is not acceptable for determining transuranic radioactivity.

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