Homeland Security
Science and Technology

TechNote

U.S. Department of Homeland Security
SAVER
System Assessment and Validation for Emergency Responders

The U.S. Department of Homeland Security (DHS) established the System Assessment and Validation for Emergency Responders (SAVER) Program to assist emergency responders making procurement decisions. Located within the Science and Technology Directorate (S&T) of DHS, the SAVER Program conducts objective assessments and validations on commercially available equipment and systems, and develops knowledge products that provide relevant equipment information to the emergency responder community.

SAVER Program knowledge products provide information on equipment that falls under the categories listed in the DHS Authorized Equipment List (AEL), focusing primarily on two main questions for the emergency responder community: "What equipment is available?" and "How does it perform?" These knowledge products are shared nationally with the responder community, providing a life- and cost-saving asset to DHS, as well as to Federal, state, and local responders.

The SAVER Program is managed by the National Urban Security Technology Laboratory (NUSTL), which also prepared this TechNote.

For more information on this and other technologies, contact the SAVER Program by e-mail or visit the SAVER website.

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Handheld Explosive Trace Detectors

Individuals who carry explosives or objects that contain explosives are likely to be contaminated with traces of explosives, microscopic residues that are invisible to the naked eye. There are three configurations of explosive detectors: handheld, portable/movable, and fixed-point/standalone. Handheld detectors are small and light enough to be held and operated in the hand and usually require no assembly. There are three kinds of explosives: homemade, commercial, and military, and not all detectors can detect all three explosive types. Some detectors can also detect narcotics, chemical warfare agents, or toxic industrial chemicals.

Figure 1. Handheld Explosive Trace Detector

Photo Courtesy of Implant Sciences Corporation

Detector Overview

Sensitivity–the lowest amount of explosive traces detectors can reliably detect–is a key performance parameter of these detectors. It is generally expressed in terms of nanograms (ng), picograms (pg), or femtograms (fg), with fg being more sensitive than pg and pg being more sensitive than ng. It can also be expressed in terms of parts per billion (ppb), parts per trillion (ppt), or parts per quadrillion (ppq). In order for a handheld explosive detector to be designated as a trace detector, the research community generally agrees that the trace amount detected can be no more than a few hundred of ng, usually tens of ng. The sensitivity of a commercially available handheld explosive trace detector should be independently verified before purchase to ensure it can detect at trace levels.

Figure 2. Vapor-Sampling Mode

Photo Courtesy of Laser Detect Systems Ltd.

Figure 3. Particle-Sampling Mode

Photo Courtesy of Morpho Detection Inc.

Detectors are usually operated in either vapor-sampling mode or particle-sampling mode. Vapor-sampling mode requires the user to hold the detector inches away from the object being screened, and air is drawn into the detector and analyzed for explosive traces. In particle-sampling mode, the user swabs the surface of an object with a wipe and collects a sample of explosive traces that may be present; the wipe is then

inserted into the detector and analyzed. Traditionally, particle-sampling mode is more sensitive than vapor-sampling mode, but requires physical contact with the object; also, wipes are consumable. Many detectors can be operated in both vapor- and particle-sampling mode.

Some detectors require a radioactive source to operate, so the entity utilizing these detectors must train its personnel about radiation safety before using these detectors and might need to calibrate the detectors annually. However, they usually bear a minimal amount of radioactivity. These detectors can be purchased with an NRC General License from the Nuclear Regulatory Commission, and do not require a specific license.

Rapid screening is essential in explosive detection due to the large number of passengers, luggage, and packages needing to be screened at checkpoints. Cold start time (ready time) is the time needed for the detector to reach operational readiness; it usually varies from few minutes to half an hour. Sleep time is the time needed to resume operational readiness, assuming the detector is still within its operational temperature range. Clear-down time is the time needed to recover from an alarm before the next scan can be performed. The analysis time is the time needed to analyze the result of a scan. Generally sleep time, clear-down time, and analysis time are in a range of a few seconds and for some detectors are near instantaneous.

MIL-STD-810G is a U.S. Military Standard that is approved by the U.S. Department of Defense to examine the ruggedness of equipment and devices. Detectors that pass this standard can sustain drops from human height and prevent radioactive sources or hazardous chemicals from escaping. ASTM International is an international standards organization that develops and publishes technical standards. ASTM E2520 is an overall performance standard for particle-sampling explosive trace detectors. ASTM E2677-14 is a standard test method for determining the limits of detection in explosive trace detectors.

Some detectors are available on GSA Advantage. GSA Advantage is an online acquisition site where federal agencies can purchase commercial products with pre-negotiated volume discount pricing.

Methods to Detect Explosives

Unless specified, methods introduced in this TechNote are all commercially available in handheld explosive trace detectors. The sensitivity of these methods has not been verified by NUSTL.

Colorimetrics is one of the oldest, simplest, and most widely applied methods to detect explosives. Some vendors claim this method is able to detect down to ng levels, but these claims have not been independently verified. Colorimetrics works by applying a chemical reagent to a sample of an unknown material and observing a color reaction.

Ion mobility spectrometry works by observing the mobility of ions in a uniform electric field. Detectors using this method can be sensitive down to pg levels. Radioactive sources are used in some ion mobility spectrometry detectors. The majority of commercially available explosive trace detectors are based on this method.

Detectors that use *thermo redox* to detect explosives draw air into the detectors and pyrolize the traces in the air. This method has relatively more false alarms as it is known to falsely identity fertilizers as explosives. Nonetheless, the sensitivity of this method is good to at least pg level.

Chemiluminescence is the emission of light from a chemical reaction. The sensitivity of this method is ng levels. The chemical reaction is in gas-liquid form. Due to the simplicity of this method, it is possible to combine it with other explosive detecting methods.

A method called *amplifying fluorescent polymer* synthesizes polymers that bind to explosive molecules. The explosive molecules then cause the polymer to "quench" or to stop emitting light. The sensitivity of this method is in the order of fg. Detectors using this method have successfully found buried landmines.

Major Explosive Chemical Compounds

Some vendors list the chemical compounds their detectors have successfully detected (which may or may not have been independently verified). Below are some common chemical compounds found in explosives. TNT is yellow insensitive crystals that can be melted and cast without detonation. Nitrocellulose is nitrated polymer, which can be a high or low explosive depending on nitration level and conditions. Acetone peroxide is highly unstable white organic peroxide. RDX, PETN, and HMX are powerful explosives which can be used pure or in plastic explosives. C-4 is RDX plastic explosive plasticized to be adhesive and malleable.