High Energy Research Laboratory Area (HERLA) Capabilities

BACKGROUND

Battelle is the world's largest, independent, nonprofit research and development (R&D) organization with the objective of using science for the benefit of mankind. As a 501(c)(3) charitable trust, we are committed to advancing R&D and translating scientific discovery and technology advances into societal benefits. We continuously improve our capabilities by investing millions of dollars annually to funding internal R&D to investigate complex problems and apply the successful results of our research into innovative and effective solutions; partner with academia and industry experts for additional support; and gain critical insights through our work for Government and commercial clients. Battelle has supported the government in classified testing through TS//ORCON and TS//SCI level efforts for the DoD and their Other Government Agency partners. Battelle manages comprehensive SCIF, SIPR, JWICS and other agency info-system access and controls through our Special Programs Office and can support classified efforts for the government at any level of protection.

HERLA FACILITIES AND CAPABILITIES

Battelle has been conducting energetic research related Research, Design, Test, and Evaluation (RDT&E) for nearly 50 years. Battelle's High Energy Research Laboratory Area (HERLA) facility provides a complete range of energetics design (in both primaries and secondaries), engineering, modeling, testing, and low-rate initial production capabilities. We have the proven capacity to carry a new energetic concept from conception, through formulation, prototype design and manufacture, characterization, and performance testing, to the manufacture of dozens to thousands of units. All Battelle blast facilities are co-located at the HERLA with prototype manufacturing capabilities, allowing prototype energetic materials to be experimentally evaluated without the need for a DOT Interim Hazard Classification.

Battelle has strong technical credentials, including PhDs, MSs, professional engineers (PEs), and program management professionals (PMPs) with backgrounds in detonation science, materials science, mechanical & chemical engineering, chemistry, physics, and computational modeling. We can provide a full range of synthesis, formulation, test design and execution, simulation, and other energetics RDT&E services. Battelle is approved for the secure handling of limited distribution and classified information and test articles. They are supported by extraordinarily versatile and proven indoor and outdoor test facilities and analytical laboratories.

Battelle's Laboratory for Applied Synthesis, Testing, Characterization, and Handling of Energetic Materials (BLASTCHEM)

BLASTCHEM has the capability to do synthesis, formulation, process optimization, and characterization of new energetic ingredients and formulations up to the 100 g scale. It incorporates benchtop and continuous flow experimental techniques to perform research on nitramine ingredients, explosive and propellant formulations. It is capable of chemical manipulation of sensitive energetic materials, including primaries and homemade explosives (HME). BLASTCHEM personnel include chemists and chemical engineers who are subject matter experts experienced with handling highly sensitive materials safely and effectively.

Our automated synthesis and formulations bench incorporates pharmaceutical technology modified for strong nitric acid and energetic material processing, putting Battelle on the leading edge of automated small-scale energetics research. In addition to wet-chemistry facilities and equipment, the lab is outfitted with instrumentation for characterization of chemical and physical properties such as Raman, FTIR, XRD, LC-MS, and DSC, as well as equipment for evaluating sensitivity of new materials for internal safety and handling knowledge. Materials generated in the laboratory can be easily transferred to the adjacent *Detonation Science and Combustion Laboratory* for processing and/or testing performance. The capabilities of BLASTCHEM, the HERLA, and Battelle's King Avenue facilities allow the study of energetics from synthesis to manufacture with the necessary analysis and characterization at every step.

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Detonation Science and Combustion Laboratory

The Detonation Science and Combustion Lab supports a variety of sample production and small-scale experimental equipment to characterize the performance and shock-to-detonation transition of explosive formulations. Molding powders of primary and secondary explosives can be pressed using a 350 kN UTM press. This press allows precision control of force during loading and unloading of the molding powder, enabling high-quality pressed parts to be made from difficult materials. A 35 g NEW internal blast facility applies state-of-the-art diagnostics (including photon Doppler velocimetry, fiber- and pin-based time of arrival diagnostics, and manganin pressure gauges) to perform detonator-driven experiments to evaluate fuze components, characterize explosive sensitivity and performance, and gather data to parameterize computational models that enable digital engineering.

EFI and Electric Gun Laboratory

The EFI (Exploding Foil Initiator) and Electric Gun Laboratory features several electric guns fire sets with charge voltages of 10 kV to 60 kV and total stored energy of up to 100 kJ. This lab is used to characterize the performance of EFI devices (fireset voltage vs. flyer velocity and flatness, GO-NOGO characterization, etc.) using Photon Doppler Velocimetry (PDV) and other advanced diagnostics as needed. The flyers generated by the electric gun systems are also used as impactors in shock physics and detonation science experiments to characterize material performance under shock loading. This can include inert materials (to measure the shock Hugoniot relations for modeling, high-speed impact experiments, etc.), and energetic materials (to characterize the Hugoniot, reacted product equations of state, James initiation space, shock sensitivity, etc.).

Mid-scale Explosives Preparation Facilities

Battelle is fully equipped for precision cast loading and press loading of military high explosives. Melt-pour explosives are processed in a steam-jacketed melt kettle with a maximum capacity of 25 lb NEW. A LabRAM II is available for the formulation of molding powders, processing of cast-cure explosives, and for other energetic mixing operations at the <1 kg scale. All relevant laboratory equipment for explosive density and composition analysis are available. Static x-ray inspection of charges is available on-site for quality control. Support equipment for the mixing and loading of small quantities of pyrotechnics or incendiaries is also available.

Figure 1: Explosive melt-cast preparation at Battelle

Mid-scale Pressing Facilities

For pressing operations for prototyping and low-rate production, we created a dedicated pressing facility which houses three remote pressing machines up to 150-ton capacity. Battelle scientists have the flexibility to develop a range of pressing operations to include the use of primaries. Battelle maintains a machine shop that includes Computer Numerical Control (CNC) machines for fabrication of prototypes. We also have 3D printers for printing components, molds, etc.

Outdoor Blast Range *(1 lb NEW)*

Battelle's West Jefferson, OH facility also features a 25-yard radius outdoor blast range for experiments of up to 1 lb NEW that produce minimal or no-fragment hazard. This range is used for experiments with wide-angle high-speed camera coverage, and/or free-air blast overpressure and impulse measurement.

Figure 2: Battelle Outdoor Blast Range Grenade Test

High Energy Research and Tunnel Facility (25 lb NEW)

This multi-purpose research facility is used for a variety of shaped charge jet, explosively formed penetrator, terminal ballistic and static detonation experiments. Mann barrels of all common calibers and a 30-40mm powder gun are used in this facility. Gun testing includes reactive materials, penetrator rounds, fragment simulation projectiles and any suitable payload. The facility incorporates a 110-foot long, 14-1/2-foot diameter ballistic tunnel connected to a 30 X 13 x 12 foot explosive containment chamber designed to contain the blast from up to 25 lbs. of TNT. Projectiles may be fired into the separate blast containment chamber, through a port in the blast containment doors, to impact explosives, electromagnetic armor, or otherwise hazardous targets in the chamber.

The chamber has ample access ports installed in the ceiling and side wall of the blast chamber to accommodate orthogonal flash radiography, high-speed camera coverage, PDV, gas sampling or other diagnostic equipment. An instrumentation room integral to the building allows for easy multiple-channel high-speed data acquisition and on-site data reduction. This facility also has a dedicated computer and image scanner for processing digital X-rays. A set of X-ray imaging phosphor plates of various lengths are available for static (e.g., explosive charge composition analysis) and dynamic (e.g., projectile characterization) activities.

Figure 3: High Energy Research Facility JS-12.

Large Internal Blast Facility *(50 lb NEW)*

This facility is designed to contain the blast of up to 50 pounds of explosives, making it the largest privately owned blast containment facility in the U.S.

The 40-foot-diameter chamber allows large fixtures and equipment to be easily moved in and out of the chamber through 10-foot-square blast doors. An integral instrumentation room accommodates high-speed photography, flash radiography, PDV, and other data acquisition equipment associated with energetic events.

Figure 4: Test in the Large Internal Blast Facility JS-10

Battelle 100 m^3 Gas-Forming Reaction Chamber

HERLA also has a custom made steel-walled containment chamber designed to contain vapor and aerosol contaminants for dissemination testing (i.e. for dissemination model validation). The chamber includes static and ventilated state configurations to mimic either an unventilated enclosed area or a ventilated area (i.e. transportation Chamber ventilation system is equipped with scrubbing system that can be modified for a variety of contaminants vessel).

Shipping and Storage of Ammunition and Energetics

HERLA can receive, ship, and store explosive materials and ordnance in all applicable quantities. We can securely test and store classified items and complete test reports on classified information systems as needed. Battelle is currently approved by the DSS and DCMA for the storage and use of SRC I-IV Arms Ammunition and Explosives. HERLA maintains onsite DSS approved storage for non-energetic classified test equipment including targets/threats/sensors etc. Sufficient storage is available to support large programs including palletized classified equipment.

Table 1. Experimental Testing and Experimental Capabilities of Battelle

Energetic Material Characterization		
Vacuum Thermal Stability	Thermal Stability	DSC/TGA
Material Compatibility	Wood's Metal Bath	Ignition Temperature
Var. Confinement SCO/FCO	SCO/FCO	Small-Scale Burn
Electrostatic Discharge	Drop-weight Impact	Friction
Small-Scale Gap Test (SSGT)	NOL Large-Scale Gap Test (LSGT)	Expanded Large-Scale Gap Test
Cap Sensitivity	Thermal Expansion Coeff.	Compressive Strength
Bulk Density	Irreversible Growth	Exudation
Var. of Properties with Age	Toxicity of Reaction Products	Detonation Velocity
Critical Diameter	Detonation Pressure	Cylinder Expansion (CYLEX)
Detonation Wave Curvature	Disc Acceleration Experiment	1D Pop Plot (Wedge/Cutback)

BATTELLE ADVANCED MATERIAL AND CHEMISTRY CAPABILITIES

Advanced Materials and Chemistry are foundational capabilities that underpin virtually every research area conducted by Battelle. Focus areas supported by our Advanced Material and Chemistry labs include Advanced Material Characterization, Chemical and Biological Engineering; Materials Physics, Simulation and Advanced Systems; Microfabrication and Coatings; and High Energy Research as described in 2.1 above.

Advanced Material and Chemistry Lab facilities. Our facility includes millions of dollars of intricate instruments and diagnostic equipment that cannot be found in total in smaller organizations and businesses. Our facilities have the potential to support several BPA tasks, like providing erosion and wear analysis of ballistic tubes.

- **Center for Characterization of Advanced Material (CCAM):** provides scanning electron microscope, optical microscopy, and X-ray diffraction.
- **Spectroscopy Lab:** a diverse array of instrumentation to identify and quantify various organic/inorganic materials including Fourier Transform Infrared, Raman, UV/Vis/NIR, and Fluorescence Spectroscopy.
- **Physical Testing:** Provides Environmental chambers for hot/cold and humidity-controlled testing, Instron machines for mechanical testing. Battelle also provides corrosion analysis and testing with our Corrosion Science Labs providing electrochemical parameter tests, accelerate exposure testing, mixed flow gas testing and failure analysis. A highlight of Battelle's corrosion capabilities includes our Florida Materials Research Facility (FMRF) with two locations south of Daytona Beach-Ponce DeLeon Inlet providing corrosion, fouling, and coatings analysis, atmospheric testing and immersion.
- **Nuclear Magnetic Resonance Lab:** for verification and monitoring of materials and organics.

Analytical Modeling. Battelle high performance modeling covers optimized designs to maximize performance measured by such metrics as strength, weight, size/shape, shock/vibration, noise, and temperature. We provide analytical models and scoping calculations in structural, thermal, fluid, high energy/blast, electrical/radiographic, chemical, and material for example, Cerius, Accelrys, Gaussian, Spartan, DryAdd, Codessa etc.

Microfabrication Class 100 Cleanroom. Battelle clean rooms provide photolithography, vacuum deposition, and wet chemical processing. This facility has made Battelle a provider of optical coatings and Explosive Foil Initiators (EFI). Battelle has experience designing, manufacturing, and testing energetic initiators, including high-simultaneity (100 ns) initiator arrays for linear cutting charges, EFI and Reactive Semiconductor Bridge (RSB) technologies for fuze miniaturization and ruggedization, and redesign of existing initiator systems for improved reliability. Battelle currently manufactures two styles of initiator systems based on semiconductor (integrated chip) fabrication techniques: a low-voltage RSB and high-voltage Exploding Foil Initiator styles (EFI). In previous projects Battelle designed novel initiators using EFI's for 40mm grenade launched top attack anti-personnel munitions, hybrid dual liner shape charges for penetration of double reinforced concrete, and for electronic initiated detonation.

Biological, Energetics and Chemical RTD&E. Battelle developed the Resource Effective Bio-Identification System (REBS). REBS is a rugged, battery-powered system capable of autonomous and continuous operation reliable, and high-tech detection system capable of identifying new biological and chemical agent materials.

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