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ALE3D Simulation and Measurement of Violence in a Fast Cookoff Experiment for LX-10*

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Fast cookoff is of interest in the areas of fire hazard reduction and the development of directed energy systems for defense. During a fast cookoff (thermal explosion), high heat fluxes cause rapid temperature increases and ignition in thin boundary layers. We are developing ALE3D models to describe the thermal, chemical, and mechanical behavior during the heating, ignition, and explosive phases. The candidate models and numerical strategies are being evaluated using benchmark cookoff experiments.

Fast cookoff measurements were made in a Scaled–Thermal-Explosion-eXperiment (STEX) for LX-10 (94.7% HMX, 5.3% Viton A) confined in a 4130 steel tube with reinforced end caps. Gaps were present at the side and top of the explosive charge to allow for thermal expansion. The explosive was heated until explosion using radiant heaters. Temperatures were measured using thermocouples positioned on the tube wall and in the explosive. During the explosion, the tube expansion and fragment velocities were measured with strain gauges, Photonic-Doppler-Velocimeters (PDVs), and micropower radar units. A fragment size distribution was constructed from fragments captured in Lexan panels.

ALE3D models for chemical, thermal, and mechanical behavior were developed for the heating and explosive processes. A multi-step chemical kinetics model is employed for the HMX while a one-step model is used for the Viton. A pressure-dependent deflagration model is employed during the expansion. A Steinberg-Guinan model represents the mechanical behavior of the solid constituents while polynomial and gamma-law expressions are used for the equation of state of the solid and gas species, respectively. Parameters for the kinetics model were specified using measurements of the One-Dimensional-Time-to-Explosion (ODTX), while measurements for burn rate were employed to determine parameters in the burn front model. The simulations include radiative and conductive transport across the dynamic gaps between the explosive charge and metal case. Model results are compared to measurements for the temperature fields, time to explosion, and wall expansion rates.

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