S

ENGINEERING CHANGE NOTICE

Page 1 of 2

1. ECN 638723

Proj.
ECN

2. ECN Category (mark one) Supplemental ☐ Direct Revision ☒ Change ECN ☐ Temporary ☐ Standby ☐ Supersedure ☐ Cancel/Void ☐		3. Originator's Name, Organization, MSIN, and Telephone No. E. M. Miller, FDNW, B4-44, 376-3832		4. USQ Required? ☒ Yes ☐ No	5. Date 8/16/99
		6. Project Title/No./Work Order No. Waste Management Hanford Solid Waste	7. Bldg./Sys./Fac. No.		8. Approval Designator S
		9. Document Numbers Changed by this ECN (includes sheet no. and rev.) WHC-SD-SQA-CSA-20395 Rev. 0	10. Related ECN No(s). N/A		11. Related PO No. N/A
12a. Modification Work ☐ Yes (fill out Blk. 12b) ☒ No (NA Blks. 12b, 12c, 12d)		12b. Work Package No. N/A	12c. Modification Work Completed N/A Design Authority/Cog. Engineer Signature & Date		12d. Restored to Original Condition (Temp. or Standby ECNs only) N/A Design Authority/Cog. Engineer Signature & Date
13a. Description of Change Language in the CSER was revised to make it more precise to resolve comments in Part B of Waste Management CSER Review Team Report, February 1999.					
13b. Design Baseline Document? ☐ Yes ☒ No					
14a. Justification (mark one) Criteria Change ☐ Design Improvement ☐ Environmental ☐ Facility Deactivation ☐ As-Found ☒ Facilitate Const. ☐ Const. Error/Omission ☐ Design Error/Omission ☐					
14b. Justification Details Language in the CSER was revised to make it more precise to resolve comments in Part B of Waste Management CSER Review Team Report, February 1999.					
15. Distribution (include name, MSIN, and no. of copies) See distribution list.					
RELEASE STAMP DEC 03 1999 DATE STA 4 ID: 4					

ENGINEERING CHANGE NOTICE				Page 2 of <u>2</u>	1. ECN (use no. from pg. 1) 638723																																										
16. Design Verification Required ☐ Yes ☒ No	17. Cost Impact <div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> ENGINEERING Additional ☐ \$ _____ Savings ☐ \$ _____ </div> <div style="width: 45%;"> CONSTRUCTION Additional ☐ \$ _____ Savings ☐ \$ _____ </div> </div>			18. Schedule Impact (days) Improvement ☐ _____ Delay ☐ _____																																											
19. Change Impact Review: Indicate the related documents (other than the engineering documents identified on Side 1) that will be affected by the change described in Block 13. Enter the affected document number in Block 20.																																															
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DISTRIBUTION SHEET

To Distribution List	From FDNW Criticality and Shielding	Page 1 of 1			
		Date 12/03/99			
Project Title/Work Order CSER 95-007: Acceptability of Bettis Laboratories Waste Shipment to WHC Solid Waste, Rev. 1		EDT No. N/A			
		ECN No. 638723			
Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
Waste Management Project					
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R. P. Bushore	T4-56	X			
M. F. Hackworth	T4-51	X			
J. O. Hanley	T4-05				X
J. A. Locklair	T3-06	X			
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5

CSER 95-007: Acceptability of Bettis Laboratories Waste Shipment to WHC Solid Waste

E. M. Miller

Fluor Daniel Northwest, Inc.

Richland, WA 99352

U.S. Department of Energy Contract DE-AC06-96RL13200

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Key Words: Central Waste Complex, criticality, safety

Abstract: The purpose of this document is to evaluate a potential discrepancy between the Solid Waste Management (SWM) criticality prevention specifications and a proposed receipt from Bettis Laboratories. The analysis has been performed to determine the acceptability of the Bettis Laboratories waste container with respect to SWM criticality requirements.

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CSER 95-007

Title: ACCEPTABILITY OF BETTIS LABORATORIES WASTE SHIPMENT TO WHC SOLID WASTE

Prepared by: Edward M. Miller Date: 12 AUG 99
E. M. Miller, Criticality & Shielding

Reviewed by: Joe Greenborg Date: 08/12/99
J. Greenborg, Criticality & Shielding

Approved by: Hans Toffer Date: 8/16/99
H. Toffer, Manager, Criticality & Shielding

1. INTRODUCTION AND SUMMARY

This analysis resolves an apparent discrepancy between two different requirements of the Central Waste Complex and 200 Area Low-Level Burial Grounds Criticality Prevention Specifications (CPS-SW-149-00002 and CPS-SW-149-00003, respectively). The analysis is being performed to enable Solid Waste Management to accept a specific package from Bettis Laboratories. This package meets the requirements of Section 2.1.1 in that the total fissile content of the drum is less than 200g and the fissile material occupies greater than 20% of the container volume. The package may not appear, however, to meet the requirements of Section 2.1.5 for maximum enrichment of uranium bearing waste, as will be described below.

Based on this analysis for the Bettis drum package, the waste is shown to be critically safe under all conditions for which the 55-gallon drums (17C, 17H, or UN1A2) specification applies. This package can be accepted under the 55-gallon drum limitations on the quantity of fissile material. No change to the CPS is required to store this drum.

2. DESCRIPTION OF CONTAINER AND PACKAGING

The container of waste from Bettis consists of a 55-gallon drum (17C, 17H, or UN1A2), in which are contained 24 smaller containers (8 inch juice cans). One of the small cans contains 2.45g of uranium oxide powder enriched to 97.59% 235U. The remaining 23 small cans contain a total of 90.1g of uranium with enrichments varying between 2.66% and 18.72% 235U. Total amount of 235U in the entire container (55-gallon drum) is 81.25g. Figure 1 depicts the details of the fissile material and containers in the Bettis waste shipment evaluated.

3. APPLICABLE CRITICALITY PREVENTION SPECIFICATIONS

Two specific criticality limits could apply to the Bettis package. The first is Section 2.1.1 (CPS-SW-149-00002) which allows 200g of fissile material in a 55-gallon drum, if the fissile material occupies 20 percent or more of the container volume, and 100 g of fissile material if the fissile material occupies less than 20 percent of the container volume. The second limit which could apply is Section 2.1.5 (CPS-SW-149-00002) which sets maximum amounts of uranium based on enrichment. Of most significance to the Bettis package is the CPS limit that specifies

a maximum of 180g total uranium if the maximum enrichment (wt% ^{235}U) is greater than 75.0 wt%. Given the specific situation, this latter limit is excessively conservative, as will be shown below.

4. EVALUATION OF LOADING LIMITS

Two methods have been used to show that the Bettis package is well within the criteria of Section 2.1 of the CPS. The first method is to sum the fractions of the maximum total uranium for each enrichment over the allowable mass at that enrichment and show that the sum of the fractions is less than or equal to 1.0. The difference between the sum of the fractions and 1.0, represents additional safety margin over that required by the criticality safety limit in the CPS. The second method is to equate all fissile uranium, ^{235}U , to ^{239}Pu and to compare this total mass with the drum mass limit for plutonium (Section 2.1.1).

4.1 Sum of Fractions

The sum of fractions method is an arithmetic technique used to compare how closely a specific package approaches the subcriticality margin for packages when different components within that package have separate values for the subcriticality margin. It is commonly used by criticality and engineering in determining category 1 and category 3 limits for waste matrices based on limits for individual radionuclides. In this case the sum of the fractions is used to compare how closely the Bettis package comes to the subcriticality margin given in the criticality specification by the uranium subcriticality mass limits for specific uranium enrichments.

The sum of fractions method is used in the following manner. The total quantity of component A is divided by the limit for component A, yielding fraction A. Similarly for all other components, yielding a fraction for each component. The sum is then taken of all the fractions. If the sum of the fractions is greater than 1 then the limit has been exceeded. If the sum of the fractions is less than or equal to 1 then the limit has not been exceeded.

For the Bettis package we have the following calculation of the sum of fractions for uranium enrichments: Component A, 2.45g total uranium, 97.59% enriched; Component B, 901g total uranium, 20% enriched. This is conservative for component B because the actual enrichment ranges from 2.66% to 16.72%. Based on the fact that there are only 81.25g of ^{235}U , average enrichment of component B is closer to 9%. The subcriticality limit for component A is 180g total uranium. The subcriticality limit for component B is 1200g total uranium.

Fraction A:
 $= 2.45\text{g}/180\text{g} = 0.0136.$

Fraction B:
 $= 901\text{g}/1200\text{g} = 0.7508$

The sum of the fractions:
 $= 0.7508 + 0.0136 = 0.7644 < 1$

By the sum of the fractions, the Bettis package is within the subcriticality limits given for uranium bearing waste.

4.2 Comparison to allowable Pu gram loading in a 55 gallon drum

The CPS allows 55 gallon drums which contain 200g fissile material if the material occupies greater than 20% of the container volume, and 100g fissile material if the material occupies less than 20% of the container volume.

The Bettis waste package contains a total of 81.25g ^{235}U , which will be distributed over more than 20% of the container volume. This is less than the 200g limit. As an extra conservatism, it is also less than the 100g limit. This comparison also neglects the fact that in the Bettis package there is a significant amount of ^{238}U which acts as a neutron poison. This would not be the case if the 200g fissile material were all plutonium.

5. REVISION OF CPS LIMITS

The Bettis package meets the criteria of the CPS for 55-gallon drums. The sum of fractions analysis shows that the package is within the required margin of subcriticality for enriched uranium specified in the uranium limits in the CPS. No revision to the current CPS is required for this specific waste package. This evaluation has been performed to document the status of the Bettis package.

However, the sum-of-fractions method described in this evaluation can be used to show that packages of uranium (^{235}U in ^{238}U) with several different enrichments are adequately within criticality mass limits (0.225 times the minimum critical mass as specified in CSER 82-003 for uranium bearing waste). The sum-of-fractions method is as conservative for multiple enrichment packages as the table of maximum allowable mass per enrichment in CPS-SW-149-00002 is for single enrichment packages of uranium. The sum-of-fractions method can also be used for combining all or some fissionable materials in a package into one value to compare to an equivalent limit (e.g. $119 \text{ FGE} = 1.0 \text{ FGE/g } ^{239}\text{Pu} \text{ times } 0.225 \text{ times } 531 \text{ g } ^{239}\text{Pu}$, minimum critical mass for ^{239}Pu). Incorporation of the sum-of-fractions method is to include that the numeric evaluation is done by trained criticality safety engineers or criticality safety representatives and that the calculation is checked and documented by criticality safety personnel. Operators and field personnel are to be required only to check that the final sum-of-fractions number for a package be within a limiting number (i.e. normally 1.0) or an equivalent limit for the units used in the sum (e.g. 119 for FGEs).

6. REVIEWER COMMENTS

6.1 E. M. Miller (Rev. 0, 1995)

The independent technical review of the report, "CSER 95-007, ACCEPTABILITY OF BETTIS LABORATORIES WASTE SHIPMENT TO WHC SOLID WASTE" was done by E. M. Miller, a criticality engineer in the Consequence Analysis group. His comments are as follows.

This CSER justifies the acceptance of a drum containing more total uranium than is allowed by CPSs CPS-SW-149-00002 and CPS-SW-149-00003 for the highest uranium enrichment in the container, because the amount of highly enriched uranium is so small as to be insignificant for a criticality assessment. This reviewer concurs completely with the conclusion and approach taken for these small amounts of uranium that have large margins of safety. Note that if all the 81.25 grams of U-235 were in 97% enriched uranium ($81.25\text{g}/0.97 = 83.5\text{g}$), the total amount of uranium would be less than half the limit of 180 grams total uranium at an enrichment of greater than 75% specified in the CPSs. This barrel's reactivity addition to a storage array is far less than the 200 or 100 grams fissile material allowed by the CPSs.

6.2 J. Greenborg (Rev. 1, 1999)

J. Greenborg, a criticality engineer in the Criticality and Shielding group, did the independent technical review of CSER 95-007, Rev. 1. His comments are as follows.

This reviewer also concurs completely with the conclusions, approach and the margin of safety. The models and the calculations based on the data in this document were checked and found correct. The subject container of this document was not delivered to Hanford, as such, the original source information is not available, and cannot be checked for consistency. The technical peer review checklist for this review is attached.

7. REFERENCES

SD-SQA-CSA-20121	"CSAR 80-021, Packaging, Storage and Disposal of Solid Waste (55-gallon drums, Unrestricted H/Pu Only)."
SD-SQA-CSA-20101	"CSAR 80-021, Addendum 5, 55-Gallon Drums and Boxes in Above Ground (Surface) Storage."
SD-SQA-CSA-20130	"CSAR 82-003, Packaging, Storage and/or Disposal of Solid Waste (Burial Containers and Uranic Burial)."
SDAR-69-1G-7-M-0401	Applicable Storage Disposal/Approval Record.

MSF-069 Uranium Enriched Mixed Waste

FIGURE 1

<u>Container ID</u>	<u>% U-enr</u>	<u>Gm U-235</u>
23061-01	9.40	7.89
23061-03	9.40	1.51
23061-04	9.40	0.63
23061-06	9.87	3.47
23040-01	9.40	0.50
23040-02	9.40	1.12
23040-03	9.40	0.72
23183-01	5.92	3.53
23183-02	5.86	4.21
23183-03	5.85	0.57
23170-04 or DI-37	5.85	2.14
23170-05 or DI-38	5.86	6.45
23170-06 or DI-39	5.98	4.74
23180-01	2.66	1.12
23180-02	2.66	0.59
15775-01	16.21	8.11
15775-02	16.21	1.25
15775-03	16.21	0.50
23179-01	16.72	5.67
23179-02	16.72	2.05
23179-03	16.72	1.06
18077-02	11.04	7.53
18077-01	11.03	13.41
DI-252 or KD103-01	97.59	2.39
TOTAL	=	<u>81.25</u>

Practice 134 290 1112
Publication Date 01Mar99
Attachment 02 - Sheet 1 of 1

FLUOR DANIEL NORTHWEST

TECHNICAL PEER REVIEWS

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed:

Title:

Author:

Date:

Scope of Review:

Yes	No*	NA	
☒	☐	☐	** Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
☒	☐	☐	Problem completely defined.
☐	☐	☒	Accident scenarios developed in a clear and logical manner.
☒	☐	☐	Necessary assumptions explicitly stated and supported.
☐	☐	☒	Computer codes and data files documented.
☒	☐	☐	Data used in calculations explicitly stated in document.
☐	☐	☒	Data checked for consistency with original source information as applicable.
☒	☐	☐	Mathematical derivations checked including dimensional consistency of results.
☒	☐	☐	Models appropriate and used within range of validity or use outside range of established validity justified.
☒	☐	☐	Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
☐	☐	☒	Software input correct and consistent with document reviewed.
☐	☐	☒	Software output consistent with input and with results reported in document reviewed.
☒	☐	☐	Limits/criteria/guidelines applied to analysis results are appropriate and referenced.
			Limits/criteria/guidelines checked against references.
☒	☐	☐	Safety margins consistent with good engineering practices.
☒	☐	☐	Conclusions consistent with analytical results and applicable limits.
☒	☐	☐	Results and conclusions address all points required in the problem statement.
☒		☐	** Review calculations, comments, and/or notes are attached.
☒	☐	☐	Traceability
☒	☐	☐	Document approved (i.e., the reviewer affirms the technical accuracy of the document).

Jess Greenberg
Reviewer: (Printed and Signed)

08/12/99
Date

* All "NO" responses must be explained below or on an additional page.

** Any calculations, comments, or notes generated as part of this review should be signed, dated and attached to this checklist. Such material should be labeled and recorded in such a manner as to be intelligible to a technically qualified third party.

NUCLEAR ENGINEERING