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TECHNICAL NOTE

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Propellant Identification by Particle Size Measurement

The identification of propellants in evidential materials or from ammunition samples is of considerable interest in forensic investigations. Recently the thermal decomposition of nitrocellulose small arms propellants was studied in an effort to provide a method of identifying different samples [*1,2*]. In these studies it was established that differences in thermal characteristics do not provide reliable methods for differentiation between propellants.

Modern production techniques produce propellants uniform in both physical characteristics and thermal properties. While the thermal properties and chemical composition differ little for the various propellants, the physical characteristics may provide a way of distinguishing between various propellants. This report presents the results of particle size measurements that show that propellants can be identified in this way.

Experimental Methods

The particle dimensions for twelve different propellants were determined by a Gaertner Comparator (Fig. 1). With this instrument the particle is magnified 40 times and its image is displayed on a screen. A reference point is provided on the screen. Movement of the sample is achieved by micrometre adjustments that provide a direct measure of the particle size when the length of the image traverses the reference point on the screen. With the comparator, dimensions were optically measured on the nearest 0.001 mm. In each case ten individual particles of each propellant were chosen at random for measurement. Different manufacturing lots were selected where possible for each propellant to ascertain whether variations existed on that basis. In some cases the lots used to check for process changes had been manufactured ten years apart.

The propellants used include those having configurations of long cylindrical rods (I), short cylindrical rods (II), short cylindrical rods with axial holes (III), and circular disks with or without holes (IV). These configurations along with spherical (ball powders) particles are the usual shapes of particles of small arm propellants. Spherical propellants were not included in this study owing to the large variation in particle size for the same propellant.

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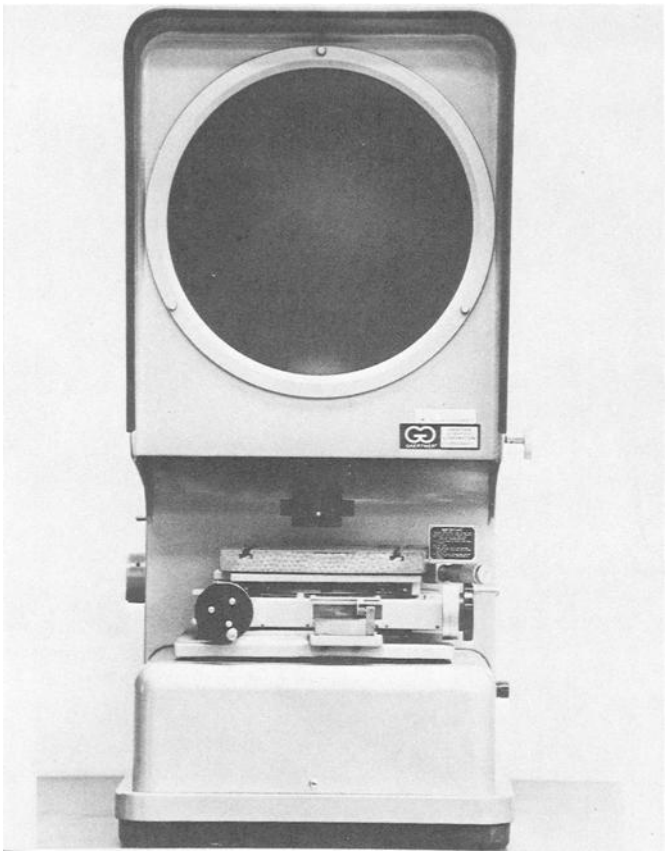

FIG. 1—*The Gaertner Comparator.*

Results and Discussion

The results of the particle size determinations are shown in Table 1. For the cylindrical particles, both length and diameter are reported. For propellants having the form of circular disks, only the diameter is reported. The mean measurements are shown as well as the average deviation from the mean and the standard deviation.

The fact that the particles have considerable uniformity enables size measurement alone to become a useful parameter. In the case of Du Pont IMR 4198®, the two lots used were manufactured at different times about twelve years apart, yet the particles have similar dimensions. In the cases of Du Pont IMR 3031®, 4320®, and 4227® three lots of each propellant were used with similar results. It appears that manufacturing processes are standardized to the extent that particles of the same propellant from different lots possess physical characteristics that are extremely similar.

The data shown in Table 1 reveal some interesting characteristics. For example, it is clear that one could not differentiate between Du Pont 4198, 3031, and 4064® on the basis of particle length. However, the diameters of these particles are 0.670, 0.754, and 0.814 mm, respectively. The standard deviations found indicate that these diameters are sufficiently different so that they clearly distinguish between these three similar propellants. Similarly, the data shown in Table 1 indicate that the particles having cylindrical forms

TABLE 1—*Particle size data for common propellants.*

Propellant[a]	Particle Type[b]	Length, mm			Diameter, mm		
		Average	Standard Deviation	Average Deviation	Average	Standard Deviation	Average Deviation
Du Pont 4198 (A)	I	2.217	0.067	0.051	0.679	0.015	0.013
Du Pont 4198 (B)	I	2.150	0.097	0.071	0.661	0.020	0.017
Du Pont 3031 (A)	I	2.168	0.134	0.088	0.754	0.014	0.013
Du Pont 3031 (B)	I	2.189	0.077	0.068	0.751	0.016	0.014
Du Pont 3031 (C)	I	2.194	0.083	0.070	0.756	0.013	0.011
Du Pont 4320 (A)	II	1.127	0.036	0.029	0.896	0.018	0.016
Du Pont 4320 (B)	II	1.128	0.044	0.036	0.867	0.019	0.015
Du Pont 4320 (C)	II	1.141	0.047	0.040	0.874	0.024	0.018
Du Pont 4064	I	2.165	0.077	0.070	0.814	0.020	0.016
Du Pont 4895	II	1.526	0.048	0.036	0.826	0.027	0.023
Du Pont 4227 (A)	III	0.659	0.055	0.043	0.635	0.009	0.006
Du Pont 4227 (B)	III	0.638	0.065	0.062	0.609	0.023	0.016
Du Pont 4227 (C)	III	0.628	0.058	0.051	0.620	0.015	0.011
Hercules Green Dot	IV	...	...	...	1.347	0.120	0.097
Du Pont 700X	IV	...	...	...	1.538	0.084	0.067
Hercules Red Dot	IV	...	...	...	1.641	0.055	0.045
Hercules Unique	IV	...	...	...	1.647	0.057	0.042
Hercules Bullseye	IV	...	...	...	0.846	0.028	0.022
Hercules 2400	IV	...	...	...	0.815	0.034	0.024

[a] A, B, and C indicate different lots of the same propellant.

[b] Type I: long cylindrical rods; Type II: short cylindrical rods; Type III: short cylindrical rods with axial holes; and Type IV: circular disks with or without perforation.

can all be distinguished from each other on the basis of length or diameter measurements, or both.

In the case of the propellants that have circular disk-shaped particles, identification is also possible. For example, Unique® can be distinguished from Bullseye® and Green Dot® on the basis of diameter. It can not, however, be identified from Red Dot® and 700X® on this basis. However, Du Pont 700X particles have a central perforation while Unique does not. Hercules Red Dot and Green Dot have red and green central spots giving these powders their names and making their identification relatively easy if several particles of each are present. Unique has no such coloration and can, therefore, be distinguished from Red Dot and Green Dot. Also, the edges of the Unique particles are smooth and rounded while those of Red Dot and Green Dot are not. Thus, those propellants having circular disk particles can be distinguished on the basis of particle size and other characteristics.

While only a representative number of propellants have been examined, the particle size and configuration are sufficient to enable many identifications to be made. In fact, all the propellants used in this work could be identified. If a specific powder can not be identified uniquely, it can at least be differentiated from almost all others. This is more than can be done on the basis of thermal measurements [*1,2*]. Thus, comparison of propellant particles with a highly precise optical comparator will usually enable an exact identification to be made.

References

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[*2*] House, J. E. and Zack, P. J., "Thermal Decomposition of Nitrocellulose Propellants," *Journal of Forensic Sciences,* Vol. 22, No. 2, April 1977, pp. 332-336.

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