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SHORT COMMUNICATION

Bursting Smoke as an Infrared Countermeasure

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ABSTRACT

This paper describes the experimental setup for the evaluation of bursting smoke for anti-infrared role using SR-5000 spectroradiometer and a source of IR radiation (8-13 μm) using cadmium-mercury-telluride (CMT) detector cooled by liquid nitrogen. The particle size and shape of the powders used in the bursting smokes were determined microscopically using Carl Zeiss Jena Neophot-21. Highest attenuation of 97-100 per cent was produced for about 12 s usinga mixture of bronze flakes and chaff, and for about 8 s using a mixture of bronze copper lined flakes, bronze flakes and chaff.

1. INTRODUCTION

Smokes have been used in defence for a large number of applications like screening, blanket ground installations from aircraft observation, creating dummy screens, training and simulating battlefield atmosphere, and as a countermeasure to hi-tech weapons using infrared sensors and guidance systems[1-5]. Smokes can be created by condensation of vaporised material, dispersion of solid/liquid and explosive dissemination of finely powdered material using explosive energy in the form of bursting charge, termed as bursting smoke[6-7]. These bursting smokes produce large sized particles almost instantaneously and hence hold promise as an infrared countermeasure.

Most of the information on the use of bursting smokes as a countermeasure to IR sensors is in the form of patents[8-10] only. In the present investigation, a number of bursting smokes (various powders, like bronze copper lined flakes, bronze flakes, graphite, carbon black, dolomite, french chalk and chaff) and a central high explosive charge were evaluated for attenuation of IR in the 8-13 μm using SR-5000 spectroradiometer. The results for few powders dispersed explosively (to give bursting smoke) along with an experimental setup for the evaluation of bursting smoke for anti-infrared role using SR-5000 spectroradiometer are presented (Fig. 1).

2. EXPERIMENTAL DETAILS

Eight types of powders were used to produce bursting smoke. The powder was hand-tamped in a cylindrical tin container (inner diameter (ID) 86 mm, outer diameter (OD) 89 mm, length

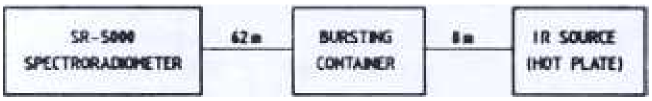

Figure 1. Experimental setup

160 mm) having a central aluminium tube (ID: 8 mm, OD: 10 mm, length: 160 mm) containing 7 g of plastic explosive PEK-2. The container was closed using a disc and a cup and placed at a

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Table 1. Attenuation of IR source (8-13 μm) by explosive dissemination of powders

Powder dispersed	Source of powder	Average charge weight (g)	Average percentage attenuation in (8 - 13 μm)	Duration of attenuation (s)
Bronze-copper lined flakes.	Metal Powder Co. Ltd, Thirumangalam.	1690	93 - 100	13.0
Bronze flakes	-- do --	1680	-- do --	13.0
Dolomite	Locally available	1520	93 - 100	5.5
Graphite	Graphite India Ltd, Bombay	455	88 - 100	11.0
Carbon black	Locally available	463	58 - 100	11.00
French black	-- do --	1040	85 - 100	5.0
Bronze flakes and chaff mixture	Flakes from Metal Powder Co. Ltd; Thirumangalam & Chaff from Garware Polyester, Pune.	640 (flakes) 280 (chaff)	97 - 100	12.0
Mixture of bronze flakes, bronze-copper lined flakes and chaff.	- do -	300 (bronze flakes) 300 (copper flakes) 240 (chaff)	97 - 100	8.0

Detector used : CMT with liquid nitrogen; bursting charge: 7 g PEK-2; Distance between spectroradiometer and source:70 m; relative humidity: < 35 %

distance of 8 m from the source of IR radiation (hot plate). The distance between SR-5000 spectroradiometer and hot plate was kept at 70 m. The bursting smoke was produced by explosive dissemination of powders using electric detonator No. 108, while the cadmium-mercury-telluride (CMT) detector (cooled by liquid nitrogen) was used for detection of IR radiation in 8-13 μm. The details of the powders used for dispersion and the attenuation results obtained are given in Table 1. The bursting was carried out using same type of container for all the experiments. Hence, the volume of container was constant and therefore charge weight varied because of change in density of powders.

Table 2. Average particle size and shape of powders

Powder	Average particle size	Shape
Bronze-copper lined flakes	10 μm & agglomerates	Irregular spear shaped, flaky
Bronze flakes	3-10 μm & agglomerates	Irregular spear shaped, flaky
Dolomite	10 μm	Irregular
Graphite	2-6 μm	Round and irregular
Carbon black	0.1-1 μm	Very small
French chalk	1-5 mm	Irregular spear shaped
Chaff	15 mm length 1 mm width	Rectangular, flaky

The particle size and shape of the powders were determined microscopically using Carl Zeiss Jena Neophot-21. Table 2 gives the average particle size and shape of the powders.

3. RESULTS & DISCUSSION

Bronze-copper lined flakes, bronze flakes and dolomite produced average attenuation between 93 to 100 per cent. The duration was around 13 s for flakes, while it was only 5.5 s for dolomite. Graphite powder gave 88-100 per cent average

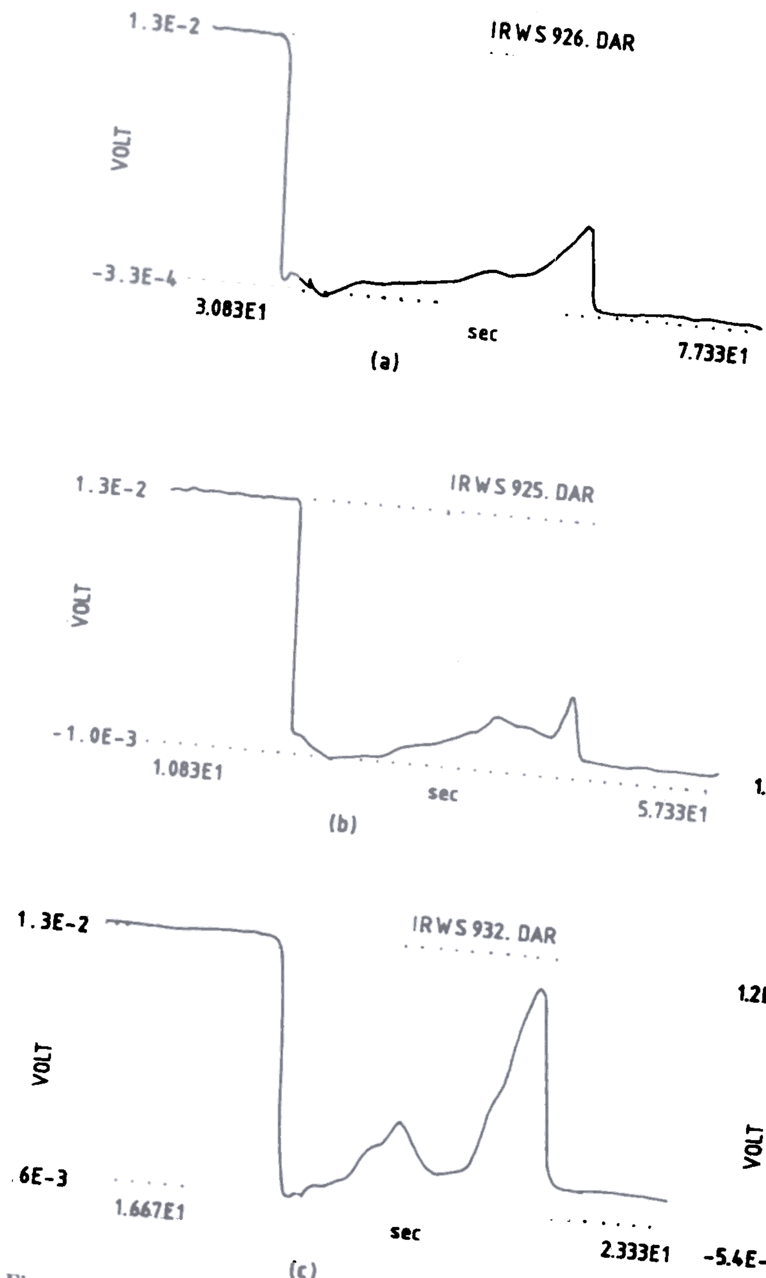

Figure 2. Typical spectra in radiometric mode (8-13μ) for (a) bronze-copper lined flakes, (b) bronze flakes & (c) dolomite.

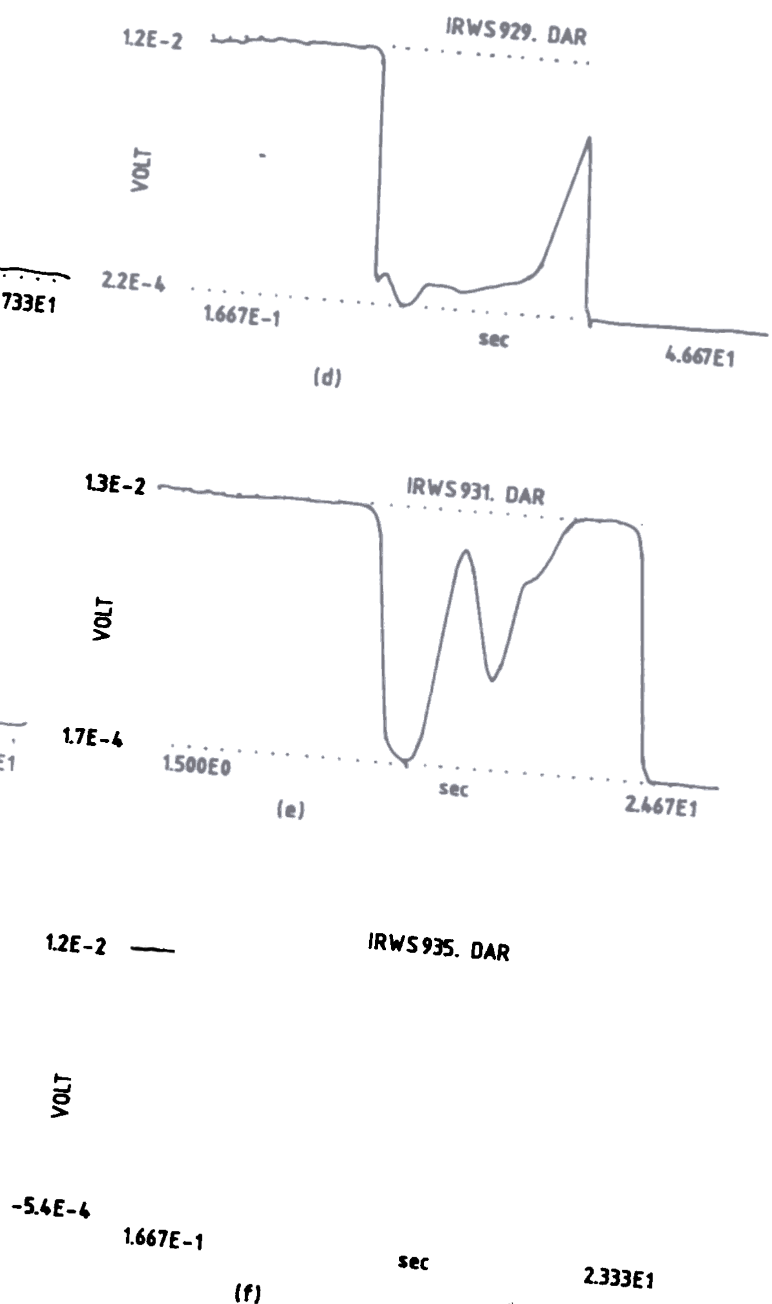

Figure 3. Typical spectra in radiometric mode (8-13μ) for (d) graphite, (e) carbon black, and (f) french chalk.

attenuation for 11 s, while carbon black produced only 58-100 per cent attenuation for the same period. French chalk produced 85-100 per cent average attenuation for 5 s (Fig. 2). A mixture of bronze flake, and chaff gave attenuation between 97 to 100 per cent for around 12 s, while a mixture of bronze-copper lined flakes, bronze flakes and chaff produced similar attenuation for about 8 s. The highest attenuation of 8-13 μm radiation has been produced by a mixture of chaff with bronze flakes and a mixture of chaff with bronze copper-lined flakes and bronze flakes. Alone, bronze flakes or bronze-copper-lined flakes or dolomite powder gave lower attenuation than the chaff mixture, but higher than graphite powder. French chalk powder produced lower attenuation than graphite, whilev the least attenuation was produced by carbon black.

4. CONCLUSION

The IR attenuation was produced due to physical blocking of IR radiation by particulate material, and larger the size of particles of the flakes, more was the attenuation produced for longer wavelengths (8-13 µm). In case of bronze-copper lined flakes, bronze flakes and a mixture of flakes with chaff, higher attenuation and higher duration (as compared to other powders) might be due to larger particle size and floating of the material in air to physically block the IR radiation, in view of its flaky nature. Dolomite had also given higher attenuation of 8-13 µm wavelengths because of its higher average particle size, but duration was low because the matter was not flaky in nature. The other powders (French chalk, graphite and carbon black) had smaller size, and hence, were capable of producing lower attenuation for longer wavelengths (8-13 µm) (Fig. 3).

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REFERENCES

1. Cacket, J.C. Monographs on pyrotechnic compositions. RARDE, Fort Halstead, Kent, England, 1965, 1.
2. Ellern, Herbert. Military & civilian pyrotechnics. Chemical Publishing Co. Inc., New York, 1968.
3. Enginering Design Handbook, Military Pyrotechnic Series, Part 4. Design of ammunition for pyrotechnic effects. US Army Material Command, 1974, AMC-706 -188 USA, 3.33.
4. Amarjit Singh. & Avachat, S.G. Behind the smoke screen. *Science Reporter*, 1994, **31**(12), 13-16.
5 Holst, GC, Tactical smoke increases survivability. *Armour*, 1984, **94**, 20-25.
6. Kaye, S.M., Encyclopaedia of explosives and related item. (US Army Armament Res & Dev Command, Large Calibre Weapon Systems Laboratory, Dover, New Jersey, 1978. AD A-057762).
7. Conkling, J.A. Chemistry of pyrotechnics - basic principles and theory. Marcel Dekker Inc, New York. and Basel, 1985. pp.168-76.
8. Shukis, S.P.; Schneider, C.J. & Gasiecki, E.A. Statutory Invent Regist. US 360 (United States Dept of the Army) 3 Nov 1987. *Chemical Abstracts,* 1988, **108**, 58947d.
9. Sellman, L.E.; Janon, F. Jr. & Beyth, WW. AAI Corpn USA Patent 4, 704, 966. 10 Nov 1987.
10. Weber, M. Pyrotechnische Fabric F Feistel, German Patent DE 3, 238, 455. 19 April 1984.

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