The Influence of Combustion Properties on the Hazards Potential of HD1.3 Materials

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Energetic items are hazard classified in the United States according to their hazards potential. Hazard classification is assigned at the system level; however, the energetic fill found in the item is a major player in the assignment of the Hazard Division (HD). Hazard Division (HD)1.3 includes substances and articles that present a mass fire hazard with a minor blast and/or fragment hazard, while HD1.4 substances and articles present moderate fire, no significant blast or fragment. The hazard for HD1.1 substances and articles, in contrast, is mass detonation/explosion, producing blast overpressures as the primary effect (Reference 1). Recent interest in the thermal effects of HD1.3 items and substances relative to the assignment of their various quantity distance (QD) arcs has prompted a closer look into the ignition and combustion properties of some of these materials.

Three combustion properties play a critical role in thermally driven hazards: ignitability, burning rate, and burning area. Laboratory data have been generated for several HD1.3 and HD1.1 materials to illustrate the role of these properties in relation to the thermal hazard threat.

The HD1.3 materials are often propellants that have been designed to burn and, in many cases, will burn vigorously at ambient or low pressure. In contrast, the HD1.1 materials have been designed to detonate rather than burn and are often difficult to ignite under similar conditions.

Laboratory ignition and combustion data are being generated for HD1.1 and 1.3 substances. These data are used to identify their hazards potential with respect to a thermal threat. A comparison of the ignitability for an HD1.1 nitramine-based propellant and an HD1.3 AP-based propellant tested at 0.69 MPa can be seen in Figure 1. The nitramine containing propellant is also nitro-plasticized and is readily gasified. In contrast, the AP-based propellant gasifies after a longer exposure and is immediately followed by complete combustion. Complete ignition is not achieved in the nitramine-based propellant until an exposure time of nearly 100 msec is applied. The lengthy pre-ignition period, which is characteristic of formulations of this type, allows for the accumulation of highly reactive pre-ignition products that play a significant role in the deflagration-to-detonation (DDT) hazard (Reference 2).

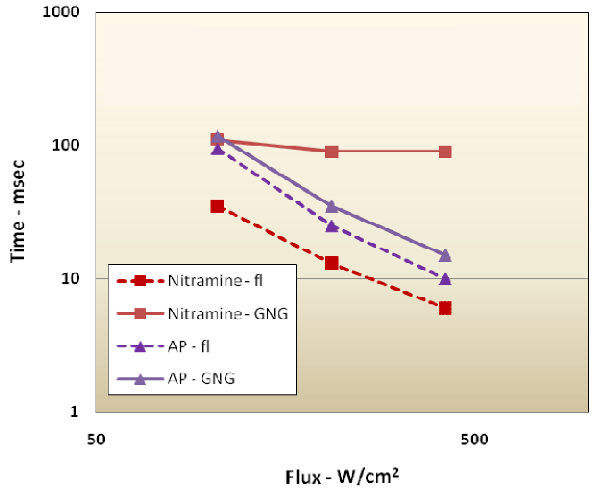

FIGURE 1. A Comparison of HD1.1 and 1.3 Substance Ignition (0.69 MPa).

Once an energetic solid has been ignited, the rate of conversion of solid to gas is important. Evaluation of the effectiveness of frangible walls, blowout panels, and doors is based on the rate of pressurization caused by the material. For a burning event, the linear burning rate of the material as a function of pressure as well as the available surface area of the energetic are required. The burning rates as a function of pressure for samples of HD1.1 and 1.3 substances are given in Figure 2. The burning rates merge as pressure increases, illustrating the contribution of confinement to pressurization behavior.

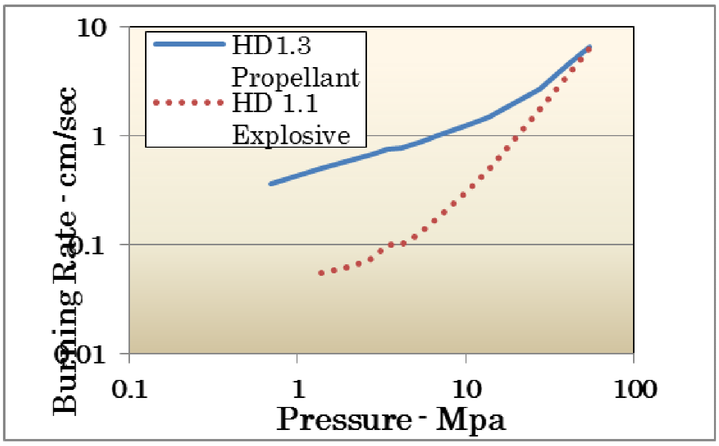

FIGURE 2. A Comparison of HD1.1 and 1.3 Substance Burning Rates.

The effect of surface area on pressurization rate for a single (1P) and a 7 perforation (7P) gun propellant is given in Figure 3. A series of combustion tests in sub-scale magazines are being used to evaluate the role of gun propellant surface area and loading density relative to venting, pressurization, plume, and fireball formation (Reference 3).

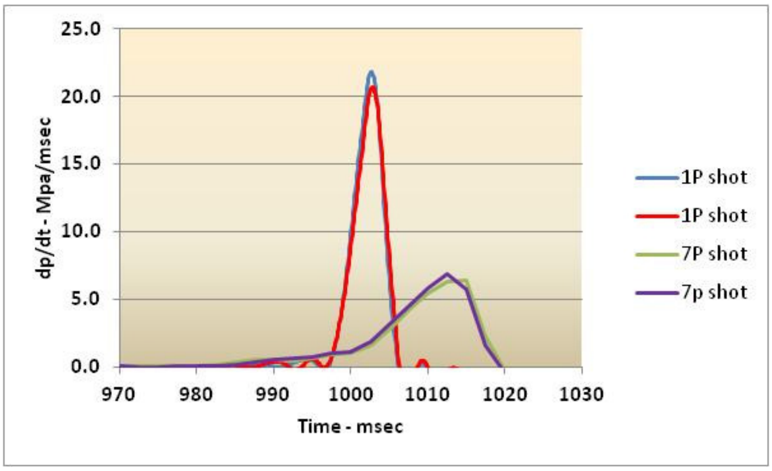

FIGURE 3. Surface Area Effects on Pressurization Rate.

References

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3. Naval Air Warfare Center Weapons Division. *Combustion of Hazard Division 1.3 M1Gun Propellant in a Reinforced Concrete Structure,* by A. Farmer, K. P. Ford, J. Covino, T. L. Boggs, and A. I. Atwood. China Lake, California, NAWCWD, August 2015. (NAWCWD TM 8742, publication UNCLASSIFIED.)