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UO2 AEROSOL RELEASE FROM POOLS OF SODIUM*

J. C. Petrykowski, A. W. Longest, A. L. Wright

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Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831

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UO₂ Aerosol Release From Pools of Sodium

J. C. Petrykowski, A. W. Longest, A. L. Wright
Oak Ridge National Laboratory

Experiments in the Fuel Aerosol Simulant Test (FAST) facility at Oak Ridge National Laboratory measure the release of UO₂ aerosols from sodium pools to assess the potential release of fuel aerosols from liquid metal fast breeder reactors (LMFBRs) following hypothetical core disruptive accidents (HCDAs). In nine undersodium experiments recently completed, aerosol concentrations in the cover gas were lower than concentrations in Wright's¹ underwater experiments. Analysis of heat transfer between the UO₂ and pool reveals that greater subcooling and higher thermal diffusivity of sodium are responsible for reductions in aerosol concentrations.

Aerosols are generated by energizing UO₂ pellets in a vaporizer using a capacitor discharge (CD) technique.² Discharge occurs in a pool of coolant, either sodium or water, producing an energetic bubble with condensed and fragmented UO₂ aerosols. Heat, mass and momentum transfer between bubble and coolant determines whether the bubble breaks through the pool and releases aerosols into the cover gas. Aerosol concentration is measured in the cover gas by gas sampling. Because radiative cooling rapidly condenses UO₂ vapor, coolant vaporization at the bubble surface may be required to sustain the bubble during transport to the cover gas. Coolant vaporization can be enhanced by heating the pool; sodium temperatures are ~810 K while water temperature varies from 300 to 360 K.

Aerosol concentrations are shown in Fig. 1 for an undersodium experiment (FAST-105) and an underwater experiment (FAST-43). Cover gas

pressures, capacitor discharge energies and vaporizer depths varied less than 8% and do not account for the large disparities in measured aerosol concentrations. In fact, a greater disparity exists between concentrations when other undersodium and underwater experiments are compared.³ These observations suggest that aerosol transport is considerably different in sodium than in water.

Analysis of the coolants' thermal boundary layers indicates that differences in thermophysical properties (i.e., vapor pressure, diffusivity, emissivity) account for delayed surface vaporization of sodium relative to water. The boundary layer model assumes coupled conduction-radiation heat transfer between coolant and bubble and is similar to Bradley's⁴ except that curvature is neglected because the layer is relatively thin. The relative surface vaporization inception time is plotted in Fig. 2 as a function of the coolant emissivities. For all emissivities considered, surface vaporization of sodium takes much longer to occur because of greater diffusivity and subcooling. Assuming an emissivity of 0.3, Fig. 3 shows that $\sim 10^2$ ms elapse before sodium is vaporized. This exceeds by an order of magnitude the measured period of oscillation of a UO₂ vapor bubble in sodium and supports Tobias's⁵ conclusion that bubbles collapse before vaporization can occur.

It appears, therefore, that surface vaporization can be precluded as a mechanism for sustaining bubbles in the undersodium experiments. Buoyant migration of bubbles is reduced in sodium relative to water. As a result, the aerosol release to the cover gas was lower in the undersodium experiments. This data will contribute to a more mechanistic assessment of LMFBR source terms.

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- Figure 2. Onset of surface vaporization of sodium and water. Initial subcooling is 340 K and 10 K respectively.
- Figure 3. Surface vaporization of sodium by a 4500 K source.

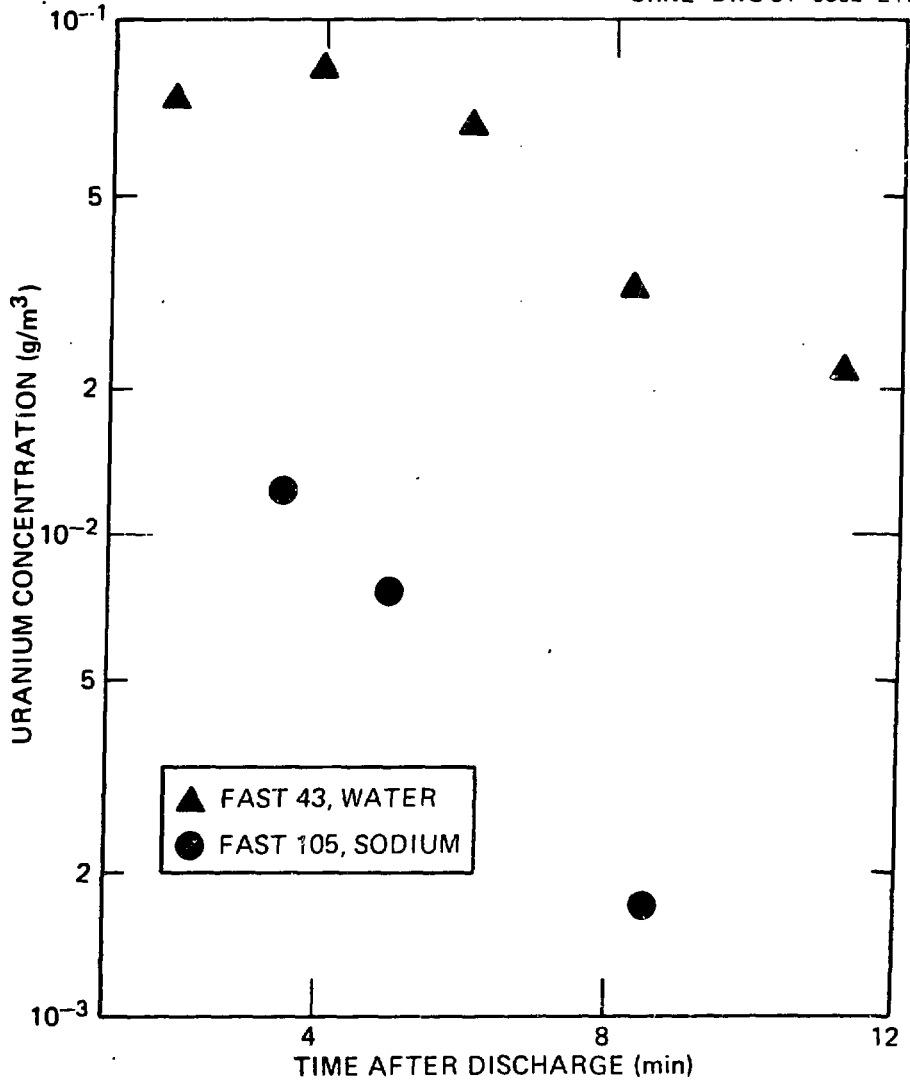


Fig. 1. Measured aerosol release from pools of sodium and water.

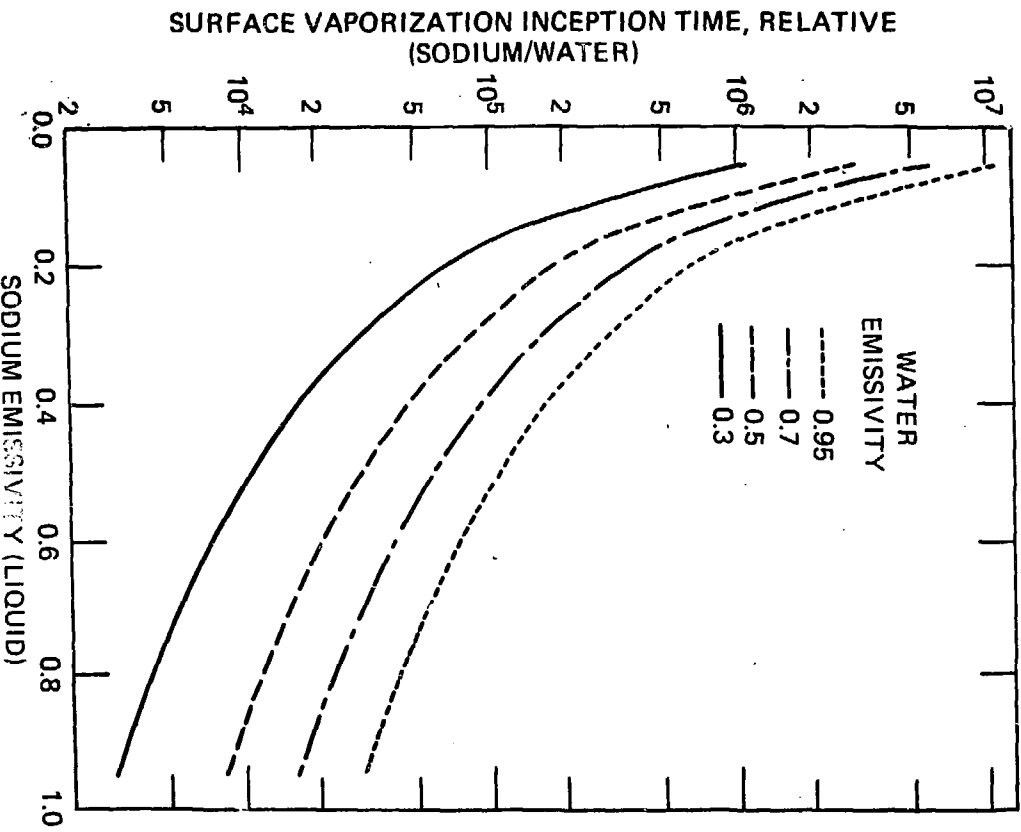


Fig. 2. Onset of surface vaporization of sodium and water. Initial subcooling is 340 K and 10 K respectively.

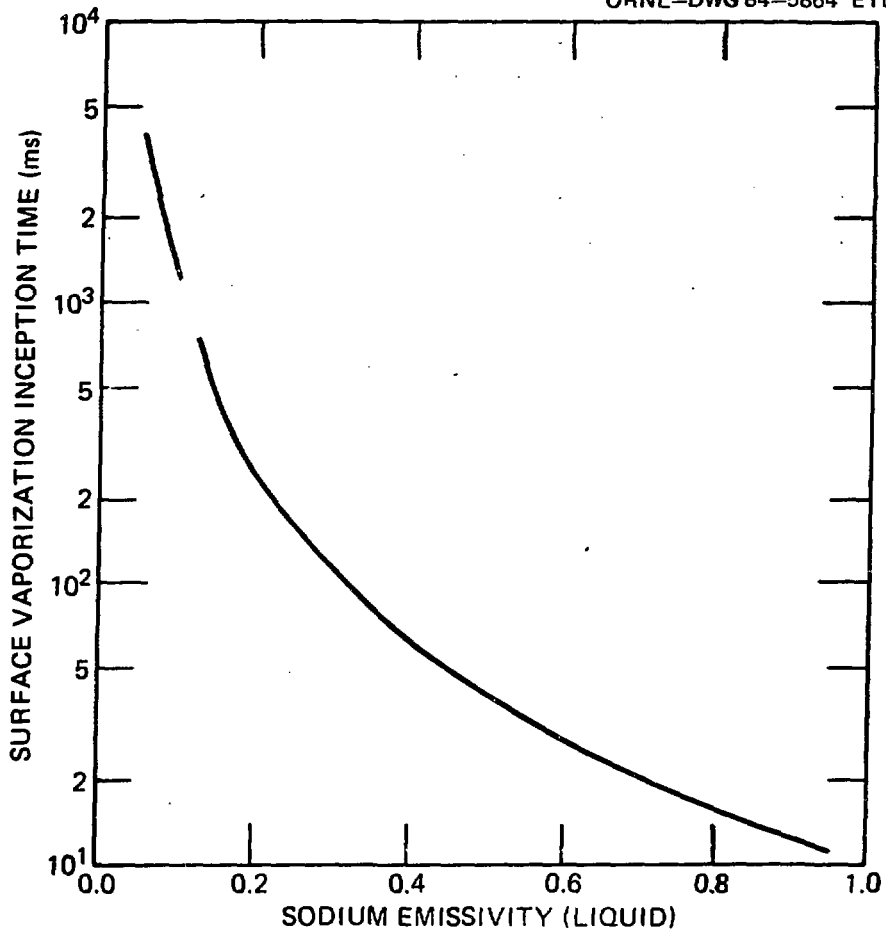


Fig. 3. Surface vaporization of sodium by a 4500 K source.