J Forensic Sci, Jan. 1976, Vol. 21, No. 1

J. K. Sinha,[1] *M.Sc.*

Time of Firing of Shot Shells

Estimation of the time lapse since a cartridge or a firearm was fired is an important aspect of forensic ballistics. In the past efforts have been made to correlate the time lapse with the chemical changes of the firearm discharge residues. Both qualitative and quantitative variation of the combustion products with the passage of time have been studied by examining barrel washings and dry swabs pushed through the barrel [*1,2*]. Such examinations, however, did not yield satisfactory results, because, besides the time factor, chemical changes of the discharge residues were found to be significantly influenced by the atmospheric conditions. It was also difficult to extract the total quantity of combustion products by dry or wet methods for correct quantitative estimation. Various other phenomena, such as presence of carbon monoxide, mercury vapour, and pollen grains, have also been utilized by various workers to ascertain the time of firing [*2,3*]. Their limitations in correlating the time lapse are well known.

This paper describes attempts to correlate the time lapse by utilizing the phenomenon of efflux of discharged gases which is expected to be comparatively less influenced by normal variation of the atmospheric conditions. The study has been made with special reference to 12-bore, Indian Ordnance Kirkee Factory (K.F.) manufactured, fired cartridges.

Theory

The combustion products of firearm discharge residues are both solid and gaseous. The nature and quantity of gases produced depend on the type of the propellant used, type of the primer used, and on other allied factors. The gases produced during firing are occupied inside the barrel and the cartridge during the entire passage of the projectile until it leaves the barrel. After the projectile leaves the barrel, the gases start escaping from both the cartridge and the barrel. The quantity of gases escaped per unit time will depend on the quantity of gases occupying the constant volume, the thermal conditions, the combined effect of the partial pressures of various gases, van der Waals forces, the molecular forces acting between the molecules of the various gases produced during firing, and the surrounding atmospheric conditions. The actual mechanism of efflux of gases is still being studied, and it is expected that various gases produced during firing and their rate of escape will be nearly similar when fired from the same firearm using ammunition of the same make. Considering the above factors, the rate of escape of discharge gases is expected to be a time-variant factor. The time variant phenomenon of the escaped gases has been observed for sufficiently long time to form the basis of the present investigation.

Received for publication 15 Dec. 1974; revised manuscript accepted 31 March 1975; accepted for publication 4 April 1975.

[1] Assistant director, Forensic Science Laboratory, Chandigarh, India.

Experimentation

Experimental firings were conducted through a 12-bore S.B.B.L. gun using 12-bore, 2½-in. (6.35-mm), K.F. special, Indian Ordnance Factory manufactured cartridges. The barrel of the gun was cleaned after every fire. The fired cartridges were marked serially. The time and date of fire were noted on each of them. They were placed in vertical positions keeping the mouth upwards so that the gases could escape freely. They were also kept apart at considerable distance (about 2 metres) from each other.

The rate with which the gases of the fired cartridges escaped were determined indirectly by chemical spot tests. The escaping gases, which contain some nitro compound, can be detected by diazotization and coupling reaction. The reagents, *L*-naphthylamine and sulfanilic acid in acetic acid, develop pink color with the escaping gases. The relative rate of escape of gases at different times can be determined by ascertaining the time taken by the reagents to develop color with the escaping gases.

The intervals chosen for study were 6 hours, 12 hours, and 24 hours after firing and then after every 24 hours up to 10 days. Reagents were prepared as follows: (1) 0.03 g of *L*-naphthylamine, boiled for a few minutes in 100 cm^3 of water, and mixed with 30 cm^3 of glacial acetic acid; and (2) 1 g of sulfanilic acid, dissolved by warming in 100 cm^3 of 30% acetic acid. Freshly prepared solutions were used at each interval. The procedures adopted for development of color were as follows.

The fired cartridge was kept vertically, keeping the base downward. A small plastic piece of suitable size having a small hole at the center was placed over the mouth of the cartridge. A small filter paper piece was placed over the plastic piece covering the central hole but without touching the fired cartridge. A drop of the mixed reagent solution was placed over the filter paper covering the central hole. The time taken by gases escaping through the hole to develop pink color was noted. After the reagent had dried, a fresh drop of the same reagent was added after approximately every 8 to 10 min. To study the variation in time taken to develop color by cartridges fired at the same time, three separate cartridges fired at the same time were studied at each interval. The room temperature and the general condition of weather (cloudy, sunny, or rainy) were noted (Table 1 and Fig. 1). Controls on unfired cartridges, after taking out wads, shots, and propellant, and on cartridges having unburned powder but without wads and shots, were performed by adopting aforesaid procedure. It was observed that after 40 to 45 min, faint pink color appeared due to auto-oxidation.

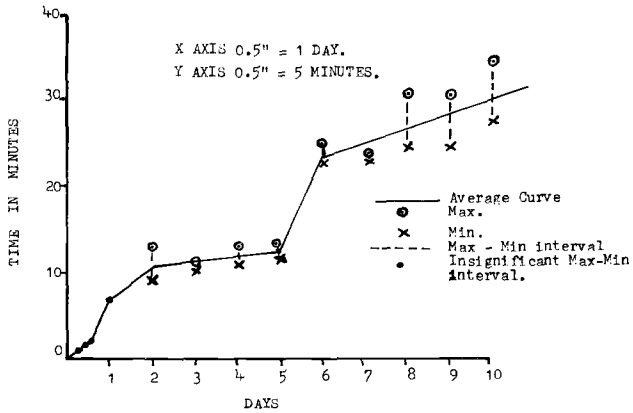

FIG. 1—*Color development variation (minutes) with the time lapse after firing (days).*

TABLE 1—*Results of tests to measure time intervals after firing for three cartridges.*

Time Lapse After Firing	Time Taken to Develop Color		Temperature and Weather at Observation
	Cartridges a, b, and c	Mean	
6 h	48 s		
	50 s	49 s	85 °F sunny
	49 s		
12 h	1 min 55 s		
	1 min 50 s	1 min 50 s	85 °F fair
	1 min 45 s		
18 h	1 min 40 s		
	2 min 20 s	2 min 10 s	84 °F fair
	2 min 30 s		
24 h	6 min 50 s		
	7 min	6 min 56 s	86 °F fair
	7 min		
2 days	10 min 30 s		
	9 min	10 min 46 s	88 °F sunny
	12 min 50 s		
3 days	10 min 40 s		
	10 min 40 s	10 min 46 s	88 °F sunny
	11 min		
4 days	11 min		
	11 min 40 s	11 min 53 s	90 °F sunny
	13 min		
5 days	11 min 50 s		
	12 min 15 s	12 min 28 s	88 °F sunny
	13 min 20 s		
6 days	23 min		
	23 min 20 s	23 min 46 s	87.5 °F sunny
	25 min		
7 days	23 min		
	23 min 40 s	23 min 16 s	86 °F fair
	23 min 10 s		
8 days	25 min		
	24 min 50 s	26 min 56 s	88 °F sunny
	31 min		
9 days	25 min		
	31 min	28 min 40 s	86 °F fair
	30 min		
10 days	30 min		
	35 min	31 min	90 °F sunny
	28 min		

Celsius temperature = (Fahrenheit deg − 32)/1.8.

Discussion

It can be seen from Table 1 that the time duration to develop color in the reagents by escaping gases tends to increase with the time lapse after firing. The increase is, however, not uniform. Besides insignificant increase in certain intervals, there are overlapping observations. A choice of suitable interval may, therefore, be essential to eliminate overlappings to interpret the observations for correlation with the time of firing under certain limits.

The suitable time intervals in the present case would be within 24 hours, 2 to 5 days, and 6 to 10 days, as the minimum of one interval is distinctly different from the maximum of the preceding interval. A fire of 24 hours can be differentiated from a fire of 2 to 5

days, which in turn can be differentiated from a fire of 6 to 10 days. The suitable time intervals may be different with different firearms. It has been observed that in general a time duration of up to about 3 min to develop color indicates a fire within 24 hours irrespective of the firearm and the type and make of 12-bore paper cartridge used. However, it is desirable that the results be verified before arriving at any conclusion. The effect of temperature and normal variation in the general weather condition has not shown characteristic influence, especially when the observations are made within a very short period. Some of the observations repeated at different time (after 10 days from the earlier tests) were found in general to be in agreement with the observations made earlier (Table 2).

To ascertain time of firing in actual criminal cases, the cartridge should be preserved so that the gases are allowed to escape freely as far as practicable. Investigations to achieve the most suitable way of preserving shells are still being carried out. Thorough investigations are also being made to ascertain the variations in the observed readings due to extreme variations in temperature, pressure, humidity, and general condition of weather, due to the different conditions under which cartridges are expected to be recovered and kept and the different types of ammunitions and firearms used. The possibility of estimating the time lapse since a firearm was fired is also being investigated. This involves further complicated variable factors such as the condition of the barrel before the questioned fire and the numbers of fire.

TABLE 2—*Repeated tests to measure time intervals after firing for three cartridges.*

Time Lapse After Firing, days	Time Taken to Develop Color		Temperature and Weather at Observation
	Cartridges a, b, and c	Mean	
2	10 min 12 min 9 min 10 s	10 min 23 s	86 °F fair
3	9 min 30 s 11 min 50 s 13 min 40 s	11 min 40 s	89 °F sunny
4	14 min 50 s 12 min 11 min 30 s	12 min 46 s	91 °F sunny
5	11 min 12 min 11 min 30 s	11 min 30 s	91 °F sunny
6	21 min 30 s 27 min 27 min 30 s	25 min 20 s	92 °F sunny
7	21 min 21 min 30 s 21 min 40 s	21 min 23 s	85 °F cloudy
8	22 min 27 min 50 s 31 min	26 min 56 s	86 °F sunny
9	31 min 23 min 21 min 50 s	25 min 16 s	88 °F sunny
10	30 min 25 min 40 s 25 min	26 min 53 s	88 °F sunny

Celsius temperature = (Fahrenheit deg − 32)/1.8.

Summary

The possibility of ascertaining approximate time of firing by utilizing the phenomenon of rate of escape of gaseous products of combustion has been investigated with special reference to 12-bore, 2½-in. (6.35-mm), fired cartridges made by the Indian Ordnance Factory. The relative rate of escape of gases has been determined indirectly by ascertaining the time needed to develop color in reagents by escaping gases by diazotization and coupling reaction. It has been observed that although the time to develop color tends to increase with the time lapse after firing, the observations are not interpretable for all possible time intervals due to overlapping and insignificant increase in certain intervals. A choice of suitable time intervals may be found to be useful in ascertaining the approximate time of firing, which may be determined experimentally in each case.

Normal variation due to atmospheric conditions has been found not to have significant influence under certain limits. The method suggested has been found to be comparatively more useful than the already existing methods.

Acknowledgment

The author is thankful to Dr. B. R. Sharma, Director, Forensic Science Laboratory, for his keen interest in the work.

References

[*1*] Lucas, A., *Forensic Chemistry and Scientific Criminal Investigation,* Edward Arnold & Co., London, 1948, pp. 179–191.

[*2*] Meier, J., "Establishing When a Shot Was Fired," *International Criminal Police Review,* No. 234, 1970, pp. 22–26.

[*3*] Price, G., "Recent Advances in Ballistics Laboratory Methods," *Journal of the Forensic Science Society,* Vol. 8, Nos. 2 and 3, 1968, pp. 83–90.

Forensic Science Laboratory
Chandigarh, India