DEC 03 1999

DT A# 4

(4) **ENGINEERING DATA TRANSMITTAL**

1. EDT № 614636

2. To: (Receiving Organization) Distribution	3. From: (Originating Organization) SA&NE	4. Related EDT No.: N/A
5. Proj./Prog./Dept./Div.: T-Plant	6. Design Authority/Design Agent/Cog. Engr.: Harvey Goldberg	7. Purchase Order No.: N/A
8. Originator Remarks: N/A		9. Equip./Component No.: N/A
		10. System/Bldg./Facility: N/A
		12. Major Assm. Dwg. No.: N/A
11. Receiver Remarks: ~~N/A~~ RPB USQ T-99-082, Technical Baseline Document	11A. Design Baseline Document? ◯ Yes ● No	13. Permit/Permit Application No.: N/A
		14. Required Response Date: N/A

15. DATA TRANSMITTED

(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	(F) Approval Designator	(G) Reason for Transmittal	(H) Originator Disposition	(I) Receiver Disposition
1	HNF-4922		0	Addendum To CSER 78-001: ~~PRW~~ PWR Core 2 Blanket Fuel Storage Cell 4, 221-T Building	NSC	1	1	1

16. KEY

Approval Designator (F)	Reason for Transmittal (G)	Disposition (H) & (I)
E, S, Q, D OR N/A (See WHC-CM-3-5, Sec. 12.7)	1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION (See Approval Designator for required signatures)

(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN
1		Design Authority	[signature]	11-15-99	T3-28	1	1	Peer Review J. Greenborg	[signature]	9/22/99	B4-44
		Design Agent				1	1	Operations S.D. Elliott	[signature]	10/13/99	T3-28
1	1	Cog. Eng. H.J. Goldberg	[signature]	21 Sept 99	B4-44	1	1	CSR R.P. Bushore	[signature]	10/26/99	T3-28
1	1	Cog. Mgr. H. Toffer	[signature]	9/22/99	B4-44						
		QA									
1	2	Safety J.A. Locklair	[signature]	10-27-99	T3-06						
		Env.									

18. [signature] H.J. Goldberg 21 Sept 99 — Signature of EDT Originator / Date	19. [signature] D. Levinskas ~~R.J. Nicklas~~ 12/1/99 — Authorized Representative for Receiving Organization / Date	20. [signature] H. Toffer 9/22/99 — Design Authority/ Cognizant Manager / Date	21. DOE APPROVAL (if required) Ctrl No. ____ ◯ Approved ◯ Approved w/comments ◯ Disapproved w/comments

DISTRIBUTION SHEET

To	From	Page 1 of 1
Distribution List	FDNW Criticality and Shielding	Date 12/03/99
Project Title/Work Order		EDT No. 614636
Addendum 1 to CSER 78-001: PWR Core 2 Blanket Fuel Storage Cell 4, 221-T Building (HNF-4922)		ECN No. N/A

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
Waste Management Project					
R. B. Barmettlor	T3-28				X
R. P. Bushore	T4-56	X			
S. D. Elliott	T3-28	X			
J. A. Locklair	T3-06	X			
N. K. Myers	T3-28	X			
R. J. Nicklas	T4-56				X
DOE-RL					
S. J. Altshuler (ABD)	R3-79	X			
L. T. Nirider (ABD)	A5-55	X			
T. A. Shrader (WMD)	R3-81	X			
Fluor Daniel Hanford					
S. T. Almodovar	A3-02	X			
Fluor Daniel Northwest					
H. J. Goldberg	B4-44	X			
J. Greenborg	B4-44	X			
L. L. Reetz (3)	B4-45	X			
G. L. Koci	B4-09	X			
H. Toffer	B4-44	X			
Central Files (Orig +2)	B1-07	X			
Docket Files (2 copies)	A3-02	X			

S

Addendum 1 to CSER 78-001: PWR Core 2 Blanket Fuel Storage Cell 4, 221-T Building

Harvey J. Goldberg
Fluor Daniel Northwest, Inc.
Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

EDT/ECN: 614636 UC: N/A
Org Code: 32900 Charge Code: 101658 AJ60/TO 4740-4
B&R Code: N/A Total Pages: 8

Key Words: PWR, reactor fuel, storage pool, actinides, Shippingport

Abstract: The analysis examines zircaloy-clad fuel degradation and extends the permitted storage time by ten years for Shippingport Core 2 blanket fuel assemblies in the 221-T, Cell 4 storage pool.

12/3/99
Release Approval Date

Approved for Public Release

Addendum 1 to CSER 78-001: PWR Core 2 Blanket Fuel Storage Cell 4, 221-T Building

Prepared by: Harvey Goldberg
Harvey Goldberg
Criticality and Shielding

Date: 21 September 1999

Reviewed by: Jess Greenborg
Jess Greenborg
Criticality and Shielding

Date: 22 Sept 99

Approved by: Hans Toffer
H. Toffer., Manager
Criticality and Shielding

Date: 22 September 99

Table of Contents

Addendum 1 to CSER 78-001: PWR Core 2 Blanket Fuel Storage Cell 4, 221-T Building

1. Introduction

Irradiated pressurized water reactor (PWR) Core 2 (PWR-2) blanket fuel assemblies from the Shippingport PWR have been stored in the 221-T canyon water pool for twenty years. The fuel is in the form of small wafers of UO_2, which were initially natural enriched uranium (0.72% ^{235}U). The uranium oxide wafers have a pyrolytic carbon coating, which prevents the fuel from reacting with a zircaloy-4 grid which provides structural strength and holds the wafers in place to form fuel plates. Thirty fuel plates comprise a sub-assembly which are held together by zircaloy-4 end plates. Two identical oxide fuel plate sub-assemblies are welded together to form a square structure with two zircaloy-4 extensions welded to the ends.

Seventy-two PWR-2 assemblies are stored in the 221-T canyon water pool. Eight of these assemblies were irradiated in the center of the reactor core to an average burnup of 24,538 Mwd/MTU. The remaining assemblies had a burnup of 16,200 Mwd/MTU. These assemblies were placed in the canyon in 1978 and 1979 (WHC 1996). The original Criticality Safety Analysis Report (CSAR) (WHC 1990) analyzed the criticality safety of their storage and concluded that they were safe from a criticality standpoint. It was also mentioned in this CSAR that the assemblies were scheduled to be stored for twenty years.

The Criticality Prevention Specification (CPS) for this storage configuration (RHO 1978), included in (WHC 1990), specifies that the fuel "will be stored in Cell 4 up to 20 years", and that "no special handling or storage requirements for criticality control during ... interim storage up to 20 years" were necessary. The purpose of this addendum is to extend the period of coverage for this material.

2. Limits

There are no special storage requirements for criticality control during storage of the fuel for an additional 10 years. At the expiration of this interval the issue of fuel integrity and its effect on the question of criticality shall be revisited. Additional review shall be made prior to any movement of these fuel elements.

3. Analysis

The actinide content of the assemblies is a function of the original fuel composition, irradiation history, and decay time. The fuel was removed from the reactor in 1974. The actinide composition was calculated with the computer code Origen2 based on the bulk composition and known operational history (Bergsman 1994). The results are listed in Table 1. Actinides with mass less than 100 g per assembly are not listed except ^{241}Pu, which is fissile.

Table 1: Actinide Masses per PWR-2 Fuel Assembly (g)		
Isotope	Time since Reactor Discharge	
	25 Years (1999)	30 Years (2004)
^{235}U	484	484
^{238}U	219,000	219,000
^{239}Pu	1,110	1,110
^{240}Pu	409	410
^{241}Pu	80.6	63.3
^{241}Am	197	213

Note that the total fissile nuclide (^{235}U, ^{239}Pu, and ^{241}Pu) inventory is approximately 0.8 wt% of the total uranium. In addition, ^{240}Pu, a neutron absorber, constitutes approximately 25 wt% of the Pu. In addition, the reactivity decreases slowly with time overwhelmingly due to the decrease in ^{241}Pu.

The original CSAR (WHC 1990) analyzed this system in terms of the infinite multiplication factor (k_∞) for the blanket assemblies fully flooded with water at 25°C. Table 2 lists these results.

Table 2: Fuel Assembly Reactivity	
Assemblies	k_∞
Aggregate Blanket	0.89
Most Reactive (High Burnup) Blanket	0.91

Even if all of the fuel assemblies were high burnup assemblies the effective multiplication factor (k_{eff}) of the assemblies would be less than 0.91 due to neutron leakage. A more reactive state could be reached if the fuel were somehow separated from the zircaloy cladding and then arranged in the most reactive configuration, or if the fuel were to escape from the cladding and the pool were to have a mixture of sludge and fuel chunks at the bottom. However such a change of the physical state of the assembly is not considered credible, especially in light of the continued monitoring of the pool water for radioactivity.

A report on Shippingport operations (Atherton 1983) states, "Throughout core lifetime, the data from the defected element monitoring system indicates that no defects existed in any fuel element". Bradley, et. al. (Bradley, 1981) stated that "Data from current and past examinations were compared, and no significant degradation of the Zircaloy cladding was indicated after almost 21 yr. in water storage." These results are consistent with previous examinations by the same team (Johnson 1977).

reactor for 17 years. For more than 12 years the coolant temperature was above 200 °C in an irradiation environment. Even with these extreme conditions, localized attacking of the cladding was not observed.

If the integrity of the particular spent fuel assemblies in the 221-T canyon water pool were to degrade, the isotopes in the fuel, especially those that are most soluble would dissolve into the pool water. The most significant of these is cesium, which is rather soluble and is easily detectable due to its 0.662 MeV gamma ray emission. This γ-ray is actually due to its progeny, barium. The water in the storage cell is sampled and analyzed at least once each month. These samples are examined for the presence of ^{60}Co and ^{137}Cs-Ba . Data obtained from the T-Plant PWR-2 storage pool water sampling program have indicated no degradation in the confinement of the fuel. Concentrations of ^{137}Cs have remained constant at ~ 1×10^{-6} □Ci/ml.

4. Conclusions

The conclusions of the original analysis remain valid at this time. Past experience with zircaloy clad fuel has indicated that the integrity of the assembly can be expected for another ten years. The present water monitoring system offers sensitivity adequate for early detection of assembly degradation so that timely remediation can be affected.

5. References

Atherton, 1983, WAPD-335, *Shippingport Operations During PWR Core 2 Depletion (April 1965 to February 1974)*, R. Atherton and W. A. Budd, Bettis Atomic Power Laboratory, West Mifflin, Pennsylvania, 1983.

Bradley, 1981, PNL-3921, *Examination of Zircaloy-Clad Spent Fuel after Extended Storage*, Bradley, E. R. , Bailey, W. J. , Johnson, A. B., Jr., and Lowrey, L. M., Pacific Northwest Laboratory, Richland, Washington, 1981.

Hillner, 1980, WAPD-TM-1412, *Corrosion and Hydrating Performance Evaluation of Three Zircaloy-2 Clad Fuel Assemblies After Continuous Exposure in PWR Cores 1 and 2 at Shippingport, Pa.*, E. Hillner, Bettis Atomic Power Laboratory, West Mifflin, Pennsylvania, 1980.

Johnson, 1977, BNWL-2256/UC-70, *Behavior of Spent Nuclear Fuel in Water Pool Storage*, A. B. Johnson, Pacific Northwest Laboratory, Richland, Washington, 1977.

RHO, 1978, *RHO-MA-165, Criticality Prevention Specification 80.10-3, PWR Core 2 Blanket Fuel Storage Cell 4, 221-T Building*, Rockwell Hanford Operations, Richland, Washington, 1978. (This document is included in [WHC 1990]

WHC, 1990, WHC-SD-SQA-CSA-20153, *CSAR 78-001, PWR Core 2 Blanket Fuel Storage Cell4, 221-T Building*, R. L. Miller, Westinghouse Hanford Company, Richland, Washington, 1990.

WHC 1996 WHC-SD-WM-ES-394, Rev 0, *Removal Plan for Shippingport Pressurized Water Reactor Core 2 Blanket Fuel Assemblies from T Plant to the Canister Storage Building*, Westinghouse Hanford Company, Richland, Washington, 1996.

6. Technical Review

TECHNICAL PEER REVIEWS

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: HNF-4922
Title: Addendum to CSER 78-001: PWR Core 2 Blanket Fuel Storage Cell 4, 221-T Building
Author: Harvey J. Goldberg
Date: September 15, 1999
Scope of Review: Full Document

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

Jess Greenborg [signature]
Reviewer: (Printed and Signed)

Date 9/22/99

* 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.

Reviewer's Comments:

The reviewer agrees that the decay of the actinides in the Shippingport blanket fuel will continue to reduce reactivity. The reviewer also agrees that an additional 10 year storage of this material in the 221-T canyon water pool will not result in corrosion of significance and the material will remain in a safe state. Various reviewer comments have been resolved and incorporated.