Implications of Underwater Explosive Binder Systems on Slow Cook-off Violence and Interactions with Warhead Venting

L.A. Nock, G.W. Lawrence, M. H. Sherlock, K. D. Gibson, D. N. Sorensen

Naval Surface Warfare Center
Indian Head EOD Technology Division (NSWCIHEODTD)
4103 Fowler Road, Indian Head MD 20640

The slow cook-off (SCO) test for Insensitive Munitions (IM) compliance requires a slow heating rate (3.3°C/hr) until reaction occurs whereby the ensuing reaction is characterized by degree of violence. A Type V (burn) reaction or better is required to pass the SCO IM metric. Latent venting is a common physical approach used to reduce the SCO violence of warheads. In addition to venting, there are two chemical approaches that can be manipulated to improve the SCO response. One approach fine-tunes the decomposition chemistry through binder selection and ingredient combinations to induce a reaction at a lower temperature to slow the rate and extend the decomposition over a larger temperature range in order to thermally consume the material before it reaches critical temperature where run-away reactions occur. The second approach is to exploit the mechanical properties of the thermally softened energetic material to assist with evacuation of material via venting pathways.

Generally, bulk underwater warheads do not pass the IM SCO requirement due to heavy warhead confinement and rich oxidizer content of the explosive, typically 40-50% by weight ammonium perchlorate (AP) oxidizer, with high explosive, and aluminum fuel. Three underwater explosive formulations containing three chemically different binder systems have been evaluated using inexpensive small scale methods to characterize the thermochemical and thermophysical decomposition properties and subsequent physical interactions with vent ports. These methods include: accelerated rate calorimetry (ARC), rheology measurements of binder gum stocks at elevated temperatures of interest, variable confinement cook-off tests (VCCT), and vented-Scaled Thermal EXplosion (vented-STEX) tests. Small scale tests results are presented and correlated to larger scale SCO tests where possible. Information gleaned from this investigation provides insight for designing new energetic formulation approaches that optimize the opportunity for venting warheads via conventional schemes to mitigate the reaction violence in SCO.