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EUROPEAN MANUFACTURERS GROUP

RHEINMETALL
WAFFE MUNITION

2007 Insensitive Munitions & Energetic Materials Technology Symposium

Miami, Florida
October 15-18, 2007

Particles for Energetic Materials
Influence of Particle Size and Specific Surface for Energetic Formulations

Dr. Paul Wanninger

Particles for Energetic Materials

Particles

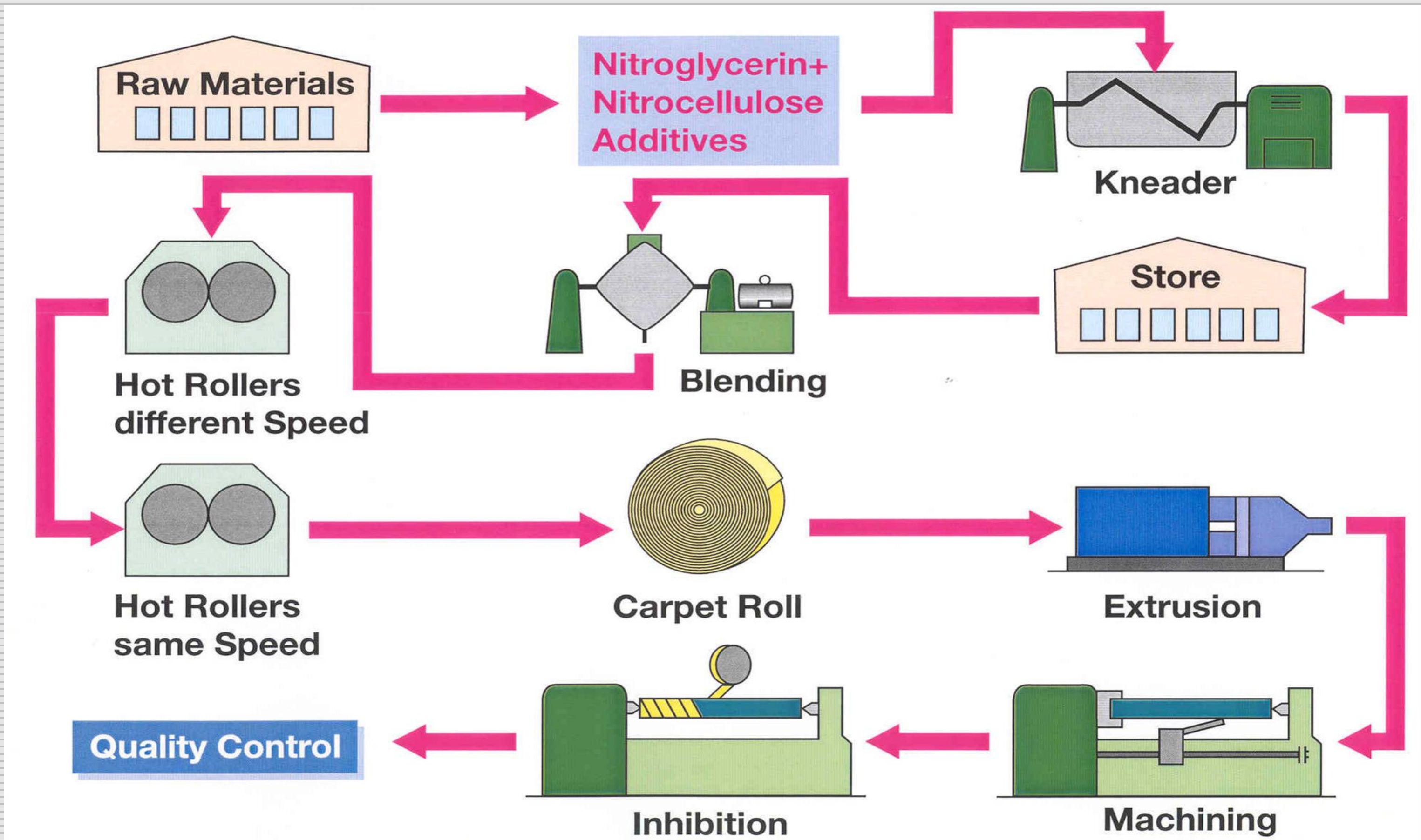
- Catalytic effects
  - Burning modifier

- Processing effects
  - Size
  - Surface
  - Polarity

- Effects on Vulnerability
  - Tensile strength
  - Young's modulus

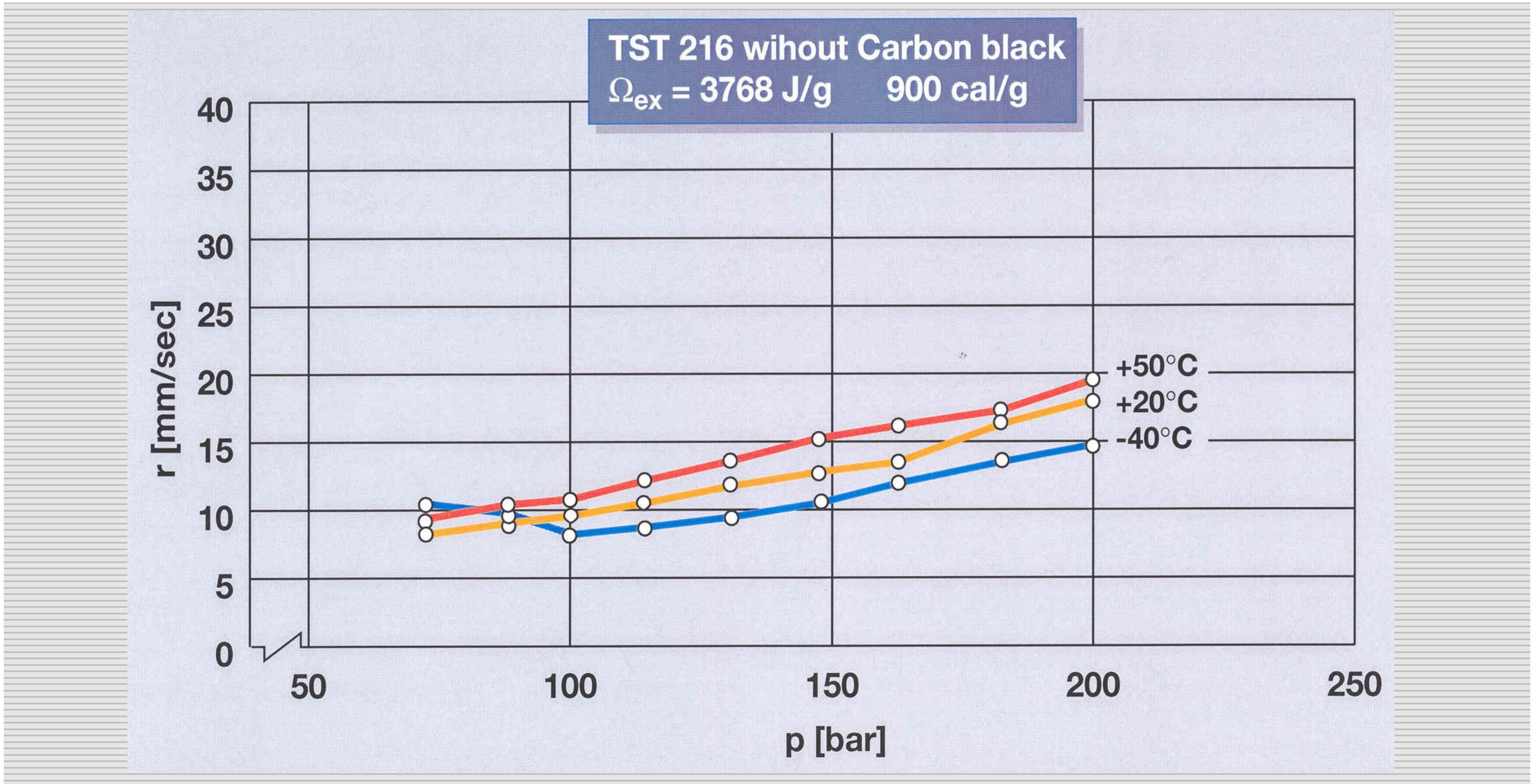
Particles for Energetic Materials

Double Base Propellants



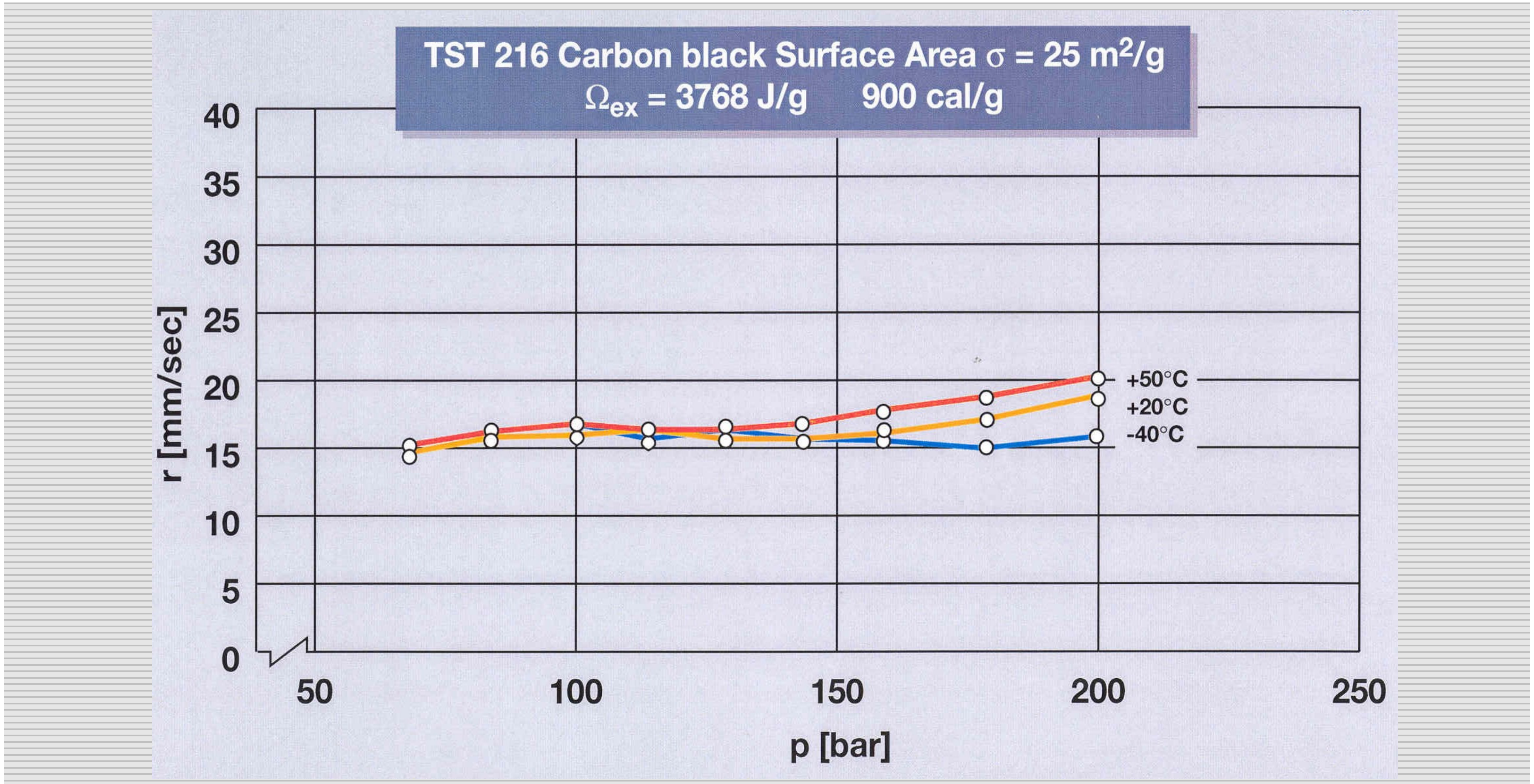
Particles for Energetic Materials

Influence of Specific Surface



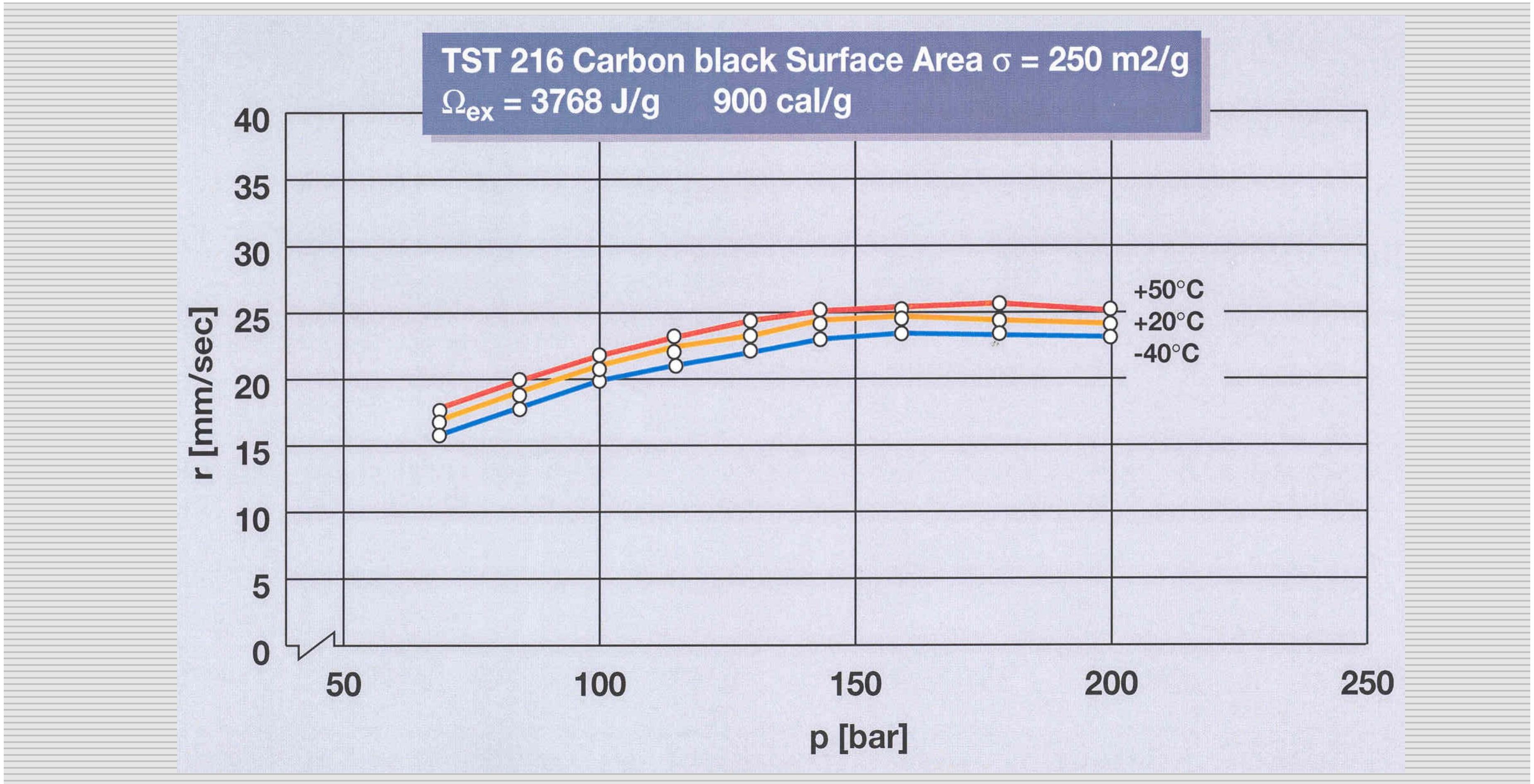
Particles for Energetic Materials

Influence of Specific Surface



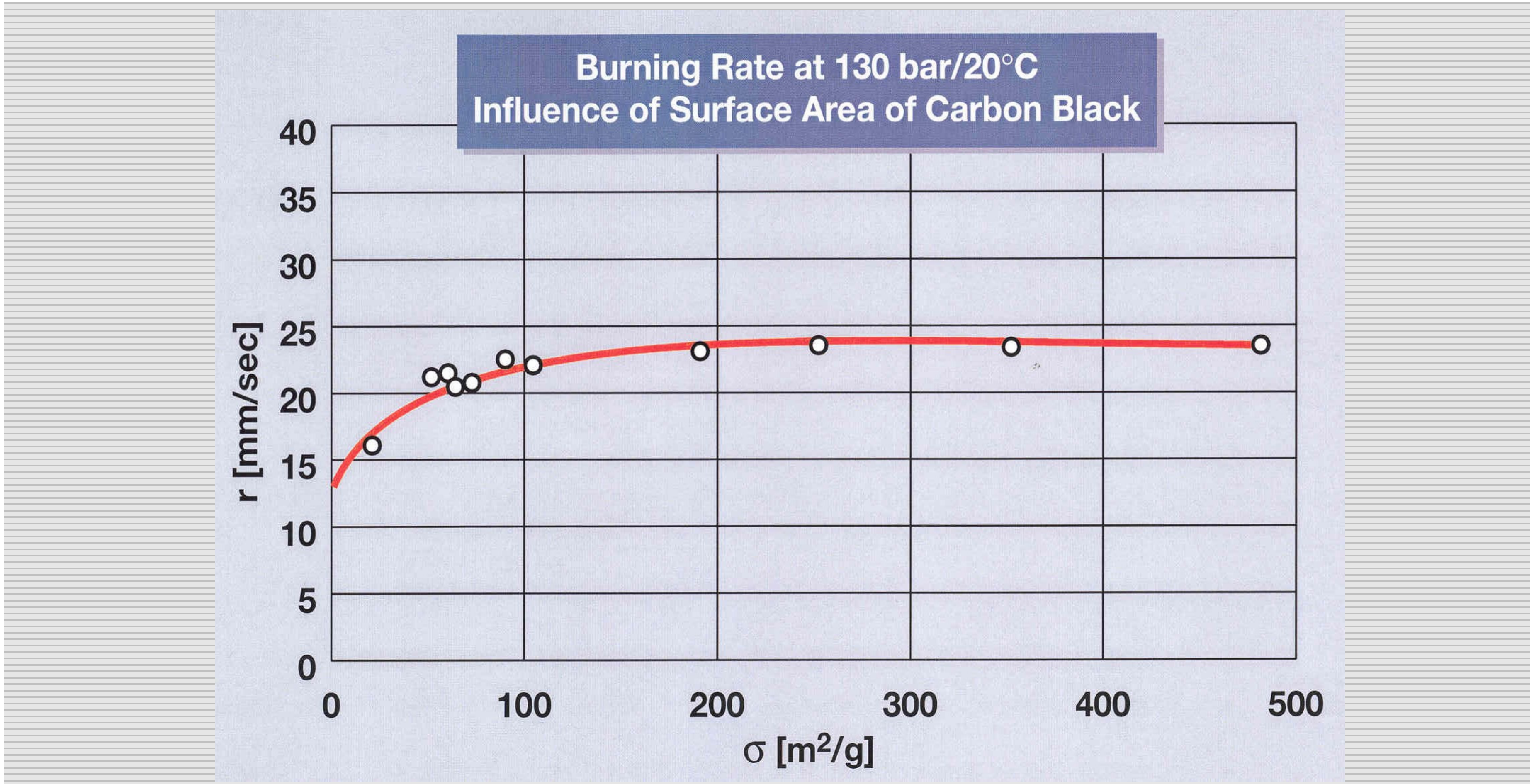
Particles for Energetic Materials

Influence of Specific Surface



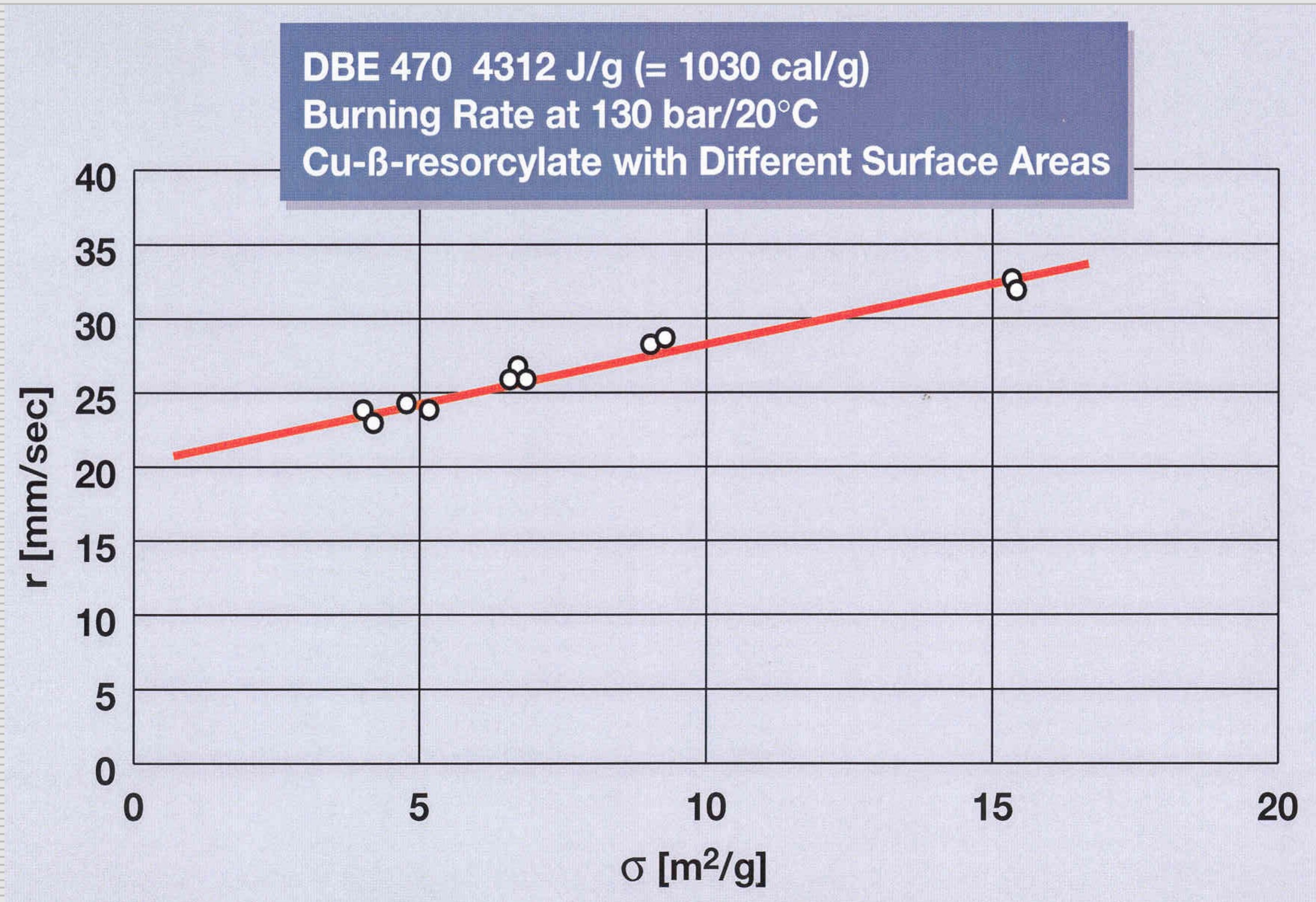
Particles for Energetic Materials

Double Base propellants



Particles for Energetic Materials

Influence of Specific Surface



Particles for Energetic Materials

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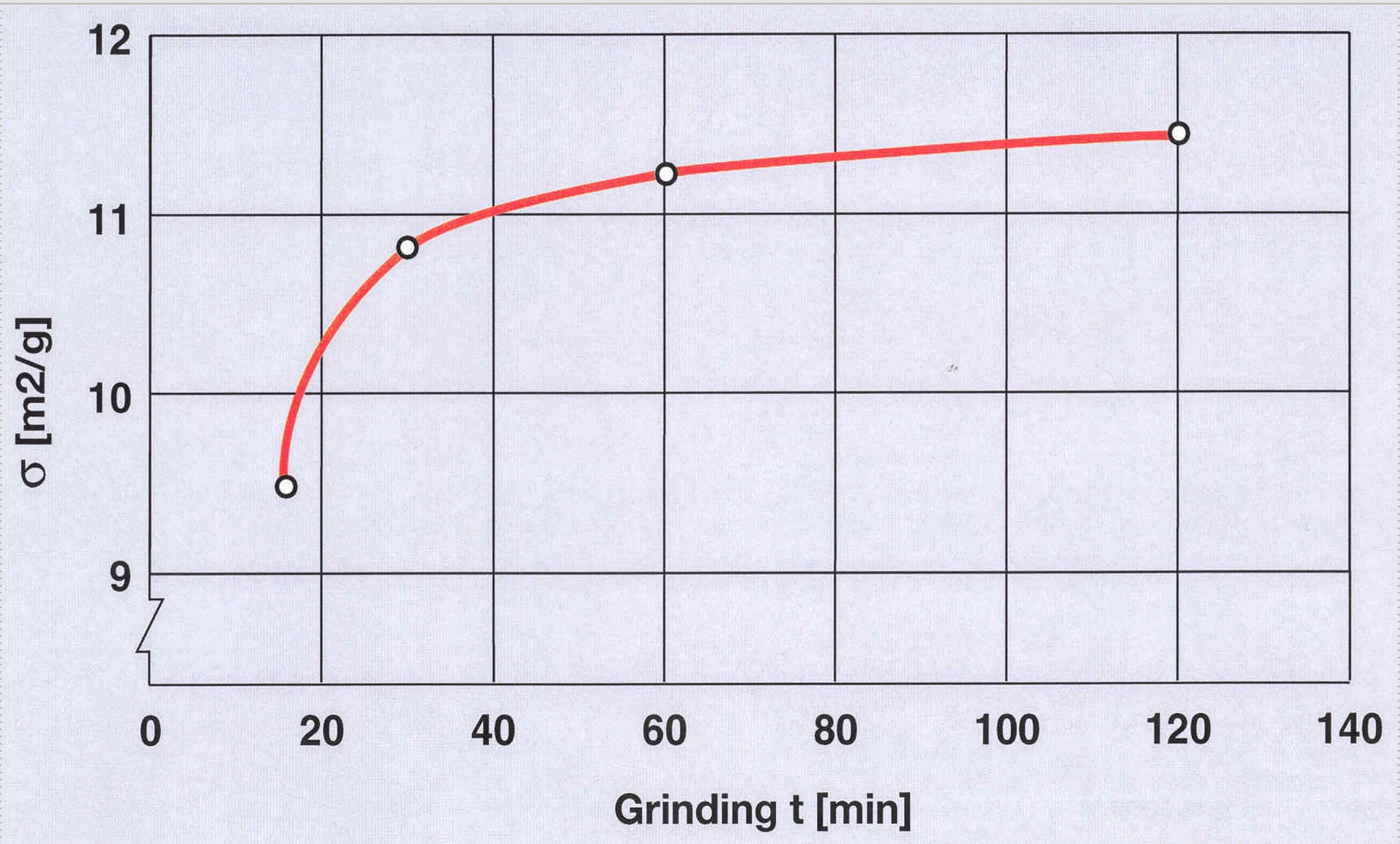
Grinding Time vs Surface Area of Copper-ß-resorcylate



Particles for Energetic Materials

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HE Charges Properties

Formulation

Binder
Plasticiser
Bonding agent
Antioxidans
Catalyst
Metal powder
High explosive

e.g. RDX, HMX
2 or 3 different
grain sizes

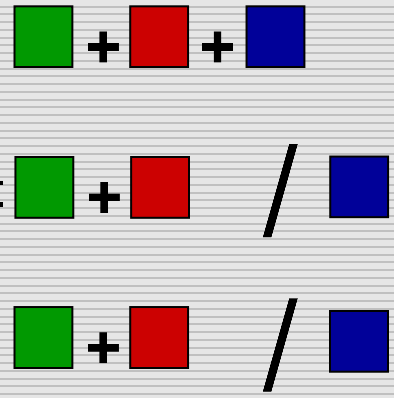
Curing agent

Process

Batch

Bicomponent

Extrusion



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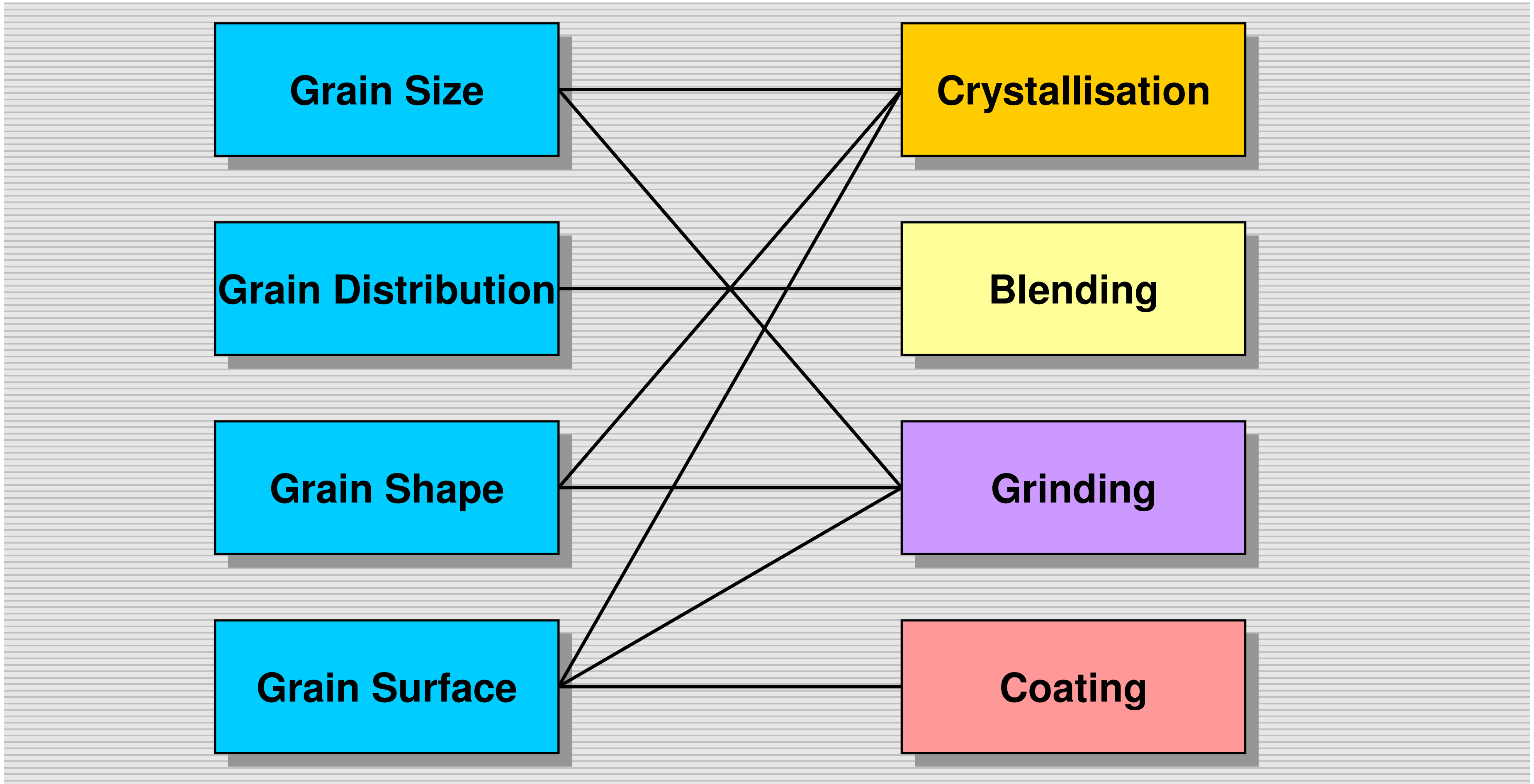
New Warheads
Preparation of Explosives



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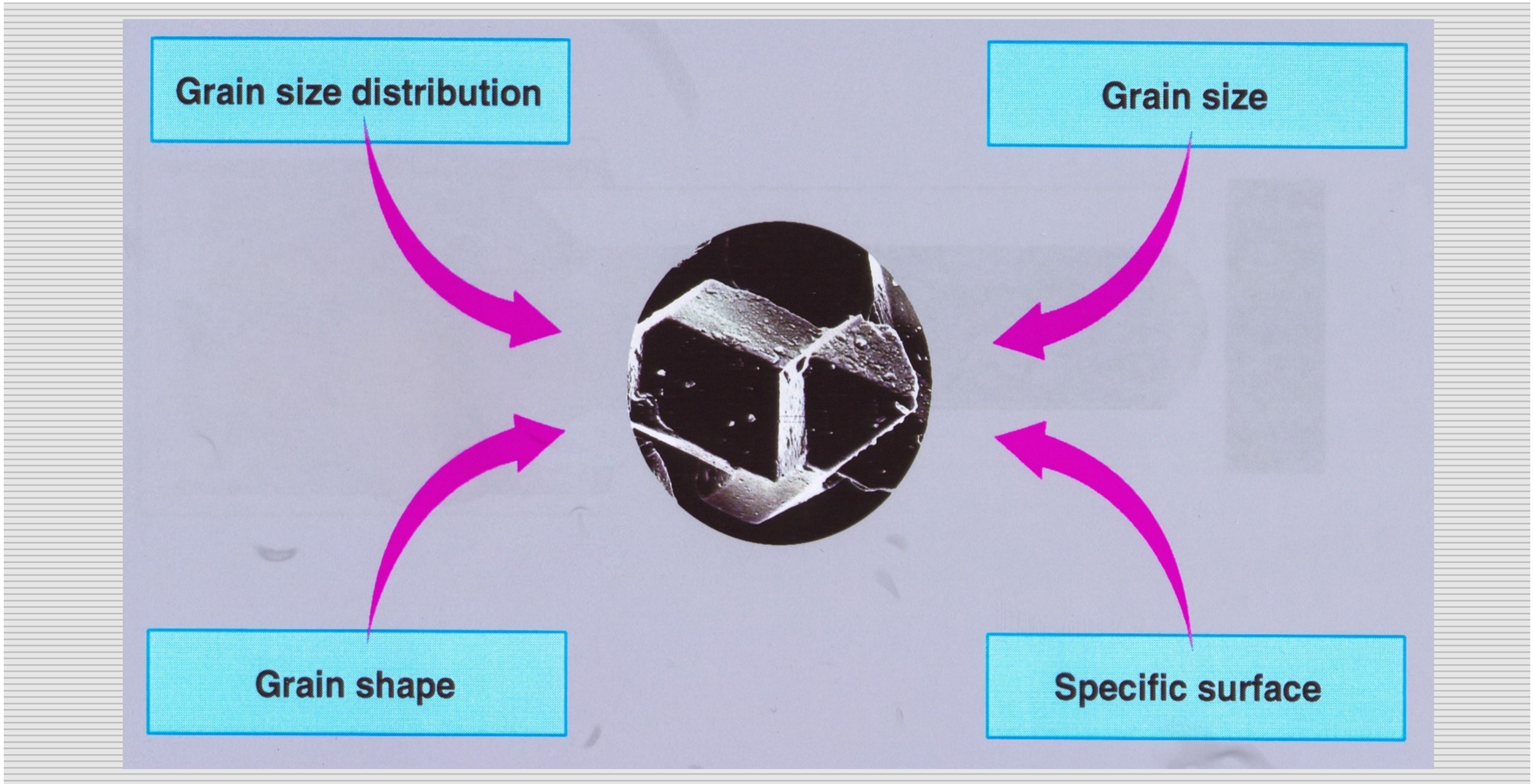
Determining Parameters



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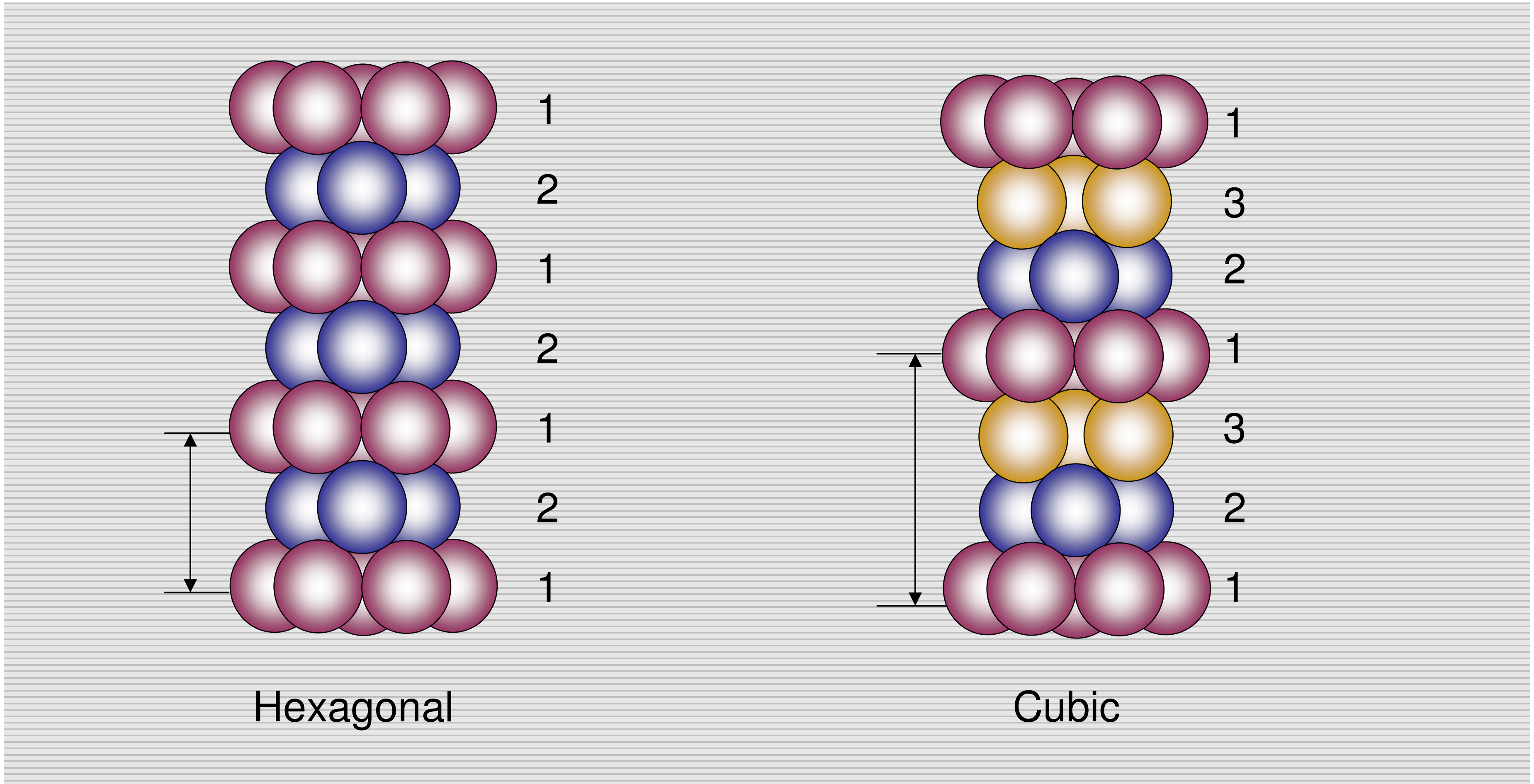
Packaging of spheres



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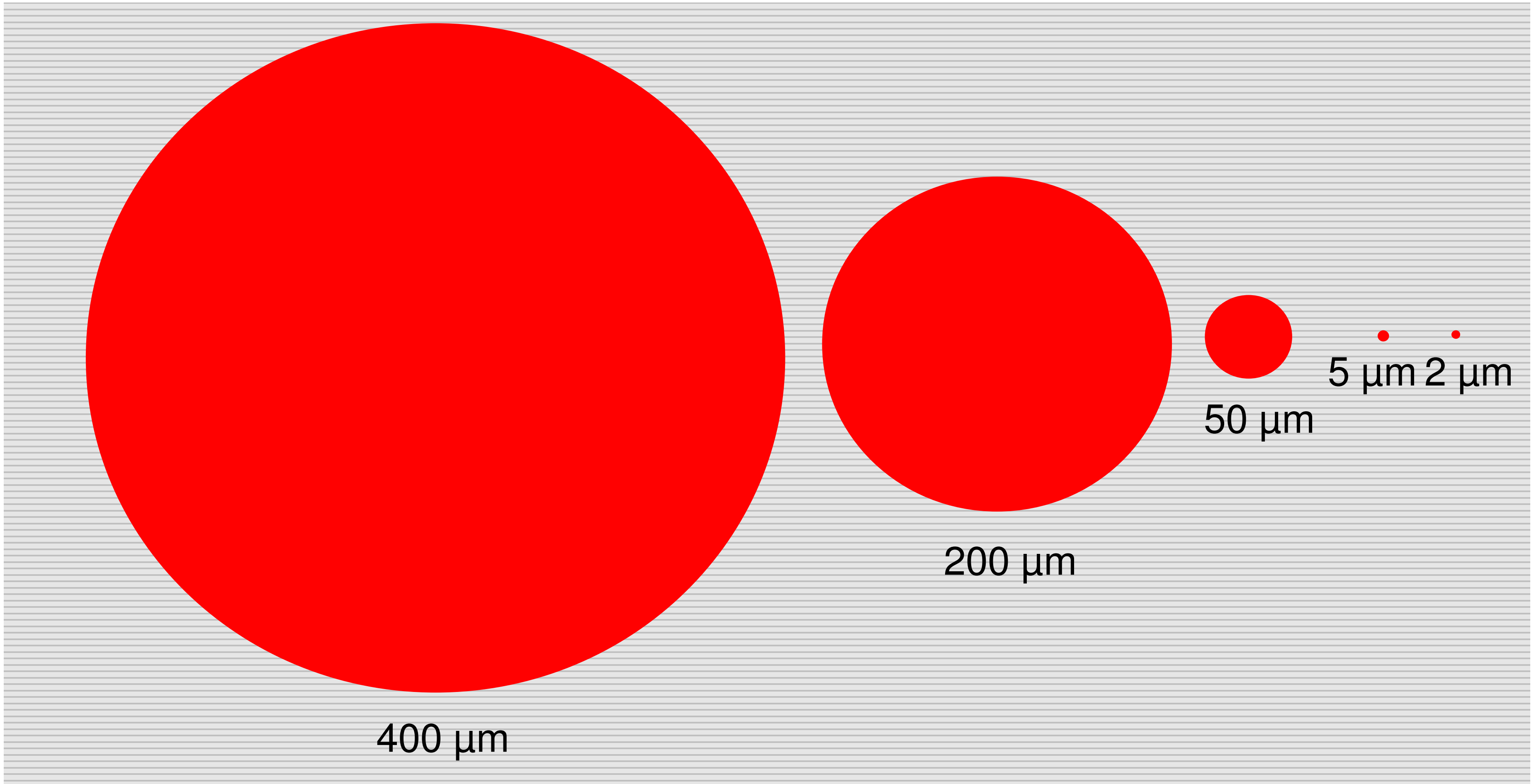
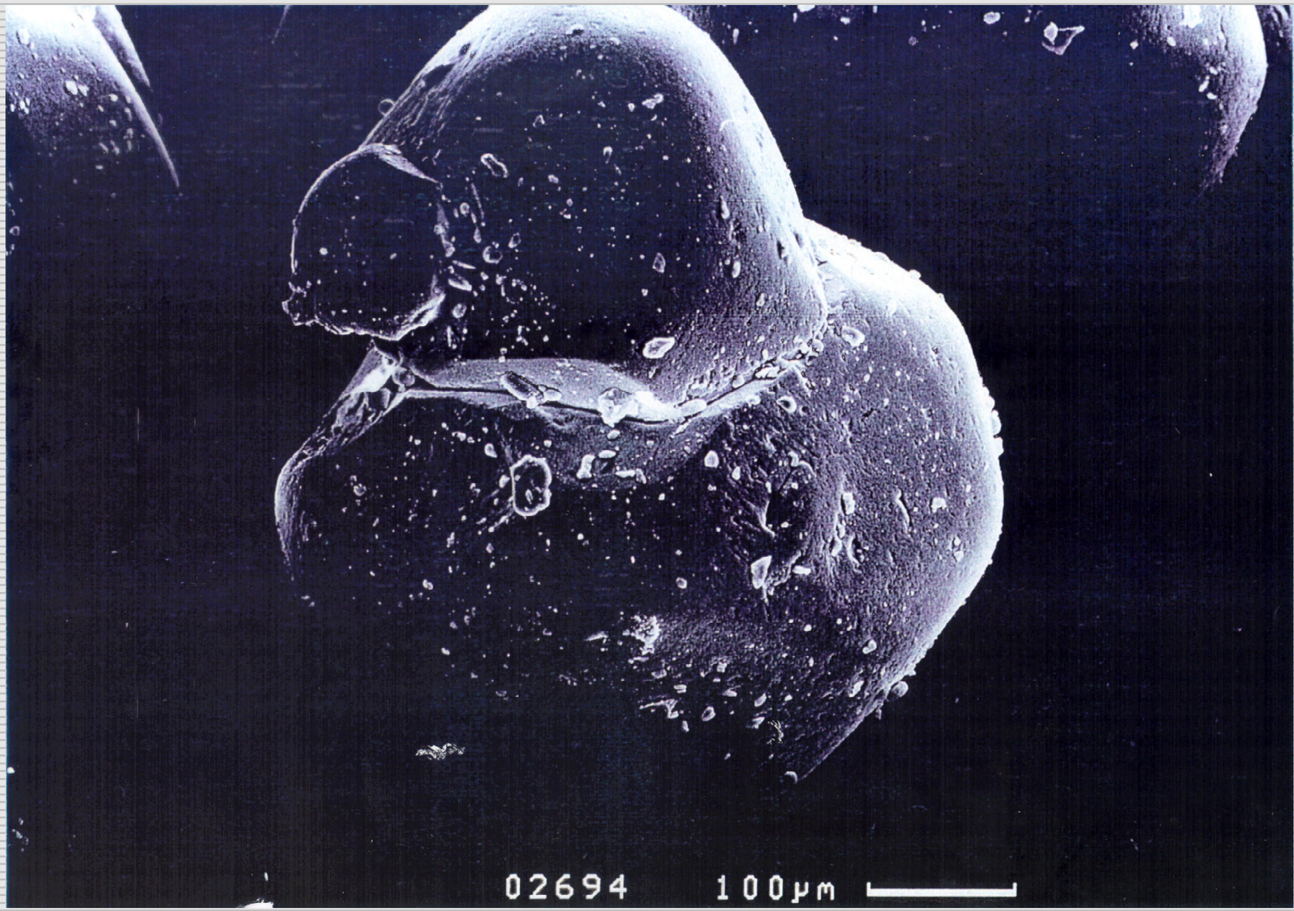
Particle Size Comparison



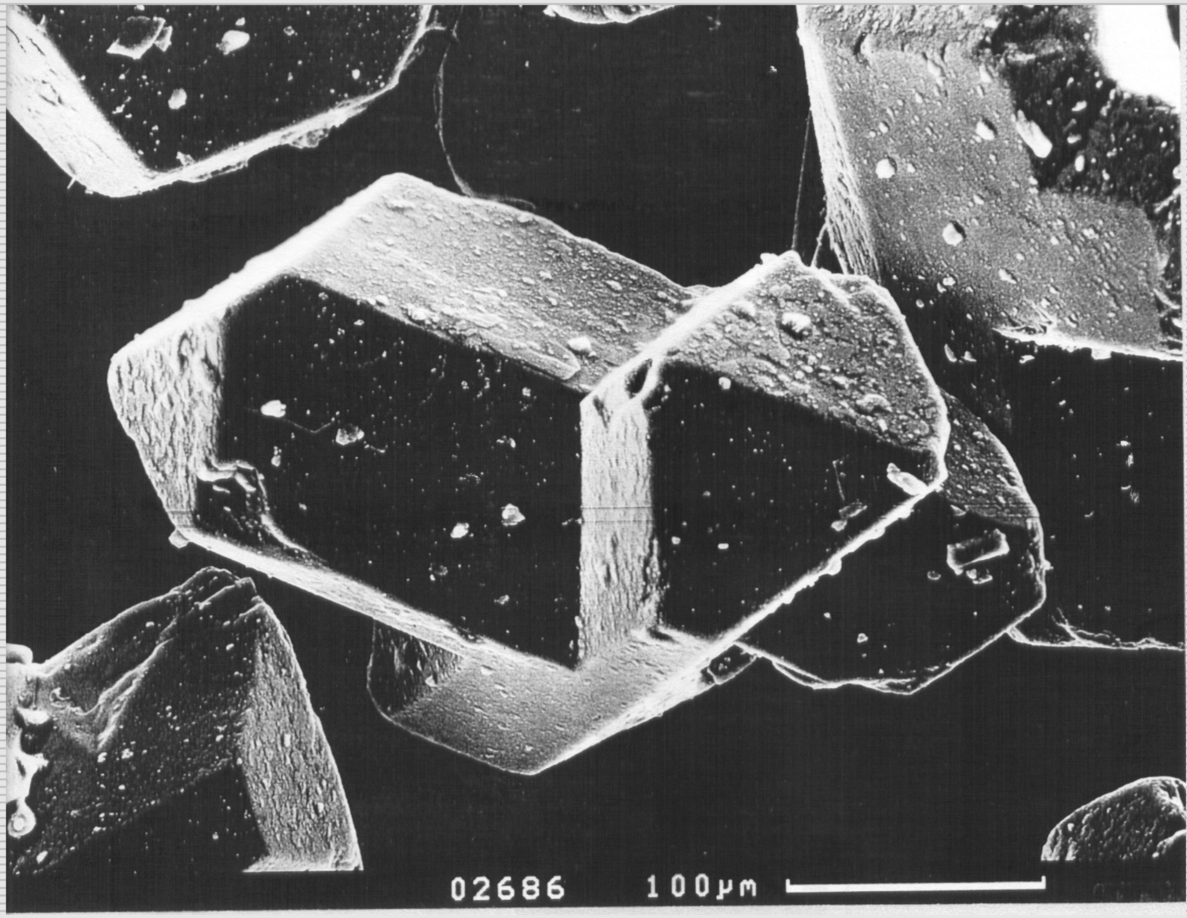
Particles for Energetic Materials

RDX



Particles for Energetic Materials

HMX



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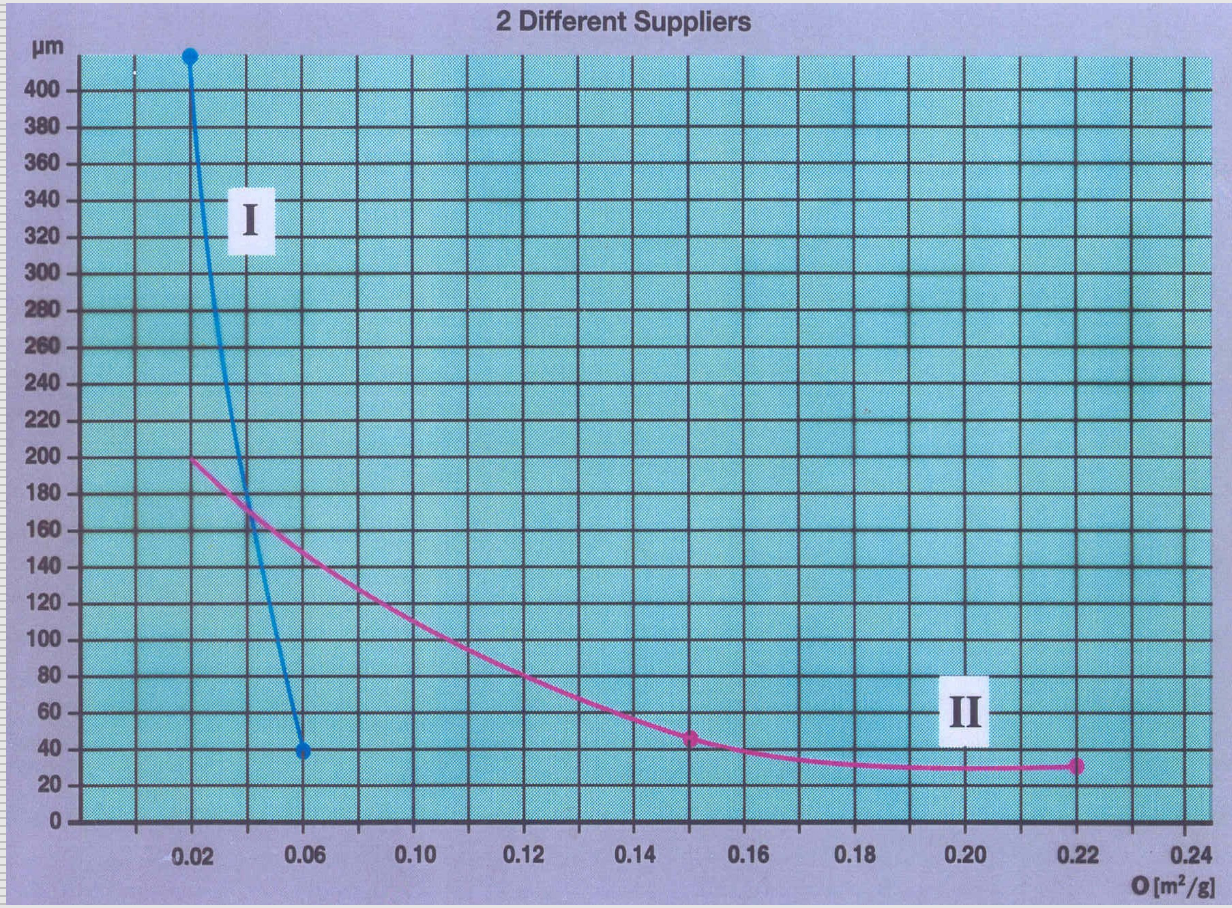
Grain Size vs Specific Surface HMX



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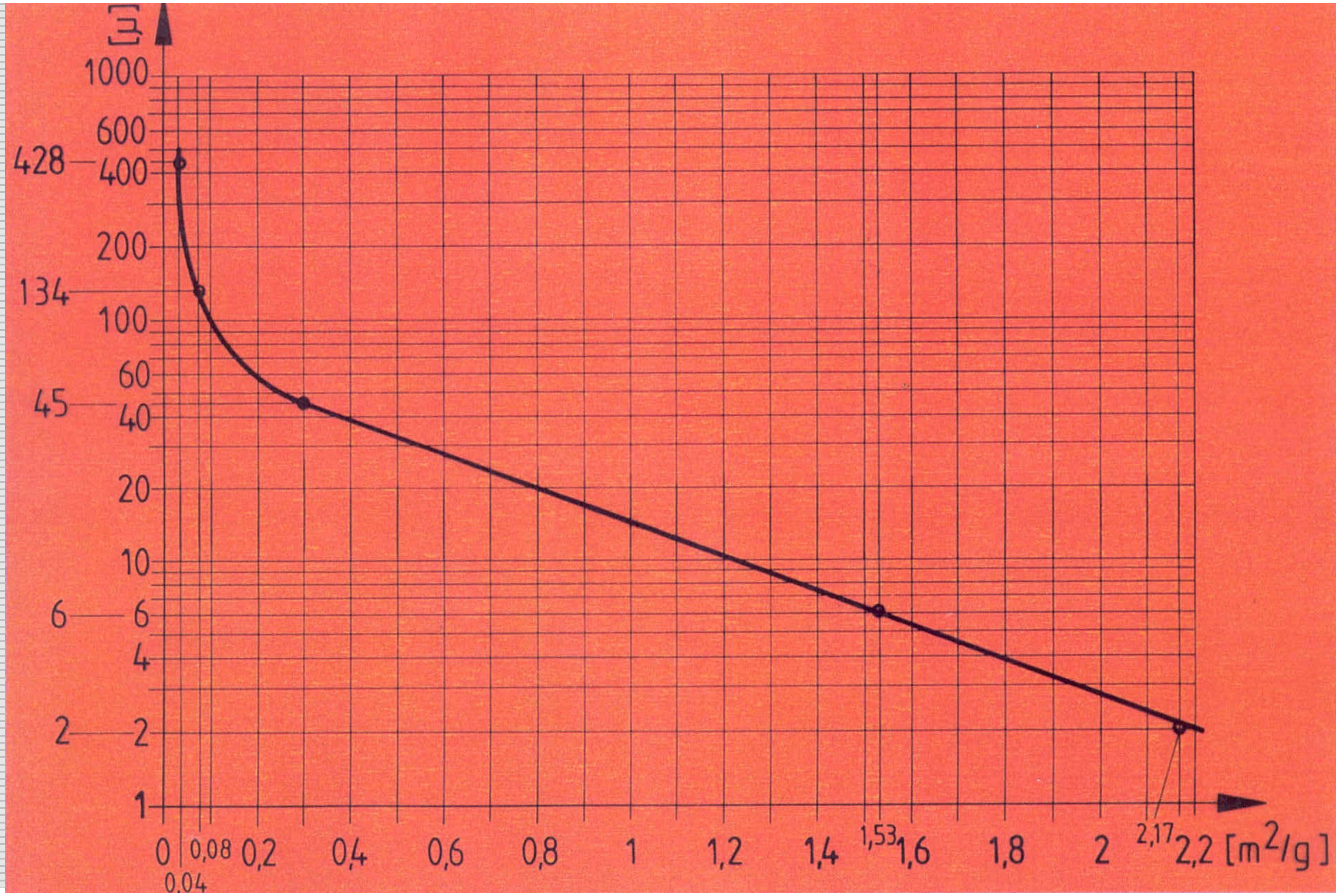
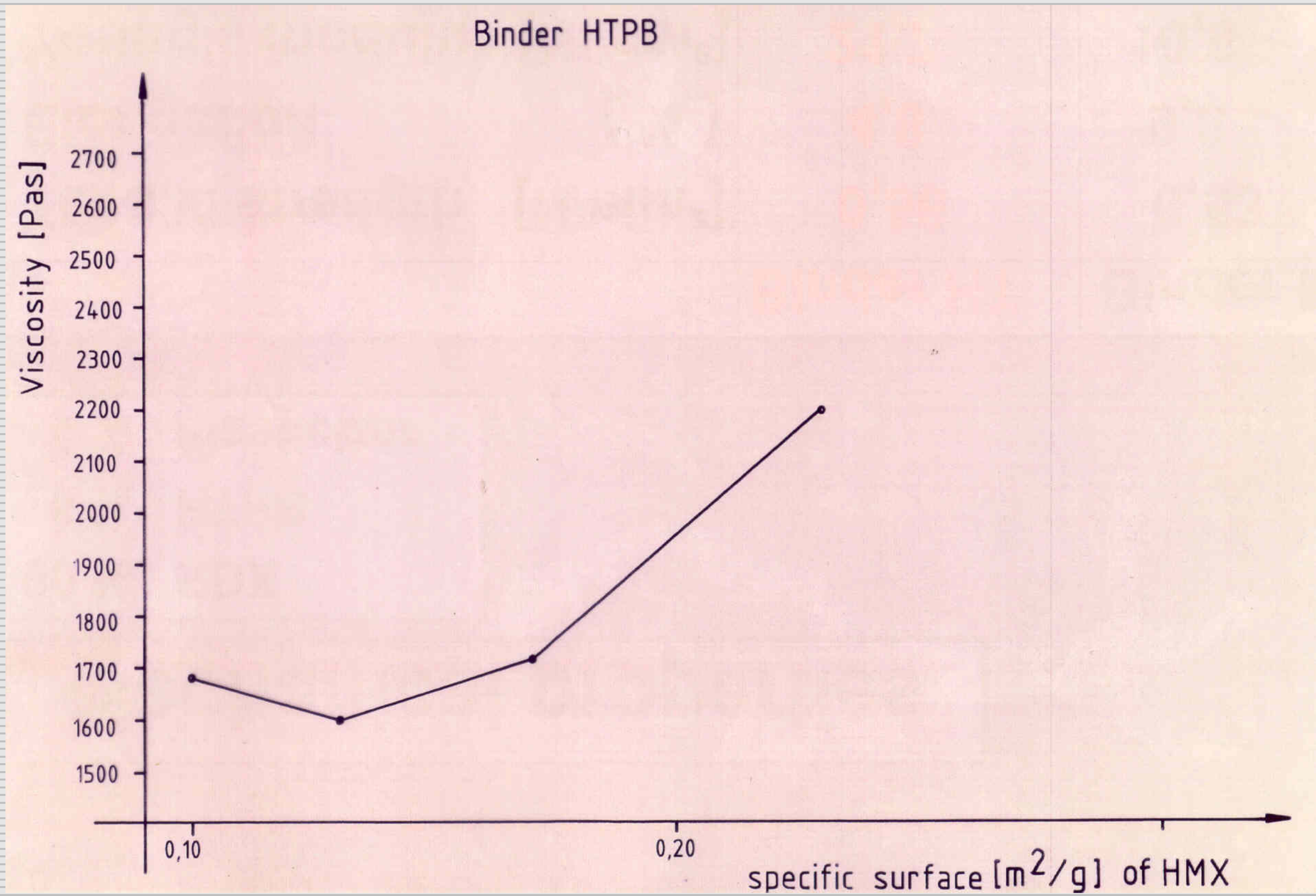
Specific Surface vs grain size HMX



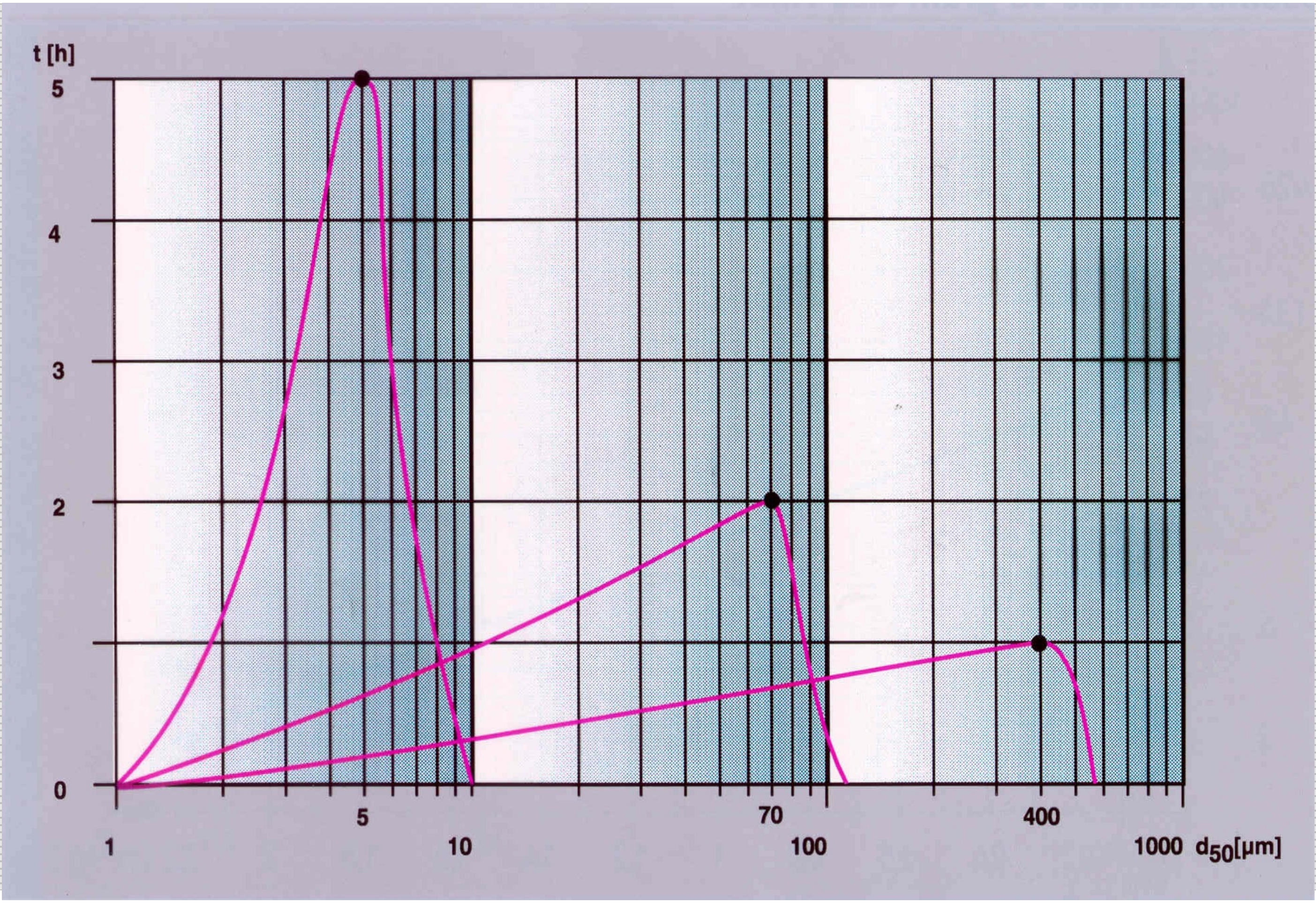
Particles for Energetic Materials

Viscosity vs specific surface of HMX



Particles for Energetic Materials

Grinding vs Time



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Sensitivity to impact

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Influence of crystal shape

Included air

Included solvent

Impurities (grit)

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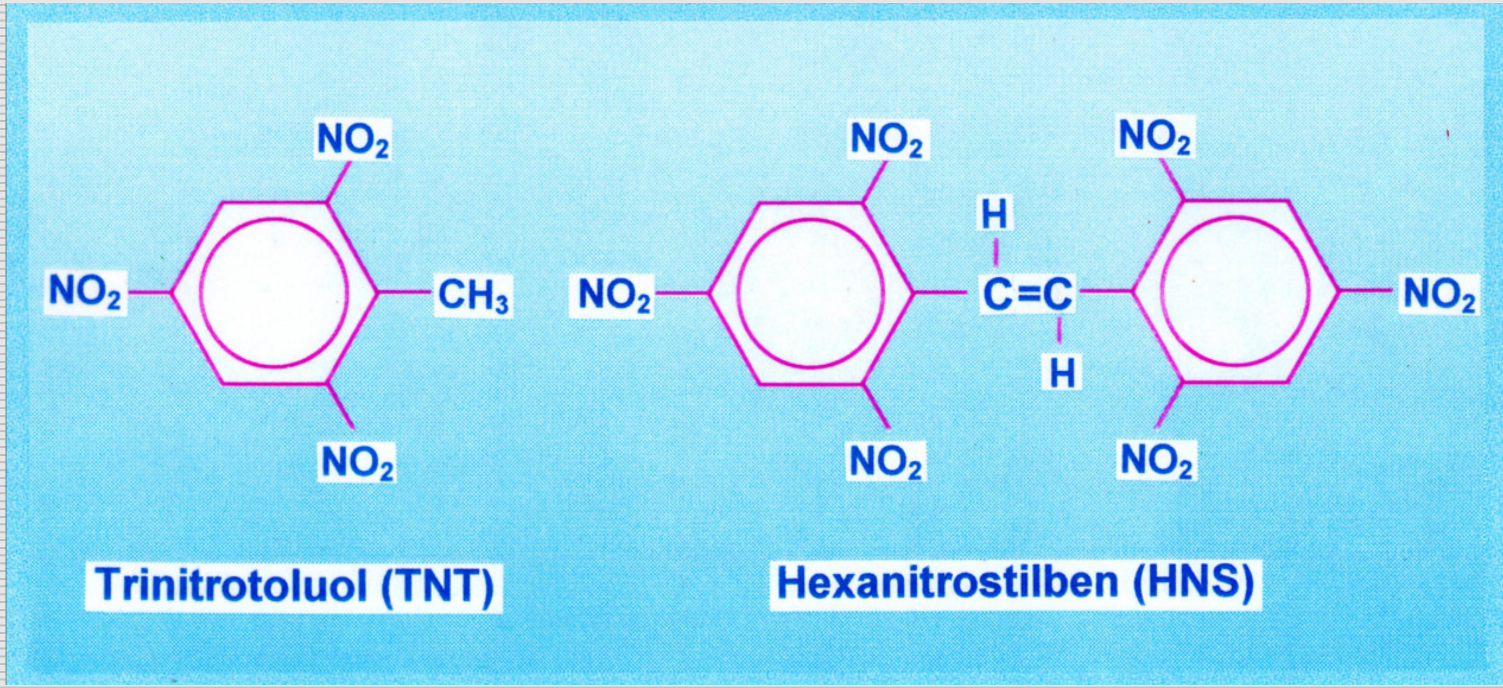
TNT / HNS Comparison of Molecules



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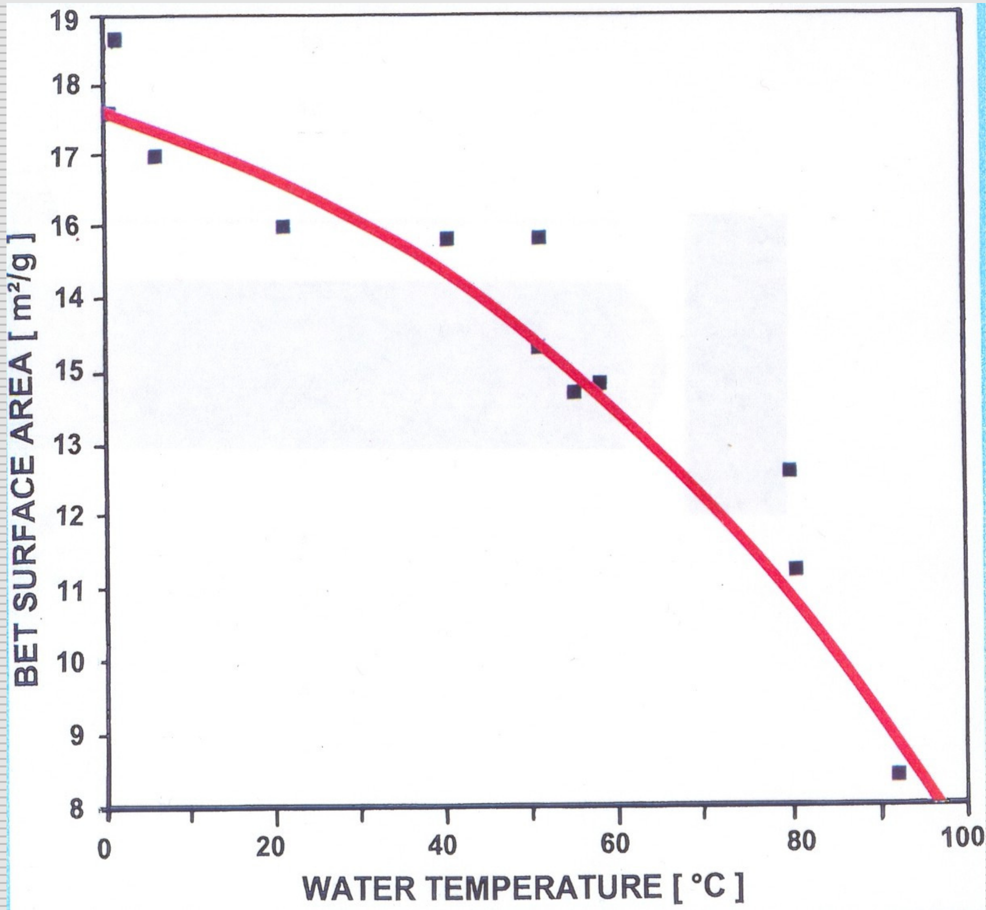
Water Temparature vs Bet Surface Area
Reverse Addition



The surface area of HNS is increased as the water tempe-rature is decreased in the case of reverse addition

Particles for Energetic Materials

Influence of Preparation

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HNS

Reference	Preparation method	Origin	Aspect - Grain size
HNS "ANM1"	Recristallized in nitric acid, and grinded	FRANCE SNPE	Rounded Specific area 4 - 6 m^2/g
HNS "ANM1" "Fine"	"Ultimate" grinding of HNS ANM1	FRANCE SNPE	Rounded Specific area 14 m^2/g
HNS IV (Specification WS 32 972 A)	Recistallized in Diméthylformamide	USA	Flat needle shape Specific area 11 m^2/g

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Specific Surface

Al

according to mil-A-512-A

Specific surface

Company	Type	specific surface [m^2/g]
A	Al powder	0,26
A	Al powder +0,3% $Cr0_3$	0,75
A	Al powder spherical	0,10
B	Al powder I	5,01
B	Al powder +0,3% $Cr0_3$	0,22
B	Al powder spherical II	3,54

Particles for Energetic Materials

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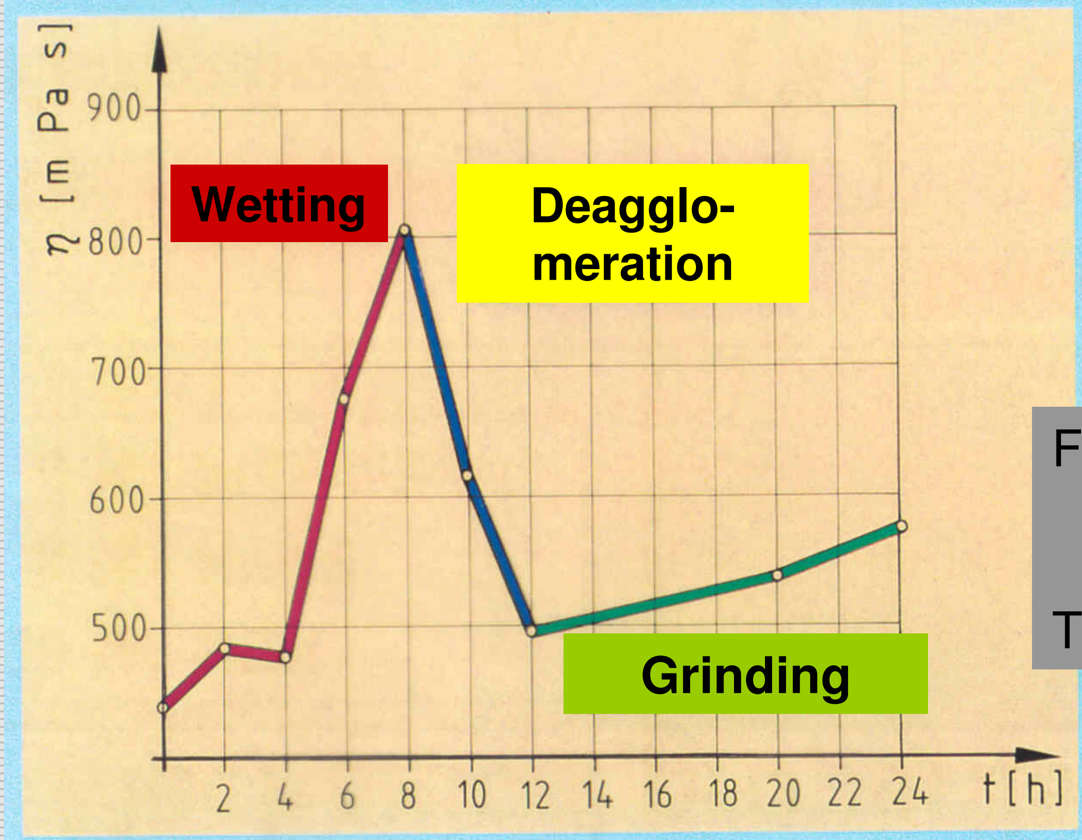
Particles

	Specific Surface Area Measurements (m^2/g)	
Material	Microscope S_{cal}	Sorptometer S_S
0 – 10 µ Al	0,444	0,379
10 – 20 µ Al	0,161	0,250
20 – 30 µ Al	0,105	0,210
30 – 40 µ Al	0,094	0,197
40 – 50 µ Al	0,077	0,178
Alco – 123 Al	0,299	0,244

Particles for Energetic Materials

Viscosity TNT / HMX



Formulation	63 % HMX
	37 % TNT
Temperature	95 ° C

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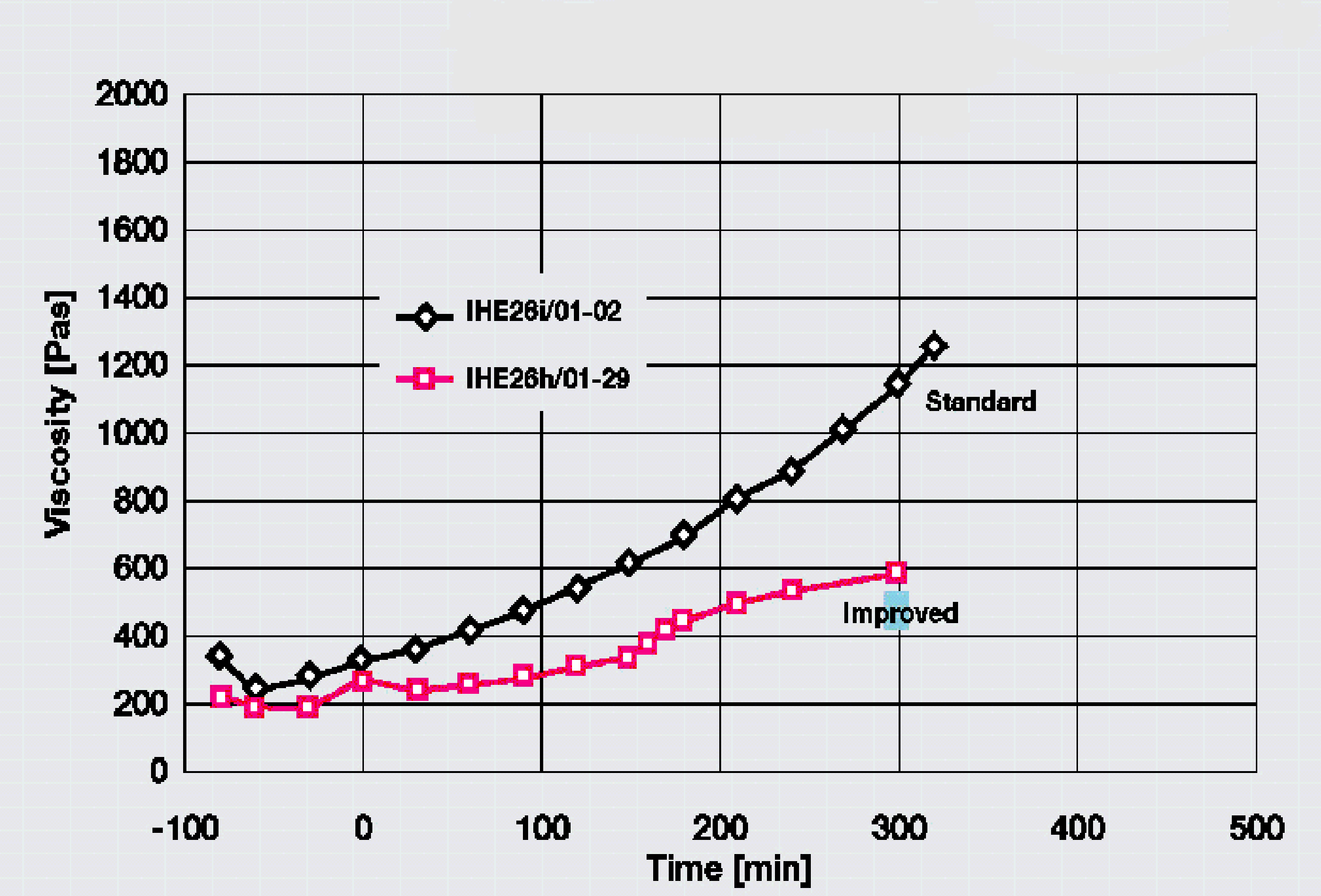
Rh 26 Influence of Lecithine



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Rh 26 90% Solid – Addition of Bonding Agent

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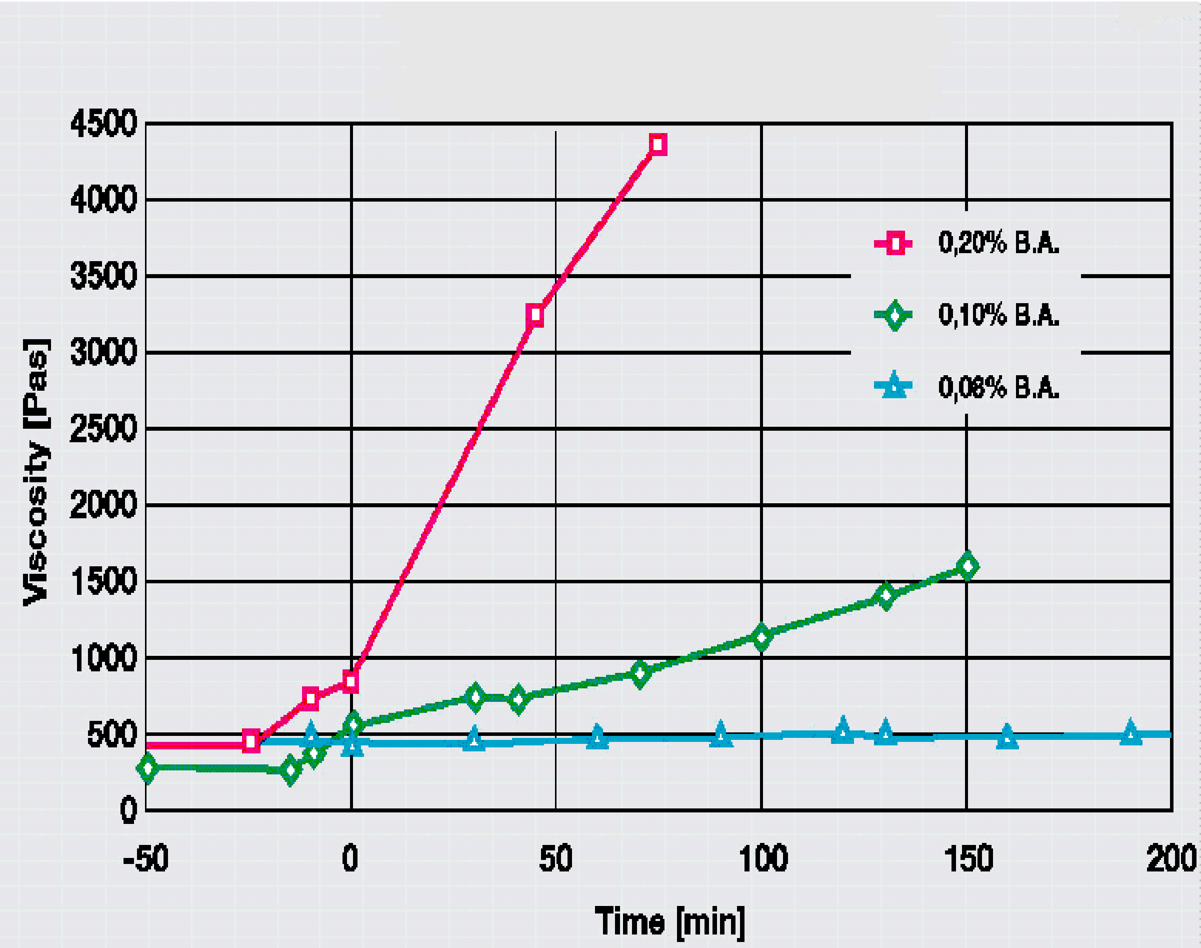

Particles for Energetic Materials

Influence of coating

	Specific surface
Fine virgin particles with polar groups	0,1978 m^2/g
Fine coated (Saturated) particles	0,1880 m^2/g

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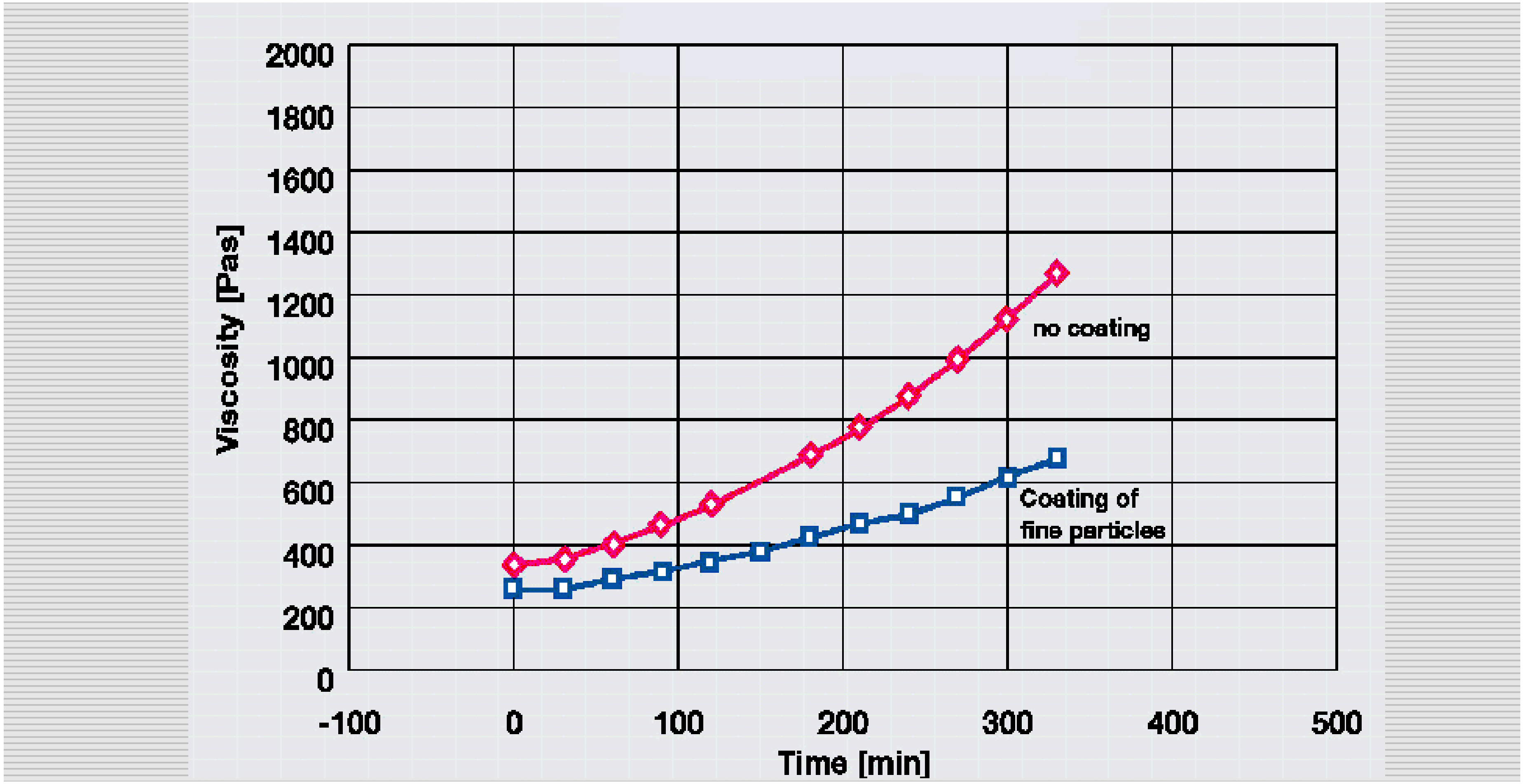
Rh26 Influence of Coating



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Processability

To decrease viscosity

- Grain size distribution
- Spherical grains
- Coated grains
- Non polar surfaces

} ⇒ **Low specific surface**

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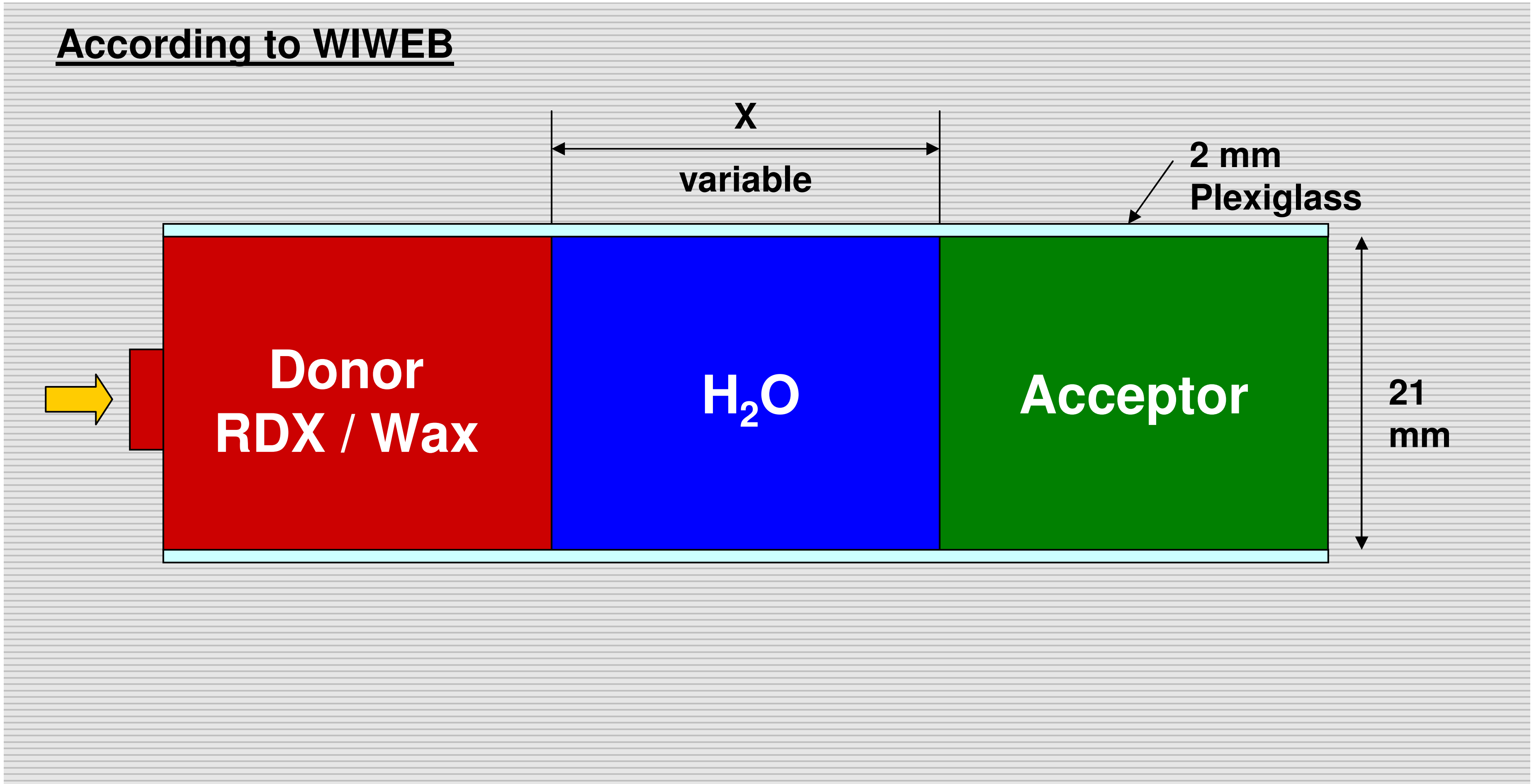
GAP - Test 21 mm



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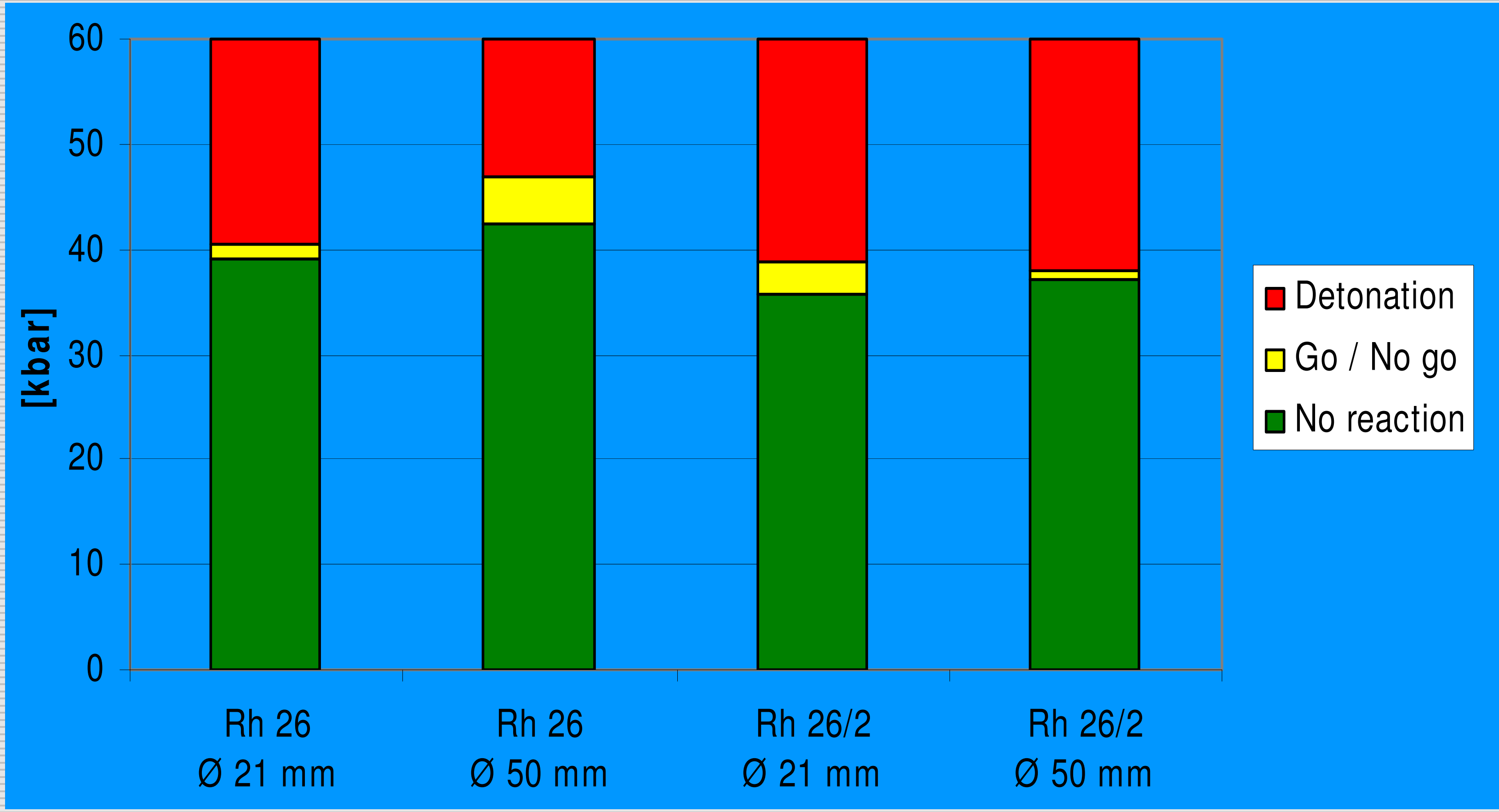
IHE GAP-Test Rh 26®



Particles for Energetic Materials

Initiation

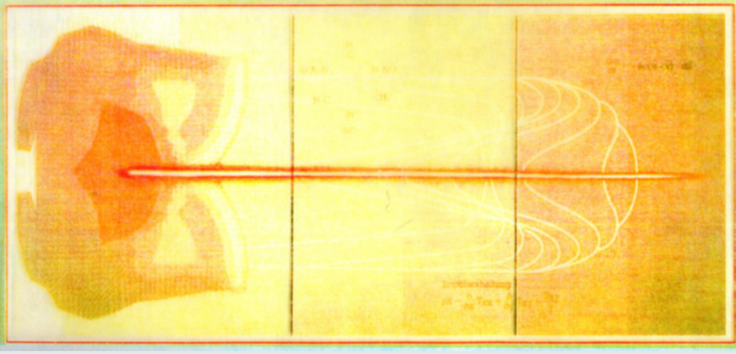
Mechanical properties → Shock wave

Material → Critical diameter

Grain size → Critical diameter

Porosity → Hot spots

Cavities → Hot spots



CRITERIA $v^2\,d$ (M. Held)

Particles for Energetic Materials

Critical diameter

RDX		AP	
Size [µ]	D_{cr} [mm]	Size [µ]	D_{cr} [mm]
100	2,5	5	23
400	5,0	200	76

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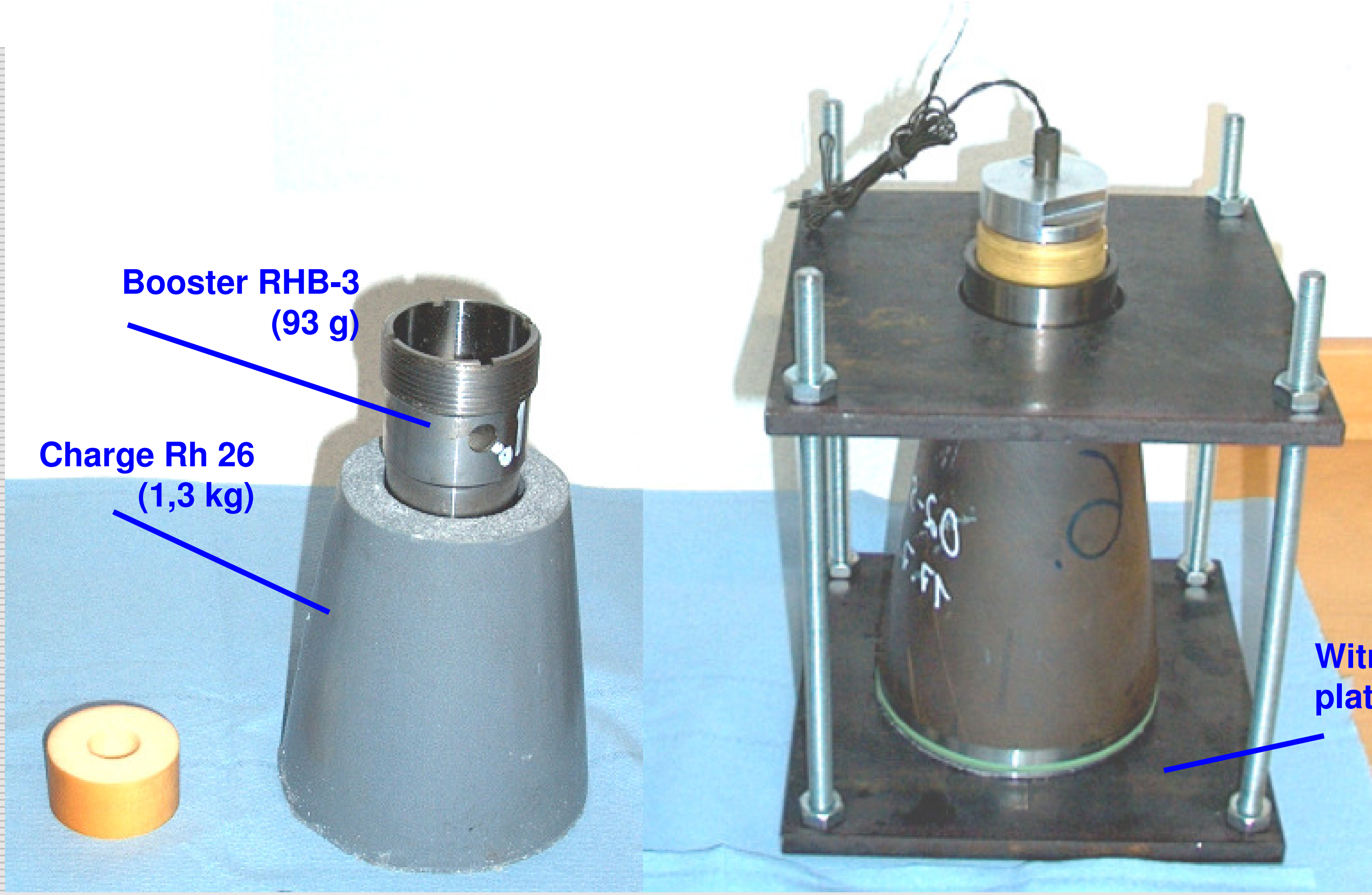
155 mm HE – RH 30, Initiability of Rh 26 Charge



Particles for Energetic Materials

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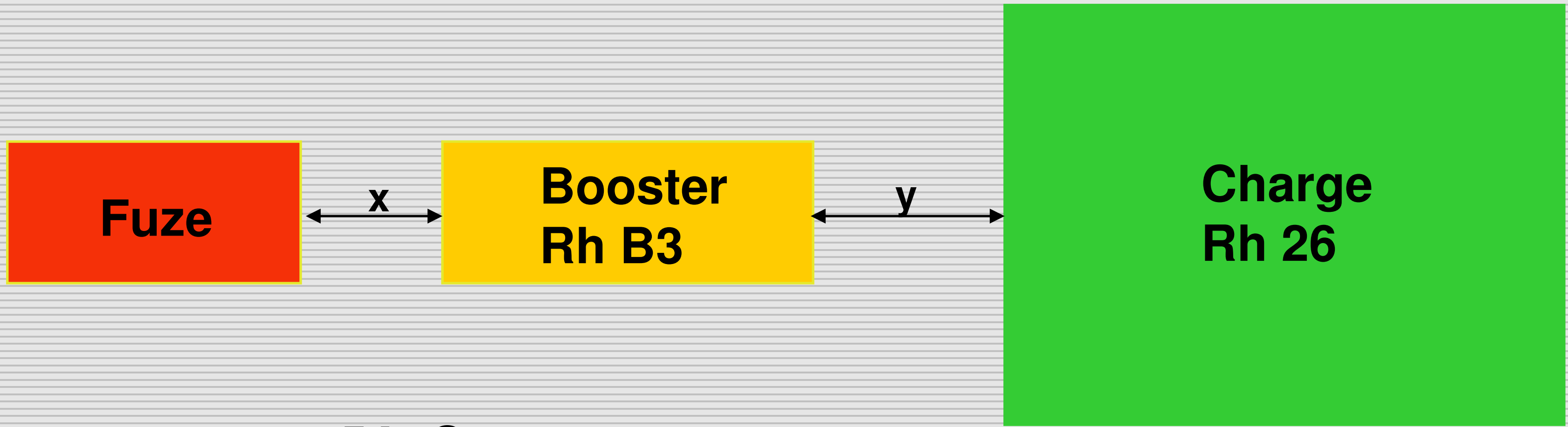
155 mm HE RH 30, Initiability



at - 54° C

X max 19 mm
Y max 16 mm

→ **Safe Initiation**

Initiation Criterias

-Grain size	Run distance
- Mechanical properties	Critical diameter
- Defects	Hot Spots
- Confinement	Energy output

$V^2 \cdot d$ criteria Prof. M. Held

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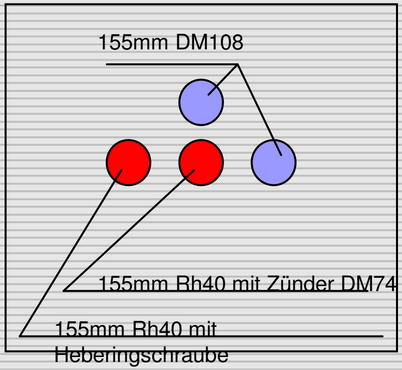
Bullet Attack Trial Set
155 mm Rh 40-IHE



Particles for Energetic Materials

Bullet Attack
Ammunition 155 mm HE-RH30

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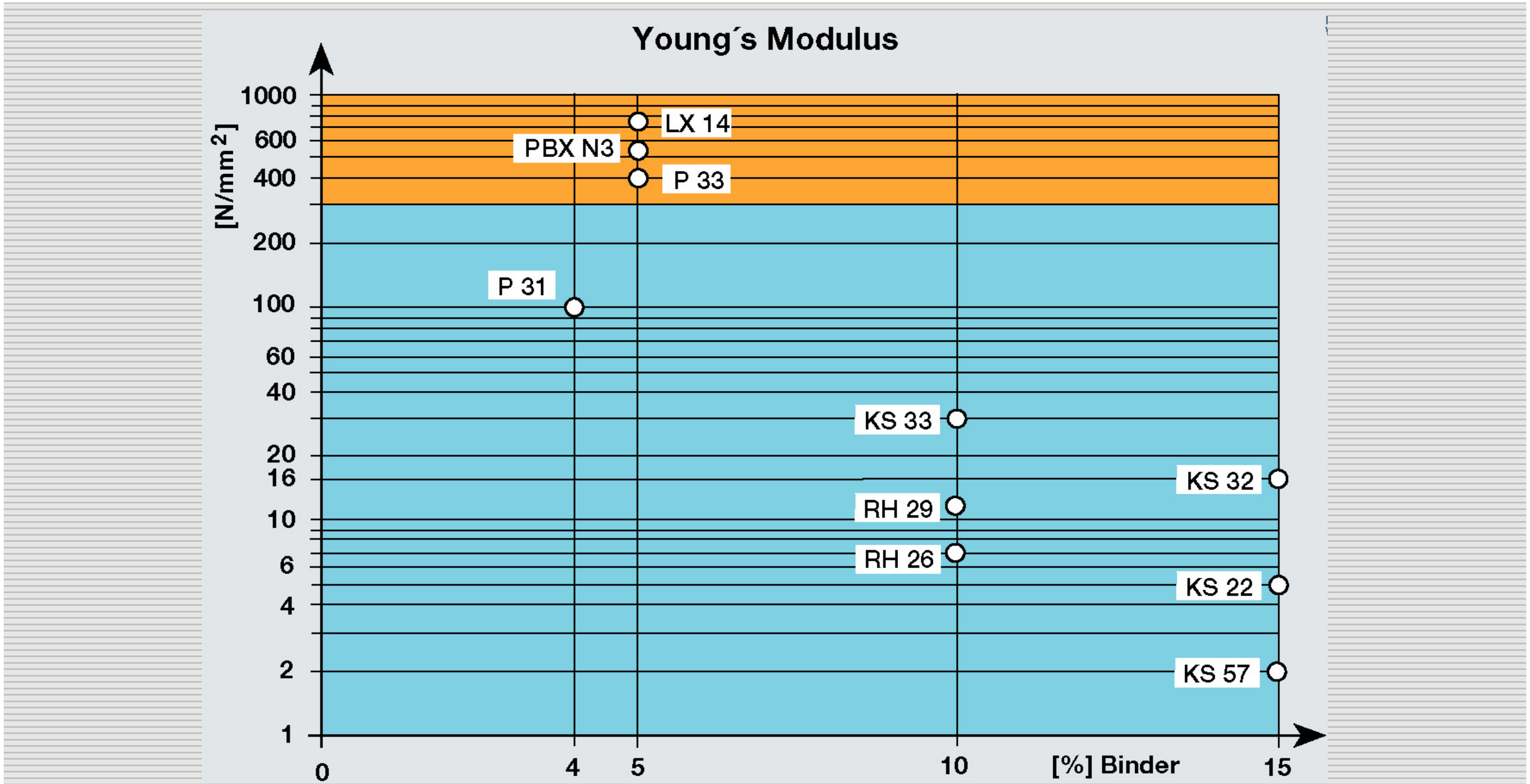
Bullet Attack

No reaction

Particles for Energetic Materials



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Raw Material

Sensitivity to impact

- Influence of grain size
- Influence of crystal shape
- Included air
- Included solvent
- Impurities (grit)

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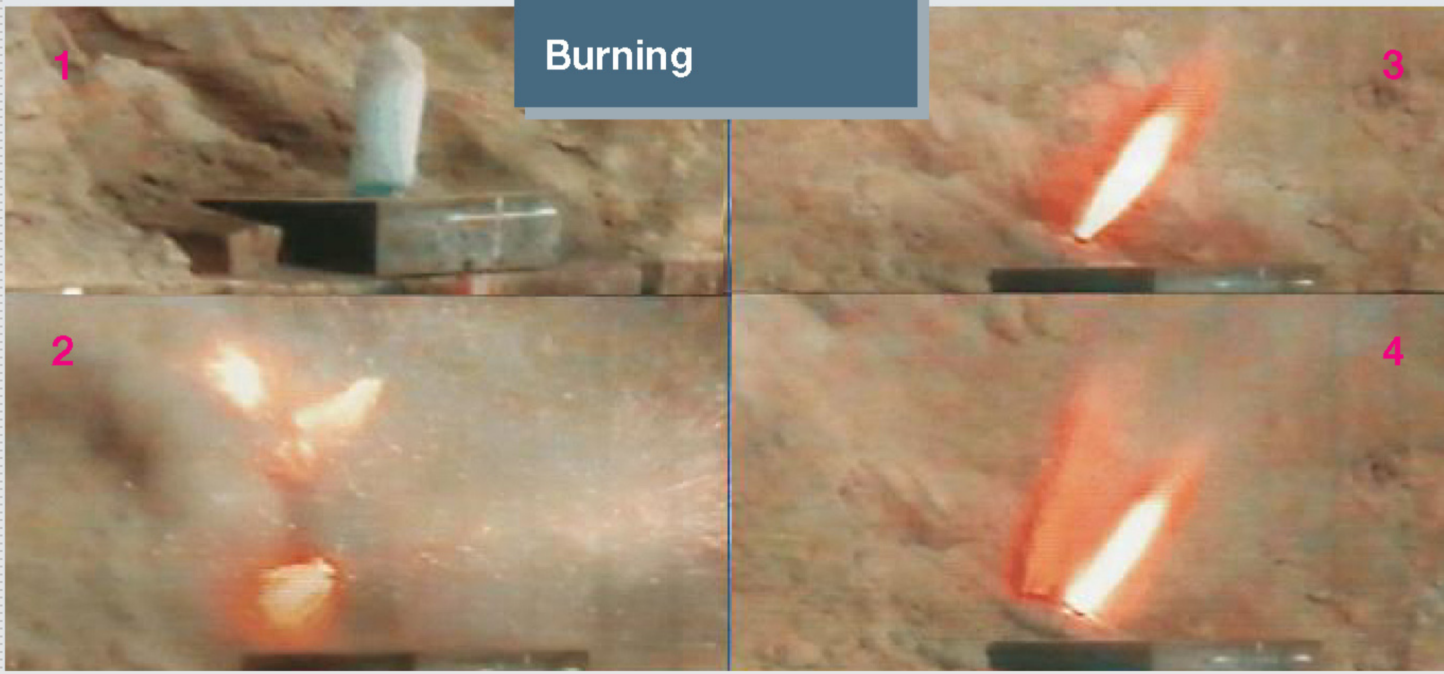
Bullet Impact

Hard Core 20 mm

T = -40°C

Charge RH26

Burning



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Conclusion

The physical and the chemical status of high explosive particles have a very strong influence on propellants and the high explosive charges, as you have seen on some paradigms

Conclusion

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