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Achieving STANAG 4439 IM Shaped Charge Requirements on 155mm Shells: An Update

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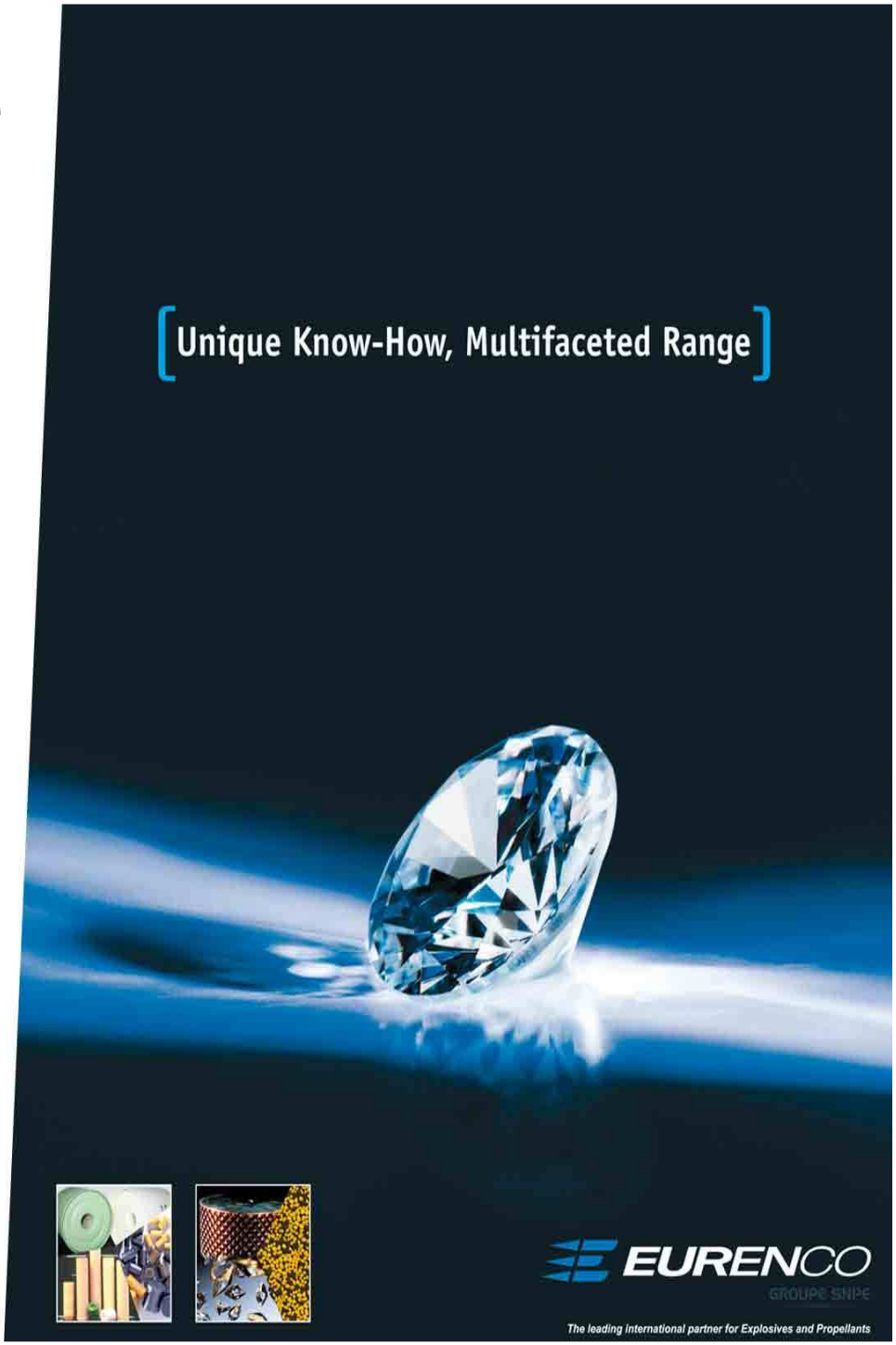


OUTLINE

- **Scope**
- **Method**
- **Formulation phase results**
- **Assessment against different Shaped Charges**
- **Conclusions**

SCOPE OF THE STUDY

Define Cast PBX formulations for IM large calibre applications (155mm)

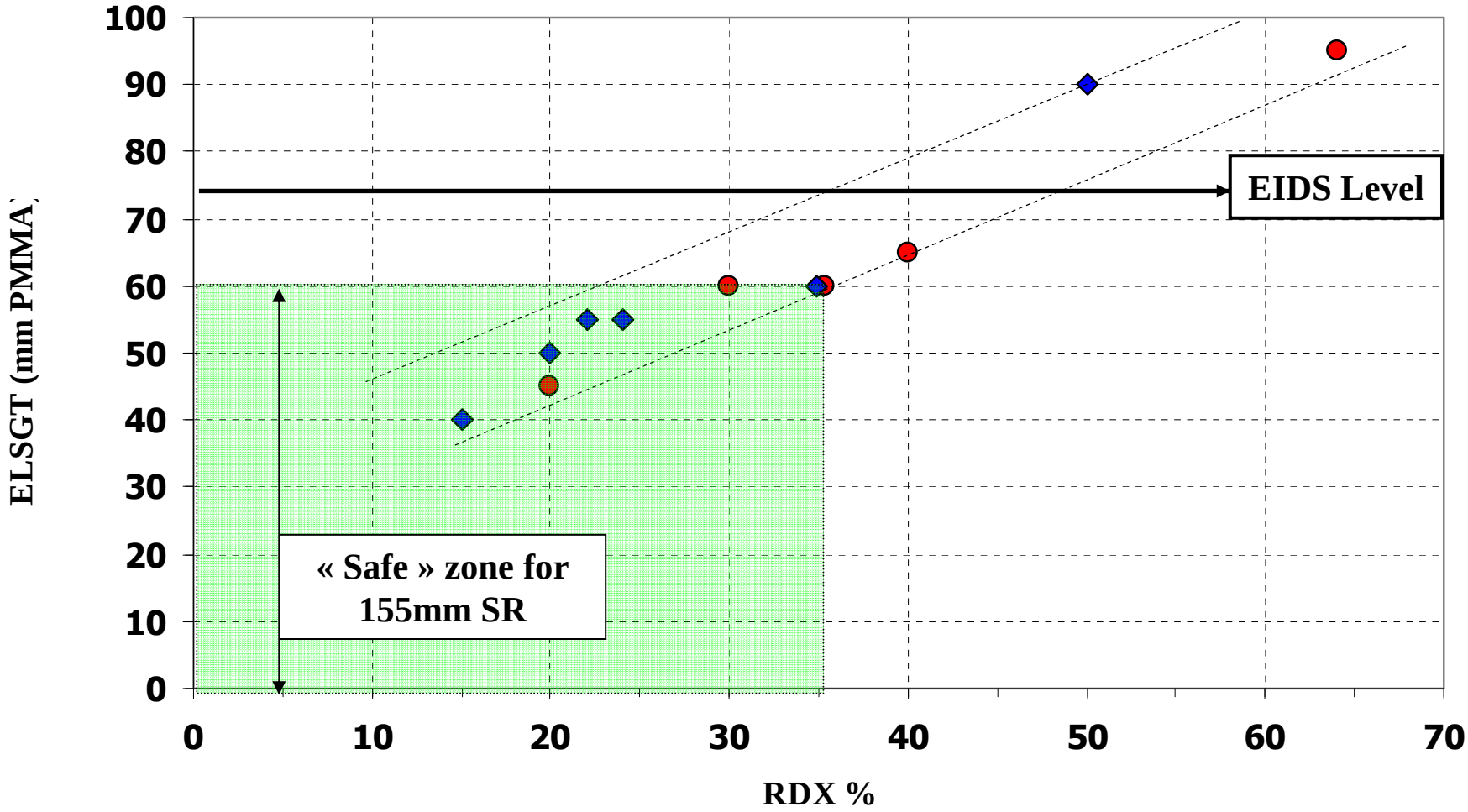
- **Meeting Shaped Charge jet and Sympathetic Reaction without shielding / packaging**
- **Using mature raw materials (RDX, NTO, Al, binder)**
- **Using batch or proprietary bicomponent process**

METHOD

- **Establish desirable characteristics**
- **Measure the influence of NTO/RDX ratio against specs (ref.1)**
- **Finalize 2 formulations (without and with Aluminium)**
- **Assess them against Shaped Charge jets in 155mm shells**

Former Results

ELSGT versus I-RDX content

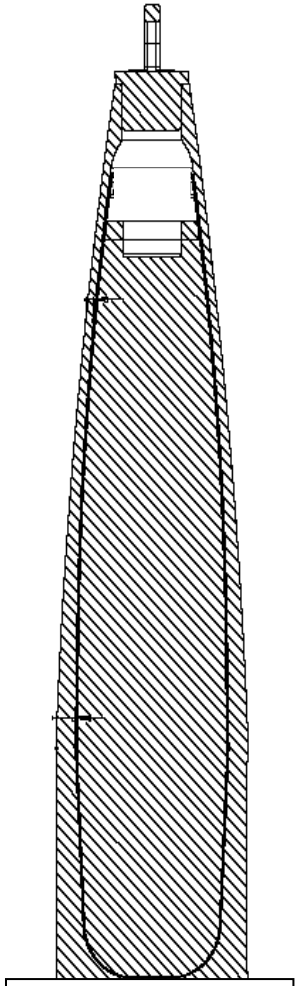


Final Formulations

	B2267A	B2268A
Formulation	**I-RDX ® / NTO HTPB**	**I-RDX ® / NTO / Al HTPB**
Viscosity (Pa.s) **at casting time** **6 hours after casting**	 **100** **250**	 **300** **600**
Density	**1.65**	**1.76**
Mechanical properties (tensile) **max stress (MPa)** **max strain (%)**	 **0.72** **7.2**	 **0.72** **8.6**
Hardness (Shore A)	**70**	**71**
Detonation velocity (m/s) **cylinder Ø 50 mm** **computed**	 **7570** **7680**	 **/** **7440**
ISGT (cards)	**95**	**50**
ELSGT (mm PMMA)	**55**	**40**
Unconfined Critical diameter (mm)	**$30 < \Phi_c < 36$**	**$50 < \Phi_c$**

Assessment against Shaped Charge Jet - 155mm shells

Test Procedure :	**STANAG 4526 ed.2**	
Shaped Charges : (provided by TDA)	**Φ 68 mm**	**(Tête 23)**
	Φ 84 mm	**(AT4CS)**
	Φ 112 mm	**(RCC)**
Shell bodies : (provided by RWM)	**155 mm**	
Explosive grains : (≈ 9 Kg)	**1. B2267A**	
	2. B2268A	

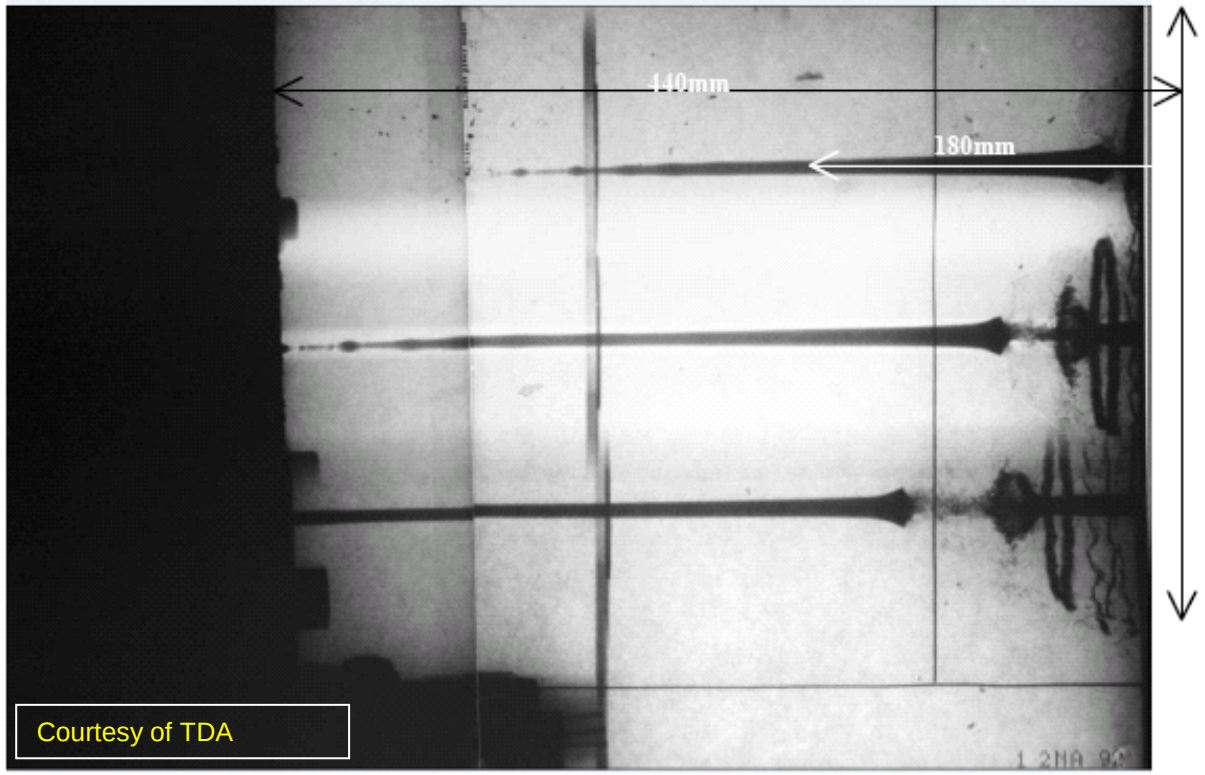


155mm shell

Not to scale

Shaped Charge Jet Characterization

RCC Φ 112 mm

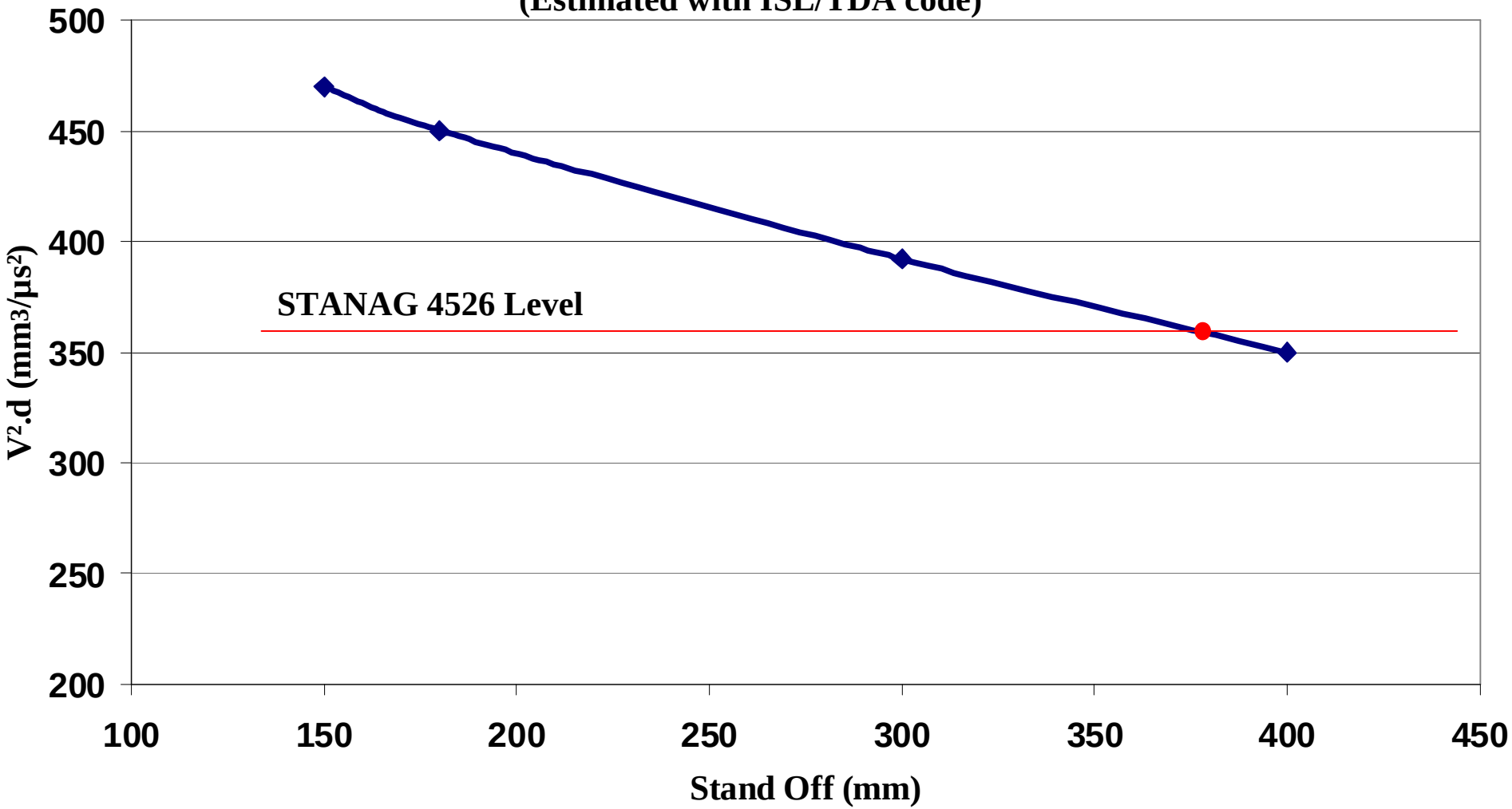


Flash X Ray - Δt ≈ 10µs

Shaped Charge Jet - Characterization

$V^2.d$ versus Stand Off - RCC ⌀ (112 mm

(Estimated with ISL/TDA code)

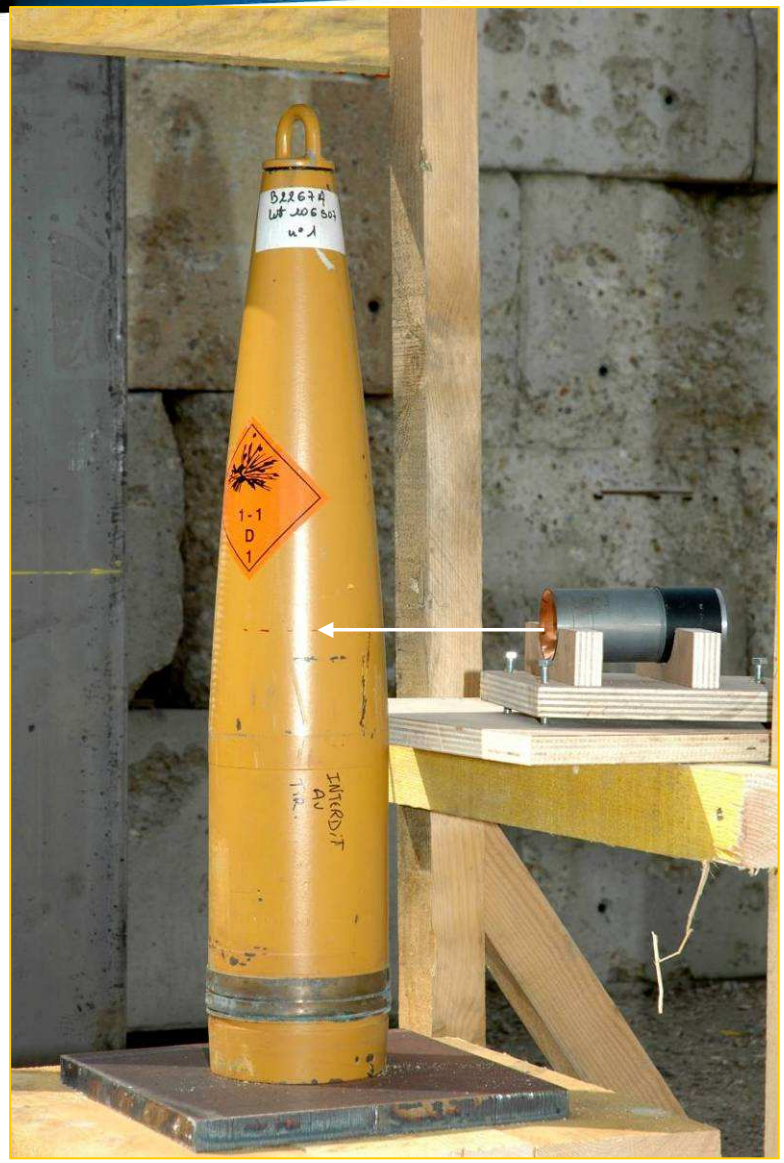


Shaped Charge Jet – Test Programme

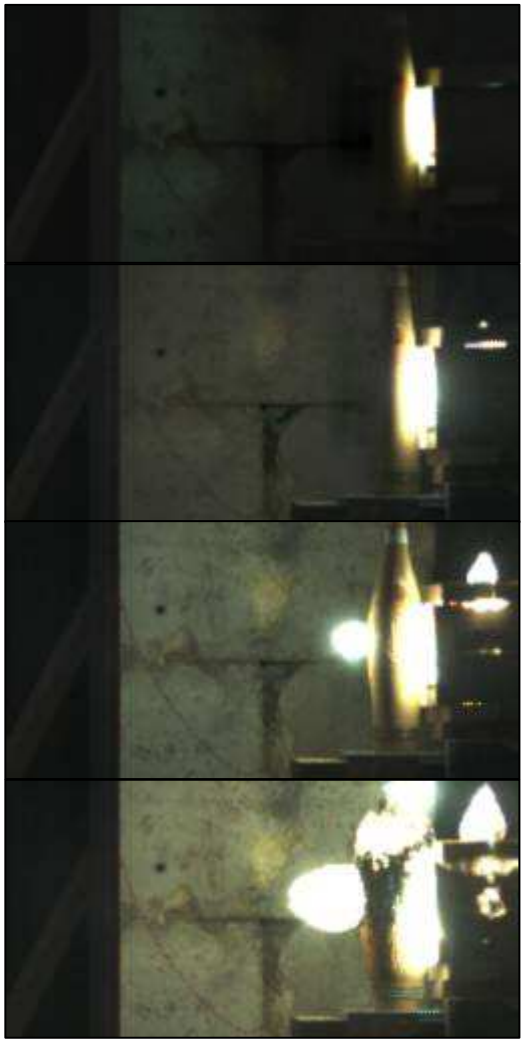
$V^2.d$ versus Stand-Off

Stand-Off (mm)	Tête 23 Φ 68 mm	AT4CS Φ 84 mm	RCC Φ 112 mm
150	300 (ref.2)		470
180		360 STANAG Level	450
280			400

Shaped Charge Jet Tests
155mm shells



Shaped Charge Jet Test – 155
B2267A – AT4CS
(at 360 $mm^3/\mu s^2$: STANAG Spec)



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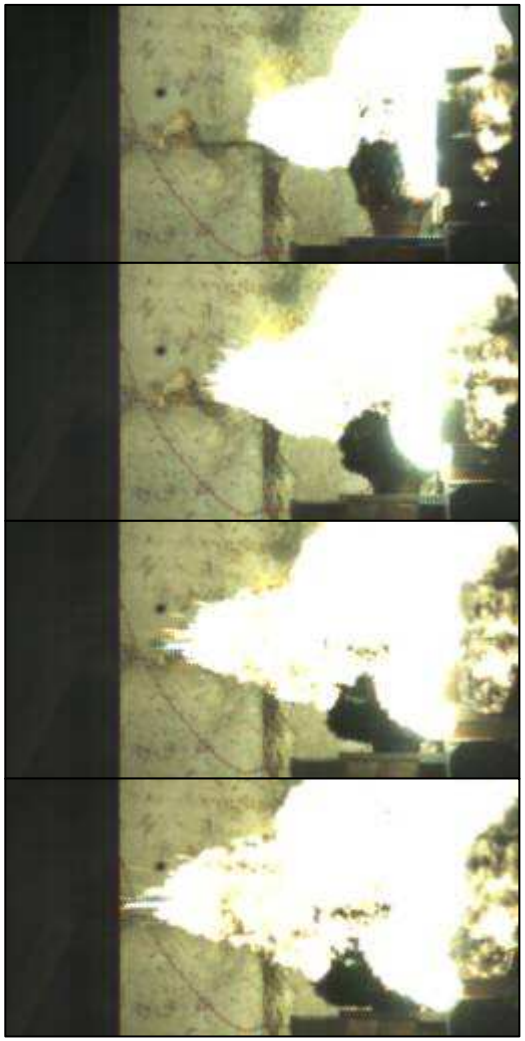
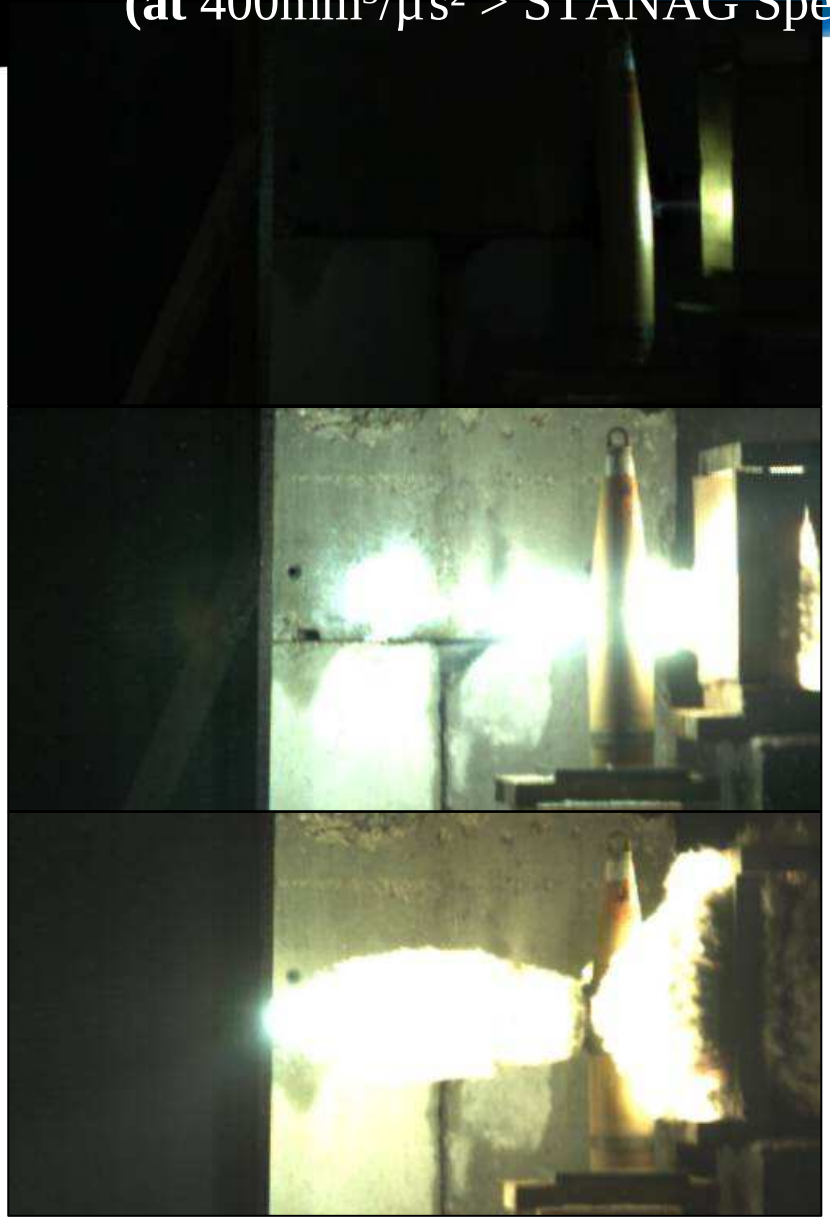


Shaped Charge Jet Test – 155
B2267A – AT4CS
(at 360 $mm^3/\mu s^2$ = STANAG Spec)

- Witness screen and plate were perforated.
- No HE was collected
- Small fragments were collected

<u>Detonation (Reaction Level I) = Fail</u>

Shaped Charge Jet Test – 155
B2268A – RCC
(at 400mm³/µs² > STANAG Spec)



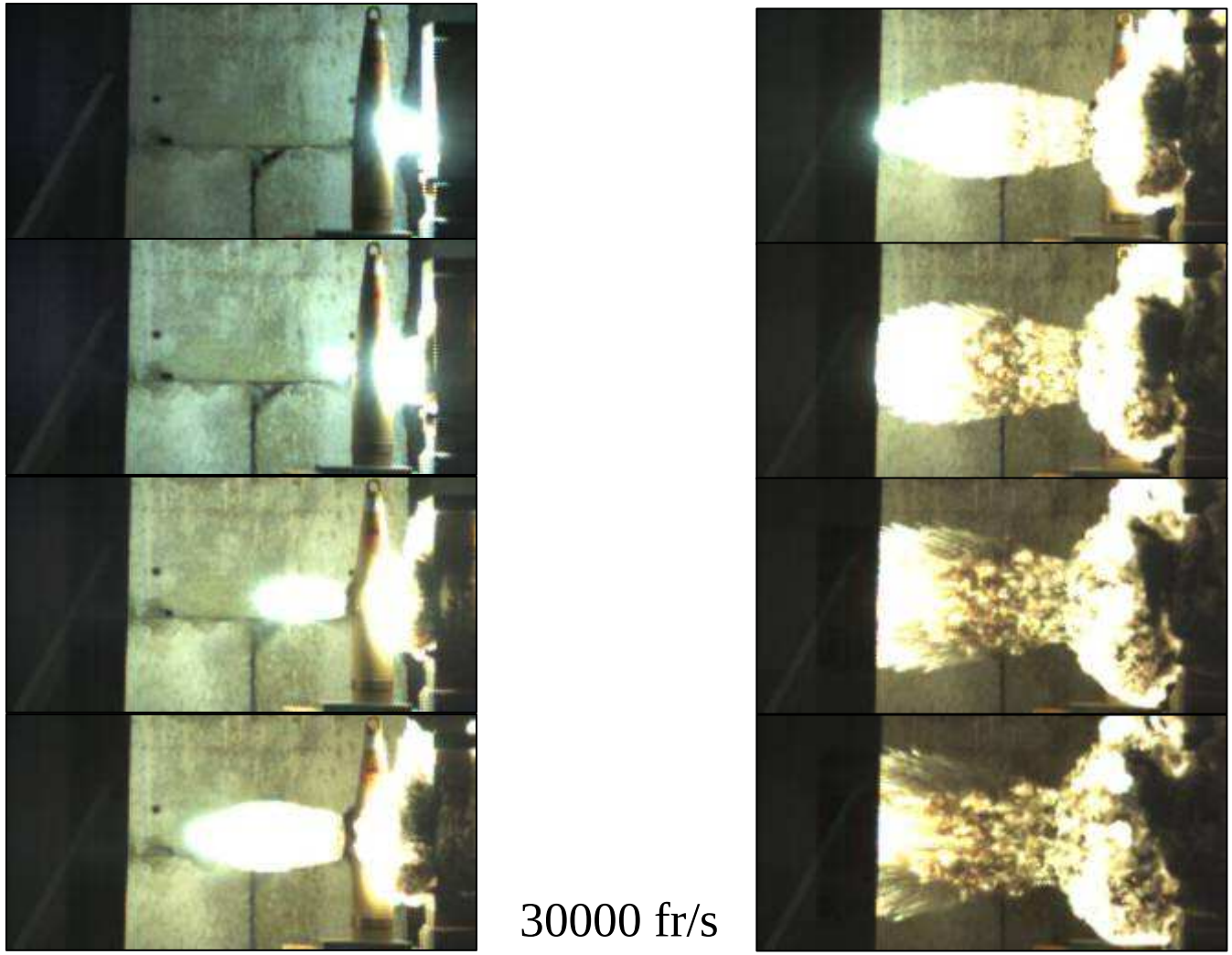
(12500 fr/s)

Shaped Charge Jet Test – 155
B2268A – RCC
(at 400 $mm^3/\mu s^2$ > STANAG Spec)

- No perforation in witness screen and plate,
- More than 8 kg of HE have been collected (≈ 90%),
- Shell body was broken in few large pieces (thrown beyond 15m)

Reaction Level IV = PASS

Shaped Charge Jet Test – 155
B2268A – RCC
(at 450 $mm^3/\mu s^2$ > STANAG Spec)



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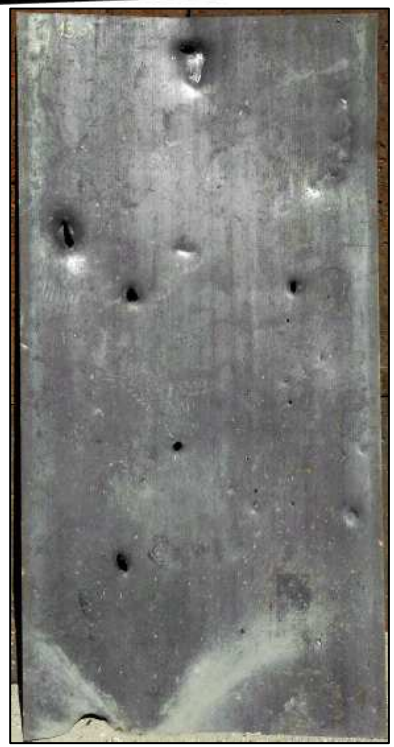
Shaped Charge Jet Test – 155
B2268A – RCC
(at 450 $mm^3/\mu s^2$ > STANAG Spec)



- 6 perforations in witness screen, slight imprint in plate
- More than 5,5 kg of HE have been collected (≈ 60 %),
- Shell body is broken in large pieces (thrown beyond 15m)

Reaction Level III/II (?) : PASS/FAIL (?)

Summary of Test Results

Reaction Levels

$V^2.d$	B2267A	B2268A
300	III Ref.2	V Ref.2
360 (STANAG Level)	I	/
400	/	IV
450	/	III / II

Conclusions

- EURENCO has tailored cast PBX formulations, NTO/RDX based, which exhibit optimized IM/Performances trade-offs for large caliber applications (155mm to GP bombs).

- Low level gap test results allow B2267A and B2268A to meet EIDS criteria as well as in-house ELSGT requirements for Sympathetic Reaction in 155mm configuration.

- V^2D stimuli have been varied from 300 to 450 $mm^3/\mu s^2$ and limits have been determined for B2267A and B2268A

- B2267A passes at 300 $mm^3/\mu s^2$ and fails against 360 $mm^3/\mu s^2$ (STANAG spec)

- B2268A exceeds STANAG 4439 Shaped Charge jet requirement

- A specific shaped charge should be defined and extensively characterized (under MSIAC leadership ?) to provide a reliable standard for community.

References/Acknowledgements

References

Ref. 1: Tailored Formulations for IM 155 Artillery Shells. B.Mahé *et alii* 2007 IMEMTS, Miami, USA.

Ref. 2: Tailored Sensitivity Explosive Formulation. B.Nouguez and B.Mahé 2009 IMEMTS, Tucson, USA

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