THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**CHEMICAL WARFARE AGENT DETECTOR**
APPLICATION:	**DETECTION OF TOXIC CHEMICALS AND CHEMICAL AGENTS IN INDOOR AIR**
TECHNOLOGY NAME:	**M90-D1-C**
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The U.S. Environmental Protection Agency (EPA) supports the Environmental Technology Verification (ETV) Program to facilitate the deployment of innovative or improved environmental technologies through performance verification and dissemination of information. The goal of the ETV Program is to further environmental protection by accelerating the acceptance and use of improved and cost-effective technologies. ETV seeks to achieve this goal by providing high-quality, peer-reviewed data on technology performance to those involved in the design, distribution, financing, permitting, purchase, and use of environmental technologies. Information and ETV documents are available at www.epa.gov/etv.

ETV works in partnership with recognized standards and testing organizations, with stakeholder groups (consisting of buyers, vendor organizations, and permitters), and with individual technology developers. The program evaluates the performance of innovative technologies by developing test plans that are responsive to the needs of stakeholders, conducting field or laboratory tests (as appropriate), collecting and analyzing data, and preparing peer-reviewed reports. All evaluations are conducted in accordance with rigorous quality assurance (QA) protocols to ensure that data of known and adequate quality are generated and that the results are defensible.

Subsequent to the terrorist attacks of September 11, 2001, this ETV approach has been applied to verify the performance of homeland security technologies. Monitoring and detection technologies for the protection of public buildings and other public spaces fall within the Safe Buildings Monitoring and Detection Technology Verification Program, which is funded by EPA and conducted by Battelle. In this program, Battelle recently evaluated the performance of the Environics USA Inc. M90-D1-C chemical warfare (CW) agent detector for detecting CW agents and toxic industrial chemicals (TICs). This verification statement, the full report on which it is based, and the test/QA plan for this verification are available through a link on the ETV Web site (www.epa.gov/etv/centers/center11.html).

VERIFICATION TEST DESCRIPTION

The objective of this verification test of the M90-D1-C, a commercially available detector, was to evaluate its ability to detect one TIC and two CW agents in indoor air. This verification focused on the scenario of a detector used by first responders to identify contaminants and guide emergency response activities after chemical contamination of a building. The following performance characteristics of the M90-D1-C were evaluated: response time, recovery time (i.e., the time to return to baseline after detection of a target chemical), identification accuracy, repeatability, response threshold, temperature and humidity effects, interference effects, cold-/hot-start behavior, battery life, and operational characteristics. Repeatability was assessed for the M90-D1-C responses, response times, and recovery times.

This verification test took place between August 6 and October 1, 2004. Response time, recovery time, accuracy, and repeatability were evaluated by challenging the M90-D1-C with known vapor concentrations of one target TIC and two CW agents. The M90-D1-C performance at low target analyte concentrations was evaluated to assess the response threshold. Similar tests conducted over a range of temperatures and relative humidities (RHs) were used to establish the effects of these factors on detection capabilities. The effects of potential interferences in an emergency situation were assessed by sampling selected interferences both with and without the target analytes present. The M90-D1-C was also tested with a nerve agent simulant after a cold start (i.e., without the usual warm-up period) from room temperature, from cold storage conditions (5°C), and from hot storage (40°C) to evaluate the delay time before readings could be obtained and the response and response speed of the M90-D1-C once readings were obtained. Battery life was determined as the time until the M90-D1-C performance degraded as battery power was exhausted, in continuous operation. Operational factors such as ease of use, data output, and cost were assessed by observations of the test personnel and through inquiries to the vendor. All testing was carried out on a single unit of the M90-D1-C. Environics chose to provide a single engineering unit for this test because Battelle's surety license decontamination requirements prevent returning the entire instrument after exposure to CW agents.

Testing was limited to detecting chemicals in the vapor phase because that mode of application was judged most relevant to use by first responders. Testing was conducted in two phases: detection of one TIC (conducted in a non-surety laboratory at Battelle) and detection of two CW agents (conducted in a certified surety laboratory at Battelle's Hazardous Materials Research Center). The TIC used in testing was hydrogen cyanide (HCN; North Atlantic Treaty Organization military designation AC). The CW agents were sarin (GB) (purity 85.1%) and sulfur mustard (HD) (purity 95.8%).

For relevance to use by first responders, most test procedures were conducted with challenge concentrations of the TIC or CW agent that were at or near immediately dangerous to life and health (IDLH) or similar levels. The table below summarizes the challenge concentrations used in testing. Response thresholds were tested by repeatedly stepping down in concentration.

QA oversight of verification testing was provided by independent Battelle QA staff, who conducted a technical systems audit, a performance evaluation audit, and a data quality audit of all the test data.

Target TIC and CW Agent Challenge Concentrations

Chemical	Concentrations	Type of Level
AC	50 parts per million (ppm) 50 milligrams per cubic meter (mg/m^3)	1 x IDLH
GB	0.13 ppm (0.75 mg/m^3)	4 x IDLH
HD	0.63 ppm (4.1 mg/m^3)	7 x AEGL-2[(a)]

[(a)] AEGL = Acute Exposure Guideline Level; AEGL-2 levels are those expected to produce a serious hindrance to efforts to escape in the general population. The AEGL-2 value of 0.09 ppm (0.6 mg/m^3) for HD is based on a 10-minute exposure.

TECHNOLOGY DESCRIPTION

The following description of the M90-D1-C was provided by the vendor and does not represent verified information.

The M90-D1-C is designed to detect and identify nerve, blister, blood, and choking agents using Environics' patented open-loop ion mobility spectrometry (IMS) technology to provide continuous, real-time operation without the need for expendable desiccant cartridges or membranes. The M90-D1-C is fully automatic and provides the operator with audible and visible alarms upon detecting CW agents. The M90-D1-C display identifies the agent class (Nerve, Blister, Blood), indicates the relative agent concentration (Low/Medium/High), and indicates whether the concentration is increasing or decreasing. This alarm information can be provided to a remote computer/control station through the data connector on the M90-D1-C. The M90-D1-C can be upgraded to detect new agents by changing data libraries. It is fully ruggedized to meet appropriate military standards.

The M90-D1-C is a multiapplication instrument, capable of operating as a point detector to provide an early warning of approaching toxic chemical gas or as a chemical agent monitor to identify and monitor personnel, vehicles, and equipment for contamination. The M90-D1-C is generally carried by people, but it can be installed on vehicles. It also can be used as a fixed detector, operating without constant supervision. Both local and distant alarms are provided, and the M90-D1-C can be used to automatically trigger closing down ventilation systems to secure buildings and positions from further agent contamination.

The M90-D1-C contains two sensor units: an aspiration-type IMS sensor and a semiconductor sensor. Simulant tubes are provided to check sensor performance. The M90-D1-C can operate from 115/240 volts alternating current, from batteries, or from vehicle power supplies. It weighs 4.7 kilograms (10 pounds, 6 ounces), and it is 28.0 centimeters (cm) (11.02 inches) long, 10.5 cm (4.12 inches) wide, and 28.0 cm (11.02 inches) high. The M90-D1-C is designed to operate in temperatures between -30°C and 55°C (-22°F and 131°F) and at RHs up to 99%. The M90-D1-C has a programmed initial startup delay of less than 10 minutes and not less than a 5-minute delay after power is recycled. It comes with a carrying case so that the M90-D1-C can be carried over the shoulder or as a front or rear backpack.

VERIFICATION OF PERFORMANCE

The performance of the M90-D1-C is summarized below. The M90-D1-C was tested with AC, HD, and GB. However, contrary to prior indications from the vendor, the M90-D1-C tested was not programmed to respond to AC. Also, it did not respond to HD, although it was programmed to do so and did respond to the vendor-supplied simulants. The vendor reported that the spectral signature produced by the M90-D1-C during the HD challenge did not match that programmed into the detector's library and suggested that the HD used may have been contaminated. However, the purity of the HD used in testing was 95.8%. M90-D1-C response to HD has been documented in previous government tests conducted for the Domestic Preparedness Program by Soldier and Biological Chemical Command. Because the M90-D1-C did not respond to HD, the results summarized below are for testing with GB only.

Response Time: For GB, the M90-D1-C response time was minimally affected by temperature or humidity, with response times usually 10 seconds or less. In six of 10 runs at the high temperature level (35°C), the M90-D1-C did not alarm for GB.

Recovery Time: The recovery times for GB were about 30 seconds in most cases, but exceeded 600 seconds for all runs at low temperature and medium humidity and for all runs at room temperature and high humidity.

Accuracy: The M90-D1-C identified GB accurately in most temperature and RH conditions and in all tests with interferents present. However, at the high temperature (35°C), the M90-D1-C did not respond to the presence of GB in six of 10 test runs, including all five runs at 35°C and 50% RH. Including these 10 runs, the overall

accuracy of identification was 91% (60/66) for GB. The M90-D1-C response at a given GB concentration was unaffected by a preceding higher or lower concentration.

Repeatability: Except for the absence of GB response in some tests at 35°C, as noted above, there was no evidence that variation in either temperature or humidity had an effect on repeatability of the M90-D1-C response or response time for GB. Data were insufficient to assess whether temperature had an effect on the repeatability of recovery time for GB.

Response Threshold: For GB, the M90-D1-C response threshold was between 0.05 and 0.1 mg/m^3 (0.008 and 0.017 ppm), which is below the IDLH concentration for GB of 0.2 mg/m^3 (0.035 ppm).

Temperature and Humidity Effects: Temperature had an effect on the M90-D1-C response to GB. As the temperature increased, with a 50% RH, the level of the response decreased. At the high temperature (35°C), the M90-D1-C unit gave a "Low" response or did not respond at all to the presence of GB. Humidity did not affect the M90-D1-C response to GB.

Interference Effects: Ammonia floor cleaner vapors and latex paint fumes consistently produced false positive alarms for GB when sampled by the M90-D1-C. However, none of the interferents had an effect on the response to GB when the agent and interferent were sampled together. Interferents did not significantly affect the response time or recovery time of the M90-D1-C in sampling GB. A decrease in recovery time was observed upon each successive run, with the shortest recovery time occurring in the last test run for four of the five interferents.

Cold-/Hot-Start Behavior: In the room temperature cold-start test using a nerve agent simulant, the delay time was 8 minutes and 17 seconds. In the cold temperature (5°C) cold-start test, the M90-D1-C produced a "Failure" alarm after 8 minutes and 17 seconds and never reached a ready state. After being powered off for 2 minutes, the delay time was 6 minutes and 20 seconds. For the hot temperature (40°C) cold-start test, the delay time was 8 minutes and 20 seconds. In all three tests, the M90-D1-C responded to the simulant as a "Low" nerve alarm.

Battery Life: The battery life test was conducted by powering on a fully charged nickel metal hydride (NiMH) battery pack and allowing the M90-D1-C to warm up fully, then operate continuously until battery power was depleted. The battery life test was conducted with a nerve agent simulant. The M90-D1-C responded to the simulant as a "Low" nerve alarm. At 1 hour and 47 minutes after start-up the "Low Battery" light came on, followed immediately by a "Failure" alarm. At this time, the M90-D1-C did not respond when challenged with the simulant.

Operational Characteristics: The M90-D1-C has two caps that must be removed for it to operate properly. The power/test switch has two options other than On/Off, which are to be used when testing the M90-D1-C with a simulant to ensure proper operation. The M90-D1-C also has a separate switch to control the volume of the audio alarm. The M90-D1-C has several lighted indicators (Nerve, Blister, Blood, High, Med, Low, Low Batt, Failure, and Power Mode) to show the status of the detector and took 8 minutes or more to reach a ready state after being turned on. It can operate on two types of rechargeable batteries (NiMH and nickel cadmium) and two types of one-time-use batteries (lithium and magnesium). The M90-D1-C produced only one "Failure" alarm during testing, i.e., that during the cold temperature cold-start test noted above.

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