Explosive Blast Effects on Latent Fingerprints

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ABSTRACT

People can be identified by fingerprints located on blast affected fragments recovered during the investigation of bombing scenes. We placed 4 aluminium plates (100 mm x 100 mm x 3 mm) and 2 steel plates (150 mm x 150 mm x 45 mm) with latent fingerprints on them at a distance of 0.25-1 m from a 0.7 kg charge of CompB, and the same number of plates also containing fingerprints at a distance of 0.125-0.5 m from a 0.09 kg explosive charge in a separate experiment. We found that the blast-affected fingerprints were detectable by the Cyanoacrylate Fuming Method and that the blast damage to the fingerprints complied with the scaling law. Damage to the fingerprints was greater on the light plates than on the heavy plates. The mechanism of damage is likely to be due to excessive blast pressure and heat.

Keywords

Explosive blast, latent fingerprints, cyanoacrylate fuming, scaling law, Composition B, Pentolite

1. INTRODUCTION

Criminal investigations involving bombings can be enhanced by the identification of people involved into the construction and operation of an Improvised Explosive Devices (IEDs). Fingerprints are historically one of the most valuable forms of physical evidence that is capable of identifying an individual; however a common belief held by many scene investigators is that the recovery of fingerprints from bombing debris is largely impractical due to the resultant blast and incendiary effect. The increasing use of IEDs, including vehicle borne IEDs has highlighted a need to identify if this belief held true or whether an operational procedure could be adopted that would assist in the identification of debris suitable for fingerprint examination.[1]

Fingerprints exist in one of three forms, visible, impression and latent. A 'fingerprint' is the reproduction of the friction ridge skin which is located on the undersides of the fingers, palms, toes and soles of the feet. A latent 'fingerprint' is formed upon touching an object and transferring a film of natural secretions and contaminants to the touched object, leaving an impression of the ridges. Such prints may not be visible until enhanced by physical or chemical processes. Numerous variables are associated with the depositing of latent fingerprints, these include:

- The quantity and composition of matter on the skin's surface capable of being deposited on an object;

- The amount of skin surface exposed and therefore available to deposit such matter;

- The environmental conditions, including the length of time the latent print had been deposited;

- The pressure exerted upon contact;

- The duration of contact, and;

- The receptive capabilities of the receiving surface, e.g. porous v. non-porous, glossy v. matt.

Cyanoacrylate Fuming (often called the super glue method of developing latent fingerprints) coupled with the application of a staining agent is a common, economic and efficient method adopted by Investigators to enhance latent fingerprints.[2]

Although latent fingerprints left on blast affected objects may be recovered and used to identify suspects the impressions may also suffer damaged as a result of conductive heat, radiative heat, overpressure and abrasion which are produced by the detonation of an explosive charge. To examine all debris for fingerprints would be an exhaustive undertaking. Being able to predict what IED fragments are likely to contain detectable fingerprints would eliminate unnecessary work and enable the development of timely intelligence. To answer this question we sought to determine the minimum distance from the explosive charge at which fingerprints were detectable with the Cyanoacrylate Fuming Method, and how this distance depended on the mass of the explosive charge.

In this paper, we present the results of our findings, and discuss it in terms of the mechanisms that potentially cause damage to latent fingerprints by explosive blast effects.

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2. METHODS

2.1 Explosive blast exposure

The experiments were conducted using the Explosive Chamber at the Defence Science & Technology Organisation. We placed polished aluminium plates (100 mm x 100 mm x 3 mm) at the distances of 0.25 m, 0.5 m, 0.75 m and 1 m from a 0.7 kg charge of CompB (RDX/TNT = 60%/40%), and polished steel plates (150 mm x 150 mm x 45 mm) at the distances of 0.5 m and 1 m from a 0.7 kg CompB charge in the same experiment, as shown in Figure 1. In a separate experiment, we placed aluminium plates of the same description at the distances of 0.125 m, 0.25 m, 0.375 m and 0.5 m away from a 0.07 kg CompB charge (0.09 kg of explosive with the booster in total). Also in this experiment, we positioned steel plates of the same description as in the previous experiment at the distances of 0.25 m and 0.5 m away from the 0.07 kg CompB charge (0.09 kg of explosive with the booster in total). All charges were initiated by an electrical detonator coupled with a Pentolite booster weighing approximately 0.02 kg. In both experiments the plates had plain (unpainted) surfaces and a set of four fingerprints had been placed in a similar fashion on both sides of each plate. All plates were positioned on 1.2 m high pedestals made of MDF.

Figure 1. Four aluminium plates and two steel plates are located at the distances 0.25 – 1 m away from a 0.7 kg CompB charge.

2.2 Cyanoacrylate Fuming Technique

The concepts behind latent fingerprint chemical development techniques are to apply something that chemically reacts with one or more of the constituent of a fingerprint. The resultant reaction will give all present latent impressions a new chemical composition rendering them visible. The fingerprints are then stained and photographed using UV fluorescence.

The plates that were to be examined for latent fingerprints were placed in an airtight tank, a few drops of Cyanoacrylate (superglue) added and then allowed to evaporate. Super glue reacts with the traces of amino acids, fatty acids, and proteins in a latent impression and the moisture in the air to produce a visible, sticky white material that forms along the ridges of the fingerprint. This forms a profile of the entire latent fingerprint, which upon being stained with Ardrox 970 P25 fluoresces under UV light, the image then being digitally photographed.

3. RESULTS

In the after-blast scene, the metal plates were scattered around the explosive chamber together with the debris resulting from the destruction of the MDF pedestals. Some of the plates which were originally closest to the explosive charge were deformed by the explosive blast (Figure 2), however fingerprints could still be seen. The plates were collected, and taken to the South Australia Police Fingerprint Bureau for development of the latent fingerprints by the Cyanoacrylate Fuming Method.

Figure 2. An aluminium plate after exposure to blast located 0.25 m away from 0.7 kg explosive charge.

Figure 3 shows an image of the fingerprint which was recovered from the aluminium plate shown in Figure 2.

Figure 3. The UV light picture of the latent fingerprint developed by the cyanoacrylate fuming technique.

All of the identified latent fingerprints were photographed in UV light, labelled and numbered. The results from experiments using the 0.7 kg and 0.09 kg explosive charges are shown in Tables 1 and 2 respectively. For each blast-exposed plate, it is shown whether the fingerprints were detected by the cyanoacrylate technique on one side, on two sides, or no fingerprints could be acquired.

Table 1. Blast damage to the fingerprints located on the aluminium and steel plates, dependant upon the plate's distance to the 0.7 kg explosive charge. Survival of the fingerprints from blast damage in each metal plate is measured by the number of sides where the fingerprints survived on each plate after exposure to blast.

Distance from plate to 0.7 kg CompB charge (m)	Scaled distance $d_0=d/m^{1/3}_{charge}$	Number of sides on plate where fingerprints survived the blast (0, 1 or 2)	
		aluminium plate	steel plate
0.25	0.28	1	n/a
0.5	0.56	1	1
0.75	0.84	2	n/a
1	1.12	2	2

Table 2. Blast damage to the fingerprints located on the aluminium and steel plates, dependant upon the distance to the 0.09 kg explosive charge. Survival of fingerprints on each plate is measured by the number of sides where the fingerprints survived after exposure to blast.

Distance from plate to 0.09 kg CompB charge (m)	Scaled distance $d_0=d/m^{1/3}_{charge}$	Number of sides on plate where fingerprints survived the blast (0, 1 or 2)	
		aluminium plate	steel plate
0.125	0.28	2	n/a
0.25	0.56	1	2
0.5	0.84	2	n/a
0.75	1.12	2	2

It is worth to note that the aluminium plates were scattered around the explosive chamber while the steel plates were found on the floor of the chamber in their original positions, the MDF pedestals having been destroyed.

4. DISCUSSION

Due to the complex nature of explosions, it is not possible to easily predict the magnitude of the blast effects. However, there is a vast collection of experimental data from the explosion of 1 kg of TNT, which has been chosen as the reference explosion. The values for an arbitrary explosion can be found relating to the reference explosion through a relation known as the scaling law. It relates the distances at which the same effect will be felt for different explosive amounts. The scaling factor is $W^{1/3}$, where W = the equivalent amount of TNT (in kg). W is found by multiplying the mass of the explosive by its relative strength (RS).

Explicitly:

$$d_W = d_o W^{1/3}$$

Where: d_o is the distance from 1 kg TNT, d_w is the distance from the W kg of TNT equivalent.

When applying the scaling law, it is presumed that the target is mechanically damaged by the peak overpressure of the blast. The scaling law states that if you want to obtain the same peak overpressure at a longer distance from a charge, you have to increase the mass of the charge proportionally to the cube of the distance. Thus, we can calculate the peak overpressure at any distance from the charge of any mass if we know the peak overpressure generated by a charge of a certain mass at a certain distance.

Assuming that the damage to the fingerprints from the explosive blast follows the scaling law of the peak overpressures; Figure 4 shows the graph of the damage to the fingerprints versus the scaled distance. We had to ascertain the measure of survivability of the fingerprint from the explosive blast. Because there could be variation between the fingerprints when placed on the metal plates, results could have a margin of error; this is reflected in Tables 1 and 2 by describing fingerprint survivability in the following manner:

- Survival of the detectable fingerprint at least on one side (proximal or distal to the explosive charge) – subscribed to the level "1",

- Survival of the detectable fingerprint on both sides of the plate – subscribed to the level "2".

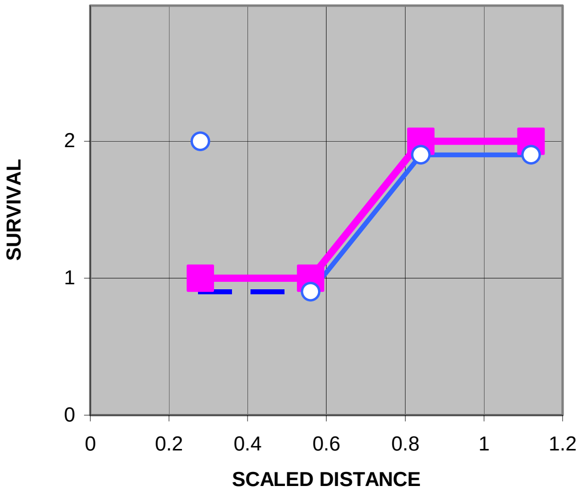

Fig.4. Survival of the fingerprints versus the scaled distance (circles for the 0.09 kg explosive charge and squares for the 0.7 kg charge).

We concluded that there is an approximate compliance with the scaling law.

It is curious to note that the steel plates, located in the same places as the aluminium plates in the pre-blast scene, sustained less fingerprint damage than the aluminium plates. We presume that the light aluminium plates were thrown by the blast and flew together with the shock wave, and thus stayed in the high-pressure high-temperature zone for a longer time, and thus sustained more damage compared to the steel plates which stayed at the same place. Thus, the damage to the fingerprints depended on the loading conditions. However, the survival of the fingerprints depended on many factors one of which was the material property of the fingerprinted plates.

In a separate experiment, we placed car panel plates (10 cm x 10 cm, painted from one side) and plated car handles at distances of 0.28, 0.56 and 0.84 m from a 1 kg CompB charge, and subjected them to the explosive blast. The fingerprints on both car panel plates and car door handles survived much better at a scaled distance of 0.84 than at a distance of 0.56 and 0.28. This pattern fits well into the scaling law which we established for the survival of blast-affected fingerprints on aluminium plates. However, both the painted and the rough unpainted sides of the car panel were a worse substrate for the fingerprints than polished metal plates in terms of the image quality of the lifted fingerprints, so that the direct comparison of survivability of fingerprints on polished metal plates and on painted metal plates was difficult to establish at this stage.

5. CONCLUSION

We have found that the explosive blast damage to fingerprints is a function of the mass of explosive charge and of the distance to the charge, and complies with the scaling law. The chemical substance, which the fingerprint residue consists of, is likely to be damaged both by the pressure and heat of the explosive blast, and thus becomes undetectable by the cyanoacrylate fuming method. The fingerprints on the heavy steel plates survived at closer distances than the fingerprints on lighter aluminium plates, possibly due to a difference in blast loading or different material properties. The scaling law for survival of fingerprints seems to hold for both painted and polished metal surfaces.

6. ACKNOWLEDGEMENTS

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7. REFERENCES

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