



FOCUS ARTICLE

Explosives Characterization Testing

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Know your Energetic Materials

There are many reasons to test energetic materials in your workplace. Frequently, testing is focused on desired outcomes and how well the material fulfills expectations. Certainly, performance, reliability and quality control testing must be an integral part of any product development and on-going product manufacture. For products that are energetic, these tests are often very rigorous to ensure a high degree of confidence in the product's performance and reliability. For example, small variations in composition, particle size distribution, density, or shape can lead to large differences in energetic output, targeted performance or safety of use or handling.

In addition to these high profile purposes, there are other reasons to **test energetic materials**. These include:

- >> DOT / UN / NATO Shipping Classification
- >> Facility and magazine siting
- >> Maximum Credible Event
- >> In-process Safety
- >> Regulatory Compliance

- >> Improved Process Efficiencies
- >> Risk Management
- >> Incident Avoidance
- >> New Business Opportunities

Below, we discuss these in more detail.

DOT / UN / NATO Shipping Classification

No explosives move in commerce without appropriate Competent Authority approval. Commercial enterprises and military development alike often find that a well planned product roll-out schedule can be suddenly delayed by not planning sufficiently ahead for the required testing and analysis involved in obtaining required shipping authorizations. For example, the US DOT currently states that applicants should expect action on explosives shipping request in approximately 120 days after the required test and recommendation report, support documentation and application have been submitted. Explosives approval applicants planning on a one or two week turn-around by the US DOT will

have an unpleasant surprise. In addition, sufficient product must be available for the required tests. If applicable, appropriate packaging materials must also be available for the required tests. Getting a time slot for the tests at an approved facility or arranging for an approved witness to come to your facility may also be constraints on the schedule if not planned and prepared for in advance.

The required tests vary depending on the classification sought, the material (substances or articles) and test results. While manufactures of many products can self-classify if they have the ability to properly perform the requisite tests and analysis, this is not the case with explosives and certain other energetic materials. Commercial interests must use a DOT approved laboratory witness for these tests. Military interest must have the concurrence of the Joint Classifiers for the armed services.

Facility and Magazine Siting

Maximum Credible Event

The very nature of manufacturing a product implies change. As energetic materials change, the energetic character of these materials may also change, either lessening or increasing the hazard. One aspect in which the hazard can change is in the Maximum Credible Event (MCE). The MCE is defined as the worst-case credible event, including process upset conditions. Knowing the MCE for a process or area, one can properly site that process to protect nearby and off-site personnel and facilities through appropriate facility siting, blast-resistant construction, quantity limitations, process modifications or other means. Knowing the MCE for each major step in a process may also provide opportunities for improved facility utilization. This leads to improved product flow, siting and other process design decisions for existing and new processes. Knowing the MCE for a particular juncture in the process may require testing, analysis or both.

In-Process Safety

Regulatory Compliance

Accurate and adequate understanding of process materials is the foundation of a valid and useful hazards analysis. Appropriate testing of process materials at various stages provides the in-process understanding required. OSHA's [Process Safety Management](#) (PSM) standard, the Contractor's Safety Manual and various Military requirements all recognize the value of on-going site safety programs and process hazards analyses for manufacturing processes involving explosives.

Improved Process Efficiencies

There are several sets of basic safety data a company must have to establish and maintain safe and efficient operations. These include sensitivity, reactivity, and stability data. Specific tests to provide some of this data may be prescribed, such as the UN Tests for the Transport of Dangerous Goods, and related tests required by the Department of Transportation. Similarly, the Military, ATF, and other regulatory or contractual entities may prescribe particular data, based on specific standards, methods or protocols. More importantly, knowing the in-process sensitivity and reactivity of your materials allows you to determine the appropriate level of process potentials that will maximize process efficiencies while maintaining appropriate safety margins.

For example, in a cutting operation, the blade temperature must not exceed the auto-ignition temperature for the material you are cutting. This applies not only for normal cutting, but also for if the blade suddenly stops and is left stuck in the material for a period of time. Knowing both the auto-ignition temperature of the material being cut and the blade temperature as a function of tip speed and other variables, allows for the cutting process optimization without compromising process safety.

In-process classification, specific process simulations or standard sensitivity or reactivity data may be needed, depending on the application.

Risk Management

Incident Avoidance

Of course, as discussed above, In-Process Classification, [Process Hazards Analysis](#), and Risk Assessments are designed to avoid incidents of injury or facility loss. However, often the true cost of a serious incident is many times the direct losses. These additional costs may include legal fees, investigation costs, fines, long-term medical or disability, clean-up, lost image, lost sales, lost market share, etc. When one views the full picture, it is critical to proper risk management to have adequate process and material data.

Sometimes, to understand the hazards, it is necessary to obtain additional data, including testing larger scale scenarios or more indepth analysis. For example, the data required to determine the true hazards of an upset condition are not necessarily developed in a standard product development cycle. But a serious incident, even if loss of life is avoided, can quickly cause havoc with schedules, budgets and even client interest in the final product.

New Business Opportunities

Knowing your materials better not only helps to protect you from loss, but may also help you discover new markets, potential enhancements or to identify needs that are unmet in the market.

Table 1: Examples of Common Explosives Testing

Sensitivity Tests	Reactivity Tests	Thermal / Stability Tests
Impact Sensitivity (TIL, Screen, PROBIT)	Time-Pressure	Differential Scanning Calorimeter (DSC)
Friction (TIL, Screen, PROBIT)	Deflagration to Detonation Transition	Accelerated Rate Calorimetry (ARC)
ESD (TIL, Screen, PROBIT)	Internal Ignition	Simulated Bulk Acceleration Temperature
Critical Height (to explosion or detonation)	Koenen	Thermal Stability
Critical Diameter (detonation propagation)	Vented Pipe	Heat of Combustion
Card Gap	Single Package	Self Accelerating Decomposition Temperature, SADT
Dust Explosibility (minimum energy, minimum concentration)	Stack (Propagation)	Self Heating Substances
Dielectric Strength	Bullet Impact	Vacuum Stability
Thin Layer Propagation	Slow Cook-Off	Compatibility
Cap Sensitivity	TNT Equivalency	Henkin Time-to-Explosion

DEKRA is an approved test agency, recognized by the United States Department of Transportation (DOT) to test and examine explosives or potentially explosive substances and recommend the proper shipping classification. We have the skills and credentials to assist you in all your test and analysis needs for energetic materials or processes. For more information regarding process hazards analysis, system safety, material characterization, DOT and other regulatory compliance, and any associated testing, please contact us at 847-925-8100 or email us at process-safety-usa@dekra.com

DEKRA Process Safety

The breadth and depth of expertise in process safety makes us globally recognized specialists and trusted advisors. We help our clients to understand and evaluate their risks, and work together to develop pragmatic solutions. Our value-adding and practical approach integrates specialist process safety management, engineering and testing. We seek to educate and grow client competence to provide sustainable performance improvement. Partnering with our clients we combine technical expertise with a passion for life preservation, harm reduction and asset protection. As a part of the world's leading expert organization DEKRA, we are the global partner for a safe world.

Process Safety Management (PSM) Programs

- >> Design and creation of relevant PSM programs
- >> Support the implementation, monitoring, and sustainability of PSM programs
- >> Audit existing PSM programs, comparing with best practices around the world
- >> Correct and improve deficient programs

Process Safety Information/Data (Laboratory Testing)

- >> Flammability/combustibility properties of dusts, gases, vapors, mists, and hybrid atmospheres
- >> Chemical reaction hazards and chemical process optimization (reaction and adiabatic calorimetry RC1, ARC, VSP, Dewar)
- >> Thermal instability (DSC, DTA, and powder specific tests)
- >> Energetic materials, explosives, propellants, pyrotechnics to DOT, UN, etc. protocols
- >> Regulatory testing: REACH, UN, CLP, ADR, OSHA, DOT
- >> Electrostatic testing for powders, liquids, process equipment, liners, shoes, FIBCs

Specialist Consulting (Technical/Engineering)

- >> Dust, gas, and vapor flash fire and explosion hazards
- >> Electrostatic hazards, problems, and applications
- >> Reactive chemical, self-heating, and thermal instability hazards
- >> Hazardous area classification
- >> Mechanical equipment ignition risk assessment
- >> Transport & classification of dangerous goods

We have offices throughout North America, Europe, and Asia.

For more information, visit www.dekra.us/en/process-safety/

To contact us: process-safety-usa@dekra.com

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