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14. ABSTRACT HQ ACC/SGXH requested the U.S. Air Force School of Aerospace Medicine (USAFSAM) to perform developmental testing and analysis to identify a commercial off-the-shelf (COTS) solution for replacement of the current HazMatID™ on the 886H allowance standard. The Bioenvironmental Engineering (BE) consultant branch (USAFSAM/OEC) collaborated with members from the BE education and training branch (USAFSAM/OED), Proficiency Analytical Testing program (USAFSAM/OET), and the Pilot Unit from Shaw AFB to determine the best replacement for the HazMatID™. Representatives from the Pilot Unit were specifically recommended for inclusion in the selection process by HQ ACC/SGXH to ensure the recommended COTS solution meets user criteria, i.e., ease of operation while wearing personal protective equipment, dependability, and durability in the field. HQ ACC/SGXH will purchase half of the required equipment sets in FY2013, with the remainder purchased in FY2014. Vendors from three different companies presented their equipment to the group for evaluation on 10-12 December 2012.					
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DEPARTMENT OF THE AIR FORCE
USAF SCHOOL OF AEROSPACE MEDICINE (AFMC)
WRIGHT-PATTERSON AFB OH

9 May 2013

MEMORANDUM FOR HQ ACC/SGXH
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FROM: USAFSAM/OEC
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Wright-Patterson AFB, OH 45433-7951

SUBJECT: Consultative Letter AFRL-SA-WP-CL-2013-0010, HazMatID™ Replacement Project

1. INTRODUCTION:

a. *Purpose:* HQ ACC/SGXH requested the United States Air Force School of Aerospace Medicine, Consultative Services Division (USAFSAM/OEC) perform developmental testing and analysis to identify a commercial off-the-shelf (COTS) solution for replacement of the current HazMatID™ on the 886H allowance standard. USAFSAM/OEC collaborated with members from the Bioenvironmental Engineering (BE) Force Development Division (USAFSAM/OED), Proficiency Analytical Testing program (USAFSAM/OET), and the Pilot Unit from Shaw AFB to determine the best replacement for the HazMatID™. Representatives from the Pilot Unit were specifically recommended for inclusion in the selection process by HQ ACC/SGXH to ensure the recommended COTS solution met user criteria (i.e., ease of operation while wearing personal protective equipment (PPE), dependability, and durability in the field). Vendors from three different companies presented their equipment to the group for evaluation on 10-12 December 2012.

b. *Participants:*

- (1) Chief, Special Projects Branch, USAFSAM/OEC
- (2) BE Consultant, USAFSAM/OEC
- (3) Chief, Education and Training Branch, USAFSAM/OED
- (4) NCOIC, Special Projects Branch, USAFSAM/OEC
- (5) BE Consultant, USAFSAM/OEC
- (6) Pilot Unit Representative, Shaw AFB
- (7) BE Consultant, USAFSAM/OEC
- (8) BE Consultant, USAFSAM/OEC
- (9) CBRN Consultant, USAFSAM/OEC
- (10) OEH Consultant, USAFSAM/OETO

- (11) OEH Consultant, USAFSAM/OETO
- (12) OEH Consultant, USAFSAM/OET
- (13) Contractor, Battelle

c. *Vendor Representatives:*

- (1) DoD Senior Account Manager, Smiths Detection
- (2) DoD Senior Product Manager, Smiths Detection
- (3) Federal Government Programs, Thermo Scientific
- (4) Regional Sales Manager, Bruker Corporation

d. *Equipment:*

- (1) Bruker Corporation – Mobile-IR
- (2) Smiths Detection – HazMatID™ Elite
- (3) Thermo Fisher Scientific – TruDefender

2. LITERATURE REVIEW: To determine a replacement for the Smiths Detection HazMatID™ on the 886H allowance standard, a search of Fourier transform infrared spectroscopy (FTIR) instruments was conducted to develop a list of possible candidates. This search resulted in three companies with FTIR products being selected for further consideration. The three companies were selected based on their ability to develop quality instruments, provide user support during equipment malfunctions and breakdowns, and produce the equipment within the required timelines for replacing the HazMatID™. The three companies with FTIR products selected for further evaluation were the Bruker Corporation Mobile-IR (Figures 1 and 2), Smiths Detection HazMatID™ Elite (Figures 3 and 4), and Thermo Fisher Scientific TruDefender (Figures 5 and 6).



Figure 1: Front View of Mobile-IR



Figure 2: Close-Up View of Mobile-IR



Figure 3: Front View of HazMatID™ Elite



Figure 4: Close-Up View of HazMatID™ Elite



Figure 5: Front View of TruDefender



Figure 6: Close-Up View of TruDefender

a. Once the three instruments were selected, a separate literature search was conducted to compare the capabilities of the instruments to each other. This review consisted of searching the Defense Technical Information Center (DTIC) databases including the DTIC Online Access Controlled database and the Federal Emergency Management Agency Responder Knowledge Base for third-party independent testing on the equipment. Additionally, the vendors were contacted for any independent testing information they had conducted, along with any qualifications such as military standard (MIL-STD) specifications that their equipment were certified to meet.

b. Due to the lack of independent testing and evaluation, the panel decided it was best to set the starting point of this evaluation by assuming that the three pieces of equipment have equivalent capabilities based upon the technology used and the specifications met by the vendor (i.e., MIL-STD certifications, etc.). Searches for independent third-party evaluations for the products from Bruker Corporation and Thermo Fisher Scientific were unsuccessful. Direct contact with the vendors also failed to provide this information. The only exception was Smiths Detection, which provided a document with the results of chemical agent and toxic industrial chemical testing. The document is listed as "Business Sensitive" and therefore will not be attached to this letter.

3. METHODOLOGY: To evaluate the capabilities of the three different pieces of equipment without conducting an actual chemical analysis and reproducibility study, a literature review was conducted along with hands-on classroom training followed up with a questionnaire. Lastly, BE technicians operated the equipment while in Level A PPE to determine the best instrument for purchase.

a. Part of the literature review consisted of obtaining third-party independent evaluations of the equipment to determine how well the instruments performed. This was partially met using the “*Chemical, Biological, Radiological Technology Survey*.” This survey evaluated the analytical, diagnostic, mobility, and field use capability for each piece of equipment in the equipment list at the time of the survey. A limitation of using this survey is that the Smiths Detection HazMatID™ 360 was evaluated instead of the HazMatID Elite, and in the case of the Bruker Mobile-IR, there was no survey for this piece of equipment or any similar device from Bruker.¹ Each of the vendors was also contacted for independent, third-party evaluations of their equipment. Smiths Detection was able to provide several documents for review, while Thermo Fisher Scientific and Bruker did not have these data available.

b. Vendor representatives were then contacted to schedule presentations and demonstrations of their products. Vendor presentations were conducted from 10-12 December 2012. The presentations enabled the audience to compare and contrast the three direct reading instruments to the current HazMatID™. The audience asked questions regarding the reliability of the instrument, ruggedness of the instrument, maintenance options and loaner programs, etc. Following each of the presentations, the group tested sample chemicals in both liquid and solid form to develop a feel for how easy each instrument operated. After testing multiple samples on the equipment, the participants were asked to fill out a survey (see Attachment 1) to subjectively rate the equipment.

c. The Pilot Unit representative conducted a separate evaluation of each piece of equipment during the course of the week using criteria set forth from previous evaluations made by the Pilot Unit. A summary of his evaluations along with his recommendations for the 886H working group are in Attachment 2. One of the most important aspects for testing the equipment by the Pilot Unit representative was to suit up in Level A PPE to simulate real-world conditions for which the equipment would be used. This testing and evaluation was conducted on 14 December 2012 and is shown below in Figures 7 and 8.

¹ **Emanuel P, Caples M.** Chemical, biological, radiological technology survey. Alexandria, VA: Defense Threat Reduction Agency; 2011 Jan. Retrieved 18 March 2013 from <https://www.dtic.mil/DOAC/document?document=CBRNIAC-CB-197730&collection=ac-tems&contentType=PDF&citationFormat=1f>.



Figure 7: Sampling in Level A PPE



Figure 8: Processing a Sample in Level A PPE

4. RESULTS:

a. *Bruker Mobile-IR:*

(1) *Positives:* The instrument has a multitude of software libraries available for purchase that would allow the user to customize the instrument to the user's needs.

(2) *Negatives:* This instrument is labeled as "Mobile," but in reality weighs 28 pounds. The Mobile-IR's computer operating system was extremely slow, and during the demonstration would not operate properly within a 2-hour timeframe. The battery life is limited to approximately 3 hours of use on a single charge, and the battery cannot be removed and replaced by the user. Additionally, the chemical software libraries that come with the standard instrument package do not give the equivalent capabilities of the current HazMatID™. Additional software libraries are available for purchase; however, they are very expensive and would be cost prohibitive when compared to the other two instruments.

(3) *Overall Assessment:* The easiest of the three instruments to eliminate from the list was the Bruker Mobile-IR. The consensus of the group was that this instrument is best suited for a nonemergency response environment such as a laboratory, where the weight of the instrument, lengthy start-up time, and limited chemical identification software libraries are not as big of an issue.

b. *Thermo Fisher Scientific TruDefender:*

(1) *Positives:* This instrument is truly a mobile instrument that can be easily carried by a technician during an emergency response. Additionally, all chemical identification libraries for the TruDefender are included in the standard equipment purchase price, negating the need to purchase additional libraries to meet the needs of the Air Force. Navigation through the main

menus is easy and intuitive, and the Chemometric software offers advantages for identifying mixtures.

(2) *Negatives:* The user needs to memorize many different rules when analyzing a sample. For instance, if the instrument does not identify the unknown after a certain period of time, the user would be required to determine that the instrument could not identify the unknown and stop the instrument from continuing to try to process information. This requires the user to keep track of how much time has passed during the analysis of an unknown. The consensus within the group is that the instrument should “time-out” and alert the user that it cannot identify the unknown. Additionally, a flashing red screen is used to show that the instrument is working toward identifying the unknown sample; however, this is counterintuitive to most operators who may view this as the equipment has an error or is not working. The group recommends changing the color to green to show that the instrument is working toward identifying the unknown sample. The screen is difficult to read in ambient lighting due to the screen color and the multiple spectra on the graphs. In addition, the solid sample press was awkward since the clearance between the sample well and the press does not allow the user in Level A PPE to clean the press without rotating it completely to the right. The sample press also has a rubber piece designed to make opening and closing the press easier; however, it is not permanently attached to the press and would be lost fairly quickly in a real-world environment. Lastly, this instrument’s libraries can only be updated by downloading the updated files to an SD card, which would be problematic based on the availability of SD card slots on the current laptops in the field.

(3) *Overall Assessment:* The TruDefender was viewed by the group to be a very good instrument, but the user interface and software upgrade method need to be improved before it would be considered for inclusion in the 886H equipment package.

c. *Smiths Detection HazMatID™ Elite:*

(1) *Positives:* The Smiths Detection HazMatID™ Elite addressed many of the previous concerns regarding the current HazMatID™. The operating mechanism has been changed to eliminate the optical alignment step in the process, and the source now only operates while a sample is being analyzed. The elimination of moving optical sensors will bring the maintenance of the HazMatID™ Elite in line with that of the TruDefender. The HazMatID™ Elite has eliminated the use of a stylus and touch screen operation by using large, oversized buttons for navigating through the menus. The instrument has buttons with lights that illuminate the only possible options for navigation, thereby simplifying the decision making process for the user. Pictures are used to illustrate the individual steps in the process of identifying a sample. The screen was also very easy to read in ambient lighting. A key feature of the HazMatID™ Elite is the use of Wi-Fi technology to enable the user to send the results of the sample to a laptop without having to communicate the results in the hot zone using a radio. This also allows those in the cold zone to further analyze the results of the sample instead of requiring the technician in the hot zone to use advanced techniques to identify the unknown.

(2) *Negatives:* While the screen background and spectra line colors are easily visible indoors or when outside under partially cloudy conditions, the screen becomes difficult to read when outside under full sunlight. Lastly, it was noted by the group that the instrument needs

either a carrying case or handle to make it easier for a technician to carry the instrument in and out of the hot zone while minimizing the risk of dropping the instrument in the process.

(3) *Overall Assessment:* The HazMatID™ Elite is a significant improvement over the previous model, with the elimination of moving parts that would require frequent maintenance, the improvement of the user interface (larger buttons, elimination of the stylus pen), and the use of Wi-Fi technology to enable the user to send information digitally versus passing information over the radio.

d. *Literature Review Results:* There were no direct-comparison, third-party, independent studies conducted among the products the group evaluated during this survey. Since there were no studies available to directly compare the products being presented, we instead compared the previous versions of the Thermo Fischer Scientific TruDefender to the HazMatID™ 360. Using the “*Chemical, Biological, Radiological Technology Survey*” as the basis for this comparison, we determined that while the TruDefender had a slight edge in the ratings scoring over the HazMatID™ 360, presumably the scores were close enough to be considered equivalent (see footnote on page 4). The other assumption that was made was that the Bruker Mobile-IR performed similarly to the other two direct reading instruments to move the evaluation along due to the lack of data available for review.

e. *Survey Questionnaire Results:* The HazMatID™ Elite achieved an average score of 25.5 out of a maximum of 30 points. The Thermo Fischer Scientific TruDefender was second with an average score of 22.4. The Bruker Mobile-IR was not evaluated, since the equipment performed so poorly that it was decided by all attendees that it was not a suitable replacement for the current HazMatID™.

5. RECOMMENDATIONS AND CONCLUSIONS:

a. Based on the vendor presentations, actual use of the instruments to identify liquids and solids, ease of use in Level A PPE, and with discussion within the group the consensus recommendation to the 886H Working Group is that the BE career field procure the HazMatID™ Elite.

b. In addition to purchasing the HazMatID™ Elite, the group recommends the purchasing of a stand-alone laptop in order to take advantage of the Wi-Fi capability of the HazMatID™ Elite, as well as to update laptops on the current 886H inventory that may be in need of upgrading. Lastly, the group recommends that the 886H Working Group purchase the software for additional analysis from Smiths Detection for use on the laptop computers. This software allows for more in-depth analysis of the samples collected, and with the Wi-Fi capability would allow quicker processing of a scene than what is possible with the current HazMatID™.

c. If you have any further questions regarding this report, please contact Capt Marc Graessle at DSN 798-3858 or marc.graessle@us.af.mil.



JEREMY M. MINITER, Maj, USAF, BSC
Chief, Special Projects Branch

2 Attachments:

1. Sample Questionnaire
2. Pilot Unit Assessment

Attachment 1

Sample Questionnaire

Criteria for Evaluating HazMat ID Replacement

Direct Reading Instrument: Smiths Detection HazMatID Elite

1. How difficult is it to navigate through the instrument's menus?

① Next to Impossible ② Difficult ③ Average ④ Relatively Easy ⑤ Extremely Easy

2. Are the buttons large enough/easy to operate?

① No, they are too small ② A little too small ③ Average ④ Fairly easy to operate ⑤ Yes, it was very easy to operate

3. Is the display easy to read?

① Next to Impossible ② Difficult ③ Average ④ Relatively Easy ⑤ Extremely Easy

4. How easy is it to analyze a sample?

① Next to Impossible ② Difficult ③ Average ④ Relatively Easy ⑤ Extremely Easy

5. Ease of use in a Level A suit?

① Next to Impossible ② Difficult ③ Average ④ Relatively Easy ⑤ Extremely Easy

6. Would you recommend purchasing this piece of equipment?

① Absolutely not ② No, there are better DRIs ③ Maybe with some changes ④ Yes ⑤ Absolutely

Total Score:

Attachment 2 Pilot Unit Assessment

HazMatID™ Elite

Background: The HazMatID™ Elite is a handheld unknown solid and liquid chemical identifier that uses FTIR spectroscopy. It has the capability to identify chemical warfare agents, explosives, toxic industrial chemicals, narcotics, and suspicious powders, among other dangerous chemical classes.

Analysis is performed by placing a small amount of unknown substance onto the diamond attenuated total reflectance (ATR) sensor and applying pressure with an integrated press for solid samples. The sample interface also includes an integrated well for the containment of liquids and surface films.

The HazMatID™ Elite is replacing the original HazMatID™.

Findings: While testing the HazMatID™ Elite, I found it to be a very user-friendly piece of equipment. For the purpose of going down range, its light weight and rugged structure are key. It has the ability to wirelessly transfer data and results to a safe zone location via Wi-Fi, and it can be decontaminated for reuse. However, I would have liked for it to be certified as intrinsically safe and to have safeguards to protect the exposed ATR sensor and display screen.

HazMatID™ Elite's battery life is sufficient with a 4-hour operation life. It has an impressive temperature range (-4 to 122 °F). It has an audible alarm feature for priority alert notification of hazardous material and has a feature to alert the user of a problem before other results can be seen. The instrument also gives the user the ability to manage methods and the 10,000-spectra library.

Conclusion: Although I see room for improvement with the equipment because it is not certified as intrinsically safe and does not have safeguards for screen and sensor protection, I believe this piece of equipment would be very useful in the various training and real-world environments. As the 886H Pilot Unit representative, I recommend this piece of equipment for approval.

Pilot Unit Representative

TruDefender FT

Background: The TruDefender FT is a lightweight, handheld unknown solid and liquid chemical identifier that uses FTIR spectroscopy. It has the capability to identify chemical warfare agents, explosives, toxic industrial chemicals, narcotics, and suspicious powders, among other dangerous chemical classes.

Analysis is performed by placing a small amount of unknown substance onto the diamond ATR sensor and applying pressure with an integrated press for solid samples. The sample interface can also analyze unknown liquids without applying pressure.

The TruDefender FT would be replacing the original HazMatID™.

Findings: While testing the TruDefender FT, I found it to be a useful piece of equipment to take down range. It is very lightweight, rugged, and has a very clear vibrant screen display for day or night operations. It can be decontaminated for reuse and can send analyzed results from a hazardous area back to incident command center via email or SMS text. This instrument also gives the user the ability to search and utilize a 12,000-spectra library.

However, I think the rubber knob on the press would get lost fairly quickly, as well as the water-sealing door at the bottom of the unit that is being held on by a thin rubber cord. The SD card that holds the backup data is obsolete, and the unit cannot test for unknown biological substances.

Conclusion: The TruDefender FT is an effective piece of equipment that has some features that I would like changed or slightly modified. As the 886H Pilot Unit representative, I do not recommend this piece of equipment.

Pilot Unit Representative

Mobile-IR

Background: The Mobile-IR is a self-contained, wireless, mobile infrared spectrometer for identification of unknown substances. The Mobile-IR analyzes solids and liquids with an embedded computer with a large touch screen display. The unit uses FTIR technology, providing a wider spectral coverage and higher spectral resolution.

Findings: As I operated the Mobile-IR, I found it to be awkwardly heavy to be considered for taking into a hazardous environment. It was difficult to operate and very time consuming to get it started and up to operating capabilities. The software is out of date compared to other candidates. The battery is not accessible and has a very short life of 3 hours away from the charger.

The Mobile-IR can be decontaminated by immersion. It has a wide variety of libraries available for purchase, and analyses can be downloaded to a USB thumb drive and taken to the incident command center for further analyses. The estimated life cycle of the unit is 5 years, with a 1-year warranty.

Conclusion: The Mobile-IR is a very heavy and slow piece of equipment. It has a more limiting temperature range of 23-104 °F than any of its competitors. The touch screen feature is not ideal for operations in Level A suits. The Windows operating system is out of date; the additional spectra library is very expensive; and the initial library is limited to only explosives, chemical warfare agents, and white powders. As the 886H Pilot Unit Representative, I do not recommend this piece of equipment.

Pilot Unit Representative