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MEMORANDUM TO: Gary M. Holahan, Director
Division of Systems Safety and Analysis
Office of Nuclear Reactor Regulation

FROM: Farouk Eltawila, Acting Director
Division of Systems Analysis and Regulatory Effectiveness
Office of Nuclear Regulatory Research

SUBJECT: RISK-INFORMED REQUIREMENTS FOR DECOMMISSIONING

As part of its effort to develop generic, risk-informed requirements for decommissioning, NRR requested (Reference 1) an evaluation of the offsite radiological consequences of beyond-design-basis spent fuel pool accidents. In response to that user need, we completed an in-house analysis (References 2 and 3). Recently, NRR requested additional consequence calculations using fission product inventories at 30 and 90 days and two, five, and ten years after final shutdown to provide additional insight into the effect of reductions in inventory available for release. Specifically, NRR requested that a release fraction of .75 be used for volatile isotopes and ruthenium and .01 for fuel fines. NRR also requested that consequence estimates be made for two evacuation cases: (a) evacuation beginning three hours before the release begins and (b) evacuation 1.4 hours after the release begins.

Because of radioactive decay, spent fuel pool accident progression will change from 30 days to ten years. Radioactive decay has five effects on spent fuel pool accident progression, which are listed in Table 1. Each of these effects will result in lower offsite consequences. The first effect is that the decay heat is lower allowing more time to mitigate the fission product release. The second effect is that fewer assemblies will have a high enough decay heat to heat up to the temperatures needed to release fission products. The third effect is that there is a lower fission product inventory in each assembly available for release. The fourth effect is that, after a long enough period of time, the assemblies will not be able to heat up to the temperatures needed to release fission products from the fuel pellets, resulting in a drop in the release fraction. The fifth effect is that the longer heat-up time provides more time to evacuate.

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Table 1 Effect of Radioactive Decay On Accident Progression

Effect of Radioactive Decay on Accident Progression	Analysis Needed to Estimate Consequence Decrease
longer heat-up time providing more time to mitigate release	heat-up of assemblies and timing of mitigation
lower decay heat resulting in fewer assemblies releasing fission products	heat-up of assemblies
lower fission product inventory per assembly available for release	radioactive decay
lower release fraction per assembly	heat-up of assemblies
longer heat-up time providing more time to evacuate	heat-up of assemblies and timing of evacuation

As noted above, NRR requested that RES investigate the third effect, that is, the lower fission product inventory in each assembly available for release. As requested by NRR, RES performed these consequence calculations using the release fractions in the first row of Table 2. These release fractions may be considered to be an upper bound, because rubbling of the spent fuel after heat-up to about 2500K is expected to limit the release. Therefore, RES also performed consequence calculations using the release fractions from Reference 4. These release fractions may be considered to be a lower bound. The results of these calculations are given in Tables 3 and 4 for the higher and lower release fractions, respectively. Because these consequence calculations were performed without considering (a) the smaller amount released as a result of mitigation, (b) the smaller number of assemblies releasing fission products, and (c) the smaller release fraction per assembly, the results are believed to be a severe underestimate of the decline in consequences as a function of time. Also, to determine whether the early or the late evacuation case is realistic at each decay time, a realistic assessment of the time to heat up to the point of releasing fission products is required.

Table 2 Fission Product Release Fractions

Source Term	Release Fractions								
	noble gases	iodine	cesium	tellurium	strontium	barium	ruthe-nium	lantha-num	cerium
upper bound	1	.75	.75	.02	.01	.01	.75	.01	.01
lower bound	1	1	1	.02	.002	.002	$2x10^{-5}$	$1x10^{-6}$	$1x10^{-6}$

Table 3 Results based on Upper Bound Source Term

Case	Decay Time	Mean Consequences within 100 Miles (Surry population, 95% evacuation)		
		Early Fatalities	Societal Dose (rem)	Cancer Fatalities
69b	30 days	164	$1.57x10^7$	14,100
69c	90 days	145	$1.45x10^7$	13,000
45b	1 year	54.9	$1.17x10^7$	10,300
71b	2 years	10.1	$9.64x10^6$	7,930
71c	5 years	.217	$7.72x10^6$	5,160
71d	10 years	.0314	$7.22x10^6$	4,520
70b[a]	30 days	4.23	$1.01x10^7$	10,300
70c[a]	90 days	2.90	$9.51x10^6$	9,360
46b[a]	1 year	.543	$7.94x10^6$	6,880
72b[a]	2 years	.0960	$6.87x10^6$	5,110
72c[a]	5 years	.00762	$5.86x10^6$	3,490
72d[a]	10 years	.00293	$5.62x10^6$	3,150

[a]Based on evacuation before release.

Table 4 Results based on Lower Bound Source Term

Case	Decay Time	Mean Consequences within 100 Miles (Surry population, 95% evacuation)		
		Early Fatalities	Societal Dose (rem)	Cancer Fatalities
73a	30 days	1.75	$4.77x10^6$	2,460
73b	90 days	1.49	$4.63x10^6$	2,390
73c	1 year	1.01	$4.54x10^6$	2,320
73d	2 years	.658	$4.50x10^6$	2,270
73e	5 years	.238	$4.31x10^6$	2,120
73f	10 years	.0888	$4.37x10^6$	2,100
74a[a]	30 days	.0881	$4.34x10^6$	2,090
74b[a]	90 days	.0686	$4.25x10^6$	2,050
74c[a]	1 year	.0484	$4.20x10^6$	2,000
74d[a]	2 years	.0342	$4.20x10^6$	1,990
74e[a]	5 years	.0145	$4.07x10^6$	1,900
74f[a]	10 years	.00627	$4.18x10^6$	1,930

[a]Based on evacuation before release.

ok

References:
1. Memorandum from G. Holahan to T. King dated March 26, 1999
2. Memorandum from A. Thadani to S. Collins dated November 12, 1999
3. Memorandum from F. Eltawila to G. Holahan dated August 25, 2000

Attachments:
1. Effect of Source Term and Plume-Related Parameters on Consequences
2. Response to Public Comments on the Consequence Assessment

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