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On the Sensitiveness of 2,4,6-Trinitrotoluene to Impact

by

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It has been reported by Rinkenbach [1], that TNT (2,4,6-trinitrotoluene), in molten state at 90°, is nearly as sensitive to impact as nitroglycerine at room temperature.

However, Robertson [2] reported that the insensitiveness of picric acid at 80° can be expressed by the number 75, while at 15° it is characterized by the number 100, i. e. the sensitiveness at 80° increases by 25%, as compared with that at 15°.

It should be expected, on the basis of the latter numbers that the increase of the sensitiveness of TNT with rising temperature is less significant than given by Rinkenbach [1].

The present work was carried out in order to elucidate this discrepancy.

Experimental

The sensitiveness of TNT to impact was examined by means of the falling weight method, using the known apparatus introduced by the Militärversuchsamt in Berlin [3]. The "piston apparatus" described by Andreev [4] (Fig. 1) was used, as it gives more uniform results at elevated temperatures than Kast's [5] piston apparatus modified by one of us and Pietrzyk [6].

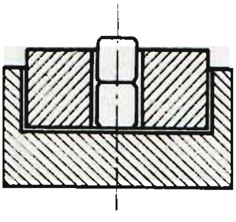

Fig. 1

The pistons were made of PN NQE steel hardened to 60° Rockwell. Their diameter was 9.997 ± 0.003 mm. They were well cleaned with acetone and dried. They were used only once.

The piston apparatus was kept in a thermostate jacket filled with water passing through a Höppler thermostate. When temperature above

100°C was required, the jacket was filled with lubricating oil pumped through an electric thermostate provided with an electric thermoregulator.

The samples of explosives (0.02 ± 0.005 g.) were put in a small dish made of tin-foil (0.1 mm. thick).

Per cents of explosions were determined by striking the samples with a falling weight of 10 kg. from various heights: 15, 30 and 50 cm. The recoils: 4.0, 5.5 and 11 cm. and the calculated work were 2.7, 3.1 and 5.0 kgm/cm²., respectively.

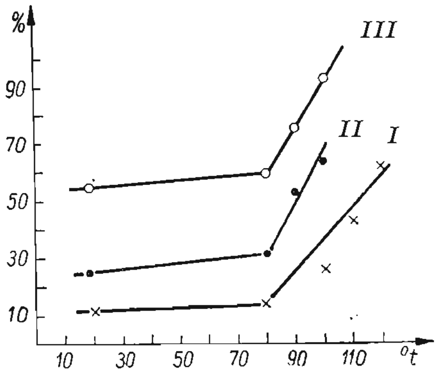

Fig. 2

The experiments were repeated 100 times at every height.

Pure TNT (freezing t. 80.35°C.) was pulverized and sievied to the size of grains of 0.15-0.25 mm.

Picric acid (m. p. 122°) and tetryl (m. p. 128.6°) of the same size of grains were also used as standard explosives, at room temperature.

The preliminary experiments have shown that the sensitiveness of TNT between room temperature and its melting temperature does not change considerably. Therefore the sensitiveness between these limits has not been investigated.

The results are tabulated (Table I) and presented in diagrammatic form (Fig. 2).

It can be seen (from the dispersion of the points forming the curves) that the exactness of the experiments increases with the increase of the height from which the weight falls.

TABLE I

Substance	Temperature	Per cent of explosions at the height of		
		25 cm. curve I	30 cm. curve II	50 cm. curve III
TNT	18	—	24	54
	20	11	—	—
	80	13	—	—
	81	—	31	59
	90	—	48	75
	100	25	63	89
	110	43	—	—
	120	62	—	—
Picric acid	18°	—	50	75
Tetryl	18°	48	81	94

Discussion

Each curve can be regarded as being formed of two straight lines (Fig. 3): AB and BC with the slopes α_1 and α_2 respectively. The point of interception B corresponds to the temperature near the melting point of TNT, i. e. near 80-81°C.

The equation of each lines is, of course,

$$p = a + bt \tag{1}$$

where

p – % of explosions,
t – temperature in centigrades,
a, b – coefficients.

Obviously, the coefficient a corresponds to the probability of explosions p at temperature $t = 0$.

The coefficient b signifies, of course, the slope of the lines:

$$b = \text{tang}\,\alpha\,. \tag{2}$$

The values of a and b have been calculated. For the lines BC (where more than two points exist) the method of least squares has been used. The calculated values are tabulated (Table II).

TABLE II

	Curve I		Curve II		Curve III	
	$(AB)_I$	$(BC)_I$	$(AB)_{II}$	$(BC)_{II}$	$(AB)_{III}$	$(BC)_{III}$
a	10.3	—87.5	22	—107	52.6	—70
b	0.033	1.2	0.111	1.68	0.079	1.57

There is a characteristic increase of the slope of the lines BC as compared with that of AB. A strong influence of temperature on the sensitiveness of TNT, particularly at elevated temperatures, seems to confirm the view formerly expressed by one of the authors of the present paper [7], that sensitiveness of explosives to impact has mainly a thermal character. This assumption was then based on a similarity of the curves of sensitiveness of mixture to impact and to high temperature.

The thermal character of sensitiveness to impact seems to be now generally admitted [8].

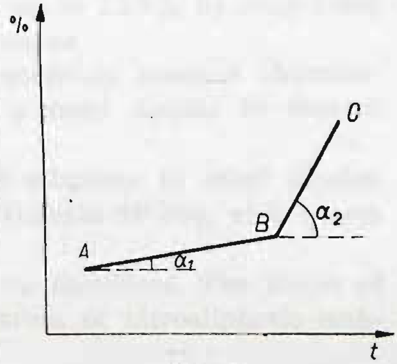

Fig. 3

From a practical point of view the experimental data may possess a certain importance (Table I). It is evident that the sensitiveness of molten TNT between 81 and 100° is clearly below the sensitiveness of tetryl at room temperature. The sensitiveness of TNT at 90° is of the order of that of picric acid at room temperature.

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