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1	1	Cog.Eng. GF Boothe	<i>[Signature]</i>	10/20/94	G6-46	TR Pauly	<i>[Signature]</i>	10/24/94	G6-47	1	1
1	1	Cog. Mgr. DE Ball	<i>[Signature]</i>	10/20/94	G6-46	TL Yount	<i>[Signature]</i>	10/24/94	G6-47	1	1
1	1	QA H. Spanheimer	<i>[Signature]</i>	10/26/94	G6-47	MM McCarthy	<i>[Signature]</i>		N3-13	3	
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1	1	RR Ames	<i>[Signature]</i>	12/13/94	N3-13	OSTI (2)	<i>[Signature]</i>		L8-07	3	
1	1	TL Erickson	<i>[Signature]</i>	12/20/94	H5-33	Central Files (2) + orig.	<i>[Signature]</i>		L8-04	3	

18. G. F. Boothe Signature of EDT Originator Date 10/20/94	19. Authorized Representative Date for Receiving Organization	20. D. E. Ball Cognizant Manager Date 12/20/94	21. DDE APPROVAL (if required) Ctrl. No. ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments
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APPROVED FOR PUBLIC RELEASE

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12/22/94

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**CRITICALITY CLASSIFICATION OF WASTE
RECEIVING AND PROCESSING MODULE 2A**

October 1994

Gary F. Boothe

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Westinghouse Hanford Company
Richland, Washington

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CRITICALITY CLASSIFICATION OF WASTE RECEIVING AND PROCESSING MODULE 2A

1.0 INTRODUCTION

The purpose of this document is to evaluate the criticality potential of the Waste Receiving and Processing Module 2A (WRAP 2A) and to demonstrate that the facility is an exempt facility, under the provisions of the Nuclear Criticality Safety Manual (WHC 1994). The WRAP 2A maximum potential transuranic (TRU) contents of feedstreams and product inventories are discussed. Total plant fissionable materials are estimated. The WRAP 2A operations and processes are then discussed relative to the potential concentration of fissionable material and criticality safety.

2.0 SOURCE TERMS AND INVENTORIES

The purpose of the WRAP 2A facility is to treat contact-handled (< 200 mrem/hr), low-level (non-TRU), radioactive mixed waste so that it will be suitable for mixed waste trench burial at Hanford. The facility will receive drummed and boxed waste from 17 waste streams, consisting of sludge, debris, and particulate. The waste is "conditioned", and then mixed with either grout or polyethylene. This mixture is loaded into boxes (4x4x4 ft) and then disposed of in the mixed waste trench.

A change in the initial Functional Design Criteria and initial facility design greatly lowered the potential facility inventory of fissionable materials. Primarily, the change resulted in the removal of incoming lag storage and the cure storage of product boxes, which was the greater part of the total inventory, as initially specified in the source term document (Boothe 1994).

A conservative design basis inventory for WRAP 2A, consistent with the current facility design, is as follows:

1. Waste Que Storage	12 drums on 3 pallets
2. Drum Elevator	1 drum
3. Waste Drum Accumulation Conveyors	6 drums
4. Particulate Grout Mixing Tanks	8 DE (4 drum per tank)
5. Particulate Grout Product Box	4 DE (1 product box)
6. Debris Product Box	6 DE (1 product box)
7. PE dryer	2 DE
8. PE Feed Hopper	10 DE
9. PE Product Box Filling	7 DE (1 product box)
10. PE product Box Cooling Storage	14 DE (2 product boxes)
11. Box Breakdown Area	15 DE (4x4x8 ft waste box)
12. Sample Management Area	1 drum
13. Sample Management Area	4 DE (1 product box)
TOTAL	90 drum equivalent

DE = drum equivalent = 7.4 cubic feet of waste volume

Assuming that each drum equivalent (DE) could contain the maximum 100 nCi/g of TRU, and that each DE weighs 135 kg, and assuming 12% Pu-240 @ 0.175 Ci/g, the total maximum possible TRU facility inventory is given by:

$$(90 \text{ DE} \times 1.0\text{E}-7 \text{ Ci/g} \times 135,000 \text{ g/DE}) / (0.175 \text{ Ci/g}) = 6.9 \text{ g TRU}$$

It should be emphasized that the above inventory is not credible and is overly conservative. This inventory should not be used for any purpose other than this document. Also, it is noted that Np-237 occurs in the feed specification for WRAP 2A and in the hazard categorization document. However, the Np-237 meets the exempt materials requirements of Section 5 of the criticality safety manual due to moderation in the waste matrix. The typical drum in WRAP 2A will have much less than 100 nCi/g of TRU. The actual TRU anticipated in the waste streams is indicated by the alpha content in the Table, which was derived for contamination control purposes and is repeated here in its entirety.

Besides TRU, the only other significant fissionable material that may enter the WRAP 2A facility is U-235 (assumed to be 1% enriched). The total quantity of U-235 in 219 existing drum equivalents of debris waste is 22.8 grams and forecast waste is not expected to differ significantly. All received waste will meet the facility fissile inventory restrictions, based on TRU plus U-235 content. The exempt facility limit of 3% of a minimum critical mass can take the enrichment value into account, but for comparison, the exempt quantity of fully enriched uranium is about 24 grams of U-235. Natural and depleted uranium are not controlled for criticality safety.

3.0 WRAP 2A PROCESSES

The conditioning and treatment of the WRAP 2A feedstreams prior to immobilization with grout or polyethylene is described thoroughly in the Advanced Conceptual Design Report, and consists only of:

1. Size Reduction. For example, in the box breakdown area, large items will be crushed, sawed, etc., so that they will be suitable for immobilization with grout or polyethylene.
2. Screening. The particulate and sludge will pass through screens to separate fines from larger items, prior to mixing with grout or polyethylene.
3. Chemically Neutralizing or Deactivating Contained Liquids. This pretreatment (conditioning) will be accomplished in fume hoods adjacent to the main processing line. It is not credible that fissionable material would be significantly concentrated by this chemical treatment, since the contained liquids probably do not contain the material in the first place, and secondly, the volume of chemicals treated at one time (liter quantities) is small. For example, the maximum amount of TRU contained in an entire liter of contained liquid could only be about 0.00167 grams, even if the liquid had 100 nCi/gram TRU.

TABLE
WRAP 2A FEEDSTREAM RADIOLOGICAL CHARACTERIZATION

No.	WASTE FORM	QUANTITY (DE) ¹		TYPICAL ALPHA		TYPICAL B/G ²		mrem per hour ³	CONTROL LEVEL ⁴
		existing	future	nCi/g	Ci/drum	nCi/g	Ci/drum		
1A	183-H SOL. LIQ.	2,767	0	0.03	6.3E-6	< 5.0	1.0E-3	< 1.0	RCA
1B	183-H SOLIDS	4,436	0	0.09	1.9E-5	< 5.0	1.0E-3	< 1.0	RCA
1C	183-H SLUDGE	4,890	0	0.45	1.0E-4	< 5.0	1.0E-3	< 1.0	RCA
1D	183-H MISC. WASTE	700	0	0.002	4.0E-7	< 5.0	1.0E-3	< 1.0	RCA
2A	AMMONIUM SULPHATE POWDER	0	31,280	0.15 TO 0.9	2.0E-4 TO 3.3E-5	455	1.0E-1	100 (MAX) ⁵	HOOD
2B	ION EXCHANGE RESIN	0	1,947	0.002	5.2E-8	455	1.0E-1	100 (MAX) ⁵	HOOD
2C	FERRIC HYDROXIDE SLUDGE	0	19,062	0.00008	1.8E-8	0.00035	7.7E-8	< 1.0	RCA
5A1	ELEMENTAL MERCURY	8	46	0.0	0.0	< 5.0	1.0E-3	< 1.0	RCA
5A2	MERCURY CHEMICALS	21	116	0.0	0.0	< 5.0	1.0E-3	< 1.0	RCA
5A3	MERCURY CONTAM. WASTE	35	195	0.008	1.2E-6	< 5.0	1.0E-3	< 1.0	RCA
5C1	ELEMENTAL LEAD	254	2,977	0.0	0.0	666	9.0E-2	0.1 to 90 ⁶	HOOD

No.	WASTE FORM	QUANTITY (DE) ¹		TYPICAL ALPHA		TYPICAL B/g ²		mrem per hour ³	CONTROL LEVEL ⁴
		existing	future	nCi/g	Ci/drum	nCi/g	Ci/drum		
5C2	LEAD CHEMICALS	1	5	0.0	0.0	< 26	3.5E-3	0.01 to 3.5 ⁶	HOOD
5C3	LEAD CONTAM. MATERIALS	83	469	0.0	0.0	< 518	7.0E-2	0.02 to 70 ⁶	HOOD
7	THERMAL TREATMENT ASH	0	9,831	18.0	4.0E-3	741	1.0E-1	100 (MAX)	HOOD
9A	PARTICULATE AND SLUDGE	133	11,906	5.6	7.5E-4	68	1.5E-2	0.1 to 15 ⁶	HOOD
9B	SOLIDS AND DEBRIS	127	61,217	5.6	7.5E-4	703	9.5E-2	0.01 to 95 ⁶	HOOD
9C	CONTAINED LIQUID	45	2,000	0.0	0.0	333	4.5E-2	0.01 to 45 ⁶	HOOD

NOTES:

1. DE means 55 gallon (7.4 ft³) drum equivalents. Two drum densities are assumed for the feedstreams when calculating radionuclide concentrations from total Curie content. A density of 1.06 g/cm³ (sludge) is assumed for 1A, 1B, 1C, 1D, 2A, 2B, 2C, 7, and 9A. A density of 0.65 g/cm³ (cellulose) is assumed for the other feedstream drums. Waste boxes are assumed to be equivalent to 4.5 drums.
2. B/G means beta/gamma emitters. The total Curie content of beta/gamma was usually determined from the recorded external dose rate of waste drums, assuming ORIGEN waste decayed 25 years and a waste matrix density of 0.65 g/cm³. The external dose rate data is considered more reliable than other estimates of radionuclide content, which are not always consistent with the dose rates. Also, the dose rate quantifies the more critical radionuclides relative to radiation protection and containment requirements.
3. It is conservatively assumed that a drum contact dose rate of 1.0 mrem/hr results from 0.001 Ci of MFP.
4. Control level is either containment in a glovebox or hood, or control in a RCA. An alternative would be to handle waste in a HEPA-filtered, ventilated area that is on-mask. The latter type of containment is not preferred or recommended from a radiological protection standpoint. The control-level criteria used is from the Radiological Design manual (WHC 1988). Feedstreams 1A, 1B, 1C, 2A, 2C, 7, and 9A were assumed to have highly dispersible contamination. The other feedstreams were assumed to have moderately dispersible contamination. For a drum containing gram quantities of alpha, the effective "hood threshold" is 2.0 nCi/g alpha activity. For a waste matrix containing up to 1,000 nCi/g of moderately dispersible beta/gamma, the WHC-CM-4-9 criteria results in a "hood threshold" of 0.001 Ci of MFP per drum, which is essentially a drum that reads 1.0 mrem/hr.
5. The need for a hood is due to the high content of MFP that is assumed for a portion of this feedstream. What fraction of the feed drums that would exceed the hood threshold of 1.0 mrem/hr is not known at this time.
6. It is estimated that 80% of the drums in retrievable storage and 96% of the low-level waste (LLW) drums in the Central Waste Complex (CWC) read less than 1.0 mrem/hr and are therefore below the beta/gamma hood threshold of 0.001 Ci/drum dictated by WHC-CM-4-9. The percentages were derived from the recorded dose rates for drums in retrievable storage and the CWC.

4.0 CONCLUSIONS

As can be seen from the above, the inventory of fissionable material within the facility cannot exceed 6.9 g TRU or 22.814 g U-235 and there is no process that would significantly concentrate or differentiate the small concentrations of TRU or U-235 in the feedstreams. Therefore the total facility inventory will always be far below the exempt quantity limit of 3% of a critical mass of fissionable materials. The WRAP 2A facility is therefore an exempt facility under the provisions of the criticality safety manual.

5.0 REFERENCES

- Boothe, G. F., 1994, *Radiological and Chemical Source Terms for Solid Waste Operations Complex*, WHC-SD-W306-TI-110, Rev 1, Westinghouse Hanford Company, Richland, Washington.
- WHC, 1994, *Nuclear Criticality Safety Manual*, WHC-CM-4-29, Westinghouse Hanford Company, Richland, Washington.
- WHC, 1988, *Radiological Design*, WHC-CM-4-9, Revision 0, Section 5, Figures 1-4, Westinghouse Hanford Company, Richland, Washington.