conf. 790602-8

PREPRINT UCRL- 82135

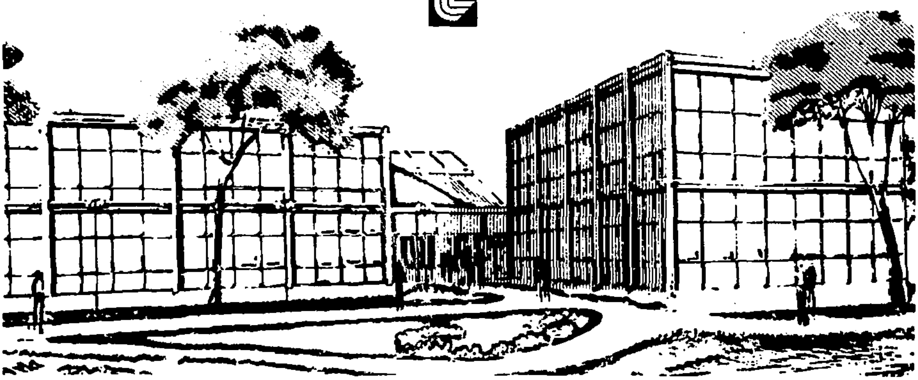
Lawrence Livermore Laboratory

ENHANCED SAFETY IN THE STORAGE OF FISSILE MATERIALS

G. E. WILLIAMS AND N. J. ALVARES

JANUARY 1979

This paper was prepared for submittal to the 1979 American Nuclear Society Meeting to be held in Atlanta, Georgia on June 3-8, 1979.



ENHANCED SAFETY IN THE STORAGE OF FISSILE MATERIALS*

G. E. Williams and N. J. Alvares
Lawrence Livermore Laboratory
University of California
Livermore, California 94550

INTRODUCTION

The need for increased storage capacity in existing fissile-material storage vaults is a problem encountered by criticality safety specialists. Unfortunately, construction of additional vault space may be prohibitively expensive because of extensive security and safety standards.[1] Criticality safety calculations indicate storage limits could be increased if a neutron absorber were used to isolate unusually massive (over mass) units.

MATERIAL FABRICATION

The Plastics Shop at Lawrence Livermore Laboratory (LLL) has fabricated a "plastic-like" supporting material impregnated with a neutron-absorbing agent that is suitable for "lining" the inner surfaces of fissile-material storage containers. This material consists, by weight, of 50% food-grade borax, 25% coal tar, and 25% epoxy resin. It costs much less than commercially available materials, can absorb enough neutrons to isolate units of fissile material, and possesses such structural qualities as flexibility and machinability.

The Plastics Shop mixed the ingredients and appropriate catalysts in a commercial dough mixer to form a liquid with strong thermal-neutron-absorption properties. Then they poured the liquid into storage containers, slowly rotating each container on its side until each was uniformly lined. After the liner set, they added part of the liquid to the bottom and lid of each container.

*Work performed under the auspices of the U. S. Department of Energy by the Lawrence Livermore Laboratory under contract number W-7405-ENG-48.

ADVANTAGE FOR CRITICALITY SAFETY

Monte Carlo neutron-transport and criticality safety code MORSE-C indicated a much enhanced safety margin for containers lined with neutron absorber. For example, a flooded 4 X 4 X 4 array of 10-kg oralloy spheres packed as closely together as permitted in 0.038-m^3 containers has a multiplication constant, k, of about 0.93, and would exceed the Laboratory convention that a k greater than 0.9 is unacceptable. However, the same array would have an effective k of only about 0.70 if each part were enclosed in a cylinder lined with neutron absorber. This reduction in the state of criticality would allow solid spheres (over mass units) of up to 26 kg of oralloy or 6 kg of plutonium to be stored in floor storage areas of the Laboratory's Central Vault without exceeding an effective k of 0.9. Without neutron absorber, only 18.5 kg of oralloy or 4.5 kg of plutonium would be permitted.

FIRE-RESISTANT PROPERTIES

General safety considerations demanded the absorber have several properties to ensure it did not increase other hazards while reducing the criticality hazard in fissile-material storage vaults. One significant hazard associated with any hydrocarbon is its flammability. To ensure containers lined with neutron absorber would not appreciably increase the possibility or severity of fire, the Fire Science Group of LLL tested the fire-propagation properties of a free-standing sheet of absorber; the duration and intensity of fire necessary to cause the neutron absorption properties of a lined container to fail; and smoke-evolution properties.

The fire-propagation tests proved no unsupported burning of absorber occurred regardless of the intensity or duration of exposure to flame.

For endurance testing, the Fire Science Group partially or totally immersed several lined containers in a 160,000-kJ/min flame. After each test, some of which lasted 20 min, they assessed the condition of the liner. Although water trapped in the borax turned to steam, causing the liner to separate from the container wall, the collapse was not severe enough to damage the container's contents or to degrade its neutron-absorption properties.

Before fire testing, the Fire Science Group tested lined containers for their neutron-absorption properties. After exposing each container to flames for 10-20 min, they reevaluated its neutron attenuation. For a ^{252}Cf fission spectrum moderated by 25 cm of D_2O, the liner reduced the low-energy neutron flux by an average factor of about 50 before and after fire testing. These tests also showed the neutron-absorption properties of the liner were not greatly affected despite the partial collapse and loss (as much as 8%) of absorber in the form of steam.

The absorber's smoke-evolution properties were largely dependent on the mode of exposure. While slabs of absorber smoked very little when exposed to flames, smoke was prevalent in the absence of flames. Exposure to high-flux radiant heat (2.5 to 5 W/cm^2) proved the liner must be considered a heavy smoke producer.

OTHER PROPERTIES

The Laboratory's Criticality Safety Committee subjected the absorber to additional tests to determine its other properties. To determine whether the absorber lost its neutron-absorption characteristics if wet, they immersed a sample of absorber in water. After 60 hr only 1.3% of the absorber dissolved presumably because the coal tar and resin waterproofed most of the borax, proving sprinkler systems, rain, or accidental flooding should not degrade the absorber's performance.

They found the absorber pliable at room temperature and rigid and breakable at freezing temperatures. Although unsupported sheets of absorber sagged when exposed to the sun and smelled of coal tar (like creosote), the odor lessened with time and was not a serious disadvantage.

CONCLUSION

The Laboratory's neutron absorber for lining fissile-material storage containers is strong and pliable at room temperatures and will survive even the severe conditions of a fire without losing its neutron-absorption properties. It costs less to produce than commercially available materials and is easily adaptable for many uses. Safe for use in fissile-material storage vaults, the absorber preserves enhanced criticality safety in storage arrays, even for over mass units.

REFERENCE

1. "General Design Criteria, Part II," Energy Research and Development Administration Manual Chapter 6301 (March 1977).