Applications Overview of IHDIV NSWC’s Reactive Materials

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## Applications Overview of IHDIV NSWC’s Reactive Materials

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- Composite Materials
- Reactive Materials
- Naval Architectures
- Naval Engineering

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What are Reactive Materials?

Reactive Materials” refers to materials that either react with themselves (thermites, intermetallics) or combust violently with air (Al, Ti, Hf) upon impact releasing energy.

- An energetic material consisting of two or more solid-state reactants that together form a thermo-chemical mixture
- Typically metal-metal and/or metal-metal oxide mixtures with and without binders
- Materials with higher predicted energy per unit volume than conventional energetics
- Energy release management is critical to obtain useful energy from RMs
  - RM formulation (particle size, density, structural properties etc..)
  - System engineering

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ENERGY COMPARISON
Classes of Reactive Materials

- Self-Propagating High-temperature Synthesis (SHS) - **more energy**
  - Thermitic - metal/metal oxide reactions
    - Thermite and MIC reactions
  - Intermetallic reactions
    - Aluminides
    - Borides
    - Carbides
  - Metal/fluorine systems

- Ultra-fine powders - **energy management**
  - ALEX (exploded wire)
  - MIC ingredients
  - Nano-laminates
  - Mechanochemical Synthesis (MCS)
  - Energy Saturated Media (ESM)
  - Hf and Ti powders
Potential Applications

- Biological agent defeat
- Material destruction
- Target damage using structural reactives
  - Reactive fragments
  - Enhanced blast effects
- High Explosive Target Countermeasure
- Improved underwater explosives
- Manufacturing
- Metal cutting/concrete cutting
- Propellant/Explosive additives
Advantages of an RM

- Additional energy by replacing inert components with an RM
- Adaptable to a variety of applications
- Offers kill mechanisms that resulting in lower collateral damage
- Many RMs are 4.1 Flammable solid versus 1.1 detonable explosives
- Improved Insensitive Munitions (IM) sensitivity
- Minimal gas evolved during combustion
- Warhead fill would survive high impacts from penetration
Biological Agent Defeat Application

- HE overpressure and target damage will result in large release of live agents and massive collateral damage downwind.

1 GRAM 10 BILLION SPORES

8,000 Spores 50% Lethal

Anthrax Spores
RM that produces a long thermal pulse, low overpressure and biocides will be effective against biological agents.

In FY2005, IHDIV NSWC demonstrated the Vulcan Fire intermetallic / oxidizer payload against Anthrax simulant during the Agent Defeat ACTD Program.

**Effective Kill Environment**
- Sustained target temperature >500F
- Biocides created
  - Cl₂
  - Titanium Dioxide
- Very low overpressure
High Explosive Target Countermeasure Application

- RMss may be effective countermeasure to HE targets. The goal is to identify RM candidates that can destroy these targets with minimal collateral damage
  - Maximize target break-up and combustion
  - Prevent target detonation response

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Test chamber simulates HE target impacted by RM projectile. It incorporates an HE bulk and rubble zone to simulate impact damage.

- Data Collection
  - Temperature vs Time
  - Pressure vs Time
  - Chamber damage serves as a witness to HE response
  - HE consumption
- Scalable
  - Chamber was sized to hold ~380g but can be scaled
Material Destruct Application

- Sustained high temperature is required to destroy materials. An RM producing high overpressure is not desired.
- The Vulcan Fire (VF) intermetallic RM with and without oxidizer was demonstrated for material destruct application.
Underwater Warhead Application

- Increase underwater warhead performance by reacting water with an RM.
- The challenge is to react and mix RM with external water fast enough to support shock impulse and bubble.
- Small scale tests conducted in FY09 indicate that the aluminum-water reaction was fast enough to increase shock impulse and bubble energy.
Structural RM Applications

Reactives augment Kinetic Energy Effects with Chemical Energy to Enhance Lethality and Battle Damage Indication.

- IHDNSWC has developed the highest performing RMs with densities >5.5 g/cc. Goal is to increase density to steel (7.8 g/cc)
  - For a reactive fragment impacting a target, the break-up and react as a FAE inside the target
  - For enhanced blast, an RM case will immediately breakup during HE event and react as a FAE

HE detonation disperses Structural RM and initiates fuel/air combustion with heated/dispersed RM particles resulting in increased blast.
RM are fired from 1K to 8K ft/sec. They penetrate thin steel plate and break up finally impacting on anvil in test chamber.

We can collect peak and quasistatic pressure data, spectroscopy data, pyrometry data, flash x-ray images, high speed optical photography, reaction gas sampling, and RM debris collection in a single shot.

Quasistatic pressure generally accepted as performance metric.
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