Lead-Shielded Spent-Fuel Transport Casks: The Thermal Switch Concept

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INTRODUCTION

There are at least four families of transport casks designs depending on the selected gamma shielding and construction materials : lead casks, depleted uranium casks, forged steel casks, and cast iron casks. These four designs co-exist in the transport cask world market. The purpose of this paper is to provide an historical approach to the lead cask design through ROBATEL 40-year design experience.

IMPROVEMENTS IN LEAD-SHIELDED CASKS DESIGN - THE THERMAL SWITCH CONCEPT

The first spent-fuel transport casks were lead casks. In 1954, ROBATEL manufactured the first lead shielded container for transportation of spent fuel from the French reactor Zoé.

In 1964, the IAEA regulations set design requirements under hypothetical accident conditions and ROBATEL invented the "Thermal Switch" concept to increase the fire resistance of lead casks.

The Thermal Switch is an integrated thermal protection and neutron shielding placed in the lead cask multilayer structure (from the inside out : stainless steel, lead, Thermal Switch, steel). The Thermal Switch properties are : (1) good mechanical resistance to maintain lead geometry under normal conditions, (2) good thermal conductivity to ensure heat evacuation under normal conditions and after hypothetical accident conditions, (3) good resistance to low temperatures, and (4) high thermal capacity to absorb the heat during a regulatory fire.

The first material used as a Thermal Switch was plaster. Increasing thermal payload and neutron shielding requirements led to development along the years of more effective Thermal Switches.

In 1973, ROBATEL performed a fire test on a slice of a 32-ton cask to verify the Thermal Switch thermal properties. The results of this test, validating the concept, were presented to the PATRAM'74 conference in Miami (Bochard, C.M. *Improvements in the field of thermal transfer to type B packagings for transportation of irradiated fuel elements with high residual power*, PATRAM'74 conference).

The next improvement was the development in 1988 of "ROBATEL PNT7" compound. This compound composed of hydrogenated and borated materials binded with a refractory material combines harmoniously thermal protection and neutron shielding functions. The PNT7 compound has the following characteristics : (1) very good stability after a fast aging at normal temperature, (2) 100 to 1000 times better radiation resistance than the best organic materials, (3) incombustibility, (4) good thermal conductivity, (5) no galvanic reaction with steel and lead, (6) very good resistance to freeze/thaw cycles, and (7) very high energy absorption capabilities. Copper fins embedded in the PNT7 compound improve thermal conductivity by a factor of 10, thereby increasing heat evacuation capabilities.

The application of the Thermal Switch concept to lead cask design was validated by extensive testing and analysis during development of the BR-100 cask, a 100-ton rail-barge cask designed for the U.S. Department of Energy in cooperation with Babcock & Wilcox and presented to the PATRAM'88 conference in Washington DC (Mc Guinn, E.J., Childress, P.C., Bochard, C.M. *BR-100 spent fuel shipping cask*, PATRAM'88 conference).

CONCLUSIONS

Lead casks provided with the ROBATEL Thermal Switch are a viable alternative to transportation. The Thermal Switch concept has been validated by testing and analysis. It has been extensively used along the years with 65 type B casks licensed by ROBATEL between 1965 and 1995.

REFERENCES

Bochard, C.M. *Improvements in the field of thermal transfer to type B packagings for transportation of irradiated fuel elements with high residual power*, PATRAM'74 conference, Miami (1974).

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