



# Energetic Materials

Strengthening the nuclear deterrent, conventional munitions, and homeland security with new energetic materials and applications.

## Central to the Mission

Energetic materials (EM) such as explosives, thermites, propellants, and pyrotechnics are central to LLNL's national security mission. EM are utilized throughout a nuclear weapon and also provide the energy source for most conventional munitions.

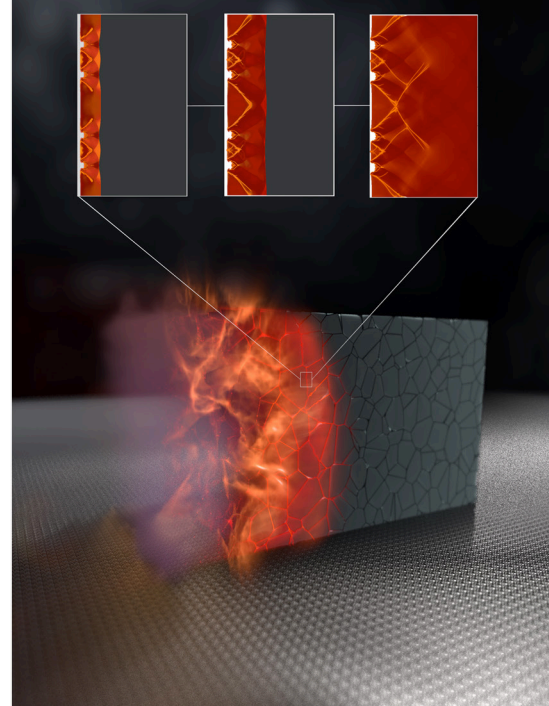
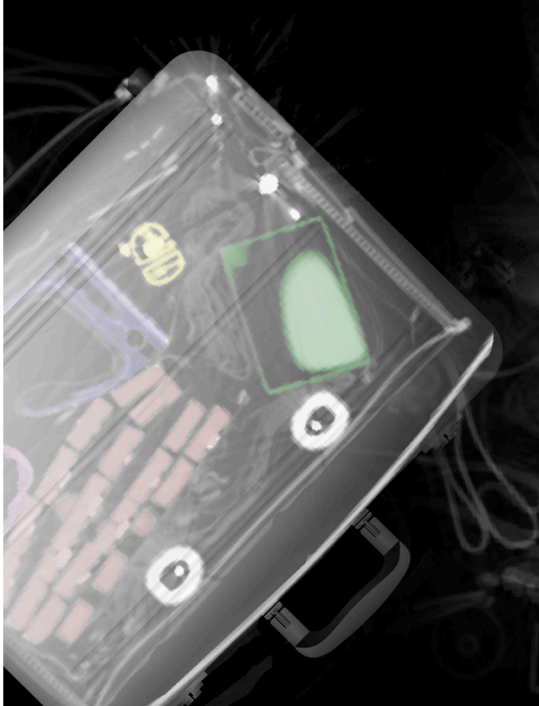
LLNL is a Department of Energy/National Nuclear Security Administration Center of Excellence for the research, development, synthesis, formulation, and characterization of explosives. The primary mission of LLNL's EM Enterprise is to ensure the safety, security, and effectiveness of the U.S. nuclear deterrent. Researchers also apply their expertise to develop solutions for Department of Defense conventional weapons, explore new ways to detect and defeat home-made explosives for the Department of Homeland Security, and develop strategies to counter the threat of improvised explosive devices for nuclear counterterrorism.

Experimental facilities at Livermore's Main Site (Site 200) and remote Site 300 together enable experimental activities that, when coupled with high-fidelity modeling and simulation, provide the basis for scientific advances in EMs.

## Accomplishments

LLNL scientists have developed numerous new energetic materials (EMs), especially high explosives—HEs; experimental techniques for their characterization; and computational models (e.g., Cheetah and ALE3D) to predict their behavior. These advancements form much of the scientific basis for the modern EM R&D community. EMs developed by LLNL are used by Livermore and Los Alamos nuclear weapon programs, and the Department of Defense (DOD) uses LLNL explosives, initiation systems, and models for their unique weapon designs.

- First to design an all-insensitive-high-explosive (IHE) booster and main charge system and introduced an out-of-line detonator.
- New explosive (LLM-105) is the baseline booster material for the W80-4 and W87-1 Life Extension Programs (LEPs).
- Leading the remanufacture efforts of critical IHEs for the W80-4 and W87-1 LEPs after 30 years of inactivity. HEAF researchers defined the production parameters, and LLNL's Forensic Science Center developed chemical analysis protocols.
- Full-scale fire-safety tests provide high-fidelity data to characterize HEs and their reaction products, providing data to greatly improve simulation models.
- Groundbreaking capabilities predict the effects of material aging on explosives' performance and improve assessments of weapon service life.
- Research at DOE user facilities is obtaining never-before-captured high-resolution data in the reaction zone of a detonating HE.
- LLNL HE expertise was applied to the Source Physics Experiment (SPE) to improve physics-based models used to detect foreign nuclear explosions amidst a background of earthquakes and mining events
- New explosive threats have been characterized for homeland security using advanced x-ray, dual-energy, and computed tomography processing.
- Patented E.L.I.T.E.™ (Easy Livermore Inspection Test for Explosives) system for first-responders uses chemical reaction to quickly detect explosives.



## Scientific Underpinnings

Ensuring the continued safety, security, and effectiveness of the nation's nuclear deterrent, countering threats from adversaries, and supporting DOD conventional munitions research requires outstanding inquiry performed by exceptional scientists working at world-class facilities. EM scientists explore the energy released during energetic chemical reactions, the mechanical response, and long-term aging characteristics. Taking advantage of Livermore's family of supercomputers and advanced simulation codes, scientists improve EM performance and safety. Projects are enabled by both real-time and post-test analytical diagnostics that were established with the assistance of Forensic Science Center scientists and are found only at LLNL. Science-based object views for the EM Enterprise include:

- Enhanced predictive modeling including detonation performance, chemistry, safety, mechanical properties, computed tomography, simulated radiography, and effects are coupled to LLNL's renowned high-performance computing resources to interpret, extend, and enhance EM formulations and components.
- Novel diagnostics for EM detection, detonation, and abnormal hazard response shed light on fundamental chemical reactions and properties.
- A core LLNL competency is investigating materials under extreme conditions of pressure and temperature. EM experiments are conducted on platforms ranging from OMEGA EP (at the University of Rochester's Laboratory for Laser Energetics) and the Dynamic Compression Sector (at Argonne National Laboratory's Advanced Photon Source), to firing tanks and gas guns located at HEAF.
- Responsive EM manufacturing and materials developments improve the quality of EM components and make possible new formulations with advanced geometries that can be manipulated to govern precise properties.
- Novel applications of EMs (e.g., pulsed power, energy sources, laser-matter interactions, laser initiation) strengthen national security.
- World-class facilities include HEAF for creating and detonating EMs up to 10 kg HE; Site 300 facilities for synthesizing, formulating, manufacturing, and testing HE up to 60 kg; the Contained Firing Facility and Flash X-Ray for stockpile stewardship; and the Forensic Science Center, which supports LLNL's global security counterterrorism programs and enhances fundamental understanding of EMs.

## The Future

LLNL will continue to help provide high confidence in the safety, security, reliability, and effectiveness of EMs used in the nation's nuclear deterrent. Researchers will be particularly focused on ensuring LLNL meets the goals of the W80-4 and W78-1 LEPs and enabling transition to an all-insensitive-high-explosive nuclear stockpile for enhanced safety and surety.

The breadth of EM research will include advanced conventional weapons for DOD, including increased use of insensitive technologies, new gun propellants, warheads to penetrate hard targets, and high-speed explosive projectiles. Research will also continue to include meeting the needs of the Department of Homeland Security and its Transportation Security Administration, and countering the threat of nuclear proliferation.

## Principal Sponsorship

- DOE/NNSA, DOD, DHS/TSA

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