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TECHNICAL REPORT No. 72-03

ASSESSMENT OF THE VAPOR TRACE ANALYZER AS AN EXPLOSIVE DETECTOR

FINAL REPORT

By

Louis S. D'Elicio
Applied Chemistry Branch

MARCH 1972

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ABSTRACT

Hydronautics-Israel Ltd. has developed an instrument known as the Vapor Trace Analyzer (VTA) for detecting vapors of TNT and nitroglycerin-based dynamite. The Defense Special Projects Group (DSPG) has funded the U.S. Army Land Warfare Laboratory to assess the capabilities of the VTA as an explosive detector. This report describes a series of tests which attempt to assess the VTA's ability to detect explosive vapors emanating from people and clothing which have been in contact with explosives and from luggage and wrapped postal parcels that contained or had contained explosives. Dynamite, TNT and C-4 were the explosives employed during these tests.

FOREWORD

The Defense Special Projects Group (DSPG), aware of the VTA and its potential impact on explosive surveillance techniques, requested that the U.S. Army Land Warfare Laboratory (USALWL) conduct preliminary tests on the VTA to assess its capabilities as an explosive detector. USALWL responded with a proposed preliminary test plan (see Appendix I). DSPG concurred with the test plan and funded USALWL to: (1) procure one Hydronautics VTA, (2) conduct tests to assess the VTA as an explosive detector, and (3) provide a final report.

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1.0 BACKGROUND:

1.1 In recent years, not only in this country but throughout the world, there has been a significant increase in the use of explosives by individuals seeking to intimidate, disrupt, and even destroy civilian and military activities. As a result, law enforcement agencies have sought methods to deter such operations. One approach given considerable attention is the development of new applications for standard scientific instrumentation techniques. These techniques could assist in the detection of contraband explosives on personnel and in luggage, particularly at points of embarkation and debarkation. It was toward this goal that the Hydronautics-Israel Ltd. addressed its research in 1969.

1.2 The culmination of their research effort resulted in an instrument known as a Vapor Trace Analyzer (VTA) (See Figure 1). Based on the principle of gas chromatography - a well-known technique - the instrument is rather unique in that it was designed primarily as an explosive detector for TNT and nitroglycerin-based dynamite. In addition to its explosive detection capabilities, features such as portability, automatic operation, and ease of data interpretation aroused the Israeli Government's interest to the extent that they are presently conducting feasibility tests with this instrument.

2.0 SUMMARY:

2.1 The VTA, when operated in accordance with the instruction manual, detected TNT and a nitroglycerin-based dynamite; however, under similar test conditions, the probability of a dynamite detection far exceeded that of TNT.

2.2 Air sample collection techniques used in conjunction with the VTA were effective in obtaining dynamite detections, whereas, the same techniques provided virtually no TNT detections.

2.3 The technique of sampling employed during these tests, i.e., a reading requires 30 seconds, although very effective in detecting dynamite, would be a tedious and highly inefficient method for handling large volumes of traffic.

2.4 A serious operational deficiency in this system was the problem of recorder saturation. Occasionally in the dynamite mode, but predominantly in the TNT mode, upon receipt of a large dose of explosive, the recorder became saturated; consequently, instrument purging was required for periods ranging from several minutes to a few hours.

2.5 While there were several mechanical and electrical malfunctions, most problems were minor in nature. The malfunctioning of the oven's thermocouple and the inability to deactivate the sound alarm presented instances where factory maintenance was required. As a result of factory maintenance of the oven, the system was inoperative for two weeks.

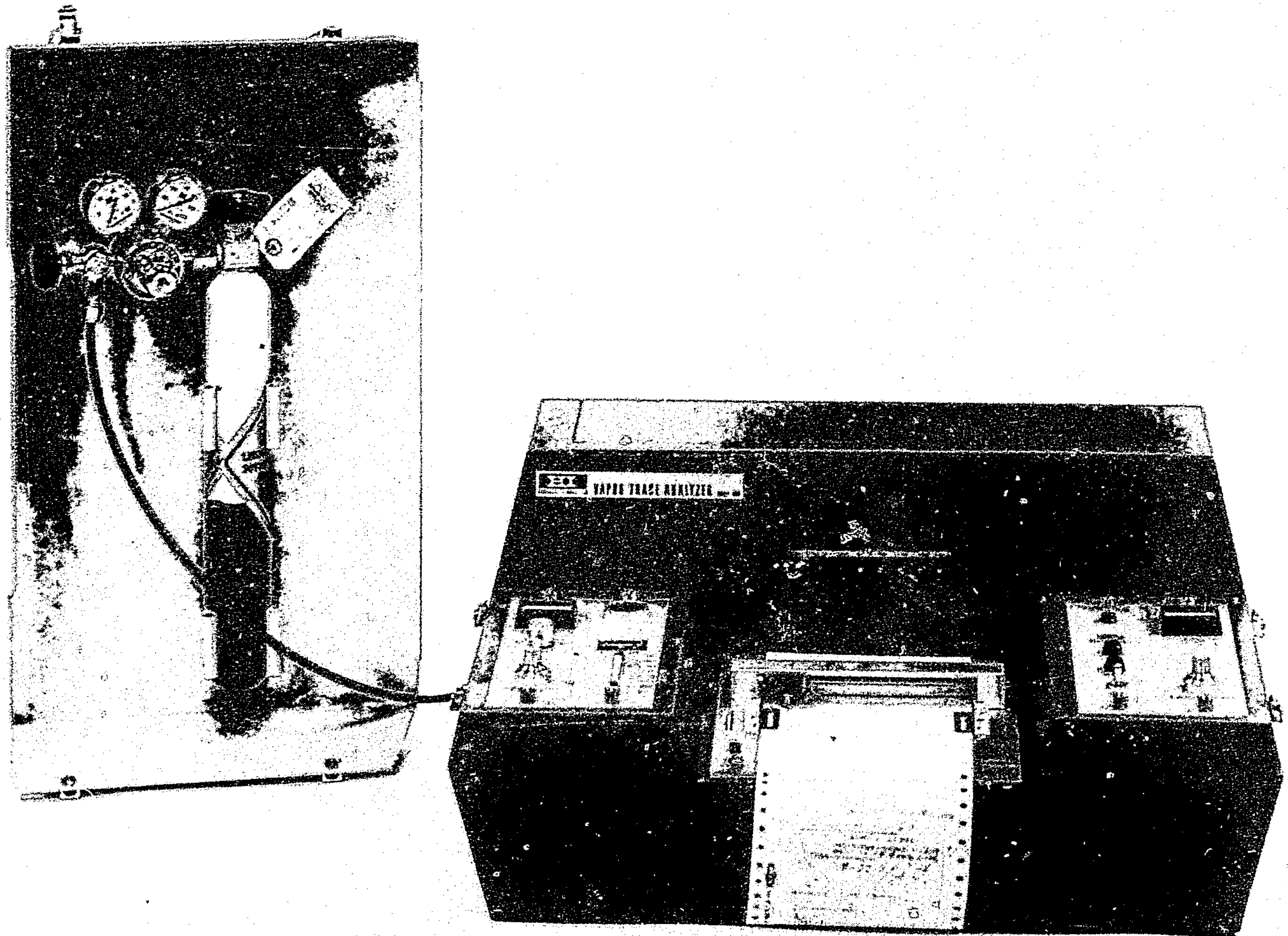

Figure 1. Vapor Trace Analyzer - Model 103A.

2.6 Of the interferences tested, none produced an interfering signal when the VTA was operational in the dynamite mode. On the other hand, in the TNT mode, when using the first peak to identify TNT (dual peak signature), interferences on that peak were noted with Mennen's Skin Bracer and Right Guard Deodorant. Shifting the TNT identification to the second peak eliminated this problem. This peak was specific for TNT, yet none of the interferences produced a signal near it.

2.7 The instruction manual, although adequate from the standpoint of theoretical description, neglected to convey the possible complexities involved in data interpretation; also it failed to properly equip the operator in the handling of all the maintenance problems associated with the instrument. The major manual deficiency was the lack of electrical schematic diagrams.

2.8 Although effective as an explosive detector under controlled conditions, the usefulness of the detector as a field instrument is dubious, because of some limiting factors such as its weight of 83 pounds, its power requirements of 110 V AC, 60 Hz, 0.5 Kw and its warm-up time of 45 minutes.

2.9 During these tests, the capability to monitor a small, closed room for dynamite was proven feasible.

2.10 Though not as easy to detect as an exposed stick of dynamite, dynamite enclosed in a heat-sealed polyethylene bag and concealed in a wrapped parcel was detected by sampling the exterior of the parcel.

2.11 Drying the TNT, containing 10% water as received, overnight at 75^{o}-$80^{o}C$ provided a more specific VTA signature for this explosive.

3.0 DESCRIPTION OF TEST MATERIALS:

3.1 Explosives:

a. Dynamite - 40% Special Gelatin
Manufacturer: DuPont
Stick Weight: 8.5 oz
Weight of approx. 1/3 stick: 2.9 oz

b. Trinitrotoluene (TNT)
Manufacturer: Eastman Organic Chemicals
Weight per Sample: 6 oz
Molecular Weight: 227.13
Water Percentage: 10%

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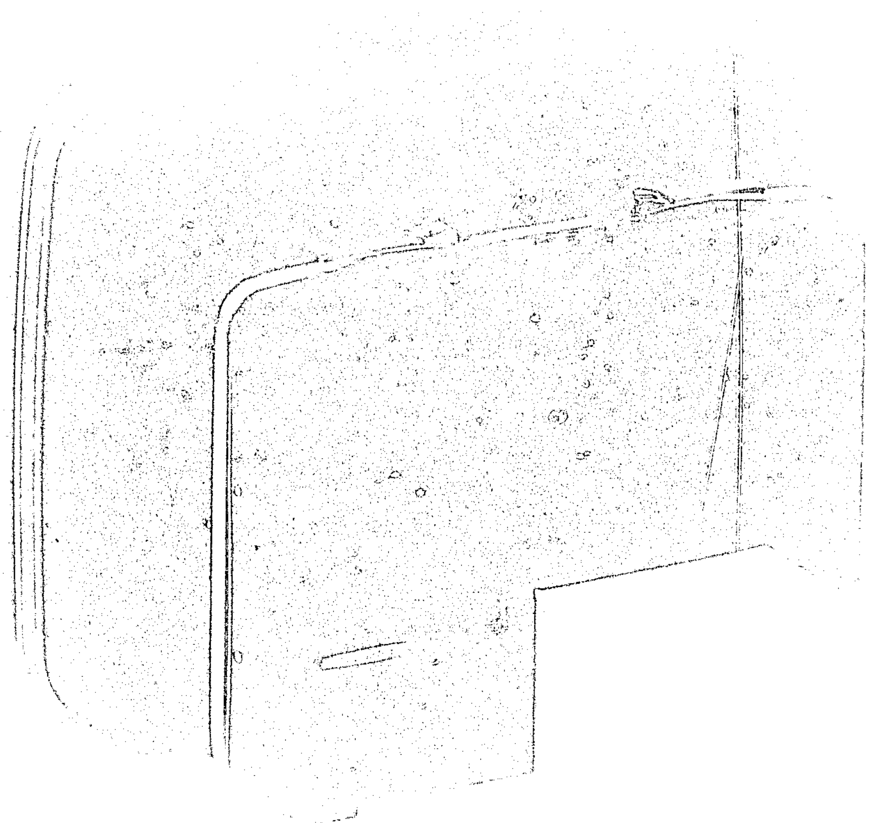

Figure 2. Containers: Luggage, Attache Case and Wrapped Parcel.

(6) Parts:

(a) Oven - cylindrical shape; maximum temperature 500°C

(b) Chromatographic Column - 30 cm, 1.5mm ID, Teflon; packed with 15% D.E.G.S. on 30/60 Chromosorb W.A.W.

(c) Proportional Temperature Control:

Temperature range: Ambient to 500°C
Current - up to 5 Amp
Stability - ±0.2°C

(d) Electron Capture Detector - cylindrical shape; contains 150 mc H^3 foil, average standing current generated 8-10 x 10^{-9} A.F.S.

(e) Electrometer - ranges from $1x10^{-8}$ A.F.S. to $3x10^{-10}$ A.F.S. in five steps; noise-free at all levels.

(f) Suppression Current - ranges from $0\text{-}20x10^{-9}$ A.F.S. continuously adjusted.

(g) Voltage Supply - Supplies 5, 10, 15, 20 and 25 V DC
Stability: ±0.5%

(h) Recorder - single channel, strip chart potentiometry recorder.

4.0 DISCUSSION AND RESULTS:

4.1 The following is a comprehensive review of the results of tests conducted under this task in the evaluation of the Vapor Trace Analyzer. This review encompasses discussions on the VTA, the instruction manual, the test results on dynamite and TNT under the various test conditions, and the results of some additional tests considered pertinent to a more thorough understanding of the instrument and its operation. The first topic to be discussed and evaluated is the instruction manual provided with the instrument.

4.2 Manual: The manual is entitled "Instruction Manual for Vapor Trace Analyzer Model 103A". It describes and illustrates the theory, operation and maintenance of the VTA. The VTA theory is thoroughly and adequately discussed. However, the portion of the manual dealing with the VTA operation and maintenance fails to provide an inexperienced operator with sufficient instructions to effectively operate and maintain the instrument. The following observations noted during the course of this evaluation illustrate the deficiencies of the manual:

a. Several of the figures are misleading:

(1) Figure 6, "Power Supply Panel" - although labeled as a 10 amp fuse, a 5 amp fuse is used.

(2) Figure 10 "Recorder" - the ON-OFF switch is not labeled.

(3) Figure 13 "Component Location" and Figure 21 "Fuse Replacement" - the printed circuit board illustrated in both photographs is not applicable to this VTA.

b. Under "Operation Instructions":

(1) Para. 43, Step 8 - With the prescribed temperature adjustment setting for the desired temperature, it required 1 to 1½ hours to attain and stabilize the temperature.

(2) Calibration Charts for TNT and Dynamite - Referred to in the manual (Para. 43, Step 8), calibration charts were provided with the instrument. However, while the charts did provide parameter criteria and peak configurations on which to initiate the set-up procedure, it was soon determined that these charts could not be duplicated even though identical procedures were followed using the same instrument.

(3) Para. 43, Step 18 - During some operations three peaks were evidenced prior to the explosive peaks, not two as stated, (see Figure 3). The cause of the three peaks was attributed to the electronics involved in: (a) rotating the valve to the flush position, (b) rotating the valve to the sample position, and (c) heating of the wire by electrical pulses.

c. Under "Maintenance":

(1) Para. 48, Step 15 - No warning appeared indicating the case with which the teflon valve could be crossthreaded. Such an occurrence would permanently damage the valve, resulting in a malfunction.

(2) Para. 48, Step 25 - no plexiglas cover was provided with the instrument.

(3) The absence of any electrical circuit schematics was considered a deficiency. This was best illustrated with the failure of the column oven and the malfunctioning of the sound alarm. Total reliance on the manufacturer was required for maintenance. The manufacturer indicated such schematics would be made available to the VTA owner, shortly.

(4) A description of the procedure to adjust the sensitivity of the sound alarm was omitted.

(5) Due to a modification in the valve housing, the exploded view shown in Figure 18 is no longer applicable to the instrument under test.

(6) Figure 20, "Microswitch Adjustment", is not applicable to the instrument under test.

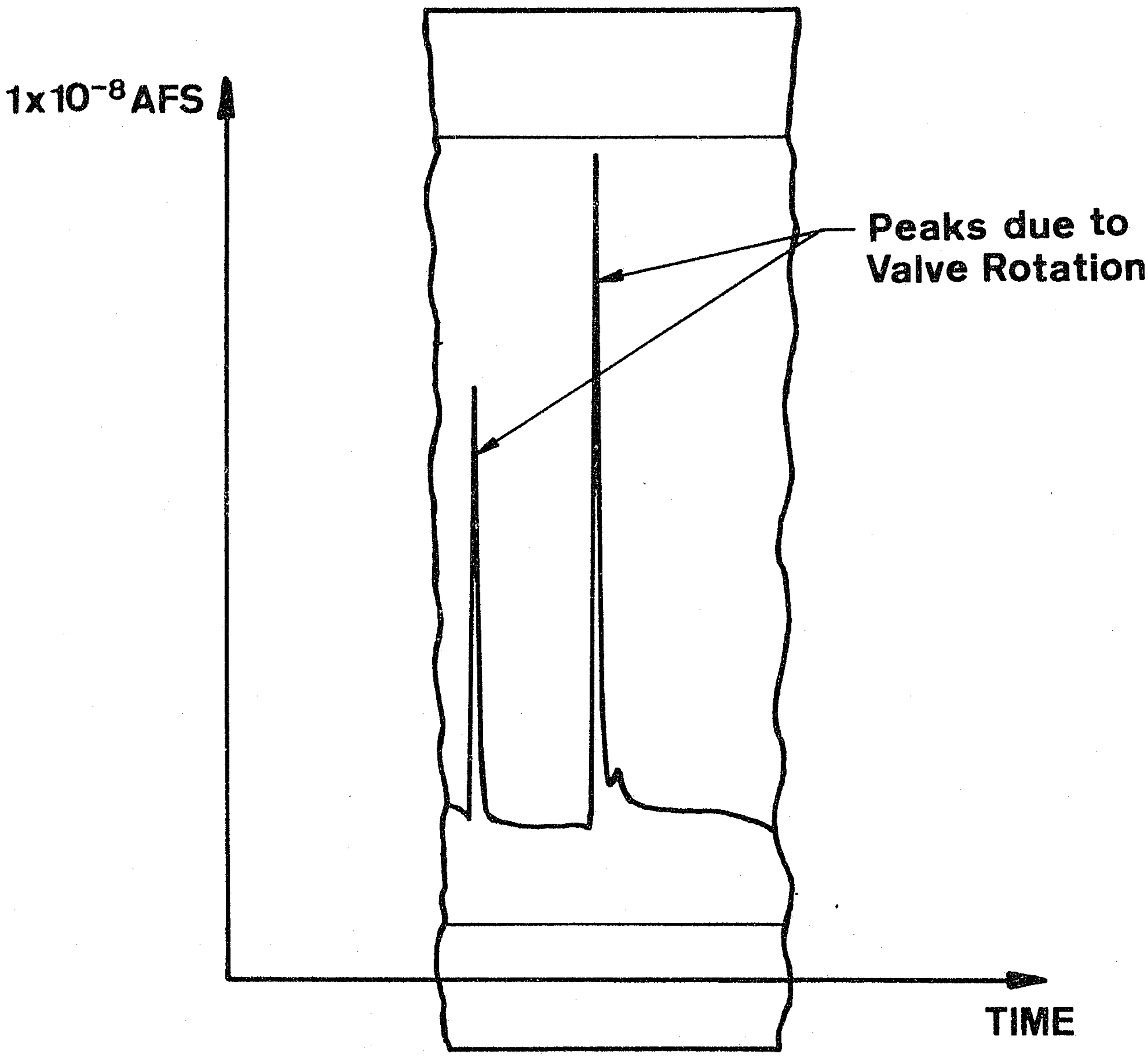

FIGURE 3. Vapor Trace Analyzer's Strip Chart Record of a Blank Cycle Trace (Three Peaks)

4.3 Operator Training: The present operator training policy pursued by the manufacturer is to provide the prospective VTA operator with a two-day course in theory, operation and maintenance. During this course, the theoretical portion, similar to that presented in the manual, is elaborated upon and the practical aspects of operation, data interpretation and maintenance are discussed in some detail. With this training, a VTA operator is considered to be qualified to set up and operate the instrument. In reality the trainee becomes familiar with positive detections but receives no training in the intricacies of the various strip chart presentations. Maintenance training consists of changing light bulbs and fuses, cleaning and replacing the sampling valve and valve housing, and preparing and replacing the chromatographic column. Experience has shown that the most extensive VTA down-time was attributable to electrical failures. Because of the electronic nature of the instrument, namely, its logic circuits, only a qualified technician should attempt to troubleshoot and correct these problems.

4.4 Instrument Limitations and Problem Areas: Limitations and problem areas experienced during this evaluation are discussed briefly in this section of the report.

a. Warm-up time is one of the major limitations of this system. Although the time required to raise the oven to the designated temperature was less than 45 minutes, the time required to achieve a stabilized standing current very often exceeded one hour. Without the stabilized standing current, the base line varied, presenting problems in data interpretation. In addition to the warm-up time, subsequent to testing, particularly at the elevated TNT temperatures (160-175°F), a 20 minute shut-down time was required to preclude any damage to the column.

b. A power requirement of 110/220 V AC, 50/60 Hz; 0.5 Kw, limits the versatility of the VTA in many field operations.

c. For many users, the most important feature of the VTA, next to its ability to detect dynamite is response time. The two primary factors affecting the VTA's response time are the sampling and retention times. Sampling time, preset by the manufacturer, is predicated upon the user's requirements. Presently, the manufacturer provides a choice of one of two capabilities: (1) either a 5 and 30 second sample time, or (2) a 30 and 60 second sample time. Once the instrument is set with a capability, the operator, by means of a toggle switch located under the Electrometer Panel, can switch to the desired sampling time. While the operator has no control, other than this, over the sampling time, he does have rather significant control over the retention time. To increase retention time the carrier gas pressure, column temperature or both, is decreased. To decrease retention time the carrier gas pressure or column temperature are increased or the column length shortened. Any combination of the three may be used to decrease retention time.

Typical sampling times: 5, 30, 60 seconds
Typical retention times: 9-35 seconds
Typical response times: 15-100 seconds

d. During initial testing, the lecture bottle pressure valve failed to properly regulate the gas flow. This problem was solved by reverting to the use of large gas cylinder.

e. A loose printed circuit board located in the power supply panel, was determined as the cause of the failure of the position lights. Replacement of the PCB corrected the malfunction.

f. Jamming of the strip chart recorder paper occurred several times. Improper positioning of the roll in its carriage and deformed rolls were the principal causes of jamming.

g. The light/sound alarm presented two types of malfunctions. On several occasions, the alarm actuated upon depression of the recorder ON-OFF button. This was corrected by depressing the Stop Alarm. The second malfunction was the failure of the alarm to stop after depression of the Stop Alarm button. A bad solder connection was discovered and the problem rectified.

h. Purging of the instrument subsequent to inoperative periods was required. Purging periods up to 15 minutes were required after the instrument was in the standby mode for from 1-2 hours. Saturation of the recorder and subsequent purging, particularly after sampling TNT, presented a serious and persistent hindrance to further testing.

i. During the course of testing, the most serious system component failure was the oven. The oven, which heats the column and detector, failed to maintain a stable elevated temperature. The instrument was returned to the manufacturer and the fault determined to lie in a malfunctioning thermocouple. A complete new oven assembly was obtained, and in addition, it was recommended that the valve housing be replaced with a new, modified housing. The entire operation resulted in a two-week cessation in testing.

j. Valve maintenance was required, as specified in the manual, after approximately 300 cycles. The "sniffing" fan acted as a miniature vacuum cleaner, drawing into the system lint and dust particles which lodged on the platinum wire, plugged the valve and rendered the VTA ineffective. Sampling of clothing, particularly pockets, accelerated this condition.

k. The chromatographic column required change only three times during the course of approximately 2000 valve cycles. Imminent column failure was discerned by peak broadening.

4.5 Dynamite and TNT Tests:

a. The series of tests pursued in this evaluation are outlined in Appendix II. During these tests, however, some modifications were made including the addition of tests considered pertinent or of considerable interest. The procedures followed in the operation of the VTA were those recommended in the accompanying instruction manual. In an effort to limit the number of test variables, the operating parameters were kept constant or restricted to a very narrow range, whenever possible.

Temperatures (Dynamite)	=	60, 75°C
Temperatures (TNT)	=	155, 175°C
Carrier Gas Pressure	=	30, 40 psi
Range, AFS	=	1×10^{-2}, 3×10^{-10}
Sampling Cycle	=	30 seconds

Originally, three explosives were to be evaluated. TNT, Dynamite and C-4. The initial tests indicated that C-4 could not be detected. It was deleted and only TNT and dynamite tests were conducted.

b. Attache Cases, Luggage and Wrapped Parcels Containing Dynamite:

(1) For the dynamite portion of these tests, one stick of dynamite was placed in each of the three types of containers after each container was sampled empty. The containers were sampled immediately, one hour and then 24 hours later. The results of these tests are reported in Table I.

(2) With the attache cases detection was observed with each sampling (See Figure 4). The sampling technique consisted of manually compressing the sides of the closed container and sampling the air expelled from the edges of the case.

(3) The luggage, contained rags (to simulate clothing) and toiletries, in addition to the dynamite. The luggage was examined in three positions: (a) Closed - using the compression technique employed with the attache cases; (b) Slightly Open - lifting the lid a sufficient distance to insert the probe to a depth of one to two inches and (c) Open - fully opening the luggage in order to examine the interior. Operating in the dynamite mode, no false alarms occurred during any of the luggage tests where only rags and toiletries were used. Detections were obtained upon the addition of dynamite. The most effective position for the detection of dynamite was the slightly open position.

(4) Next, two wrapped parcels were examined by sampling the exterior. One parcel contained a dynamite stick, the other, a dynamite stick enclosed in a heat-sealed polyethylene bag, wall thickness 3½ mils. After one hour, the stick of dynamite not in the plastic bag, produced strong positive detections. After the same period, positive, but weak detections were obtained from similar samples taken from the parcel containing the plastic-wrapped dynamite.

c. Attache Cases, Luggage and Wrapped Parcels Containing TNT:

(1) The TNT supplied in the tests was in flake form, having a 10% moisture content and packaged in a 500 gram bottle. The initial calibration tests revealed a signature for TNT (See Figure No. 5) with a peak

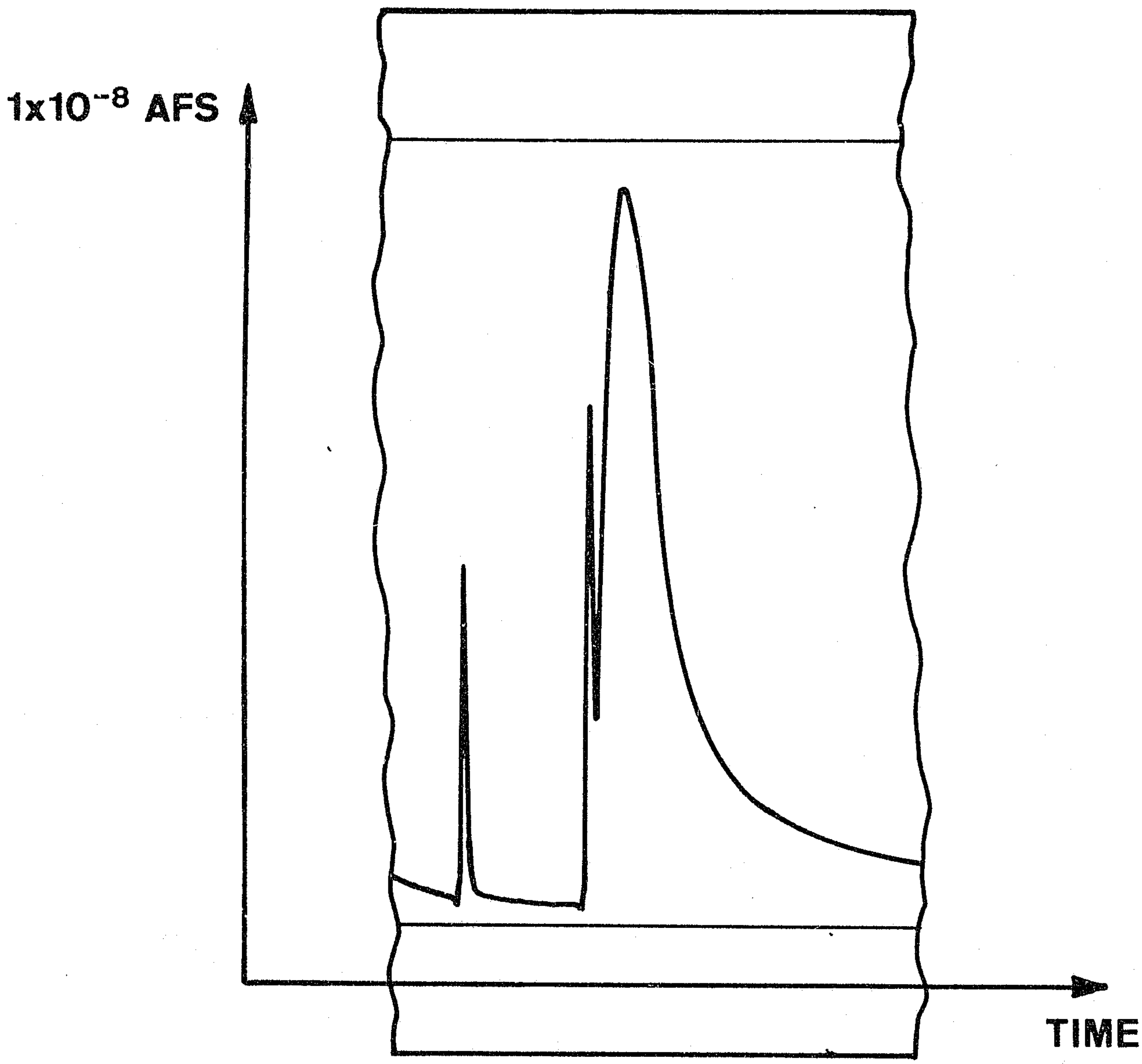

FIGURE 4. Vapor Trace Analyzer's Strip Chart Record of a Dynamite Detection

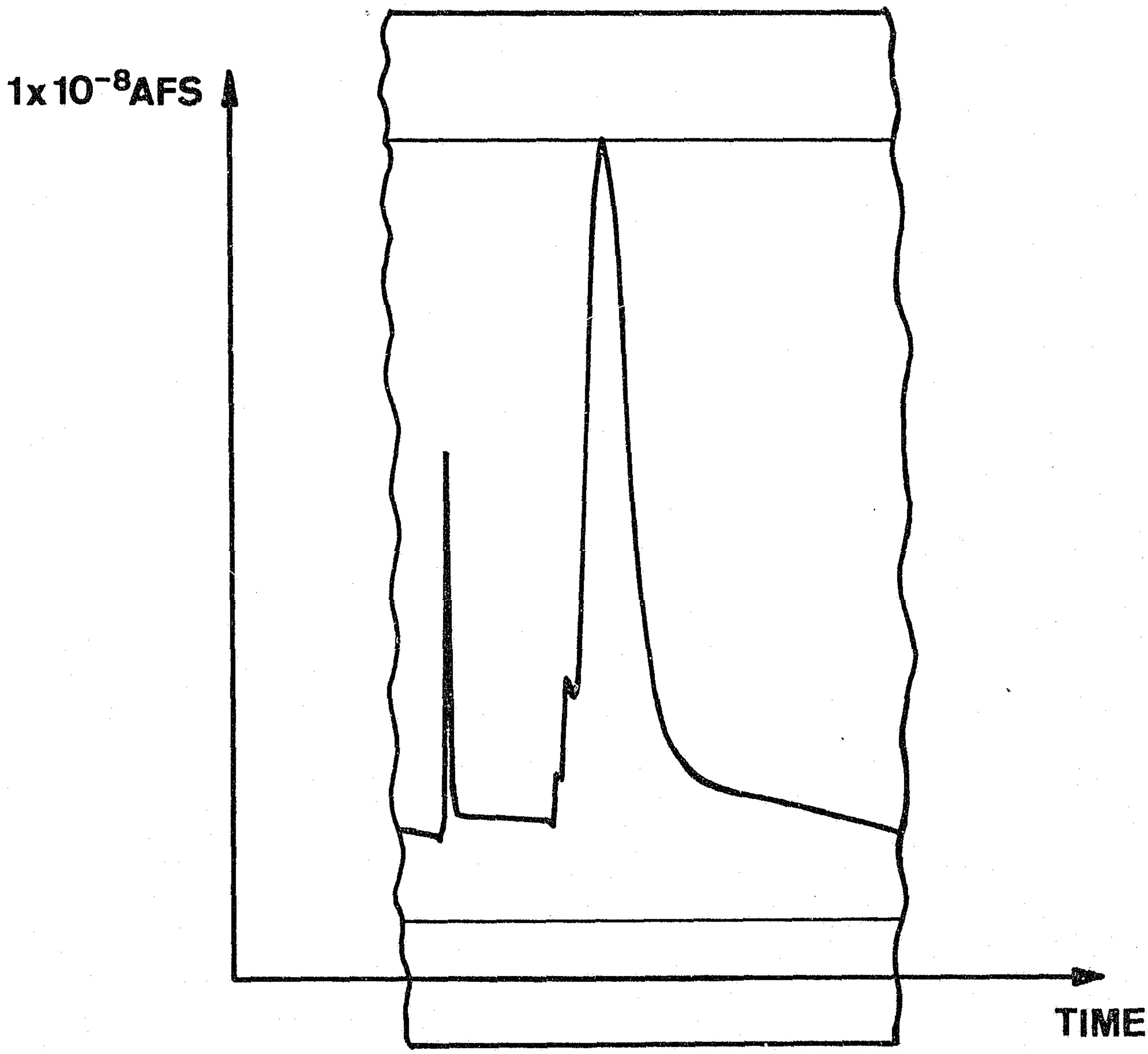

FIGURE 5. Vapor Trace Analyzer's Strip Chart Record of a TNT Detection(Before Drying TNT)

at a retention time (R.T.) of approximately 9 seconds. With the sound alarm set on the 9 second peak, (assumed to be the TNT peak) two toiletries,- Mennen's Skin Bracer and Right Guard deodorant used for the interference tests produced false alarms.

(2) It was decided to reduce the moisture content of the TNT. This was achieved by oven-drying, overnight, at a temperature of 75-80°C. After the drying, five six ounce samples of TNT were weighed and enclosed in heat-sealed, polyethylene bags (3½ mils wall thickness). Each bag was perforated with 30-40 pin holes to allow the vapors to diffuse through the polyethylene. These bags were used as the TNT test samples.

(3) A VTA chromatograph was taken to determine the signature of the dried TNT. It showed two peaks with the presence of a second peak, not seen previously. (See Figure 6). Setting the sound alarm on the second peak, as the identifying TNT peak, the toiletries were retested with no resulting false alarms. This shift in peak identification was in consonance with previous tests conducted by the manufacturer. The first peak was attributed to dintrotoluene (DNT), while the second peak was attributed to TNT. Henceforth, the second peak was utilized as the identifying TNT peak.

(4) The test procedures followed for the TNT tests were identical to those for dynamite. The results of these tests are reported in Table I.

(5) Achieving clear, concise TNT signals during the R.T. calibration was extremely difficult. The problem was attributed to the fact that in order to register a signal, the probe had to be placed in close proximity to the TNT. As a result, often times an excessive dose was received by the instrument causing saturation of the recorder. Subsequent purging of the instrument required anywhere from several minutes to a few hours before testing could resume.

(6) The detection evidenced on the one hour attache tests was assumed to be from an accumulation of TNT, the result of a large sample dose. While testing, when the initial peak appeared immediately, a series of blank cycles was conducted to purge the instrument. However, the magnitude of the signal, instead of decreasing, increased with continuing blank cycle runs until the peak achieved a maximum, then, gradually decreased as the instrument was purged. This phenomenon occurred several times, each time requiring approximately a dozen blank cycle runs to purge the instrument.

d. Individuals' Hands and Clothing: One-third of a dynamite stick, when handled by an individual for a period of 5-10 seconds, was sufficient to provide a strong detection signal. As with the container tests, detection of the presence of dynamite on individuals proved very successful. On one test, designed to simulate explosive removal due to manual activities, the subject was requested to rub the hands with a dry towel. The VTA detected all the subjects. Only after washing the hands with soap and water did the instrument fail to produce a 100% detection capability. Detections

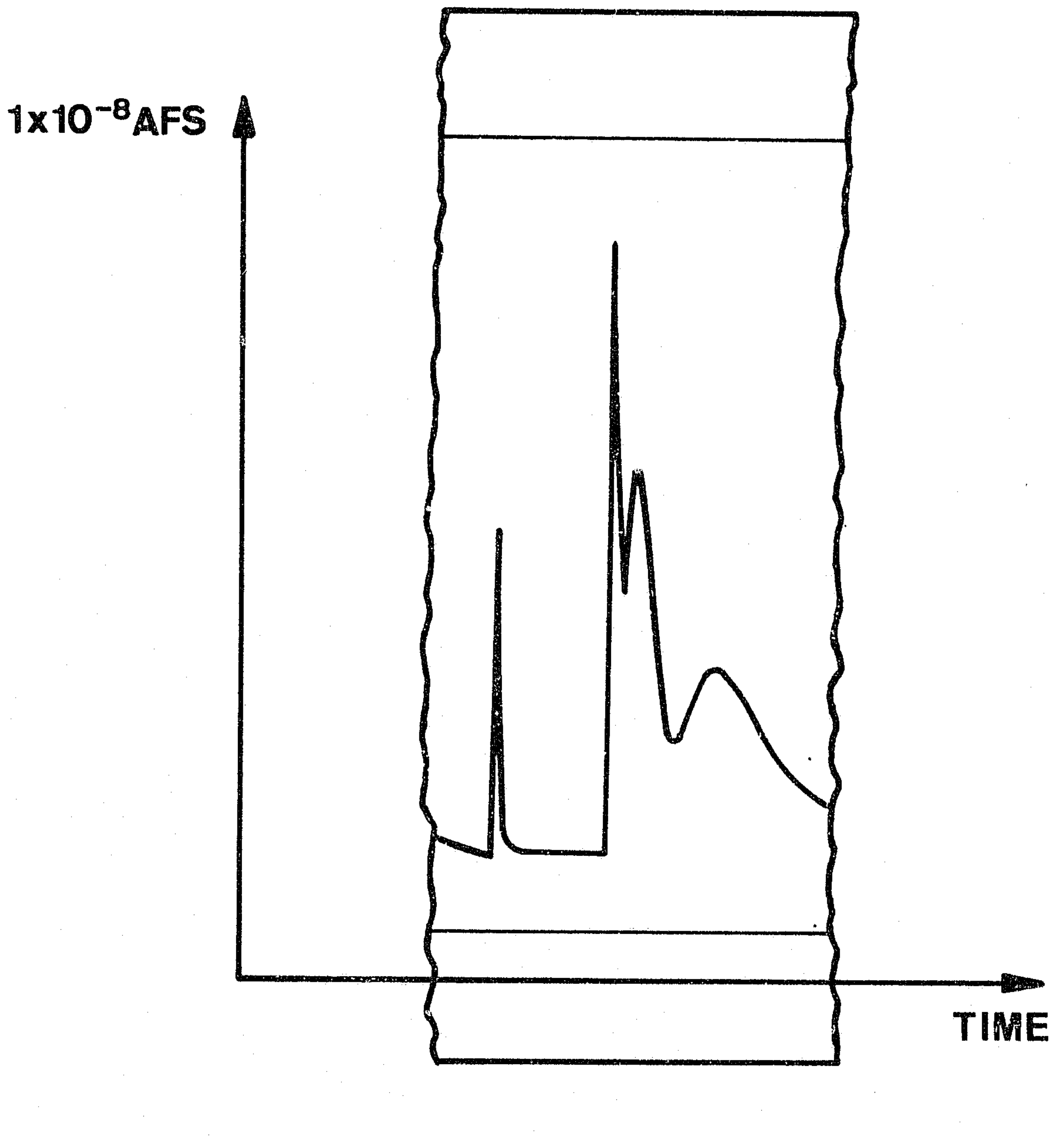

FIGURE 6. Vapor Trace Analyzer's Strip Chart Record of a TNT Detection (After Drying TNT)

of TNT were, at times, impossible to achieve using the identical conditions under which dynamite was detected. For example, the TNT required more than mere contact with the hands, as did dynamite. Rubbing the explosive into the palm of the hand was required. When sampling with the probe less than one inch from the contaminated area, whether on hands or clothing, no detections occurred. When contacting the same area with the probe, saturation of the recorder resulted. Although considerable care was exercised in sampling, saturation of the recorder was frequent and unavoidable with extensive periods of time expended purging the instrument. The results of these tests are reported in Table I.

e. Hypodermic Syringe Tests: Using a hypodermic syringe to pierce the packages a 100 cc air sample was extracted from the wrapped parcel that had contained an explosive for 24 hours. Three separate wrapped parcels were investigated. The first parcel contained one dynamite stick, the second, one dynamite stick enclosed in a heat-sealed polyethylene bag (3½ mil wall thickness) and the third, a TNT sample. The extracted sample was injected into the VTA probe over the 30 second sampling cycle. The results (Table II) showed the sample extracted from the parcel containing the dynamite produced a strong detection signal; from the plastic-wrapped dynamite, a weak detection signal and from the TNT parcel, no signal.

f. Vacuum Chamber Tests: Subsequent to the 24 hour wrapped parcel vacuum chamber tests, the parcel was placed in the chamber and subjected to a vacuum of 4 inches of mercury for a period of ten minutes. Upon repressurization to atmospheric pressure, air was sampled from the chamber through the suction tubing. With the dynamite parcel, air samples indicated positive detections. When the chamber contained the TNT parcel, no detections were observed. The results of these tests are reported in Table III.

f. Interferences:

(1) Several items were studied as potential interferences (Table IV) which would arise during the course of inspecting passengers and luggage for contraband explosives. These included: dynamite, TNT, C-4, shaving cream, shaving lotions, soaps, deodorants, rags and cigarette smoke. In the case of TNT and dynamite, each was evaluated as to its possible interference during operation in the other explosive's mode.

(2) There were two types of interferences encountered and both occurred while operating in the TNT mode. The first type of interference was noted during the initial tests conducted in the TNT mode. Here, the first peak of the TNT signature was utilized as the identifying peak with the result that two toiletries caused false alarms because of the proximity of their retention times to that of the TNT. However, by the drying technique previously discussed in Para. g.(1). above this problem was resolved.

(3) The second type of interference was that which caused the instrument to register detections while blank cycles were being run.

The cause of this problem was assumed to be the result of a large sample of explosive entering the instrument, adsorbing to the tubing, valves, etc., and subsequently desorbing at random intervals.

(4) None of the other items tested created interferences in the TNT mode and none of these items caused an interference while the VTA operated in the dynamite mode.

h. Room Tests:

(1) The objective of these tests was to determine the time required to detect dynamite after it had been planted in a room. A military, truck-mounted, expandable van, located adjacent to the VTA test facility (a 25' trailer) was selected to conduct these room tests. The van's interior dimensions were:

Height	6'3"
Width	13'8"
Length	17'1"

Total Volume = 1,459 cu ft

In order to gain access to the interior of the van for sampling, a 3/8" hole was drilled into each of the adjacent walls of the vehicles and a 3 ft teflon tube was inserted to bridge the gap between vehicles. This tubing served as the sample inlet to the room. All air samples taken from the uncontaminated van produced negative results. After placing the dynamite sticks in the van, the room temperature was read with all the doors and windows closed then the VTA actuated. The room was continually sampled until a detection was indicated.

(2) After each test the explosives were removed, the vapors exhausted and the van resampled and only upon the absence of a detection, verified by the VTA, was the dynamite replaced. No attempt was made to cover or conceal the explosives.

(3) During these tests, two electrometer scales - $1x10^{-8}$ and $3x10^{-10}$ AFS - were employed. After acquiring detections on the highest sensitivity scale, the electrometer was switched to the lowest sensitivity in order to determine if it also indicated a detection. It did in each instance.

5.0 RECOMMENDATIONS:

5.1 Redesign the VTA with a goal toward expanding its versatility to include field, as well as laboratory operations. Some design modifications which should be considered are reduction in overall size and weight, battery operation and reduction in the sampling and response time.

5.2 Develop more rapid and efficient techniques for sample collection which would be applicable in the detection of contraband explosives.

5.3 Conduct comparative evaluations with other available detectors to ascertain the relative effectiveness of the VTA in the role of an explosive detector.

5.4 Develop a manual which includes a thorough description not only of theory, but also of the VTA operation, data interpretation and maintenance.

Appendix I

Table I

Vapor Trace Analyzer Test Results for Dynamite and TNT Standard Sample Procedure, Ambient Conditions

Test Target	Target Mode	VTA Test Mode: Dynamite No. Tests	Dynamite No. Dect.	TNT No. Tests	TNT No. Dect.
Hands	Clean	10	0	4	0
	Contaminated with Dynamite	11	11	0	0
	Contaminated with TNT	0	0	4	4
	Wiped, Dry Towel	15	15	2	2
	Washed, Soap and Water	10	8	2	0
Clothing Pockets	Clean	9	0	4	0
	Contaminated with Dynamite	13	13	0	0
	Contaminated with TNT	0	0	3	3
Luggage	Open,-Empty	4	0	4	0
	Open,-with Rags (R)	4	0	4	0
	Open,-with Rags & Toiletries (RT)	4	0	4	0
	Immediately after insertion	-	-	-	-
	Closed,-RT + Dynamite	7	0	0	0
	Closed,-RT + TNT	0	0	4	0
	Slightly Open,-RT + Dynamite	4	4	0	0
	Slightly Open,-RT + TNT	0	0	4	0
	Full Open,-RT + Dynamite	4	0	0	0
	Full Open,-RT + TNT	0	0	4	0
	After One Hour Exposure	-	-	-	-
	Closed,-RT + Dynamite	4	1	0	0
	Closed,-RT + TNT	0	0	4	0
	Slightly Open,-RT + Dynamite	4	3	0	0
	Slightly Open,-RT + TNT	0	0	4	0
	Full Open,-RT + Dynamite	4	2	0	0
	Full Open,-RT + TNT	0	0	4	0
	After Twenty-Four Hours Exposure	-	-	-	-
	Closed,-RT + Dynamite	6	2	4	0
	Closed,-RT + TNT	0	0	0	0
	Slightly Open,-RT + Dynamite	4	4	4	0
	Slightly Open,-RT + TNT	0	0	0	0
	Open,-RT + Dynamite	4	4	4	0
	Open,-RT + TNT	0	0	0	0
Attache Case	Open Empty	4	0	4	0
	Closed,-Immediately after Dynamite Insertion	5	5	0	0
	Closed,-Immediately after TNT Insertion	0	0	5	0
	Closed,-One Hour After Dynamite Insertion	5	5	0	0

Table I (Continued)

Test Target	Target Mode	VTA Test Mode: Dynamite No. Tests	Dynamite No. Dect.	TNT No. Tests	TNT No. Dect.
Attache Case	Closed,-One Hour After TNT Insertion	0	0	5	1*
	Closed,-24 Hours After Dynamite Insertion	4	4	0	0
	Closed,-24 Hours After TNT Insertion	0	0	4	0
Parcels	Open Empty	5	0	2	0
	Wrapped,-Immediately After Prepared	-	-	-	-
	Dynamite as Received	3	3	0	0
	TNT as Received	0	0	2	0
	Dynamite Wrapped in Plastic	2	0	0	0
	Wrapped,-One Hour after Prepared	-	-	-	-
	Dynamite as Received	2	2	0	0
	TNT as Received	0	0	0	0
	Dynamite Wrapped in Plastic	2	2	0	0
	Wrapped,-24 Hours after Prepared	-	-	-	-
	Dynamite as Received	2	2	0	0
	TNT as Received	0	0	3	0
	Dynamite Wrapped in Plastic	2	2	0	0

* Detection not attributed to TNT.

Table II

Vapor Trace Analyzer Test Results for Dynamite and TNT Sample Taken by Piercing Parcel with Syringe

Test Target	Target Mode	VTA Test Mode: Dynamite No. Tests	Dynamite No. Dect.	TNT No. Tests	TNT No. Dect.
Room Air	Clean Room Air Through Syringe	2	0	2	0
Parcel	Wrapped 24 Hours After Preparation	-	-	-	-
	Dynamite	2	2	0	0
	TNT	0	0	2	0

Table III

Vapor Trace Analyzer Test Results for Dynamite and TNT

Parcel Placed in Vacuum Chamber

Chamber Pressure 4" of Mercury for Ten Minutes

Test Target	Target Mode	VTA Test Mode: Dynamite No. Tests	Dynamite No. Dect.	TNT No. Tests	TNT No. Dect.
Chamber	Clean	2	0	2	0
Parcel	Wrapped, 24 Hours after Preparation	-	-	-	-
	Dynamite	2	2	0	0
	TNT	0	0	2	0

Table IV

Vapor Trace Analyzer Test Results for Interference Materials

Test Target	VTA Test Mode: Dynamite No. Tests	Dynamite No. Dect.	TNT No. Tests	TNT No. Dect.
Old Spice Shampoo	2	0	2	0
Right Guard Deodorant	2	0	2*	0
Mennen's Skin Bracer	2	0	2*	0
Mennen's Spray Deodorant	2	0	2	0
Rapid Shave Cream	2	0	2	0
Dial Soap	2	0	2	0
Dynamite	-	-	2	0
TNT	2	0	-	-
C-4	2	0	2	0

* When 1st TNT peak was used false alarms occurred.

Table V

Vapor Trace Analyzer Test Results for Dynamite
Room Air Samples from Dynamite Storage Area

Room Temperature	No. Sticks Dynamite	Time Required for Detection (min.)
$44^{\circ}F$	1	22
$50^{\circ}F$	5	Immediate
$70^{\circ}F$	1	3

Record of VTA Operations:

Total Hours of Operation (approximately) = 150

Number of Valve Cycles (approximately) = 2,000

Appendix II

Evaluation Test Plan for the Vapor Trace Analyzer

Evaluation Test Plan for the Vapor Trace Analyzer

The evaluation test plan is as follows:

1. Type Explosive:

a. The three explosives to be employed in this evaluation will be: TNT, dynamite and plastic explosive. Each will be measured with the instrument under various conditions and in varying quantities.

b. The following will be the targets from which air samples will be investigated:

(1) Examination of An Individual's Hands:

(a) Before contact with each explosive.

(b) Immediately after contact with each explosive.

(c) After five minutes of manual labor subsequent to handling each explosive.

(d) After washing hands with soap and water.

(2) Examination of Clothing:

(a) Before contact with each explosive.

(b) After handling each explosive.

(c) After wiping hands on clothes while working with each explosive.

(d) After placing an unwrapped block of each explosive in a pocket and then removing it.

(e) After placing a block of each explosive, wrapped in plastic, in a pocket and then removing it.

(3) Examination of Luggage:

(a) Before contact with each explosive.

(b) Trace of explosive in closed and open luggage.

(c) Block of explosive (wrapped and bare) in closed and open luggage.

(4) Examination of Wrapped Parcels:

(a) One empty wrapped parcel.

(b) Three wrapped parcels, each containing an explosive.

(c) By means of a hypodermic syringe, extract an air sample from each of the parcels mentioned above.

(d) In a vacuum chamber, place a wrapped parcel. Seal the chamber and evacuate the air through a valve. Shut the valve and allow time for the vapors within to reach equilibrium. Open valve to the atmosphere and after repressurization, sample the air from the chamber.

2. Operator Training:

a. It is required that Hydronautics Inc. provide with delivery of the equipment at least one person qualified to operate the instrument and to train an operator on equipment operation and maintenance.

b. Some of the aspects of operator training which will be investigated are:

(1) To determine the number of persons and time required to assemble instrument.

(2) Does an operator require special skills to assemble, operate or maintain the equipment?

(3) Can the operator be trained to interpret the data he has collected?

3. Technical Characteristics: The following are the technical characteristics which will be investigated:

a. The effect of varying the detector's pressure and temperature.

b. Time required for each of the various functions of the detector (sampling time, etc.).

c. Total time required from sample intake to recorder printout (response time).

d. Power requirements.

e. Portability.

f. Life expectancy of replaceable components, e.g. teflon valve, chromatographic column, etc.

g. Ease of replacement of replaceable components.

h. Time required to flush between detections.

Appendix III

List of References

1. "Instruction Manual for Vapor Trace Analyzer, Model 103A" Hydronautics-Israel Ltd, Paras. 4-7, 10, 16.

2. Technical Manual 9-1300-21, "Military Explosives", Pages 7-81, Para. 7-28(h), November 1967.

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13. ABSTRACT

Hydronautics-Israel Ltd. has developed an instrument known as the Vapor Trace Analyzer (VTA) for detecting vapors of TNT and nitroglycerin-based dynamite. The Defense Special Projects Group (DSPG) has funded the U.S. Army Land Warfare Laboratory to assess the capabilities of the VTA as an explosive detector. This report describes a series of tests which attempt to assess the VTA's ability to detect explosive vapors emanating from people and clothing which have been in contact with explosives and from luggage and wrapped postal parcels that contained or had contained explosives. Dynamite, TNT and C-4 were the explosives employed during these tests.

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