Evaluation of the Hazards Posed by High Energy Bangers

Part 2. Damage to Hand Simulants

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ABSTRACT

This paper reports the development and construction of hand simulant models and their use to evaluate the extent of injury to persons holding, or being near to, high energy bangers when they are initiated.

The test work suggests a risk of severe injury to the hand and wrist from flashbangers containing more than 1 g of composition, with amputation of the hand being possible for the more powerful items examined.

Keywords: potassium perchlorate, barium nitrate, aluminium, flash composition, bangers, damage, firecracker, small salute

Introduction

A previous paper[1] reported details of the noise and overpressure generated when energetic bangers (large firecrackers or small salutes) are initiated, together with estimates of the TNT equivalence of barium nitrate/aluminium and potassium perchlorate/aluminium flash compositions.

In connection with evaluating the hazards associated with the use of such fireworks, a brief qualitative study was undertaken of the effects of powerful fireworks on simulated human hands. This short paper reports the method used to fabricate the model hands and the results obtained when they were used to assess the potential hazards to users posed by high energy bangers.

Experimental

Model Hand Construction

Model hands were constructed around plastic skeletal hands of the type supplied to medical schools.[2] The skeleton was encapsulated in a 25% gelatine/water gel to simulate flesh. Such a mixture has previously been used as a flesh simulant for ballistic wound studies.[3]

Moulds were made from the open palm and closed fist of an adult male, and these were used to cast the gelatine mix around the jointed plastic bones. The metal support wires that connected the plastic bones were left in place to simulate the muscles and tendons in the human hand.

The open palm version of the hand was made to determine the effect of a banger initiating in the open hand or on the fingers, whereas the closed fist hand was constructed to replicate the enclosure of a banger in the fist.

Figures 1 and 2 illustrate the construction of the open-palm and closed-fist model hands, respectively.

To improve the visual presentation of the gelatine, the model hands were sprayed with a flesh coloured paint producing samples with the final appearance of the example shown in the right of Figure 1. Additionally, as the tests were to be video recorded to provide evidence of the potential damage to human hands, the gelatine flesh simulant was dyed red to improve visualisation.

Table 1. Damage to the Model Hands from High Energy Bangers.

Banger Composition	NEC* (g)	Position on / in Hand	Damage
barium nitrate/ aluminium flash	1	open palm	Scorching, no structural damage
		open fingers	
		closed fist	Severe scorching, no structural damage
	10	open palm	Surface damage, damage to wrist due to flexing
		open fingers	Damage to structure of fingers, loss of end bone to one finger, loss of 'flesh' on fingers
		closed fist	Severe damage to structure of hand with multiple loss of fingers and severe 'flesh' loss
potassium perchlorate/ aluminium flash	0.5	open palm	Scorching, no structural damage
		open fingers	
		closed fist	Severe damage to structure of fingers with some 'flesh' loss
	5.0	open palm	Damage to structure of several fingers, loss of end bones on four fingers, loss of 'flesh' on fingers
		open fingers	Severe damage to fingers, loss of digits and flesh on fingers. Some damage to wrist due to flexing
		closed fist	Severe damage to structure of hand with multiple loss of fingers, bones of the palm and severe 'flesh' loss

*NEC = net explosive content

Test Programme

Tests were undertaken using barium nitrate/ aluminium flashbangers with 1 and 10 g loadings and potassium perchlorate/aluminium flash-bangers with 0.5 and 5 g loadings.

The bangers were placed in three positions; on the open palm, on the fingers of the open hand and in a closed fist.

In the case of the closed fist, a gelatine sheet was wrapped around the bangers to ensure a close fit in the clenched fist.

Results and Discussion

The results from six tests with each banger type are summarised in Table 1.

To illustrate the differing extents of damage to the model hands produced by fireworks of different strengths, Figures 3 and 4 show the results from barium nitrate/aluminium flash composition and Figures 5 and 6 display the results of tests using potassium perchlorate/aluminium flash.

The range of damage found corresponded well with the findings from the pressure and noise measurements reported in an earlier study,[1] with the potassium perchlorate/aluminium bangers causing the most severe damage.

The damage to the hand simulants also showed a strong visual correlation to the sorts of damage to the human hand produced by fireworks, as reported by Nicolai and Van Twisk.[4] This suggests that the simulants may provide a viable means of assessing damage to the hands caused by the misuse of other small pyrotechnic devices or explosive articles.

Figure 1. Construction of skeletal hand simulant in open-palm version.

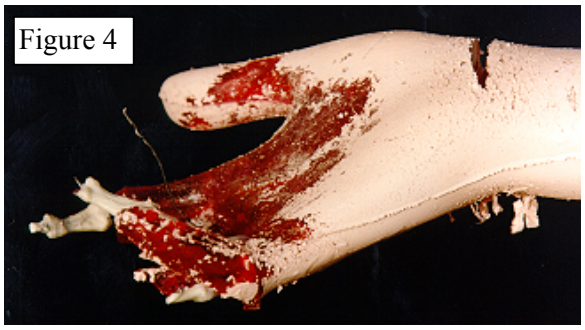
Figure 2. Plastic skeletal hand encapsulated in gelatine in closed-fist version.

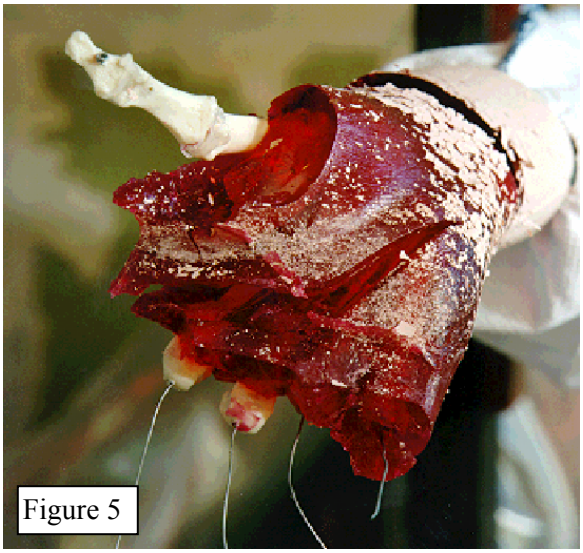
Figure 3. The effect of a 10 g barium nitrate / aluminium flash composition banger initiated on the open fingers.

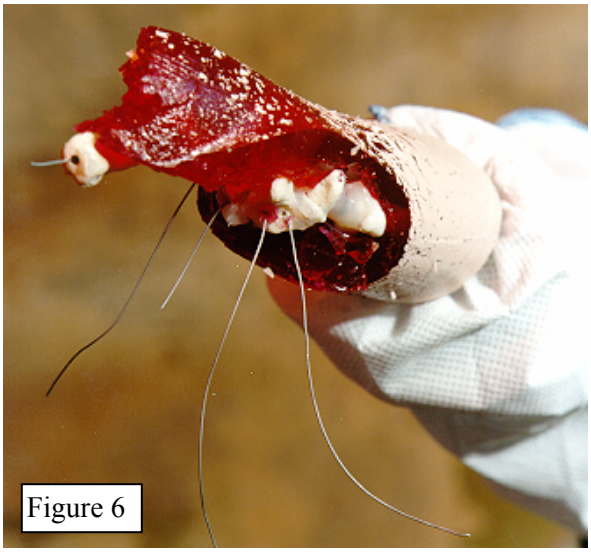
Figure 4. The effect of a 10 g barium nitrate / aluminium flash composition banger initiated in a closed fist.

Figure 5. The effect of a 5 g potassium perchlorate / aluminium flash composition banger initiated on the open fingers.

Figure 6. The effect of a 5 g potassium perchlorate / aluminium flash composition banger initiated in a closed fist.







Conclusions

Test work using simulated hands suggests that the damage resulting from the misuse of bangers containing potassium perchlorate/aluminium flash composition is greater than that when the bangers contain barium nitrate/aluminium flash.

The damage found with bangers containing 10 g of the barium nitrate-based composition was approximately equivalent to that obtained with 5 g of the potassium perchlorate-based composition.

The good qualitative correlation between the results reported in this paper and literature data on actual injuries to the hand caused by fireworks suggests that the simulants may have wider application for assessing the effects on the human hand from the misuse of other small pyrotechnics and explosive articles.

Acknowledgement

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References

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