newsletter

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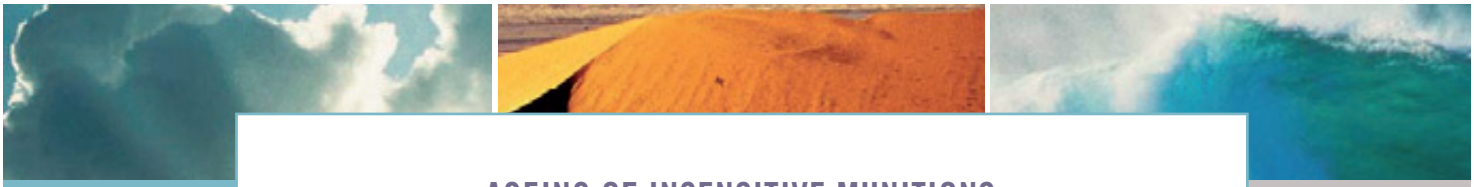
EUROPEAN MANUFACTURERS GROUP

INSENSITIVE MUNITIONS EUROPEAN MANUFACTURERS GROUP



EDITORIAL

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President

AGEING OF INSENSITIVE MUNITIONS

The tests required by the regulations whether domestic or transnational determine classification for Insensitive Munitions. When the latter advance in years and reach their mid life cycle or more, stakeholders and manufacturers are concerned about ageing: are the IMness performances still the same? Has the low sensitiveness of energetic materials the same characteristics? Stakeholders and manufacturers have to guarantee that these do not deteriorate in the course of time. An example is detailed in these pages with PBX-KS 32 in the ALARM warhead, produced at TDW 22 years ago and now reinspected.

Experiments about ageing of Cast PBX presented at the MSIAC workshops at Helsinki, indicate that most of long life IM formulations have no significant difference in the mechanical properties (e.g. Young's modulus) which shows the ageing reaction. Nevertheless, ageing assessments have to be conducted on the whole system, as well as on all the energetic materials used in order to guarantee the end user all IMness performances along the life cycle. MSIAC has dedicated several workshops on the issue, the findings are available for consultation in MSIAC data bank.

N° 3
JUNE 2008

CONTENT

Is ageing unlikely to have an effect upon IM signature or hazard classification level ?

Patrick Touzé, gives his views as Director of MSIAC (Munitions Safety Information Analysis Center)

IMEMG: The current general basis for determining the IM signature of munitions is a testing programme limited to a few full-scale tests. If this methodology is used without considering the effect of changes that may occur to munitions as a consequence of ageing, is there a risk of generating an IM assessment that is no longer valid after a number of years in service?

P. Touzé: Yes, and this could lead to serious consequences. For example, the consequences of an accident involving aged IM could be catastrophic if the munitions were classified, stored and handled as e.g. HD 1.2 (unit risk), HD 1.2.3 or HD 1.6, yet degrade on ageing and become HD 1.1.

IMEMG: The effect of ageing upon reduced vulnerability energetic materials and related IM technologies is then of great interest, all the more so as more IM systems are developed and introduced into service.

P. Touzé: In fact, in order to gain confidence that munitions meeting IM requirements retain their IM characteristics, a greater understanding is required in related areas including:

- Critical ageing mechanisms;
- Tools to monitor these changes including the use of non-destructive testing, in-built sensors and data logging systems;
- Modelling and simulation to predict the ageing of materials and their response to threat stimuli;
- Surveillance methodologies for IM systems.

(cont'd from page 1)

The generally held 'feeling' of experts is that ageing is unlikely to have an effect upon IM signature or hazard classification level. However, this 'feeling' is only based on guess work or very limited and fragmented studies. Enhanced international co-operation and data sharing will allow for improved knowledge and understanding and prevent the first point of detection for an issue being in a service environment, causing loss of life or capability.

IMEMG: How is the international IM Community ready to go further on this issue ?

P. Touzé: Several international activities have already been conducted (e.g., the MSIAC Workshop of May 2005), are ongoing (e.g., under TTCP TP4, which held an "Ageing of IM" workshop in February 2008) or are about to start (e.g., under the EDA). Similarly, related standards are being developed (for instance, STANAG 4666 on Ageing Characteristics of PBX). Participation of experts in these activities can only be strongly encouraged.

Member companies

CEA / Direction des Applications Militaires
EURENCO France
MBDA-F
NEXTER Munitions
ROXEL
SNECMA Propulsion Solide
TDA Armements

AWE
BAE Systems - Land Systems
Chemring Energetics UK
MBDA-UK

DIEHL BGT Defence
JUNGHANS Microtec
Rheinmetall Waffe Munition
TDW

SEI Società Esplosivi Industriali

NAMMO Raufoss

A new company has joined

Last April, Chemring Energetics UK Ltd (part of the Chemring Group) joined IMEMG. This new member company, located in Scotland & Wiltshire manufactures a wide range of energetic components and sub-systems for Munitions, Missiles, Demolition Stores and the CAD/PAD market. Chemring Energetics UK has a commitment to Insensitive Munitions in the form of research and product development for UK and overseas applications that includes rocket motors/propellants, explosive trains, initiators, fuzes and detonators.

The melt-cast composition XF 13 333 developed by NEXTER Munitions

The LU211 IM artillery round, developed and produced by Nexter Munitions, has been successfully tested and qualified by the French Authorities.

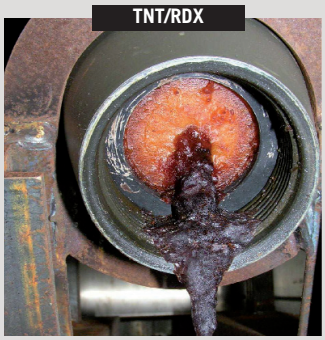
The NTO based melt-cast explosive XF 13 333 (EIDS) exceeds very significantly the requirements of most major STANAGs 4439, 4224 and 4518. This High Explosive composition offers a high level of user safety while maintaining a terminal efficiency comparable to that of composition B.

The XF 13 333 composition remains safe regarding the ageing. The accelerated cycle determined by the DGA represents more than 20 years of shelf life. The outline of the tests carried out with the LU211 IM includes specific sequence like:

- long time storage conditions A & B (2 different range of temperature)
- operational storage and exposure
- random vibrations
- drop test
- thermal chock
- laboratory inspection and firing tests

In addition :

- **the mechanical properties are preserved : no degradation after uni-axial compression** ***(method NF T 70 314)***
- **the impact and friction sensitiveness are maintained : no degradation after ISI** ***(method NF T 70 500)*** **and ISF** ***(method NF T 70-503)***
- **It has to be highlighted that the composition XF 13 333 is free of exudation after ageing**



Specific exsudation test without sealing plug
DGA/ETBS protocol
Duration : 15 cycles/ 24 hours
Temperature : +40°C to +70°C

Ageing of TDW's KS32: experience and new requirements

The ageing of polymer bonded explosives (PBX) has been studied intensively since the days when these high explosives were introduced for the first time.

The prediction of changes in the chemical, mechanical and thermal properties of these PBXs, however, especially of those with possible influence on performance and insensitivity of the warheads, is still not entirely settled.

This article summarizes results from artificially accelerated and natural ageing of KS32, a cast cured PBX composition with 85% HMX and 15% HTPB-based binder manufactured by TDW, Germany, and used in many warhead applications.

Accelerated ageing

Accelerated ageing tests with PBX KS32

In the 1986-1988 time frame the first accelerated ageing tests with KS32 based on the "10 Degrees Rule" were performed at test temperatures between 60°C and 90°C. The test samples were not sealed hermetically, therefore sufficient oxygen could access the test samples.

KS32 samples after accelerated ageing compared with unaged material showed:

- Depletion of antioxidant
- Reddish discolouration
- Increase of Shore A Hardness
- Increase of Young's modulus.

These changes were assessed to be acceptable and from 1989 on KS32 was used for series production.

Influence of catalyst on accelerated ageing

The accelerated ageing tests performed with KS32 also showed an influence of the catalyst on the ageing behaviour. In the presence of oxygen the catalyst vanadylacetyl-acetonate (VAA) intensified the ageing process: the depletion of the antioxidant and later an increase of hardness were accelerated. This effect could be diminished by using a lower concentration of VAA or a replacement using the catalyst dibutyltin-dilaurate DBTL.

In 2003 tests at TDW concerning the ageing behaviour have been performed again.

Two identical samples of KS32, only varying in the type of catalyst, have been stored at 75°C for accelerated ageing. During storage only a loose cover of aluminium foil was applied to allow the access of oxygen. The content of the antioxidant BKF was measured before storage, after 21 days storage and after 42 days storage (see Fig). The KS32 sample with catalyst VAA had a residual content of only 6% antioxidant, the KS32 sample with catalyst DBTL still had 68% antioxidant compared with the content before storage.

Natural ageing

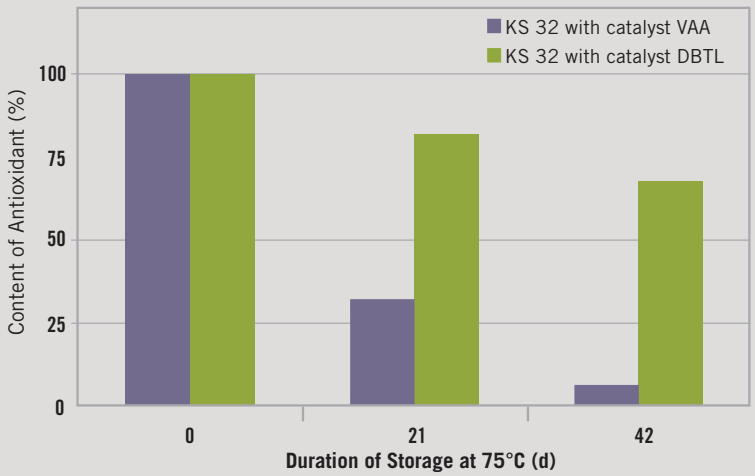
A surveillance programme had been conducted by the customer of the firstly delivered KS32 warheads. The detailed analysis of the PBX was performed by QinetiQ, UK, and TDW, Germany, in parallel, examining outer and the inner areas of the charge, as well.

The types of changes for the naturally aged KS32 are similar to those of the accelerated ageing tests, showing a depletion of antioxidant and a discolouration ("pinking") on the surfaces of the material. But the extent for the naturally aged material was smaller than for the accelerated aged samples. The minimal concentration of antioxidant measured by TDW was still more than 50% of the nominal value required for new material. The results indicate that the KS32 composition and the design of the appropriate warhead were successful in reaching the service life required by the customer. Furthermore the good condition of the KS32 charge enabled a lifetime extension programme for the warhead with a final goal of thirty years.

Conclusions

A comparison of the accelerated ageing results of KS32 performed twenty years ago and the naturally aged material from warheads indicates a more severe effect by the artificially accelerated ageing. This can be explained considering the test design of the accelerated ageing conducted in 1987: application of the conservative "10 Degrees Rule" and a loose confinement of the samples allowing the access of oxygen. These factors established a more demanding situation than the sealed environment of a PBX charge inside a "real world" warhead.

VK,
WP,
Dr. HM



news

A new version of the IM card

IMEMG issued its new card which compares the different national regulations of their member companies and the test requirements for the IM.

SIMPLIFIED REPRESENTATION OF THE IM REQUIREMENTS

THREAT	TEST PROCEDURES STANAG	TEST PROCEDURES Stimuli	NATO STANAG 4439 AOP 39	UK STANAG 4439 JSP 520	GERMANY STANAG 4439 BMVg Fü S VII 1 - 03-51-60	ITALY DG-AT IM Guidelines 2000 Φ	ITALY ΦΦ	ITALY ΦΦΦ	FRANCE DGA MURAT Doctrine Instruction DGA/IPE 260 July 1993 ★	FRANCE ★★	FRANCE ★★★[1]	USA MIL-Std 2105-C
Magazine/Store Fire or Aircraft/Vehicle Fuel Fire	4240	FH	V	V	V	V	V	V	IV[2]	V[3]	V[3]	V
Fire in adjacent Magazine, Store or Vehicle	4382	SH	V	V	V	V	V	V	III	V	V	V
Small Arms Attack	4241	BI	V	V	V	V	V	V	III	III	V	V
Reaction propagation in Magazine, Store, Aircraft or Vehicle	4396	SR	III	III	III	III	III	III	III	III	IV	III
Fragmenting Munitions Attack	4496	FI	V	V	V		I[4]	V	I	III	V	V
	4496	FI Heavy Fragment					I[4]	V	I	III	IV	
Shaped Charge Weapon Attack	4526	SCJI	III	III	III		I[4]	III	I	I	III	III
Specific to French IM doctrine												
Drop during handling operation (12m)	4375								NR	NR	NR	
Severe Electric Electromagnetic Threat	4235 / 4236 / GAM DRAM 01-02								NR	NR	NR	

(1) All EIDS Energetic Materials (2) Without propulsion (3) Only after 5 minutes (4) One or more as per THA

The above STANAG 4439 tests and levels of reaction are subject to Threat Hazard Analysis

Type of Response June 2008

	English	Français	Deutsch	Italiano
N R	No Reaction	Non Réaction	Keine Reaktion	Nessuna Reazione
V	Burning	Combustion	Abbrand	Combustione
IV	Deflagration	Explosion	Deflagration	Deflagrazione
III	Explosion	Déflagration	Explosion	Esplosione
II	Partial detonation	Détonation partielle	Teilweise Detonation	Detonazione parziale
I	Detonation	Détonation	Vollständige Detonation	Detonazione

Munition Test Procedures

Stimuli		English	Français	Deutsch	Italiano
FH	4240	External Fire (Fast Heating)	Incendie externe	Schnelle Aufheizung	Incendio rapido
SH	4382	Slow Heating	Echauffement lent	Langsame Aufheizung	Incendio lento
BI	4241	Bullet Impact	Impact de balle	Projektilbeschuss	Impatto con proiettili di piccolo calibro
SR	4396	Sympathetic Reaction	Réaction par influence	Sympathetische Reaktion	Reazione per influenza
FI	4496	Fragment Impact	Impact d'éclat	Splitterbeschuss	Impatto con scheggia
SCJI	4526	Shaped Charge Jet Impact	Impact de jet de charge creuse	Hohlladungsbeschuss	Impatto con dardo di carica cava

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Cast cured PBXs to guarantee IM signature throughout life cycle

Munitions vulnerability assessments are performed during each development program to demonstrate the IMness requirements. Today, many new munitions pass these criteria. Nevertheless, none experimental evaluation has been carried out to prove that munitions keep their IM signature along their life cycle. This signature is the result of the munitions architecture including of course the explosive grain but also the fusing, the body and the various inert materials.

Moreover, the munitions life duration is guaranteed under contracts with regard to S3 (Safety and Suitability for Service) according to life cycles. The explosive grain is a key element; its life duration prediction is based on chemical and physical changes according to temperature cycling. Since the 80's, cast cured PBXs (Plastic Bonded Explosives) are used in many different munitions, such as missile and underwater warheads, general purpose bombs and more recently shells and mortars.

Numerous experimental data are available to demonstrate that the service life can be guaranteed for more than 20 years. With this aimed some advanced characterisations focused on the potential changes in mechanical properties and specific safety tests such as Friability Test or Card Gap tests can be performed. These characterisations bring precise and valuable information on the explosive actual state versus ageing.

In parallel, methodologies allow predicting munitions responses to each vulnerability trial. These methodologies are based on small scale testing, taking into account various reaction mechanisms, and on numerical modelling validated by full scale tests. In this way, it is also possible to estimate the most probable responses of ageing munitions and the IM signature all along various life cycles.

The results related to major industrial cast cured PBXs developed by EURENCO are for example available for the bullet impact tests. These qualified formulations are filled with RDX, HMX, HMX/NTO, HMX/PETN, RDX/AP/Al or RDX/NTO/AP/Al. Cast PBXs samples have been aged at 20°C and 60°c

1 *Shaped charge jet test on a mortar round filled with HBU88B, a RDX based, qualified cast PBX.*
A reaction level type IV was recorded.

up to 8 years ! No significant variation has been recorded on samples concerning their mechanical properties and no change has been recorded with regards to the Bullet Impact test reaction levels. This family of cast PBXs is particularly stable versus time and temperature.

It is expected that it is quite similar for other threats. For example, the stability of Card Gap test results is major evidence for Sympathetic Reaction and Shaped Charge Jet or Fragment Impacts results. Nevertheless these methodologies remain to be fully validated for the overall IM signature determination. Necessary work is currently being undertaken, some with the support of European Defence Agency, to close the loop. It will take time to attain this goal, as ageing, even accelerated, is a long process…

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