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A Survey of High Explosives Traces in Public Places

REFERENCE: Crowson CA, Cullum HE, Hiley RW, Lowe AM. A survey of high explosives traces in public places. J Forensic Sci 1996;41(6):980–989.

ABSTRACT: This survey was carried out to determine the background levels of explosives traces in public places. Samples were taken at various transport sites. Police sites were also sampled to assess how likely it is that a suspect could be contaminated. The survey showed that traces of the high explosives nitroglycerine (NG), trinitrotoluene (TNT), pentaerythritol tetranitrate (PETN), and cyclotrimethylene trinitramine (RDX) are rare within the general public environment. Only four low level traces of RDX were detected. NG, probably associated with the use of firearms, was detected at a number of police sites, but traces of other explosives were rare. The results of the survey indicate that it is unlikely that someone in public areas could become significantly contaminated with explosives. Traces of NG found on suspects who have had contact with police sites must be interpreted in the light of the survey results. The analytical procedures used would also have detected ethylene glycol dinitrate (EGDN) if present at levels greater than 2 ng, mononitrotoluenes, if present, at levels greater than 50 ng and the most common isomers of dinitrotoluene if these had been present at levels in excess of 10 ng. None of these were detected. The relatively high volatility of EGDN and the mononitrotoluenes would, however, cause traces of these compounds to disperse rapidly.

KEYWORDS: forensic science, explosives traces, survey, ethylene glycol dinitrate, nitroglycerine, trinitrotoluene, pentaerythritol tetranitrate, cyclotrimethylenetrinitramine, dinitrotoluene, mononitrotoluene

Currently, only limited and unsystematic data are available to assess the likelihood that a suspect might have become innocently contaminated with traces of high explosives through contact with the general public environment. The aim of the work described in this paper was to increase the available data so that better assessments of the likelihood of innocent contamination may be made. To the knowledge of the authors, no such survey has previously been reported in the open literature.

Public means of transport come into contact with very large numbers of people, from a wide cross section of society, and were thus considered particularly suitable as sampling sites to measure the extent of trace explosives contamination in the public environment. Samples were therefore taken from taxis, buses, underground (subway) trains, underground stations, passenger aircraft, and airports.

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Suspects might also argue that they had become innocently contaminated with explosives traces during detention at police stations or travel in police vehicles. Therefore, samples were collected from police station custody suites, police vehicles, and civilian personnel working at police stations.

Forensic trace explosives samples are normally collected either by wiping a surface with a swab, or by vacuum onto a filter. The former technique is best suited to nonporous surfaces such as hands or table tops, and the latter is often used for rough, porous surfaces such as textiles. Both of these techniques were used as appropriate, during the survey.

Materials and Methods

Sampling Kits

To ensure consistent and easy sampling of a variety of different sites, it was decided to design and build standardized sampling kits. The resulting kits contained all materials required to take swab samples, including quality-assured cotton wool swabs, ethanol to moisten the swabs, and five pairs of disposable gloves. Figure 1 is a photograph of a sampling kit.

Each kit was packed into a labeled Securitainer (a cylindrical plastic pot with sealable lid), which was then double wrapped in nylon bags. All 140 kits were built on one day, the whole procedure being carried out in a dedicated explosives trace laboratory, which is regularly sampled to ensure the absence of explosives traces. Each kit was given a unique number to identify it. In addition to the specially built sampling kits, standard hand-test kits previously prepared by the laboratory were used from stock, and some standard premise kits were used in the supplementary sampling of taxis. These kits are prepared and quality assured in essentially

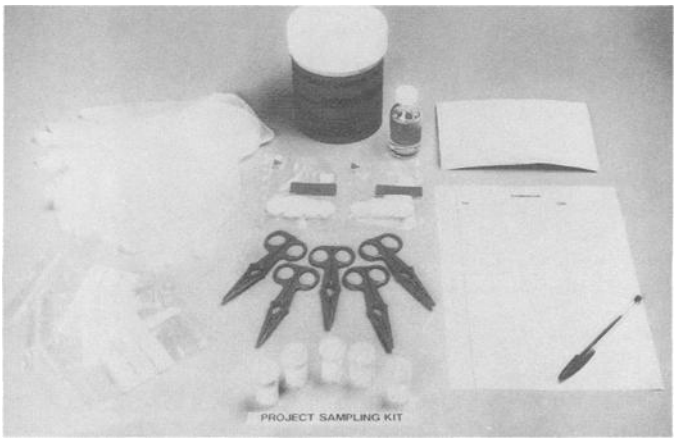

FIG. 1—*Photograph showing the contents of a sampling kit.*

the same way as the specially manufactured survey kits. The hand-test kits contain materials for taking ethanol-soaked cotton wool swabs from hands and scrapings from under fingernails, and the premise kits were very similar to the kits specially built for the project.

Kits were also prepared for the taking of samples by vacuum, and used with a portable Whatman twin-head vacuum pump. The kits contained either two or three vacuum tubes in self-sealing polythene bags and a length of plastic tubing (approximately 1.5 m) for connection to the pump. The vacuum tubes consisted of 8-mL capacity glass syringe barrels with 4-mm luer fittings. Placed into the base of each tube was a 13-mm outside diameter AP25 prefilter beneath a 13-mm outside diameter PTFE/HDPE membrane filter. The wide ends of the syringe barrels were sealed with size 13 solid rubber bungs before and after use.

Quality Assurance of Sampling Kits

One in 20 of the kits built were quality-assurance tested as follows:

(1) enter the trace laboratory according to the standard operating procedure, donning a disposable oversuit, overshoes, and gloves;
(2) clean the workbench and cover with glazed paper;
(3) put on a clean pair of disposable gloves, take a control swab sample from the glazed paper, and the front of the oversuit;
(4) open the kit to be tested and don a pair of gloves from the kit. Remove the glazed paper from the kit and open it out on the work surface;
(5) lay out the contents of the kit onto its glazed paper;
(6) use one pair of the kit forceps and the pair of gloves currently being worn for all the swabbing. Use five swabs, each moistened with methyl-*tert*-butyl ether (MTBE) solvent, to sample in turn the kit gloves, forceps and solvent bottle exterior, securitainer and lid, note paper and pen, and glazed paper, placing each swab in a separate labeled vial taken from the kit after use;
(7) extract the samples by adding 4 mL of MTBE to the first vial and pounding the swab with a Pasteur pipette. Use the pipette to transfer the MTBE to the next vial and repeat the procedure for each vial, finally, transferring the MTBE solution to a fresh nonkit labeled vial;
(8) repeat this procedure with two further aliquots of MTBE to produce a final extract of about 12 mL;
(9) evaporate the sample to 0.75 mL under nitrogen and add 4.25 mL of n-pentane; and
(10) clean up the extract (using the method outlined below) and analyze.

The kit ethanol was quality assured separately in each case by transferring 5 mL to an evaporation tube, evaporating down to about 20 μL under nitrogen, adding 5 mL of 15:85 MTBE:n-pentane solvent and using the normal clean up and analysis procedures. In addition to the samples produced from the kits, control samples taken during the preparation of kit components, the building of the kits, and the quality assurance of the kits, were also worked up, cleaned up and analyzed. All of the chosen kits and the control samples were found to be free of explosives.

Sampling of the Chosen Areas

On arrival at the chosen site, personnel carrying out the sampling donned a disposable suit and boots where appropriate. The specially built sampling kits were then used as follows:

(1) open the kit, keeping it in the nylon bag, don a pair of gloves, and lay out the contents of the kit on the glazed paper;
(2) take a control swab sample from the glazed paper and the front of the oversuit;
(3) use the pen and note paper to draw a plan of the site, and note each area to be sampled;
(4) don a fresh pair of gloves and swab the first area. Label the swab vial;
(5) repeat for the remaining areas using fresh gloves, forceps, vials, and swabs for each area. (The kits contained some spare swabs that could be used if an area required more than one swab.); and
(6) seal the samples and notes into the securitainer and seal this into a nylon bag.

The hand-test kits were used in an essentially similar fashion to take swab samples from hands and (gently) to recover any material trapped under fingernails. Vacuum sampling was carried out as follows:

(1) fit the tubing to the vacuum pump (turned off) at one end and to a vacuum tube at the other;
(2) remove the rubber bung from the end of the vacuum tube and turn on the vacuum pump. Check that the filter and prefilter have not been displaced from the base of the tube;
(3) use the first vacuum tube as a control. Draw clean air through it for 1 to 2 min. Switch off the pump, disconnect, restopper, and return the tube to its self-sealing bag labeled as a control;
(4) connect another vacuum tube, remove the bung, and switch on the pump;
(5) pass the vacuum tube over the surface at an angle, making light contact with that surface. The effect of this is to disturb any dust and particulate matter, which is then sucked into the vacuum tube. Continue until either the vacuum tube is full or the desired surface has been completely sampled; and
(6) turn the vacuum pump off, disconnect the vacuum tube, and replace the bung.

Each site required different samples to be taken; even within each class of site, there were significant differences. However, in every case, the areas chosen for sampling were those that were most likely to have been in contact with people and their clothing. Typical areas for each class of site are given in Table 1.

All of the areas were sampled either during or after their normal usage and before any cleaning procedures were carried out. Only two passenger aircraft were sampled because of the difficulties involved due to the very rapid turnaround of such aircraft needed to maximize their air time.

Processing of the Samples

All sample processing was carried out in the trace laboratory. Each kit and each sample were processed separately to avoid cross-contamination. Swabs in vials were removed from the Securitainer and a fresh set of laboratory vials was labeled to correspond with the sample vials. Any excess ethanol was removed from each swab

TABLE 1—*Areas sampled.*

Site	Number sampled	Areas sampled
Taxis	25	Passenger seats, folding seats, upholstery floor, inside of doors and windows, armrests, and glass partition.
Buses	10	Seat hand rails—lower deck, grab rails—lower deck, window fastenings—whole bus, stairway grab rails, money tray, bell pushers, seat hand rails—upper deck, grab rails—upper deck, seat upholstery—lower deck, seat upholstery—upper deck.
Underground trains	11	Grab rails, strap handles, PVC seat tops, armrests, and door buttons.
Underground stations	4	Ticket machines, ticket barriers, public telephones, journey planners, escalator belts, stairway grab rails, and platform seats.
Passenger aircraft	2	Armrests, seats, toilet doors and handles, trays, door seals, air filters, and luggage compartment handles.
Airports	2	Baggage search benches, baggage search X-ray machine belts, baggage trolley handles, travelator belts, escalator belts, departure lounge seats, departure lounge tables, and departure lounge telephones.
Police station custody suites	9	Cell bench and mattress, cell walls, cell door interior, cell call bells and toilet flushers, custody officers desk and benches, fingerprint room and equipment, and interview room desks and chairs.
Police vehicles	21	Instruments, gear stick, steering wheel, dashboard, inside of front doors and windows, inside of rear doors and windows, seats, and upholstery floor.

using a Pasteur pipette and transferred to the appropriate vial. The ethanol was evaporated down to 20 μL under nitrogen on a heating block set at 80°C. The swab was further extracted with three 4-mL aliquots of MTBE, pounding the swab thoroughly with the Pasteur pipette after adding each aliquot. The aliquots were added to the appropriately labeled vial (already containing the remaining ethanol) and evaporated down to leave 0.75 mL of solution. 4.25 mL of n-pentane was then added. The resulting sample was cleaned up using the method outlined below (1,2). Each vacuum tube was extracted by adding 12 mL of MTBE in three 4-mL aliquots. The eluate was collected in an appropriately labeled vial, evaporated, and cleaned up in the same way as the swab extracts.

Summary of Cleanup Process

Cleanup tubes consisted of a 230-mm glass Pasteur pipette containing a 4-mm depth of Amberlite XAD-7 polymeric adsorbant confined between discs of Whatman GF/D glass fiber filter paper. Each cleanup tube was washed thoroughly before use, first with 1 mL of ethyl acetate, then with 1 mL of MTBE, and finally, with 1 mL of 15:85 MTBE:n-pentane. The sample was passed through the cleanup tube under gravity flow and the eluate retained. A further 1 mL of 15:85 MTBE:n-pentane was then passed through the tube and the XAD-7 was blown free of solvent. Explosives were retained on the XAD-7 and were recovered by eluting with 0.8 mL of ethyl acetate. The resulting final extract was collected in an appropriately labeled septum vial with a microvolume insert. It was concentrated down to about 50 μL under a stream of dry nitrogen at room temperature ready for analysis.

Analysis of Samples

Gas chromatography with chemiluminescence detection (GC/TEA) (3), and where necessary, combined gas chromatography/mass spectrometry (GC/MS) were used to detect, identify, and confirm the presence of explosives traces. Although the most common high explosives ethylene glycol-dinitrate (EGDN); NG, TNT, PETN, RDX, the mononitrotoluenes, and dinitrotoluenes may all be detected by these techniques, the explosive cyclotetramethylene tetranitramine (HMX) and the propellant ingredient nitrocellulose are not sufficiently volatile to be detected. The inability to detect these materials was not regarded as a significant drawback because HMX is a very uncommon explosive normally used together with the more common explosives, and nitrocellulose has uses other than as an explosive; for example, in paints and coatings. Thus, the detection of nitrocellulose alone would be of little evidential value. It would, in principle, be possible to conduct a background survey for HMX using techniques such as combined liquid chromatography/mass spectrometry.

The volume of each extract was estimated before analysis by comparing it by eye with a known volume of ethyl acetate in a similar vial. If a sample appeared particularly dirty, it was concentrated only to about 100 μL so as not to overconcentrate any contaminants that might have caused degradation of the GC/TEA and GC/MS analytical systems. A standard solution (known as TEA standard) containing 11 common explosives was used for retention time comparisons. The composition of the solution is given in Table 2.

A solution containing 5 ng/μL, each of 2-fluoro-5-nitrotoluene (FNT), and the fragrance Musk Tibetine (2,6-dinitro-3,4,5-trimethyl-*tert*-butylbenzene, MT) in ethyl acetate solvent (mixed reference solution) was used as a retention time reference. An aliquot of each sample or standard solution is combined in a microlitre syringe with this reference solution before injection.

The GC ovens were Carlo Erba Mega Series ovens of types HRGC 5300, HRGC 5300-HT, or 8000 series with split/splitless injection ports having glass liners lightly plugged at the midpoint with deactivated silica wool. Three types of GC column were used under the conditions given in Table 3.

TABLE 2—*Composition of explosives standard solution.*

Explosive	Concentration (ng/μL)
Ethylene glycol dinitrate (EGDN)	0.1
2-nitrotoluene (2-NT)	0.6
3-nitrotoluene (3-NT)	0.6
4-nitrotoluene (4-NT)	0.6
nitroglycerine (NG)	0.2
2,4-dinitrotoluene (2,4-DNT)	0.4
2,6-dinitrotoluene (2,6-DNT)	0.3
3,4-dinitrotoluene (3,4-DNT)	0.2
2,4,6-trinitrotoluene (TNT)	0.4
Pentaerythritol tetranitrate (PETN)	0.75
Cyclotrimethylene trinitramine (RDX)	0.5

TABLE 3—*Details of gas chromatography columns.*

Column	Oven program	Carrier pressure
SGE type 12QC2/BP1 0.25. 12-m polyimide clad silica, 0.22-mm ID, 0.33-mm OD, coated with bonded dimethylsiloxane 0.25-μm film thickness.	80°C/1 min + 20°C/min to 200°C/2 min.	250 kPa
SGE type 12QC2/BP5 0.25. 12-m polyimide clad silica, 0.22-mm ID, 0.33-mm OD, coated with bonded 5% diphenyldimethylsiloxane 0.25-μm film thickness.	80°C/1 min + 20°C/min to 200°C/2 min.	250 kPa
Chrompack CP-Sil-19CB, 4-m cut from 25-m polyimide clad silica, 0.25-mm ID, 0.39-mm OD, coated with bonded 7% cyanopropyl-7% phenyl-1% vinyldimethylsiloxane 0.21-μm film thickness.	70°C/1 min + 20°C/min to 250°C/2 min.	70 kPa

The detectors were Thermedics TEA Model 610 detectors modified to minimize dead volume. The instrument settings were as follows:

- pyrolysis oven temperature: 750°C,
- interface oven temperature: 250°C,
- reaction chamber pressure reading: 0.5–2mmHg (70–270Pa), and
- thermoelectric cooler temperature reading: −5°C to −10°C.

Data collection, integration, and plotting was carried out using Hewlett-Packard 3365 Chemstation software and hardware. TEA standard was always injected before analyzing samples to check that the systems were operating correctly and to provide a means of calibration. Along with 0.2 μL of mixed reference solution, 0.8 μL of TEA standard solution was injected, and the resulting chromatogram was examined. A typical TEA standard chromatogram for the BP5 column type is given in Fig. 2. The peak height responses to RDX and PETN were compared with that for TNT. If they were less than 50% of the TNT response, then remedial action was taken to restore the instrument response.

Standard analyses were carried out both before and following the analyses of samples. If a sample was found to be explosives free, a following sample was analyzed. If this further sample was also found to be explosives free, another sample was analyzed. After any sample that yielded possible explosives peaks, the TEA standard was analyzed. Different syringes were used for injecting samples onto each of the three column types, and standards were always injected using a syringe set apart for this purpose.

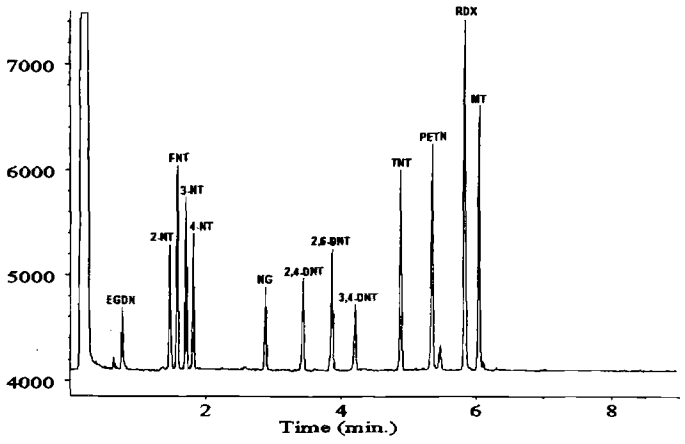

FIG. 2—*A typical TEA standard chromatogram for the BP5 column type.*

Interpretation of Chromatograms

Each sample chromatogram was examined looking for distinct and well-formed peaks. To be distinct, a peak must be at least three times as intense as the baseline noise level in adjacent portions of the chromatogram. Peaks that were obviously broad or in other ways malformed when compared with the peak shape of the corresponding explosive standard were rejected. If any candidate peaks were present, their relative retention times (RRT) were compared with those of the explosive standards most recently analyzed. The relative retention times were calculated from the following expression:

$$\textit{Relative retention time} = \frac{\textit{Retention time of peak}}{\textit{Retention time of reference marker}}$$

The reference marker chosen was that which was closest to the suspect peak, but if as sometimes happens, one of the markers was obscured, the other was used. If the RRT of any sample peak was within ± 0.5% of that of a standard explosive, then that explosive was recorded as having been possibly detected using that particular column type. The percentage difference in RRT's was calculated as follows:

$$\textit{RRT percentage difference} = 100 \times \frac{[RRT_{samp} - RRT_{std}]}{RRT_{std}}$$

The mass of an explosive possibly detected in a sample injection was estimated by a comparison of its peak area with that of the corresponding standard peak. The following expression was used to calculate the mass injected:

$$\textit{Mass sample injected} = \textit{Mass standard injected} \times \frac{\textit{Peak area}_{sample}}{\textit{Peak area}_{standard}}$$

The total mass of explosive in the sample solution was estimated using the following expression:

$$\textit{Total mass} = \textit{Mass injected} \times \frac{\textit{Total volume of sample}}{\textit{Volume injected}}$$

The precision of the resulting estimate is relatively poor. For explosives other than PETN, errors of ± 30% are to be expected, although for PETN, errors of ± 60% are probable, assuming single analyses of standard and sample in each case. These estimates are based upon coefficients of peak area variation measured for clean solutions and take the probable errors to be twice the expected

coefficient of variation. The presence of contaminants in the sample solutions will reduce the expected precision even further.

Detection using a single column type was not regarded as sufficient for confirmed identification of an explosive. Samples in which one or more explosives had been possibly detected on one column type were subsequently analyzed (confirmed) using a second column type, and if necessary, a third. A positive explosive detection was only recorded if analyses using all three column types gave consistent results. This procedure is the same as that applied to forensic samples analyzed at the Forensic Explosives Laboratory. Quantitative results presented in the tables are the average of the three analyses.

Samples found to contain RDX were analyzed by GC/MS for further confirmation of this identification. The analytical system consisted of a Fisons/Carlo-Erba 8000 series GC operated as for the GC/TEA method, connected to a Fisons/VG MD800 Quadrupole mass spectrometer operated in electron impact mode at unit mass resolution. The gas chromatograph contained a BP-5 column. Mass spectra were directly compared with those obtained when TEA standard solution was analyzed under identical conditions.

Results and Discussion

Background Information

When interpreting the results presented below, it is necessary to bear in mind that many people have legitimate access to explosives and could thus act as a source of contamination. Such people include military personnel and quarry workers. In addition, some explosives are used in other applications, for instance, PETN and NG have some medical uses. In the past, NG was very widely used in the manufacture of commercial blasting explosives, but this usage has nowadays almost ceased. NG is still commonly used in gun propellant formulations. TNT and RDX are used in military explosives, and PETN is used in detonating cord. RDX and PETN can be found in Semtex-H, which is a plastic explosive, similar to those used for military demolition purposes. In recent years, the Provisional IRA have made use of Semtex-H and PETN detonating cord during their terrorist activities in the United Kingdom.

It should be noted that in most cases, the samples were taken from a relatively large surface area compared with that of a human hand. A person coming into contact with the chosen surface would normally be exposed to a much smaller area than what was sampled. Thus, contact transfer of explosives traces from the surfaces sampled would probably not result in contamination of the person to the same level as that upon the whole surface.

Taxis

Ten taxis waiting in the taxi rank at Heathrow airport were sampled. Taxis from this rank make frequent return trips to central London and surrounding areas. Visual inspection and information gained from the taxi drivers suggested that they had not been thoroughly cleaned inside for a long time. The analysis results are presented in Table 4. Only two of the taxis contained any explosives traces. Taxi 2 yielded two low level traces of RDX, and Taxi 6 yielded one very low level trace of RDX. Such levels are consistent with the taxis having transported items or people contaminated with explosives. A chromatogram for the vacuum sample of the passenger seat of Taxi 8 using a BP5 column is given in Fig. 3, as an example of a negative chromatogram for a relatively dirty

TABLE 4—*Taxi results.*

Taxi	No. of areas sampled	Area of detection	Explosive detected	Approx. amount (ng)
1	6	none	NED*	NED*
2	6	glass partition	RDX	7
		passenger seats	RDX	18
3	5	none	NED*	NED*
4	6	none	NED*	NED*
5	5	none	NED*	NED*
6	4	inside of doors and grab handles	RDX	5
7	5	none	NED*	NED*
8	5	none	NED*	NED*
9	5	none	NED*	NED*
10	5	none	NED*	NED*

*NED = no explosives detected.

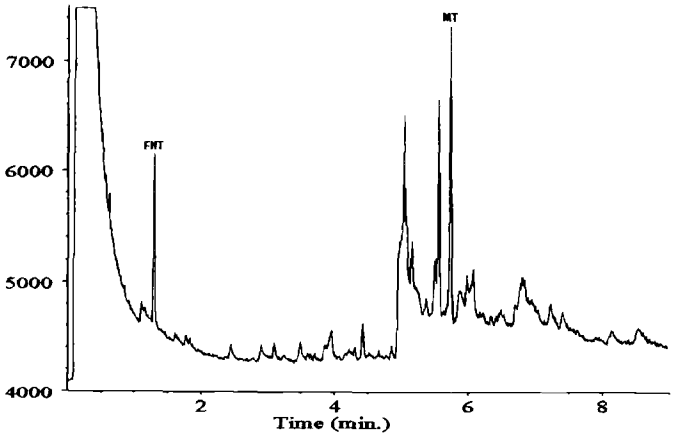

FIG. 3—*An example of a negative chromatogram for a relatively dirty sample—taxi 8 vacuum sample of passenger seat—BP5 column.*

sample. This data seemed to indicate that a surprisingly high proportion of taxis contain explosives traces, when compared with the data as a whole. Therefore, it was necessary to investigate further by sampling more taxis. Ten more taxis were sampled at Heathrow airport, and a further five in the taxi center on Pancras Road in central London. None of these taxis were found to contain explosives traces. The results are summarized in Table 5. These results suggest that the first ten taxis were not typical of the entire population of taxis and highlight the danger of drawing statistical conclusions from very small samples of a given population.

Buses

A total of ten buses from three separate London Buses Ltd. garages, Tottenham, Bow, and Stockwell, each used for different routes, were sampled. Buses K858LGN and WLT994 were single deck buses although the others were double deck. The results are summarized in Table 6. No explosives were detected in samples taken from the buses at Stockwell garage (BYX242V, K858LGN, G132PGK, and WLT994) or those from buses at Bow garage (JJD444D and KYV549X). Controls taken on the day when four buses were sampled at Tottenham garage were found to contain RDX. Thus, all results for samples taken on this day have been disregarded. The cause of the positive controls was investigated and eliminated to revisit Tottenham garage. On the second visit, samples were taken from two buses previously sampled (B164

TABLE 5—*Taxi results—supplementary sampling.*

Taxi	No. of areas sampled	Area of detection	Explosive detected	Approx. amount (ng)
11	4	none	NED*	NED*
12	5	none	NED*	NED*
13	6	none	NED*	NED*
14	5	none	NED*	NED*
15	6	none	NED*	NED*
16	4	none	NED*	NED*
17	4	none	NED*	NED*
18	5	none	NED*	NED*
19	5	none	NED*	NED*
20	5	none	NED*	NED*
21	5	none	NED*	NED*
22	6	none	NED*	NED*
23	4	none	NED*	NED*
24	4	none	NED*	NED*
25	4	none	NED*	NED*

*NED = no explosives detected.

TABLE 6—*Bus results.*

Bus	No. of areas sampled	Area of detection	Explosive detected	Approx. amount (ng)
BYX242V	11	none	NED*	NED*
K858LGN	4	none	NED*	NED*
JJD444D	9	none	NED*	NED*
KYV549X	10	none	NED*	NED*
G132PGK	10	none	NED*	NED*
WLT994	6	none	NED*	NED*
B164 WUL	10	none	NED*	NED*
SMK 708F	9	none	NED*	NED*
JJD 391D	9	none	NED*	NED*
CUV 340C	9	none	NED*	NED*

*NED = no explosives detected.

WUL, SMK 708F), and a further two buses (JJD 391D, CUV 340C). No explosives were detected in all samples and controls taken on the second visit. Investigations suggested that the positive controls had resulted from the inadvertent use of a vehicle previously contaminated by RDX for travel to the sampling site. The vehicle in question was only used for the initial visit to Tottenham garage.

Underground Trains

Underground trains at the Golders Green and Ealing Broadway depots were sampled. These trains serve the Northern and District lines respectively. The underground train samples were mainly analyzed using composite injections, consisting of 0.2 μL of each of four samples from the same carriage, because their contaminant content was low. No explosives were detected in any of the samples. In view of the number of people using each underground carriage during the morning rush hour in central London, if there was any significant background in the environment, one would expect to detect explosives traces in these carriages. No vacuum samples were taken from underground carriages because of the lack of 240 V electrical supplies at the sites. A chromatogram of a composite injection of the four samples taken from underground carriage 7078, using a BP1 column, is given in Fig. 4 as an example of a negative chromatogram for a relatively clean sample.

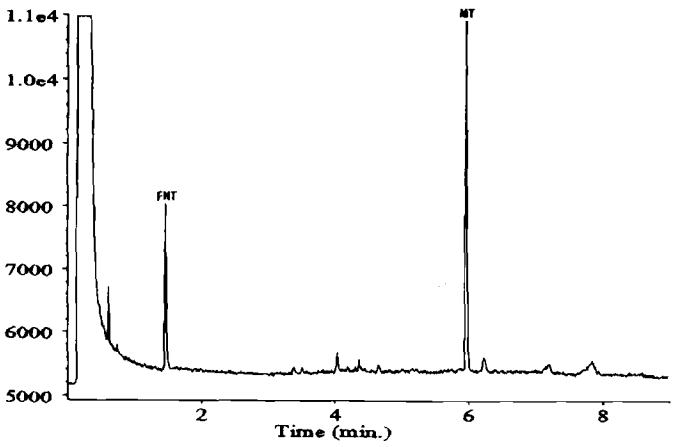

FIG. 4—*An example of a negative chromatogram for a relatively clean sample—underground carriage 7078 composite injection—BP1 column.*

Underground Stations

Samples were taken at Paddington, Piccadilly Circus, Green Park, and Baker Street, all of which are central London interchange stations. No explosives were found in any of the samples taken from underground stations. The point made above regarding the numbers of people using underground trains applies equally to stations. No vacuum samples were taken at the underground stations because there were no upholstered areas.

Passenger Aircraft

Samples were taken from two British Airways aircraft, a Boeing 767, flight number BA657, arriving at Heathrow airport from Tel Aviv, and a Boeing 737, flight number BA2004, arriving at Gatwick airport from Manchester. The results are summarized in Table 7 along with those for the airports. No explosives were detected in samples taken from either of the aircraft.

Airports

Samples were taken at both Heathrow and Gatwick airports. Only one explosives trace was detected, a low level trace of RDX on the 10 grey plastic work tops of the central search area at Gatwick airport. This may reflect the fact that many military personnel pass through the airport, and they could be contaminated with RDX. The chromatogram for this sample, analyzed using a

TABLE 7—*Airport and aircraft results.*

Airport/ aircraft	No. of areas sampled	Area of detection	Explosive detected	Approx. amount (ng)
Gatwick airport	16	work tops central search area	RDX	19
Heathrow airport	18	none	NED*	NED*
Boeing 767 at Heathrow	8	none	NED*	NED*
Boeing 737 at Gatwick	7	none	NED*	NED*

*NED = no explosives detected.

BP5 column, is contained in Fig. 5 as an example of a positive chromatogram. Bearing in mind the number of people using these airports on a daily basis, if there was any significant background level of explosives in the environment, the discovery of many more traces would have been expected. The results for the airports are summarized in Table 7 along with those for the passenger aircraft.

Police Station Custody Suites

The results for the sampling carried out at nine police station custody suites are contained in Table 8. No explosives traces were detected in four of the nine police stations, and only 8 of the 87 samples taken contained any explosives traces. The presence of low levels of NG is not surprising because armed officers will frequently be passing through custody suites, and NG is used in gun propellants. Therefore, NG traces from materials or suspects that have had contact with uncontrolled police premises must be interpreted accordingly. Indeed, cell nine at Heathrow police station is used for the storage of firearms and suspected firearms collected from suspects, thus, providing an interesting comparison. The NG peak on the BP-1 system for cell nine at Heathrow police station had a relative retention time difference of 1.02%, which is outside the limits given in the standard method. However, because it was a large clear peak and within the limits on the BP-5 and CPSIL systems, it has been recorded as NG.

A very low level of RDX was found on the desks in the main office of Paddington Green Secure Unit. However, to set this in context, there was less RDX than that which would cause serious concern if detected during the weekly quality assurance procedure carried out in the FEL trace explosives laboratory. Following the discovery of such a trace in the laboratory, the affected area would be thoroughly cleaned. The presence of RDX indicates that a contaminated person or item has entered the office at some time, leaving a very small explosive trace. Suspects are confined to a separate part of the unit and are not allowed into the office for any reason.

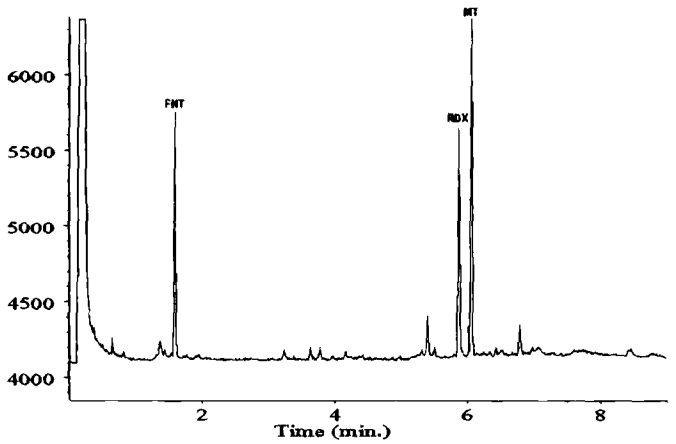

FIG. 5—*An example of a positive chromatogram—Gatwick airport central search area work tops—RDX—BP5 column.*

TABLE 8—*Custody suite results.*

Custody suite	No. of areas sampled	Area of detection	Explosive detected	Approx. amount (ng)
Charing Cross	9	none	NED*	NED*
Croydon	9	interview room 2	NG	6
		fingerprint room	NG	2
Heathrow	9	taped interview room	NG	2
		cell 9—gun storage	NG	10
Paddington Green secure unit	18	main office desks	RDX	4
		swing door between office and cells	NG	11
Peckham	9	none	NED*	NED*
Sevenoaks	7	none	NED*	NED*
Stoke Newington	8	interview rooms 1 & 2	NG	7
Vauxhall	9	none	NED*	NED*
Wembley	9	fingerprint room	NG	4

*NED = no explosives detected.

Police Vehicles

Samples were taken from a variety of different types of vehicle based at each of the nine police stations visited. The vehicles were all in use, and were likely to have been used for the transportation of suspects detained for various reasons. The results are summarized in Tables 9A, 9B and 9C. Eight of the 21 vehicles were found to contain traces of NG, which is not surprising considering they are likely to have been used by armed officers. Therefore, NG traces from items or people that have been transported in uncontrolled police vehicles must be interpreted accordingly. No explosives were detected in 12 of the vehicles. K224EUC contained traces of RDX and PETN, as well as NG. Enquiries subsequent to the analysis revealed that this particular vehicle may have been used to transport explosives for police dog training purposes. A low level of RDX was detected on the floor of K296EYT, which is consistent with it having been used to transport items or people contaminated with explosives traces.

Police Civilian Personnel

The personnel chosen for sampling using hand-test kits were civilian personnel working at the various police stations coming into contact with the general police station environment. They were traffic wardens, typists, and other administrative staff. Twenty three people were tested resulting in 48 samples (excluding controls). No explosive traces were found in any of the samples taken. This indicates that there is little possibility of picking up explosives traces onto hands by entry into the main reception and office areas of a police station. Additionally, these people are a cross section of the public who have traveled to work by various means, indicating that such actions are very unlikely to lead to innocent contamination with explosives.

GC/MS Confirmations

The presence of RDX was further confirmed by GC/MS in the following samples:

TABLE 9A—*Police vehicles sampled.*

Vehicle registration	Police station	Vehicle type	No. of areas sampled	Area of detection	Explosive detected	Approx. amount (ng)
K217EUC	Charing Cross	Vauxhall Astra	6	floor	NG	10
J557CYV	Charing Cross	Peugeot 309	6	none	NED*	NED*
K821FHM	Charing Cross	Leyland Daf 200 van	5	none	NED*	NED*
L932GUL	Croydon	Leyland Daf 400 van	5	inside of sliding and rear doors	NG	3
L905GUL	Croydon	Rover Metro	5	seats	NG	2
				floor	NG	6
D63GYX	Croydon	Leyland Daf 400 van	5	none	NED*	NED*
K605FUU	Peckham	Rover Metro	6	none	NED*	NED*
L82GUL	Peckham	Rover Metro	6	none	NED*	NED*
L892GUL	Peckham	Leyland Daf 200 van	5	none	NED*	NED*
K822FHM	Heathrow	Leyland Daf 200 van	5	inside of rear doors	NG	90

*NED = no explosives detected.

TABLE 9B—*Police vehicles sampled.*

Vehicle registration	Police station	Vehicle type	No. of areas sampled	Area of detection	Explosive detected	Approx. amount (ng)
K224EUC	Heathrow	Vauxhall Astra	6	instruments	NG	10
				inside of front doors and windows	NG	80
				inside of rear doors and windows	RDX	111
				PVC seat backs	NG	3
				floor	NG	64
					PETN	109
					RDX	65
				seats	NG	43
					RDX	62
E577LYO	Paddington Green	Land Rover	4	PVC bench seats	NG	52
				inside of rear door and window	NG	15

TABLE 9C—*Police vehicles sampled.*

Vehicle registration	Police station	Vehicle type	No. of areas sampled	Area of detection	Explosive detected	Approx. amount (ng)
E98KUL	Paddington Green	Leyland Daf 200 van	7	inside of sliding and rear doors	NG	3
				inside of front doors and windows	NG	55
				parcel shelves	NG	17
K499UKO	Sevenoaks	Peugeot 309	6	none	NED*	NED*
K886FHM	Stoke Newington	Ford Fiesta	6	none	NED*	NED*
H191YYK	Stoke Newington	Vauxhall Astra	6	none	NED*	NED*
L199GYN	Vauxhall	Leyland Daf 400 van	8	none	NED*	NED*
L141GUL	Vauxhall	Leyland Sherpa van	5	none	NED*	NED*
K296EYT	Vauxhall	Ford Sierra	5	floor	RDX	12
L961GUL	Wembley	Rover Metro	6	none	NED*	NED*
E279KUL	Wembley	Leyland Daf 200 van	7	instruments	NG	49
				floor	NG	90

*NED = no explosives detected.

- Gatwick central search area—plastic work tops,
- Taxi 2—glass partition,
- Taxi 6—inside of doors and grab handles,
- Paddington Green secure unit—main office desks, and
- Police vehicle K224EUC—inside of rear doors.

No attempt was made to confirm the presence of explosives traces in vacuum samples, because in general, they contained higher levels of co-extracted materials that would have made it impossible to draw reliable conclusions from this technique.

Limits of Detection

The GC/TEA method used for the analyses has a very high sensitivity, and is capable of detecting picogram quantities of the common explosives in clean solutions. However, the samples obtained during this project were, despite the use of a cleanup procedure, frequently contaminated with much co-extracted material. The effect of such co-extractives upon chromatograms is particularly visible in the latter part of the chromatogram contained in Fig. 3. For such samples, the detection limits of the method are determined mainly by the level of baseline noise. Thus, limits of detection for the complete analysis procedure have been estimated for the explosives NG, TNT, PETN, and RDX on the following basis. Suitable chromatograms were chosen and a clean peak that had a height approximately three times that of the baseline noise was chosen. Its area was then related to the areas for the various explosives peaks in the previous TEA standard chromatogram. The amount of explosive that such a peak would have represented in the sample was then calculated in the usual way. The results given in Table 10A are for the average of two relatively clean samples for each column, and the results given in Table 10B are for the average of two relatively dirty samples for each column.

Conclusions

Summary

All the results are summarized in Tables 11A and 11B.

Public Areas

Traces of the high explosives NG, TNT, PETN, and RDX are rare within the general public environment. In fact, no traces of NG, TNT, or PETN were detected at any of the public sites sampled during this project. Additionally, the levels that were detected in areas frequented by the public were very low, amounting in total to 49-ng of RDX. The techniques used would also have detected EGDN, and nitrotoluenes had they been present, but none were, in fact, detected. Therefore, it is unlikely that a member of the public would be innocently contaminated with a significant quantity of explosives.

TABLE 10A—*Estimates of limits of detection for relatively clean samples.*

Explosive	BP-1 column	BP-5 column	CPSIL19 column
NG (ng)	1.8	1.0	0.9
TNT (ng)	2.2	1.1	1.3
PETN (ng)	3.1	2.2	1.7
RDX (ng)	1.3	0.6	1.3

TABLE 10B—*Estimates of limits of detection for relatively dirty samples.*

Explosive	BP-1 column	BP-5 column	CPSIL19 column
NG (ng)	3.1	3.1	5.8
TNT (ng)	2.9	2.8	6.6
PETN (ng)	4.0	4.9	8.5
RDX (ng)	2.3	2.0	4.1

TABLE 11A—*Results summary public sites.*

Site	No. of samples analyzed (exc. controls)	No. of controls	No. of samples requiring further GC/TEA analysis (exc. controls)	No. of positive samples
Taxis	124	43	31	3
Buses	87	19	28	0
Underground trains	44	11	6	0
Underground stations	33	4	6	0
Passenger aircraft	15	4	4	0
Airports	34	11	7	1
Total	337	92	82 (24.3%)	4 (1.2%)

TABLE 11B—*Results summary police sites.*

Site	No. of samples analyzed (exc. controls)	No. of controls	No. of samples requiring further GC/TEA analysis (exc. controls)	No. of positive samples
Custody suite	87	10	34	8
Police vehicle	120	41	52	19
Police personnel	48	46	3	0
Total	255	97	89 (34.9%)	27 (10.6%)

Police Areas

The majority of police areas sampled were found to be free of explosives, but low levels of NG were found at five of the police stations and in eight of the police vehicles. Bearing in mind that armed officers will have used these sites, these findings are not surprising. In respect of explosives other than NG, a very low level of RDX was found at one police station, and low level traces were found in two police vehicles.

Recommendations

Although this survey has provided much useful data in an area that has been previously uninvestigated, the number of sites sampled is relatively small. Further work at more sites and different types of sites would obviously increase the value of the data.

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