

Practice of the shielding design of low-level radioactive waste transport containers

With the rapid development of the global nuclear energy industry, the number of nuclear power plants is constantly increasing, and the application of nuclear technology in medicine, industry and scientific research is also becoming more and more widespread. Along with this, the generation of low-level radioactive waste is also increasing. Low-level radioactive waste refers to radioactive waste with a relatively low radioactivity and a short half-life. Although its radioactivity is relatively low, it still poses a potential threat to human health and the environment. Therefore, the safe and efficient transportation and disposal of low-level radioactive waste are of vital importance. During the transportation of low-level radioactive waste, to prevent the leakage of radioactive substances and protect transportation personnel and the public from radiation hazards, specialized transportation containers are required. The shielding performance of the transportation container directly affects the safety of the transportation process. Poor shielding effect may lead to radiation leakage, causing radiation accidents and having a significant impact on human health and the environment.

This study aims to optimize the design of transportation containers for low-level radioactive waste in compliance with SSR-6 requirements. Specifically, these requirements stipulate that the surface radiation level must be less than 2 mSv/h, and the radiation level at a distance of 2 meters from the transportation vehicle should not exceed 0.1 mSv/h, alongside meeting specified transportation capacity criteria. The container is designed to hold 400 liters of cement-bound low-level radioactive waste contained within steel drums (weighing 0.8 tons). The radioactivity is primarily measured through gamma radiation, with cobalt-60 contributing approximately 85.6% and exhibiting a surface dose rate ranging from 2 to 10 mSv/h.

The shielding performance of the container was assessed using TopMC software via Monte Carlo simulation techniques. A geometric model was developed that simplified the structure while assuming a worst-case scenario for dose effects during transport. The type and thickness of shielding material were optimized to achieve an effective balance between mass, volume, and adherence to SSR-6 dose limits. Results indicated that a carbon steel layer with a thickness of 45 mm emerged as the optimal choice, yielding a surface dose rate of only 1.17 mSv/h; this option proved superior to lead alternatives concerning weight, cost-effectiveness, and manufacture. Furthermore, an experimental investigation into the shielding performance of the container was conducted wherein measurements were taken on the radiation dose rate at its surface to validate the accuracy of numerical simulation results. In conclusion, strategic design considerations for containers can effectively meet regulatory standards while enhancing operational efficiency and minimizing worker exposure risks. A carbon steel shielding layer measuring 45 mm provides a practical solution for ensuring safe transportation practices regarding low-level radioactive waste.

Country or International Organization

Instructions

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