# The Search for Permanent Shielding Materials for Use in the New DOE Type-B $^{252}$Cf Shipping Cask

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In late 1993 a search was undertaken to determine what materials were best suited for use in a new Department of Energy Type-B $^{252}$Cf shipping cask. The materials would not only have to shield against the neutrons, but also against the prompt photons from the $^{252}$Cf and the secondary photons produced by the neutrons in the surrounding shielding materials.

This project was undertaken because the existing Oak Ridge National Laboratory (ORNL) Type B containers (Snowball and Cannonball) were designed and built in the years before detailed records and supporting data were required (current regulations). The new cask is to replace the existing ORNL containers, and is designed to contain up to 60 mg of $^{252}$Cf. This new cask will be capable of air, land, or sea transport.

The following constraints were applied:

a) the cask was to be used to transport a maximum of 60 mg of $^{252}$Cf ,

b) the cask was to be composed of a primary and secondary shield,

c) the maximum dose at the cask outer surface was to be 1.2 mSv/h (120 mrem/h) and at 2 m from the cask outer surface was to be 0.075 mSv/h (7.5 mrem/h), and

d) the maximum dose at 1 m from the surface of the primary shield, without a secondary shield, was to be 10 mSv/h (1 rem/h).

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The following materials were used in the search: hafnium hydride ($HfH_2$), high-density concrete (high in hydrogen and iron), yttrium hydride, borated polyethylene, boron-lead-polyethylene, beryllium boride, boron carbide and zirconium, zirconium hydride, Hambergite, zirconium boride, NS-4-FR (hydrogen, carbon, nitrogen, oxygen, aluminum, boron carbide), water extended polyester (WEP - hydrogen, oxygen, boron carbide), tungsten (W), and stainless steel (SS). A total of 65 combinations of the above materials were used in the study.

The initial conceptual design was a cask composed of several spherical shells. The inner most sphere was a void, to contain the $^{252}Cf$ source. The next spherical shell contained a material to absorb the prompt photons, followed by a shell of stainless steel, followed by the primary shielding material, followed by another shell of stainless steel, followed by the secondary shielding material, and finally followed by an outer shell of stainless steel.

The shielding calculations were carried out using the one-dimensional discrete-ordinates radiation transport code ANISN. The shielding materials search yielded a list of materials which were optimized for weight and size; further studies at ORNL reduced this list to one in which the materials would also met other requirements, e.g. fabrication ease, thermal properties, economics, etc. Final results showed that the cask with the smallest radius was one with the following configuration of materials: void/$HfH_2$/NS-4-FR/SS/NS-4-FR/SS. The cask with the smallest mass was one with the following configuration: void/W/NS-4-FR/SS/NS-4-FR/SS.