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DOMESTIC PREPAREDNESS PROGRAM: TESTING OF THE CAM -CHEMICAL AGENT MONITOR (Type L) AGAINST CHEMICAL WARFARE AGENTS SUMMARY REPORT

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This report characterizes the chemical warfare (CW) agent detection potential of the commercially available CAM Chemical Agent Monitor (Type L). This instrument was tested against HD, GB and GA vapor at various conditions. This report is intended to provide the emergency responders concerned with CW agent detection an overview of the detection capabilities of these instruments.

14. SUBJECT TERMS

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PREFACE

The work described herein was authorized under the Expert Assistance (Equipment Test) Program for the U.S. Army Soldier and Biological Chemical Command (SBCCOM) Program Director for Domestic Preparedness. This work began in January 2000 and was completed in August 2000.

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DOMESTIC PREPAREDNESS PROGRAM: TESTING OF THE CAM – CHEMICAL AGENT MONITOR (Type L) AGAINST CHEMICAL WARFARE AGENTS SUMMARY REPORT

1. INTRODUCTION

The Department of Defense (DOD) formed the Domestic Preparedness (DP) Program in 1996 in response to Public Law 104-201. One of the objectives is to enhance federal, state and local capabilities to respond to Nuclear, Biological and Chemical (NBC) terrorism incidents. Emergency responders who encounter a contaminated or potentially contaminated area must survey the area for the presence of toxic or explosive vapors. Presently, the vapor detectors commonly used are not designed to detect and identify chemical warfare (CW) agents. Little data are available concerning the capability of the commonly used, commercially available detection devices to detect CW agents. Under the Domestic Preparedness (DP) Expert Assistance (Test Equipment) Program, the U.S. Army Soldier and Biological Chemical Command (SBCCOM) established a program to address this need. The Applied Chemistry Team (ACT), formerly known as the Design Evaluation Laboratory (DEL), at Aberdeen Proving Ground, Edgewood, Maryland, performed the detector testing. ACT is tasked with providing the necessary information to aid authorities in the selection of detection equipment applicable to their needs.

Several instruments were evaluated and reported during Phase 1 testing in 1998 and Phase 2 testing in 1999. Phase 3 continues the evaluation of available detectors, including the CAM (Type L) from Graseby Dynamics Ltd., reported herein. In addition, Phase 3 evaluations include the SABRE 2000 from Barringer Technologies, Inc., the ppbRAE Photo-Ionization Detector from RAE Systems, the SAW MiniCAD from MicroSensor Systems, Inc., and the UC AP2C Detector from Proengin, which will be reported separately.

2. OBJECTIVE

The objective of this test is to assess the capability and general characteristics of the CAM Chemical Agent Monitor (Type L) to detect chemical warfare agent vapors. The intent is to provide emergency responders concerned with CW agent detection an overview of the detection capabilities of this instrument.

3. SCOPE

This evaluation attempts to characterize the CW agent detection capability of the CAM (Type L). Due to time and resource limitations, the investigation is only concerned with testing against Tabun (GA), Sarin (GB), and Mustard (HD). These representative CW agents are believed to be the most likely threats. Test procedures follow the established Domestic

Preparedness Detector Test and Evaluation Protocol developed in the Phase 1 Test Report[1]. The test concept was as follows:

a. Determine the Minimum Detectable Level (MDL), which is the lowest concentration level where repeatable detection readings are achieved for each CW agent tested. The military Joint Services Operational Requirements (JSOR)[2] served as a guide for detection sensitivity objectives.

b. Investigate the humidity and temperature effects on detector response.

c. Observe the effects of potential interfering vapors upon detector performance in both the laboratory and the field.

4. DETECTOR DESCRIPTION

Graseby Dynamics (http://www.grasebydynamics.com/cam.htm), Herts, UK or Fairfax, VA, USA, is the manufacturer of the CAM - Chemical Agent Monitor (Type L). Two units were loaned to the Domestic Preparedness program for inclusion in the detector evaluations. These units were randomly labeled A and B.

The instrument is a lightweight, hand-held point detector that is capable of detecting nerve or blister agents. The detector is easy to use with a simple on/off switch and a mode button to switch from blister to nerve agent detection. The Operator's Manual[3] gives the CAM temperature performance range from -25°C to +45°C. The unit weighs 1.9 kg including the 6V Lithium-Sulfur Dioxide (Li/SO2) battery. The detector can also operate from external 12 Volt DC power sources. When used with a power supply it operates continuously, and no daily servicing is required. Therefore, during the evaluation, 110 Volt AC adapters were used to ensure that the detector performance would not be affected by poor battery condition.

There are several variants of the Chemical Agent Monitor (CAM) due to continuous product improvements including software enhancements to increase the range of agents detected. The Type L version is the standard CAM production unit incorporating the CAM2 hardware with the enhanced CAMplus software. Figure 1 is a digital image of the CAM Type L detector.

The CAM has two operating modes. The G mode monitors for nerve agents (e.g. GA and GB) and the H mode monitors for blister agents (e.g. HD). It should be noted that the CAM is not capable of simultaneous detection of both H and G agents. The appropriate mode must be manually selected before use. However, switching between modes only takes seconds unless the detector has been grossly contaminated. The selected mode is shown on the liquid crystal display (LCD).

If the battery is low, a BL will appear on the display. There is also a 'WAIT' message that appears on the display when the unit is warming up or not yet ready for normal operation. During normal operation, sample air is drawn into the unit through the nozzle at a sampling rate of 400 milliliters per minute. Replacement nozzle filters are provided to prevent the nozzle assembly from becoming contaminated with liquid or dust.

Figure 1. CAM Type L

The CAM employs ion mobility spectrometry (IMS) detection techniques. Molecules of a sample are ionized by a 10-millicurie Ni^{63} beta radiation source. The ions are classified according to their mobility relative to an on-board dopant vapor source. The hazard level is assessed by a microcomputer, and the liquid crystal display (LCD) indicates the detection response accordingly by an increasing number of lighted bars. Up to eight bars can be lit according to the degree of "hazard" detected. The first three bars indicate low concentration, bars 4-6 indicate high concentration, and 7 to 8 bars indicate very high concentration.

5. TEST PROCEDURE

5.1 CALIBRATION

Operating procedures were followed according to the CAM (Type L) Operator's Manual. No formal instrument calibration is required to place the CAM into operation. The detector undergoes a self-test procedure when powered on with the nozzle protective cap in place. This nozzle protective cap ensures that only clean air is sampled during this initialization. The unit is usually ready for use within 60 seconds.

There is a "confidence sampler" provided with the detector to verify detection performance. The confidence sampler is clearly marked at each end with a G (for nerve simulant) or an H (for blister simulant). The instruments are exposed to each of the simulants for a qualitative indication of functionality. During the confidence check, a response of several bars will occur within seconds when exposed to the respective simulant for the selected mode.

5.2 AGENT CHALLENGE

The agent challenges were conducted using the Multi-Purpose Chemical Agent Vapor Generation System[4] with Chemical Agent Standard Analytical Reference Material (CASARM) grade CW agents where available. Agent testing followed successful instrument start up and confidence check. The vapor generator system permits testing of the instrument with humidity and temperature-conditioned air without agent vapor to assure the background air does not interfere before challenging it with similarly conditioned air containing the CW agent vapor. With the instrument's inlet placed under the cup-like sampling port of the vapor generator, the CAM unit is exposed to the conditioned air for approximately one minute to establish a stable background and ensure that the instrument does not exhibit undesired responses to the air.

Agent challenge began when the solenoids of the vapor generation system were energized to switch the air streams from conditioned air only to similarly conditioned air containing the agent. Each detector was tested three times under each condition. The elapsed time that the detector was exposed to the agent vapor until it produces the intended "number of bars" signal was recorded as the response time. For the purpose of this evaluation, exposure times were extended to two minutes in order to observe the maximum signal achieved for that condition. The time required after agent exposures until the displayed bars cleared was recorded as the recovery time.

The detectors were each tested with the agents GA, GB and HD at varying concentration levels at ambient temperatures (20^{o}C to 24^{o}C) at 50% relative humidity to determine the minimum detectable level (MDL). In addition, the detectors were tested at relative humidity conditions of <10% and 90%, and at temperature extremes of –25°C for GA and GB, 0°C for HD, and +40°C for HD, GA and GB agents to observe temperature and humidity effects. Temperature extremes were based on the manufacturer's stated operating range using agent concentrations that approximated the MDL. HD could not be tested below 0°C due to physical property limitations. Although HD freezes at approximately +15°C, the calculated HD volatility of 92 mg/m^3 at 0°C easily produces a vapor concentration that is considered potentially hazardous.

5.3 AGENT VAPOR QUANTIFICATION

The generated agent vapor concentrations were analyzed independently and reported in mg/m^3, as well as in parts-per-million (ppm) units in the results tables. The vapor concentration was quantified by utilizing the manual sample collection methodology[5] using the Miniature Continuous Air Monitoring System (MINICAMS®) manufactured by O. I. Analytical, Inc., Birmingham, Alabama. The MINICAMS® is equipped with a flame photometric detector (FPD), and it was operated in phosphorus mode for the G agents and sulfur mode for HD.

This system normally monitors air by collection through sample lines and subsequently adsorbing the CW agent onto the solid sorbent contained in a glass tube referred to as the pre-concentrator tube (PCT). The PCT is located after the MINICAMS® inlet. Then the concentrated sample is periodically heat desorbed into a gas chromatographic capillary column for subsequent separation, identification, and quantification.

For manual sample collection, the PCT was removed from the MINICAMS® during its sampling cycle and connected to a measured suction source to draw the vapor sample from the agent generator. The PCT was then re-inserted into the MINICAMS® for analysis. This "manual sample collection" methodology eliminates potential loss of sample along the sampling lines and the inlet assembly when the MINICAMS® is used as an analytical instrument. The MINICAMS® was calibrated daily using the appropriate standards for the agent of interest. The measured mass equivalent (derived from the MINICAMS chromatogram) divided by the total volume (flow rate multiplied by time) of the vapor sample drawn through the PCT produces the sample concentration that converts into number of mg/m^3.

5.4 FIELD INTERFERENCE TESTS

After the sensitivity tests, the units were tested outdoors in the presence of common potential interferents such as the vapors from gasoline, diesel fuel, jet propulsion fuel (JP8), kerosene, Aqueous Film Forming Foam (AFFF, used for fire fighting), household chlorine bleach and insect repellent. Vapor from a 10% HTH slurry (a chlorinating decontaminant for CW agents), engine exhausts, burning fuels and other burning materials were also tested. CW agents vapors were not present in these tests.

The field tests were conducted outdoors at M-Field of the Edgewood Area of Aberdeen Proving Ground in August 2000. These experiments involved open containers, truck engine exhausts, and fires producing smoke plumes, which were sampled by the detectors at various distances downwind. The detectors were placed subjectively at distances based on wind speeds and the nature of dissemination of the interferent to achieve moderate exposures to the potential interferent (e.g. 0.5-2 meters for vapors and 2-5 meters for smokes). The objective was to assess the ability of the instruments to withstand outdoor environments and to resist responding when exposed to the selected substances.

A confidence check was performed on each detector at the beginning of each testing day to assure detector sensitivity. The external nozzle filters were used during the field tests as recommended by the manufacturer. The CAM units were exposed to each interferent for three trials of up to three minutes exposure per trial with approximately five minutes recovery time between trials. If a detector showed a large signal, it was removed from the area immediately to prevent gross contamination of the unit. Confidence sample checks were conducted periodically throughout the day.

5.5 LABORATORY INTERFERENCE TESTS

The laboratory interference tests were designed to assess the effect on the detectors of vapor exposure from potential interfering substances in a controlled environment, without the presence of CW agent. The substances were chosen based on the likelihood of their presence during an emergency response by first responders. Additionally, laboratory interference tests were conducted to assess the detection of CW agent in the presence of two of the vapors (vapor from diesel fuel and AFFF).

The units were tested against 1% of the ambient headspace concentrations of vapors of gasoline, JP8, diesel fuel, household chlorine bleach, floor wax, AFFF, Spray 9 cleaner, Windex, toluene and vinegar. They were also tested against 25 ppm NH_3 (ammonia). If the instrument showed responses at these 1% saturation concentrations, it was tested at the 0.1% concentration of the interferent. A dry air stream carries the headspace vapor of the substance by sweeping it over the liquid in a tube or through the liquid in a bubbler to prepare the interferent gas mixture. Thirty milliliters/minute or three milliliters/minute of this vapor saturated air was then diluted to three liters/minute with the conditioned air at 23°C and 50% RH to produce the 1% or 0.1% concentration of interferent test mixture, respectively. The 25 ppm ammonia was derived by proper dilution of the 1% NH_3 vapor (10,000ppm) from an analyzed compressed gas cylinder with the appropriate amount of the conditioned air.

For the tests that included CW agent, the interferent test gas mixture was prepared similarly. The resultant stream of three liters/minute of CW agent concentration was used as the dilution stream to blend in with the 3 or 30 milliliter per minute of the substance vapor to obtain the desired 0.1 or 1% mixture of the substance vapor in the presence of CW agent concentration. The two units were tested three times with each agent/interferent combination.

6. TEST RESULTS

6.1 MINIMUM DETECTABLE LEVELS

The minimum detectable level (MDL) for the two CAM units tested are shown in Table 1 for each agent at ambient temperatures and 50% RH. The MDL values were recorded at the lowest CW agent concentration exposure that consistently produced a three bar response. The two units were consistent in their responses. Although one or two bar response indicated a detection, the three bar response level was chosen as the MDL for “alarm” because that is the level set for detection alarm on similar type of detection devices such as the current military Automatic Chemical Agent Detector Alarm (ACADA).

The current military requirements for CW agent detection are also listed in Table 1 as references to compare the detector’s performance. The Joint Service Operational Requirements (JSOR) for CW agent sensitivity for point detection alarms, the Army’s current established values for Immediate Danger to Life or Health (IDLH), and the Airborne Exposure Limit (AEL) are the current military requirements. Army Regulation (AR) 385-61 provides IDLH and AEL values for GA and GB, and an AEL value for HD. Army regulation AR 385-61 does not establish an IDLH for HD due to concerns over carcinogenicity.

The CAM units detected GA and GB at concentrations between the JSOR and IDLH levels. HD was detected at a concentration approximately 10 times lower than the JSOR level in 4-5 seconds. Lower MDL represents better detection sensitivity. Neither unit was able to respond down to the current AEL values for GA, GB or HD.

Table 1. Minimum Detectable Level (MDL) at 3 Bar Response from CAM Type L , Ambient Temperatures and 50% Relative Humidity

AGENT	Concentration in mg/m^3, (ppm) and Response Times			
	CAM Type L MDL	JSOR*	IDLH**	AEL***
HD	0.16 (0.024) in 4-5 seconds	2.00 (0.300) in 120 seconds	N/A	0.003 (0.0005) up to 8 hours
GA	0.11 (0.016) in 23-93 seconds	0.10 (0.015) in 30 seconds	0.20 (0.03) up to 30 minutes	0.0001 (0.000015) up to 8 hours
GB	0.15 (0.026) in 20-40 seconds	0.10 (0.017) in 30 seconds	0.20 (0.03) up to 30 minutes	0.0001 (0.000017) up to 8 hours

* Joint Service Operational Requirements for detectors.
** Immediate Danger to Life or Health values from AR 385-61 to determine level of CW protection. Personnel must wear full ensemble with SCBA for operations or full face piece respirator for escape.
*** Airborne Exposure Limit values from AR 385-61 to determine masking requirements. Personnel can operate for up to 8 hours unmasked.

6.2 TEMPERATURE AND HUMIDITY EFFECTS

Tables 2, 3 and 4 list the range of response of the two units at various test conditions for HD, GA and GB, respectively. The CAM detectors successfully demonstrated CW agent detection at different temperature and humidity conditions. The results show the number of bars observed and response time at several concentrations for each evaluated condition. The units showed faster response times, an increase in the number of bars displayed, and longer recovery time as the agent concentrations were increased. Exposure times were extended an extra one to three minutes to assure the response was the maximum bar response achievable for that concentration level. Table 2 shows the CAM units displayed a three bar response for HD in less than 10 seconds in all cases except in 90% RH. Humidity affected the HD detection sensitivity by requiring longer response times and a higher concentration for a three bar alarm. For example, the units produced a three bar response at a concentration of 0.03 mg/m^3 at 10% RH but required a higher concentration of 0.40 mg/m^3 for a similar response at 90% RH. Most recovery times were less than 30 seconds, however at concentrations higher than 1.0 mg/ m^3 the recovery time was between 30 and 90 seconds.

Table 2. CAM Type L Responses to HD Vapor Concentrations at Various Temperatures and Relative Humidity Conditions

Conditions		HD Concentration		CAM Type L	
Temperature °C	% RH	mg/m³	Ppm	Bar Response	Response Time (seconds)
20-22	<10	**0.01**	0.002	1	60-69
20-22	<10	**0.02**	0.003	2	61-72
20-22	<10	**0.03**	0.005	2-4	6-87
20-22	<10	**0.05**	0.007	3	6-7
20-22	<10	**0.06**	0.009	3-4	5-8
20-22	<10	**0.11**	0.016	4	3-5
20-22	<10	**1.70**	0.257	7-8	1-3
20-22	<10	**5.40**	0.817	8	1-2
20-22	<10	**11.00**	1.663	8	1-2
20-22	50	**0.03**	0.005	No Response	No Response
20-22	50	**0.07**	0.011	1-3	7-30
20-22	50	**0.10**	0.015	2-3	8-37*
20-22	50	**0.16**	0.024	3-4	4-5
20-22	90	**0.08**	0.012	1**	62-63
20-22	90	**0.15**	0.023	1-2	62-72
20-22	90	**0.40**	0.061	2-3	11-58
0	0	**0.01**	0.001	1-2	17-26
0	0	**0.04**	0.006	3-4	5-7
0	0	**0.60**	0.089	5-6	2-3
40	<10	**0.01**	0.002	1***	17-22
40	<10	**0.09**	0.015	2-4	4-14
40	<10	**0.75**	0.121	6-7	2

*Unit B required 174 seconds to alarm for one of the three trials.
**Unit A only, Unit B showed no bars at this condition.
***Unit B only, Unit A showed no bars at this condition.

Table 3 shows the CAM units displayed a three bar response for GA in less than 120 seconds in all cases except cold temperatures. At –25°C, GA detection required longer response times and up to seven minutes recovery time. Recovery times for GA concentrations less than 5 mg/m^3 were between 10 and 120 seconds. At the higher concentrations tested, two to eight minutes was required for recovery after agent exposure.

Table 3. CAM Type L Responses to GA Vapor Concentrations at Various Temperatures and Relative Humidity Conditions

Conditions		GA Concentration		CAM Type L	
Temperature °C	%RH	mg/m^3	ppm	Bar Response	Response Time (seconds)
20-24	<10	**0.02**	0.003	1	34-154
20-24	<10	**0.04**	0.006	1	17-38
20-24	<10	**0.06**	0.009	1	11-19
20-24	<10	**0.10**	0.015	3	21-167*
20-24	<10	**0.32**	0.048	3	11-40
20-24	<10	**5.00**	0.741	4-6	1-8
20-24	<10	**9.35**	1.405	6-8	9-51
22-24	50	**0.02**	0.003	1**	43-64
22-24	50	**0.04**	0.006	1	11-26
22-24	50	**0.08**	0.012	1-2	14-35
22-24	50	**0.11**	0.016	3	23-93
22-24	90	**0.03**	0.005	1	16-28
22-24	90	**0.10**	0.015	2-3	30-90
-25	<10	**0.01**	0.001	1	55-222
-25	<10	**0.03**	0.003	1-2	54-349
-25	<10	**0.09**	0.011	3	99-114
40	<10	**0.44**	0.070	3-4	5-8

*Unit A was flashing a 3 bar alarm on and off before 2 minutes.
**Unit B only, Unit A gave no alarm for this trial.

Table 4 shows the CAM units displayed a three bar response in less than 90 seconds in all cases except Unit A at high temperature (40°C). At 40°C, Unit A would not respond with more than one bar at 0.13 mg/m^3 even after a 3 minute GB exposure. Humidity did not have an appreciable affect on GB detection sensitivity. Cold temperature, however, required the longest response time, up to 89 seconds, and a longer recovery time, up to five minutes. As expected, higher agent concentrations produced faster responses with an increase in the number of bars displayed, and required a longer time to recover. Most recovery times after GB exposure were between 45 and 120 seconds up to about 9 mg/m^3. At this higher concentration, recovery time was between 4-1/2 and 18 minutes with one bar remaining on the display. Recovery times were faster after HD exposures than after GA and GB, in general.

Table 4. CAM Type L Responses to GB Vapor Concentrations

Conditions		GB Concentration		CAM Type L	
Temperature °C	% RH	mg/m^3	Ppm	Bar Response	Response Time (seconds)
20-24	<10	**0.02**	0.003	1	17-36
20-24	<10	**0.06**	0.010	1-2	9-46
20-24	<10	**0.15**	0.026	3	20-80
20-24	<10	**3.06**	0.533	5	3
20-24	<10	**8.00**	1.315	5-7	3-11
20-24	50	**0.06**	0.010	1-2	12-21
20-24	50	**0.15**	0.026	3-4	20-40
20-24	50	**9.00**	1.592	5-7	5-8
20-24	90	**0.08**	0.014	1-2	10-66
20-24	90	**0.13**	0.022	3	10-36
-25	0	**0.01**	0.001	1	27-190
-25	0	**0.07**	0.010	3	34-89
40	<10	**0.13**	0.018	1-3*	13-19

*Unit A showed 1 bar response even with an exposure of three minutes. Unit B showed 3 bar response for all trials at this condition.

6.3 FIELD INTERFERENCES

The results of the interferent exposures are presented in Table 5. Bar response means the unit showed "agent" detection response of one or more bars in the absence of CW agent producing a "false" agent detection response when challenged with potential interferent substances. Upon responding to an interferent, the unit was immediately removed from the area to prevent over contamination of the unit.

The ambient temperature and relative humidity levels during these tests were in the range of 27-32°C and 45-80% RH, with gentle wind. The units were fitted with the filtered nozzle standoff pieces as recommended by the manufacturer to curtail contamination from the uncontrolled outside environment and the interferents. The two CAM units were evaluated with one unit in G mode and the other in H mode. The mode selection was at random and switched throughout the field tests. Each unit was exposed for three trials to every interferent listed except for the doused wood fire smoke, where the units could only be exposed once after dousing the fire. The units showed proper response on confidence checks between tests.

Table 5. CAM Type L Field Interference Testing Summary for Units A and B

Interferent	H Mode (Alarms/Trials)	H Mode Bar Response	G Mode (Alarms/Trials)	G Mode Bar Response
Gasoline Exhaust, Idle	1/3	1 bar	0/3	No response
Gasoline Exhaust, Revved	0/3	No response	1/3	1 bar flashed
Diesel Exhaust, Revved	3/3	3-4 bars	3/3	3 bars
Gasoline Vapor	0/3	No response	0/3	No response
Diesel Vapor	0/3	No response	0/3	No response
JP8 Vapor	0/3	No response	3/3	2-3 bars
Kerosene Vapor	0/3	No response	0/3	No response
AFFF Vapor	0/3	No response	3/3	4-5 bars
Bleach Vapor	2/3	2 bars	0/3	No response
Insect Repellent	0/3	No response	3/3	3-4 bars
HTH Vapor	0/3	No response	0/3	No response
Burning Gasoline Smoke	0/3	No response	1/3	1 bar
Burning JP8 Smoke	0/3	No response	1/3	1 bar
Burning Kerosene smoke	0/3	No response	0/3	No response
Burning Diesel Smoke*	2/3	1-3 bars	3/3	1-3 bars
Burning Cardboard Smoke	3/3	1-3 bars	3/3	1-4 bars
Burning Cloth Smoke	3/3	4-6 bars	3/3	1-3 bars
Burning Wood Fire Smoke	3/3	4-10 bars	3/3	4 bars
Doused Wood Fire Smoke**	1/1	4 bars	1/1	4 bars
Burning Tire Smoke	3/3	2-4 bars	3/3	3-8 bars
TOTALS (False Alarms/Trials)	21/58		31/58	

* Testing in heavy diesel smoke caused both units to exhibit HD and G alarms simultaneously.
**Only exposed once each to the doused wood fire.

Both CAM units showed false responses for all trials against the revved diesel exhaust, burning cardboard smoke, burning cloth smoke, burning wood fire smoke, and burning tire smoke indicating interference in H and G mode. In addition, false nerve agent detection response occurred for all three trials in G mode for JP8 vapor, AFFF vapor, insect repellent and burning diesel smoke. In H mode, 1 out of 3 trials produced a false alarm for gasoline exhaust (revved and idle) and burning diesel smoke. Two out of 3 trials resulted in false blister responses for bleach vapor exposures. One out of 3 trials false nerve agent response for burning gasoline smoke and burning JP8 smoke. Only 1 trial each could be accomplished for the doused fire smoke and both CAM units showed large responses in both the G and H modes during that exposure. The false response rates are calculated as 36% for H mode (21 responses out of 58 trials) and 53% for G mode (31 responses out of 58 trials). False responses mean an "agent" response occurred when no agent was involved in these tests.

Post field test responses against known HD and GA challenges in the laboratory showed the CAM units to have no adverse residual effects from the field tests. The units responded to the agent challenges with similar response levels and response times as when tested at similar pre-field test conditions.

6.4 LABORATORY INTERFERENCE TESTS

Table 6 presents the results of testing the detectors with conditioned air containing GB or HD in the presence of diesel fuel vapor or AFFF vapor. The tests were completed at ambient temperatures (22-23° C) and 50% RH. Both CAM units were able to detect HD and GB in the presence of 1% diesel vapor and detect HD in the presence of 1% AFFF with similar response levels and times as when the interferents were not present. However, 1% AFFF vapor produced false positive response in the G mode prohibited testing of the unit against GB. Therefore, the AFFF concentration was reduced to the 0.1% level where the CAM showed no response. The CAM was able to detect the 0.11 mg/m^3 GB satisfactorily.

Table 6. Results of Laboratory Interference Tests with Agents

Agent	Substance	Concentration		CAM Alarm Response	
		mg/m^3	ppm	Bars	Seconds
GB	1% AFFF	0.11	0.019	Not Applicable*	Not Applicable*
	0.1% AFFF	0.11	0.019	2-3	15-42
	1% Diesel	0.19	0.033	3	14-48
HD	1% AFFF	0.06	0.009	3	9-14
	1% Diesel	0.07	0.010	3	9-12

*Units showed 1-3 bars response against 1% AFFF, therefore could not be evaluated for AFFF plus GB.

Laboratory evaluations to determine if other potential interferent vapors would cause the instrument to show false agent responses are summarized in Table 7. These tests did not include use of CW agent and were conducted at ambient temperature and 50% RH. If a bar response occurred for the substance at the 1% saturation level, the concentration was reduced to 0.1%

saturation and tested again. CAM unit A was tested in the H mode and unit B was tested in the G mode.

Table 7. Results of Laboratory Interference Tests Without Agents

Substance	Unit A in H Mode		Unit B in G mode	
	1%	0.1%	1%	0.1%
AFFF	No Response	Not Tested	1-3 bars	No Response
Bleach	No Response	Not Tested	No Response	Not Tested
Diesel	No Response	Not Tested	No Response	Not Tested
Floor Wax	No Response	Not Tested	2 bars	Not Tested
Gasoline	No Response	No Response	3 bars	No Response
JP8	No Response	Not Tested	3-4 bars	Not Tested
Spray 9	No Response	No Response	4-5 bars	3 bars
Toluene	No Response	Not Tested	No Response	Not Tested
Vinegar	4-8 bars	3 bars	No Response	No Response
Windex	No Response	No Response	6 bars	1 bar
Ammonia (25ppm)	No Response	Not Tested	2-3 bars	Not Tested

Unit A, in H-mode, false alarmed for 1 out of 11 substances tested at the 1% concentration level. Response occurred for vinegar at both the 1% and the 0.1% saturation levels. Other substances that did not cause false alarms at the 1% level were either not tested or did not respond at the 0.1% level.

Unit B, operated in the G-Mode, gave response on seven of the 11 tests at the 1% saturation level. Spray 9 and Windex continued to produce detection responses when concentrations were lowered to the 0.1% concentration level. Gasoline showed no response at the reduced 0.1% level. Unfortunately, three of the substances that showed responses at the 1% testing in the G mode missed the 0.1% retesting.

Although bleach caused false agent responses during the field trials, bleach at the 1% saturation concentration tested in the laboratory did not produce any false detection response.

7. CONCLUSIONS

Conclusions are based solely on the results observed during this testing. Aspects of the detectors, other than those described in the scope, were not investigated.

Civilian first responders and HAZMAT personnel use Immediate Danger to Life or Health (IDLH) values to select levels of protection during consequence management of an incident. The CAM Type L units tested have demonstrated CW agent vapor detection for HD, GA and GB. The threshold sensitivity is better than the current JSOR sensitivity requirements for HD detection and approximates the JSOR and IDHL values for GA and GB at all conditions tested. The instrument cannot detect at the AEL concentration levels.

The instruments can detect the CW agents over a wide range of humidity and temperature conditions. Humidity appears to have slightly reduced HD detection sensitivity but does not affect GA and GB detection sensitivity. Both CAM units behaved similarly at all conditions tested.

The controlled laboratory environment tests with potential interferent substance vapors showed the CAM unit in H mode only falsely responded to 1% and 0.1% saturation of vinegar vapor. However, the CAM unit in G mode falsely responded to more than 50% of the substances tested at 1% saturation levels.

The field interferent testing showed false agent responses to engine exhausts, smoky environments, and vapors for 65% of the interferents tested in G mode and 45% of the interferents tested in H mode.

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