Completion of the Irradiation of Silicon Carbide Cladding Tube Specimens in the High Flux Isotope Reactor



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May 2018



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Fusion & Materials for Nuclear Systems Division

Completion of the Irradiation of Silicon Carbide Cladding Tube Specimens in the High Flux Isotope Reactor

Alicia Raftery Christian Petrie Gregory Hirtz Yutai Katoh Kory Linton

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ACRONYMS

HFIR	High Flux Isotope Reactor
ORNL	Oak Ridge National Laboratory
LWR	Light-water reactors
PTP	Peripheral target position
DPA	Displacements per atom
LAMDA	Low Activation Materials Development and Analysis
PIE	Post-irradiation examination

EXECUTIVE SUMMARY

This document outlines the irradiation of silicon carbide cladding tube specimens in the High Flux Isotope Reactor at Oak Ridge National Laboratory. The cladding tube specimens consisted of monolithic, composite, and coated SiC specimens in order to test the effect of these various materials on the overall cladding performance during irradiation. A total of 18 specimens were irradiated for one cycle, with 9 specimens irradiated at low heat flux conditions and 9 specimens at high heat flux conditions. The specimens were inserted in cycle 475 in September 2017 and reached an average irradiation dose of approximately 2.6 dpa.

1. INTRODUCTION

Silicon carbide (SiC) is being considered as an alternative to zircaloy cladding in light water reactors (LWRs) due to its potential for superior performance during accident scenarios. Identified SiC material properties that may improve cladding behavior during accidents include a high temperature strength, oxidation resistance, and stability under irradiation [1,2]. However, there are still a number of challenges regarding validation of SiC as a cladding for LWRs. For example, recent studies show that SiC has a high temperature dependence on swelling, which may create complicated stress states and micro-cracking in the material during irradiation [3]. In addition, poor hydrothermal corrosion of SiC in water could be detrimental for cladding performance during normal reactor operation [4]. Coated SiC specimens and SiC composites are currently under investigation due to the potential of the coatings to mitigate these issues [5].

This report briefly describes the experimental test matrix and summarizes the successful irradiation of 18 coated and composite SiC cladding tube specimens in the High Flux Isotope Reactor (HFIR). Half of the specimens were irradiated with high heat flux conditions and the other half at low heat flux irradiation conditions.

2. EXPERIMENTAL TEST MATRIX

The experiment consisted of two different rabbit designs in order to isolate the effect of irradiation damage in the absense of a temperature gradient in the material. The high heat flux design is used to simulate LWR reactor conditions while the low heat flux design is used to eliminate the temperature gradient across the cladding. Three low heat flux rabbits and three high heat flux rabbits were irradiated to a target temperature of approximately 300-350°C. The irradiated specimens consisted of a collection of various SiC materials: monolithic, composite, and duplex coated samples.

2.1 LOW HEAT FLUX DESIGN

The low heat flux design contains three hollow SiC tube specimens backfilled with a helium-argon gas mixture, which maintains a minimal temperature gradient across the specimens. The three SiC specimens are separated by aluminum centering thimbles and a compression spring is used at the end to keep all of the samples held in place within the rabbit. Figure 1 shows a schematic of the low heat flux rabbit design. The monolithic SiC specimens act as the temperature monitor during the irradiation, removing the need for additional thermometry.



Figure 1. Schematic of design for rabbit used to irradiate silicon carbide tube specimens under low heat flux conditions [6].

2.2 HIGH HEAT FLUX DESIGN

The high heat flux design has a molybdenum heater located in the center of the samples. The heater drives the temperature gradient, simulating operating reactor cladding conditions. The outer surface of the sample is in contact with an aluminum sleeve surrounded by aluminum foil within the rabbit housing for adequate heat removal. The heat flux is approximately 0.66 MW/m² at the outer surface of the cladding [7]. Figure 2 shows a schematic of the high heat flux design. A SiC temperature monitor was located inside of the molybdenum tube to verify the temperatures reached during irradiation.



Figure 2. Schematic of rabbit design used to irradiate silicon carbide tube specimens under high heat flux conditions [6].

3. IRRADIATION IN HFIR

The 18 silicon carbide specimens were irradiated in HFIR for one cycle in September 2017. The specimens were put into peripheral target positions (PTP), with each specific rabbit location listed in Table 1. The target irradiation conditions included a fluence of $2.3 \times 10^{21} - 2.4 \times 10^{21}$ n/cm² and irradiation temperature of approximately 325°C at the surface of the specimen [6]. Additional documents regarding the insertion of the rabbits into HFIR are included in Appendix A.

Heat Flux	Rabbit	Sample ID	Core Position	SiC Material Type
Low	SCL01	CVD-L	A1-5	Monolithic
Low	SCL01	SA3-1	A1-5	Inner Composite, Outer Monolithic
Low	SCL01	N1N3(1)	A1-5	SiC/SiC Composite
Low	SCL05	CVD-Q	D1-5	Monolithic
Low	SCL05	6-RP-CR	D1-5	Inner Monolithic, Outer Composite
Low	SCL05	2-TM-CrN	D1-5	SiC/SiC Composite
Low	SCL06	CVD-R	G7-4	Monolithic
Low	SCL06	3-RP-CrN	G7-4	Inner Monolithic, Outer Composite
Low	SCL06	7-TM-TiN	G7-4	SiC/SiC Composite
High	ATFSC06	CVD-E	G4-4	Monolithic SiC
High	ATFSC06	GA-TGI-C-1	G4-4	SiC/SiC Composite
High	ATFSC06	N1N3(8)	G4-4	SiC/SiC Composite
High	ATFSC07	CVD-H	A1-4	Monolithic SiC
High	ATFSC07	TYPE S-1	A1-4	Inner Composite, Outer Monolithic
High	ATFSC07	SA3-2	A1-4	Inner Composite, Outer Monolithic
High	ATFSC09	CVD-G	A4-4	Monolithic SiC
High	ATFSC09	1-TM-CrN	A4-4	Inner Monolithic, Outer Composite
High	ATFSC09	4-RP-CrN	A4-4	SiC/SiC Composite

Table 1. Rabbit information and irradiation location for the SiC tube cladding specimens.

The irradiation dose during the cycle, measured in displacements per atom (dpa), was calculated for two SiC monolithic specimens using an online tool developed by Joseph Burns at ORNL. This tool calculates the evolution of dose and fluence during the irradiation of specimens in HFIR based on the material type and location in the reactor (<u>http://jburns33.pythonanywhere.com/</u>). The results for the progression of dose during irradiation of the two specimens were calculated using threshold displacement energies of 40 eV for silicon and 20 eV for carbon [8]. The total calculated accumulated dose for specimen CVD-L in rabbit SCL01 was 2.67 dpa (Figure 3) and the total accumulated dose for CVD-E specimen in ATFSC06 was 2.61 dpa (Figure 4). The doses are slightly different due to the different axial locations.



Figure 3. Plot of accumulated dpa throughout the irradiation cycle for the monolithic CVD-L (rabbit SCL01) sample located in peripheral target position A1 axial location 5, which reached a total dose of approximately 2.67 dpa.



Figure 4. Plot of accumulated dpa throughout the irradiation cycle for the monolithic CVD-E (rabbit ATFSC06) sample located in peripheral target position G4 axial location 4, which reached a total dose of approximately 2.61 dpa.

4. CONCLUSION

Six rabbit capsules successfully completed irradiation in HFIR after one cycle in September 2017. This concluded the design, build and irradiation of protyopical and model SiC-based ATF SiC cladding under a high and low radial heat flux scope under the Nuclear Science User Faciltiy (NSUF) Work Package: UF-18OR020710 for fiscal year 2018. The capsule shipment, hotcell disassembly, and Low Activation Materials Development and Analysis (LAMDA) laboratory post-irradiation examination (PIE) are underway. An initial report of the shipments and disassembly under Work Package UF-18OR020711 will follow this report in September 2018 and LAMDA PIE will continue until the end of fiscal year 2019.

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APPENDIX A: HFIR IRRADIATION DOCUMENTATION

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	Lact							35	11-14	A-4	Platform	mo	ť
		Complet	tion Date	8/21/1	7			36	11-14	Platform	Δ-4	200-	
	(30)							00	11.11			10151	

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Issue Date: 5/02/2007

PE	RIPHER	AL TA	RGET WORK	SCHEDU	ILE (PTWS)		REV. 11	PWPF- Page	1167.1 1 of 1
The chan Endin Refer Endin <u>AND</u>	ges to sta g Rabbit (ence Calc g Rabbit (SBLOCA ; g Rabbit (Inting con Configura ulation:_ Configura accidents	figuration and rest ation is adequately <u>C-HFIR-2001-026, C-</u> ation is adequately s. Reference Calc	ulting endir cooled une HFIR-2003-0 cooled une ulation: <u>C</u>	g configuration der 130% reac 40, <i>C-HFIR-2004</i> der reactor trar -HFIR-2001-02	n were reviewed tor overpower c <u>060, C-HFIR-2018</u> nsient conditions 26 (C-HFIR-201 used flow conditions	I and meet th onditions. - <i>019, C-HFIR-2</i> s associated v 7-002)	e limits below 1 <u>016-041, C-</u> HF with LOOP –	N: IR-2017-00
Refer	ence Calc ired/Appro	ulation: oved by:	<u>C-HFIR-200</u>	01-026 (C-F	HEIR-2017-002			8	/17/17 Date
Revie	wed/Appr	oved by:	R	RD Exp. a	nd Fab. Interfa	ce OR RRD Sa	fety Analyst	8	/17/20 Date
Starting C	onfiguratio	on for: <u>1</u>	1-08	•	Identi	fier: 475 - 1	2		
End plug	Ре 5-0	os 1. 5-20	Pos 2	Pos 3 S-72	Pos 4 S-74	Pos 5 FCAB06	Pos 6 FCZ0	Po 2	s 7
Activity	Move #		Unit No. (s)		FROM	г	0	DHSS initial	Confirm
Transfer	N/A	PTP-	11-08	Targe	Bundle	PTP Unthrea	ding Plate	ma	ps
Unload	N/A	Rabbit	s in PTP11-08	PTP L	Inthreading	Dump Tray	17	ma	s
Store	N/A	FCAB	06	Dump	o tray	Sto Basket '	E'	ms.	N
	N/A	S-74		Dump	o tray	Sto Basket '	A'	ma	w
	N/A								
	N/A			-					
4	N/A								
	N/A								
	IN/A								
Transfer	N/A	PTP	11-08 w/ end plug	PTP U Plate	Inthreading	Loading station	on	ma	11
Load	1					Position 7			
	2	FCZ02		Dump	tray	Position 6		ma	is
	3	SCL01		Pool	side	Position 5		ma	N
	4	ATFSC	07	Pool	side	Position 4		ma	M
e.	5	S-72		Dump	tray	Position 3		ma	N
	6	S-87	0	Dump	tray	Position 2		man	M
Transfer	/ N/A	PTP- 1	1-08 w/end plug	Loadi	ng station	Target Bundl	9	200-	
Ending Cor	figuration	for: 1	1-08		-			1/1/1/	
End plug	D	 0s 1	Pos 2	Pos 3	Pos 4	Pos 5	Posf	6 Po	s 7
	5-0	5-20	S-87	S-72	ATFSCO	7 SCL01	FCZC)2	
Comments	on mecha	anical op	eration or appeara	nce of the	PTP rabbit hole	der:			
					9 A.				

	ERIPHE	RAL TA	ARGET WO	RK S	CHEDU	LE (PTWS) F	REV. 11	PWPF Page	-1167 e 1 of 1
The cha	inges to st	tarting cc	onfiguration and	t result	ting ending	g configuratio	n were reviewed	and meet the	e limits bel	ow:
□ Endi	ing Rabbit	Configu	ration is adequ	ately c	coled und	er 130% read	ctor overpower co	onditions.		
Refe □ Endi	rence Cal ng Rabbit	Configu	ration is adequ	ately c	ooled und	er reactor tra	nsient conditions	associated v	vith LOOP	
AND	SBLOCA	acciden	its. Reference	Calcul	ation: <u>C-</u>	HFIR-2001-0	26 (C-HFIR-2017	-002)	-	
End	ing Rabbit	Configu	ration is adequ	ately c	ooled und	er a 50% red FIR-2017-00	luced flow condition	on.		• 7
Bror	arod/App	roved by		12001	0201011	Herei	The D			8/17/
Piet	areu/App	loved by		-	F	RRD Exp. and	d Fab. Interface	/		/ Dat
Rev	iewed/Apr	proved by	y:		à.	MA	1 Wh		_	8/17/
				RR	D Exp. an	id Fab. Interfa	ace OR RRD Saf	ety Analyst		/ Dá
01	0	lan fam '	11 10		,	Iden	tifier: 475 - 13	3		
Starting	Jonfigurat		11-12				uner. <u>470 re</u>			
End plug	P	os 1	Pos 2	F	os 3	Pos 4	Pos 5	Pos 6	Po	s 7
	5-0	5-23	S-25		3-56	S-20	S-53	FCAB02	2	
Activity	Move #		Unit No. (s)		F	ROM	то		DHSS	Confir
									Initial	IIIIua
Transfer	N/A	PTP-11	1-12		Target B	Bundle	PTP Unthreadir	g Plate	m2	m
Unload	N/A	Rabbit	s in PTP-11-12		PTP Unf	threading	Dump Tray		ma	MY
Store	ΝΙ/Δ	FCAF	302		Dump T	rav	Sto Basket 'E'		mo	es.
Store	N/A	S-20	102		Dump T	ray	Sto Basket 'A'		m	N
	N/A	0-20			Dump			e		
	N/A		*		-					1
	N/A	· ·			2					
л	N/A			-		15				
	N/A							5 NG	1.1	
				34.3	DTD					
Transfer	N/A	PTP	<u>11-12_</u> w/ end pl	ug	PIPUn	threading	Loading station		mor	N
Indioioi										
Load	1	1					Position 7			
Load	1	S-53	,		Dump T	ray	Position 7 Position 6		2/12	N
Load	1 2 3	S-53 SCL05	1		Dump T Pool si	ray ide	Position 7 Position 6 Position 5		M12 M2	1 <u>5</u> 1 <u>5</u>
Load	1 2 3 4	S-53 SCL05 SCL02	5		Dump T Pool si Pool si	ray ide ide	Position 7 Position 6 Position 5 Position 4		M2 M2 M2	NS NA M
Load	1 2 3 4 5	S-53 SCL05 SCL02 S-56	5		Dump T Pool si Pool si Dump T	ray ide ide ray	Position 7 Position 6 Position 5 Position 4 Position 3		M2 M2 M2 M12	N NA M NA
Load	1 2 3 4 5 6	S-53 SCL05 SCL02 S-56 S-25	5		Dump T Pool si Pool si Dump T Dump T	ray ide ide ray ray	Position 7 Position 6 Position 5 Position 4 Position 3 Position 2		M2 M2 M2 M2 M2 M2	N NA M NA NA
Load	1 2 3 4 5 6 7	S-53 SCL05 SCL02 S-56 S-25 5-05-2	3		Dump T Pool si Pool si Dump T Dump T	ray ide ray ray ray	Position 7 Position 6 Position 5 Position 4 Position 3 Position 2 Position 1		M2 M2 M2 M2 M2 M2 M2	1 <u>1</u> 1 <u>1</u> 1 <u>1</u> 1 <u>1</u> 1 <u>1</u> 1 <u>1</u>

Issue Date: 11/07/2012

PE	RIPHE	RAL TARGET WORK	SCHEDULE (PTWS	5) REV. 11	PwPF-1167. Page 1 of 1
The eber	naes to st	arting configuration and re	sulting ending configuration	on were reviewed and meet	the limits below:
⊡ Endir	nges to si na Rabbit	Configuration is adequate	ly cooled under 130% rea	ctor overpower conditions.	
Refe	rence Cal	culation: C-HFIR-2001-026, C	-HFIR-2015-019, C-HFIR-2016	5-041	d with LOOP
Endir	ng Rabbit	Configuration is adequate	ly cooled under reactor tra	ansient conditions associate	
□ Endi	na Rabbit	Configuration is adequate	ly cooled under a 50% rea	duced flow condition.	
Refe	rence Cal	Iculation: C-HFIR-20	001-026	7/A	4/17
Prep	ared/App	roved by:	Len	d Lab Interface	
			RRD Exprai	IU Fab. Interlace	8/17
Revi	ewed/App	proved by:	RRD Exp. and Fab. Inter	face OR RRD Safety Analys	st <u>a/7/</u> Date
				X	
Starting C	Configurat	tion for: 11-09	Ider	ntifier: 475 - 14	
End plug	Po	os 1 Pos 2	Pos 3 Pos 4	Pos 5 Pos	6 Pos 7
	S	-78 S-54	S-3 S-62	S-76	
		11-14 NI- 7-1	EPOM	то	DHSS Confirm
Activity	Move #		TROM .	0	initial initial
Transfer	N/A	PTP-11-09	Target Bundle	PTP Unthreading Plate	m2 P
Unload	N/A	Rabbits in PTP-11-09	PTP Unthreading	Dump Tray	mr for
Store	N/A	S-76	Dump Trav	Sto Basket 'A'	mar B
31016	N/A	0.10			
	N/A	2			
	N/A				
	N/A				
	N/A			× *	
	N/A			· · · · · · · · · · · · · · · · · · ·	
			DTD Unthroading		
Transfer	N/A	PTP- <u>11-09</u> w/ end plug	Plate	Loading station	ma to
Load	1		6	Position 7	
	2	S-62	Dump Tray	Position 6	mr ling
	3	SCL03	Pool side	Position 5	ma the
	4	ATFSC06	Pool side	Position 4	m2 mg
	5	S-3	Dump Tray	Position 3	hin the
	6	S-54	Dump Tray	Position 2	mr ty
· .	7	S-78	Dump Tray	Position 1	m2 for
Transfer	N/A	PTP- 11-09 w/end plug	Loading station	Target Bundle	MR
					9
Ending C	onfigurati	on for: 11-09			
End plug	j F	Pos 1 Pos 2	Pos 3 Pos 4	Pos 5 Pos	3 6 Pos 7
	5	S-78 S-54	S-3 ATFSC	06 SCL03 S-6	62
Common	ts on mer	chanical operation or appea	arance of the PTP rabbit h	older:	
		where we are a second of the second s			

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Issue Date: 11/07/2012

The chan Endin Referr Endin <u>AND</u> Endin Referr Prepa	nges to sta ng Rabbit ence Calo ng Rabbit SBLOCA ng Rabbit ence Calo	arting configu Configuratior culation: <u>C-H</u> Configuratior accidents.F	ıration and r า is adequat <u>FIR-2001-02</u> า is adequat	resultir tely co	ng ending	configuratio	n woro reviewed			
□ Endin Refere □ Endin <u>AND</u> : □ Endin Refere Prepa	ig Rabbit ence Calo ig Rabbit SBLOCA ig Rabbit ence Calo	Configuration culation: <u>C-H</u> Configuration accidents. F	ו is adequat <u>FIR-2001-02</u> ו is adequat	tely co	.g onung		II WELE LEVIEWED a	and meet the	e limits belo	ow:
Refer Endin <u>AND</u> : Endin Refere Prepa	ence Calo Ig Rabbit SBLOCA Ig Rabbit ence Calo	culation: <u>C-H</u> Configuration accidents. F	FIR-2001-02	6. C-HF	oled unde	r 130% read	tor overpower co	nditions.		
 Endin <u>AND</u> Endin Refere Prepa 	ig Rabbit SBLOCA ig Rabbit ence Calo	Configuratior accidents. F	n is adequat		IR-2008-04	45, C-HFIR-2	016-041			
□ Endin Refere Prepa	ig Rabbit ence Calo		Reference C	tely co Calcula	oled unde tion: <u>C-H</u>	r reactor tra FIR-2001-0	nsient conditions 26	associated w	vith LOOP	
Refer Prepa	ence Cal	Configuration	n is adequat	tely co	oled unde	r a 50% red	uced flow conditio	n.		,
Prepa		culation:		2001-0	020	11.00	Tapp		\leq	2/17
	ared/Appr	oved by:			R	RD Exp. and	d Fab. Interface	/	4	/ Dat
Bavia	wod/App	round by:				IM	O TAL	_		3/17/:
Kevie	swearyph	loved by.		RRD	Exp. and	Fab. Interfa	ace OR RRD Safe	ty Analyst	· _	Dat
					F	/				
Starting Cr	onfigurati	on for: <u>11</u> .	-03	2		Iden	tifier: 475 - 15			
							D	Deef	Do	o 7
End plug	Pc	os 1	Pos 2	Po	os 3	Pos 4	Pos 5	POS 6		57
	S	-1	S-69	5	-9	5-02	FCATO	TOATU	,	
A -41, 114, 1	Mayo #	Linit	No (s)		FR	OM	то		DHSS	Confir
Activity	wove #	Unit	10. (3)		115	0111	5		initial	initial
Transfer	N/A	PTP11-03	3		Target Bu	Indle	PTP Unthreadin	g Plate	MR	-en
Unload	Ν/Δ	Rabbits in F	PTP- 11-03		PTP Unth	reading	Dump Tray		no	Fur
Unioau			<u> </u>		Plate		Sto Basket 'A'		mn	- Cor
Store	N/A	S-52				ay	Sto Basket A		1010	
	N/A					ay		к		
	N/A	8 v.			Dump Tr	ay av				
		4. ¹			Dump Tr	ay av				3
	N/A				Dump Tr	ay av				
					Dump Tr	av			1	
	N/A			1000	Dump m					
Transfer	N/A	PTP- 11-03	3 w/ end plu	Iq	PTP Unth	nreading	PTP Loading St	ation	mo	in
Transfor	4				Plate Dump tra	M	Position 7			
Load	1	FCATOO			Dump tra	y N	Position 6		ma	an
	2	FCAT00			Dumn tra	V	Position 5		ma	En
	1	SCL06			Pool sid	le	Position 4		ma	ty
	5	S-9			Dump tra	IV.	Position 3		ma	an
	6	S-69			Dump tra	iy	Position 2		mz	hy
	7	S-1			Dump tra	iy	Position 1	4	ma	-m
Tronsfer	NI/A	DTD 11 02	w/end plug		Loading	station	Target Bundle		ma	
Transfer	N/A	FIF- <u>11-03</u>		,	Louding				1.11	1
Ending Co	onfiguratio	on for: 11-0	13							
Linuing OU	angulatic							D 0		20.7
End plug	P	os 1	Pos 2	P	los 3	Pos 4		FCATO	8	JS 1
		5-1	5-69		5-9	SULUB	FUATU	LICAIO		
Comments	s on mecl	nanical opera	tion or appe	earanc	e of the P	TP rabbit ho	older:			e
× 1	2									

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PE	RIPHER	AL TARGET WORK S	CHEDULE (PTWS)	REV. 11	PWPF- Page	1167.1 1 of 1
The char Endin Refer Endin <u>AND</u> Endin Refer Prepa Revie	ges to sta g Rabbit (ence Calc g Rabbit (SBLOCA a g Rabbit (ence Calc ared/Appro	rting configuration and result Configuration is adequately c ulation: <u>C-HFIR-2001-026, C-HF</u> Configuration is adequately c accidents. Reference Calcul Configuration is adequately c ulation: <u>C-HFIR-2001-</u> oved by:	ing ending configuration poled under 130% react IR-2003-040, C-HFIR-2004-0 poled under reactor tran ation: <u>C-HFIR-2001-02</u> poled under a 50% redu 026 RRD Exp. and	a were reviewed and meet the lor overpower conditions. 160, C-HFIR-2007-020, C-HFIR-20 sisient conditions associated v 6 inced flow condition. Fab. Interface	e limits belov 17-003 vith LOOP - - - 8	v: / <u>(z/c2</u> Date /17/2
		RR	D Exp. and Fab. Interfac	ce OR RRD Safety Analyst		Date
Starting C	onfiguratio	on for: 11-14	Identit	fier: 475-17		
End plug	Po S-	os 1 Pos 2 -17 5-05-24	Pos 3 Pos 4 S-86 FCAB04	Pos 5 Pos 6 S-23 FCZ0	Po 5	s 7
Activity	Move #	Unit No. (s)	FROM	ТО	DHSS initial	Confir initia
Transfer	N/A	PTP-11-14	Target Bundle	PTP Unthreading Plate	ma	ns
Unload	N/A	Rabbits in PTP-11-14	PTP Unthreading Plate	Dump Tray	ma	14
Store	N/A	FCAB04	Dump Tray	Sto basket 'E'	ms	NS
	N/A	S-23	Dump Tray	Sto basket 'A'	ma	as
×	N/A			и <u>к</u>		
	N/A				e	
	N/A					
	N/A			1		
	N/A					
Transfer	N/A	PTP- <u>11-14</u> w/ end plug	PTP Unthreading Plate	Loading station	ma	N
Load	1			Position 7		
	2	FCZ05	Dump Tray	Position 6	ma	12
	3	SCL04	Pool side	Position 5	nu2	ns
	4	ATFSC09	Pool side	Position 4	m	ms
	5	S-86	Dump Tray	Position 3	ms	as
	0	5-05-24	Dump Tray	Position 2	Sus	ns
· · · ·	6					
	7	S-17	Dump Tray	Position 1	MD	BA

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End plug	Pos 1	Pos 2	Pos 3	Pos 4	Pos 5	Pos 6	Pos 7
	S-17	5-05-24	S-86	ATFSC09	SCL04	FCZ05	

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