Advanced Trace Explosives Detection Testbed

S. Rose-Pehrsson,[1] R. Colton,[1] G. Collins,[1] B. Giordano,[1] D. Rogers,[1] M. Hammond,[1] C. Tamanaha,[1] C. Field,[1] M. Malito,[2] and R. Jeffries[2]
[1]*Chemistry Division*
[2]*Nova Research, Inc.*

Introduction: The Department of Defense (DoD) and the Department of Homeland Security (DHS) need improved explosives detection systems to protect personnel and platforms from attack from insurgents and terrorists both at home and abroad. Therefore, research is under way for the development of new materials and sensors for explosives vapor detection. However, uniform, reliable methods for evaluating new detection systems are limited, making assessment of the new products difficult. Drawing from much experience in hazardous chemical vapor generation and detection, the Naval Research Laboratory's Chemistry Division has developed a comprehensive testbed for trace explosives vapor generation and assessment of sensor technology.[1]

A multidisciplinary team of scientists and engineers from the Chemistry Division came together to design and construct the state-of-the-art trace explosives detection testbed, shown in Fig. 4, which facilitates the development and evaluation of advanced trace explosives detection technologies. The testbed is a fully automated system using NRL-developed custom software that is controlled by a touch screen graphical user interface (GUI). Six sample ports are available for individual or multiple, simultaneous testing of novel sensors and materials. The testbed consists of SilcoNert™-treated stainless steel gas lines, a custom mixer, and a dual distribution manifold (see Fig. 5) enclosed in a custom oven, which can operate at temperatures up to 150 °C. The dual manifold was designed to permit rapid switching between clean air and the analyte sources, via computer-controlled actuators that drive custom feed-throughs to open and close all valves. All oven-enclosed components are bakeout-compatible, but the manifold may be easily exchanged with a duplicate manifold to prevent any possibility of cross contamination between different explosive analytes. The testbed employs a zero-grade air source with temperature and humidity control, and vapor generation systems for comprehensive testing of trace levels of explosives and potential interferents.

FIGURE 4
Advanced Trace Explosives Detection System Testbed with touch screen GUI.

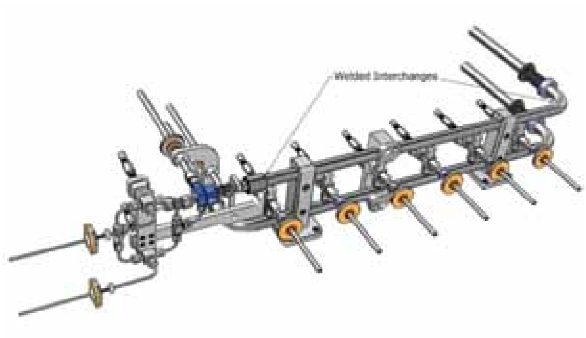

FIGURE 5
Dual manifold with six sample ports.

The touch screen interface allows a user to control and monitor all system components, enabling a wide variety of test conditions including different vapor concentrations, test mixtures, and test durations. Standard and custom test protocols are easily developed and implemented. The system was designed to enable the implementation of test protocols developed by any testbed-equipped laboratory, facilitating interagency sensor/material research collaborations and accelerating the validation of prototype commercial systems.

Custom sensor chambers, as shown in Fig. 6, were designed for evaluating materials and sensors. The Impactor Sample Chamber accommodates a variety of sensor types, directs the test vapor directly onto the sensor, and can be individually heated. An online verification system that uses a thermal desorption/gas chromatography/mass spectrometry/electron capture detector has also been incorporated into the testbed. The testbed was analytically characterized using both TNT and RDX for concentrations from parts per trillion (ppt) to parts per billion (ppb) in humid air from

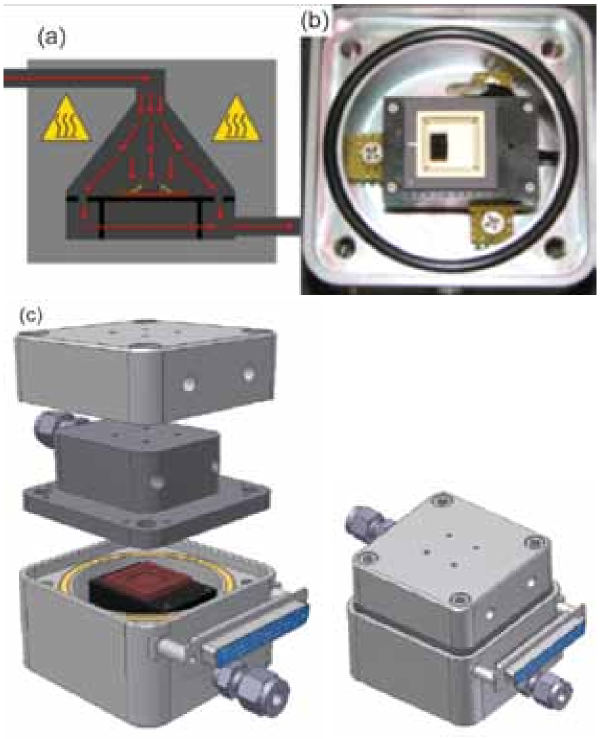

FIGURE 6
(a) Schematic of the Impactor Sample Chamber with the red arrows indicating the gas flow into the chamber, onto the sensor, and out to the exhaust. (b) A prototype sensor array mounted in a pin grid array and loaded into the Impactor Sample Chamber. Electrical connections to the device are made through the packaging and the zero insertion force (ZIF) socket (black). (c) Impactor Sample Chamber.

20% to 85% relative humidity (RH). Consistent results were observed at all six sample ports.

The NRL testbed is the only one of its kind in the world to provide quantitative results for explosive vapors over such a wide concentration range. NRL is using the testbed to evaluate sensor systems under development in the Chemistry Division. We expect to use the system to evaluate new materials and sensors being developed by DHS in the future. A second testbed was constructed and delivered to the Transportation Security Laboratory for evaluating new detection systems of interest to DHS. The concepts used for the DHS testbed were applied to the development of another testbed using large domes to provide uniform vapors over a large area for the evaluation of entire instruments or arrays of sensors. Both testbeds are now being expanded to include more threats and potential interferents. The Advanced Trace Explosives Detection System will allow DoD and DHS to assess technologies in a consistent manner, thus providing our troops and TSA personnel the best technologies to safeguard personnel and platforms.

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Reference

[1] "NRL/DHS/TSL Advanced Trace Explosive Detection Testbed, Operations Manual," NRL/PU/6180--10-544, Naval Research Laboratory, September 2010.