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Dose Rate Evaluation for Spent Fuel Aging Areas at Yucca Mountain (Revised)

Georgeta Radulescu and Shiaw-Der Su

Yucca Mountain Project, Bechtel SAIC Company LLC, 1180 Town Center Drive, Las Vegas, NV 89144
Georgeta_Radulescu@ymp.gov

INTRODUCTION

The spent nuclear fuel (SNF) aging system at the proposed Yucca Mountain repository will provide site-specific casks and aging pads for thermal management of commercial SNF with a heat rate in excess of the waste package thermal output limit. An aging pad can accommodate 1,000 MTHM of SNF, containing a total of 100 aging casks with a horizontal module of 20 casks, and 80 vertical site-specific casks arranged in a 2x40 array.

The proposed aging system will provide five aging areas in two separate locations. The first location will contain a single pad designated as Aging Area 17A (1,000 MTHM capacity). The second location will contain Aging Areas 17B through 17E (20,000 MTHM total capacity), each consisting of five aging pads arranged in a compact rectangular configuration.

This paper presents calculated dose rates as a function of distance from Aging Areas 17A and 17B through 17E. In addition, the paper evaluates the effect of design parameter variations on dose rates with focus on spacing between casks and spacing between pads in Aging Areas 17B through 17E.

DESIGN PARAMETER SELECTION

The design parameters used in this evaluation include the dose rate criterion for a site-specific cask, cask spacing, and aging pad spacing, as discussed below.

Dose Rate Criterion

The site-specific cask uses a maximum dose rate of 60 mrem/h at one meter from its surface as a design criterion. This limit is similar to the design basis adopted for the storage casks that have been approved by the U. S. Nuclear Regulatory Commission (NRC) for use at nuclear power plants.

Cask Spacing

The center-to-center spacing of the casks in the same row may vary between 4 m (13 ft) and 5.5 m (18 ft). A closer spacing would provide more self-shielding between the casks with a resultant reduction in the skyshine radiation component outside the aging pad, but an increase in the dose rate inside the pad due to direct radiation.

Aging Pad Spacing

For Areas 17B through 17E, the center-to-center spacing of the aging pads may vary between 36.5 m (120 ft) and 43 m (140 ft). A larger pad spacing is beneficial in reducing the direct radiation component from an adjacent pad.

SHIELDING ANALYSIS

The dose rate calculations [1] used the MCNP computer code [2] to determine dose rates at point locations around a cask and within air volumes placed at selected distances. A calculation addressed a single aging pad consisting of a 2x40 array of vertical site-specific casks with volumetric sources. The contribution from the horizontal module is not a concern, as the module itself reduces both direct and skyshine radiation to a relatively insignificant level.

The site-specific cask was approximated by a TN-32 dry-storage cask that contains a design basis radiation source for pressurized-water-reactor spent fuel with the characteristics of 3.5 wt% initial U-235 enrichment, 45 GWd/MTU burnup, and 7 year cooling. The geometric modeling included dry air that extends 2000 m skyward and at least 200 m horizontally behind source and tally volume locations.

RESULTS

Table I presents the results of the dose rate variation with distance for the base case of the 4-m cask array pitch in each aging pad, and the pad spacing of 43 m for Aging Areas 17B through 17E. Higher dose rates are calculated inside the aging pad, as much as ~230 mrem/h in the middle of the pad for the base case.

The change in the cask array pitch from 4 m to 5.5 m would result in a decrease in the dose rate inside the pad by approximately 50%, as more spacing reduces the direct radiation component. However, at distant locations outside the aging area where the skyshine radiation component is predominant, the larger pitch would produce a higher dose rate by ~20% relative to the base case of the 4 m pitch.

The impact of the aging pad spacing on the dose rates either inside or outside the aging area is of secondary order. A larger pad spacing mainly serves to reduce the direct radiation component from an adjacent pad.

Table I. Dose Rate Versus Distance (4-m Cask Pitch for All Pads, and 43-m Pad Spacing for 17B through 17E).

	Dose Rate (mrem/h)[1]	
Distance (m)[2]	17A	17B through E
6.1	5.30E+01	5.79E+01
10	3.63E+01	4.09E+01
20	1.81E+01	2.26E+01
30	1.09E+01	1.50E+01
40	7.39E+00	1.09E+01
50	5.42E+00	8.51E+00
60	4.07E+00	6.71E+00
70	3.18E+00	5.45E+00
80	2.34E+00	4.39E+00
90	1.88E+00	3.82E+00
100	1.47E+00	3.20E+00
200	2.49E-01	7.17E-01
300	6.05E-02	2.28E-01
400	1.71E-02	8.00E-02
500	5.24E-03	2.81E-02
600	1.91E-03	1.13E-02
700	7.29E-04	4.30E-03
800	3.14E-04	1.60E-03
900	1.23E-04	6.99E-04

[1] Relative error is less than 10%.
[2] Distance from the surface of the outermost cask row.

CONCLUSIONS

This calculation demonstrates that the MCNP code is a viable tool for determination of the direct and skyshine radiation dose contributions from the proposed repository aging areas. The code provides statistically satisfactory results, which compare favorably to those for similar existing NRC-certified storage casks.

The design parameters selected for the aging system produce some measurable effects on the dose rates both inside and outside the aging pads. In particular, the cask array pitch affects the worker dose calculated inside the pad, and the skyshine dose beyond the protective area fences. The effect of the pad spacing is relatively minor.

REFERENCES

1. Bechtel SAIC Company, *Dose Rate Evaluations for Spent Nuclear Fuel Aging Areas*, 170-00C-HAP0-00400-000-00A, Bechtel SAIC Company, Las Vegas (2004).
2. J. F. BRIESMEISTER, Ed., *MCNP-A General Monte Carlo N-Particle Transport Code*, LA-12625-M, Version 4b, Los Alamos National Laboratory, Los Alamos (1997).