THE CLASS/DIVISION 1.6. : AN ANALYSIS OF WHAT ARE EIDS HIGH EXPLOSIVES AND WHICH EXPLOSIVE EFFECTS ARE 1.6. ARTICLES LIKELY TO PRODUCE

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ABSTRACT :

The new C/D 1.6 is now taken into consideration for both transportation (UN Recommendations and US/DOT Regulation) and storage (US/DOD Safety Standards, NATO Principles).

Furthermore, the UN Test Serie 7 has now about five years of existence, and is more and more used as a reference to evaluate the behavior of new less sensitive high explosives (HE) to accidental stimuli.

The first aim of this paper is to relate SNPE experience in testing HE with the EIDS Tests, and consequently to help identifying what kind of HE are potential candidates for 1.6. munitions. Results are then presented concerning the behaviors at Tests 7a) to 7 f) for melt cast HE, pressed PBX and cast PBX.

Based on an analysis of some properties of EIDS, and on the results observed with articles containing EIDS and submitted to the article Tests 7g) to 7k), some trends are presented to illustrate what hazards may be expected from munitions containing EIDS.

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1 - INTRODUCTION

The increasing efforts to improve platforms survivability has led to look for less sensitive munitions, which means munitions with reduced severity of damage when hit or in case of accident.

Although these requirements were adapted, at the starting point, rather to "crisis time" scenarios, it is obvious that the corresponding solutions should also provide benefits for "peace time" situations (storage and transportation).

This is the origin of the new C/D 1.6 : extremely insensitive articles which do not have a mass explosion hazard. This division comprises articles which contain only Extremely Insensitive Detonating Substances (EIDS), according to the UN tests 7a) to 7f 1, 2, 3 , and which demonstrate a negligible probability of accidental initiation or propagation, verified by tests 7g) to 7k) as shown on table 1.

Article Tests	**C/D 1.1 1**	**C/D 1.2 1**	**C/D 1.3 1**	**C/D 1.4 1**	**C/D 1.6 1**
External Fire : 7 g) or 6 c)	Instantaneous explosion of total contents	No inst. expl. but metallic projections	No metallic projections but thermal effects	No hazardous effects at d ≥ 5 m	No hazardous effects at d ≥ 5 m
Slow cook off : 7 h)	/	/	/	/	No reaction more severe than burning
Bullet impact : 7 j)	/	/	/	/	No detonation
Sympathetic detonation : 7 k) or 6 b)	Instantaneous explosion of total contents	No inst. explosion of total contents	No inst. explosion of total contents	No inst. explosion of total contents	No propagation of detonation

TABLE 1 : Acceptance criteria for the different C/D.

At this time, the C/D 1.6 has been officialy adopted in several regulations, with more of less quantified benefits :

- the UN Recommendations for the transportation of dangerous goods offer the possibility to ship explosive articles 1.6 N under UN N° 0486, but without any advantages compared to the recommendations for 1.1 articles 5 .

- the Hazardous Materials Regulations of the US DOT seem to be in the same position than the UN Recommendations 6 .

- the Allied Ammunition Storage and Transport Publication N° 3 (AASTP3), Manual of NATO Principles for the Hazard Classification of Military Ammunition and

Explosives, follows the UN scheme for classification, with C/D 1.6 [7]. The publication AASTP1, Manual of NATO Safety Principles for the Storage of Military Ammunitions and Explosives, is also considering C/D 1.6, but also without indicating the rules for Quantity/Distances [8]. This question seems to be still discussed at NATO AC 258, with a proposal being to take the largest of two distances [9] :

- safety distance for the storage of a single 1.1 articles, with only a blast effect,

- safety distance for the storage of the whole amount of munitions considered as 1.3 articles.

• the US DOD Ammunition and Explosives Safety Standards [4] is indicating Q/D rules for 1.6 ammunitions, which are close to the 1.3 rules in the general case, and may offer lower Q/D under special conditions (for example when 1.6 items are packed in non flammable pallets and stored in earth-covered steel or concrete arch magazines : IBD and PTR -- 1OO ft).

Then, excepted for the storage US regulation, there is few advantages at this time offered by the new C/D 1.6. One reason for that may be the poor knowledge concerning the real behavior of 1.6 articles, which are now only at the beginning of being available, due to the recent progress in energetic materials technology.

But experience is now growing about what are more precisely EIDS High Explosives, and which explosive effects are 1.6 articles likely to produce when submitted to accidental threats. SNPE experience in that field is then described, based on results obtained whith both classical and new formulations, and is also expanded with other data available in the open litterature.

2 - EXISTING AND POTENTIAL EIDS

2.1. Scope

The intention is here to gather as much as possible existing data concerning the behavior of High Explosives to EIDS tests, in order to give an idea of what kind of energetic materials may be or not considered as EIDS.

The four next tables are then presenting known or expected results to tests 7a) to 7f), according to the UN expression of result :

\+ means that the substance is too sensitive,

\- means that the substance is not too sensitive.

High explosives have been separated in four main families :

- melt cast high explosives (table 2)
- pressed PBX (table 3)
- inert binder cast cured PBX (table 4)
- energetic binder cast cured PBX (table 5)

2.2. Melt cast High Explosives

The knowledge of the position of melt cast high explosives is available for the most classical formulations.

The results of table 2 show that only new NTO based compositions, with a high percentage of wax and aluminum (10 % wax and 20 % Aluminum in AFX 644), can meet all the EIDS criteria. A NTO/TNT composition formulated by SNPE satisfied all criteria but the SCO criterion.

TEST	**TNT** [10,11]	**Compo. B** [1,10,11]	**Octol** [10,11]	**Tritonal 85/15** [10,11]	**HBX1**	**HBX3** [10]	**AFX 644** [12]	**NTO/TNT 60/40** [10]
EIDS Cap test: 7a)	-	+	[+]	[-]	[+]	[-]	-	-
EIDS Gap test :7b)	+	+	+	+	[+]	[+]	-	-
Friability test : 7c-d)	-	+	+	-	[+]	-	-	-
Susan test : 7c) (1)	-	+	+	+	?	[-]	-	[-]
EIDS Bullet impact test : 7d) (1)	-	+	+	-	[+]	[-]	-	-
EIDS External Fire test : 7e)	+	+	+	-	[+]	-	-	-
EIDS Slow Cook Off test : 7f)	+	+	+	[-]	[+]	?	-	+
EIDS	NO	NO	NO	NO	NO	NO	YES	NO

TABLE 2 : EIDS Test Results for Melt Cast High Explosives

[ ] expected result — - : acceptance criteria is met
(1) Alternative methods to friability test — + : acceptance criteria is not met

As a general comment, it can be said that classical TNT based high explosives, with RDX or HMX as a filler, can't meet the EIDS criteria. Other results have also shown that introduction of only 10 % RDX in a NTO/TNT formulation led to fail most of the EIDS tests.

On another hand, even if the presence of NTO allows to pass the 70 mm criterion at Gap Test, it is important to keep in mind that the density, and then porosity, of such materials is very influential on the shock sensitivity. This has recently been emphazised by J. CORLEY and C. STEWART, showing that Go/No Go PMMA thickness has changed from 33 to 63 mm for different AFX 644 variants [13].

2.3. Pressed PBX

Four pressed PBX have been identified with sufficient data to analyse their position according to the EIDS criteria (table 3). But in this family, the informations concerning the composition are only schematized, in order to make a distinction between :

- pressed PBX with only HMX (more than 95 %),
- pressed PBX with only TATB (more than 95 %),
- and pressed PBX with roughly 50 % HMX and 50 % of a less sensitive energetic material (total filler content more than 95 %).

Test	**HMX** **[10]**	**HMX/TATB 50/50** **[10]**	**HMX/NTO 50/50** **[10]**	**TATB** **[1]**
EIDS Cap test : 7a)	[+]	+	[+]	-
EIDS Gap test : 7b)	[+]	[+]	[+]	-
Friability test : 7c-d)	+	-	-	-
Susan test : 7c) (1)	[+]	[-]	[-]	-
EIDS Bullet impact test : 7d) (1)	[+]	[-]	[-]	-
EIDS External Fire test : 7e)	[+]	[-]	[-]	-
EIDS Slow Cook Off test : 7f)	[+]	+	?	-
EIDS	NO	NO	?(2)	YES (3)

TABLE 3 : EIDS Test Results for Pressed PBXs

[ ] expected result — - : acceptance criteria is met
(1) Alternative methods to friability test — + : acceptance criteria is not met
(2) Based on SNPE Composition P 15636
(3) Based on PBX 9502

These results seem to indicate that only pressed PBX without HMX can satisfy the EIDS criteria. When HMX is introduced with the proportion of 50 % of the filler, the shock sensitivity and the behavior to SCO are compromised at an unacceptable level. More information are needed to identify the maximum ratio of HMX leading to pass those two tests.

2.4. Cast cured PBX with inert binder

This family is probably the one with the more information available concerning results to EIDS tests. The table 4 try to summarize the behaviors observed or expected with the more representative formulations with inert binders. It demonstrates that several of these formulations meet all the EIDS criteria.

TEST	**HMX**	**RDX**	**HMX NTO**	**RDX NQ Al**	**RDX NQ AP Al**	**RDX AP Al**	**HMX AP Al**	**RDX NTO AP Al**
	[10]	**[10]**	**[10]**	**[14]**	**[15]**	**[10, 15]**	**[10]**	**[10]**
EIDS Cap test : 7a)	+	-	-	-	-	-	-	-
EIDS Gap test : 7b)	+	+	-	-	-	-	-	-
Friability test : 7c-d)	-	+	-	?	?	-	-	-
Susan test : 7c) (1)	-	?	-	-	-	-	?	?
EIDS Bullet impact test : 7d) (1)	-	-	-	-	-	-	-	-
EIDS External Fire test : 7e)	-	-	-	-	-	-	-	-
EIDS Slow cook off test : 7f)	-	-	-	-	-	-	-	-
EIDS	NO (2)	NO (3)	YES (4)	YES (5)	YES (6)	YES (7)	YES (8)	YES (9)

TABLE 4 : EIDS Test Results for Inert Binder Cast Cured PBX

[ ] expected result — + : acceptance criteria is not met
- : acceptance criteria is met

(1) Alternative methods to friability test

(2) Based on SNPE composition ORA 86 (HMX - PU)

(3) Based on SNPE composition HEXABU (RDX - HTPB)

(4) Based on SNPE compositions B 2214 (NTO - HMX - HTPB)
and B 2248 (NTO - HMX - HTPB)

(5) Based on ARC Composition

(6) Based on ARC Composition AFX 770 (RDX - AP - NQ - Al - HTPB)

7) Based on SNPE Composition B 2211 (RDX - AP - Al - HTPB)
and ARC Composition AFX 931 (RDX - AP - Al - HTPB)

(8) Based on SNPE Composition B 2237 (HMX - AP - Al - HTPB)

(9) Based on SNPE Composition B 2245 (RDX - NTO - AP - Al - HTPB)

2.5. Cast cured PBX with energetic binder

Like for the inert binder PBX, table 5 try to summarize the behaviors observed or expected with the more representative formulations of the family with energetic binders.

TEST	**HMX** [10]	**HMX** [10]	**HMX NTO** [10]	**HMX NTO** [10]	**HMX NTO Polynimmo** [17]	**HMX Al** [10]
EIDS Cap test : 7a)	+	+	-	-	-	+
EIDS Gap test : 7b)	+	+	-	-	-	+
Friability test : 7c-d)	+	?	-	-	-	-
Susan test : 7c) (1)	?	+	?	?	?	?
EIDS Bullet impact test : 7d) (1)	-	-	-	-	-	-
EIDS External Fire test : 7e)	-	+	-	-	-	-
EIDS Slow cook off test : 7f)	-	+	?	?	-	-
EIDS	NO (2)	NO (3)	?(4)	? (5)	YES (6)	NO (7)

TABLE 5 : EIDS Test Results for Energetic Binder Cast Cured PBX

[ ] expected result + : acceptance criteria is not met

- : acceptance criteria is met

(1) Alternative methods to friability test

(2) Based on SNPE composition B 3014 (HMX)

(3) Based on ARC composition AFX 235 (HMX)

(4) Based on SNPE composition B 3021 (NTO - HMX)

(5) Based on SNPE Composition B 3110 (HMX - NTO - Al)

(6) Based on DRA Composition CPX 413 (HMX - NTO - POLYNIMMO)

(7) Based on SNPE Composition B 3108 (HMX - Al)

2.6. Discussion

The results and estimations presented in tables 2 to 5 show clearly that few of the classical formulations of HE may be candidate for the EIDS classification :

- up to now, only a NTO based melt cast HE with 10 % wax and 20 % aluminum met all the EIDS criteria. The use of TNT as the only binder leads to violent reaction at slow cook off. Addition of RDX or HMX will lead to fail most of the EIDS Tests.
- concerning the pressed PBX, present results indicate that only HE without HMX can be EIDS.

On another hand, several cast cured PBX for main charges can be EIDS, with both inert and energetic binders, and even with a high percentage of HMX or RDX. Unfortunately, this can't be said for booster HE, mainly due to the Cap Test (sensitivity to a detonator)

In the case of energetic binder cast cured PBX, the criterion to slow cook off Test 7 f) is the more difficult to meet. But some new formulations are on the way to pass this test (B 3021 and B 3110 for example).

3 - EXPECTED EXPLOSIVE EFFECTS WITH MUNITIONS CONTAINING EIDS

The classification as 1.6 article needs the assessment of ammunition containing EIDS as main charge (and as booster if stored and shipped fuzed) to the four following tests :

- **External fire** - no events which would require the article to be confined to Division 1.1, 1.2 or 1.3.

This means that there will be no detonation, no deflagration and no explosion, no perforation and no indentation of the three witness screens, no more than 10 metallic projections with mass exceeding 25 g thrown over 50 m, no metallic projection with mass exceeding 150 g thrown over 15 meters, no fireball beyond 4 meters, no jet of flame extending more than 3 meters, no irradiance higher than 4 KW/m^2 at 15 meters, and no fiery projections beyond 15 meters.

- **Slow cook off** - no reaction more severe than combustion

This means that the case will only melt or weaken sufficently to allow mild release of the combustion gases. Case debris and package elements stay in the area of test except for case closures which may be dislodged and thrown up to 15 meters.

- **Bullet impact** - no detonation

- **Propagation test** - no propagation of detonation.

Although performing these four tests gives an answer to the question about explosive effects with 1.6 ammunitions, there is an interest in trying to relate the EIDS properties and those effects :

- at first, because performing the tests is often costly enough to try to avoid them if the acceptance criteria has a reasonable chance of not being met,

- secondly, because much more data are now avaiblable concerning the EIDS test, rather than 1.6 article tests. The analysis of EIDS properties can than be helpfull to increase the knowledge about the expected explosive effects.

This analysis can be made for the four threats considered by 1.6 classification :

- concerning the detonation propagation, we already presented data showing that the 70 mm PMMA criterion at EIDS Gap Test occurs only as a filter not too severe, and as less severe as the confinement will be heavy and the article diameter will be large 18 ,

- at bullet impact, with an acceptance criteria being only no detonation, it has also been demonstrated that the friability test criterion (less than 15 MPa/ms at 150 m/s) is well adapted for predicting (-) result at the article test 18 ,

- but on the contrary, the EIDS test for external fire and slow cook off appeared now as good filters only to prevent violent reactions (more severe than type IV). Then the acceptance criteria described before for these two threats, relevant to the 1.6. article tests, can't be related easily to the corresponding EIDS properties.

The main reason for that is the difference between the energetic material properties assessed by EIDS tests and the explosive effects accepted, especially for the behavior to external fire :

- an EIDS gives only a pressure burst at test 7 e), which means that it can't transitate from burning to deflagration, even when confined.

This should only prevent the effects expected from 1.1. or 1.2 munitions.

- the acceptance criterion is the same than for C/D other than 1.1, 1.2 and 1.3, which means it is essentially based on the thermal effects by the burning of the munition, all metallic projections being very limited.

Then the main properties related to these thermal effects are the burning rate and the combustion energy, which are very poorly assessed through the EIDS tests (only the friability test gives a rough idea of the ability to burn quickly).

The consequence is then that EIDS high explosives may be both low energy materials from a combustion point of view (like PBX with NTO and HTPB binder), or materials which can lead to high thermal effects by only their burning (like AP - Aluminum based PBX).

4 - CONCLUSION

The analysis of data related to EIDS tests has shown that only few classical HE (melt cast or pressed) are existing or potential EIDS. On the contrary, PBX corresponding to different intended roles, and being EIDS, are now available.

A more detailed examination of the EIDS properties showed also that explosive effects at external fire may be quite different from one EIDS to another one. Then the assessment on munition needs really to be performed.

REFERENCES

[1] UN Recommendations on the Transport of Dangerous Goods, Tests and Criteria, ST/SG/AC.10/11/Rev. 1, 1990

[2] J. WARD, "Hazard Class/Division 1.6 Test protocol" 24th Defense Explosives Safety Seminar, St Louis, August 28-30, 1990

[3] M. SWISDAK, "Hazard Class/Division 1.6. : Articles containing Extremely Insensitive Detonating Substances, NSWC TR 89-356, NSWC, December 1, 1989

[4] DOD Ammunition and Explosives Safety Standards, DOD 6055.9-STD, October 1992

[5] Recommendations on the Transport of Dangereous Goods, Eighth revised edition, 1994

[6] 49 CFR - Parts 106, 107, 110, 171 - 180, 397 - April 15, 1993

[7] AC 258 (TR) (WPC) IWP/2-91, Draft AASTP3, September 6, 1991

[8] AC 258 - D/425, May 1992

[9] J.C.BESSON " What Q/Ds for H.D. 1.6 " 25 th Defense Explosives Safety Seminar, Anaheim, August 18-20, 1992

[10] SNPE Results

[11] B.M. DOBRATZ, P.C. CRAWFORD, LLNL Explosives Handbook, UCRL-52997 Change 2, January 31, 1985

[12] J. CORLEY, D.J. DESPREY, "Fuzed Insensitive General Purpose Bomb Containing AFX-644" IMTS, Williamsburg, June 15-18, 1992

[13] J. CORLEY, A.C. STEWART, "Fuzed Insensitive General Purpose Bomb Containing AFX-644", International ADPA Symposium on Energetic Materials, Orlando, March 21-24, 1994

[14] K.J. GRAHAM, "Extremely Insensitive Detonating Substance Tests" 25 th Defense Explosives Safety Seminar, Anaheim, August 18-20, 1992

[15] J. CORLEY, et al, "Sensitivity and Performance Evaluation of a 1.6 Candidate Explosive AFX 770", 25 th Defense Explosives Safety Seminar, Anaheim, August 18-20, 1992

[16] S. STRUCK, K. GRAHAM, R. LYNCH, "Plastic Bonded Explosives for Warhead Applications", International ADPA Symposium on Energetic Materials, Orlando, March 21-24, 1994

[17] S. GAULTER, A. CUMMING, C. LEACH "The formulation of an Insensitive High Explosive Based on HMX, NTO and POLYNIMMO, IMTS, Williamsburg, June 6-9, 1994

[18] J. ISLER "Classification tests for assignment to hazard class division 1.6. : SNPE two years experience", 25 th Defense Explosives Safety Seminar, Anaheim, August 18-20, 1992