Dose Rate Distribution from a Standard Waste Drum Arrangement

N. Zoeger¹, A. Brandl²

¹Nuclear Engineering Seibersdorf GmbH, 2444 Seibersdorf, Austria
²Environmental and Radiological Health Sciences, Colorado State University, Fort Collins, CO 80523, USA

1 Introduction
• Dose rates as a function of the distance between source and detector are only known for a limited number of geometries (e.g. point source, line source, plane circular source)
• For most source-detector geometries numerical calculations or Monte Carlo Simulations are necessary to determine the dose rate in dependence of the distance.

2 Objectives
• The dose rate distribution from a set of six 200-liter waste drums arranged on a standard wooden pallet should be calculated by Monte Carlo Simulation
• Data should be fitted with analytical functions for future estimation of the dose for personnel at the Austrian Interim Radiological Waste Storage facility at Seibersdorf.

3 Materials and Methods
• Monte Carlo Simulations were performed using the MCNP computer code

Assumptions and conditions:
- Waste drums are filled with concrete with a density of 2.3 g/cm³
- Drum contains ⁶⁰Co in a homogeneous distribution (gamma energies of 1.17 MeV and 1.33 MeV)
- Model of waste drum according to figure 1, Modeled source-detector geometries see figure 2
- Particle histories were chosen for statistical uncertainties on the result below 1%

Figure 1: Model of the waste drum. Measures in cm. The detector (D) was set to the mid-height of the concrete cylinder inside the drum.

Figure 2: Modeled geometries. Measures in cm. Two detector locations were considered: D¹: in front of the center drum D²: between two drums in the front row. Detector distances along the x-axis were 5m to 20 m.

4 Results and Discussion
The results for the two detector positions are compared in figure 3.

Figure 3: Comparison of the two detector geometries. In the far-zone (distances > 1m) both distributions are equal. In the near-zone (below 1m) dose rates vary up to a factor of two, which is most likely due to the slightly increased surface-to-detector distance due to the cylindrical waste drum curvature.

The data for detector position D¹ were fitted to smooth analytical functions (see figure 4).

Figure 4: Least-square fits of the far- and near-zone. Near-zone: Dose rate follows a logarithmic function

\[ DR = 7 \times 10^{-12} \ln(x) + 3 \times 10^{-11} \]

Far-zone: power-law function

\[ DR = 2 \times 10^{-8} x^{1.841} \]

Dose rate (DR) in units rem h⁻¹ per gamma ray.

5 Conclusions
• Most conservative dose rate was obtained in the mid-height and the center of the drums
• No single analytical function was found by fitting
• The power law function for x>1m closely approximates the 1/r² relationship for point sources.

Authors
Alexander Brandl, PhD
alexander.brandl@colostate.edu

Norbert Zoeger, PhD
norbert.zoeger@res.at