

[ Unique Know-How, Multifaceted Range ]

*A new generation of binder  
for cast PBX*

*B. Mahé, EURENCO*

*B. Le Roux, SME*





## ➤ Eurenco and Cast-cured PBX

- ☞ EURENCO, a subsidiary of SNPE Matériaux Energétiques has a long history of promoting cast-cured plastic bonded explosive technology
- ☞ first productions began at Sorgues plant in 1974 at industrial scale
- ☞ EURENCO has
  - all equipments necessary for production according to batch process
  - developed and a patented worldwide new process for loading small items (shells)
  - a large catalogue of formulations qualified according to STANAG 4170



## ➤ STANAG 4170-qualified compositions

	<b>Binder</b>	<b>HMX</b>	<b>RDX</b>	<b>NTO</b>	<b>PETN</b>	<b>AP</b>	<b>AL</b>	<b>Main applications</b>
<b>ORA86B</b>	Inert	<input checked="" type="checkbox"/>						Missile WH – Shaped charge
<b>HBU88B</b>	Inert		<input checked="" type="checkbox"/>					Mortar and shells – WH
<b>B2238A</b>	Inert		<input checked="" type="checkbox"/>					Booster – WH – Shells
<b>B2188A</b>	Inert	<input checked="" type="checkbox"/>			<input checked="" type="checkbox"/>			Booster – SCO Safety Device
<b>B2214B</b>	Inert	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>				Penetrators – Missile WH
<b>B2211D</b>	Inert		<input checked="" type="checkbox"/>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Underwater torpedoes/mines
<b>RH26-2</b>	Inert		<input checked="" type="checkbox"/>					Shells
<b>PBXN-110</b>	Inert	<input checked="" type="checkbox"/>						Missile WH – Shaped charge
<b>PBXN-109</b>	Inert		<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>	GP bombs, Heavy penetrator
<b>B3108B</b>	Energetic	<input checked="" type="checkbox"/>					<input checked="" type="checkbox"/>	Missile WH – enhanced blast



## ➤ Cast-cured PBX

### ☞ A binder

Prepolymer (HTPB - PU – PE - ....)

Curing agent (IPDI - MDCI - ....)

Plasticizer (DOA - DOZ - IDP - ....)

Additives (processing aid – anti oxidant – catalyst)

### ☞ Explosives fillers

I-RDX<sup>®</sup>

RDX

HMX

NTO .... depending of required performances



## ➤ How to improve performances

### ☞ Energetic binder

B3108B : polyester plasticized by nitrated oil (NGI and BTTN)

*limited industrial application due to mandatory specific installations  
(synthesis and handling of nitrated oil)*

*still used at the industrial scale for specific application (high performance  
missile warhead)*

### ☞ Powerful explosive filler

B2266A : CL20 (laboratory scale)

*no industrial application due to the very high cost of raw materials*

☞ Higher filler content

HBU88B: 88% I-RDX<sup>®</sup>

PBXN-110: 88% HMX

*limitation due to process constraints:*

*viscosity (< 5 kpoises)*

*pot life (> 6 hours)*

*Feasible by*

*-increasing the plasticizer content*

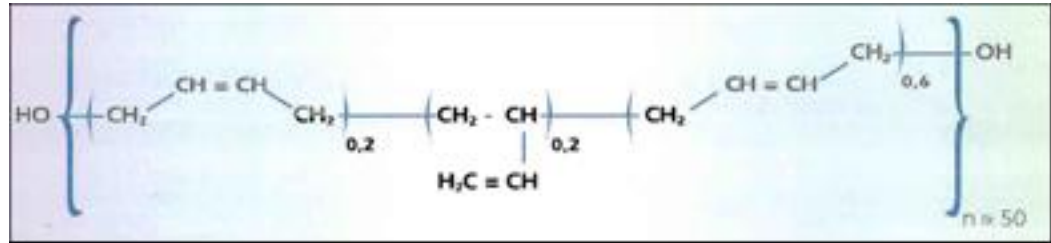
*-optimizing grain sizes for the explosives*

*-adding specific processing aids*

☒ using a lower viscosity prepolymer



## ➤ HTPB

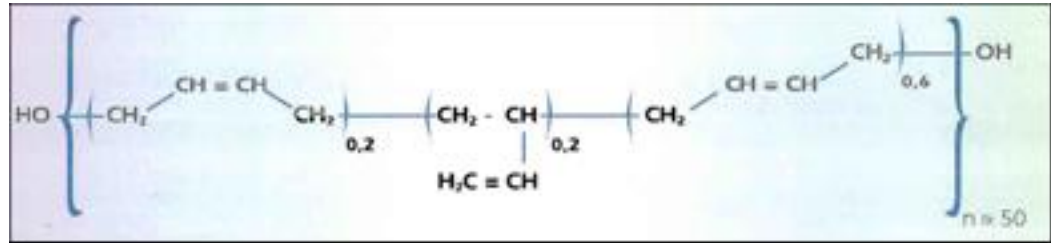


## ☞ R45HTLO

density	0.90
molecular weight	2 800
viscosity	50 poises
hydroxyl value	0.83 meq/g
moisture content	0.05 %



➤ HTPB



*R45HTLO*

<i>density</i>	<i>0.90</i>
<i>molecular weight</i>	<i>2 800</i>
<i>viscosity</i>	<i>5 000 mPa.s</i>
<i>hydroxyl value</i>	<i>0.83 meq/g</i>
<i>moisture content</i>	<i>0.05 %</i>

☞ **R20LM**

<b>0.90</b>
<b>1 220</b>
<b>19 poises</b>
<b>1.7 meq/kg</b>
<b>0.05 %</b>

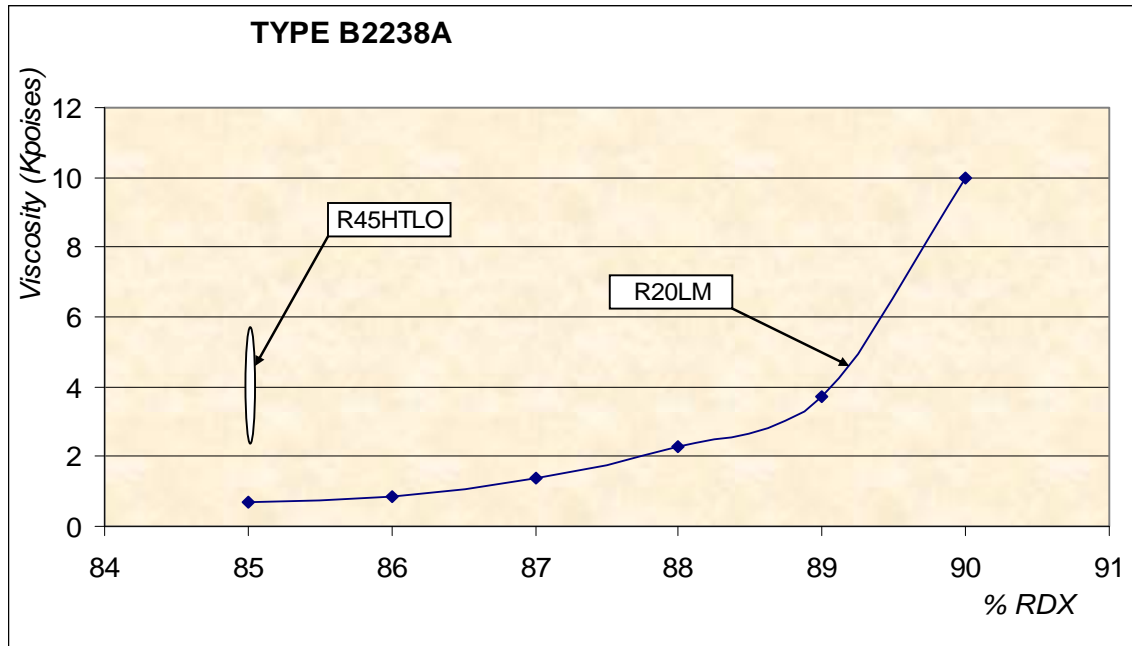




B2238A as a reference formulation:

*HTPB polymer*

*crude RDX : 85 → 89 %*

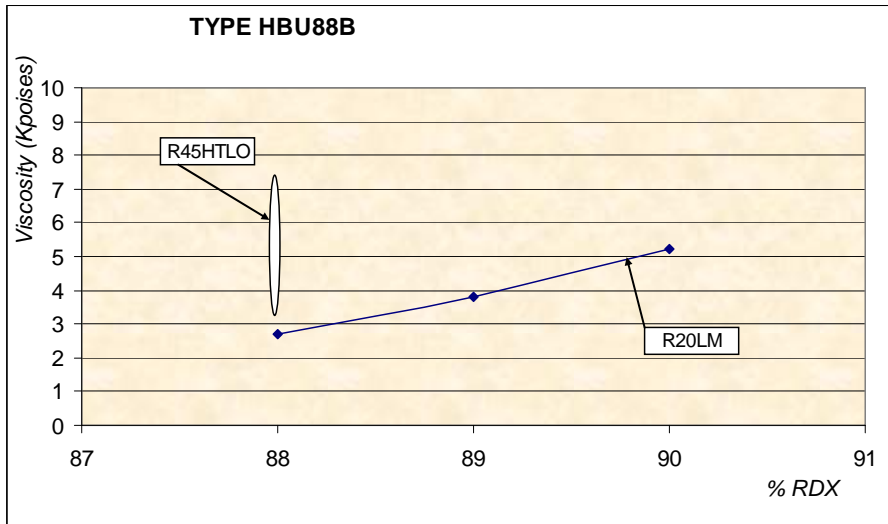




## B2263A (HBU88B) as a reference

*HTPB polymer*

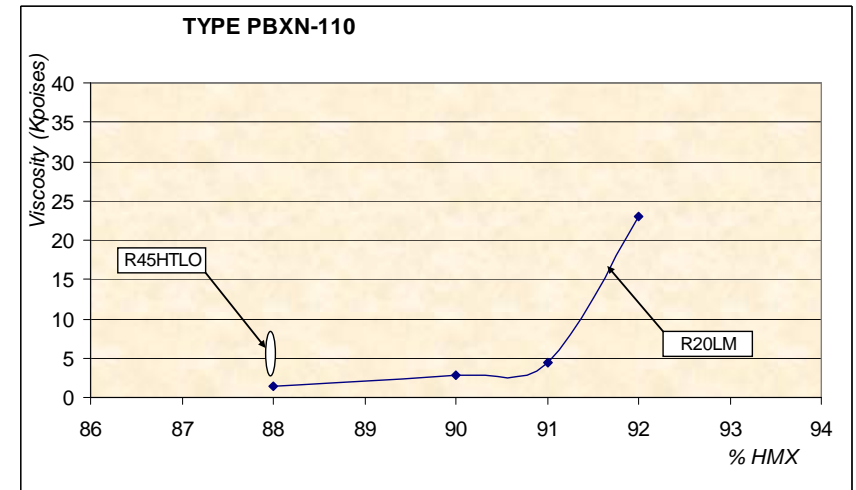
*I-RDX<sup>®</sup> 88 → 90 %*



## PBXN-110 as a reference

*HTPB polymer*

*HMX 88 → 91 %*





Two new formulations have been defined and scale up to the industrial scale

B2265A (HBU90) : 90 % I-RDX<sup>®</sup>

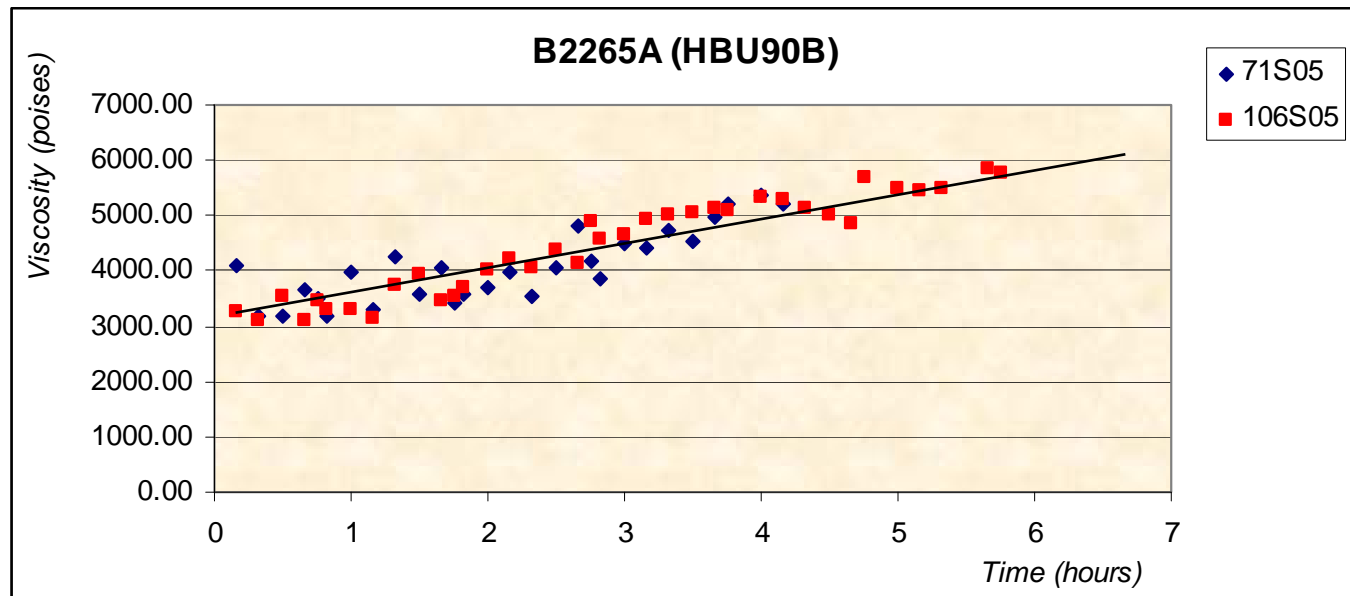
B2273A (OCTABU90) : 90 % HMX

Performances and physical properties, IM characteristics were determined

Their qualifications according to STANAG 4170 were carried out



## Viscosity





## Performances & Physical properties

	<u>B2263A (HBU88B)</u>	<u>B2265A (HBU90A)</u>
Ingredients		
PBHT	R45HTLO - 12%	R20LM - 10%
I-RDX®	88%	90%
Density	1.62	1.65
Detonation velocity (m/s)	8 180 m/s	8 290 m/s
Pcj Mbar (calculated)	0.271	0.283
Mechanical properties(tensile)		
- 45°C Sm ( <i>stress</i> )	3.0 MPa	2.5 MPa
em ( <i>strain</i> )	9.9 %	3.1 %
+ 20°C Sm ( <i>stress</i> )	1.05 MPa	0.91 MPa
em ( <i>strain</i> )	10.6 %	4.5 %
+60°C Sm ( <i>stress</i> )	0.73 MPa	0.65 MPa
em ( <i>strain</i> )	8.4 %	3.6 %
+70°C Sm ( <i>stress</i> )	/	0.56 MPa
em ( <i>strain</i> )	/	3.2 %



## Ageing

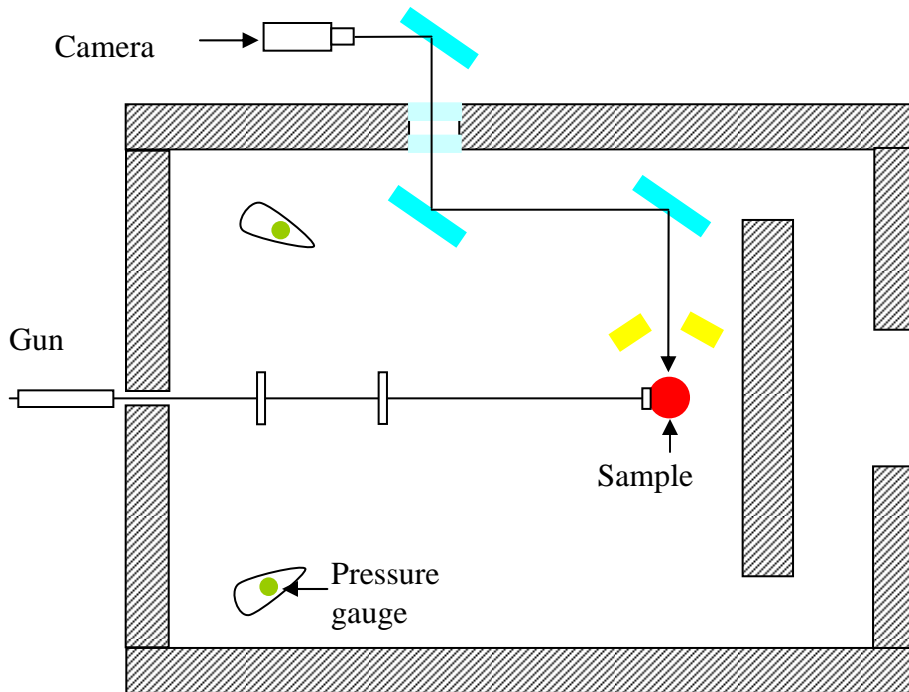
	T0		T0 + 6months at 60°C	
Temperature test	Sm (MPa) <i>Stress</i>	em (%) <i>Strain</i>	Sm (MPa) <i>Stress</i>	em (%) <i>Strain</i>
-45°C	2.5	3.1	2.77	4.8
+20°C	0.91	4.5	0.99	4.0
+70°C	0.56	3.2	0.57	3.3



## Safety properties

	<u>B2263A (HBU88B)</u>	<u>B2265A (HBU90A)</u>
Ingredients PBHT I-RDX®	R45HTLO - 12% 88%	R20LM - 10% 90%
Shock sensitivity (BAM test)	24 J	35 J
Friction sensitivity (BAM test)	23+/30 at 353N	11+/30 at 353N
Shock sensitivity (30 Kg fall hammer)	HLNR ≥ 4 m HLNP ≥ 4 m	HLNP ≥ 4 m HLNR = 3.75 m
Gap Test (acetate cards) ( <i>STANAG 4488 Annex B</i> )	150	155
Self ignition temperature	209 °C	210 °C
Long term cook-off temperature	126 °C	123 °C

## Bullet impact (12.7 AP)



Steel cylinder :

3 liters content

Breakup pressure: 25 to 30 MPa

Explosive to test :

Ø 123 mm

H 240 mm





**12.7 AP : 450 m/s**

No reaction



**12.7 AP : 550 m/s**

Pneumatic explosion after 20 minutes  
31 % product recovered



**12.7 AP : 890 m/s**

Reaction after 5 minutes  
all product burnt



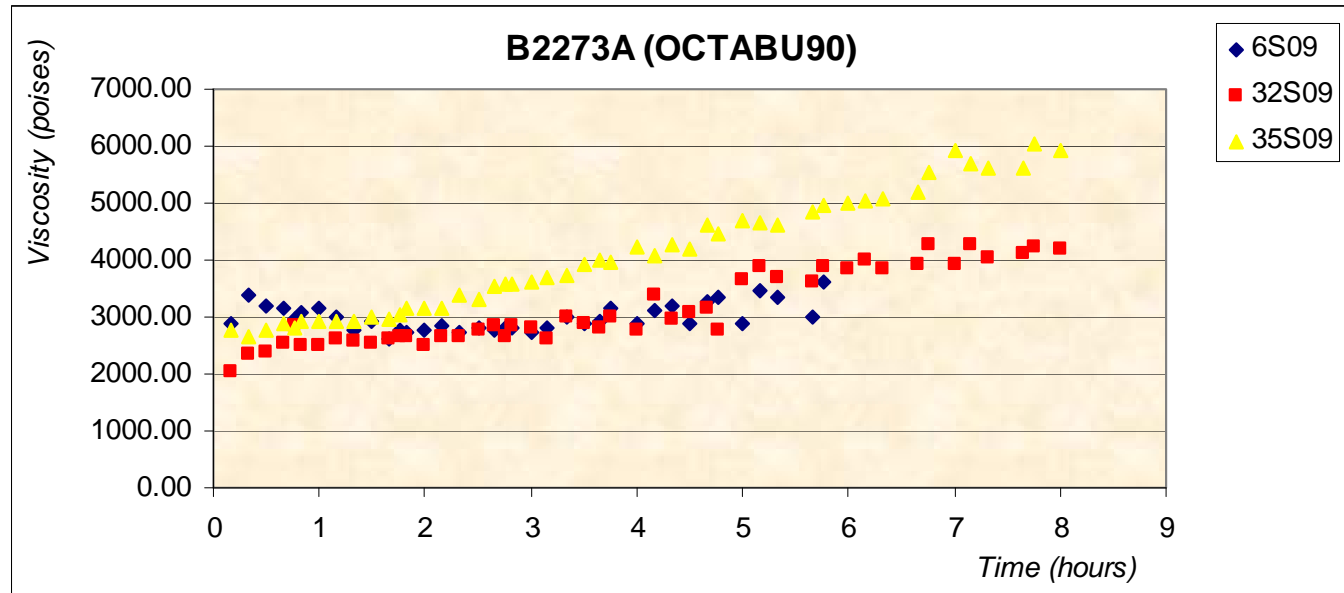
**12.7 AP : 1150 m/s**

Reaction after 5 minutes  
all product burnt





## Viscosity





## Performances & Physical properties

	<u>PBXN-110</u>	<u>B2273A (OCTABU90A)</u>
Ingredients PBHT HMX	R45HTLO - 12% 88%	R20LM - 10% 90%
Density	1.685	1.715
Detonation velocity (m/s)	8370 m/s	8 510 m/s
Pcj Mbar (calculated)	0.295	0.310
Mechanical properties (tensile)		
- 45°C Sm ( <i>stress</i> )	1.0 MPa	2.1 MPa
em ( <i>strain</i> )	9.8%	6.3%
+ 20°C Sm ( <i>stress</i> )	0.41 MPa	0.68 MPa
em ( <i>strain</i> )	10.6%	9.0%
+60°C Sm ( <i>stress</i> )	0.24 MPa	0.62 MPa
em ( <i>strain</i> )	10.2%	7.6%



## Safety properties

	<u>PBXN-110</u>	<u>B2273A (OCTABU90A)</u>
Ingredients PBHT HMX	R45HTLO - 12% 88%	R20LM - 10% 90%
Shock sensitivity (BAM test)	36 J	49 J
Friction sensitivity (BAM test)	14+/30 at 353N	10+/30 at 353N
Shock sensitivity (30 Kg fall hammer)	HLNR $\geq$ 4 m HLNP = 2.25 m	HLNP $\geq$ 4 m HLNR = 2.75 m
Gap Test (acetate cards) ( <i>STANAG 4488 Annex B</i> )	170	180
Self-ignition temperature	229 °C	243 °C

## Bullet impact

**12.7 AP : 450 m/s**

No reaction



**12.7 AP : 550 m/s**

No reaction



**12.7 AP : 870 m/s**

All product burnt  
during 15 minutes



**12.7 AP : 1140 m/s**

All product burnt  
during 15 minutes





## ➤ SUMMARY

- ☞ Poly Bd<sup>®</sup> R20LM is a HTPB with a low molecular weight and a low viscosity
- ☞ when used to prepare a cast cured PBX (instead of PolyBd<sup>®</sup>R45HTLO), the viscosity of the paste is significantly decreased. That allows to increase the percentage of the filler content
- ☞ two formulations containing 90 % of I-RDX <sup>®</sup> and 90 % of HMX have been developed, characterized and transferred at the industrial scale
- ☞ detonation performances are increased about 5 % in comparison with HBU88B and PBXN-110
- ☞ main safety and IM characteristics are maintained, especially a very good behavior under bullet impacts
- ☞ B2265A is qualified by the French MOD according to the STANAG 4170
- ☞ B2273A qualification is in progress



Thank you for your attention