

# West Valley Demonstration Project

Doc. Number OSR-IRTS-10

Revision Number 0

Revision Date \_\_\_\_\_

**TITLE:**

CRITICALITY CONTROL DURING PROCESSING  
OF HIGH LEVEL WASTE THROUGH ION EXCHANGE COLUMNS  
CONTAINING TI-COATED ZEOLITE

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RECORD OF REVISION

PROCEDURE

If there are changes to the procedure, the revision number increases by one. These changes are indicated in the left margin of the body by an arrow (>) at the beginning of the paragraph that contains a change.

Example:

> The arrow in the margin indicates a change.

Rev. No.	Description of Changes	Revision On	Dated
		Page(s)	
0	Original Issue	All	



RECORD OF REVISION (CONTINUATION SHEET)

Rev. No.	Description of Changes	Revision On	Dated
		Page(s)	



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TYPE: OSR                      TITLE: Criticality Control During                      NUMBER: OSR-IRTS-10  
                                 Processing of High Level Waste  
OSR [X]                      Through Ion Exchange Columns  
                                 Containing Ti-Coated Zeolite  
Tech. Reqmn't. [ ]

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CRITERIA: Prevent criticality on an ion exchange column containing  
                 Ti-coated zeolite.

UNACCEPTABLE EVENTS: Inadvertent criticality.

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Safety Limit	X	Reporting Requirements: DOE-ID CONTROLLED
LCO	X	QOR
LCS		
Surveillance Reqmn't.	X	

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Technical Requirement	DOE-WVPO CONTROLLED
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Operating Limit	WVNS CONTROLLED
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IMPLEMENTING PROCEDURES:

ACM-2701

ACM-Gross-1201

ACM-2703

Others under development-to be approved prior to ORR.



OPERATIONAL SAFETY REQUIREMENT

Criticality Control During Processing of High Level Waste Through Ion Exchange Columns Containing Ti-Coated Zeolite

APPLICABILITY

This OSR applies to the processing of all liquid high-level waste (HLW) through ion exchange columns containing Ti-coated zeolite in the STS.

OBJECTIVE

Limit the  $k_{eff} + 2\sigma$  to less than 0.95 by limiting the mass of fissile Pu (Pu-239 plus Pu-241) that could accumulate on an STS ion exchange column containing Ti-coated zeolite to less than 1 kg during processing of liquid HLW.

SAFETY LIMIT (SL)

1. A maximum of 1 kg (Pu-239 plus Pu-241) accumulated on an ion exchange column containing Ti-coated zeolite.

LIMITING CONDITIONS FOR OPERATION (LCO)

1. No more than a calculated maximum of 750 g (Pu-239 plus Pu-241) or 250 Ci alpha Pu, whichever is more restrictive, may be accumulated on an ion exchange column containing Ti-coated zeolite.
2. At least two independent methods of determining the cumulative volume of HLW processed through the STS ion exchange columns shall be operational during liquid HLW processing. If failures occur during processing, such that only one method of process volume measurement is available, an additional method shall be placed in service within 24 hours. If this cannot be accomplished, a flush sequence shall be initiated.



SURVEILLANCE REQUIREMENTS (SR)

1. (Reference LCO No. 1) Method No. 1 to control accumulation of alpha Pu to less than or equal to 250 Ci.

During processing for each ion exchange column containing Ti-coated zeolite, at least once every 36 hours a column inlet sample, and a column outlet sample shall be taken. The alpha Pu concentration of these samples shall be determined. The product of the difference in the inlet and outlet concentrations and the volume processed since the last samples were drawn shall be recorded as the activity of alpha Pu that has accumulated on the ion exchange column during that period. The concentration difference used for this calculation shall be the greater of that calculated for either the current samples or for the last samples. The total activity of alpha Pu accumulated on each ion exchange column containing Ti-coated zeolite shall be documented at least once every 36 hours to ensure compliance with LCO No.1.

2. (Reference LCO No. 1) Method No. 2 to control accumulation of fissile Pu (Pu-239 plus Pu-241) to less than or equal to 750 g.

Prior to initiating processing of liquid HLW through an ion exchange column containing Ti-coated zeolite, a liquid HLW feed sample shall be taken (at a sampling point different from that in SR No. 1) and the Pu-239 plus Pu-240 concentration shall be determined. This concentration value shall be used to determine the appropriate range (Column 1, Table 1) and the corresponding maximum allowable volume of HLW which may be processed (Column 2, Table 1). Additional samples shall be taken every 7 to 10 days during processing. This ensures that the concentration has remained within the range established by the initial sample. If the concentration increases to within a higher range (Column 1, Table 1) corresponding to a lower volume of HLW which may be processed (Column 2, Table 1), then the lower volume shall be considered to be the maximum allowable volume to be processed. If this new limiting volume has already been exceeded, a flush sequence shall be initiated.



3. (Reference LCO No. 1 and 2)

The volume processed through an ion exchange column containing Ti-coated zeolite shall be determined at least once every 36 hours and verified by a second independent measurement.

4. Quarterly, during HLW processing through ion exchange columns containing Ti-coated zeolite, the activity ratio of Pu-238 to the sum of Pu-239 plus Pu-240 shall be determined.

BASIS

This OSR implements the double contingency principle for processing of liquid HLW through ion exchange columns containing Ti-coated zeolite, as required by DOE Order 5480.5 and ID 5480.5A, "Safety of Nuclear Facilities."

The SI was based on criticality assessment calculations using a modified one group and a combination of Monte Carlo neutron transport and discrete ordinates calculations for aqueous Pu-239 solutions (Yuan, 1990; Caldwell, 1990). These analyses are conservative for aqueous liquids since they constitute highly thermalized systems. There is no potential for criticality in an ion exchange column loaded with Ti-coated zeolite for accumulations of less than 1 kg (Pu-239 plus Pu-241).

LCO No. 1 allows 750 g (Pu-239 plus Pu-241) to be accumulated on an ion exchange column loaded with Ti-coated zeolite. This value provides an adequate margin of safety such that exceeding the SL of 1 kg (Pu-239 plus 241) will be incredible. Additionally, it is recognized that the concentration determined for SR No. 2 could increase during the period of HLW processing, such that the new value falls into the next higher range. If this occurs, the calculated LCO of 750 g (Pu-239 plus Pu-241) will not be violated as long as the processed volume has not exceeded the original maximum allowable volume. SR No. 2, which ensures that LCO No. 1 is adhered to, is based upon Pu mass isotopic ratios as reported in WVSP 89/011. Using this information, the conversion factor of 9.6 g (Pu-239 + Pu-241) per Ci (Pu-239 + Pu-240) was calculated (Prowse, 1991). The activity of Pu-239 plus Pu-240 is used based upon characteristic alpha energies and the methods of analyses used in the laboratory for reporting Pu concentration.

Similarly, the conversion factor of 2.86 g (Pu-239 plus Pu-241) per Ci alpha Pu was calculated, where alpha Pu activity is the sum of the alpha activities of Pu-238, Pu-239, Pu-240, and Pu-242. (Note: Pu-242 activity is negligible).



Thus, limiting the activity on an ion exchange column containing Ti-coated zeolite to less than 262 Ci alpha Pu ( $750 \div 2.86$ ) ensures that less than 750 grams of (Pu-239 plus Pu-241) are accumulated. Allowing for small variations in the mass isotopic ratios and additional conservatism, LCO No. 1 was chosen to be 250 Ci alpha Pu. Hence, provided new mass isotopic ratios do not increase the conversion factor of 2.86 to greater than 3.0 (assured by SR No. 4), the amount of Pu-239 plus Pu-241 will not exceed 750 grams provided no more than 250 Ci alpha Pu is accumulated per ion exchange column.

LCO No. 2 requires redundant volume measurement and thereby reduces the probability of an incorrect process volume determination.

#### ATTACHMENTS

Table 1 - Criteria for Determining the Maximum Allowable Volume of High Level Waste to be Processed Through Ion Exchange Columns Containing Ti-Coated Zeolite

#### REFERENCES

"Criticality Safety Analysis for WVNS Sludge Tanks and Related Processing Equipment " J. T. Caldwell, October 1990

FB:91:0012, "Criticality Evaluation: Sludge Wash and Mobilization System - Zeolite Column," Y. Yuan, October 1990

FB:91:0060, "Criticality Control of an Ion Exchange Column Loaded with Ti-coated Zeolite," J. J. Prowse memo to D. J. Pauth, March 1991.

WVSP 89/011, "Receipt, Analysis and Blending of Actual West Valley Vitrification Feed Components," L. A. Bray, Pacific Northwest Laboratory, October 1988

NUREG/75/014, "Reactor Safety Study - An Assessment of Accident Risks in U. S. Commercial Nuclear Power Plants," October 1975



TABLE 1

Criteria for Determining the Maximum Allowable  
Volume of High Level Waste to be Processed  
Through Ion Exchange Columns Containing  
Ti-Coated Zeolite

Column 1		Column 2
Concentration of		Corresponding Maximum
Pu-239 plus Pu-240		Allowable Volume
(μCi/mL)		of HLW to be
		Processed
		(Gallons)
Greater	But	
than or	less	
equal to	than	
0.000	0.005 .....	1,000,000
0.005	0.020 .....	400,000
0.020	0.050 .....	200,000
0.050	0.100 .....	130,000
0.100	0.150 .....	100,000
0.150	0.200 .....	80,000
0.200	0.250 .....	65,000
0.250	0.300 .....	55,000
0.300	0.350 .....	50,000
0.350	0.400 .....	45,000
0.400	0.450 .....	40,000
0.450		May not be processed