APPENDIX H

SPECIAL INVESTIGATION UNIT STAFF SUMMARY ON THE FOX VEHICLE

THE FOX VEHICLE

The XM93 Nuclear Biological and Chemical (NBC) Reconnaissance Vehicle (the FOX) was utilized during Operation Desert Storm because, "These vehicles were dedicated systems of NBC detection, warning, and sampling equipment integrated into a high speed, high mobility, wheeled, armored carrier capable of performing NBC reconnaissance on primary, secondary, or cross-country routes." [U.S. Army Field Manual 3-10-2, Chapter 2, 10 August 1994] However, its actual performance did not prove to be what was anticipated since the desert conditions found in the Persian Gulf War (PGW) were not those in which the FOX was originally designed to operate (the roads and firm terrain of Europe). Further complicating its use was the fact that the training provided to the American operators was not thorough enough to enable them to develop the expertise necessary to utilize the FOX capabilities to its maximum. "The number of hours of instruction on the MM1 [the mobile mass spectrometer] taught by German instructors varied and no certification exam was administered."[Report from Bruker Analytical Systems, Inc., Subject: Analysis of MM-1 Data for Sarin False Alarm and CS Identification, October 2, 1996, pp 2-3]

The FOX vehicles were designed to provide an initial alerting mechanism to warn personnel of possible ground contamination (solid or liquid) by dangerous chemicals, and to confirm this presence by means of the MM-1, found on-board the FOX. The MM-1 is capable of operating in two modes (the AIR MONITOR MODE and the SURFACE MONITOR MODE), each with multiple methods of operation utilizing the two-wheel surface samplers extending behind the vehicle.

In the AIR MONITOR MODE, the MM-1 is continuously monitoring for chemical agents until the operator starts a more specific analysis (e.g. performing a series spectrum which analyzes each substance). The MM-1 initially searches for a fingerprint of 4 ions for each compound selected by the operator from the MM-1 data bank at the beginning of the inspection cycle. While the AIR/HI method results in high sensitivity and rapid response, the single spectra method that is initially employed only analyzes the compound with the highest concentration in the sampling probe. Any analysis requires a complete spectrum of all ions present before a verification can be achieved. However, the temperature of the probe must be at its low setting (120 degrees C.) to allow the MM-1 to provide a more accurate reading of the compound's ions because this temperature allows for optimum separation of multiple chemical components, thus allowing the presence of any one compound to be verified. The use of the MM-1's probe in the AIR/HI method was intended to "sniff" vapors of an agent *whose identity was already confirmed* and thus establish the boundaries of its presence. "This is one reason why ANY alarm must be verified by the FULL SPECTRUM [series spectrum] even though the spectrum will not be as fast to alarm."[1] (emphasis original)

The SURFACE MONITOR MODE performs one cycle of several measurements before it is repeated again by the operator. This mode takes almost twice the time of the AIR MONITOR MODE and is significantly more complex to operate and analyze. Accordingly, because of time constraints (both in the class room in 1990 and under the expected battlefield conditions), it was decided by the U.S. Army Training and Doctrine Command that the AIR

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MONITOR MODE would be the only mode authorized for use by U.S. FOX crews during the Gulf War. "However, US operators were not trained to perform series spectrums ..."[2] This was an omission that would prove to be critical when various chemical alarms occurred that were not verified to be a hazardous agent.

In addition, the experts in the FOX system performance and capabilities at the U.S. Army's Chemical and Biological Defense Command, Edgewood, Maryland, noted that the MM-1 is approximately 500 times less sensitive to nerve agent vapors than the M43A1.[3]
The M43A1 is a fixed point nerve agent detector that is combined with the M42 alarm to form the M8A1 Automatic Chemical Agent Alarm.

The following narrative addresses those reported occasions in the PGW that were able to record the actual circumstances and the related extent of participation by the FOX vehicle.

THE U.S.MARINE BREACHING OPERATIONS

The Marines were required to breach two minefields stretching across southern Kuwait fully expecting to encounter some sort of
chemical warfare (CW) from Iraq. "If anyone suspected a chemical incident, they were directed to call a FOX reconnaissance vehicle to check out the area."[4] This aspect could only occur after three events preceded it; (1) locating the leading edge of the agent, (2) clearing the lanes with explosive line charges, and (3) confirming the clearing by sending through armored equipment set out with plows, rakes, or rollers. Moreover, in this operation, the FOX was used only for on-the-move vapor detection because of the anticipated inability to stop while under fire long enough to perform a spectrum analysis. In fact, in this operation, the alarm indication on the MM-1 screen was thought to have been generated by the FOX sampling wheels going through an area that was dirty with pools of oil and residue in the sand. Essentially creating a false positive, "...becausethe Fox reconnaissance vehicle may incorrectly alert to a chemical warfare agent in an environment of heavy concentrations of petroleum-based hydrocarbons."[5]

However, as stated by the FOX operator going through the first minefield lane, there was no

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[2] Information Paper, The Fox NBC Reconnaissance Vehicle, OSAGWI, JULY 29, 1997, FN 9.

[3] Ibid, p. 3 of 13.

[4] Case Narrative, US Marine Corps Minefield Breaching, OSAGWI, July 29, 1997, p.8.

[5] Ibid, FN 56, p.18.

artillery attack.[6] In addition, the operations plan (OPLAN) provided three waiting areas before reaching the minefields that could have been utilized by the moving forces as necessary. Therefore, one may conclude when the MM-1 alarmed nothing prevented the FOX from stopping and performing a full spectrum analysis, if indeed the operator had been trained and knew how to do it.

In view of the lack of expertise on the part of the U.S. operators cited above and the stated limited use of the capability of the FOX's MM-1, it is difficult to understand how the FOX could have been of any operational value in the manner the Marines used it during the breaching operations on 2/24/91.

AL JABER AIR BASE

The Kuwaiti Air Base of Al Jaber is located approximately 50 miles southwest of Kuwait City. It became a prime target for the U.S. Marines when it was learned that there was a dense concentration of Iraqi long-range artillery in the vicinity.[7] Accordingly, after crossing the minefields on the first day of the ground war (2/24/91), the Marines captured the air base for their use as a forward base for their aircraft and simultaneously neutralized the long range artillery threat.

It was during this first day of combat that the Iraqi forces set fire to the nearby Al Burquan oil fields, resulting in heavy black smoke surrounding the battlefield. Iraqi soldiers captured that first day revealed that only conventional munitions were stored in Al Jaber's bunkers, not chemical warfare rounds.[8]
The fact of no chemical munitions stored at Al Jaber was a small measure of confidence, however, as five chemical alerts occurred on the night of 24/25 February, 1991. It was later determined that these alerts resulted from mistaking smoke from Iraqi artillery fire and the heavy oil-fire smoke. The 1st Marine Division [MarDiv] FOX vehicles were not present at Al Jaber during these alerts; however, NBC personnel performed tests after each alert was sounded and no positive results were obtained (indicating no chemical agents were present)[9] using M256A1 kits. The M256 kit is portable, expendable and capable of detecting and

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[6] Ibid, p.17.

[7] Case Narrative, Al Jaber Air Base, OSAGWI, September 22, 1997, p.6.

[8] Ibid, p.8.

[9] Ibid.

identifying chemical agents. The "A" version will detect even lower levels of nerve agent.[10] A sixth alert occurred at 1800 hours on the 25th and this too was determined not to be chemical agents by using the M256 kits.

The seventh alert (thought to have been a blister agent) occurred at 1908 hours on the 25th by the FOX vehicle operating north of Al Jaber and attached to Task Force Ripper. The FOX was in a stationary position (awaiting a possible Iraqi counterattack) with wind conditions of 10-15 mph, gusting to 30-40 mph. Two of the four-man crew were sitting on top of the vehicle, while the other two were inside. The two on top were not wearing either the mask with hood, or the gloves of their protective clothing (considered to be at MOPP-2 level).[11] At the time of the alert, the FOX was using the AIR-HI method, which is 100 times less sensitive than an M256A1 kit in detecting chemical agents.[12] The FOX crew did not note any characteristic odor of mustard gas and did not report any symptoms, despite being in the open at only the MOPP-2 level. The alert ended when the MM-1 operator changed methods to begin a spectrum analysis (the temperature of the probe must be at its low setting to begin the "confirmation" cycle).[13]

Subsequent use of the M256A1 kits revealed negative results and an analysis of the FOX alert tape by the 1st MarDiv NBC officer also resulted in its being classified as a "false positive", attributing the alert to the smoke from the oil fires.[14] However, the tapes were "lost" and unable to be further analyzed; the crew did not smell any mustard gas; there were no physical symptoms manifested by anyone; and there were no casualties.[15]

One may conclude that the FOX was not able to provide a confirmation of the suspected chemical agent because the MM-1 operator had not been sufficiently trained, there were insufficient procedures in place, or the FOX wasn't being used as originally intended.

FOX DETECTIONS IN AN ASP/ORCHARD

On February 28,1991, a FOX was sent to inspect an Ammunition Supply Point(ASP)

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[10] Ibid, p.27.

[11] Ibid, p.12.

[12] Ibid, p.13.

[13] Ibid, p.15.

[14] Ibid, p.18.

[15] Ibid, p.22.

southwest of Kuwait International Airport that was alleged to contain chemical munitions (in fact, "[i]t was Standard Operating Procedure to assume the possibility of chemical weapons in any Iraqi ASPs."[16]). It was during this inspection that the FOX alarmed three times, indicating traces of chemical agents. Although the tapes that were made of these alerts were subsequently lost and could not be further analyzed, the 1st MarDiv NBC Officer (to whom the tapes were sent) believed that nothing would be found since the Explosive Ordnance Demolition [EOD] team at the ASP did not find any chemical weapons.[17]

After the EOD inspection, the ASP was dismantled during cleanup operations in Kuwait and no chemical weapons were found. The alerts have been attributed to false positives possibly caused by battlefield contaminants, including burning oil wells. The lack of physical symptoms from personnel walking about the ASP without protective clothing underscored the absence of chemical agents.[18]

At that particular time in the ASP, the FOX vehicle was operating with its probe in the AIR-HI method and as such, "...aninordinate amount of liquid must be present to create sufficient vapors to cause the MM-1 to alarm."[19] None of the Marines inspecting the ASP found large puddles of liquid or leaking munitions. In an attempt to support the FOX alarms, it was alleged that "...theMM-1 operator did whatever he was trained to do to get and print a full spectrum,..."[20] This does not add to the certainty of a chemical agent's presence since statements from the Office of the Special Assistant for Gulf War Illnesses [OSAGWI] have indicated that U.S. operators were not sufficiently trained to perform such an analysis[21].

This sequence of events adds to the conclusion that under these circumstances the FOX's MM-1 was only a superficial detector at best.

REPORTED MUSTARD AGENT EXPOSURE

The next recorded opportunity for the FOX vehicle to contribute to the Gulf War CW

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[16] Case Narrative, Fox Detections in an ASP/Orchard, OSAGWI, September 23, 1997, p.10.

[17] Ibid, p.18.

[18] Ibid, p.23.

[19] Ibid, pp.22-23.

[20] Ibid, p.23.

[21] See FN 3 supra.

defensive effort occurred on March 1, 1991, when a soldier was "likely" exposed to a chemical agent while exploring enemy bunker complexes in southeastern Iraq.[22] The soldier was wearing Nomex tanker coveralls and a ballistic protective vest (which were subsequently tested to assist in confirming the exposure) but no gloves.

The development of blisters on the soldier's forearm later in the day was consistent with exposure to mustard agent and was diagnosed and treated as such by medical personnel at C Company, 45th Support Battalion.[23] The first of two FOX vehicles was then used to attempt to get a contamination reading from the soldier's jump suit and after an hour of testing (the length of time needed because of a high concentration of sweat, oil, and other petroleum based products in the suit), the MM-1 operator was able to get a reading of "...anunusual blister agent(HQ)" [Mustard].[24]

The second FOX was utilized in the next two days but the jump suit had already been incinerated and only the soldier's flak jacket remained. The MM-1 operators of both FOXs noted that alarms registered readings of HQ mustard, but they were unable to obtain a spectrum of HQ because, as previously stated, the single spectra method only analyzes the compound with the highest concentration and the concentration of fat, oil and wax was always higher than the concentration of HQ.[25] Later, in an attempt to obtain HQ vapor samples from the suspected bunker, a FOX rammed the bunker wall and then backed its probe into the resulting hole with no success. This was attributed to the fact that HQ does not produce vapors at the temperature when the sampling was done.

Analysis of the single spectra of the MM-1 tapes did not verify the agent alarms, but they did confirm the detected material as HD (a form of mustard agent).[26] However, a full spectrum analysis [which was not done] is required to confirm a detection since the FOX's MM-1 design lends itself to many false positives.[27] This raises a question, since there appears to have been a misunderstanding on the part of the German FOX MM-1 manufacturer as to what was being taught. The German experts believed the U.S. personnel were being taught a procedure that included the full spectrum analysis: "Likewise, this is also why the standard procedure the soldiers are taught for operation of the MM-1 REQUIRES a spectrum for

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[22] Case Narrative, Reported Mustard Agent Exposure, OSAGWI, August 25, 1997, FN 9, p.4.

[23] Ibid, p.6.

[24] Ibid, p.7.

[25] Ibid, p.8.

[26] Ibid, p.11.

[27] Ibid, p.12.

verification. There is no firm identification UNLESS the spectrum identifies the agent."[28] (emphasis original)

This can only be viewed as additional information supporting the conclusion that there was insufficient training with the FOX, specifically with the MM-1.

REPORTED DETECTION OF CHEMICAL AGENT

Another reported use of the FOX's detection and confirmation capabilities occurred on September 16, 1991, at Camp Monterey, Kuwait (located approximately 15 miles north of Kuwait City and 7 miles south of the Iraqi border). This camp had been a Kuwaiti Brigade headquarters that was taken over by the Iraqis and used as a Corps headquarters by them during the PGW. The incident leading to the FOX involvement occurred when wooden crates containing metal cans were being moved from a building intended to be used by U.S. troops. One of the cans broke and spilled white powder, causing two soldiers to become sick. They displayed tearing and eye irritation symptoms, as well as nausea, leading to the belief that a chemical agent might be present.[29]

The first of two FOX vehicles arrived in response to this concern and its initial inspection alerted for Sarin (GB), a nerve agent. This positive reaction elicited the need to have a second FOX inspection which also alerted to GB; however, it also alerted to CS, an irritant agent used for riot control. The civilian MM-1 operator (who was the contractor employee responsible for the maintenance of the MM-1 on all the FOX vehicles under CENTCOM's control during the Gulf War)[30] performed a full spectrum analysis on the substance using first one and then the other FOX vehicle spectrometer to ensure that the same technique and procedures were used. These examinations confirmed the presence of CS and *not Sarin.*

Tapes that had been made simultaneously with the analyses were subsequently sent to three different independent mass spectrometry experts. "All three expert reviews confirmed that the initial Sarin detection was a false positive and that the full spectrum analyses of both FOX reconnaissance vehicles correctly identified the riot control agent CS."[31] The false positive alert to Sarin was explained by the search method used by the FOX MM-1 procedure previously described [page 1].

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[28] Ibid, p.5.

[29] Case Narrative, Reported Detection of Chemical Agent at Camp Monterey, Kuwait, OSAGWI, May 15, 1997, p.5.

[30] Ibid, p.2.

[31] Ibid, p.6.

The Camp Monterey incident added another dimension to an objective review of the occasions in the Gulf War when U.S. forces employed the FOX vehicle. This may have been the only occasion when the full capability of the MM-1 was properly utilized and served to alleviate the fears of exposure to an Iraqi chemical agent.

KUWAITI GIRLS' SCHOOL INCIDENT

[Comment on this incident will be added after the OSAGWI publishes its case narrative in the near future.]

CONCLUSIONS

In each case (with the exception of the Camp Monterey incident) when the FOX was used in an attempt to confirm [or deny] the presence of a chemical agent, its success seemed to be limited at best. The common thread in each case was the apparent lack of training or experience of the MM-1 operators in maximizing the way they used the mobile mass spectrometer and its probe that acquired the samples to be analyzed.

As was previously noted, the training provided to the U.S. forces consisted only of the AIR Monitoring Mode and then requiring them only to conduct a single spectra of the substance that caused an alert while the probe was in the AIR-HI method. It was also noted earlier that *an actual verification could be obtained only when a full mass spectrum* is run.

The validity of this recommended approach is borne out by the fact that the contractor's MM-1 operator in the Camp Monterey incident was able to properly use the MM-1 in both FOX's (by conducting the full spectrum as part of the analysis) to confirm the presence of CS, thus dispelling the fear of possible exposure to Iraqi chemical agent(Sarin).

In fact, because the Army wished to ensure that there would be no false negatives and a dangerous agent like Sarin would not be detected, the MM-1 interference parameter (an electronic field used to shield unwanted compounds from being read by the spectrometer) was set very low. The resulting setting led to more false positives occurring than might have been anticipated; however, these could have been disregarded if a full spectrum had been conducted confirming that they were false, as was intended by the German designers of the MM-1.[32]

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[32] Ibid, p.2.

Investigation of the circumstances surrounding the choice of the FOX, its subsequent acquisition, and its placement in the U.S. inventory revealed that a Tactics, Techniques, and Procedures (TTP) Manual was not in place until the TTP Manual, FM 3-101-2, was published in August, 1994. This fact was verified in discussions with various civilian subject matter experts and Army personnel. They also confirmed that the lack of these procedures hindered utilizing the FOX's capabilities to their maximum and allowed U.S. forces to improvise various procedures which would have been counter-indicated if their futility had been fully appreciated.

One may conclude that the rationale for using the MM-1 in the more expedient mode (AIR MONITOR) without the full spectrum analysis was flawed because the operators were unable to provide an actual confirmation whenever the FOX alerted. As it was utilized, the presence of the FOX vehicle only provided a false sense of security and could not offer the certainty of knowing whether or not anyone had been exposed to a CW agent.

LESSONS LEARNED

The FOX was designed as a reconnaissance system to detect, identify, and mark persistent ground contaminated areas. **It can be used as a primary vapor identification and verification system only when utilizing the MM-1's full spectrum (series spectrum) analysis.** While various ways of using the FOX are being considered, the resultant doctrine will have to emphasize this fact in very definitive terms.

In the event that battlefield conditions preclude using the FOX as originally intended, where mobile, tactical conditions prevail and use of the FOX sampling wheels is contra-indicated, then **THE FOX's MM-1 SHOULD NOT BE USED NOR RELIED UPON FOR CW DEFENSIVE MEASURES.**[33]

Most importantly, the MM-1 operators must be taught and trained to perform a full spectrum analysis as part of their routine instruction on the mass spectrometer, regardless of its increased complexity and need for more time to acquire proficiency. When other enhancements are made to the FOX vehicle's capabilities, these too must be added to the course of instruction along with sufficient time to permit the operators to become proficient with the new equipment.

Among the many lessons learned in various areas of interest in the Persian Gulf War, none may have a greater impact for future operations in similar conflicts than what was gained from the use (or lack) of the NBCRS XM93, "THE FOX VEHICLE".

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[33] Confirmed through discussions with subject matter expert, Mr. Bryan J. Keirn, Engineering Technician, NBC Defense Systems, Aberdeen Proving Ground, Maryland, SEPTEMBER 30, 1997.

Appendix II: Update to FOX NBCRS Vehicle Procedure Review

The following is a summary of FOX field demonstrations and instrument demonstrations performed during an SIU visit to the U.S. Army Edgewood facility at Aberdeen Proving Ground on Sept. 30, 1997.

Purpose:

To clarify procedures for obtaining mass spectra of chemical reagents in field situations, from the FOX vehicle.

To examine modifications in procedures and instrumentation which would improve the results obtained by field troops using the FOX.

Meeting:

1. The Edgewood presentations included a field demonstration of the FOX vehicle with oil of wintergreen substituted for nerve agent. The demonstration vehicle was the MM1 used in the Gulf during 1991.

The FOX operations expert, Brian Kehrn demonstrated the Army Manual procedures for using the FOX to detect chemical agents, including what supposedly happened during a Marine breaching situation in 1991. Apparently the Marines used the FOX mass spectrometer in a continuous air monitoring mode for which it was not designed. The proper procedure for verifying the presence of a nerve agent was also demonstrated. The latter is a more rigorous procedure requiring the recording of more mass spectra with appropriate interpretation of the results and several more minutes of time spent at a location of interest.

Mr. Vince Averna (SIU) focused attention on the usage of the FOX to detect vapors in the air high and air low modes of operation. Air high was apparently the method used by the Marines in the 1991 incident. The use of the air mode is only recommended for defining a broad perimeter around an area where liquid reagent has been identified and confirmed. The 9/30/97 Edgewood demonstration showed that detection of oil of wintergreen sprayed on the ground gave approximately the same results when operated in either the air high or air low mode, with both results only at the alarm level. That is, operation with the inlet tube up in the air, at either 180 degrees or 120 degrees, gave essentially the same result. The ineffectiveness of the MM1 for air monitoring is due primarily to the low flow rate for vapor streams into the inlet nozzle and up into the mass spectrometer. The system was designed to inject liquid or solid samples with concentrated reagent which is then vaporized at an appropriate temperature for analysis.

The lessons learned from the use of the FOX vehicle in the Gulf theater in 1991, include the following:
the necessity to store some or all of the mass spectra obtained on the computer disk

and not to erase and re-record after 72 spectra

the necessity to keep paper tape outputs of all initial spectra and all verification spectra obtained during field operations (and to ensure that those paper tapes are handled properly and transmitted back to command center for storage)

the necessity to leave the M8 or the M43A1 vapor sensor on since this is the only reliable way to detect chemical vapors while the vehicle is moving. This has been facilitated by eliminating the possibility for false positives and thus false alarms from vehicle exhaust (see below for description of improved M22 (ACADA))

more peaks of the mass spectra should be used to positively and specifically identify chemical reagents,and eliminate uncertainties from interfering species. The next generation of these mass spectrometers will detect using both parent ions and daughter ions rather than just daughter ions. The latter are ionized fragments of the full compound. Currently only daughter ions are used and fragments from other compounds or from smaller molecules can cause interfering peaks.

2. The second part of the Edgewood briefings consisted of descriptions of newer versions of instrumentation, which have been integrated into the FOX vehicle and field operations, since 1991.

The improved technology most relevant to improving detectability of chemical agents with the FOX vehicle (now the M93A1 FOX NBCRS) is the M22 Automated Chemical Agent Detector Alarm (ACADA). This unit will be mounted in a new location in the back of the FOX vehicles in place of the earlier chemical vapor sensor. Earlier versions produced false alarms due to vehicle exhaust and were therefore turned off most of the time. The M22 units are in production now and the Army plans to buy 40,000 units. The current cost is $10,000 per unit based on current slow production rates.

The new M22 operates on the same principle as the portable hand-held CAM and ICAM detectors, for mustard and GB/GD type nerve reagents. Each of these are mass mobility spectrometers using a time-of-flight separator. The new M22 (and the ICAM) is capable of monitoring both mustard reagents and nerve reagents at the same time, while eliminating false signals from hydrocarbon fumes (i.e. vehicle exhaust). The M22 uses dual time-of-flight separation cells, rather than a single cell as in the earlier versions. As reagent enters the detector it is diverted via a T junction to both of the cells to characterize it.

The new detector ionizes an organophosphorus compound (OPC) (GB,GD type nerve agent) by protonating the OPC with acetone (AC). A Ni63 ion source facilitates this process. Acetone is used for this process in the M22 because it has a convenient electron affinity. It is stored in a sealed container in the detector for this purpose. The reaction of interest is as follows:

$$H+(AC)+ OPC \text{ ----} H+OPC + AC \qquad (1)$$

This is an exothermic reaction, meaning that it will proceed readily. The electrometer detector in the M22 detects the H+OPC ion, thus giving a positive indication for a nerve agent. The time-of flight region separates such ions by applying a charge to plates at each end of the cell. Ions move towards the detector at different speeds depending on their mass and other properties. The specific time that the ion hits the detector (an electron collector or electrometer) can indicate what type of OPC is present. The M22 is pre-programmed to identify a list of agents of concern.

The analogous reaction to Reaction (1) with a hydrocarbon (vehicle exhaust, etc., denoted HC) does not proceed, since it is endothermic (requires added energy). That is,

H+(AC) + HC ---- no reaction (2)

Mustard type reagents are converted to a negative ion in these types of detectors via reactions such as,

O2- + HM -----O2 + HM-, where M= mustard (3)

Thus, the detector must be able to detect negative ions for mustard reagents (sulfur containing substances) and positive ions for organophosphorus compounds. In earlier models of these types of detectors (e.g. CAM), the polarity on opposite ends of the time-of-flight cell was reversed (i.e. the charge on the electrometer plates) as needed to detect either mustard or nerve. In the M22 and the ICAM, one cell is set-up to detect positive ions and one to detect negative ions. Thus using the T-configuration to send sample gas to both cells, the detector will determine which of the two types of reagent is present.

If the detector indicates a positive response for both cells, indicating the presence of both a phosphorus compound and a sulfur containing compound it can indicate a VX type of nerve agent which contains both sulfur and phosphorus.

3. Other new generation instruments described to us at Edgewood were the ICAM, the M21 and the LSCAD. The latter two are infrared detectors for viewing clouds of chemical vapors from a distance. These are more fully described in other documentation (e.g. DoD NBC Defense, Annual Report to Congress, March 1997).