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approved on Apr-06-2010. (This statement was added by the EDMS system to the quality record upon its validation.)

Solid Waste Activity Calculation from AP1000 UKP-GW-GL-003, Revision 0

Westinghouse Electric Company LLC P.O. Box 355 Pittsburgh, PA 15230

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REVISION HISTORY

Revision	Description of Changes
0	Initial Submittal

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Phoe Surte 3 Su Stoc	enix Ho	siness Park /ay		We	stinghous	e Electric Co	ompany
		Solid waste	Activity Cal	culation f	rom AP100	00	
		AKER SOLU	AP1000 RA		• 63000333	2	
			LIENT PRO			-	
					1003110	deller 02/10	
2	S1	Update to include Steam Generator Sludge Activity	01/03/2010	A Carson	D Mayes	J McLeary	See Westinghouse Cover Sheet
1	S1	Solid waste Activity Calculation from AP1000	04/02/2010	A Carson	D Mayes	J McLeary	See Westinghouse Cover Sheet
Rev	PEM	Description	Date	Ву	Checked	Approved	Approved
	Status						Client
	D	OCUMENT NUMBER	63000333	- 000	- 000	- 111 -	C - 0014

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PER File

Technical File

H & S File

	REVISION SUMMARY
evision	Description of Change
1	First Issue. The calculation includes the activity fingerprint for General LLW, and supersedes 63000333-000-000- 111-C-0010 (UKP-GW-GL-013) and 63000333-000-000- 111-C-0013, the activity fingerprints for CPS Resin and Waste Oil respectively
2	Updated to include activity fingerprint for Steam Generator Sludge. This now supersedes 63000333-000-000-111-C-0012

		Colutionet	Project Number:	Area:	System:	Discip. Code:	Doc. Type:	Sequen. Number:	Rev:	2
	A	kerSolutions [®]	63000333	000	000	111	С	0014	Status:	S1
<u> </u>									Pag	e 3 of 31
1										
	ossary	y								
3										
4 Cf/ 5 CP		Conditions for Acceptance Condensate Polishing System								
6 DC		Design Control Document								
7 ILV		Intemediate level Waste								
8 LL		Low level Waste								
-	WR	Low level Waste Repository								
	GBD	Steam Generator Blowdown								
11										
12										
13										
14 Bq		Becquerel								
15 Ci		Curie								
₁₆ Te	•	Tonne								
17										
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22										
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Aker Solutions	63000333	000	000	111	С	0014	Status:	S1
							Pag	e 4 of 31
1 Purpose of Calculation								
2								
3 As part of the Generic Design Assessme	ent (GDA) for the We	stinghouse	e AP1000 i	nuclear po	wer statio	n, it is nece	essary to demon	strate
4 that all waste produced from the operation	on, maintenance and	l decommis	ssioning of	such a pla	ant will be	disposable	e. This process h	as
5 included obtaining acceptance in princip	le from the Low Leve	el Waste R	epository (LLWR).				
6								
7 The purpose of this calculation is to dete	rmine the activity of	the followi	ng Low Lev	vel Waste	(LLW) str	eams;		
8 1. General LLW								
9 2. Condensate Polishing Resin								
10 3. Waste Oil								
11 4. Steam Generator Sludge								
12								
13 This calculation will determine the conce	entration of the isotop	es presen	t in each o	f the waste	e streams	and will als	so determine the	final
14 weight and volume of the waste package	e to be disposed of.							
15								
16 The activities of the following isotopes a	re specifically require	ed to show	that the w	aste will be	e disposal	le at the l	ow Level Waste	
17 Repository (LLWR);	- specifically roquite				p.000k			
18								
19 Uranium								
20 Ra-226								
21 Th-232								
22 Other alpha								
23 C-14								
24 I-129								
25 H-3								
26 Co-60								
27 Other radionuclides								
28								
29 Introduction								
30 31 General LLW								
32 The general LLW that will arise is expect	ted to consist of a ra	nge of slig	htly contan	ninated ma	aterials TI	nis will inclu	ude: Plastics: Pa	per:
33 Incinerator ash; Metallic Items; Clothing;			-					,
34 The rates of arising for different material						esentative	of the stream	
35 averages. No large items that may requi		-						
36		2 3						
37 Condensate Polishing Resin								
38 The Condensate Polishing Kesin	s) is used to remove	corrosion	aroducte a	nd ionic in	nurities fr	om the cor	densate	
39 system during plant startup, hot standby		-			-			
40 shutdown operations.			al secolida		iennistry, s			
41								
42 The CPS resin can become contaminate	d with radionuclides	if there is	leakane fr	om the priv	mary circu	it to the se	condary circuit	
43 Therefore the only radionuclides that will								
44						,		
45 Although the radionuclides will decay ov	er time and hence th	e activity v	vill decreas	se, activitie	es will initi:	ally be calc	ulated without	
46 taking this decay into account. This will p		-				-		
47				- addring (
48 Waste Oil								
49 Waste radioactive oil arises from motor	oumps in the chemic	al and volu	ume contro	l system	Waste oil	may also a	rise from spills a	nd leaks
50 from gear boxes or other sources.								
	The information	©Aker Solutions E on this sheet may b						

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	·		•			•	Pag	e 5 of 31
1 The oil is a standard commerically availa	able lubricating oil that	at is norma	ally expected	ed to be no	on-radioac	tive.The vo	olumes and activ	ities
2 stated are based on very conservative e	stimates. The oil will	become c	ontaiminat	ed with rad	dioactivity	if there is a	a pump seal leak	
3 or other such failure in the equipment. A	s a result of this the	activity it is	s expected	to have w	ill be simila	ar to the ac	ctivity that would	be
4 expected to arise from a primary to seco	ndary circuit leakage	e i.e. simila	r to reacto	r coolant.				
5								
6 Steam Generator Sludge								
7 The steam generators produce steam fro	om the secondary sid	de water sy	stem to di	rive the ste	am turbin	es. This pr	ocess of generat	ing
8 steam can cause a buildup of sludge on	the tubes within the	steam gen	erators. Tl	ne materia	l may be c	orrosion p	roducts	
9 containing magnetite usually non-radioa	ctive. Also impurities	from mak	eup water	and possit	bly from co	ondenser tu	ube leaks that bu	ild
10 up over the cycle. This sludge is periodic	ally removed to prev	ent it casu	ing problei	ms with he	at transfer	and corro	sion of the tube	s within
11 the steam generators.								
12								
13 Assumptions								
14 The following assumptions have been m	ade during this calcu	ulation;						
15 1 General LLW will have the same act	ivity as that produced	d from Size	ewell B					
16 2 The CPS resin has an operating time				ef 1)				
17 3 0.25% Fuel defects (Ref 7)								
18 4 Fission gases have been excluded a	s they don't hold up	on the lon	Exchange	Resin				
19 5 There is a 90 day storage period in t	he CPS resin tank du	uring which	h the radio	nuclides w	ill decay p	rior to cond	ditioning (Ref 1)	
20 6 All primary to secondary circuit leaka		-						
21 7 No allowance has been made for the				-		System		
22 8 Primary to secondary circuit leakage								
23 9 Realistic primary circuit activities are	_	-		1-8 of the	European	DCD		
24 10 Resin:cement ratio is 50:50 (Ref 1								
25 11 Density of cement mixture is 2.4 Te/	· · · · · · · · · · · · · · · · · · ·							
26 12 A total of 1m3 of waste radioactive o		ver the life	time of the	e plant (inc	ludes 0.08	38m3 for si	(Pof 10)	
					10000 0.00		(Rei 10)	
			• • •	3 at 20C				
				J al 200				
30 16 The sludge has the same activity as 31 17 The sludge has the same density as								
	-							
					of 10)			
33 19 Secondary circuit activities are used		1.1-5 of th	e ⊨uropea	n DCD (R	er 19)			
34 20 Secondary side density is assumed t	to be that of water							
35								
36								
37								
38								
39								
40								
41								
42								
43								
44								
45								
46								
47								
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50								
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						· · · · · ·			,,		P	age 6 of 31
1 Results												
2 The Total activity tr	iggers fo			e been taken froi	m Referer	ice 13 and	are outli	ned k	elow;			
3 Uranium	=	90000										
4 Ra-226 & Th-232	=		MBq									
5 Other Alpha	=	90000										
6 C-14	=	15000										
7 I-129	=	15000										
8 H-3	=	3000000										
9 Co-60	=	600000										
0 Other radionuclides	• =	4500000	MBq	Note 1								
2 Note 1: This Also ir	ncludes t	the Co-60	Activity	,								
13 The calculation of t					pages 10) to 30 of th	is calcul	ation	<u>'</u>			
4												
5 General LLW												
6 The volume of gen					original es		46.9 r					
7 The total weight of	this volu	ime of wa	ste was			=	ד 23.44	е				
8												
9 The total activity co	ncentrat	tions of th	e releve	ent Istopes are;								
20												
21 Uranium	=	0.00	MBq									
22 Ra-226	=	0.00	MBq									
23 Th-232	=	0.00	MBq									
24 Other alpha	=	0.33	MBq									
25 C-14	=	0.29	MBq									
26 I-129	=	0.00	MBq									
₂₇ H-3	=	0.15	MBq									
28 Co-60	=	12.65	MBq									
29 Other radionuclides	6 =	214.19	MBq									
30												
31 Comparing total ac	tivities of	f the istop	es withi	in the general LL	W and the	e total activ	ity trigge	ers fo	r the L	LWR, it is	evident that the	e activity
32 within the waste is	much lov	wer than t	he trigg	ers for the repos	itory and t	therefore it	is expec	ted t	hat thi	s waste wil	l be acceptable	by the
33 LLWR Also given t	ne large	difference	e betwe	en the actual act	tivity and t	he triggers	it is not	expe	cted th	nat change	s to the overall	waste volu
affect the activity w	ithin the	waste sig	nificant	ly enough to pre	vent it bei	ng accepte	d by the	LLW	R. Thi	s is demor	strated by the	results
below which show t	he activi	ities using	the inc	reased volume of	of waste;							
36												
The volume of gen	eral LLW	/ to be dis	sposed	of per year from	improved	estimate is		=		9 m ³		
The total weight of	this volu	ime of wa	ste is					=	25.95	5 Te		
39												
₄₀ Uranium	=	0.00	MBq									
11 Ra-226	=	0.00	MBq									
12 Th-232	=	0.00	MBq									
13 Other alpha	=	0.37	MBq									
_{I4} C-14	=	0.32	MBq									
₁₅ I-129	=	0.00	MBq									
_{l6} H-3	=	0.17	MBq									
17 Co-60	=	14.01	MBq									
1		007 10										
18 Other radionuclides	5 =	237.18	MBq									
	5 =	237.10	MBq									

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													Paç	ge 7 of 31
1	Condensate Polishing	a Resir	<u>1</u>											
2	The total conditioned	volum	e of the wast	te to he c	lisposed of	ie 11	.60 m	3						
3	The total weight of the						.00 11		270	kg				
4		5 Wast	e (enoupould			0110		10.	270	Ng				
6	Prior to accounting for	r deca	v during the	90day bo	ld un nerio	d within th		roci	n tank	tho t	otal activ	vity on the C	PS resin is	
7	23.92 GBq / Te.	rueca	y during the	900ay no	na up perio		e CF3	Tesi	I LATIK	uie i		nty on the C	FS Tesimis	
8	After accounting for th	ne dec	av of the rad	lionuclide	s during the	e 90 hold i	in neri	od w	ithin th		DS resin	tank the tota	al activity of the	CPS
9	resin is 9.4 GBq		ay of the fau	lonuciue	s during the	8 30 11010 0	ир реп	ou w			0 10311			
10														
11	The total activity conc	entrat	ions of the re	elevent Is	topes are;									
12				pected	Maxir	num								
13	Uranium			0		0	MBq							
14	Ra-226			0		0	MBq							
15	Th-232		=	0		0	MBq							
16	Other alpha		=	0		0	MBq							
17	C-14		=	0		0	MBq							
18	I-129		=	0		0	MBq							
19	H-3		= 88	19.0	377	795.5	MBq							
20	Co-60		= 3.	.88	1	6.6	MBq							
21	Other radionuclides		= 153	857.4	658	317.3	MBq							
22														
23	The activity concentra	ations	of the individ	ual isoto	pes stated a	above do r	not inc	ude	decay	to gi	ve worst	case and ha	ave been taken	
24	from table 6.													
25	From experience it is					-			-					
26	values are based on t	the act	ivity after a 7	7 day leal	kage and th	ie maximu	m valu	es a	re bas	ed o	n the act	ivity after a 3	30 day leakage	
27														
28	Comparing total activi													
29	activity within the was	te is l	ower than the	e triggers	s for the rep	ository and	d there	etore	it is ex	xpect	ed that t	his waste wi	Il be acceptable)
30	by the LLWR.													
31														
32	Waste Oil													
33								3						
34	The volume of waste	on to b	e aisposed (of per yea	ar will be	= 1	m							
35	The total weight of thi	s volu	me of wasto	will be		0	87 T	<u>م</u>						
36			ine of waste			= 0.		-						
37	The total activity conc	entrat	ions of the re	elevent is	otopes are									
38 39		Junio												
39 40	Uranium	=	0.00E+00	MBa										
40	Ra-226	=	0.00E+00											
42	Th-232	=	0.00E+00											
43	Other alpha	=	0.00E+00											
44	C-14	=	0.00E+00											
45	I-129	=	0.00E+00											
-	H-3	=	4.82E+01											
47	Co-60	=	2.12E-02											
48	Other radionuclides	=	8.40E+01	MBq										
49														
50														

	Ak		2	lu+i.	000	9	Proj	ect Nu	mber	:	Area:	s	ystem:	Discip. Code:		oc. ype:	Sequen. Number:	R	ev:		2
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	-																			ge 8 of	31
1		-															R, it is evic				
	within the	waste i	s mu	ICN IOW	ver thar	n the t	riggers	for the	e rep	osito	ory and	a there	etore it	is expec	tea th	at this	waste will	be acce	ptable t	by the	_
3	LLWR.																				
4			-																		
5	Steam Ge	nerator	· Slu	dge																	
6	T I I											0.09	3								
7	The volum	ne of wa	aste	sluidge	e to be	aispo	sed of	per ye	ar w	II be	=	0.09	m								
8 9	The total v	veiaht (of thi	s volu	me of w	vaster	will he					34.85	Τe								
-	The total t	weight	51 111	3 10101		14310					= `	54.00	10								
10	The total a	activity	conc	entrati	ions of	the re	lovent	isoton	<u> </u>	ro.											
11	The total a	louvity	conc	Chirat			levent	130100	03 0	10,											
12	Uranium			=	0.00	E+00	MBa														
	Ra-226			=		E+00 E+00															
	Ra-220 Th-232			=		E+00 E+00															
	Other alph	าล		=		E+00															
	C-14			=		E+00															
	I-129			=		E+00 BE-08															
	H-3			=		E+03															
	Co-60			=		5E-03															
	Other radi	onuclid	65	=		E+01															
22	ourier radi	onaona			1.00		MBq														
23	Comparin	g total a	activi	ities of	the ist	opes v	within t	he Wa	iste S	Sludo	e and	the to	otal act	tivity trigg	gers fo	r the l	_LWR, it is	evident	that the	e activit	y
24	-	-								-					-		waste will				
25	LLWR.																				
26																					
27																					
28																					
29																					
30																					
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		·						Pag	e 9 of 31
2 Conclusion									
3									
4 General LLW									
5 6 The total activity within the wa	eto is muo	h lower than the trigg	nore for the		d thorofor	o it is ovo	eted that t	his wasto will mo	ot tho
						e it is expe		The waste will the	
8 9 Also given the large difference	e hetween	the actual activity an	d the triad	ers it is not	t expected	that chan	aes to the	overall waste vo	lumes
		-					ges to the		luines
	aste signin	cantry chough to pre-		ig accepted					
11 12 Condensate Polishing Resin									
12 Condensate Polisning Resin									
	4GBa/Te a	Ipha emitters and 12	GBa/Te B	eta/gamma	a emitters	(Ref 5) T	here are no	alpha radiation	emitters
14 The upper limits for LLVV are 15 present in this waste.				s.a. gamme					
16 Given that the total activity on	the CPS r	esin after the 90 day	decay per	riod is 9 4G	Ba/Te an	d the unne	er limit for l	LW is 12GBa/Te	<u></u>
17 it can be concluded from this		-						200 10 12004, 10	,
18				C TOOLT W			<u>.</u> .		
19 It is expected that the SGBD s	svstem will	remove a certain pro	oportion of	the activity	v thus can	be expect	ted that the	e actual activity o	f the
20 CPS resin will be lower than t	-								
21									
22 Therefore it can be concluded	d based on	this very conservativ	/e calculat	ion that the	e CPS resi	n will be a	ccpeted fo	r disposal at the	LLWR
23									
24 It should be noted that a D1 for	orm with th	e data determined in	this calcu	lation has l	been acce	pted by th	e LLWR. T	he D1 form acce	epted by
25 the LLWR contains two errors									
26 1 Expected Co-60 activity st	tated as 0.0	08819 MBa							
27 2 Expected other activity sta									
28									
29 Neither of these errors affect	the conclus	sions of this calculation	on as the a	actual calci	ulated valu	ies are sti	ll within the	acceptance crite	eria
30 for disposal at the LLWR.									
31									
32 The total activity within the wa	aste is muc	h lower than the trigg	gers for the	e LLWR an	d therefor	e it is expe	ected that t	his waste will me	et the
33 Conditions for acceptance of	the the LLV	WR.							
34									
35 Waste Oil									
36									
37 Comparing total activities of the	he istopes	within the waste oil a	ind the tota	al activity tr	riggers for	the LLWR	, it is evide	ent that the activi	ty
38 within the waste is much lowe	r than the t	triggers for the repos	itory and t	herefore it	is expecte	d that this	waste will	be acceptable by	y the
39 LLWR.									
40									
41 Steam Generator Sludge									
42									
43 Comparing total activities of th	he istopes	within the Waste Slu	dge and th	ne total acti	ivity trigge	rs for the l	LWR, it is	evident that the	activity
44 within the waste is much lowe	r than the t	triggers for the repos	itory and t	herefore it	is expecte	d that this	waste will	be acceptable b	y the
45 LLWR.									
46									
47									
48									
49									
50									

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		kera	Solutio	IS	630	00333	000	000	111	с	0014	Sta	tus:	S1	
													Page	10 of 31	
1	Genera	al LLW													
2															
3	Source	Informa	ation												
4	Volume	e of Wast	e per year					=	46.87	m3		Note 2			
5	Bulk De	ensity of (General LLV	V				=	0.5	Te/m3		Ref 16			
6	The fol	lowing da	ata on the Is	otopes and	their resp	ective act	ivities have	e been rep	roduced f	rom Ref 1	6 (Assump	otion 1)			
7															
8		Nuclide	SZB Isotp	-											
9			(TBq	ı/m3)											
10															
11		H 3	3.30	E-09											
12		C 14	6.10	E-09											
13		Mn 54	1.30	E-07											
14		Fe 55	2.60	E-06											
15		Co 60	2.70	E-07											
16		Ni 63	2.00	E-07											
17		Zn 65	3.20	E-09											
18		Sr 90	2.10	E-08											
19		Ru 106	9.90	E-09											
20	A	vg 108m	3.20	E-09											
21	A	vg 110m	3.70	E-10											
22		Sb 125	2.10	E-09											
23		Cs 134	8.50	E-09											
24		Cs 137	4.30	E-08											
25		Ce 144	1.60	E-09											
26		Pm 147	2.70	E-08											
27		Pu 238	6.30	E-10											
28		Pu 239	1.50	E-09											
29		Pu 240	1.40	E-09											
30		Pu 241	1.80	E-07											
31		Am 241	2.70												
32	(Cm 242	4.70	E-10											
33	(Cm 243	2.40	E-10											
34	(Cm 244	1.60	E-10											
35		ther β / γ													
36			SZB Isotop												
37															
	Note 2:	This vol	ume has be	en taken fro	m an ear	ier versio	n of the pro	cess mass	s balance	(Ref 17). S	See Note 3	3 for			
	further														
40															
41	Calcula	ation Me	thod												
42															
43	Using t	he assun	ned volume	of waste pe	r year the	activity v	alues can b	e converte	ed to MBq	as follows	;				
44															
	Activity	(MBq) =	SZB Activit	ty x Assume	ed volume	x 100000	00								
46															
47	Taking	Tritium (H-3) as an e	example;											
48															
	Activity	of H-3 (N	/IBq) =	3.3E-09	х	46.87	х	1000000	=	1.5E-01					
50															

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				•					Paç	ge 11 of 31	
1											
	The results for	all the relevent Isotopes	are Shown in Table	e 2 Below							
3											
4	Nuclide	SZB Isotpe Activity (TBq/m3)	Activity (MBq)								
5		(твфліз)									
6			1.5E-01								
7	H 3	3.30E-09	2.9E-01								
8	C 14	6.10E-09	6.1E+00								
9	Mn 54 Fe 55	1.30E-07 2.60E-06	1.2E+02								
10 11	Co 60	2.70E-07	1.3E+01								
12	Ni 63	2.00E-07	9.4E+00								
12	Zn 65	3.20E-09	1.5E-01								
13	Sr 90	2.10E-09	9.8E-01	1							
14	Ru 106	9.90E-09	4.6E-01								
16	Ag 108m		1.5E-01								
17	Ag 110m		1.7E-02								
18	Sb 125	2.10E-09	9.8E-02								
19	Cs 134	8.50E-09	4.0E-01								
20	Cs 137	4.30E-08	2.0E+00								
21	Ce 144	1.60E-09	7.5E-02								
22	Pm 147	2.70E-08	1.3E+00								
23	Pu 238	6.30E-10	3.0E-02								
24	Pu 239	1.50E-09	7.0E-02								
25	Pu 240	1.40E-09	6.6E-02								
26	Pu 241	1.80E-07	8.4E+00								
27	Am 241	2.70E-09	1.3E-01								
28	Cm 242	4.70E-10	2.2E-02								
29	Cm 243	2.40E-10	1.1E-02								
30	Cm 244	1.60E-10	7.5E-03								
31	Other β / v	y 1.07E-06	5.0E+01								
32	Table 2:	General LLW Activity	/								
33											
		ne activity of the specific				ust be cat	egorised	as Alpha (d	α), Beta (β) or		
35	Gamma (γ) em	itters. This has been do	ne from Ref 6 and is	shown in	Table 3						
36											
37											
38											
39											
40											
41											
42											
43											
44											-
45											
46											
47											\vdash
48											\vdash
49											
50											

L	Akors	Nuclide (TBq/m3) H 3 3.30 ± -09 C 14 6.10 ± -09 Mn 54 1.30 ± -07 Fe 55 2.60 ± -06 Co 60 2.70 ± -07 Ni 63 2.00 ± -07 Ni 63 2.00 ± -07 Zn 65 3.20 ± -09 Sr 90 2.10 ± -09 Ag 108m 3.20 ± -09 Ag 108m 3.20 ± -09 Ag 110m 3.70 ± -09 Ag 110m 3.70 ± -09 Ag 110m 3.70 ± -09 Cs 134 8.50 ± -09 Cs 137 4.30 ± -09 Pu 238 6.30 ± -10 Pu 238 6.30 ± -10 Pu 239 1.50 ± -09 Pu 241 1.80 ± -07 Am 241 2.70 ± -09 Pu 242 4.70 ± -09 Pu 243 2.40 ± -10 Cm 243 2.40 ± -10 Cm 243 2.40 ± -10 Cm 244 1.60 ± -10 Cm 244 1.60 ± -10	200	Project I	Number:	Area :	System:	Discip. Code:	Doc. Type:	Sequen. Number:	R	ev.	2	
	Akera		ons	6300	0333	000	000	111	С	0014	Sta	atus:	S1	
						1						Page	12 of 31	
1														
2		H 3 3.30E-09 C 14 6.10E-09 Mn 54 1.30E-07 Fe 55 2.60E-06												_
3														_
4	Nuclide			Activity (MBq)	Decay Mo	ode (α, β	Remarks	6					_
5		(тво	/III3)			or γ)								_
6				1.58	= 01	ρ								_
7				2.98		β β								_
8					E+00									_
9				1.2E			<u>β+</u> C							_
10		Iuclide SZB Isotpe Activity (TBq/m3) H 3 3.30 E-09 C 14 6.10 E-09 Mn 54 1.30 E-07 Fe 55 2.60 E-06 Co 60 2.70 E-07 Ni 63 2.00 E-07 Zn 65 3.20 E-09 Sr 90 2.10 E-08 Ru 106 9.90 E-09 g 108m 3.20 E-09 g 110m 3.70 E-10 Sb 125 2.10 E-09 St 137 4.30 E-09 St 137 4.30 E-09 Sa 137 4.30 E-07 m 147 2.70 E-08 Su 238 6.30 E-10 Pu 240 1.40 E-09 Su 241 1.80 E-07 m 242 4.7	1.2E		_								_	
11				+01 +00	γ + β								_	
12			9.4E		-								_	
13			9.8		<u>γ+</u> β	-β+							_	
14			9.8E 4.6E		β						-		-	
15				4.00										_
16					E-01	γ+								_
17				E-02 E-02	γ + γ +	-								
18			4.0		γ + γ +	-								
19			3.20E-09 3.70E-10 2.10E-09 8.50E-09		E+00	-								_
20					E+00 E-02	γ+ β	-							_
21					E+02	β								_
22					E+00 E-02		α							_
23					02 E-02	-	а а							_
24					02 -02		a							
25				8.4E		α+		ßdeca	av is 99 90	98% of the	decay			_
26				1.3			α α	pucce	ay 13 00.00		uccay			_
27					E-02		a							_
28				1.16			μ + γ	n den	av is 99 7	'1% of the	decay			_
29					E-03		α α	4 400	ay 13 00.1		uccay			_
30					- 00 		μ /γ							_
31					+02	P .	/ Y							_
32 33					102									_
		-			aken fron	n table 3 ab	ove Thes	e are outli	ned belov	v-				_
35										.,				_
36	Uranium		0.00E+00	MBa										+
30														+
37														+
39		a												+
40														+
40														+
41														+
43	Co-60		1.27E+01											
44	Other radio	onuclides	2.14E+02											+
45														\top
46														\top
47														+
48														+
49														+
50														+

Alenno			Project	Number:	Area :	System:	Discip. Code:	Doc. Type:	Sequen. Number:	Rev.		2
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ter the D1 form	haussi sewa	to the LLN		wed estim	nates for the	a waste vo	lumes wha	are obtain	ed			
	1 was issued		vix, impro	veu estin					eu.			
olume of gener	all IW nerv	oor	_	51.9	m ³	Note 3						
signed of gener		cai	-	51.5	m	NOIC O						
sina this improv	ved volume c	of waste. tl	ne activitv	values fro	om Table 1.	, and the c	alculation	method o	utlined abo	ve. the		
			-									
<u> </u>	<u> </u>											
Needlate	SZB Isotpe	Activity										
Nuclide			Activity	(мвд)								
Н 3	3.30E	-09	1.7	E-01								
C 14			3.2	E-01								
Mn 54	1.30E	-07	-									
Fe 55	2.60E	-06										
Co 60	2.70E	-07	1.4	E+01								
Ni 63	2.00E	-07										_
Zn 65	3.20E	-09										
Sr 90	2.10E	-08										
Ru 106	9.90E	-09										
Ag 108m	3.20E	-09										
					1							
Other b/g			5.6	E+01								
Total			2.4	E+02								
Table 4:	Revised Act	ivity of G	eneral LL	.w								
Uranium												
Ra-226												
Th-232												
			MBq									
C-14			MBq									
			MBq									
Other radio	onuclides 2	.37E+02	MBq									-+
5	ter the D1 form olume of gener sing this impro- ollowing results Nuclide H 3 C 14 Mn 54 Fe 55 Co 60 Ni 63 Zn 65 Sr 90 Ru 106 Ag 108m Ag 110m Sb 125 Cs 134 Cs 137 Ce 144 Pm 147 Pu 238 Pu 230 Pu 240 Pu 241 Ag 108m Ag 110m Sb 125 Cs 134 Cs 137 Ce 144 Pm 147 Pu 238 Pu 239 Pu 240 Pu 241 Am 241 Cm 242 Cm 243 Cm 244 Other b/g Total Table 4: Uranium Ra-226 Th-232 Other alph C-14 I-129 H-3 Co-60	ter the D1 form was issued olume of general LLW per y sing this improved volume of ollowing results for the finge Muclide SZB Isotpe (TBq/r H 3 3.30E C 14 6.10E Mn 54 1.30E Fe 55 2.60E Co 60 2.70E Ni 63 2.00E Zn 65 3.20E Sr 90 2.10E Ru 106 9.90E Ag 108m 3.20E Ag 108m 3.20E Ag 110m 3.70E Sb 125 2.10E Cs 134 8.50E Cs 137 4.30E Cs 134 8.50E Cs 137 4.30E Cs 134 8.50E Cs 137 4.30E Cs 134 8.50E Cs 137 4.30E Ca 144 1.60E Pm 147 2.70E Pu 238 6.30E Pu 239 1.50E Pu 240 1.40E Pu 241 1.80E Am 241 2.70E Cm 242 4.70E Cm 243 2.40E Cm 243 2.40E Cm 244 1.60E Du 240 1.40E Pu 240 1.40E Pu 240 1.40E Pu 240 1.40E Pu 240 1.40E Pu 240 1.40E Cm 243 2.40E Cm 244 1.60E Other b/g 1.07E Total 4.59E Table 4: Revised Act Cm 244 1.60E Other b/g 1.07E Total 4.59E	Durine of general LLW per yearsing this improved volume of waste, the ingerprint of the SZB Isotpe Activity (TBq/m3)NuclideSZB Isotpe Activity (TBq/m3)H 3 3.30 ± 0.9 C 14 6.10 ± 0.9 Mn 54 1.30 ± 0.7 Fe 55 2.60 ± 0.6 Co 60 2.70 ± 0.7 Ni 63 2.00 ± 0.7 Zn 65 3.20 ± 0.9 Sr 90 2.10 ± 0.8 Ru 106 9.90 ± 0.9 Ag 108m 3.20 ± 0.9 Ag 108m 3.20 ± 0.9 Ag 110m 3.70 ± 1.0 Sb 125 2.10 ± 0.9 Cs 134 8.50 ± 0.9 Cs 137 4.30 ± 0.8 Ce 144 1.60 ± 0.9 Pm 147 2.70 ± 0.8 Pu 238 6.30 ± 1.0 Pu 239 1.50 ± 0.9 Pu 241 1.80 ± 0.7 Am 241 2.70 ± 0.9 Cm 242 4.70 ± 1.0 Cm 243 2.40 ± 1.0 Cm 243 2.40 ± 1.0 Cm 243 2.40 ± 1.0 Cm 244 1.60 ± 10 Other b/g 1.07 ± 0.6 Total 4.59 ± 0.6 Table 4:Revised Activity of GUranium 0.00 ± 4.00 Ra-226 0.00 ± 4.00 Other alpha 3.68 ± 0.11 C-14 3.17 ± 0.11 I-129 0.00 ± 4.00 H 3 1.40 ± 0.11	6300 ter the D1 form was issued to the LLWR, impro- plume of general LLW per year = sing this improved volume of waste, the activity pollowing results for the fingerprint of the waste at the state of the state of the state of the state the state of the state of the state of the state the state of the state of the state of the state the state of the state of the state of the state of the state the state of the state of the state of the state of the state the state of the state of the state of the state of the state the state of the state of the state of the state of the state the state of the state of the state of the state of the state the state of the state of the state of the state of the state the state of the state of the state of the state of the state the state of the state of the state of the state of the state the state of the state of the state of the state of the state the state of the state of the state of the state of the state the state of the state of the state of the state of the state the state of the state of the state of the state of the state the state of the state the state of the s	63000333 ter the D1 form was issued to the LLWR, improved estimated to the D1 form was issued to the LLWR, improved estimated to the waste are obtained waste, the activity values from the waste are obtained waste, the activity values from the waste are obtained waste, the activity (MBq) Nuclide SZB Isotpe Activity (MBq) H 3 3.30E-09 1.7E-01 C 14 6.10E-09 3.2E-01 Mn 54 1.30E-07 6.7E+00 Fe 55 2.60E-06 1.3E+02 Co 60 2.70E-07 1.4E+01 Ni 63 2.00E-07 1.0E+01 Zn 65 3.20E-09 1.7E-01 Sr 90 2.10E-08 1.1E+00 Ru 106 9.90E-09 5.1E-01 Ag 108m 3.20E-09 1.7E-01 Cs 134 8.50E-09 4.4E-01 Cs 137 4.30E-08 2.2E+00 Ce 144 1.60E-09 8.3E-02 Pm 147 2.70E-08 1.4E+00 Pu 238 6.30E-10 3.3E-02 Pu 241 1.80E-07 9.3E+00 Am 241 2.70E-09 1.4E+01<	6300033 000 ter the D1 form was issued to the LLWR, improved estimates for the obume of general LLW per year = 51.9 m ³ sing this improved volume of waste, the activity values from Table 1 Illowing results for the fingerprint of the waste are obtained. These at the fingerprint of the fingerprint of the transmitter of the fingerprint of the transmitter of the fingerprint of the fingerprint of the transmitter of the fingerprint of the fingerprint of the transmitter of the transmitter of the transmitter of the fingerprint of the transmitter of the fingerprint of the	63000333 000 000 ter the D1 form was issued to the LLWR, improved estimates for the waste volume of general LLW per year = 51.9 m ³ Note 3 sing this improved volume of waste, the activity values from Table 1, and the ollowing results for the fingerprint of the waste are obtained. These are outlined Nuclide SZB Isotpe Activity (TBq/m3) Activity (MBq) H 3 3.30E-09 1.7E-01 These are outlined C 14 6.10E-09 3.2E-01 Mn 54 Mn 54 1.30E-07 6.7E+000 Fe 55 Fe 55 2.60E-06 1.3E+02 Co 60 C 60 2.70E-07 1.4E+01 Ni 63 2.00E-09 Ni 63 2.00E-09 5.1E-01 Ag 100m 3.20E-09 1.7E-01 S 125 2.10E-09 1.1E-01 Cs 134 8.50E-09 4.4E-01 C 1314 8.50E-09 4.4E-01 Cs 137 4.30E-08 2.2E+00 C 144 1.60E-09 7.3E-02 Pu 238 6.30E+10 3.2E-02 Pu 238 6.30E+10 3.2E-02 Pu 241 1.40E+07	63000333 000 000 111 ter the D1 form was issued to the LLWR, improved estimates for the waste volumes whe interval interval	63000333 000 000 111 C ter the D1 form was issued to the LLWR, improved estimates for the waste volumes where obtain plume of general LLW per year = 51.9 m ³ Note 3 sing this improved volume of waste, the activity values from Table 1, and the calculation method of allowing results for the fingerprint of the waste are obtained. These are outlined in Table 4. Nuclide SZB isotpe Activity (TBg/m3) H 3 3.30E-09 1.7E-01 1.4E+01 C 14 6.10E-09 3.2E-01 Mn 54 1.30E-07 6.7E+00 Fe 55 2.60E-06 1.3E+02 C 6 0 2.70E-07 1.4E+01 N 63 2.00E-07 1.0E+01 Z n65 3.20E-09 1.7E-01 Z n65 3.20E-09 1.7E-01 Z n65 3.20E-09 1.7E-01 Ag 100m 3.20E-09 1.7E-01 S r 90 2.10E-08 1.1E-01 C 5 134 8.50E-09 4.4E-01 Pu 128 6.30E+10 3.3E-02 Pm 147 2.70E-08 1.4E+00 Pu 238	e3000333 000 000 111 C 0014 ter the D1 form was issued to the LLWR, improved estimates for the waste volumes where obtained.	63300333 000 001 111 C 0014 Status: Pri ter the D1 form was issued to the LLWR, improved estimates for the waste volumes where obtained. Pri sing this improved volume of waste, the activity values from Table 1, and the calculation method outlined above, the silowing results for the fingerprint of the waste are obtained. These are outlined in Table 4. Image: Control of the section o	6300033 000 000 111 C 0014 Status: 3 Pege 13 of 3 ter the D1 form was issued to the LLWR, improved estimates for the waste volumes where obtained. Pege 13 of 3 and the calculation method outlined above, the waste of the fingerprint of the waste are obtained. Note 3 and the calculation method outlined above, the waste of the fingerprint of the waste are obtained. Note 3 Note 3 Mode 3 Note 3 Outline of method outlined bove, the waste outlined in Table 4. Note 3 Activity (MBq) Note 3 Activity (MEq)

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1										
	Note 3: This information has be									
	these volumes (and those of the			onditioned v	olumes of	waste an	d hence s	ome have	a compaction	
	factor applied to them. See Ref	17 for more deta	ils							
5										
6	Final wasta naakaga									
	Final waste package									
8 9	Volume									
	Volume									
10 11	The Assumed Volume of waste	initially used	=	46.87	m3					
12	The Assumed Volume of Waste		-	40.07	mo					
13	Revised Volume of Waste		=	51.9	m3				Ref 10	
14										
	N.B. It is the initially assumed vo	olume of waste th	nat appear	s on the D1	form i.e. 4	47m3				
16										
17	<u>Weight</u>									
18										
19	Bulk Density of waste	= 0.5	Te/m ³						Ref 16	
20										
21	Weight of waste in waste package	ge = volume of v	aste in wa	ste packag	e x Densit	y of waste				
22										
23	Weight of waste in waste package	ge = 46.87	х	0.50						
24		= 23.44	Те							
25										
26	N.B. Using the revised volume of	of waste this will	give a total	l weight of 2	25.95 m³					
27						6.4				
	As stated in Note 3 the estimate					e of the wa	aste being	compacte	ed and some of it i	not. However
	these estimates are sufficient er	lough for this sta	ige of the c	lesign proce	288.					
30										
31										
32										
33 34										
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	1			-								Page	15 of 31	_
1	Condensa	ate Poli	ishing Resin											_
2			-											_
3	Source In								2		D (/ A			_
4			PS resin per 18 mo	nth cycle			=	204	ft ³		Ref 10			_
5	-		dary leakage rate				=	75	lb/day		Ref 2			_
-			ry to secondary lea	k at given r	ate (Assun	ned)	=	30	days		Ref 8			
			2S resin				=	0.75	Te/m ³		Ref 4			_
8	Decay tim	е						90	days		Ref 1			_
9	The fellow	din ni ni ni ni ni	a an tha lastance a			ماغانين محرفا بال	in the main		nt have h		d fram Daf			_
10	The follow	ity of CPS resin e ving data on the Isotopes a uclide Br-84 0.02 -131 0.04 -132 0.25 -133 0.14 -134 0.42 -135 0.28 kb-88 0.24	na their res	pective act	ivities with	in the prin	nary coola	int have be	een extrate	a nom kei	3		_	
11					D (0.1.1							_	
12	Νι	uclide			Nuclide		Coolant (µCi/g)							┢
13			Activity (pol/g)	-		Activity	(2009)							+
14		2r 01	0.02	-	Y-93	1 20	E-03							+
15				-	Y-93 Zr-95		E-03 E-04							+
16		-		_	Nb-95		E-04							_
17				-	Mo-95		E-04							+
18				_	Tc-99m		E-03							_
<u>19</u>		-	131 0.04 132 0.25 133 0.14 134 0.42 135 0.28 0-88 0.24 -134 5.90E-03	_	Ru-103		E-03							_
20				_	Ru-103		E-02							_
21				_	Rh-103m		E-02							_
22				_	Rh-105		E-02							_
23				_	Ag-110m		E-02							-
24	-			_	Te-129m		E-04							_
25			-	_	Te-129		E-02							_
26				_	Te-131m		E-03							-
27 28		In-54		_	Te-131		E-03							-
20		e-55		_	Te-132		E-03							-
<u>29</u> 30				_	Ba-137m		E-03							-
31		co-58	132 0.25 133 0.14 134 0.42 135 0.28 p-88 0.24 -134 5.90E-03 -136 7.40E-04 -137 7.90E-03 1-3 1 a-24 4.60E-02 r-51 2.60E-03 p-55 1.00E-03 a-55 1.00E-03 a-59 2.50E-04 p-58 3.90E-03	_	Ba-140		E-02							-
32		co-60	4.40E-04	_	La-140		E-02							-
33		n-65	4.30E-04		Ce-141		E-04							-
33 34		Sr-89	1.20E-04	-	Ce-143		E-03							+
35		Sr-90	1.00E-05	1	Ce-144		E-03							
36		Sr-91	9.80E-04	1	Pr-143		E-03							┢
37		Y-90	1.20E-06	1	Pr-144		E-03							+
38	Y	-91m	5.70E-04	1	W-187		E-03							\uparrow
39		Y-91	4.40E-06	1	Np-239		E-03							┢
40	Та	ble 5:	Reactor Coolant A	ctivity				_						T
	Calculatio			-										T
42														Τ
43	Total leak	age fror	m primary to second	dary		=	Primary	to second	ary leakag	e rate x Cl	PS operatio	on duratio	n	Τ
44						=	2250.0	lb						
45						=	1021.5	kg						
46														T
47	Volume of	CPS re	esin per 18month cy	vcle		=	5.78	m ³						T
48														
49	N.B. 1lb	o = 0.45	4Kg											Γ
50	1ft	$^{3} = 0.02$	83 m ³											

Excersion Project Number: Area: System: Dirace, Code: Sequent. Rev. 2 1 1 0 000 111 C 0014 Status: Status:			2									
		Kera	Solutions		000333	000	000	111	С	0014	Status:	S1
				•							Page	16 of 31
1												
2	Initially	/ neglectir	ng the decay ove	r 90 days the a	activity cor	centration	of primary	coolant tha	t leaks ir	to the secon	dary system can l	be
3	calcula	ated by;										
4												
5	Activity	/ =	Reactor coolant	activity x tota	l leakage f	rom primar	y to secon	dary				
6	_											
	See ta	ble 6 for r	results									
	T - 1-1 -	0 - 1	tatal anti-du af	400.040	0.0.1							
	Table	6 snows a	a total activity of	103.613	GBd							
	The ex	41	contration can th		al inte an			n on m ³ of C		. h		
	The ac	ctivity con	centration can the	en be converte	ed into an a	activity con	centration	per m° of C	PS resir	אָס וי);		
	A otivity	(concept	rotion por m ³ –	Total Ac	stivity / m ³	of rooin						
	ACTIVIT	y concent	ration per m =	TOLALAC	uvity / m	orresin						
	See ta	ble 6 for r	results									
	000 14											
	Table	6 shows a	total activity cor	centration/m ³	³ of CPS re	esin of	17.94	GBa / m ³				
							-	0247				
	This ca	an be con	verted to GBq pe	er tonne by div	iding by th	e bulk dens	sity of the C	CP resin				
							-					
	Theref	ore the to	tal activity conce	ntration of the		is	23.92	GBq / Te				
23	The lin	nits for LL	W are 4GBq/te a	Ipha emmitter	s and 12 C	Bq/te Beta	/gamma e	mmitters			Ref 5	
24												
25	The to	tal activity	concentration of	n the CPS res	in is not wi	thin the limi	its for LLW	Ι.				
26												
27												
28												
29	Now c	onsidering	g the decay perio	<u>d of 90 days:</u>								
30												
31	The ha	alf lifes of	the Isotopes wer	e determined f	rom Ref 6	and are sh	own in tab	le 7.				
				000								
	The ac	ctivity con	centration on the	CPS resin aft	er 90days	of decay ca	an be calcu	lated from	the follow	ving;		
									(\	
	Decer	od A other	Concentration (Cha/m2)	doonuad /		contration	(Cha/m2)		$-Ln(2) \times T$		
	Decay		y concentration (Guyms) = Un	uecayed A	CONTRACTION	Centration	(Curhan)		$t_{\frac{1}{2}}$	J	
	Where	Т-	Decay time (day	(2)					(÷ ,	/	-
	where			, 0)								
		-1/2 -	(uays)									
	The de	ecaved ac	tivity concentration	ons for all the i	sotopes a	re shown in	Table 2					-
	The to	tal decave	ed activity on the	CPS resin is	7.02	GBa/m ³						
	This ca	an be con	verted to GBq pe	er tonne by div	iding by th	e bulk dens	sity of the C	CP resin				
				-								
	Theref	ore the to	tal activity conce	ntration of the	CPS resin	is	9.36	GBq / Te				
48												
49												
50												

	Alcon	alutiona	Project Number:	Area :	System:	Discip. Code:	Doc. Type:	Sequen. Number:	Rev.	2	
	AkerS	olutions	63000333	000	000	111	С	0014	Status:	S1	
				·		·			Pa	ge 17 of 31	
1 T a	able 6 - Activity	per m ³ of CPS resi	n								
2											_
3	New Pole	Reactor Coolant		• .•		Activity	/ per m ³				
4	Nuclide	Activity (µCi/g)	Activity (Ci)	Activity	/ (GBq)	-	GBq/m ³)				_
5	Br-84	2.00E-02	2.04E-02	7.56	E 01	1 21	E-01				
6	ы-о4 I-131	4.00E-02	4.09E-02		E+00		E-01				
7	I-131	2.50E-02	2.55E-01	9.45			E+00				_
8	I-132	1.40E-01	1.43E-01	5.29			E-01				_
9	I-133	4.20E-01	4.29E-01	1.59			E+00				
10	I-134	2.80E-01	2.86E-01	1.06			E+00				_
11	Rb-88	2.40E-01	2.45E-01	9.07			E+00				
12	Cs-134	5.90E-03	6.03E-03	2.23			E-02				_
13	Cs-134 Cs-136	7.40E-04	7.56E-04	2.23			E-02				_
14	Cs-130 Cs-137	7.90E-03	8.07E-03	2.80			E-03				+
15	H-3	1.00E+00	1.02E+00	3.78		-	E+02				+
16	Na-24	4.60E-02	4.70E-02		E+00		E-01				_
17	Cr-51	2.60E-03	2.66E-03	9.83			E-02				_
18	Mn-54	1.30E-03	1.33E-03	4.91			E-03				_
19	Fe-55	1.00E-03	1.02E-03		E-02		E-03				
20	Fe-59	2.50E-04	2.55E-04	9.45			E-03				_
21	Co-58	3.90E-03	3.98E-03	1.47			E-02				_
22	Co-60	4.40E-04	4.49E-04		E-02		E-03				_
23 24	Zn-65	4.30E-04	4.39E-04		E-02		E-03				_
24	Sr-89	1.20E-04	1.23E-04	4.54			E-04				_
26	Sr-90	1.00E-05	1.02E-05	3.78	E-04		E-05				
20	Sr-91	9.80E-04	1.00E-03		E-02		E-03				
28	Y-90	1.20E-06	1.23E-06	4.54		7.85	E-06				
29	Y-91m	5.70E-04	5.82E-04	2.15		3.73	E-03				
30	Y-91	4.40E-06	4.49E-06		E-04		E-05				
31	Y-93	4.30E-03	4.39E-03		E-01		E-02				
32	Zr-95	3.30E-04	3.37E-04	1.25	E-02	2.16	E-03				
33	Nb-95	2.40E-04	2.45E-04	9.07	E-03	1.57	E-03				
34	Mo-99	5.60E-03	5.72E-03	2.12	E-01	3.66	E-02				
35	Tc-99m	5.10E-03	5.21E-03	1.93	E-01	3.34	E-02				
36	Ru-103	6.30E-03	6.44E-03	2.38	E-01	4.12	E-02				
37	Ru-106	7.50E-02	7.66E-02	2.83	E+00	4.91	E-01				
38	Rh-103m	6.30E-03	6.44E-03	2.38	E-01	4.12	E-02				
39	Rh-106	7.50E-02	7.66E-02	2.83	E+00	4.91	E-01				
40	Ag-110m	1.10E-03	1.12E-03	4.16	E-02	7.20	E-03				
41	Te-129m	1.60E-04	1.63E-04	6.05	E-03	1.05	E-03				
42	Te-129	2.90E-02	2.96E-02	1.10	E+00	1.90	E-01				
43	Te-131m	1.40E-03	1.43E-03	5.29	E-02	9.16	E-03				
44	Te-131	9.70E-03	9.91E-03	3.67	E-01	6.35	E-02				
45	Te-132	1.50E-03	1.53E-03	5.67	E-02	9.81	E-03				
46	Ba-137m	7.40E-03	7.56E-03	2.80	E-01	4.84	E-02				
47	Ba-140	1.10E-02	1.12E-02	4.16	E-01	7.20	E-02				
48	La-140	2.30E-02	2.35E-02	8.69	E-01	1.50	E-01				
49	Ce-141	1.30E-04	1.33E-04	4.91	E-03	8.51	E-04				
50											

	•	leave O		201	Project	Number:	Area :	System:	Discip. Code:	Doc. Type:	Sequen. Number:	Re	v.	2	
		ker5	- Activity per m ³ of CPS	ns	630	00333	000	000	111	С	0014	Stat	us:	S1	
							·						Page	18 of 31	—
	Table	6 - Activity	y per m ³ of	CPS resin	(contin	ued)									_
2			.							3					_
3		Nuclide	Activity		Activ	ity (Ci)	Activity	(GBq)		/ per m ³ 3Bq/m ³)					_
4 5		Ce-143	2.60E		2.66	6E-03	9.83	F-02	-	E-02					-
6		Ce-144	3.40E			7E-03	1.29			E-02					-
7		Pr-143	3.00E			6E-03	1.13			E-02					-
8		Pr-144	3.40E			7E-03	1.29		2.22	E-02					-
9		W-187	2.30E	-03	2.35	5E-03	8.69	E-02	1.50	E-02					-
10		Np-239	2.00E	-03	2.04	4E-03	7.56	E-02	1.31	E-02					
11		Total	2.74E	+00	2.80	E+00	1.04	E+02	1.79	E+01					
12															
13															
14															
15	N.B.	1Ci = 37G	Bq = 3.7E+	-10Bq											
16															
			e Isotopes o	outlined in	Tabe 6 h	ave either	Beta or Ga	ımma deca	ay modes	i.e. There	e is no isoto	pe which e	exhibits		
18	Alpha	Decay													
19															
20	The ac	tivity of the	e specific Is	otopes req	uired are	e taken fror	m table 6 al	oove. The	se are out	lined belo	w;				
21															
22		Uranium		0.00E+00		MBq									
23		Ra-226		0.00E+00		MBq									
24		Th-232		0.00E+00		MBq									
25		Other alph		0.00E+00		MBq									
26		C-14		0.00E+00		MBq									_
27		I-129		0.00E+00		MBq									_
28		H-3		3.78E+04		MBq									_
29		Co-60		1.66E+01		MBq									_
30		Other radi	ionuclides	6.58E+04		MBq									_
31															_
	It shou	ld be noted	d that the in	idividual isc	otopes ha	ave been t	aken from t	he undeca	ayed data	to provide	e a worst ca	ase scenar	10.		_
33															_
34															-
35															+
36 37															┢
37															-
30 39															┢
40															+
41															\square
42															1
43															
44															Γ
45															
46															
47															
48															
49															
50															

	•	Iron C	alutiona	Project Number:	Area :	System:	Discip. Code:	Doc. Type:	Sequen. Number:	Rev.	2	
		ker5	olutions	63000333	000	000	111	С	0014	Status:	S1	
									i	Page	19 of 31	_ _
-	Table	7- Activity	after 90 days decay	/	T							_
2 3 4		Nuclide	Activity per m ³ resin (GBq/m ³)	Half life (Days) (Ref 6)	(GBq/m ³)	l Activity Leakage ilb/day	(GBo Leaka	l Activity q/m ³) ge rate /day	-	Activity (GBq/m3) ge rate 25lb/day		-
5		Br-84	1.31E-01	2.21E-02	0.00	=+00		E+00		0.00E+00		-
6		I-131	2.62E-01	8.04E+00		E-04		E-05		3.72E-05		_
7		I-131	1.64E+00	9.56E-02	8.24		-	E-284		2.75E-284		
8		I-132	9.16E-01	8.67E-01		E-32		E-32		1.67E-32		
9		I-134	2.75E+00	3.65E-02	0.00			E+00		0.00E+00		
10		I-135	1.83E+00	2.74E-01	1.97			E-99		6.56E-100		
11		Rb-88	1.57E+00	1.23E-02	0.00			E+00		0.00E+00		
12		Cs-134	3.86E-02	7.54E+02		E-02		E-02		1.18E-02		
13		Cs-134 Cs-136	4.84E-03	1.31E+01	4.14		-	E-02 E-05		1.38E-05		
14		Cs-130 Cs-137	5.17E-02	1.10E+04		E-02	-	E-02		1.71E-02		
15		H-3	6.54E+00	4.51E+03	6.45			E+00		2.15E+00		
16		Na-24	3.01E-01	6.23E-01		E-44		E-45		3.44E-45		
17		Cr-51	1.70E-02	2.77E+01	1.00			E-03		5.96E-04		
18		Mn-54	8.51E-03	3.12E+02	6.97			E-03		2.32E-03		
19		Fe-55	6.54E-03	9.96E+02		E-03	-	E-03		2.05E-03		
20		Fe-59	1.64E-03	4.45E+01		E-04		E-04		1.34E-04		
21		Co-58	2.55E-02	7.09E+01		E-04		E-04		3.53E-03		
22		Co-60	2.88E-03	1.92E+03	2.79			E-03		9.29E-04		
23		Zn-65	2.81E-03	2.44E+02	2.19			E-03		7.26E-04		
24		Sr-89	7.85E-04	5.05E+01		E-03		E-03		7.61E-05		
25		Sr-69 Sr-90	6.54E-05	1.05E+04	6.50	-	-	E-04		2.17E-05		
26		Sr-90 Sr-91	6.41E-03	4.01E-01		E-70		E-70		6.44E-71		
27		Y-90	7.85E-06	2.67E+00		E-16		E-16		1.81E-16		
28		Y-91m	3.73E-03	3.45E-02	0.00			E+00		0.00E+00		
29		-		5.85E+01	9.91			E+00 E-06				
30		Y-91	2.88E-05 2.81E-02	4.24E-01				E-66		3.30E-06 1.26E-66		
31		Y-93				E-66		E-00				
32		Zr-95	2.16E-03 1.57E-03	6.40E+01 3.50E+01		E-04 E-04		E-04 E-04		2.72E-04 8.80E-05		
33		Nb-95	3.66E-02	2.75E+00		E-04 E-12		E-04 E-12		1.72E-12		
34		Mo-99	3.34E-02	2.50E-01	2.15			E-12 E-110		7.17E-111		
35		Tc-99m	4.12E-02	3.93E+01		E-03		E-03		2.80E-03		
36		Ru-103 Ru-106	4.12E-02 4.91E-01	3.74E+02	4.15			E-03 E-01		1.38E-01		
37		Ru-106 Rh-103m	4.91E-01 4.12E-02	3.90E-02		E+00		E+00		0.00E+00		
38			4.12E-02 4.91E-01	3.45E-04		E+00 E+00		E+00 E+00		0.00E+00		
39		Rh-106	7.20E-03	2.50E+02		E-03		E-03		1.87E-03		
10 1		Ag-110m Te-129m	1.05E-03	3.36E+01		E-04		E-04		5.45E-05		
11 1			1.90E-01	4.83E-02		E+00		E+00		0.00E+00		
12 10		Te-129 Te-131m	9.16E-03	4.83E-02 1.25E+00		E-24		E+00 E-24		6.47E-25		
13		Te-131	6.35E-02	1.74E-02		E+00		E+00		0.00E+00		
44		Te-131	9.81E-03	3.20E+00		E-11		E+00 E-11		1.12E-11		
45			4.84E-02	1.77E-03		E+00		E+00		0.00E+00		
46		Ba-137m Ba-140	4.84E-02 7.20E-02	1.28E+01		E-04		E+00 E-04		1.80E-04		
47			1.50E-02	1.28E+01 1.68E+00						3.75E-18		
48		La-140	8.51E-04	3.25E+00		E-17 E-04		E-18 E-05				
49 50		Ce-141	0.31E-04	3.20E+UI	1.25	∟-04	0.32	L-00		4.16E-05		

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		ker5	olutio	ns	6300	00333	000	000	111	С	0014	Status:	S1	
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	Table	7 - Activity	y after 90 da	ays deca	y (continu	led)								L
2														L
3				2			Decayed	Activity		Activity				_
4		Nuclide	Activity			e (Days)	(GBq/m ³)			q/m³)		Activity (GBq/m3)		_
5			resin (GE	Bq/m°)	(Re	ef 6)	rate 75	lb/day		ge rate /day	Leaka	ge rate 25lb/day		_
6		0 440	1.70E	00	4.00	E+00	3.55	F 00		E-22		1.18E-22		_
7		Ce-143	2.22E			E+00 E+02	1.79			E-22 E-02		5.96E-03		_
8		Ce-144 Pr-143	2.22E 1.96E			E+02 E+01	1.79	-		E-02 E-04		6.60E-05		-
9		Pr-143 Pr-144	2.22E			E-02	0.00			E+00		0.00E+00		-
10		W-187	1.50E			E-02	5.82			E-30		1.94E-30		╞
11		Np-239	1.30E			E+00	4.33			E-14		1.44E-14		-
12		Total	1.31L			E+00	7.02			E+00		2.34E+00		┢
13 14		· otai			5.17		7.021		7.00					┢
14 15														┢
15														┢
	N.B.	1Ci = 37G	Bq = 3.7E+	10Ba										┢
18			•		above is ir	correct. b	ecause Ba-	-137m is a	ctuallv in s	secular eq	uilibrium v	vith it's parent,		-
19			hich is long						-					
20			conclusions		· ·									F
21														T
22														T
23														T
24														
25														T
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43														┢
44														┢
45														┢
46														┢
47														┢
48 49														\vdash
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l	. .	waste package including <t< th=""><th>2</th><th></th></t<>		2											
		kera	Solutio	ons	630	00333	000	000	111	С	0014	Sta	atus:	S1	
	1												Page	21 of 31	_
1															
2		-	-												
3											nded to en	capsulate	the CPS		
4	resin i	n a ceme	nt formulatio	n in 200L	drums wh	ich can th	en be sent	for disposa	al to the LL	WR.					
5															
6	Volum														
7	The ce	ement to i	resin ratio wi	ll be 50:50) as per th	e similar v	waste strea	m at Sizew	/ell B			Ref 11			
8															
9							=		m ³						
10	Perce	ntage of r	esin per was	te packag	je (by volu	ıme)	=	50%							
11															
12	Total v	olume of	waste packa	age = Vol	ume of res	sin / Perce	ntage of re	sin per wa	ste packag	е					
13		<u> </u>													
14	Total	olume of	waste pack				50%								
15				=	11.60	m³									
16															
17	Weigh	<u>nt</u>													
18															_
19		Density of		=	0.75	Te/m ³						Ref 4			
20	The d	ensity of c	cement	=	2.4	Te/m ³						Ref 12			
21															
22			in waste pad					e x Density	of resin						_
23	Weigh	nt of resin	in waste pao	-	5.80	x	0.75								
24				=	= 4.35	Те									
25															
26	Weigh	it of ceme	ent in Waste	package	=		f cement in		kage x De	nsity of c	ement				
27					=	5.80	x	2.4							_
28					=	13.92	Те								_
29	T - 1 - 1 -							a a constante d							
30	I otal v	weight of	waste packa				aste packag	je + weight	of cement	i in waste	раскаде				
31				=	4.35	+	13.92								
32				=	18.27	Te	per 18 mo								
33				=	18270	Kg	per 18 mo	onth cycle							
34															\vdash
35															\vdash
36															+
37															\vdash
38															\vdash
39															\vdash
40															\vdash
41															\vdash
42															\vdash
43															+
44															+
45 46															\vdash
															+
47															-
48															-
49															\vdash
50								ions E & C Ltd.							

l		kor?	olutio	200	Project	Number:	Area :	System:	Discip. Code:	Doc. Type:	Sequen. Number:	Rev	<i>.</i>	2	
		Ker S	olutio	115	6300	00333	000	000	111	С	0014	Statu	us:	S1	
	14/	0.1											Page 22	2 of 31	—
-	Waste														-
2	0		•												-
v		e Informat							1	m ³		Dof 1			+
	Density	e of oil per	year					=	1			Ref 1			+
-	Density							=	0.869	Te/m ³		assumed			-
6	The fol	lowing dat:	a on the lea	tones and	their resp	ective activ	vitios within	the prime	arv coolan	t have he	on ovtracto	ed from Ref	3		┝
7 8		lowing date			then resp								0		-
9			Reactor 0	Coolant			Reactor	Coolant							-
10		Nuclide	Activity			Nuclide		ν (μCi/g)							-
11															-
12		Br-84	0.0	2		Y-93	4.30	E-03							-
13		I-131	0.0			Zr-95		E-04	1						
14		I-132	0.2			Nb-95		E-04							\vdash
15		I-133	0.1			Mo-99		E-03							
16		I-134	0.4	2		Tc-99m	5.10	E-03							
17		I-135	0.2	8		Ru-103	6.30	E-03							
18		Rb-88	0.2	4		Ru-106	7.50	E-02							
19		Cs-134	5.90E	-03		Rh-103m	6.30	E-03							
20		Cs-136	7.40E	-04		Rh-106	7.50	E-02							
21		Cs-137	7.90E	-03		Ag-110m	1.10	E-03	-						
22		H-3	1			Te-129m	1.60	E-04	-						
23		Na-24	4.60E	-02		Te-129	2.90	E-02							
24		Cr-51	2.60E	-03		Te-131m	1.40	E-03							
25		Mn-54	1.30E	-03		Te-131	9.70	E-03							
26		Fe-55	1.00E			Te-132		E-03							
27		Fe-59	2.50E	-04		Ba-137m		E-03							
28		Co-58	3.90E	-03		Ba-140		E-02							
29		Co-60	4.40E			La-140		E-02							
30		Zn-65	4.30E			Ce-141		E-04							
31		Sr-89	1.20E			Ce-143		E-03							
32		Sr-90	1.00E			Ce-144		E-03							
33		Sr-91	9.80E			Pr-143		E-03							\vdash
34		Y-90	1.20E			Pr-144		E-03							\vdash
35		Y-91m	5.70E			W-187		E-03							\vdash
36		Y-91	4.40E	-Ub		Np-239	2.00	E-03							┝
37						Total Activity	2.74	E+00							┢
38		Table 0: 5	leactor Co	olant cat	/14./	, istivity			<u> </u>						┢
39				orant activ	nty										┢
40	Caland	ntion Math	od												┢
	Calcula	ation Meth	100												┢
42 43	The ac	tivity of the	waste oil is	s assumed	to be 0.1	5% of the s	activity of t	he reactor	coolant T	Thus the in	sotone acti	vity shown	in table 8		\vdash
		-	ed as belov												┢
44 45	22010			-											┢
45 46	Isotopia	c activitv in	waste oil =	= isotonic a	ctivitv in r	eactor cool	ant x 0.15	%							\vdash
46 47					carry in t										┢
	The rea	sults are sh	nown in tabl	le 9											\vdash
48 49															\vdash
49															\vdash

	AkerSolutions	Project N	lumber:	Area :	System:	Discip. Code:	Doc. Type:	Sequen. Number:	Rev.	2
	AkerSolutions	6300	0333	000	000	111	С	0014	Status:	S1
		1		i				_	Pag	e 23 of 31
1	This gives the activity in UCi/g									
2	This gives the activity in μ Ci/g									
	Mass of oil over lifetime of plant = volu	ume of oil ov	/er lifetim	e of plant x	Density o	foil				
5										
	Mass of oil over lifetime of plant =	1	x	0.869	=	0.869	Те			
7					=	869000	g			
8										
9	This allows the production of a fingerp	print for the v	vaste oil,	as shown ir	n Table 9					
10										
11 12										
12										
14										
15										
16										
17										
18										
19										
20 21										
21										
23										
24										
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29 30										
31										
32										
33										
34										_
35										_
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37 38										
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46 47										
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L.	Alcons	alutiona	Project Number:	Area :	System:	Discip. Code:	Doc. Type:	Sequen. Number:	Rev	<i>'</i> .	2
	Akero	olutions	63000333	000	000	111	с	0014	Statu	IS:	S1
.				1						Page 2	4 of 31
· ·	able 9 - Activity	of waste OII									
2											
3 4 5	Nuclide	Reactor Coolant Activity	Waste oil activity (µCi/g)		il Activity Ci)		il activity 3q)		il activity Bq)		
5 6	Br-84	2.00E-02	3.00E-05	2.61	E+01	9.65	E+05	9.65	E-01		
7	I-131	4.00E-02	6.00E-05		E+01	1.93	E+06		E+00		
8	I-132	2.50E-01	3.75E-04	3.26	E+02	1.21	E+07		E+01		
9	I-133	1.40E-01	2.10E-04	1.82	E+02	6.75	E+06		E+00		
10	I-134	4.20E-01	6.30E-04	5.47	E+02	2.03	E+07	2.03			
11	I-135	2.80E-01	4.20E-04	3.65	E+02	1.35	E+07		E+01		
12	Rb-88	2.40E-01	3.60E-04	3.13	E+02	1.16	E+07		E+01		
13	Cs-134	5.90E-03	8.85E-06	7.69	E+00	2.85	E+05	2.85			
14	Cs-136	7.40E-04	1.11E-06	9.65	E-01	3.57	E+04		E-02		
15	Cs-137	7.90E-03	1.19E-05	1.03	E+01	3.81	E+05	3.81	E-01		
16	H-3	1.00E+00	1.50E-03	1.30	E+03	4.82	E+07		E+01		
17	Na-24	4.60E-02	6.90E-05	6.00	E+01	2.22	E+06		E+00		
18	Cr-51	2.60E-03	3.90E-06	3.39	E+00	1.25	E+05	1.25	E-01		
19	Mn-54	1.30E-03	1.95E-06	1.69	E+00	6.27	E+04	6.27	E-02		
20	Fe-55	1.00E-03	1.50E-06	1.30	E+00	4.82	E+04	4.82	E-02		
21	Fe-59	2.50E-04	3.75E-07	3.26	E-01	1.21	E+04	1.21	E-02		
22	Co-58	3.90E-03	5.85E-06	5.08	E+00	1.88	E+05	1.88	E-01		
23	Co-60	4.40E-04	6.60E-07	5.74	E-01	2.12	E+04	2.12	E-02		
24	Zn-65	4.30E-04	6.45E-07	5.61	E-01	2.07	E+04	2.07	E-02		
25	Sr-89	1.20E-04	1.80E-07	1.56	E-01	5.79	E+03	5.79	E-03		
26	Sr-90	1.00E-05	1.50E-08	1.30	E-02	4.82	E+02	4.82	E-04		
27	Sr-91	9.80E-04	1.47E-06	1.28	E+00	4.73	E+04	4.73	E-02		
28	Y-90	1.20E-06	1.80E-09	1.56	E-03	5.79	E+01	5.79	E-05		
29	Y-91m	5.70E-04	8.55E-07		E-01		E+04	2.75	E-02		
30	Y-91	4.40E-06	6.60E-09		E-03		E+02	2.12	E-04		
31	Y-93	4.30E-03	6.45E-06		E+00		E+05	2.07	E-01		
32	Zr-95	3.30E-04	4.95E-07		E-01		E+04	1.59	E-02		
33	Nb-95	2.40E-04	3.60E-07		E-01		E+04	1.16	E-02		
34	Mo-99	5.60E-03	8.40E-06		E+00		E+05	2.70	E-01		
35	Tc-99m	5.10E-03	7.65E-06		E+00		E+05		E-01		
36	Ru-103	6.30E-03	9.45E-06		E+00		E+05		E-01		
37	Ru-106	7.50E-02	1.13E-04		E+01		E+06		E+00		
38	Rh-103m	6.30E-03	9.45E-06		E+00		E+05		E-01		
39	Rh-106	7.50E-02	1.13E-04		E+01		E+06		E+00		
40	Ag-110m	1.10E-03	1.65E-06		E+00		E+04		E-02		
41	Te-129m	1.60E-04	2.40E-07		E-01		E+03		E-03		
42	Te-129	2.90E-02 1.40E-03	4.35E-05		E+01		E+06		E+00		
43	Te-131m	9.70E-03	2.10E-06 1.46E-05		E+00 E+01		E+04 E+05		E-02		———— — —
44	Te-131 Te-132	9.70E-03	2.25E-06		E+01 E+00		E+05 E+04		E-01		
45	Ba-137m	7.40E-03	1.11E-05		E+00 E+00		E+04 E+05		E-02		
46	Ba-13711 Ba-140	1.10E-02	1.65E-05		E+00 E+01		E+05 E+05		E-01		
47	La-140	2.30E-02	3.45E-05		E+01 E+01		E+05 E+06		E-01		
48	Ce-141	1.30E-02	1.95E-07		E-01		E+00		E+00		
49 50	06-141	1.002 04	1.00 07	1.09		0.21		0.27	E-03		

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	Table	9 - Activity	/ of waste Oil	l (contir	nued)									
2			Reactor Co	alant	Waste oi		Waste oi		Wests O	il estivity	Waste Oi			
3 4		Nuclide	Activity (µ0		waste of (μC	-	waste of			Bq)	(MI	-		
5		Ce-143	2.60E-0	3	3.90	Ξ-06	3.39	E+00	1.25	E+05	1.25	E-01		
6		Ce-144	3.40E-0	3	5.10	E-06	4.43	E+00		E+05	1.64	E-01		
7		Pr-143	3.00E-0		4.50		3.91			E+05	1.45	E-01		
8		Pr-144	3.40E-0		5.10		4.43			E+05	1.64	E-01		
9		W-187	2.30E-0		3.45		3.00			E+05	1.11			
10		Np-239	2.00E-0		3.00		2.61			E+04	9.65			
11		Total	2.74E+0	JU U	4.111	03	3.57	E+03	1.32	E+08	1.32	E+02		
12														
13														
14	N.B.	1Ci = 370	Bq = 3.7E+10)Ba										
15	IN.D.		37m value in ta		bove is inc	orrect be	cause Ba-1	l 37m is ac	tually in se	ecular equ	ilibrium wi	th it's nare	nt	
17			hich is long liv						-				,	
18			conclusions.		empaneen			J.C CO	ipaioioii te					
19														
20														
	From F	Ref 6 all the	e Isotopes out	lined in	Table 9 ha	ve either l	Beta or Ga	mma deca	y modes i	.e. There i	is no isoto	pe which e	xhibits	
	Alpha	Decay												
23														
24	The ac	tivity of the	e specific Isoto	opes req	quired are t	aken from	table 9 ab	ove. Thes	e are outli	ned below	;			
25	Uraniu	m	=		0.00E+00		MBq							
26	Ra-226	6	=		0.00E+00		MBq							
	Th-232		=		0.00E+00		MBq							
	Other a	alpha	=		0.00E+00		MBq							
	C-14		=		0.00E+00		MBq							
	I-129		=		0.00E+00		MBq							
	H-3		=		4.82E+01		MBq							
	Co-60		=		2.12E-02		MBq							
00	Other	radionuclid	es =		8.40E+01		MBq							
34														
35														
36 37														
37 38														
39														
40														
41														
42														
43														
44														
45														
46														
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48														
49														
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				1	1		1	1				Pa	age 26 of 31
1													
	Final v	vaste pac	kage										
3													
4	Volume	<u>e</u>											
5	T L	huma at O	9 (Ref 1	
6 7	i ne vo	olume of O	il to be disp	osea of pe	er year is		=	1	m3			Kerr	
7 8													
9													
	Weigh	t											
11		_											
12	Bulk D	ensity of C	Dil	=	0.869	Te/m ³						assumed	
13													
	Weigh	t of oil in w	vaste packa	ge = volur	ne of oil in	waste pad	ckage x Der	nsity of oil					
15													
16	Weigh	t of Oil in	package =		1.00	x	0.87						
17				=	0.87	Te							
18													
19	Total w	veight of w	aste packa	ge =	0.87	Те							
20													
	N.B.	This weig	ht does not	include th	ie weight o	f any cond	litioning ma	trix as the	details of	this are c	urrently un	known	
22													
23													
24 25													
26													
27													
28													
29													
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31													
32													
33													
34													
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												Page 2	7 of 31	
1														-
2	Steam Ge	enerator	<u>Sludge</u>											
3														
4	Source Ir	nformatio	n											
5														
6	The follow	ving data	on the Isotope	es and the	ir activity wi	thin the seco	ondary co	olant have	been extr	acted fro	om Ref 19			
7														
8		Nuclide	Activity (µCi/g)		Nuclide	Activity (µCi/g)								
9		Br-83	2.30E-05		Y-91m	1.80E-06								-
10		Br-84	4.00E-05		Y-91	2.30E-07								
11		Br-85	4.00E-08		Y-91 Y-92	4.90E-07								
12		I-129	4.90E-08 2.40E-11		Y-92 Y-93	4.90E-07 1.50E-07								
13		I-129 I-130	1.40E-05	ł	r-93 Zr-95	1.50E-07 2.70E-07								-
14		I-130 I-131	1.40E-05 1.10E-03	ł	ZI-95 Nb-95	2.70E-07 2.70E-07								-
15		I-131 I-132	7.30E-04	ł	Mo-95	2.70E-07 3.40E-04								\vdash
16		I-132 I-133	1.80E-04	ł	M0-99 Tc-99m	3.40E-04 3.20E-04								\vdash
17		I-133	8.10E-05		Ru-103	2.30E-04								_
18		I-135	8.70E-03		Rh-103m	2.30E-07								
19		Rb-88	2.30E-04		Rh-106	2.00E-10								
20		Rb-89	8.90E-04		Ag-110m	6.70E-07								
21		Cs-134	2.10E-03		Te-127m	1.30E-06								
22		Cs-136	3.00E-03		Te-127	3.20E-07								
23 24		Cs-137	1.50E-03		Te-129m	4.40E-06								_
24 25		Cs-138	9.50E-05		Te-129	3.80E-06								-
25		H-3	1.00E+00		Te-131m	1.00E-05								
20		Cr-51	2.20E-06		Te-131	2.80E-06								
28		Mn-54	1.10E-06		Te-132	1.30E-04								
29		Mn-56	1.30E-04		Te-134	3.20E-06								
30		Fe-55	8.40E-07		Ba-137m	1.40E-03								
31		Fe-59	2.20E-07		Ba-140	1.70E-06								
32		Co-58	3.20E-06		La-140	6.00E-07								
33		Co-60	3.70E-07		Ce-141	2.60E-07								
34		Sr-89	3.30E-06	t	Ce-143	2.20E-07								
35		Sr-90	1.50E-07	İ	Ce-144	1.90E-07								
36		Sr-91	3.30E-06	I	Pr-143	2.50E-07								
37		Sr-92	4.00E-07	I	Pr-144	1.90E-07								
38		Y-90	2.70E-08	İ		T								
39					Total	1.01								
40					Activity	1.01								
41		Table 10	: Secondary S	Side Cool	ant Activity	y								
42	Volume o	f sludge p	er year =	0.085	m3						Ref 10			
43	Density of	f sludge =		998.20	kg/m3						Ref 18			
44	Decay tim	ne =		30	days	(Assumed	to be a mi	nimum)						
45														
46														
47														
48														Ц
49														Ц
50														

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1													
2	Calculati	on metho	d										
3													
4	Total acti	vity in sluc	lge prior to de	cay is = 1.01E+	00 µCi/g								
5													
6	The half I	ifes of the	Isotopes were	e determined from	Ref 6 and are	shown in t	table 11.						
7													
8	The activ	ity concen	tration on the	sludge after 30 da	ays of decay ca	n be calcu	lated from	the follow	/ing;				
9													
10								((T)			
11	Decayed	Activity Co	oncentration (µCi/g) = Undecay	ed Activity Con	centration	(µCi/g) x I	EXP –	$\frac{Ln(2)}{t_{\frac{1}{2}}}$				
12								L	$-\frac{1}{2}$	J			
13	Where	T =	Decay time (days)									
14		t _{1/2} =	Half Life (day	rs)									
15													
16	The deca	yed activit	ty concentration	ons for all the isoto	opes are showr	in Table	11.						
17													
18		Nuclide	Initial Activity	Half Life (Days	Decayed	Activity	Decayed	Activity	Dec	cayed			
19		Huenue	(uCi/a)		⁵ γ (μC	i/g)	(Bo	q/g)	Activi	ty (MBq)			
20		Br-83	2.30E-05	1.00E-01	1.13	E-95	4.18	E-91	3.5	4E-92			
21		Br-84	4.00E-06	2.21E-02	0.00	Ξ+00	0.00	E+00	0.00	DE+00			
22		Br-85	4.90E-08	2.01E-03	0.00	Ξ+00	0.00	E+00	0.00	DE+00			
23		I-129	2.40E-11	5.73E+09	2.40	E-11	8.88	E-07	7.5	3E-08			
24		I-130	1.40E-05	5.20E-01	6.01	E-23	2.22	E-18	1.8	9E-19			
25		I-131	1.10E-03	8.04E+00	8.28	E-05	3.06	E+00	2.6	0E-01			
26		I-132	7.30E-04	9.56E-02	2.70	E-98	9.98	E-94	8.4	6E-95			
27		I-133	1.80E-03	8.67E-01	6.84	E-14	2.53	E-09	2.1	5E-10			
28		I-134	8.10E-05	3.65E-02	1.60	-252	5.92	E-248	5.02	2E-249			
29		I-135	8.70E-04	2.74E-01	8.91	E-37	3.30	E-32	2.8	0E-33			
30		Rb-88	2.30E-04	1.23E-02	0.00	E+00	0.00	E+00	0.00	DE+00			
31		Rb-89	8.90E-06	1.10E-02	0.00	E+00	0.00	E+00	0.00	DE+00			
32		Cs-134	2.10E-03	7.54E+02	2.04	E-03	7.56	E+01	6.4	1E+00			
33		Cs-136	3.00E-03	1.31E+01	6.13	E-04	2.27	E+01	1.93	3E+00			
34		Cs-137	1.50E-03	1.10E+04	1.50	E-03	5.54	E+01	4.70	DE+00			Γ
35		Cs-138	9.50E-05	2.30E-02	0.00	Ξ+00	0.00	E+00	0.00	DE+00			
36		H-3	1.00E+00	4.51E+03	9.95	E-01	3.68	E+04	3.12	2E+03			Γ
37		Cr-51	2.20E-06	2.77E+01	1.04	E-06	3.84	E-02	3.2	6E-03			Γ
38		Mn-54	1.10E-06	3.12E+02	1.03	E-06	3.81	E-02	3.2	3E-03			Γ
39		Mn-56	1.30E-04	1.10E-01	1.03	E-86	3.83	E-82	3.2	5E-83			T
40		Fe-55	8.40E-07	9.96E+02	8.23	E-07	3.04	E-02	2.5	8E-03			T
41		Fe-59	2.20E-07	4.45E+01	1.38	E-07	5.10	E-03	4.3	3E-04			T
42		Co-58	3.20E-06	7.09E+01	2.39	E-06	8.83	E-02	7.4	9E-03			t
43		Co-60	3.70E-07	1.92E+03	3.66	E-07	1.35	E-02	1.1	5E-03			t
44		Sr-89	3.30E-06	5.05E+01		E-06		E-02	6.8	6E-03			t
45		Sr-90	1.50E-07	1.05E+04		E-07		E-03		0E-04			t
46		Sr-91	3.30E-06	4.01E-01		E-28		E-24		2E-25			┢
40		Sr-92	4.00E-07	1.13E-01		E-87		E-82		1E-83			┢
47		Y-90	2.70E-08	2.67E+00	1.11			E-07		8E-08			┢
						• •	0	· • •	0.1	•			┢
49		Y-91m	1.80E-06	3.45E-02	<u> </u>	-268	1 65	E-263	1 40	E-264			1

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1														
2		Y-91	2.30E-07		5E+01	1.61			E-03		6E-04			
3		Y-92	4.90E-07	1.5	0E-01	3.05	-67	1.13	E-62	9.5	7E-64			
4		Y-93	1.50E-07	4.24	4E-01	7.68	-29	2.84	E-24	2.4	1E-25			
5		Zr-95	2.70E-07)E+01	1.95E			E-03		3E-04			
6		Nb-95	2.70E-07)E+01	1.49			E-03		8E-04			
7		Mo-99	3.40E-04		5E+00	1.77E			E-03		5E-04			
8		Tc-99m	3.20E-04		0E-01	2.76			E-35		8E-37			
9		Ru-103	2.30E-07		3E+01	1.35E			E-03		5E-04			
10		Rh-103m	2.30E-07		0E-02	4.32E			E-234		E-235			
11		Rh-106	2.00E-10		5E-04	0.00E			E+00)E+00			
12		Ag-110m	6.70E-07)E+02	6.16			E-02		4E-03			
13		Te-127m	1.30E-06		9E+02	1.075		3.97			7E-03			
14		Te-127	3.20E-07		0E-01	2.23			E-26		1E-27			
15		Te-129m	4.40E-06	3.36	6E+01	2.375		8.77	E-02	7.4	4E-03			
16		Te-129	3.80E-06	4.8	3E-02	5.41E	-193	2.00	E-188		E-189			
17		Te-131m	1.00E-05		5E+00	5.96E			E-08	-	7E-09			
18		Te-131	2.80E-06	1.74	4E-02	0.00E	+00		E+00	0.00)E+00			
19		Te-132	1.30E-04	3.20)E+00	1.965	-07	7.24	E-03	6.1	5E-04			
20		Te-134	3.20E-06	3.0	0E-02	2.99E	-307	1.10	E-302	0.00)E+00			
21		Ba-137m	1.40E-03	1.7	7E-03	0.00E	+00	0.00	E+00	0.00)E+00			
22		Ba-140	1.70E-06	1.28	3E+01	3.33E	-07	1.23	E-02	1.0	4E-03			
23		La-140	6.00E-07	1.68	3E+00	2.53E	-12	9.35	E-08	7.9	3E-09			
24		Ce-141	2.60E-07	3.25	5E+01	1.375	-07	5.07	E-03	4.3	0E-04			
25		Ce-143	2.20E-07	1.38	3E+00	6.06E	E-14	2.24	E-09	1.9	0E-10			
26		Ce-144	1.90E-07	2.85	5E+02	1.775	-07	6.54	E-03	5.5	4E-04			
27		Pr-143	2.50E-07	1.36	6E+01	5.40E	E-08	2.00	E-03	1.7	0E-04			
28		Pr-144	1.90E-07	1.20	0E-02	0.00E	+00	0.00	E+00	0.00)E+00			
29								Total A	Activity	3.14	4E+03			
30		Table 11:	Sludge Isot	opic Fing	erprint afte	r 30 days								
31														
32	Notes 1.	1Ci = 370	GBq = 3.7E+1	0Bq										
33	2.	The Ba-1	37m value in	table 2 ab	ove is incor	rect, becaus	e Ba-137r	n is actua	lly in secu	lar equili	brium with	it's parent,		
34		Cs-137, v	vhich is long l	ived in cor	nparison to	Ba-137m i.e	e. 30.1 yrs	in compa	rsion to 2.	5mins. T	his does no	ot		
35		affect the	conclusions.											
36														
37	From Ref	6 none of	the Isotopes	in Table 1	1 are Alpha	emitters								
38														
39	mass of s	ludge per	year =	Density x	Volume									
40														
41	mass of s	ludge per	year =	998.20	х	0.085								
42														
43	mass of s	ludge per	year =	84.847	kg									
44														
45	The total	activity wi	thin the sludg	e after 30	days decay	time is	3.14E+03		MBq					
46														
47	The Isoto	pic fingerp	print of the slu	idge can b	e found in ta	able 11.								
48														
49														
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1														
2	The LLW	R D1 form	n (Acceptance	e in princip	le) asks spe	ecifically for	the followi	ng istopes	:					
3														
4	Uranium			=	0	MBq								
-	Ra-226			=	0	MBq								
6	Th-232			=	0	MBq								
7	Other alp	na		=	0	MBq								
8	C-14 I-129			=	0 7.53E-08	MBq MBq								
9	H-3			=	3.12E+03									
10 11	Co-60			=	1.15E-03	MBq								
11	Other rad	lionuclides	3	=	1.33E+01									┢
12						-1								╞
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1 2 References								
3 1 EPS-GW-GL-700 Rev 0. Euro DCD,	section 11.4.2.1. Pa	11.4-4 ar	nd Table 11	.4-1.				
4 2 EPS-GW-GL-700 Rev 0. Euro DCD,								
5 3 EPS-GW-GL-700 Rev 0. Euro DCD,		stic source	terms					
6 4 Perry's Chemical Engineers' Handbo	ok, Seventh Edition.	Pg 16-10						
7 5 http://www.defra.gov.uk/environment	/radioactivity/waste/p	odf/definiti	ons0905.pd	lf				
8 6 http://nucleardata.nuclear.lu.se/Nucle	earData/toi/index.asp	<u>)</u>						
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11 9 T/WPS/320/E/02 - Nirex Waste Pack	age Specification ar	nd Guidan	ce Docume	entation Sp	ecificatio	n for 3m ³ Di	rum	
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16 14 Ans standard for waste liquid (ans/ansi 5	<i>·</i> · ·							
17 15 EPS-GW-GL-700 Euro DCD rev 0. T								
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19 17 UKP-GW-GL-004. Process Mass Ba			((6300033	3-000-000	-111-C-0	001))		
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