HNF-7342
Revision 0

Waste Encapsulation and Storage Facility Waste Analysis Plan

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

Fluor Hanford
P.O. Box 1000
Richland, Washington

INFORMATION CLEARANCE FORM

A. Information Category

- [ ] Abstract
- [ ] Journal Article
- [ ] Summary
- [ ] Internet
- [ ] Visual Aid
- [ ] Software
- [ ] Full Paper
- [ ] Report
- [x] Other ______

B. Document Number HNF-7342

C. Title Waste Encapsulation and Storage Facility Waste Analysis Plan

D. Internet Address

E. Required Information

1. Is document potentially Classified? (✓) No ( ) Yes (MANDATORY)

X [signature] 12/5/00
Manager's Signature Required

If Yes ______ (✓) No ( ) Yes Classified
ADC Signature Required

2. Internal Review Required? (✓) No ( ) Yes
If Yes, Document Signatures Below

Counsel ______

Program ______

3. References in the Information are Applied Technology (✓) No ( ) Yes
Export Controlled Information (✓) No ( ) Yes

4. Does Information Contain the Following: (MANDATORY)

a. New or Novel (Patentable) Subject Matter? (✓) No ( ) Yes
If "Yes", Disclosure No.: ______

b. Information Received in Confidence, Such as Proprietary and/or Inventions?
(✓) No ( ) Yes If "Yes", Affix Appropriate Legends/Notices.

c. Copyrights? (✓) No ( ) Yes If "Yes", Attach Permission.

d. Trademarks? ( ) No (✓) Yes If "Yes", Identify in Document.

5. Is Information requiring submission to OSTI? (✓) No ( ) Yes
If Yes UC- ______ and B&R- ______

6. Release Level? (✓) Public ( ) Limited

7. Charge Code 8159-19

F. Complete for a Journal Article

1. Title of Journal

G. Complete for a Presentation

1. Title for Conference or Meeting ______
2. Group Sponsoring ______
3. Date of Conference ______
4. City/State ______
5. Will Information be Published in Proceedings? ( ) No ( ) Yes
6. Will Material be Handed Out? ( ) No ( ) Yes

H. Author/Requestor

X Fen M Simmons [signature] 12/6/00
(Print and Sign)

Responsible Manager

X Brian Oldfield [signature] 12/5/00
(Print and Sign)

I. Reviewers

	Yes	Print	Signature	Public Y/N (If N, complete J)
X General Counsel	[ ]	Leland F. Willis	[signature]	(Y) / N
Office of External Affairs	[ ]			Y / N
X DOE-RL	[ ]	Gregory L. Sinton	[signature]	(Y) / N
Other	[ ]			Y / N
Other	[ ]			Y / N

J. If Information Includes Sensitive Information and is not to be released to the Public indicate category below.

- [ ] Applied Technology
- [ ] Protected CRADA
- [ ] Personal/Private
- [ ] Export Controlled
- [ ] Proprietary
- [ ] Procurement-Sensitive
- [ ] Business-Sensitive
- [ ] Patentable
- [ ] Predecisional
- [ ] Other (Specify) ______
- [ ] UCNI

Information Clearance Approval

APPROVED FOR RELEASE
OFFICIAL DOCUMENT
cw
Date 12-11-00

K. If Additional Comments, Please Attach Separate Sheet

HNF-7342
Revision 0

Waste Encapsulation and Storage Facility Waste Analysis Plan

Date Published
December 2000

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

Fluor Hanford
P.O. Box 1000
Richland, Washington

Chris Willingham 12-11-2000
Release Approval Date

Printed in the United States of America

CONTENTS

ATTACHMENTS

FIGURES

TABLE

This page intentionally left blank.

GLOSSARY

°C	degrees Centigrade
CsCl	cesium chloride
$CsCO_3$	cesium carbonate
HNF	Hanford Nuclear Facility (document identifier)
SrF_2	strontium fluoride
$Sr(NO_3)_2$	strontium nitrate
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
WAC	Washington Administrative Code
WAP	waste analysis plan
WESF	Waste Encapsulation and Storage Facility

METRIC CONVERSION CHART

Into metric units			Out of metric units		
If you know	Multiply by	To get	If you know	Multiply by	To get
Length			**Length**		
inches	25.40	millimeters	millimeters	0.0393	inches
inches	2.54	centimeters	centimeters	0.393	inches
feet	0.3048	meters	meters	3.2808	feet
yards	0.914	meters	meters	1.09	yards
miles	1.609	kilometers	kilometers	0.62	miles
Area			**Area**		
square inches	6.4516	square centimeters	square centimeters	0.155	square inches
square feet	0.092	square meters	square meters	10.7639	square feet
square yards	0.836	square meters	square meters	1.20	square yards
square miles	2.59	square kilometers	square kilometers	0.39	square miles
acres	0.404	hectares	hectares	2.471	acres
Mass (weight)			**Mass (weight)**		
ounces	28.35	grams	grams	0.0352	ounces
pounds	0.453	kilograms	kilograms	2.2046	pounds
short ton	0.907	metric ton	metric ton	1.10	short ton
Volume			**Volume**		
fluid ounces	29.57	milliliters	milliliters	0.03	fluid ounces
quarts	0.95	liters	liters	1.057	quarts
gallons	3.79	liters	liters	0.26	gallons
cubic feet	0.03	cubic meters	cubic meters	35.3147	cubic feet
cubic yards	0.76456	cubic meters	cubic meters	1.308	cubic yards
Temperature			**Temperature**		
Fahrenheit	subtract 32 then multiply by 5/9ths	Celsius	Celsius	multiply by 9/5ths, then add 32	Fahrenheit
Energy			**Energy**		
kilowatt hour	3,412	British thermal unit	British thermal unit	0.000293	kilowatt hour
kilowatt	0.948	British thermal unit per second	British thermal unit per second	1.055	kilowatt
Force/Pressure			**Force/Pressure**		
pounds per square inch	6.895	Kilopascals	kilopascals	0.14504	pounds per square inch

Source: *Engineering Unit Conversions*, M. R. Lindeburg, PE., Second Ed., 1990, Professional Publications, Inc., Belmont, California.

WASTE ENCAPSULATION AND STORAGE FACILITY WASTE ANALYSIS PLAN

1.0 UNIT DESCRIPTION

The purpose of this waste analysis plan (WAP) is to document waste analysis activities associated with the Waste Encapsulation and Storage Facility (WESF) to comply with *Washington Administrative Code* (WAC) 173-303-300(1), (2), (3), (4), (5), and (6). WESF is an interim status other storage-miscellaneous storage unit. WESF stores mixed waste consisting of radioactive cesium and strontium salts. WESF is located in the 200 East Area on the Hanford Facility (Figure 1). Because dangerous waste does not include source, special nuclear, and by-product material components of mixed waste, radionuclides are not within the scope of this documentation. The information on radionuclides is provided only for general knowledge.

1.1 DESCRIPTION OF UNIT PROCESSES AND ACTIVITIES

Only waste stored in capsules identified in the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1999) milestone M-92-03 are stored at WESF. No waste has been received into WESF since the return of the capsules to meet M-92-03. Before receipt of any additional waste at WESF, a revision to this WAP will be required.

WESF (225B Building) is a two-story building constructed of steel reinforced concrete, is partitioned into seven hot cells, the hot cell service area, operating areas, building service areas and the pool cell area. The treatment, storage, and/or disposal (TSD) unit boundary includes only the hot cells F and G, along with pool cells 1 through 8 and 12 (Figure 2).

The seven hot cells are labeled A through G and activities within the hot cells are performed remotely using manipulators. Only hot cells F and G are active for cesium/strontium capsule storage. The pool cell area consists of 12 pools lined with stainless steel. Each pool is equipped with a monitoring system to detect any leakage from capsules. Pool cells 1 through 8 and 12 can be used for capsule storage and are filled with water to a depth of approximately 4 meters (13 feet). The water provides cooling and shielding for the capsules.

The waste is stored in capsules consisting of stainless steel containers that provide primary and secondary containment. The maximum outer containment height is approximately 53 centimeters (~21 inches) with a maximum diameter of approximately 8 centimeters (~3 inches).

Only one waste stream is managed at WESF, which consists of the cesium chloride (CsCl) and strontium fluoride (SrF_2) salts that are stored within the capsules in the pool cells.

Additional information is located in the WESF Part A, Form 3, in the *Hanford Facility Dangerous Waste Part A Permit Application* (DOE/RL-88-21).

1.1.1 Cesium Chloride (CsCl)

Cesium was separated in B Plant from high-level waste generated in the reprocessing of the spent fuel on the Hanford Site. This separation process, also known as fractionization, was performed to remove the high-heat producing isotope cesium (cesium-137) from the underground tank waste on the Hanford Site to reduce the heat burden to the underground tanks. The fractionization process at B Plant purified the cesium in the form of cesium carbonate ($CsCO_3$). The purified $CsCO_3$ was transferred to WESF and converted to CsCl by addition of hydrochloric acid. This CsCl solution was evaporated to a molten salt and encapsulated for long-term storage. The encapsulated salt contains dangerous waste chemical impurities from the fractionization process consisting of lead, barium, chromium, cadmium, and silver. Barium is generated continuously as a result of the cesium-137 decay chain.

1.1.2 Strontium Fluoride (SrF_2)

Strontium was separated at B Plant from waste generated in the reprocessing of the spent fuel. The fractionization process removed the high-heat producing isotope strontium (strontium-90) from the underground tank waste on the Hanford Site and purified the strontium-90 in the form of strontium nitrate [$Sr(NO_3)_2$]. The purified $Sr(NO_3)_2$ was transferred to WESF and converted to SrF_2 by the addition of sodium fluoride. The SrF_2 precipitate was filtered and dried at 800°C and encapsulated for long-term storage. The encapsulated salt contains dangerous waste chemical impurities from the fractionization process consisting of barium, lead, cadmium, chromium, and silver.

1.2 CONTAINER TYPES

The CsCl and SrF_2 salts are stored in three types of containers at WESF: cesium capsules, strontium capsules, and Type W capsules. Cesium is stored in both the cesium capsules and Type W capsules. Strontium is stored only in strontium type capsules.

1.2.1 Cesium Capsules

Two types of cesium capsules are stored at WESF. The standard cesium capsule consists of a double capsule configuration of a capsule placed inside another as shown in Figure 3. Both capsules are constructed of 316L stainless steel. The inner capsule dimensions are 5.7 centimeters (2.25 inches) in diameter by 50.1 centimeters (19.725 inches) long. The inner capsule has a nominal wall thickness of 0.24 centimeter (0.095 inch). The outer capsule is 6.7 centimeters (2.625 inches) in diameter by 52.8 centimeters (20.725 inches) long. The outer capsule has a nominal wall thickness of 0.28 centimeter (0.109 inch). There are a total of 1,312 standard cesium capsules in storage.

The Type W cesium capsule is a 316L stainless steel overpack used to contain standard cesium capsules that had swollen as a result of thermal cycling, cesium chloride that had been reconfigured into pencils or pellets for use as irradiators, or the contents of capsules that had been cut up for examination purposes. The Type W capsule is 8.3 centimeters (3.25 inches) in diameter by 55.4 centimeters (21.8 inches) long. The capsule has a nominal wall thickness of 0.32 centimeter (0.13 inch). There are a total of 23 Type W capsules in storage. Table 1 shows a breakdown of the Type W capsules and contents.

Table 1. Type W Capsules and Contents.

Capsule contents	Inner capsule	Outer capsule	Number of Type W
10 Nordian™[1] pencils from Oak Ridge, each containing CsCl originating from WESF	Yes	Yes	1
Cesium chloride powder and/or pellets from Oak Ridge	Yes	Yes	2
304L stainless steel type 4 containers from Oak Ridge containing CsCl originating from WESF	No	No	1
Remnants from destructive testing of WESF capsules	No	Yes	3
Swollen WESF capsules returned from commercial irradiators	Yes	Yes	16
Total			23

The salts encapsulated in the Nordian™ pencils, powder and pellets, and Type 4 canisters were washed (Attachment 1) at Oak Ridge to remove impurities.

Compatibility and corrosion of 304L versus 316L SS was evaluated and determined to be acceptable for storage at WESF (Attachment 2).

1.2.2 Strontium Capsules

Two types of material are used to encapsulate the SrF_2. Like the standard cesium capsule, the strontium capsule consists of a capsule within a capsule as shown in Figure 4. The inner capsule is Hastelloy C-276[2]. The outer capsule for all strontium capsules is 316L stainless steel. These two metals are compatible in terms of galvanic corrosion in that the metals are within the same range in the galvanic series and are not exposed to an electrically conducting solution (Chemical Engineer's Handbook). The inner capsule is 5.7 centimeters (2.25 inches) in diameter by 48.4 centimeters (19.05 inches) long. The outer capsule is 6.7 centimeters (2.625 inches) in diameter by 51.1 centimeters (20.1 inches) long. There are a total of 601 standard strontium capsules in storage.

1.3 STORAGE CONDITIONS

WESF is permitted for storage of the capsules in either the hot cells or the pool cells. There are 1,936 capsules currently stored in the pool cells at WESF. All of the capsules are stored in the pool cells under 4 meters (13 feet) of water for shielding and cooling. Leak detection for the capsules consists of an online monitoring system. A monitor is in place on the circulation line for each pool cell. The monitoring system is calibrated to detect cesium-137 at 1.74 becquerels per milliliter (47.2×10^{-6} microcuries per milliliter) and strontium-90 at 0.87 becquerels per milliliter (23.6×10^{-6} microcuries per milliliter). This equates to 0.28 parts per trillion or 3.2×10^{-3} parts per trillion respectively for the associated dangerous waste constituent barium in the cesium and strontium salts.

---

[1] Trademark of MDS Nordian, Inc. Kanata, Ontario, Canada.
[2] Trademark of Haynes International, Inc., Kokomo, Indiana.

1.4 IDENTIFICATION OF WASTE

The Part A, Form 3, permit application for WESF (DOE/RL-88-21) identifies dangerous waste numbers, quantities, and design capacity. Waste numbers were assigned based on process knowledge that included previously obtained sampling and analysis results and process flow sheet specifications of WESF waste.

2.0 CONFIRMATION PROCESS

WAC 173-303-300 (3) and 300(6) require information be obtained, documented, and/or reported regarding waste accepted into WESF. All of the waste in storage at WESF originated at WESF. WESF does not receive waste from an offsite facility; therefore, no additional information or analysis is required to meet WAC 173-303-300(3) and 300(6). Any additional waste accepted into WESF will require a revision to this WAP.

3.0 SELECTING WASTE ANALYSIS PARAMETERS

Capsules have been stored in WESF since 1974. The parameter for safe storage of the capsules is corrosion of the containers from contact with impurities contained in the cesium and strontium salts. Studies were completed by Pacific Northwest National Laboratory confirming safe storage of the capsules through 2017 under current storage conditions (PNL-5170 and BNWL 1967). The information from these studies along with the following information meets the intent of WAC 173-303-300(5a) and (b). WAC 173-303-610(4)(d) does not apply to WESF.

Impurities in the cesium salt are estimated as listed in PNL-5170. The following data were taken on cesium feed solution and salt analyzed for corrosion analysis. Concentrations are listed as weight percent solids. Silver was added from process knowledge.

Element	Cesium feed solution Wt%	Salt analysis Wt%
Al	1.7	.14
B	--	.14
Ba	.94	.55
Ca	1.	--
Cd	--	.02
Co	--	.1
Cr	.27	1.4
Fe	.38	--
K	.79	.68
Mg	.25	.68
Na	.70	2.8
Ni	.33	.1
Pb	1.4	.14
Rb	.52	--
Si	7	.21
Sr	.18	.02
Ti	--	.02
Zn	--	.03

Impurities in the cesium salts washed at Oak Ridge are listed in HNF-2928 "Certification that CsCl Powder and Pellet Materials Meet WESF Acceptance Criteria". The concentrations are listed as follows by weight percent.

Element	Wt%
Al	.68
B	5.17
Ba	2.98
Ca	.68
Cu	.02
Fe	.04
K	1.21
Mg	.04
Mo	.009
Na	7.76
Ni	.01
Si	2.59
Sr	.01
Zn	.03

Impurities in the strontium salt are estimated as listed in BNWL-1967 "The Containment of $^{90}SrF_2$ at 800°C to 1100 °C Preliminary Results" Battelle 1975. The data listed are estimates based on process flowsheet information. The concentrations are listed in weight percent.

Element	Probable concentration (Wt %)
Al	<0.5
Ba	0.1-2.0
Ca	<0.1
Cd	<0.2
Cr	<0.1
Cu	<0.1
Fe	<0.01
H	<0.1
K	0.05-0.5
Mg	<0.1
Mn	<0.01
N	1-4
Na	<0.1
Ni	<0.05
Pb	<0.2
R(as in Rare Earths)	<2.0
Si	<0.02

This review meets the requirements of WAC 173-303-300(1) and (2) for WESF waste. This review confirms knowledge concerning waste before storage to ensure that the waste is managed properly.

In addition, a certified database is maintained in the operating record that contains information on each capsule from its origin to present storage location. The database is updated annually.

4.0 SAMPLING PROCESS

Periodic re-analysis of WESF waste managed in the WESF Storage Units based on WAC 173-303-300(5)(d), is not planned because the containers are sealed and no changes can be made to the salts. Therefore, WAC 173-303-300(4)(a) is not applicable to WESF waste.

The capsules are sealed containers whose constituents have been determined via the confirmation process in Section 2.0. No additional waste is planned or scheduled for storage at WESF. Therefore, requirements of WAC-173-303-300(5c),(d), (e), and (g) do not apply.

No additional requirements are specified in WAC 173-303-400(3); therefore, WAC 173-303-(5)(f) does not apply.

WESF is not a surface impoundment; therefore, WAC 173-303-300(5)(h) does not apply.

An exemption to the air emission standards of Subpart CC in accordance with Section 264.1082 or with 265.1083 is not being requested; therefore, WAC-173-303-300(5)(i) does not apply.

5.0 RECORDKEEPING

Records for WESF are maintained as described in WAC 173-303-380.

6.0 REFERENCES

BNWL-1967, 1975, "The Containment of $^{90}SrF_2$ at 800°C to 1100°C Preliminary Results", Battelle Northwest Laboratory, Richland, Washington.

DOE/RL-88-21, *Hanford Facility Dangerous Waste Part A Permit Application*, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Ecology, EPA, and DOE-RL, 1999, *Hanford Federal Facility Agreement and Consent Order*, Washington State Department of Ecology, U.S. Environmental Protection Agency, U.S. Department of Energy, Richland Operations Office, Olympia, Washington, amended periodically.

HNF-2928, 1998, "Certification that CsCl Powder and Pellet Materials Meet WESF Acceptance Criteria", B&W Hanford Company, Richland, Washington.

PNL-5170, 1984, "A Review of Safety Issues that Pertain to the Use of WESF Cesium Chloride Capsules in an Irradiator", Pacific Northwest Laboratory, Richland, Washington.

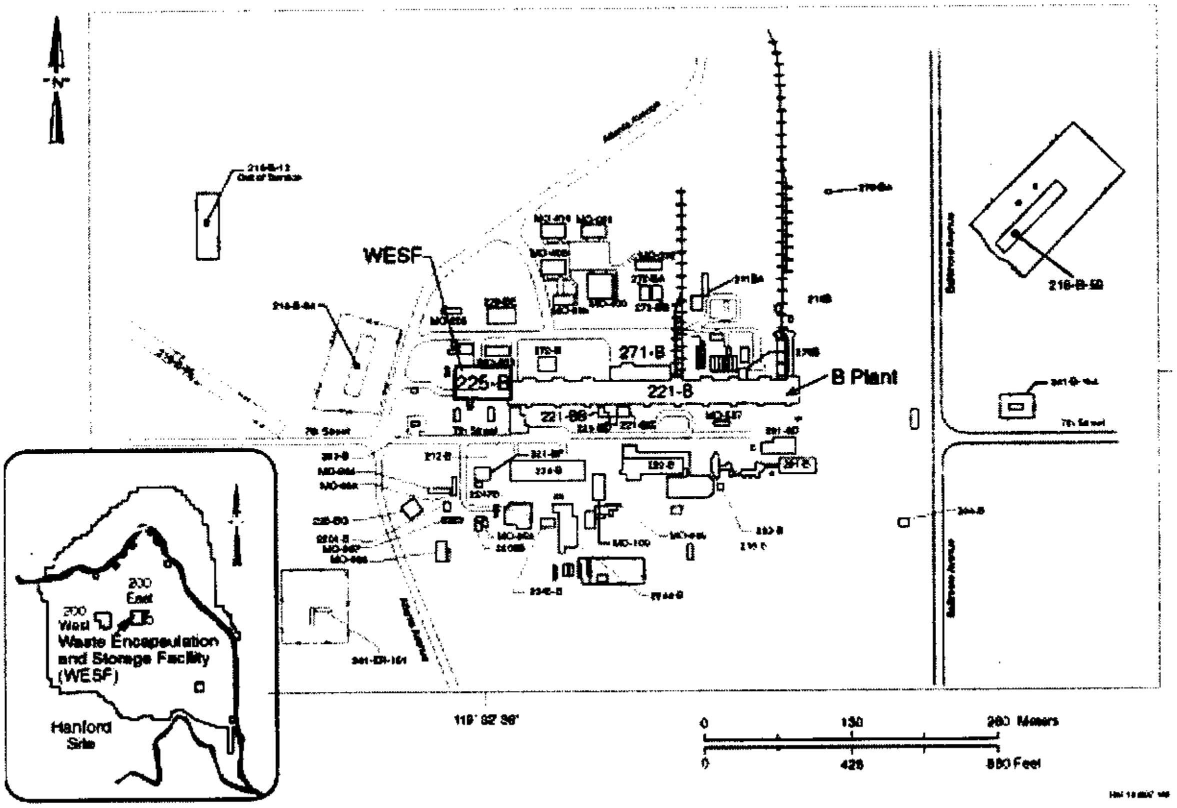

Figure 1. 200 East Area.

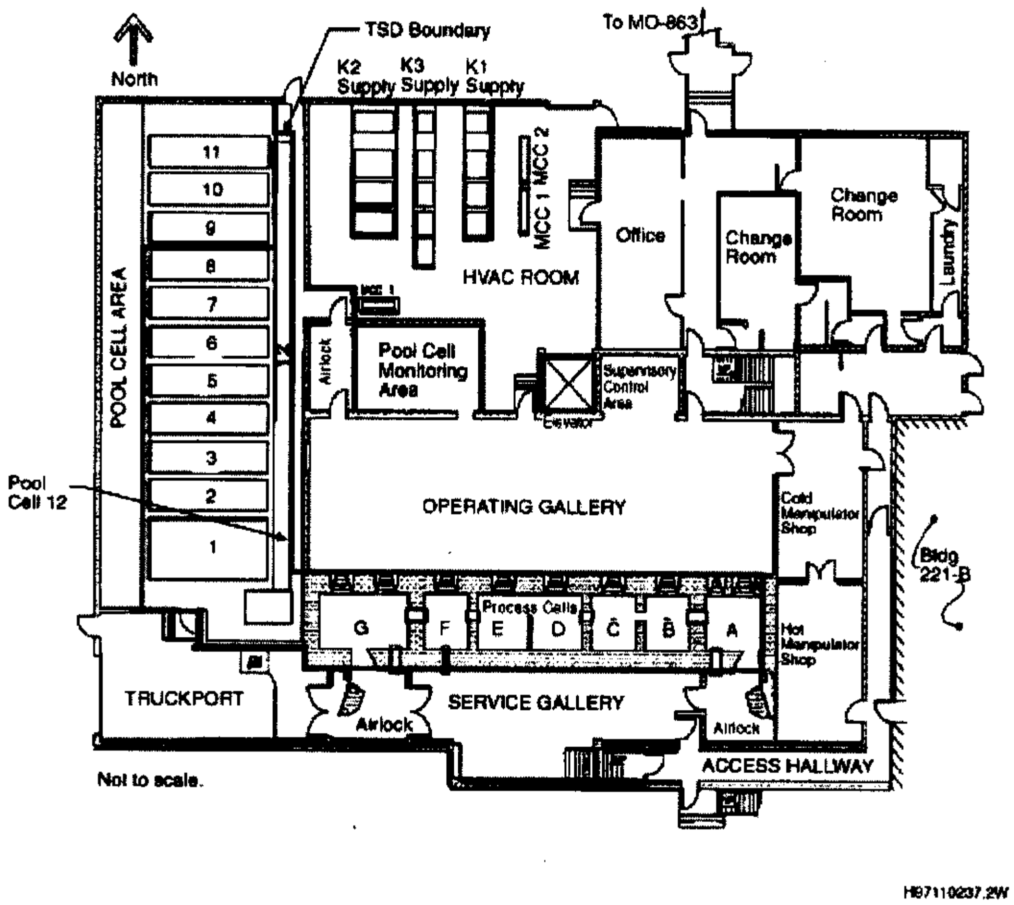

Figure 2. Waste Encapsulation and Storage Facility Treatment, Storage, and/or Disposal Boundaries.

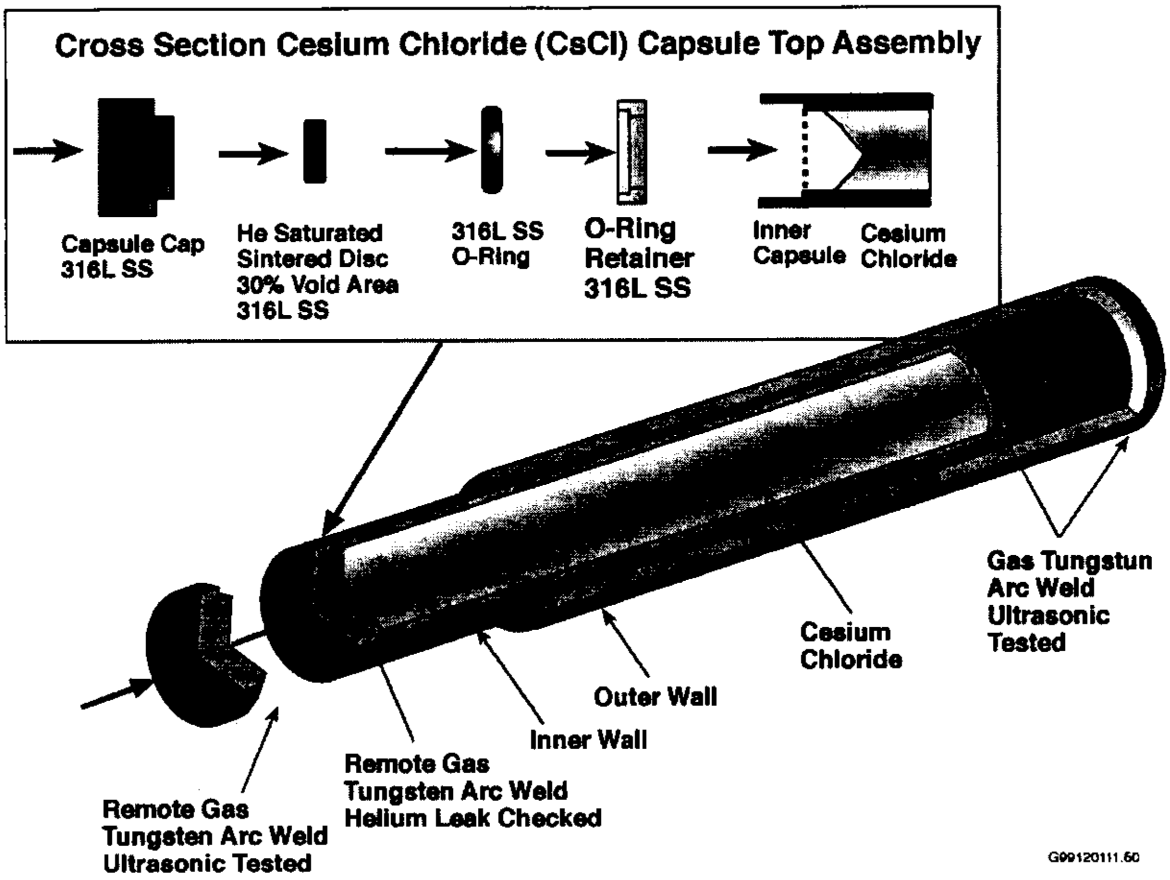

Figure 3. Standard Cesium Capsule.

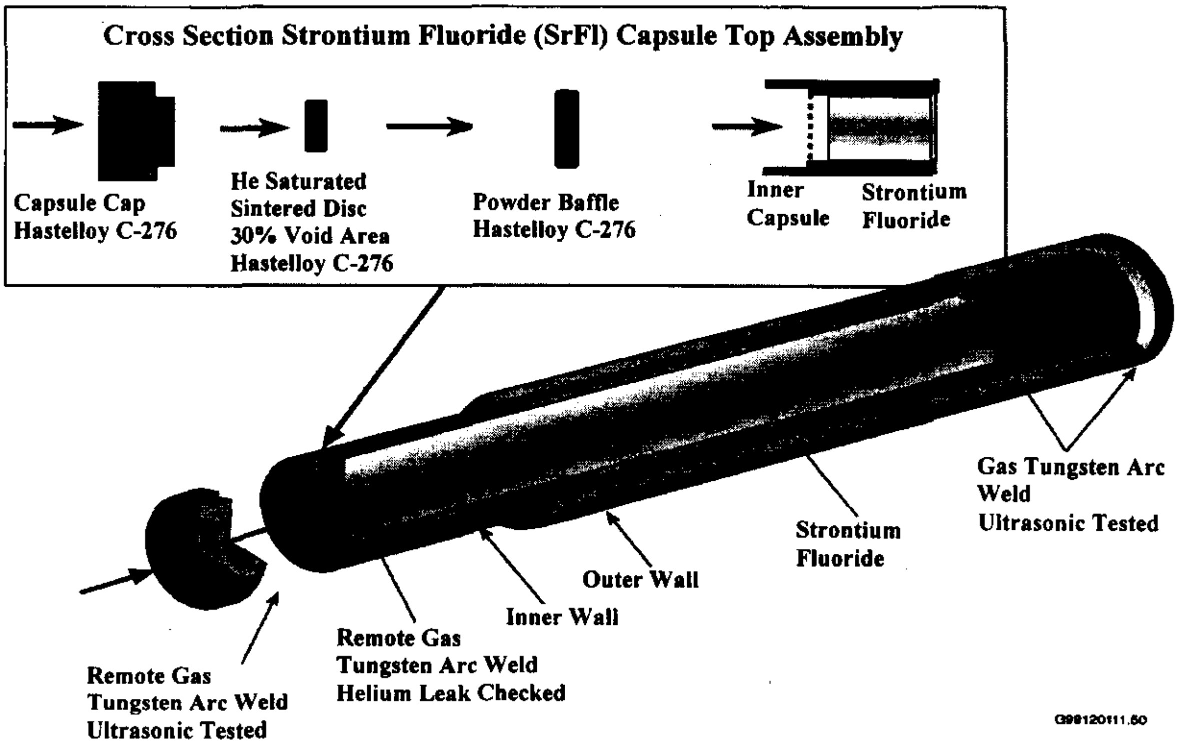

Figure 4. Standard Strontium Capsule.

ATTACHMENT 1

CERTIFICATION THAT CsCl POWDER AND PELLET MATERIALS MEET WESF ACCEPTANCE CRITERIA

This page intentionally left blank.

JUN 30 1998

Sta. 37-73 **ENGINEERING DATA TRANSMITTAL**

Page 1 of 1

1. EDT 625231

2. To: (Receiving Organization) Distribution	3. From: (Originating Organization) BWHC/324 Facility	4. Related EDT No.: 623079
5. Proj./Prog./Dept./Div.: 300 Area Stabilization Project	6. Design Authority/ Design Agent/Cog. Engr.: SD Landsman	7. Purchase Order No.: NA
8. Originator Remarks: Certification that CsCl powder and pellet materials meet WESF acceptance criteria		9. Equip./Component No.: NA 10. System/Bldg./Facility: 324 Building
11. Receiver Remarks: 11A. Design Baseline Document? [ ] Yes [X] No NA		12. Major Assm. Dwg. No.: NA 13. Permit/Permit Application No.: NA 14. Required Response Date: 6-30-98

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-2928	All	0	Certification That CsCl Powder and Pellet Materials Meet WESF Acceptance Criteria	E/Q	1/2	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	1	Design Authority MN Pereira [signature] 6/25/98 S6-51	1	1	TG Beam [signature] 6/25/98 S6-51
		Design Agent N/A	3	N/A	F.N. Simmons S6-51
1	1	Cog.Eng. SD Landsman EJB for SDL 6/25/98 L1-02			
1	1	Cog. Mgr. EJ Bitten [signature] 6/25/98 L1-02			
1	1	QA DH Sandoz [signature] 6-25-98 L1-06			
		Safety NA			Central Files B1-07
1	1	Env. DE Rasmussen [signature] 6/25/98 L1-04			

18.	19.	20.	21. DOE APPROVAL (if required)
[signature] 6/29/98 Signature of EDT Originator Date	[signature] 6/25/98 Authorized Representative for Receiving Organization Date	[signature] 6/25/98 Design Authority/ Cognizant Manager Date	Ctrl. No. N/A ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments

BD-7400-172-2 (05/96) GEF097

BD-7400-172-1

HNF-2928, Rev. 0

Certification That CsCl Powder and Pellet Materials Meet WESF Acceptance Criteria

SD Landsman
BWHC, Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

EDT/ECN: 625231 UC: 2000
Org Code: 19350 Charge Code: K4C21
B&R Code: EW7050000 Total Pages: ~~10~~ 11 V.B.

Key Words: Certification, CsCl Powder and Pellet Materials, WESF Acceptance Criteria

Abstract: This document describes the CsCl legacy material created by the Cesium Encapsulation Program (CEP) is acceptable for storage at WESF.

JUN 30 1998
DATE: HANFORD
STA: RELEASE ID:
37 73

V. L. Birkland 6/29/98
Release Approval Date Release Stamp

Approved for Public Release

A-6400-073 (01/97) GEF321

Certification That the CsCl Powder and Pellet Material Meets WESF Acceptance Criteria

This report documents that the CsCl that will be encapsulated into Inner Containers, WESF Outer Capsules, and WESF Type "W" Overpacks prior to shipping to WESF for long term storage is consistent with the material currently stored in the WESF pool cells. Process knowledge, analytical data, shipping records, and recent characterization smears obtained from South Cell are used as the basis for this conclusion. This letter describes the condition of the cell in which the CsCl, collectively called powder and pellets, was handled and the environment to which it has been exposed, the containers in which the powder and pellets have been stored to date, and the physical form and purity of the CsCl comprising the powder and pellets. The powder and pellets are legacy material created by the Cesium Encapsulation Program (CEP) and destructive analysis of two WESF capsules.

Storage Container Description

The CsCl powder and pellets are stored in release resistant containers. These containers are mechanically closed with a metallic seal. Although the release resistant container is not a special form or normal form container, it is a strong tight container. The containers housing the powder and pellets have not been involved in accidents, have not been dropped, and have not been subjected to chemically harsh environments. In October 1996 a visual inventory of the containers was performed and the powder and pellets were transferred to new release resistant containers. The containers are currently stored in D Cell in a shielded box fabricated specifically for storage of the CsCl. Prior to encapsulation of the powder and pellets, the containers will be returned to South Cell where they will be opened.

Description of CsCl

The CsCl to be packaged for shipment to WESF consists of caked powder, pelletized powder, chunks, and singly-encapsulated pellets. There are two distinct groups of material comprising the powder and pellets: material recovered from the destructive analysis of two WESF capsules (C-1502 and C-1550) and material that was purified for use in the Cesium Encapsulation Program (CEP). During packaging of the powder and pellets for shipment to WESF, separation of the two groups of material will be maintained.

The first group of CsCl is the residual material resulting from the destructive analysis of capsule C-1502, which leaked CsCl at RSI-Atlanta. This project is described in the draft report "Destructive Examination Program Cesium Capsule C1502 Report" by Oakley, Tingey, and Tingey (Attachment 1). The analysis involved removing the WESF

Outer Capsule and sectioning the WESF Inner Capsule, including the CsCl. Prior to sectioning of C-1502, C-1550 (a "sister" capsule to C-1502) was sectioned as practice. Sectioning of C-1502 occurred on September 29, 1992. After sectioning, the chunks of CsCl (approximately 80,000 Ci) were placed into release resistant containers and sealed.

The second group of CsCl is legacy material from the CEP. This physical form of this material is 13,400 Ci of pelletized CsCl (two sizes of pellets: 1-3/8" diameter x 5/8" and 5/16" diameter x 5/16") in release resistant containers, 10,800 Ci of powder in an unopened Type 4 shipping container (this material is presumed to be caked into a solid block), and 4400 Ci of small pellets in 10 singly-encapsulated Nordian capsules. Work with CsCl in South Cell in support of the CEP was initiated on October 9, 1991 and prematurely terminated on April 22, 1992. All handling of the CEP CsCl was performed in South Cell Compartment 1; the material has been stored in release resistant containers since the program was terminated. Material involved with the CEP was purified at Oak Ridge prior to shipment to the Shielded Materials Facility (SMF). Consequently, the CsCl associated with the CEP is purer than the CsCl that is encapsulated and stored at WESF. This material will be maintained and packaged separately from the material generated during destructive analysis of the WESF capsules.

Handling Cell Description

The SMF South Cell Compartment 1 was used for all handling activities associated with the powder and pellets. Compartment 1 was constructed in South Cell when the dose rates were low enough to allow personnel entry into the cell. Historically, South Cell has remained an alpha-free cell. As a result of the CEP, the dose rates in South Cell now average 11 rem/h and the dose rates in compartment 1 are 11,000 rem/h, all from CsCl contamination. Handling of unclad fuel or other material containing dispersible alpha-emitting radionuclides has not occurred in any of the compartments or in South Cell proper. A detailed contamination survey was performed in May 1989 which verified the SMF is free of alpha contamination. (Reference HNF-2849)

Comparison with WESF CsCl

The CsCl from Capsules C-1502 and C-1550 is consistent with the CsCl currently stored at WESF. Analytical data obtained as part of the CEP demonstrates that the CsCl from this program is of higher purity than WESF CsCl because the CsCl was water-washed at Oak Ridge National Laboratory (ORNL) prior to its shipment to the SMF. The analytical report for CsCl batch C-1542, which comprises the powder and pellets, is provided in Attachment 2 and demonstrates that material processing at ORNL reduced the amount of contaminants in the CsCl and did not add other contaminants. Therefore, the powder and pellets are bounded by the current WESF corrosion studies and associated design basis.

The CsCl powder and pellets originated from WESF and was shipped to the SMF either via ORNL (material from the CEP) or directly (remnants from destructive examination). The shipping records for C-1502 and C-1550 are provided in Attachment 3. No foreign material was added to this material and the contamination in Compartment 1 was a result of the CEP and the two destructive analyses; the remainder of South Cell has been maintained as an alpha-free facility. Consequently, no other radionuclide or form of Cs could have contaminated the CsCl. Recent characterization smears taken in South Cell have verified that the entire SMF is free of alpha-emitters (HNF-2849) and that waste removed from these cells would not be designated as TRU waste. Therefore, the powder and pellets, including the remnants from destructive examination of two WESF capsules, is consistent with WESF CsCl and is within the WESF Part A permit.

Conclusion

Based on process knowledge and the data provided in this report, it can be concluded that the CsCl powder and pellets are consistent with the material currently stored at WESF. In addition, process knowledge and the SMF characterization study demonstrate that the material is not contaminated with alpha contamination. Therefore, the powder and pellet material is bounded by the WESF corrosion studies and associated design basis and the material is not TRU waste. Storage of this material at WESF will not violate the WESF safety basis and is covered by the WESF Part A permit.

Attachment 1
HNF-2928, Rev. 0

DESTRUCTIVE EXAMINATION PROGRAM

CESIUM CAPSULE C1502 REPORT

David J. Oakley
Garth L. Tingey
Joel M. Tingey

December 1993

Prepared for

----
under Contract ----------

Battelle, Pacific Northwest Laboratories
Richland, Washington 99352

Attachment 2
HNF-2928, Rev. 0

7

ICP Analysis Report
K.E. Ard

Date Analyzed: 03/18 1992
Date Reported: 04/02 1992
Procedure: PNL-ALO-211
MT&E: WA55672

File: ICP5174c

Analyst: [signature]
Reviewer: [signature]

Acceptance Criteria
HS-V-C-4022 /Rev. B P. 3.8.7
Fe < 3% 80% CsCl

			Control Standard	
ALO Log#:		92-5174	ICV-1(690)	
Sample ID:		C1542-1	xx	True
ICP Run#:		479	1	1
Dilution:		8223	(ug/mL)	(ug/mL)
	(D.L.)	(ug/g)		
Ag	0.015		0.48	0.50
Al	0.11	6793	2.05	2.17
As	0.11			
B	0.02	51719		
Ba	0.003	29822	2.01	2.04
Be	0.001		0.51	0.51
Ca	0.01	6831	45.90	51.52
Cd	0.007		0.50	0.50
Ce	0.21			
Co	0.27		0.53	0.52
Cr	0.01		0.50	0.51
Cu	0.005	161 *	0.50	0.52
Dy	0.015			
Fe	0.01	431	1.99	2.04
K	0.5	12063	50.05	52.07
La	0.02			
Li	0.015			
Mg	0.01	435	24.53	25.75
Mn	0.003		0.50	0.52
Mo	0.01	85 *		
Na	0.25	77597	49.53	51.36
Nd	0.11			
Ni	0.025	849	0.50	0.50
Pb	0.08		4.98	5.14
Re	0.02			
Rh	0.13			
Ru	0.05			
Sb	0.4			
Se	0.12			
Si	0.07	25867		
Sr	0.0015	97 *		
Te	0.08			
Th	0.15			
Ti	0.01			
Tl	2			
U	1.5			
V	0.01		0.51	0.51
Zn	0.007	324	3.28	3.32
Zr	0.11			
P	1			

Total 212,731 ppm

Fe = 431 ppm / 10,000
= .0043 % < 3%

Total Impurity Conc. 212,731 ppm / 10,000
= 21.3% ⇒ 78.7% CsCl
Ref. NCR B02535

Note: 1) Values reliable to 2 1/2 significant digits.
2) Starred results (*) are qualitative only.
3) Sample results have not been adjusted for "blank" contribution.
4) At 50-100 times the D.L., precision is estimated at +/-10% and accuracy at +/-15%.
5) Calibration overrange on Ca and Mg for ICV-1. Results for information only.

Data, including calibration/QC, archived File ICP-325-601 (3/18/92)

Attachment 3
HNF-2928, Rev. 0

5/14/98 Cesium Capsule C-1550

Outer Capsule ID: C-1550
Inner Capsule ID: C-1434
Production #: 82-23
Calibration Date: 8/31/82
Capsule Type: 3
Double Capsule: YES
Capsule Age: 187
Gross Wt.: 8.762
Net Wt.: 2.692
Tare Wt.: 6.070
Melter Location: 4
Pour Temperature: 737
Pour Date: 7/20/82
Pool Cell Date: 9/01/82
PC Location: SHIP/CUT
Original KCi: 56.40
Original Wattage: 270.70
Curies per gram: 15
Wattage Decayed: 188.88
Watt Decay Date: 5/01/98
KCi Decayed: 39.35
KCi Decay Date: 5/01/98
Wattage per gram: 70
Gram Salt: 2.905
Remarks: SHIPPED TO PNL 2-28-90. CAPSULE CUT. LOOSE SALT
Remarks2:
QC Initials: CNH
OP Initials: RLJ
Destination: PNL-CUT
Date Shipped: 2/28/90
Date Updated:
DSI Number:

6/25/98 C-1502
Page 1

Outer Capsule ID: C-1502
Inner Capsule ID: C-1438
Production #: 82-23
Calibration Date: 7/23/82
Capsule Type: 3
Double Capsule: YES
Capsule Age: 191
Gross Wt.: 9
Net Wt.: 3
Tare Wt.: 6
Melter Location: 5
Pour Temperature: 737
Pour Date: 7/20/82
Pool Cell Date: 7/27/82
PC Location: SHIP/CUT
Original KCi: 56
Original Wattage: 268
Curies per gram: 14
Wattage Decayed: 186
Watt Decay Date: 7/01/98
KCi Decayed: 39
KCi Decay Date: 7/01/98
Wattage per gram: 69
Gram Salt: 3
Remarks: SHIPPED TO RSI, ATLANTA 01-22-86. SHIPPED TO ORNL 12-20-88
Remarks2: SHIPPED TO PNL. LEAKER. CUT OPEN 9-29-92
QC Initials: CNH
OP Initials: RLJ
Destination: RSI-A/OR/PNL/CUT
Date Shipped: 1/21/86
Date Updated:
DSI Number:

DISTRIBUTION SHEET

To	From	Page 1 of 1
Distribution	BWHC/324 Facility	Date 06/29/98
Project Title/Work Order		EDT No. 625231
Certification That CsCl Powder and Pellet Materials Meet WESF Acceptance Criteria/K4C21		ECN No.

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
MM Pereira	S6-81				
SD Landsman	L1-02				
EJ Bitten	L1-02				
DH Sandoz	L1-06				
DE Rasmussen	L1-04				
TG Beam	S6-51				
FN Simmons	S6-51				
SH Norton	L1-02				
GO Hayner	L5-65				
DW Templeton	R3-79				
Central Files	B1-07				

A-6000-135 (01/93) WEF067

This page intentionally left blank.

ATTACHMENT 2

CERTIFICATION THAT UNOPENED TYPE 4 CONTAINER OF CsCl IS ACCEPTABLE FOR PACKAGING DIRECTLY INTO TYPE W OVERPACK

This page intentionally left blank.

AUG 27 1998 22
Sta 37

ENGINEERING DATA TRANSMITTAL

Page 1 of 1
1. EDT 625234

2. To: (Receiving Organization) Distribution	3. From: (Originating Organization) BWHC/324 Facility	4. Related EDT No.: NA
5. Proj./Prog./Dept./Div.: 300 Area Stabilization Project	6. Design Authority/ Design Agent/Cog. Engr.: MM Pereira	7. Purchase Order No.: NA
8. Originator Remarks: Certification that unopened Type 4 container of CsCl is acceptable for packaging directly into Type "W" overpack.		9. Equip./Component No.: NA 10. System/Bldg./Facility: 324/WESF
11. Receiver Remarks: NA	11A. Design Baseline Document? [ ] Yes [X] No	12. Major Assm. Dwg. No.: NA 13. Permit/Permit Application No.: NA 14. Required Response Date: 07-30-98

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 Desig-nator	(G) Reason for Trans-mittal	(H) Origi-nator Dispo-sition	(I) Receiv-er Dispo-sition
1	HNF-3108	All	0	(same as 8)	E/Q	1/2	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	1	Design Authority MM Pereira [signature] S6-81	3	1	FN Simmons [signature] 7/31/98 S6-51
		Design Agent N/A	~~1~~		~~TC Beam~~ [signature] 8/20/98 S6-51
1	1	Cog.Eng. SD Landsman [signature] for SDL L1-02			Central Files B1-07
1	1	Cog. Mgr. EJ Bitten [signature] 7/29/98 L1-02	1	1	W.F. Bratm [signature] 8-26-98 N2-56
1	1	QA DK Sandoz [signature] for 8/26/98 L1-06			
		Safety			
1		Env. DE Rasmussen [signature] 8/26/98 L1-04			

18.	19.	20.	21. DOE APPROVAL (if required)
[signature] 9/8/98 Signature of EDT Originator / Date	[signature] 9/9/98 Authorized Representative for Receiving Organization / Date	[signature] 9/9/98 Design Authority/ Cognizant Manager / Date	Ctrl. No. [] Approved [] Approved w/comments [] Disapproved w/comments

BD-7400-172-2 (05/96) GEF097

BD-7400-172-1

HNF-3108, Rev. 0

304L Stainless Steel Resistance to Cesium Chloride

C. E. Graves
BWHC, Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

EDT/ECN: 625234 UC: 2000
Org Code: 19350 Charge Code: K4C21
B&R Code: EW7050000 Total Pages: 61 *cw 8-27-98*

Key Words: Cesium Chloride, Type 4 Canister, WESF Inner Capsule

Abstract: Certification that unopened Type 4 container of CsCl is acceptable for packaging directly into Type "W" overpack.

AUG 27 1998
DATE:
HANFORD RELEASE
STA: 31
ID: 22

Christine Willingham 8-27-98
Release Approval Date

Release Stamp

Approved for Public Release

A-6400-073 (01/97) GEF321

304L STAINLESS STEEL RESISTANCE TO CESIUM CHLORIDE

August 1998

Prepared by

C. E. Graves
Fluor Daniel Northwest
Richland, Washington

TABLE OF CONTENTS

ABBREVIATIONS / ACRONYMS

ALARA	As Low As Reasonably Achievable
C	carbon
Cd	cadmium
Cl	chlorine
Cr	chromium
CsCl	cesium chloride
Fe	iron
H	hydrogen
in.	inch
μm	micron (10^{-6} m)
Mn	manganese
Mo	molybdenum
Ni	nickel
O	oxygen
ORNL	Oak Ridge National Laboratory (Oak Ridge, Tennessee)
P	phosphorus
PNNL	Pacific Northwest National Laboratory
SEM	Scanning Electron Microscopy
Si	silicon
SS	stainless steel
WESF	Waste Encapsulation and Storage Facility

304L STAINLESS STEEL RESISTANCE TO CESIUM CHLORIDE

1.0 INTRODUCTION

B&W Hanford Company have two Oak Ridge National Laboratory (ORNL) Type 4 canisters filled with cesium chloride (CsCl) originally produced at WESF (Waste Encapsulation and Storage Facility). These canisters are constructed of 304L stainless steel per drawing ORNL 970-294. Instead of removing the CsCl from the Type 4 canisters and repacking into an Inner Capsule, it is intended (for ALARA, schedule and cost purposes) that the Type 4 canisters be decontaminated (scrubbed) and placed [whole] inside a Type "W" overpack. The overpack is constructed from 316L stainless steel.

Several tests have been run by Pacific Northwest National Laboratory (PNNL) over the years documenting the corrosion compatibility of 316L SS with CsCl (Bryan 1989 and Fullam 1972). However, no information for 304L SS compatibility is readily available. This document estimates the corrosion resistance of 304L stainless steel in a WESF CsCl environment as it compares with that of 316L stainless steel.

2.0 316L SS CORROSION RESISTANCE TO CsCl

Fullam (1972) extrapolated his short-term compatibility data to indicate the attack of 316L SS by CsCl waste at 400 °C (750 °F) over a 600 year period should not exceed 635 μm (0.025 in.). Visual inspection of photomicrographs showed little evidence of intergranular penetration but some pitting and subsurface void formation was present. Carbide precipitation was evident near the sample surface and along grain boundaries. The extent of the carbide precipitation increased with time at temperature.[†]

Bryan (1989) conducted long term (6 year) tests with WESF canisters to try to obtain more reliable estimates on the long-term corrosion resistance of 316L SS to CsCl at 450 °C (840 °F). His examination of photomicrographs also showed subsurface void formation and carbide precipitation (again, the number of precipitates increased with time at temperature).

[†] The presence of carbide precipitates reduces the corrosion resistance of the stainless steel at the grain boundaries.

Thermodynamic calculations by Bryan (1989) indicate that pure CsCl should not react with 316L SS at the test temperatures, however, certain impurities in the CsCl could react with the 316L SS. Possible impurities that could react include the less stable chlorides, such as $FeCl_2$, $NiCl_2$, and $CdCl_2$, and the less stable oxides such as Fe_3O_4, NiO and H_2O. In trying to identify the reactions, samples were analyzed by SEM (scanning electron microscopy). Bryan concludes that the only reaction that could be identified with any certainty was the leaching of Mn from the 316L SS in the reaction zone.

If impurities in the CsCl are the principal cause of corrosion, the extent of reaction should be limited by the amount of impurities available to react with the 316L SS components. The corrosion rate would initially be high and then decrease with time as the impurities are consumed. The rate controlling step for each reaction is likely to be the diffusion of the impurity reactant from the bulk CsCl to the metal/CsCl interface (Bryan 1989). If a liquid phase is present, it could accelerate this diffusion.

Bryan tabulated the effect of impurities on the phase transition temperature and melting point of CsCl (1989, pg A.17). The impurity with the greatest effect is iron. For a CsCl + 3% $FeCl_3$ system the minimum melting point is 270 °C (520 °F); melting began before a phase transition temperature could be detected. This falls well below the test temperature, thus a liquid phase would be present.

When pure molten CsCl is poured into a 316L SS capsule and allowed to solidify, the solid mass does not adhere to the wall (void spaces are formed as the mixture cools and collapses). Bryan (1989) hypothesizes that impurities cause some of the CsCl to adhere to the capsule wall. Thus, corrosion in areas where there is no CsCl/steel contact should be much less than in contact areas. If samples were [inadvertently] taken in areas of no contact, this theory could help to explain some of the data scatter in previous studies.

3.0 DISCUSSION

304L and 316L SS are both austenitic stainless steels with similar compositions (see Table 1). The lower carbon values (versus 304 and 316) improve corrosion resistance in welded structures (ASM 1990). The addition of molybdenum in 316L SS increases the steel's resistance to the initiation of pitting and crevice corrosion (ASM 1990). Both of these alloys are used extensively in the nuclear industry.

Table 1: Stainless Steel Compositions (ASM 1990, pg 843)

Type	Composition, wt.% (Remainder is Fe)							
	C	Mn	Si	Cr	Ni	P	S	Mo
304L	0.03	2.00	1.00	18 - 20	8 - 12	0.045	0.03	---

316L	0.03	2.00	1.00	16 - 18	10 - 14	0.045	0.03	2.00 - 3.00

With the great similarity in composition between the 304L and 316L SS (equal amounts of Mn and Si, near equal amounts of Cr and Ni), the potential corrosion reactions with the CsCl would also be similar (leaching of manganese in the reaction area). As subsurface void formation and carbide precipitation are the predominate corrosion features observed, the addition of molybdenum to the 316L [to reduce pitting and crevice corrosion] does not seem to provide an extra advantage to corrosion resistance.

During its stay at ORNL, the CsCl was water-washed which lowered the impurity levels (Landsman 1998), thus lowering the amount of available corrosion reactants. The lowering of iron content by washing (to <0.005%) would also minimize the potential for any liquid phase to form and decrease impurity diffusion to the surface. Water storage of this WESF canister would greatly reduce the system (CsCl/steel) temperature, which in turn would further lower corrosion rates.

Corrosion on the exterior of the Type 4 canister due to any remaining CsCl after decontamination would be minimal, as any impurity would be quickly consumed. Lastly, as no water or moisture is expected between the Type 4 canister and the WESF overpack, any possible galvanic corrosion between the 304L and 316L SS is avoided. As these two alloys are only slightly separated on the galvanic series (ASM 1990, pg 557), galvanic corrosion would be unlikely even with water present.

4.0 CONCLUSIONS

With much lower impurity levels in the water-washed ORNL CsCl and a similar steel composition, the 304L stainless steel is expected to exhibit equal to or better corrosion resistance than the 316L stainless steel in this application. Thus, packing of the Type 4 canisters within the WESF overpack is judged acceptable.

5.0 REFERENCES

ASM, 1990, "Stainless Steels" in *Metals Handbook, Volume 1 - Properties and Selection: Irons, Steels, and High-Performance Alloys*, 10th Edition, American Society for Metals, Metals Park, Ohio.

Bryan, G. H., 1989, *Cesium Chloride Compatibility Testing Program--Final Report*, PNL-7133, Pacific Northwest Laboratory, Richland, Washington.

Fullam, H. T., 1972, *Compatibility of Cesium Chloride and Strontium Fluoride With Containment Materials*, BNWL-1673, Pacific Northwest Laboratory, Richland, Washington.

Landsman, S. D., 1998, *Certification That CsCl Powder and Pellet Materials Meet WESF Acceptance Criteria*, HNF-2928, Rev. 0, B&W Hanford Company, Richland, Washington.

ORNL, "Powder Shipping Cans - Type 4 (SK-365-B)", ORNL Dwg #970-294, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

DISTRIBUTION

	MSIN
U. S. Department of Energy, Richland Operations Office	
E. M. Mattlin	A5-15
S. K. Moy	H0-12
G. L. Sinton	H0-12
Fluor Hanford	
C. K. Girres	T3-01
B. Oldfield	S6-81
F. M. Simmons (5)	S6-81
Lockheed Martin Services, Inc.	
Central Files	B1-07
DPC	H6-08

This page intentionally left blank.