Effect of Specific Surface on the Shock Sensitivity of Pressed Granular PETN*

by

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One theory of the processes leading to detonation in pressed granular explosives postulates that the rate of the chemical reaction in the build-up zone determines the shock sensitivity. If this rate is described in terms of a surface burning reaction it follows that enhanced sensitivity should result when the size of the particles which compose the explosive pressing is decreased.[1-4] While this predicted increase in sensitivity with decreasing particle size has been experimentally studied and shown to exist in gap-test measurements on propellants,[5] we know of no similar investigation of this effect on high explosives although it is often considered to be in agreement with general experience.

We have recently performed a series of experiments in which the shock sensitivity of the explosive pentaerythritoltetranitrate (PETN) has been investigated as a function of its specific surface. The sensitivity test used was a small-scale gap test,[6] a diagram of which is shown in Fig. 1. The range of specific surfaces investigated was 2,000 - 18,000 $cm^2\ g^{-1}$. The specific surface was measured by a permeameter, an instrument that determines the surface per unit mass from air permeability measurements.[7]

Two different methods for obtaining the PETN with the desired specific surfaces were used. The first involved ball-milling the largest sized material for various periods of time to reduce the average size while the second consisted of precipitating the PETN from acetone by the addition of water under different conditions to obtain individual samples with the different specific surfaces.

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The PETN acceptor (test) charges were cylindrical, one-half inch long by one-half inch in diameter and pressed to a loading density of 0.95 g cm^{-3}. The donor charges were two-tenths inch long by three-tenths inch diameter plastic-bonded RDX pellets of 1.6 g cm^{-3} density initiated by low density PETN which in turn was set off by a length of primacord. The attenuator material was one-inch diameter brass[8] cylinders of various thicknesses.

The criterion of satisfactory initiation was the production of a dent in a one-half inch thick sheet of aluminum used as a "witness" plate. Twenty shots of each particle size were fired using the "up and down" or "step" method, with an interval of one-hundredth inch brass thickness. The reported thickness is that at which 50% of the samples detonated.[9] Preliminary investigation of the normality of the distribution of these points by the method of Davies[10] shows them to be normally distributed with a standard deviation of 0.023 inch.

The data we have collected are shown in Fig. 2. It is evident that the shock sensitivity of PETN, as measured by this method, does not increase with an increase in the specific surface of the material, but rather decreases slightly over a wide range of specific surface. Experiments run at two other PETN loading densities, 0.75 and 1.4 g cm^{-3}, show the same effect. These results indicate that some mechanism other than a surface burning reaction must determine the shock initiation to detonation in granular pressings of PETN.

References

1. A. Macek, Chem. Revs., 62, 41 (1962).
2. H. Eyring, et al., Chem. Revs., 45, 144 (1949).
3. F. P. Bowden and A. D. Yoffe, Initiation and Growth of Explosions in Liquids and Solids, Cambridge at the University Press, (1952) p.5.
4. G. B. Kistiakowsky, Third Symposium on Combustion and Flame and Explosion Phenomena, Williams & Wilkins Co., Baltimore, Md., (1949) pp. 560-565.
5. J. R. Hyndman, NAVORD Report 5746, XXX, 291
6. G. P. Cachia and E. G. Whitbread, Proc. Roy. Soc. (London), A246, 269 (1958).
7. F. M. Lea and R. W. Nurse, J. Soc. Chem. Ind., 58, 277 (1939)
8. Free-Machining Yellow Brass - 66% Cu + 34% Zn.
9. W. J. Dixon and A. M. Mood, J. Am. Stat. Assoc., 43, 109 (1948).
10. O. Davies, Statistical Methods in Research and Production, Oliver & Boyd Pub., London, 2nd Ed., (Rev. 1949) pp. 20-21.

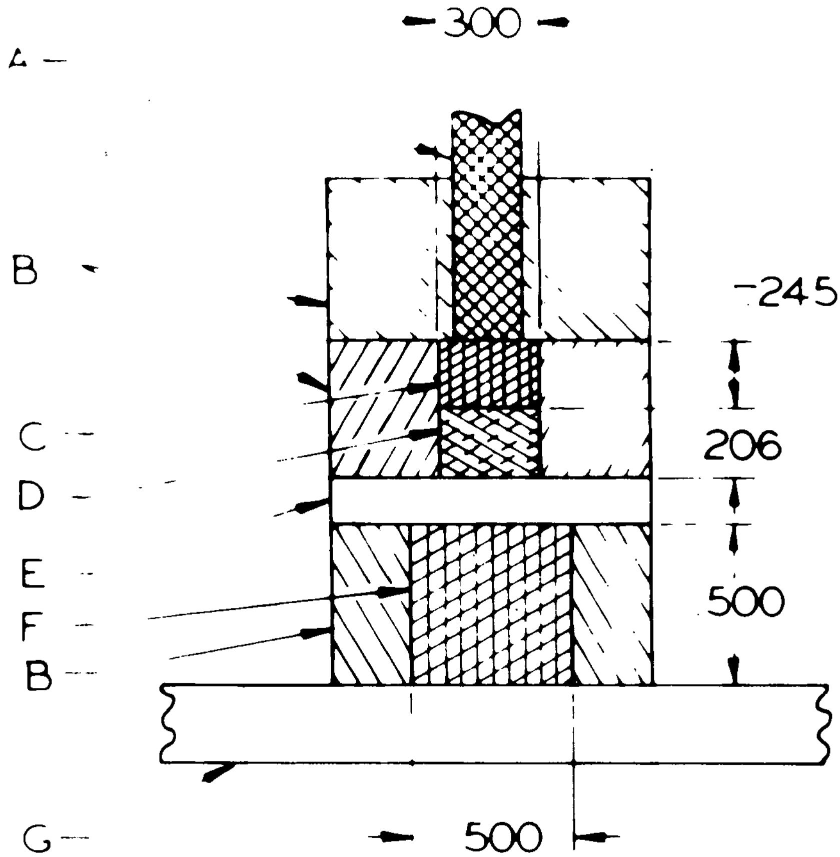

Figure 1

SMALL SCALE GAP TEST ASSEMBLY

A = Primacord; B = Plastic holders; C = PETN initiator;
D = Plastic-bonded RDX donor; E = Brass attenuator;
F = PETN acceptor (test) charge; and G = One-half inch
aluminum "witness" plate.

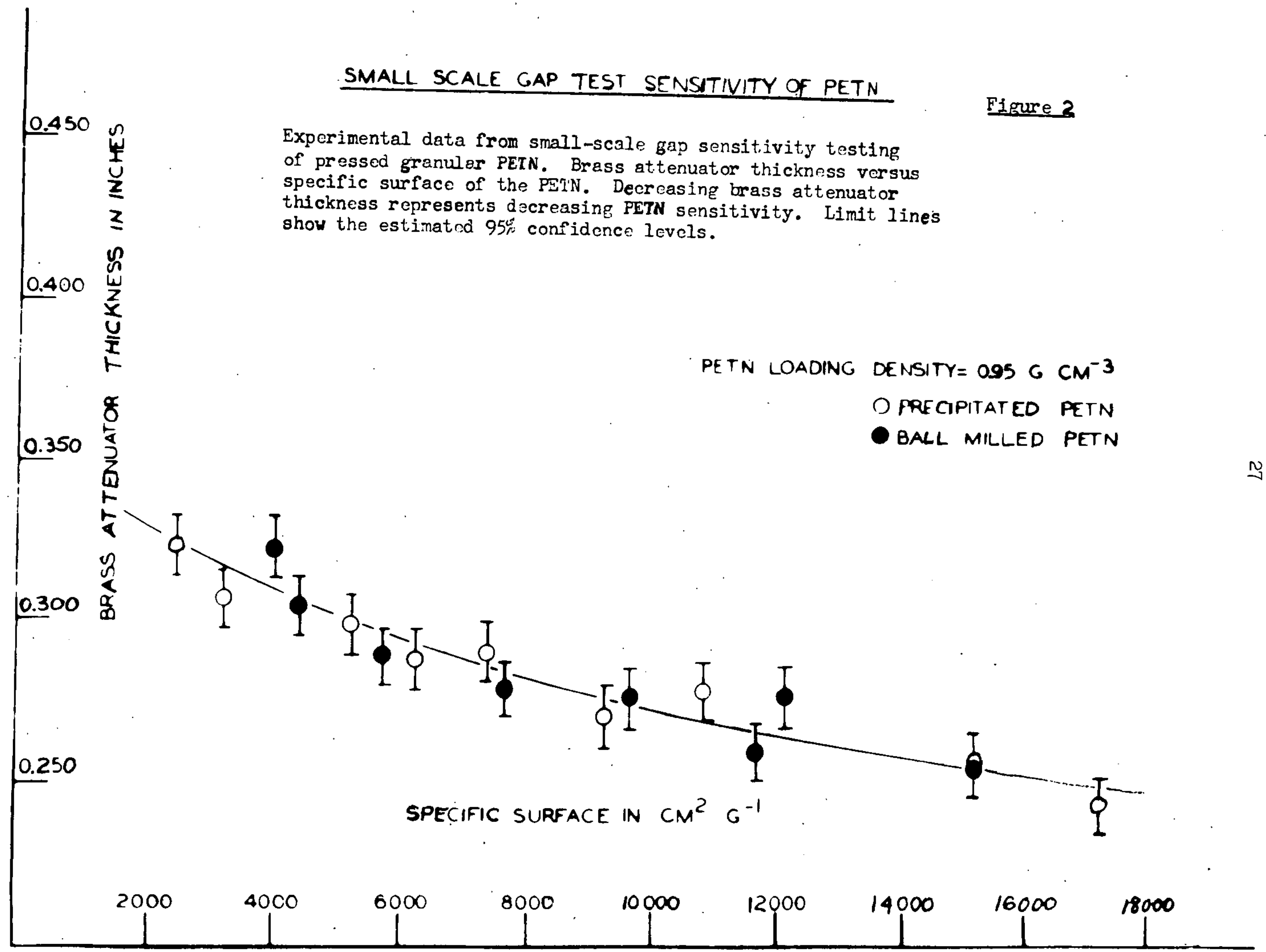

Figure 2

SMALL SCALE GAP TEST SENSITIVITY OF PETN

Experimental data from small-scale gap sensitivity testing of pressed granular PETN. Brass attenuator thickness versus specific surface of the PETN. Decreasing brass attenuator thickness represents decreasing PETN sensitivity. Limit lines show the estimated 95% confidence levels.