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SOME PROPERTIES AND CHARACTERISTICS OF HBX-1, HBX-3, AND H-6 EXPLOSIVES (U)

SAMUEL D. STEIN
GEORGE J. HORVAT
OLIVER E. SHEFFIELD

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SAMUEL FELTMAN AMMUNITION LABORATORIES
PICATINNY ARSENAL
DOVER, N. J.

ORDNANCE PROJECT TA3-5000B ITEM B

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by

Samuel D. Stein
George J. Horvat
Oliver E. Sheffield

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Picatinny Arsenal
Dover, N. J.

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Approved:
Eriksen
L. H. Eriksen
Chief, Explosives and
Plastics Laboratory

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OBJECT

To compare several HBX-type explosives (HBX-1, HBX-3, and H-6) with each other in terms of their more important chemical, physical, military, and sensitivity properties.

SUMMARY

Because of increased interest in HBX-type explosives, data on various properties of several explosives of that type was compiled and an attempt was made to compare them with each other and with Composition B and 80/20 tritonal.

The following specific findings illustrate the fact that variations in the properties of these explosives are dependent mainly on their aluminum and desensitizer content. The heat of combustion was higher and the gas volume lower for HBX-3 than for HBX-1 or H-6 because of the relatively high aluminum content of HBX-3. Because HBX-3 has a higher aluminum content, its compressive strength, tensile strength, and modulus of elasticity (Young's Modulus) were higher than those of HBX-1 and H-6. The effects of the D-2 desensitizer[1] used in the HBX-type compositions were also studied. Results indicated that it impairs the physical properties of the explosives.

In laboratory impact, friction, and bullet-impact sensitivity tests, the HBX-1, HBX-3, and H-6 explosives compared favorably with Composition B and 80/20 tritonal. However, the presence of nitrocellulose in the D-2 desensitizer used in the HBX-1, HBX-3, and H-6 compositions somewhat increased the heat sensitivity of the explosives.

Because of its higher aluminum content and lower RDX content, the HBX-3 was less brisant than the HBX-1 and the H-6. In fragmentation, the explosives fell into the following order of decreasing effectiveness: Composition B, HBX-1, H-6, 80/20 tritonal, and HBX-3. The rates of detonation of the HBX-1, HBX-3, and H-6 were less than that of Composition B and greater than that of 80/20 tritonal. Several of the references used in this investigation contain data which shows that the inclusion of the 5% of D-2 desensitizer in HBX-1, HBX-3, and H-6 impairs their blast performance.

With regard to stability, HBX-1, HBX-3, and H-6 were found to compare favorably with Composition B and 80/20 tritonal. The use of calcium chloride as a desiccant caused the HBX-type explosives to behave hygroscopically, however. This defeats the purpose for which the calcium chloride is intended. Preliminary tests with silica gel as a desiccant in these compositions indicated that the explosives are less hygroscopic when this material is used in place of calcium chloride. When the explosives were made without any desiccant, they absorbed

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[1] The D-2 desensitizer, in accordance with Specification C-MIL-C-18164 (NOrd) dtd 4 November 1954 entitled *Composition D-2,* consisted of

Wax, desensitizing	84 ±3%
Lecithin	2 ±0.5%
Nitrocellulose	14 ±1%

little or no moisture. The addition of 0.6% moisture to HBX-1, HBX-3, and H-6 did not appear to affect the stability of the explosives.

CONCLUSIONS

The thermochemical and physical properties, the brisance, and the rate of detonation of HBX-1, HBX-3, and H-6 are markedly affected by the aluminum content of the explosives.

The calcium chloride used as a desiccant in HBX-1, HBX-3, and H-6 imparts undesirable hygroscopicity to the explosives.

The D-2 desensitizer used in HBX-1, HBX-3, and H-6 reduces the performance and physical strength and increases the heat sensitivity of the explosives.

RECOMMENDATION

Investigations should be conducted to determine whether there is a need for the D-2 desensitizer and the desiccant in HBX-1, HBX-3, and H-6 explosives.

INTRODUCTION

1. In the past, the primary objective of most attempts to improve explosives was usually the attainment of a high rate of detonation or increased brisance. More recently, several compositions of the HBX type (HBX-1, HBX-3, and H-6) were developed to fulfill the need for powerful blast explosives. This need arose when, because of the increased speed of planes, guided missiles, and other primary targets, the probability of obtaining a direct hit with any projectile decreased. It is possible for a projectile containing a high blast explosive to defeat a target without a direct hit. Because of this characteristic of blast explosives and the resultant need for knowledge of their properties and characteristics, the Office of the Chief of Ordnance requested (Ref 1) that certain chemical, physical, sensitivity, and military properties of HBX-1, HBX-3 , and H-6 be determined.

2. The data obtained in compliance with Reference 1, together with other available data, is presented in this report. For purposes of comparison, similar bodies of data on Composition B and 80/20 tritonal are included. Also given are the results of limited tests to determine the effect of moisture on the stability of HBX-1, HBX-3, and H-6, and to evaluate calcium chloride as a desiccant in these compositions.

3. In this report, HBX-1, HBX-3, and H-6 explosives are referred to as HBX explosives because they contain the same materials, though in different proportions (Table 1, p 3).

RESULTS

4. Tables 2 through 7 (pp 2-6) contain the detailed findings of this investigation.

Published data on the properties of Composition B and Cyclotol is included, where available, for purposes of comparison.

a. The thermochemical properties of the several explosives (heat of combustion, heat of explosion, gas volume, explosion temperature, specific heat, and thermal conductivity) are given in Table 2.

b. Table 3, (p 4) contains detailed data on such physical properties as compressive strength, tensile strength, Young's Modulus, coefficient of expansion, and density.

c. The sensitivity characteristics (as determined by laboratory impact tests, friction pendulum tests, and rifle-bullet-impact tests) are given in Table 4, p 5).

d. Brisance characteristics (as determined by sand, ballistic mortar, and fragmentation tests) are covered by Table 5, (p 5).

TABLE 1

Chemical Composition of the HBX-Type Explosives

	HBX-1	HBX-3	H-6
Composition B	67	52	74
TNT	11	8	
Aluminum powder Class C, Type D	17	35	21
D-2 desensitizer	5	5	5
Calcium chloride, anhydrous (added)	0.5	0.5	0.5

TABLE 2

Thermochemical Properties

	HBX-1	HBX-3	H-6	Composition B	80/20 Tritonal
Heat of combustion, cal /gm	3882	4495	3972	2790*	4480*
Heat of explosion, cal/gm	919	877	923	1240*	1770*
Gas volume, cc/gm	758	491	733	—	—
Explosion temperature, °C	480	500	610 (min)	278**	470**
Specific heat					
Cal/gm/°C at 30°C	0.249	0.254	0.269	—	0.23 (-5°C)**
50°C	0.264	0.254	0.268	—	—
Thermal Conductivity, cal/sec/cm/°C at 35°C	0.97×10^{-3}	1.70×10^{-3}	1.10×10^{-3}	—	11.0×10^{-4}

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*Data taken from Reference 2

**Data taken from Reference 3

TABLE 3

Physical Properties

	HBX-1	HBX-3	H-6	Composition B	80/20 Tritonal
Compressive strength, lb/sq in.	1303	1610	1083	1610-2580[a]	2340[a]
Ultimate deformation, %	1.38	1.37	1.32	—	—
Density, gm/cc	1.75	1.86	1.76	1.68[a]	1.75[a]
Tensile strength, lb/sq in.	242	268	446	—	—
	245	586	464	—	—
	293	479	395	—	—
	405	573	439	—	—
	74[b]	459	474	—	—
Average	296	473	444	—	—
Young's Modulus (modulus of elasticity)					
E', dynes/sq cm	10.3×10^9	11.5×10^9	9.0×10^9	—	6.67×10^{10}[a]
E, lb/sq in.	1.49×10^5	1.67×10^5	1.30×10^5	—	0.97×10^6[a]
density, gm/cc	1.75	1.86	1.76	—	1.72[a]
Coefficient of expansion[c] inch/inch at 0°C	46×10^{-4}	40×10^{-4}	41×10^{-4}	—	—
at 35°C	95×10^{-4}	83×10^{-4}	83×10^{-4}	—	—
at 70	159×10^{-4}	130×10^{-4}	131×10^{-4}	—	—
Density, gm/cc					
Theoretical[d]	1.76	1.88	1.79	—	—
Cast-loaded	1.72	1.84	1.74	1.68	1.72

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[a] Data taken from Reference 2

[b] This value omitted in calculation of average

[c] Ratio of the increase in length to the original length for a given rise in temperature

[d] Data taken from Reference 4

TABLE 4

Sensitivity

	HBX-1	HBX-3	H-6	Composition B	80/20 Tritonal
Impact Sensitivity, PA apparatus 2 kg wt					
First series, inches	16	15	14	14[a]	13[a]
Charge wt, gm	0.021	0.023	0.018	0.019[a]	0.016[a]
Second series, inches	19	15	14		
Charge wt, gm	0.022	0.023	0.025		
Friction pendulum sensitivity Steel shoe	unaffected	unaffected	unaffected	unaffected [b]	unaffected [b]
Rifle bullet sensitivity[c]					
Number of bombs tested	40	40	40	40	40
Number unaffected	11	9	8	9	10
Exploded	29	31	32	31	30

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[a] Data taken from Reference 2

[b] Data taken from Reference 3

[c] Data taken from Reference 5

TABLE 5

Brisance

	HBX-1	HBX-3	H-6	Composition B	80/20 Tritonal
Sand test					
Sand crushed, gm using 0.30 gm lead azide	46.2	—	40.1		
0.10 gm tetryl + 20 gm lead azide	48.1	44.9	49.5		
0.25 gm tetryl + 0.2 gm lead azide	45.[illegible]	41.5	46.2		
Ballistic mortar test (TNT - 100)	133 [a]	111 [a]	135 [a]	133 [b]	123-136 [b]
Fragmentation test, 90 mm M71 shell					
Test data[c]	2557 2379	1478 1924	1924 2171		
Corrected data	910	476	714		
Reported data				998[b]	616[b]

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[a] Data taken from Reference 4

[b] Data taken from Reference 3

[c] Shell from Lot EGS-1-17. Magnetic Separator used in recovery of fragments.

[d] A description of the method used to correct the data is given in Paragraph 21c

TABLE 6

Detonation Velocity*

	HBX-1	HBX-3	H-6	Composition B**	80/20 Tritonal**
Rate of detonation, m/sec	7224	6917	7191	78[illegible]	6475
Density, gm/cc	1.75	1.86	1.76	1.68	1.71

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*Drum-camera method

**Data taken from Reference 2

TABLE 7

Stability

	HBX-1	HBX-3	H-6	Composition B*	80/20 Tritonal*
100°C vacuum stability test, cc/gm of gas evolved/40 hrs	0.47	0.45	0.47	0.7	0.1
100°C heat test,					
loss in wt in first 48 hr,%	0.58	0.70	0.78	0.2	—
loss in wt in second 48 hr, %	0.00	0.000	0.00	0.1	—
Explosions in 100 hr	none	none	none	none	—

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*Data taken from Reference 2

TABLE 8

Effect of Desiccants on Stability of HBX Explosives*

	Moisture %			100°C Vac Stab Test,	Hygroscopicity at 95% RH, %	
	Added	Total	Acidity, %	gas/40 hrs, cc	30°C	71°C
				With Calcium Chloride as a Desiccant		
HBX-1	—	0.73	0.011	0.47	+2.98	+1.13
	0.2	0.93		0.68		
	0.4	1.13		0.62		
	0.6	1.33		0.50		
HBX-3	—	0.54	0.049	0.45	+2.01	+0.31
	0.2	0.74		0.47		
	0.4	0.94		0.43		
	0.6	1.14		0.41		
H-6	—	0.71	0.082	0.47	+2.01	+1.77
	0.2	0.91		0.88		
	0.4	1.11		0.63		
	0.6	1.31		0.65		
				With No Desiccants		
HBX-1	—	0.00	0.029	0.36	–0.06	–0.25
	0.2	0.20		0.25		
	0.4	0.40		0.23		
	0.6	0.60		0.27		
HBX-3	—	0.02	0.049	0.46	–0.06	–0.29
	0.2	0.22		0.26		
	0.4	0.42		0.26		
	0.6	0.62		0.20		
H-6	—	0.03	0.082	0.40	–0.06	–0.25
	0.2	0.23		0.10		
	0.4	0.43		0.25		
	0.6	0.63		0.23		
				With Silica Gel** as a Desiccant		
HBX-1	—	0.06	0.031	0.73	+0.08	+0.04
HBX-3	—	0.04	0.100	0.45	+0.09	+0.05
H-6	—	0.05	0.028	0.43	+0.09	+0.06

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*All samples ground to 20/100 mesh size before tests (7 days)

**Fisher Scientific Company, Lot 541492, through No. 100 U. S. standard sieve

e. Tables 6 and 7 (p 6) present data on detonation velocity and on stability characteristics at high temperatures, respectively.

5. The results of tests to determine the effect on the stability of HBX-type explosives of using and not using desiccants and of adding moisture to the explosive are given in Table 8 (p 7). These findings may be summarized as follows:

a. The addition of moisture to the HBX-type explosives made with or without 0.5% calcium chloride had little or no effect on the quantity of gas evolved in the 100°C vacuum stability test.

b. The hygroscopicity of the HBX type explosives made with 0.5% calcium chloride was positive. The hygroscopicity was greater at 30°C than at 71°C.

c. When made without calcium chloride, the HBX-type explosives had a small loss of weight indicated by a small negative hygroscopicity value.

d. When made with silica gel as the desiccant in place of calcium chloride, the HBX-type explosives had a small positive hygroscopicity. The amount of moisture attracted to the explosives made with silica gel was much smaller than that attracted to the explosives made with calcium chloride.

DISCUSSION OF RESULTS

6. The thermochemical properties of HBX-type explosives (heat of combustion, heat of explosion, gas volume, and thermal conductivity) vary according to the chemical composition of the explosive. For example, HBX-3, which has a higher aluminum content than HBX-1 or H-6, also has a greater heat of combustion. This is understandable if we compare the heat of formation of Al_2O_3 (3800 cal/gm, Ref 6) with the heats of combustion of Composition B and TNT (2790 cal/gm and 3620 cal/gm, respectively, Ref 2). Therefore, it can be said that the explosive having the greatest aluminum content should have the highest heat of combustion. This same reasoning is applicable to various other thermochemical properties, since test results clearly show that the amount of aluminum present is the most significant single factor affecting the variations of these properties.

7. The variations in the physical properties of the explosives examined can also be explained on the basis of differences of composition. Since HBX-3 contains the highest metallic (aluminum) content, this explosive would be expected to have the highest compressive strength, tensile strength, Young's Modulus (modulus of elasticity), and density. Since aluminum has a lower coefficient of expansion than Composition B or TNT, HBX-3 would be expected to have a lower coefficient of expansion than HBX-1 or H-6. Test results (Table 3, p 4) confirmed this reasoning in both instances.

8. The most probable cause of the decrease in compressive strength of the HBX explosives is their high wax content. This is shown by the fact that Torpex-2 (essentially HBX-1 without the D-2 desensitizer has a compressive strength of 2100-2300 psi where HBX-1 has a compressive strength of only 1303 psi. Eighty-four percent of the D-2 desensitizer used in the HBX explosives is wax (Specification MIL-W-15841A(NOrd), 18 May 1953, entitled "Wax Desensitizing). In addition 0.9% of the weight of the Composition B incorporated into these explosives is wax (Purchase Description PA-PD-535, 15 September 1954, entitled, "Desensitizer Explosive"). Since the two specifications differ in many of their requirements, it is probable that the desensitizer and the Composition B contains different waxes. The total wax content of HBX-1, HBX-3, and H-6 (from both sources) are, respectively, 4.80%, 4.67%, and 4.87%.

9. From the data given in Table 4, it is evident that the HBX explosives are no more impact, friction, or rifle bullet sensitive than Composition B or 80/20 tritonal. It has been determined (Ref 7) that the wax in Composition B does not coat the RDX particles but is present in the form of droplets, each surrounded by a layer of TNT. Thus, the wax is useless for its primary purpose, which is to reduce the sensitivity of the explosive. It is probable that the wax behaves in the same way in the HBX-type explosives. Therefore, from the viewpoint of sensitivity, the need for the D-2 desensitizer in the HBX explosives is questionable.

10. Reference 8 contains data which show that H-6 will detonate at a lower temperature (290°F) than Composition B (358°F). From Table 1, it can be seen that the only difference in the composition of these two explosives is that H-6 contains aluminum, D-2 desensitizer, and calcium chloride, while Composition B does not contain any of these materials. There is no ready explanation as to why aluminum or calcium chloride should reduce the detonation temperature of H-6. The D-2 desensitizer, however, contains nitrocellulose (14%). Reference 9 states that nitrocellulose has a rapid rate of decomposition at any temperature greater than 212°F, and that this decomposition is an exothermic reaction. This phenomenon is the most plausible explanation of the greater heat sensitivity of H-6. Since HBX-1 and HBX-3 also contain the D-2 desensitizer it is believed that their sensitivity to heat would be similarly affected. The presence of the D-2 desensitizer in the HBX-type explosives may in the future impose limitations on their use in missiles and rockets and in other applications where insensitivity to heat is of vital importance.

11. It should be noted (Table 2) that the explosion temperature of H-6 as determined by the laboratory method (610°C, minimum) is higher than that of Composition B (278°C). This is contrary to the conclusion expressed in Reference 8. One reason for this seeming contradiction is that the procedures by which the two sets of data were obtained are quite different. When the laboratory

method is used, 0.02 gm of explosive is placed in a No. 8 blasting cap and immersed in a Woods metal bath. Explosion temperature is determined by finding the lowest bath temperature which will produce explosion, ignition, or decomposition of the sample within a 5-second period of immersion. As determined by this method, the explosion temperature is merely the temperature at which the heat transfer from the metal in the Woods bath to the explosive in the blasting cap is sufficient to cause the explosive to detonate in 5 seconds. This is obviously not the temperature at which the explosive detonates in actual field use. In the tests reported in Reference 8, 2 ounces of explosive was loaded in an aluminum cup and subjected to a constant heat input. The temperature was recorded continuously by means of thermocouples in the cup. Since the temperatures obtained by this method (par 10) are those at which the two explosives will detonate when exposed to steadily increasing temperatures, this test method can be said to accurately simulate true field detonation conditions.

12. In brisance (Table 5), as in thermochemical and physical properties, the relative standings of the explosives are dependent on their chemical compositions, mainly their aluminum content. In the sand test, HBX-3 crushed a smaller quantity of sand than either HBX-1 or H-6, which crushed approximately equal amounts. In the ballistic mortar test (based on a TNT value of 100), HBX-1 and H-6 were found to be comparable to Composition B. HBX-3 had a considerably lower value. In the fragmentation test, the HBX-type explosive containing the least aluminum, HBX-1, was the most brisant, giving a number of fragments approaching that obtained from Composition B. The explosive containing the most aluminum, HBX-3, gave the smallest number of fragments.

13. Table 6 shows that, when the aluminum content is increased and the RDX content decreased, the detonation velocity is reduced. HBX-3, which contains more aluminum than HBX-1 or H-6, had a lower detonation velocity than either of the other two explosives. 80/20 Tritonal, which contains no RDX, had the lowest detonation velocity and Composition B, which contains 60% RDX, had the highest detonation velocity of the five explosives examined.

14. In the 100°C vacuum stability test of the HBX-type explosives, the quantity of gas evolved was approximately the same (0.45 to 0.47 cc/gm) for all three explosives. A slightly greater quantity of gas (0.7 cc/gm) was evolved by Composition B, and a slightly smaller quantity (0.1 cc/gm) was evolved by 80/20 tritonal. In the 100°C heat test, the percentage losses in weight in the first 48 hours for HBX-1, HBX-3, H-6, and Composition B were 0.58%, 0.70%, 0.78%, and 0.2%, respectively. The HBX-type explosives did not lose any weight in the second 48 hours, but the Composition B lost an additional 0.1%. None of the explosives detonated during the first

100 hours. Considering the qualitative nature of the tests, all that can be said is that the HBX-type explosives are as stable as Composition B.

15. In aluminized explosives, it is desirable to reduce the moisture content to a minimum because water in contact with aluminum liberates hydrogen gas which may become dangerous if it reaches a sufficient concentration. Stability tests were conducted at 95% relative humidity at both 30°C and 71°C to determine the effectiveness of the calcium chloride used in the HBX-type explosives as a desiccant. Tests were also conducted with silica gel. As Table 8 indicates, the calcium chloride in the charge, being deliquescent, adsorbed moisture during storage. Explosives made without any desiccant appeared to lose moisture and a small, but insignificant, amount of gassing was evident. When the calcium chloride was replaced by silica gel, very little moisture was absorbed. It should be noted that these were only exploratory tests and that the data obtained should be confirmed by further testing. From the limited test results available, it appears that the calcium chloride used to absorb moisture from the charge defeats its own purpose by attracting additional moisture to the charge, and thus creates a potentially hazardous condition. Tests were also conducted (Table 8) to determine whether an increase in moisture content would affect the stability of HBX-type explosives. The addition of as much as 0.6% moisture to charges made with and without calcium chloride as a desiccant did not appear to affect the stability of the explosives. Apparently the need for a desiccant in the HBX compositions requires further investigation. It is quite possible that such an investigation would show that no desiccant is needed.

16. It has been noted that HBX explosives made without calcium chloride had a negative hygroscopicity. In all cases, the percent weight lost was greater than the original moisture content of the samples. This would seem to indicate that a slight amount of gassing had occurred. Most likely, as much or more gassing occurred when the explosives were made with calcium chloride or silica gel. The evidence of it was obscured, however, by the absorption of moisture by the desiccant. Probably, the amount of gassing is greater with calcium chloride than without it, since this material attracts large quantities of moisture to the charge. This is especially so at elevated temperatures when some of the moisture absorbed by the calcium chloride at lower temperatures is set free to react with the aluminum in the charge. The presence of the calcium chloride may therefore increase rather than decrease the hazard of gassing.

17. It is realized that blast, which is possibly the most important aspect of the performance of these explosives, has not been covered in this report. Various tests have been conducted by many installations and other tests are now in progress at Picatinny. The

consensus of opinion at this time is that, with respect to air blast, H-6 is the best explosive. This explosive has been repeatedly recommended for use in items requiring high-blast performance. When the results of tests now being conducted at Picatinny become available, they will be promptly reported.

18. It should be noted, however, that comparisons of HBX-1 with torpex-2 (HBX-1 made without the inclusion of 5% of D-2 desensitizer) indicate that, on the basis of peak pressure and impulse, torpex-2 gives better blast performance. References 10, 11, 12, 13, 14, and 15 are among the many reports which show this comparison. Apparently, the D-2 desensitizer has an adverse effect on the blast performance of the HBX explosives.

19. It appears that, in terms of blast performance, heat sensitivity, and physical strength, the D-2 desensitizer has a deleterious effect on HBX-type explosives. Moreover, there is evidence that the D-2 desensitizer does not effectively coat and therefore does not desensitize the RDX crystals in the explosives. With respect to the calcium chloride, the preliminary data presented indicates that this material attracts additional moisture to the explosive instead of reducing the amount of free moisture present. It is evident, therefore, that investigations should be conducted to determine whether the D-2 desensitizer and the calcium chloride are necessary in these explosives. If not they should be eliminated, both from the standpoint of performance and for reasons of economy.

EXPERIMENTAL PROCEDURE

20. The HBX-type explosives used were manufactured in accordance with specification MIL-L-14161 (ORD), dated 28 September 1955.

21. The following test procedures were used:

a. The impact sensitivity, vacuum stability, heat, explosion temperature, sand, and minimum-detonating-charge tests were conducted in accordance with Picatinny Arsenal Technical Report 1401.

b. The rifle-bullet impact test data was taken from Reference 5.

c. The fragmentation tests were conducted in accordance with Picatinny Arsenal Testing Manual 5-1, dated 24 August 1950, with the following exceptions:

(1) M54 fuzes modified in accordance with Drawing PX-97-287 were used.

(2) Each fuze was initiated by a Type II special blasting cap.

(3) A 10" × 10" × 20" box made of ½-inch-thick pine board was used to catch the fragments.

(4) Fragments were collected by pouring the sand from the recovery box through a No. 4 US standard sieve.

A magnetic separator was then used to collect the fragments which had passed through the the sieve. The resultant fragmentation data was adjusted so that it could be compared with data for Composition B and 80/20 tritonal which had been obtained before the magnetic separator was available for use. The data was adjusted by the following procedure:

(a) Percent recovery data from a number of fragmentation tests conducted without the magnetic separator was averaged.

(b) The difference between this average and the recovery percentage obtained with the magnetic separator for the HBX-loaded shell was calculated. This difference is equivalent to the total weight of all fragments which pass through the sieve but are not collected when the magnetic separator is not used.

(c) This weight difference was mathematically converted to the equivalent number of small fragments and that number was then subtracted from the total number of fragments collected for each HBX-loaded shell. The resultant value was used in comparing the data for the HBX charges with available data for Composition B and 80/20 tritonal.

d. The detonation velocity tests were conducted in accordance with Picatinny Arsenal Technical Report 1465

e. The heat of combustion tests were conducted in accordance with Picatinny Chemical Laboratory Report 127815.

f. The heat of explosion and gas volume tests were conducted in accordance with Picatinny Arsenal Chemical Laboratory Report 134476.

g. The coefficients of expansion were determined in accordance with Picatinny Arsenal Chemical Laboratory Reports 128029 and 130575.

h. The compressive strength and Young's Modulus were determined in accordance with the "Method for Determining Compressive Properties of Solid Rocket Propellants" approved 24 January 1950 by the Joint Army-Navy Panel on Physical Properties of Solid Propellants.

i. The specific heat was determined in accordance with Picatinny Arsenal Technical Report 2224.

j. The thermal conductivity was calculated from the equation:

$$K = h^2 Cpd$$

where

K = thermal conductivity

h = thermal diffusivity

Cp = specific heat

d = density

The thermal diffusivity was determined by an adaption of the method used in

Picatinny Arsenal General Laboratory Report 51-H1-1826.

(k) The stability of the HBX-type explosives made with and without desiccants and containing added moisture was determined in the following manner: Samples made with and without calcium chloride and samples made with silica gel in place of the calcium chloride were prepared. These samples were then tested for moisture content and acidity and were then subjected to the 100°C vacuum stability test. Their hygroscopicity was determined at 95% relative humidity at both 30°C and 71°C. Various amounts of moisture were added to the samples, and a 100°C vacuum stability test was conducted.

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