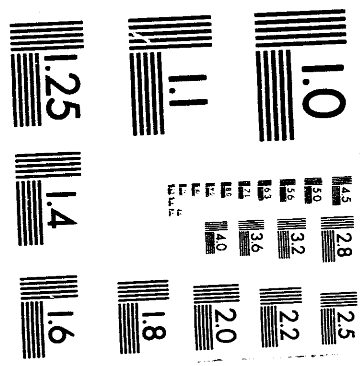

1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
6.3

1 of 1

Conf-940482--1

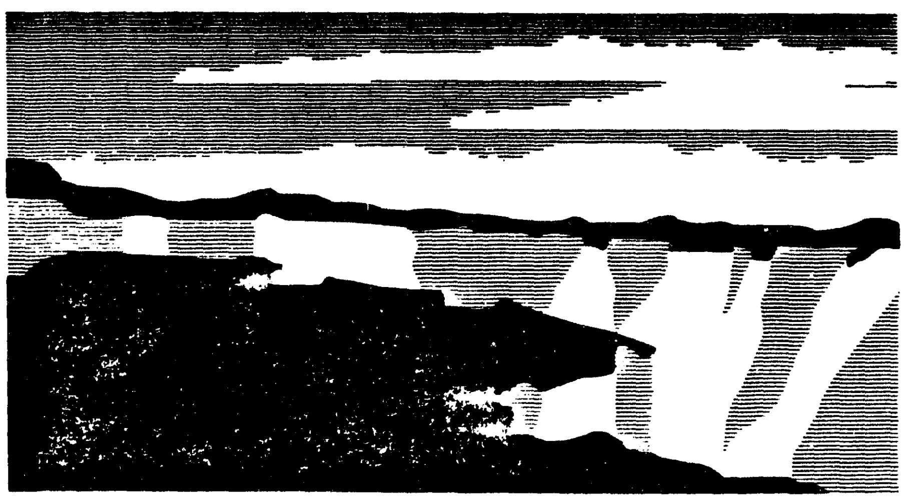
LA-UR- 93-4455

Title: CRITICALITY SAFETY ANALYSIS OF HANFORD WASTE TANK 241-101-SY

Author(s): R. T. Perry
Joseph L. Sapir
Burton J. Krohn

Submitted to: ANS 1994 Topical Meeting

MASTER



Los Alamos
NATIONAL LABORATORY

CRITICALITY SAFETY ANALYSIS OF HANFORD WASTE TANK 241-101-SY

R. T. Perry
Joseph L. Sapir
Burton J. Krohn

Reactor Design and Analysis Group, MS K551, Los Alamos National Laboratory
Los Alamos, NM 87545, (505) 665-3521

KEYWORDS: Criticality, Waste, Hanford

ABSTRACT

As part of a safety assessment for proposed pump mixing operations to mitigate episodic gas releases in Tank 241-101-SY at the Hanford Site, Richland, Washington, a criticality safety analysis was made using the Sn transport code ONEDANT. The tank contains approximately one million gallons of waste and an estimated 910 g of plutonium. The criticality analysis considers reconfigurations and underestimation of plutonium content. The results indicate that Tank SY-101 does not present a criticality hazard. These methods are also used in criticality analyses of other Hanford tanks.

INTRODUCTION

The radioactive waste storage Tank 241-101-SY at the Hanford Site, Richland, Washington, would periodically release large quantities of flammable gas that had been collecting in the noncovecting layer in the tank. The 22.9-m-diameter tank contains about 1,000,000 gallons of plutonium-containing waste, and the gas is produced through chemical reactions assisted by radiation. The gas release results from a rollover of the nonconvecting layer resulting from the gas buildup. The quantity of gas released in a rollover would overwhelm the tank exhaust fans, and thus for a short period of time, an explosive mixture of gases would remain in the top of the tank. It was proposed to mitigate this problem by placing a large pump into the tank to constantly stir the waste, so that the gas would be released as it formed and no buildup would occur.

In the course of the analysis to determine the feasibly of the proposal, independent safety analysis boards wanted assurance that the tank could not achieve critically. The safety boards did not accept the criticality analysis[1] under which the tanks were currently operated for the new proposed operating conditions. Thus, a new approach had to be taken to assure the tanks were criticality safe under the proposed operating conditions. At issue was the fact that the plutonium concentration in the tank was not exactly known, the plutonium was concentrated in the bottom layer of the tank, and that the contents of the tank would be constantly be reconfigured under the proposed operation conditions.

This paper describes the calculations, and discusses the results of these calculations made to investigate the criticality risk of Hanford Waste Storage Tank 241-SY-101.

METHODOLOGY

Eigenvalue calculations were made to investigate conservative configurations in which the concentration of plutonium in the tank was varied up to a factor of 10^5 times the reported nominal concentration. Some of our calculations incorporated a representative waste sludge composition. The nominal plutonium concentration in the tank was obtained from Reference 2, which reported measured values of plutonium concentrations from core sample composites taken at various depths. The maximum concentration of plutonium, found in the bottom layer of the tank, was 0.00165 g/gal of waste. In other layers, the concentration was 0.00010, 0.00016, and 0.00134 g plutonium per gallon of waste. Based on these core samples, the document concluded that the best estimate of the total tank plutonium inventory was 910 g.

The eigenvalue calculations were made with the Sn transport code ONEDANT.[3] Infinite dilute, 69 energy-group cross sections based on ENDF/B V data were prepared using the TRANSX[4] code. These codes and data were benchmarked by modeling some of the plutonium-water systems from Figure 1 of Reference 5 and comparing eigenvalues. Good agreement was obtained between the eigenvalues calculated and those reported in Reference 5 for those systems modeled.

RESULTS

To investigate the criticality issue associated with layering, we performed calculations for an infinite configuration (zero leakage) of a plutonium-water solution as a function of plutonium concentration. The zero-leakage assumption is, of course, conservative, as is the omission of the constituents of the radioactive waste sludge, which would produce additional parasitic captures. In addition, all of the plutonium was assumed to be ^{239}Pu. The results of these calculations indicate that at the nominally measured plutonium concentration in the bottom layer of the tank, k_∞ was calculated to be 0.00012, an extremely small value. At 100 times the reference , the k_∞ was still only 0.012. A concentration factor of 16,000 is required before the conservative, infinite configuration will become critical. We do not believe such concentrations can be achieved.

To address the issue of criticality associated with a reconfiguration in the tank, we investigated a more realistic case in which the total estimated plutonium inventory of 910 g was placed in a sphere of sludge and surrounded by an essentially infinite sludge reflector (without plutonium). A second set of calculations were made in which the 910 g of plutonium was placed in a sphere of water, which was surrounded by the sludge reflector. The representative sludge composition was taken from Table 2 of Reference 1. Although listed in the table, mercury was not included in our calculations. Because mercury is a relatively strong absorber and poor moderator, its omission is conservative.

To maintain the total plutonium inventory at 910 g in both sets of calculations, the sphere radius was reduced as the plutonium concentration was increased from its reference value of 0.00165 g/gal. The spherical volumes investigated ranged from 100 liters at a concentration factor of 2.1×10^5 to 10,000 liters at a concentration factor of 210. For large systems with low concentrations, the k_{eff} values are comparable to the infinite systems previously described. For very high concentrations and correspondingly small dimensions, leakage from the plutonium/sludge or plutonium/water sphere becomes important and the finite calculations produce lower values of k_{eff} than obtained for the infinite systems. The calculated k_{eff} for the plutonium/sludge peaks at a value of 0.97, which is 42,000 times the reference concentration, and then decreases as leakage from the small sphere begins to predominate. Thus, it appears that 910 g of ^{239}Pu dispersed in a representative sludge composition will not go critical. A plutonium/water sphere with the sludge reflector becomes critical at a radius of approximately 17 cm. These results are shown in Figure 1.

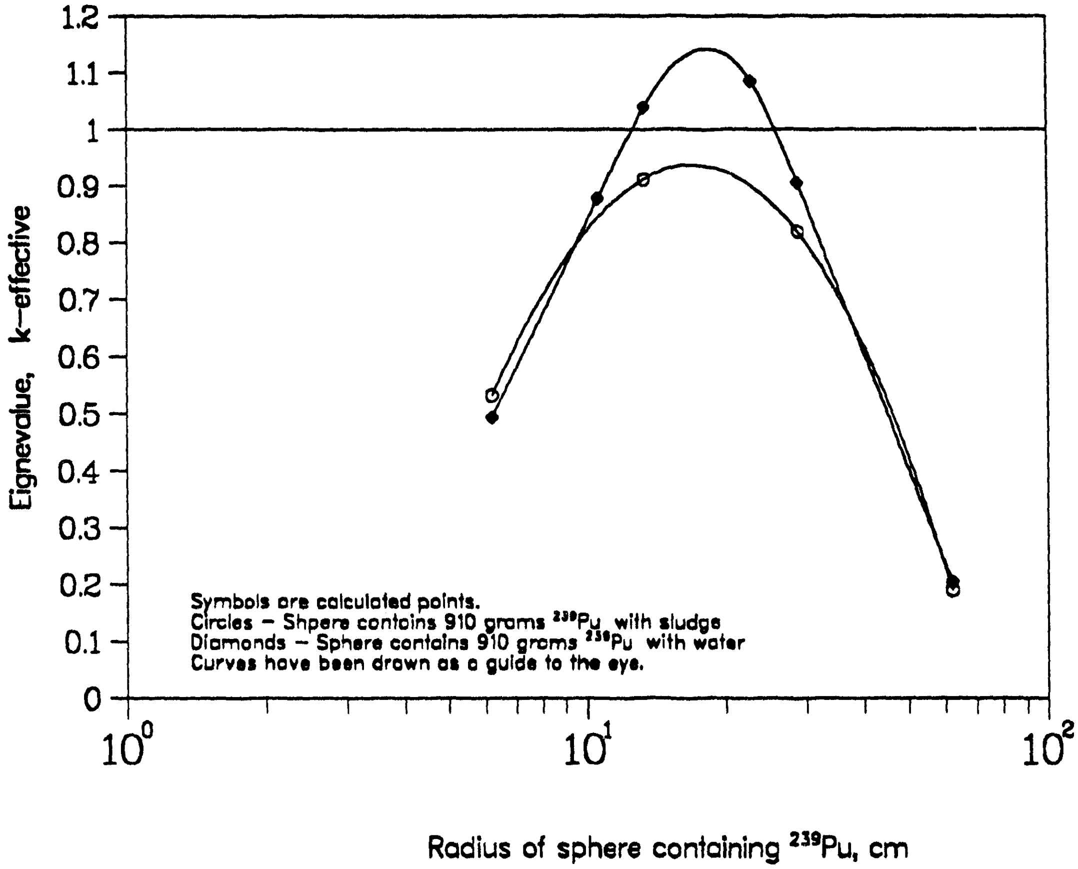


Figure 1. Eigenvalues for a ^{239}PU containing sphere with a 1-m sludge containing spherical reflector.

To address the issue of criticality associated with a reconfiguration in the tank in which 10 times the total nominal inventory, i.e., 9,100 g, is concentrated in a smaller volume, several additional criticality eigenvalues were made. In these calculations, the entire hypothetical inventory of 9,100 g was mixed in spheres of either sludge or water. A 1-m-thick reflector of sludge surrounded the spheres.

These calculations showed that for criticality to occur, the radius of the sphere containing the 9,100 g of plutonium must be smaller than 70 cm if the sphere contained plutonium and water. If the sphere contained plutonium and sludge, the radius must be less than 30 cm for criticality to be achieved. We do not believe that such concentrations can be reached even if the tank contained 9,100 g of plutonium.

CONCLUSION

We have calculated k_{eff} values for conservative representations of Tank SY-101. Based on measurements of plutonium concentrations, the k_{eff} of this tank is extremely small, below 0.00012. A very conservative representation of an infinite plutonium/water system would require the maximum measured plutonium concentration to increase by a factor of 16,000 before a critical configuration is obtained. When the total plutonium tank inventory of 910 g and the presence of sludge is included in the analysis, criticality is not reached. If the inventory is increased by a factor of 10 to 9100 g, this entire inventory must be contained in a sludge sphere of less than 30 cm for criticality to occur. We do not believe this is a creditable scenario. Based on these results we do not believe Tank SY-101 presents a criticality hazard.

REFERENCES

1. R. D. CARTER, "Criticality Safety Analysis Report for RHO-MA-149, Criticality Prevention Specification T-1,Underground Waste Storage Tanks and Associated Equipment," CSAR 79-007, Hanford Company (Revised December, 31, 1980).

2. D. A. REYNOLDS, Tank Waste Technology Applications, "Amount of Plutonium in 241-SY-101," internal memorandum 7K21-92-052, Westinghouse Hanford Company (April 3, 1992).

3. R. O'DELL et al., "User's Manual for ONEDANT," LA-9184-M, Los Alamos National Laboratory (February 1982).

4. R. E. MACFARLANE, "TRANSX-CTR," LA9863-MS, Los Alamos National Laboratory (February 1984).

5. E. D. CLAYTON, "Anomalies of Criticality," BNWL-SA-4868-Rev.2, Battelle Northwest Laboratories (September 6, 1974).

DATE FILMED

4/6/94

END