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TECHNICAL MEMORANDUM 0706

June 13, 2007

Originators: Andrew H. Thatcher, CHP, Technical Director

Subject: Kodak CFX De-Fueling Man-REM Budget

Revision: 0

ENDORSEMENT: This document contains the results of research and technical analysis which have been reviewed and approved for publication by:

Barton P. Anderson, Principal

6/15/2007

Date

1 INTRODUCTION

- 1.1 Kodak facility de-fueling operations is a complex, multi-step process that is fully detailed in the work plan. Exposures associated with the steps involved in the work plan are estimated in this man rem budget.
- 1.2 This paper will show that the predicted individual and collective dose do not approach administrative limits and that the extremity limits are a small fraction of the allowable limit.

1.3 BACKGROUND

1.3.1 The CFX has been in operation since 1975 and has been shutdown since June of 2006. The CFX was a sub-critical assembly of uranium 235 utilizing a californium 252 source¹. The californium source has remained inserted into the CFX for most of the life of the CFX such that the total estimated operational hours are 252,000 at an average power of 5.8 watts. Further details of the CFX assembly and characteristics may be located in the EKC Scoping Study.²

The CFX was designed to never exceed a K_{eff} < 0.99.

NEXTEP TM0703 Eastman Kodak Company CFX Decommissioning Project Scoping Study, Robert Newman and Ning Zhang

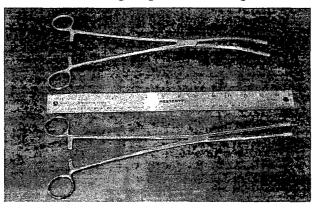
2 SCOPE

- 2.1 This paper will show that the calculated individual and collective dose does not exceed administrative limits in a maximum worst case condition.
- 2.2 The calculations are separated into the effective dose for the whole body, subject to a 5 rem/yr regulatory limit and 500 mR/yr administrative limit, and the shallow dose equivalent to the skin and extremities subject to a regulatory limit of 50 rem/yr and an administrative limit of 5 rem/yr.

3 METHODS

- 3.1 Attachment A is an Excel spreadsheet that details the major steps involved in the de-fueling operations and calculates both a total and individual dose as well as the total and individual extremity dose. Table A-1 provides calculations for gamma dose and Table A-2 contains calculations for dose due to beta radiation.
- 3.2 Numerous assumptions are necessary when calculating the dose from de-fueling operations.

 A number of significant assumptions are as follows:
 - 3.2.1 Tongs or other holding utensils will be employed during fuel plate handling. It is assumed that the distance of the extremities will be at least 6" from the source during operations. The actual tongs employed will be 14" in length (effective length 10.5 inches). The reduction in extremity dose with these tongs is approximately a factor of 15. A picture of the modified tongs is presented in Figure 3.1.



14 Inch Modified Tongs for Fuel Plate Handling
Figure 3.1

- 3.2.2 Specialty tongs will also be used for transfer of the cans from the work table to the scale and to the 2R container.
- 3.2.3 During assembly removal, individuals are assumed to stand immediately adjacent to the CFX for ease of access to the structure.
- 3.2.4 In many instances, two individuals are listed as required for a given operation and the estimated dose is doubled as a result. As a practical matter, many operations will only require a single individual with periodic assistance from the 2nd individual.

- 3.2.5 The time to perform operations is conservatively biased high.
- 3.2.6 The distance assumed for effective dose calculations is biased low.
- 3.2.7 No efficiency improvements were considered in performing the repetitive tasks associated with handling the plates and filling the canisters for loading.
- 3.2.8 No credit is provided for the reduction of beta dose by the wearing of one to two pair of gloves.
- 3.2.9 The background dose rate in the cavity (>1m from CFX or fuel plates) will be less than 1 mrem/hr and is not considered in the overall man rem budget.
- 3.3 Supporting calculations from both the CFX as well as individual fuel plates for the gamma dose are performed using the Microshield Code³ and are included as Attachment B for the estimated dose rate at 6". Additional calculations of dose from the CFX, 6M drums, and fuel plates may be found in the following technical memos (TM): TM0519⁴, TM0702⁵, TM0603⁶.
- 3.4 Beta dose calculations were performed using the Varskin V2.0 computer code⁷.

4 RESULTS

4.1 Table 4.1 displays the overall results. The Excel spreadsheet is analyzed by each step from a dose standpoint. Each step is summed individually and collectively for both effective and extremity dose.

Table 4.1

Man-Rem Budget Summary

E	dividual Total Effective Dose quivalent (rem)	Combined Total Effective Dose Equivalent (rem)	Individual Shallow Dose Equivalent (rem)	Combined Shallow Dose Equivalent (rem)
	0.089	0.150	3.4	6.2

4.2 The estimated Total Effective Dose Equivalent (TEDE) to the single individual with greatest exposure is approximately 0.09 rem, well less than both the administrative limit and the regulatory limit. In addition, that same individual is estimated to receive a shallow dose equivalent (SDE) of 3.4 rem, well less than the administrative and regulatory limit.

3

Grove Engineering, Microshield Code, Version 5.03.

MEXTEP TM05-19, Kodak CFX Core Residual Activity and Dose Modeling, D. Thatcher, CHP.

NEXTEP TM0702 Exposure Rate Estimates from Kodak MTR Plates in a 6M-55 Container, A.H. Thatcher, CHP

NEXTEP TM0603 Exposure Rate Estimates from Kodak MTR Fuel Plates, A.H. Thatcher, CHP.

Durham, J.S. VARSKIN MOD 2 and SADDE MOD 2: Dose from Skin Contamination. NUREG/CR-5873. 1992.

- 4.3 The results show that the whole body dose is not a critical issue as the worst case estimated effective dose is less than 100 mrem for a single individual. Practical considerations for ALARA therefore focus on limiting the extremity dose. Plexiglas containers are made for the temporary storage of the Type II and Type III plates to eliminate the beta dose. An open ended box is also made for the canisters so that beta exposure from the plates will be greatly diminished.
- 4.4 For the CFX, the reflector material will be left in place during decommissioning to eliminate the beta dose during operations near the CFX. Lead shielding will be placed outside of the reflector to reduce the gamma component of dose as well as reduce the very minor contribution from bremsstrahlung⁸. In addition, while the top reflector must be removed the gain access to the plates, temporary Plexiglas shields under lead sheets will be placed over the baskets not being removed.

5 CONCLUSIONS

5.1 The estimated Total Effective Dose Equivalent (TEDE) to the single individual with greatest exposure is approximately 0.09 rem, well less than both the administrative limit and the regulatory limit. In addition, that same individual is estimated to receive a shallow dose equivalent (SDE) of 3.4 rem, well less than the administrative and regulatory limit (Section 4.2).

Bremsstrahlung contributions were estimated as ~3 mrem/hr using the ISO-PC code.

ATTACHMENT A Beta and Gamma Dose Calculations

Table A-1

Gamma Dose Calculations

amma contribution	personnel involved	Distance (R) for effective dose	time (minutes)	Dose Rate (mrem/hr)	Maximum Effective Dose (mrem)	Whole Body Dose (mrem)	Dose Rate (mrem/hr)	Total Extremity Dose SDE (mrem)	Maximum Extremity Dose for a single Individual (mrem)
ly Preparation				5.60	44.65	30.86		15.06	
Concrete Block removal WEP removal	4 2	2 to 3'	75	9.00 20.00		12.00 6.67	9.00 20.00	12.00 6.67	3.0
Remove CF-252 source housing and		114	1 10	20.00	3,33	0.07	20.00	0.07	
support structure above the support		1	l	1		i		i '	
structure housing	11	1	15	28.00	7.00	7.00	28.00	7.00	7.0
ssembly									
Remove hex nuts for each of 4 control rods	1	Ι,	10	28.00	4.67	4.67	28.00	4.67	. 4.6
		······	<u>''</u>			4.07	20.00	7.01	4,4
Remove the set screws to the guide tubes	1	1	10	28.00	4.67	4.67	90.00	15.00	15.0
Remove upper support structure	2 "	1	5	28.00	2.33	4.67	28.00	4.67	2.3
Remove any additional tube penetrations		i	1						
that may pose a fuel plate removal obstacle	1		٠ ,	28.00	2.33	2.33	90.00	7.50	7.5
Remove poly above CFX	2	 	1 1	28.00	1.87	3.73	320.00	42.67	213
Remove two front angle supports	2		5	28.00	2.33	4.67	50.00	6.33	4.1
Back off screws for pressure plates 24									
Remove reflector material surrounding	1		10	28.00	4.67	4.67	80.00	15.00	15.0
CFX if possible	2	1 1	1 5	28.00	2.33	4.57	320.00	53.33	26.6
Place lead bricks around CFX - tape into		 		20.00			020.00		10.0
ptace	2	1	5	28.00	2.33	4.67	320.00	53.33	26.6
Removal									•
Remove type III fuel plates Al Remove 29 type I plates	1 2	 	2	29.00	0.93	0.93	110.00	3.67	3.6
itime to clean off plates	2	 	10		0.30	9.33 0.60	110.00	38.67 50.00	18.3 25.0
Remove and clean 4 type II plates	1	 	19		0.07	0.07	7.00	0.23	0.2
Prepare 1st stack, place into can and seal									
can	2	1.5	5	14.00	1.17	2.33	100.00	16.67	8.3
Record weight of can A Place can A Into drum 1		1.5	1 2	14.00	0.23 1.00	0.23 1.00	100.00 100.00	1.67 3.33	1.6
Place lids on 2R and drum and seal		 	10		0.33	0.67	10.00	3.33	1.8
Remove 1st drum to hoist area		1.5	5	1.50	0.13	0.25	10.00	1.67	0.8
Biremove remaining fuel from first basket ??	SPARZON.	杨宇江州大学		28.00	运输线 1.13	A	SALA 4110.00		75 Sept 1
time to clean off plates	Ext. The 2 has la.	2 to 370 - 35 1				1565 - 15455 0.14	100.00	12.07.	58 To 10 8.0
Remove type I plates from second basket	。夏·罗斯 2 州中国人	计图50%。专家[1	SECRE B	△. 20.00	A 2.67	47 Aug 200 5.33	110.00	34 SW (** 29.33	发现起: (1.36.14.0
ime to clean off plates :	Sales Inter	Saint - State State 1	Sec. 12	20	0.24	0.24	22.422.100.00	20.00	20.0
	f	1.5	3 P. C.	.14.00	A 331.17	233	110.00	18.33	9.1
record weight of can B 3880 10 8888	estar of the end	1.5		. 14.00	57 0.23	Q20 0.23	100.00	1.67	25.05 £ 21.6
place can B into drum #2 - Programme	Section 1	子中·本地改造成6		30.00	2.345 1.00	ads 55 % 1.00	-Care 100.00	B. 3.33	3.3
Remove and clean 4 type II plates	127 25	分下以及其下的 的数	Sec. 2	CO 200		S 3-1.55 A 0.07.	7.00	0.23	· · · · · · · · · · · · · · · · · · ·
Place lids on 2R and drum and seal	是不好2次。这个	14. C 63300	°2 € 4 10	35 × 2.00	್ರಾಂ 0.33	K # 1 8 2 0.67	10.00	3.33 E ≥ 3.33	1.6
Remove drum to hoist area \\ 2000000000000000000000000000000000000	· · · · · · · · · · · · · · · · · · ·	2.31 3435 135	2.413793	1.50 28.00	0.13	1957 - 0.25 17 1 2.25	44.10.00 44.64.5110.00	220 7 1.67 22 8.85	A3 : 77 (22 08
time to clean off plates 3 - 2512-9 2.5	2	30 37 21	3.62069	1.20	0.07	0.14	100.00	12.07	6.0
Remove type plates from third basket	2 (x.g)	Fund 1924	- B	20.00	2.07	5.33	110.00	29.33	14.8
time to clean off plates a like the property of the	$\{(r,s)$	R. S. G. M. C.	√ estate 12	1.20	0.24	0.24	100.00	20.00	20.0
prepare 3rd stack, place into can and seed	2 . 2	5 7 2	5 8 B	A Company	2	2.33			AL
record weight of can B	Aller Zakalan Aller y Talan Ka	30 to 1.5	. 5	14.00 14.00	1.17 0.23		110.00	18.33 1.67	9.1 1.6
place can C into drum #3	\$74. vb 10-1, 795		Protect	30.00	1.00		100.00	3.33	33
	taka Danis	A	25.34 July 2		0.07	0.07	7.00	0.23	.0.2
Place iids on 2R and drum and seal 32 ***	James (2) 54 74 1.	3 m 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	447.7410	2.00	shed √ ≤ 0.33	0.67	10.00	%√. 3.33	20
	对称2.85分别	1.5			0.13	0.25	10.00	3.19 Kits 3.1.87	3.0
	record 2 decre	European Africa Compa		28.00 1.20	3.22	6.44 (4.4) (4.4)	100.00	25.29 34.48	更新に対象される。12.6 じくごうかは35歳 17.2
Remove 9 type I plates from basket 4.	AND LOCAL	Single Property Sec.	enterestic	A SCHOOL SAN	777	STATISTICS NOT NOT	A. NO. OF TAXABLE PARKS.	medial recipit Age Speared	Live de come designable
clean and place on table	H. 1. 2	1. 14. 1	3.103448	28.00	1.45	2.90	110.00	11.38	5.6
time to clean off plates	也是两2岁的兴奋	2302578673			\$ t. 0.09	0.18	(100.00 to 100.00	15.52 mg 15.52	Marketing ball
Prepare stack, place into can and seal can	4.74	起為經濟	600000	14.00	117	Contract of		37.5	Partie Albert
Record weight of can D	CARL TERMS	5 32 TABLE 1.5	200 NO. 100 P. D.			2.33	100.00 100.00	16.67 1.67	ener in the BI
Place can D into drum 4	CHARLES STATES AND A	THE PROPERTY OF			A. 9 7 1 00	1.00	700.00		ativakti er blag 1. Vidi kommunist 3.
Remove and clean 4 type II plates ************************************	BARRES MARKET	经实现规则 实验			0.07	154 February 0.07	. 4 . 7.00		Contraction of
Place all 16 type II plates into Can E and	E-Pite			器程(140)	建	10000000000000000000000000000000000000	CONTRACTOR	7612511C2.55	CEARS NO W
	AND SAME AND ADDRESS OF	33-2-55-6-55-6-21	# C. 45	8.00	0.33	0.87	27.00	4.50	为此,是是中华2
	mar deces.	1.0° 35.32@ 1.5			0.07	2.72 Marie 0.07			arsanisar (1872). O.A
	etari Zirturia	PROGRAMMENT	10	257 3 (X)	14 38 30.27	1379 2 7243 U.Z.	200000027.00	A. Career 19 20 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	markan markan da 11.
Remove drum to holst area.	100 2	FEC. 85 148 1.5	-25 CAL 05	2.00	-39 -0.17	0.33	10.00	Sept. 23 April 1.67	RESERVED TO A STATE OF THE STAT
Remove remaining fuel from basket 4	2	1	10	28.00	4.67	9.33	110.00	36.67	18. 174 174 174 176 18.
clean off and stack	2	1	15	1.20	0.30	0.60	100.00	50.00	25.0
Prepare stack, place into can and seal can	2	4 5		14.00	4.47		100 50	40.00	
Record weight of Can F		1.5 1.5	5	14.00	1,17 0,23	2.33 0.23	100.00	16.67 1.67	8.3 1.6
Place Can F into drum 5		1.5	2	30.00	1.00	1.00	100.00	3.33	3.3
Remove all remaining type III fuel from									
GICFX	2	1.5	10	1.50	0.25	0.50	110.00	36.67	16.3
Prepare stack, place into can and seal									
	2	1.5 1.5	5	3.10	0.26	0.52	100.00	18.67	8.3
Record weight of Can G Place can G into drum 5		1.5	1 2	3.10 6.60	0.05 0.22	0.05 0.22	100.00	1.67 3.33	1.6
Place lids on 2R and drum and seal	- ż			3.00	0.50	1.00	10.00	3.33	1.6
Remove drum to hoist area	2	1.5	.5	2.00	0.17	0.33	10.00	1.67	0.8
Remove all 5 drums from cavity and place									
in loading dock	2	1.5	120	3.00	6.00	12.00	10.00	40.00	20.0
				Dose		148.88	7	7	

Table A-2
Beta Dose Calculations

Be	ta contribution	personnel involved	Distance (feet)	time (minutes)	Dose Rate (mrem/hr)	Total Extremity Dose SDE (mrem)	Maximum Extremity Dose for a single individual SDE (mrem
avity	Preparation	37-					
	Concrete Block removal	4	2 to 3"		<<1		
	WEP removal	2	1+	10	<<1		
	Remove Cf-252 source housing and						
	support structure above the support		•				i
	structure housing	1	1 . 1	15	<<1 :		
icac	sembly		-	 			
1545	Remove hex nuts for each of 4 control			 			
	rods	1	4	10	<<1	ł	ł
	ious		·	19			
			_	مه ا	1		1
	Remove the set screws to the guide tubes	11			<<1		
	Remove upper support structure	2	1		<<1		
	Remove any additional tube penetrations			i	ł	ł	l
	that may pose a fuel plate removal			ı	1		1
	obstacle	1	1		<<1		<u>l</u>
	Remove poly above CFX	2	1		<<1		
	Remove two front angle supports	2	1	5	<<1		
	Back off screws for pressure plates 24			T	1	I	
	total	1	. 1	10	<<1		<u> </u>
	Remove reflector material surrounding				<u> </u>		
	CFX if possible	2	1 1	l 5	<<1		
	Place lead bricks around CFX - tape into		<u>_</u>	 -			
	place	2		1 .	<<1	1	1
	Maria and the second se		<u> </u>		<<1		
uei r	Removal			- 2	700.0		
	Remove type III fuel plates		0.5	L			
<u>. v</u>	Remove 29 type 1 plates	2	0.5				
	time to clean off plates	2	0.5			350.0	
	Remove and clean 4 type II plates	1	0.5	2	700.0	23.3	23
	Prepare 1st stack, place into can and seal						
	can	2	0.5	5	700.0	116.7	58
	Record weight of can A	1	0.5	1	700.0	11.7	11
	Place can A into drum 1	1	0.5	2	700.0	23.3	2
	Place lids on 2R and drum and seal	2	1		200.0	66.7	
	Remove 1st drum to hoist area	2	1.5	5	200.0	33.3	16
.647 D	remove remaining fuel from first basket	7.1.1.4.2.2.2.2.3.11.1.	*** O.5				
	time to clean off plates	SAC ZOSENSK	0.5		7	84.5	
Carlot Ser	The Control of Planes	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	17 10 3111	3.02008	ACTOR OF THE SECURE	The state of the s	A SECTION OF THE SECTION OF THE
		2		8		Sendak E. Di	
41,160,4	Remove type I plates from second basket		0.5	12.174 19 407 11		186.7	
4.00	time to clean off plates	desirentations (* 1851)	Se S. 0.5	gettera/12	700.0		140
Ĭċ	prepare 2nd stack, place into can and seal		是他为	the salari day	POLICE OF SE		"是一个一个一个一个一个一个一个一个一个一个一个一个一个一个一个一个一个一个一个
par in	can:	2	V. 3.4. U.S				。1990年第二年的 5
45.5	record weight of can B	開発競争が言葉	0.5				
	place can B into drum #2	是国本代别的美国	海療法, 0.5	黑弧型 压力2			1 次の4 75 × 23,754 2
31	Remove and clean 4 type II plates	展下30世纪144054E	∋್ಪ3್ 0.5	18 E. 2	700.0	经验 500 万 净 23.3	1889 PART FROM 2
	Place lids on 2R and drum and seal	transita 2 and the	642 O 1 1	10			
205.00	Remove drum to hoist area	T. Cally 2 . Street	50.72.11.5		200.0	59.4090.Casa 33.5	200 1949 - REAL SOLD
· C	remove remaining fuel from first basket #	2		2.413793			
	time to clean off plates	2	0.5				
		and American Section 1997 in the second	0.0	J.J2008	0.15075 0.453 0	200 A	***************************************
	Remove type I plates from second basket	2	Ô.5			186.7	9
• • • •		The server ≰ are constant.					
. 9	time to clean off plates	mary Salk Sal	::, ≈ <i>i</i> ::0.5	12/4/11/12	700.0	140.0	. 14
3	prepare 2nd stack place into can and seal	Service Commence	1 7 3 6				
	can	2	0.5				
	record weight of can B	CONTRACTOR ATT.	0.5	- 34 1	700.0		
11.5	place can B into drum #2	4 2.86 Sept. 8	0.5	1230 No. 2	700.0	23.3	2
. 2.	Remove and clean 4 type II plates	8, 250 3, 1 0, 5, 560	0.5				
-	Place lids on 2R and drum and seal	2.	1				
	Remove drum to hoist area	2	1.5				

	Remove 20 plates from basket 3	2		6.896552		160.9	80.5
100 A	time to clean off plates	7 1 1 2 2 2 3 5 K W	0.5	10.34483	700.0	运工部产业241.4	120.7
1500	Remove 9 type I plates from basket 4	《公司》 《西亚斯·斯	ではいい。	Series Ser	DSATE SAN	17 (0.7)	建筑设施企业工程
影響態	clean and place on table	2.2	0.5	3 103448		72.4	36.2
图数据	TEXABLE PROPERTY OF THE PROPERTY OF	三族公司。2008年5年	\$ A 0.5	4.655172	700.0	108.6	54.3
2007	Prepare stack, place into can and seal ***	PROPERTY OF THE	建工程的	光生的		147.588 17° 1840	2011/2010/2012
	can	2.7	0.5	5 charge 5	700.0	116.7	58.3
	Record weight of can D	國際關係性議論政治	通刊程度0.5	A	700.0	三位。2015年11:7	2275-24-25374-9-3111.7
	Place can D into drum 4	是代表的社会的政策	显然於0.5		700.0	23.3	
	Remove and clean 4 type II plates	242321045822	**、次 3 0.5	理的经验证据2	700.0	23.3	是公子之子。" "如此 23.3
	Place all 16 type II plates into Can E and		至规则是		AND SEASON		A TOTAL PROPERTY.
的情報	seal can	2	0.5	上海市 5	700.0	116.7	58.3
學的數	Record weight of Can E	是是是他们的"自然"		新歌。我能力	700.0	为经验的共享。11:7	以近2017年。2 011.7
	Place can E into drum 4	是以他是49.000亿	约3670.5	经特别的12	700.0	23.3	23.3
	Place lids on 2R and drum and seal	超到出售》。2时是整點的	The State of	图3883/10	200.0	₩ . 68.7	33.3 CT 14.00 (33.3
Hert to MAGE	Remove drum to hoist area	的成為於2門期間是	》	5	200.0	33.3	S454 1919 4 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
	Remove remaining fuel from basket 4,						
	clean off and stack	2	0.5			233.3	
		2	0.5	15	700.0	350.0	175.0
	Prepare stack, place into can and seal	_		_			
	can	2	0.5		700.0	116.7	58.3
	Record weight of Can F	1	0.5		700.0	11.7	11.7
	Place Can F into drum 5	1	0.5	2	700.0	23.3	23.3
l i	Remove all remaining type III fuel from	_		i			
	CFX	2	1	10	700.0	233.3	116.7
	Prepare stack, place into can and seal	,					
	can	2	1.5		700.0	116.7	58.3
	Record weight of Can G	1	0.5		700.0	11.7	11.7
	Place can G into drum 5	1	0.5		700.0	23.3	23.3
	Place lids on 2R and drum and seal	2		10	200.0	66.7	33.3
	Remove drum to hoist area		1.5	5	200.0	33.3	16.7
	Remove all 5 drums from cavity and place	_			~~~		. <u></u> .
	in loading dock	2	1.5	120	200.0	800.0	400.0
	Total Dose					5,396.6	3,019.1

ATTACHMENT B

Microshield Calculations at 6" from the CFX and an Individual Fuel Plate

Conversion of calculated exposure in air to dose FILE: C:\MS5\DATA\KODAK\POSTSD**1\TYPE1:MS5 Case Title: MTR plate exposure This case was run on Wednesdey: June 6: 2007 at 11:45:49 AM Dose Point # 1 - (18.16.6) cm

Results (Summed over energies)	Units	Without Buildup	With Buildup	
Photon Fluence Rate (flux)	Photons/cm²/sec	5.109e+004	7.857e+004	
Photon Energy Fluence Rate	MeV/cm²/sec	3.074e+004	4.692e+004	
Exposure and Dose Rates:				
Exposure Rate in Air	mR/hr	5.979e+001	9.129 e+ 001	
Absorbed Dose Rate in Air	mGy/hr	5.219e-001	7.970e-001	
u .	mrad/hr	5.219e+001	7.970e+001	
Deep Dose Equivalent Rate	(ICRP 51 - 1987)			
o Parallel Geometry	mSv/hr	6.228e-001	9.515e-001	
o Opposed	11	4.929e-001	7.525e-001	
o Rotational	n	4.929e-001	7.525e-001	
o Isotropic	**	4.361 e-001	6.657e-001	
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		·	
o Parallel Geometry	mSv/hr	6.595e-001	1.007e+000	
o Opposed	"	6.246e-001	9.540e-001	
o Rotational	11	6.246e-001	9.540e-001	
o Isotropic	•	4.655e-001	7.106e-001	
Effective Dose Equivalent Rate	(ICRP 51 - 1987)			
o Anterior/Posterior Geometry	mSv/hr	5.495e-001	8.394e-001	
o Posterior/Anterior	**	4.820e-001	7.360e-001	
o Lateral	11	3.539e-001	5.400e-001	
o Rotational	u	4.305e-001	6.573e-001	
o Isotropic	n	3.646e-001	5.566e-001	

Microshield External Exposure Calculations at 6" from a Type I Fuel Plate Figure B-1

Conversion of calculated exposure in air to dose FILE: C:\MS5\DATA\KODAK\POSTSD^*1\CFXCUBE MS5 Case Title: CFX as a cube This case was run on Wednesday, June 6, 2007, at 11:33:31, AM Dose Point # 1, - (48:16.5;16.5) cm

Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	3.774e+004	8.509e+004
Photon Energy Fluence Rate	MeV/cm²/sec	2.284e+004	5.075e+004
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	4.438e+001	9.867e+001
Absorbed Dose Rate in Air	mGy/hr	3.874e-001	8.614e-001
` n	mrad/hr	3.874e+001	8.614e+001
Deep Dose Equivalent Rate	(ICAP 51 - 1987)		
o Parallel Geometry	mSv/hr	4.621e-001	1.028e+000
o Opposed	11	3.660e-001	8.134e-001
o Rotational	II .	3.660e-001	8.134e-001
o Isotropic	tt .	3.238e-001	7.197e-001
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSy/hr	4.894e-001	1.089e+000
o Opposed	11	4.636e-001	1.031e+000
o Rotational	**	4.636e-001	1.031e+000
o Isotropic	n	3.456e-001	7.682e-001
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	4.078e-001	9.075e-001
o Posterior/Anterior	· ·	3.578e-001	7.957e-001
o Lateral	**	2.629e-001	5.839e-001
o Rotational	11	3.196 e- 001	7.106e-001
o Isotropic	· ·	2.708e-001	6.018e-001

Microshield External Exposure Calculation at 6" from CFX
Figure B2