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TECHNICAL MEMORANDUM 0805

August 25, 2008

Originators: Andrew H. Thatcher, CHP, Technical Director

Subject: Conversion of Surface Activity Limits to Dose for the Kodak CFX

Revision: 0

ENDORSEMENT: This document contains the results of research and technical analysis which have been reviewed and approved for publication by:	
	8/25/2008
Barton P. Anderson, Principal	Date

1 INTRODUCTION

1.1 BACKGROUND

1.1.1 The Californium Neutron Flux Multiplier (CFX) operated from 1975 to 2006 at the Kodak Research Laboratories in Rochester, NY. It was dismantled and the fuel was transferred to the Department of Energy (DOE) Savannah River facility near Aiken, SC in November, 2007. All of the structural components and shielding materials were surveyed and either released or disposed of at a licensed facility. At the completion of the de-fueling operation, a characterization survey was conducted and the Radiological Characterization Report (RCR) [1] became the basis for the Decommissioning Plan (DPlan) and Final Status Survey (FSS) Plan which were forwarded to the Nuclear Regulatory Commission (NRC) in May, 2008. With the delivery of these documents, Kodak requested that the Characterization Report be accepted as the Final Status Survey Report for purposes of site decommissioning and release of NRC License SNM-1513.

[1] *Characterization Report for Kodak Californium Neutron Flux Multiplier* , Nextep Consulting Group, NRC Docket 7001703, April 2008.

1.1.2 Since the surface beta measurements taken on the wall, floor and ceiling surfaces of the labyrinth during Characterization were reported and compared with the limits provided in the License (listed in Table 1.1), NRC requested that those limits be translated into dose to confirm that they are consistent with the requirements of the License Termination Rule (LTR)[2]: namely that residual radioactivity that is distinguishable from background radiation results in a TEDE[3] to an average member of the critical group that does not exceed 25 mrem (0.25 mSv) per year.

Table 1.1
Release Limits[a] for Building Surface Contamination
(dpm/100 cm²)

Nuclide	Average ($1m^2$)	Maximum ($100cm^2$)	Removable ($100cm^2$)
Sr-90	1,000	3,000	200
Cs-137	5,000	15,000	1,000[b]
50/50 mix[4]	**1,667**	**5,000**	**333[b]**

[a] *Above background*
[b] *β/γ only*

1.2 PURPOSE

1.2.1 This document provides the technical basis for converting the surface contamination limits from NRC License SNM-1513 (expressed in dpm/100 cm^2) to an external exposure rate (mSv/hr) and, using assumptions about the occupancy of the labyrinth, translating that into a predicted annual dose to a member of the critical group with access to the area.

2 SCOPE

2.1 This document specifically addresses the conversion of the beta measurements made on the concrete surfaces of the labyrinth sub-basement. Limits for activated materials are treated separately and reported in the RCR and DPlan.

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[2] 10 CFR 20 SubPart E
[3] Total Effective Dose Equivalent: The sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).
[4] If licensed contamination is present due to a breach of the fuel plate outer cladding, it will be characterized by Sr-90 and Cs-137 present in approximately equal quantities. This is discussed in more detail in the Section 2.4.2 of the RCR and in the DPlan.

3 METHODS

3.1 The conversion calculations presume that the surface activity is equal to the release limits presented in Table 1.1 for a 50/50 mix of Sr-90 and Cs-137 subject to the following assumptions:

3.1.1 Complete in-growth of both Sr-90 and Cs-137 is assumed. Each radionuclide is present at an activity level of 833 dpm/100 cm^2 for a total activity of 1,667 dpm/100 cm^2.[5] This activity is uniformly distributed across the surface.

3.1.2 No removable contamination exists. This has been documented in the RCR.

3.1.3 The only exposure pathway is external exposure.

3.1.4 A rotational geometry is assumed for all external exposures[6].

3.1.5 In keeping with 10 CFR 20.1402, the radiological criterion of interest is the TEDE. The maximum exposure is 0.25 mSv per year to the average member of the critical group.

3.1.6 Since the TEDE is the endpoint of interest, Sr-90/Y-90, both pure beta emitters, are removed from exposure considerations. The reasoning behind the removal is that the beta emitter would only contribute to a whole body exposure as a result of bremsstrahlung. Bremsstrahlung would only be an issue if an absorber were in the path of the contamination. Since the assumption used is that any contamination is fixed at the surface, no target absorber would exist between the source and the observer to create bremsstrahlung radiation of any significance.

3.2 The Microshield computer code[7] was used to calculate the exposure from three orthogonal concrete surfaces (two walls and a floor) contaminated to the average limit in Table 1.1.

3.3 One 2m x 5m concrete surface contaminated with 833 dpm/100 cm^2 Cs-137 was modeled to obtain the dose rate at an observation point 1m from the center of the surface. Three times this value was used to predict the dose from all three surfaces such as would exist in a corner of the room. This value was integrated over a full 2,000 hours per year to obtain the annual dose received.

4 RESULTS AND DISCUSSION

4.1 The Microshield results are presented in Table 1 of Attachment A. The effective dose equivalent rate for a rotational geometry is given in the table as 3.7 E-07 mSv/hr for a single surface. The rate for three surfaces, therefore, would be 1.1 E-06 mSv/hr.

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[5] NEXTEP TM0713 *Technical Basis Document for Kodak Beta Measurements*, Andrew H. Thatcher, CHP.

[6] In reality this would seldom be the case as non-uniform exposures from the various line sources would dominate and would result in doses less than those predicted from a rotational geometry.

[7] Grove Engineering, Microshield, Version 5.03, Rockville, MD. 1998.

4.2 Using a very conservative 2,000 hours per year occupancy, the total dose to the occupant is 0.002 mSv/year (0.2 mrem/year), well below the 0.25 mSv (25 mrem) per year maximum required by the LTR.

5 CONCLUSION

5.1.1 For contamination on concrete surfaces at the limits stipulated by NRC license SNM-1513, the total dose to a full time occupant will be less than 0.002 mSv/year (0.2 mrem/year), well below the 0.25 mSv (25 mrem) per year maximum required by the LTR. (Par. 4.2).

5.1.2 The limits for surface activity contained in NRC License SNM-1513 are adequate to meet the release criteria for unconditional release contained in the License Termination Rule.

ATTACHMENT A
External Exposure from a Single Contaminated Surface

Table 1
Microshield™ Output

Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\KODAK\POSTSD~1\DPMCONV.MS5
Case Title: Case 2
This case was run on Friday, August 22, 2008 at 1:16:41 PM
Dose Point # 1 - (100,250,100) cm

Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	4.271e-002	4.342e-002
Photon Energy Fluence Rate	MeV/cm²/sec	2.632e-002	2.665e-002
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	5.160e-005	5.228e-005
Absorbed Dose Rate in Air	mGy/hr	4.505e-007	4.564e-007
"	mrad/hr	4.505e-005	4.564e-005
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	5.335e-007	5.405e-007
o Opposed	"	4.247e-007	4.302e-007
o Rotational	"	4.242e-007	4.296e-007
o Isotropic	"	3.753e-007	3.801e-007
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	5.670e-007	5.745e-007
o Opposed	"	5.363e-007	5.433e-007
o Rotational	"	5.363e-007	5.433e-007
o Isotropic	"	4.020e-007	4.072e-007
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	4.684e-007	4.743e-007
o Posterior/Anterior	"	4.121e-007	4.173e-007
o Lateral	"	3.052e-007	3.090e-007
o Rotational	"	3.684e-007	3.730e-007
o Isotropic	"	3.136e-007	3.175e-007

Kodak

Attachment (2)

Letter from Bill Lloyd, Chief Technical Officer and Senior Vice President, Eastman Kodak Company to Merritt Baker, Senior Project Manager, Fuel Facilities Licensing Directorate, NRC.

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