Conf-9306305--2

BNL-49869

Criticality Evaluation for the Storage of Converter Plates in Drums

J.P. Hu, D.C. Rorer, H.B. Liu

Brookhaven National Laboratory

Upton, NY 11973

INTRODUCTION

A criticality safety evaluation was performed to support the temporary storage of 20%-enriched uranium converter plates for future use in the Brookhaven Medical Research Reactor (BMRR). A total of twelve such plates each containing approximately one kilogram of the ^{235}U will be stored in DOT-certified 6M-drums,[1] which have the same dimensions as standard 55-gallon drums except that they are twice as high (178.5cm). Each drum contains a Celotex liner surrounding a central 12.7cm-dia steel pipe. The plates have a nominal size of 0.3cmx10.5cmx125.7cm and fit inside the steel pipe, which extends 130cm in the axial direction.

Because the accommodation of twelve plates in one drum is physically possible and more economical, this option for plate storage would be recommended provided that the criticality safety limit is not exceeded. In this paper, the neutron multiplication (K_{eff}) in drums is calculated using the Monte Carlo Neutron and Photon Transport code (MCNP).[2] For conservatism, several different configurations which could result in the most reactive conditions for K_{eff} have been examined. As part of the effort to optimize the arrangement of plates in drums, a second group of the MCNP calculations is performed using twelve plates evenly contained within two drums placed immediately adjacent to each other. The

* This work has been supported by the U.S. Department of Energy under contract No. DE-AC02-76CH00016.

model again simulates the most reactive conditions for K_{eff} estimations.

MODEL DESCRIPTION

The exact dimensions of the 6M-drum and converter plates are used in the MCNP geometry. An equal inter-plate spacing which is likely to result in a maximum K_{eff} in the package is selected in modeling. To simulate operators who would stand beside the drum during plate storage, a 30cm-thick water layer surrounding all sides of the drum is assumed in each of the cases shown in Tables 1 and 2. An additional layer of 50cm-thick concrete covering the water layer is used to simulate the floor and walls of the storage area.

The basic materials used in the MCNP model consist of ^{235}U and ^{238}U (fueled region of plates), stainless steel (assumed 100% iron for plate claddings), and the medium which fills the drum under normal storage conditions (air of 20/80 oxygen/nitrogen) or during a flooding accident (H_2O, or a mist of 50/50 water/air). The material cross-sections used in calculations are those obtained from the ENDF/B-V data libraries evaluated at 300°K, which is close to the ambient temperature in the area the drums are stored.[3]

To determine the sensitivity of the K_{eff} to a varying amount of ^{235}U from plate to plate, calculations based on the maximum (25%) and the nominal (20%) ^{235}U enrichments of the plates are carried out. In the cases which include homogenized ^{235}U within water, the H/^{235}U atom ratio instead of ^{235}U enrichment is examined for sensitivity analysis. Assuming all ^{235}U is uniformly distributed in the pipe filled with water, the $H/^{235}U$ ratio is about 23. When the mixture of ^{235}U and water fills the entire drum, the $H/^{235}U$ ratio increases to 760.

RESULTS AND CONCLUSION

Using the MCNP code, case studies for plate storage based on different combinations of materials used, plate arrangements, and ^{235}U loadings reveal that:

1. Under normal conditions when air is the only medium in the drum, the storage package remains subcritical. The K_{eff} is 0.15 for a 12-plate array in one drum, and is 0.08 for a 6-plate array in each of the two adjacent drums.
2. During a flooding accident, the maximum K_{eff} of 1.17 is obtained from the single package which is filled with water mixed with uniformly distributed uranium. When the uranium is evenly divided between two drums and homogenized with water, the maximum K_{eff} is 0.90.
3. $K_{eff} \approx 1.0$ when the amount of ^{235}U from more than ten 20%-enriched plates (or eight 25%-enriched plates) is uniformly distributed in water within the entire drum.
4. When water fills the drum or fills the pipe only, neither the concrete nor the water outside the drum will affect the value of K_{eff} by more than 4%.

These findings indicate that although the use of one drum to hold twelve plates is physically possible, it is uncertain that the package will remain subcritical during a severe light water flooding. Since the 6M-drum is not designed to be leak-tight under all hypothetical accident conditions, the option of using two drums for plate storage is recommended.

REFERENCES

1. "A Review of the Safety Features of 6M Packagings for DOE Programs," SAND88-3005/TTC-0879, U.S. Dept. of Energy (1988).
2. "MCNP 4 - Monte Carlo Neutron and Photon Transport Code System, "LA-7396-M, Rev.2, J.F. Briesmeister (ed.), Los Alamos National Lab. (1991).
3. "ENDF/B-V," Report BNL-17541 (ENDF-201), D. Garber (ed.), National Nuclear Data Center, Brookhaven National Lab. (1975).

TABLE 1

The MCNP Results of K_{eff} based on 12 Converter Plates in each 6M-Drum

No. of Drums	Enrichment of ^{235}U	^{235}U Distribution and Moderator/Reflector Present	K_{eff}+
1	25%	^{235}U uniformly dist. in water within the entire drum, air or water at drum outside.	1.17
1	25%	^{235}U uniformly dist. in water within the pipe, water at pipe outside and drum outside.	0.79
1	20%	Plates in water within the central pipe, water at pipe outside and drum outside.	0.70
1	20%	Plates in water within the pipe, mist (50/50 water/air) at pipe outside and air at drum outside.	0.67
1	20%	Plates in air within the pipe, water at pipe outside and drum outside.	0.53
1	20%	Plates in air within the pipe, air at pipe outside and drum outside.	0.15*

\+ One standard deviation is typically calculated as 0.008.

* A normal storage condition when air is the only medium in drum.

TABLE 2

The MCNP Results of K_{eff} based on 6 Converter Plates in each 6M-Drum

No. of Drums	Enrichment of ^{235}U	^{235}U Distribution and Moderator/Reflector Present	K_{eff}+
2	25%	^{235}U uniformly dist. in water within the entire drum, 2 drums closely side by side, in water.	0.90
2	25%	^{235}U uniformly dist. in water within the central pipe, water at pipe outside and drum outside.	0.80
2	20%	Plates in water within the pipe, water at pipe outside and drum outside.	0.71
2	20%	^{235}U in one 4mm-thick shell, with a radius of 6.35cm. Water in the entire drum. Air at drum outside.	0.66
2	25%	Equally-spaced rods in water within the central pipe, water at pipe outside and drum outside.	0.62
2	20%	Plates in air within the pipe, air at pipe outside and drum outside.	0.08*

\+ One standard deviation is typically calculated as 0.008.

* A normal storage condition when air is the only medium in drum.

END

DATE
FILMED
5/3/94