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Improved Insensitive Hytemp/DOA Bonded HMX and RDX Mixtures by Paste Process

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Setting of Effort

German DoD on miniaturized electric detonator and insensitive boosters required pressable insensitive high explosives

- at two initiation shock levels for NoGo (BICT-SSGT)
  - 26 kbar (TL 1376-0800)
  - 42,2 kbar (STANAG 4170)
- type V reaction at
  - Bullet Impact Test 12,7 mm mild core
  - Fast Cook Off Test

<u>Intention:</u> Use of an European made PBX W11 and PBX N9

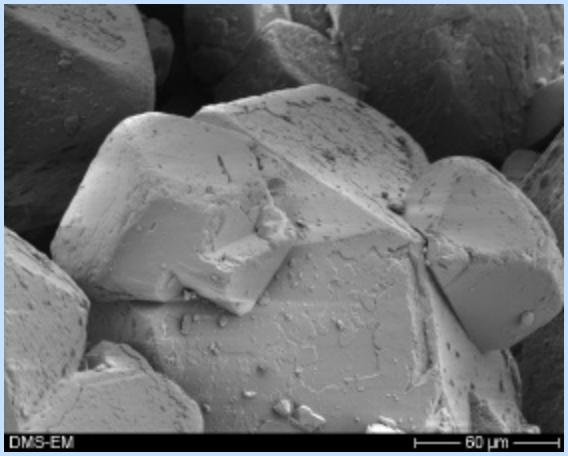
Setting of Effort (cont.)

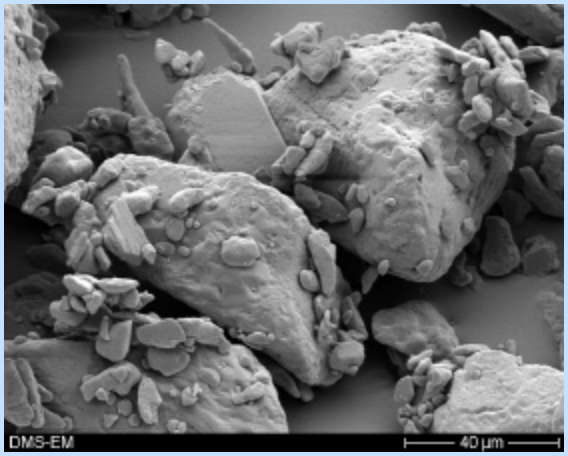
- Inspection analyses show not sufficient shock insensitivity
- Additional treatment of this PBXN9 in our high shear mixer show improvement of insensitivity close to the threshold of TL 1376-0800

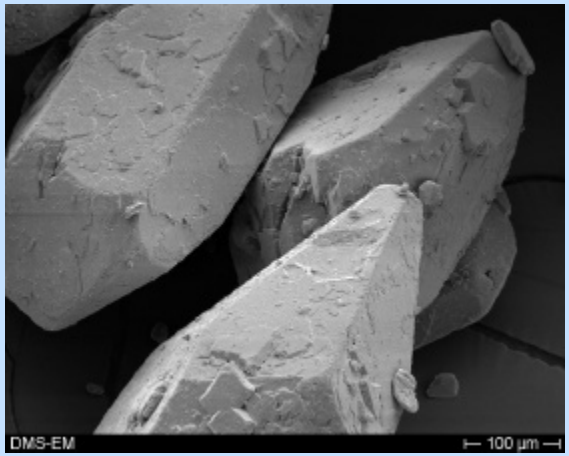
Conclusion:

- Install own capabilities to develop and produce small batches of insensitive pressable high explosives
- Develop process capable to use standard RDX and HMX crystals type B
  - Reduce required specific pressure for pressing
  - Use of the Hytemp 4454/DOA binder system
  - Use of in-house DRAIS vertical finger and J+K high shear mixer
  - Paste process using organic solvents only for additional treatment of the HE crystals during mixing

HE Crystals





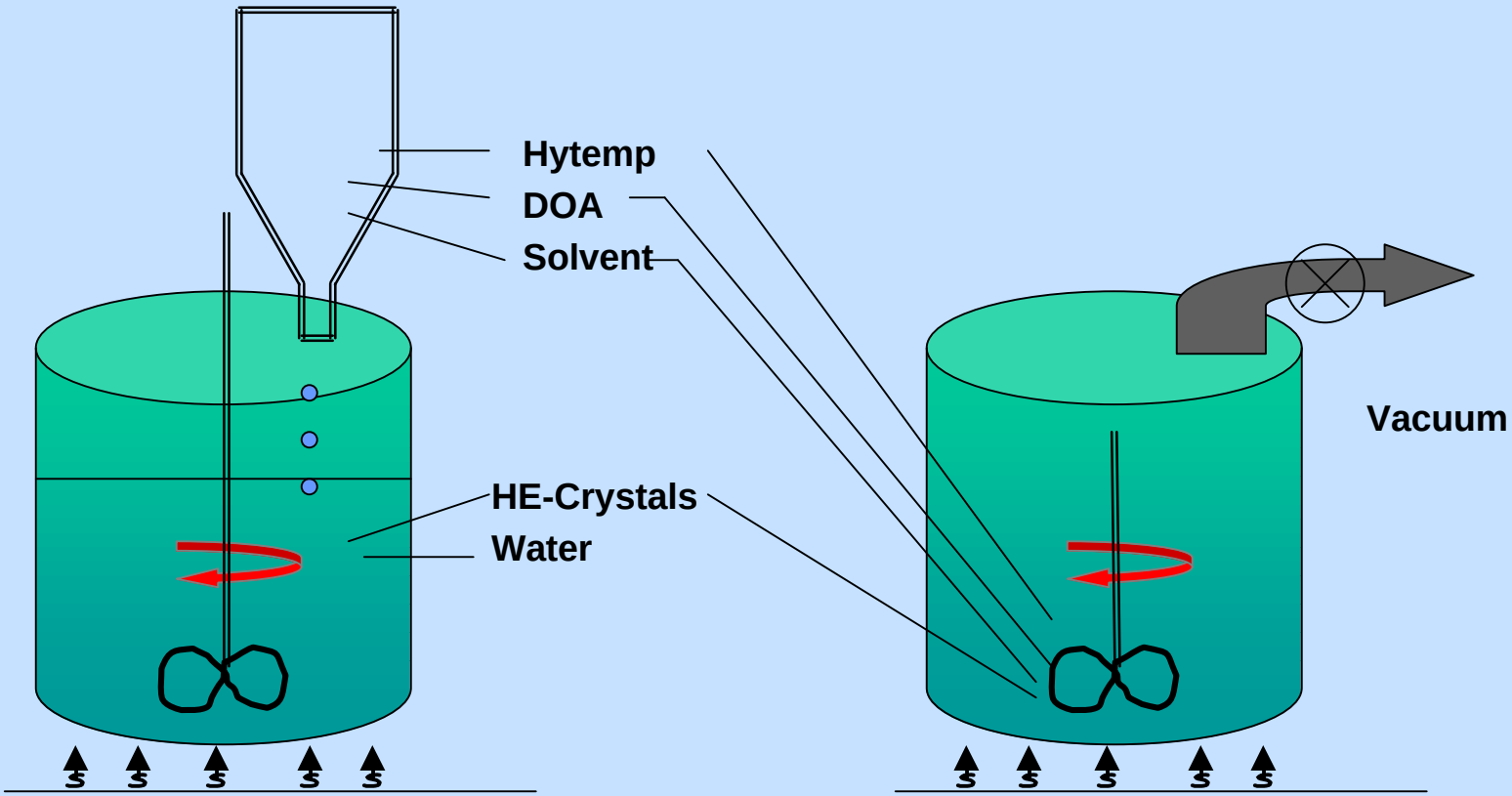


HMX / RDX Type B

Comparison

Slurry Process

Paste Process



Work Performed, First Step

Definition of a solvent (mixture) capable

- Smoothing HE type B crystal surfaces
- achieving a fully transparent lacquer of Hytemp/DOA
- having proper evacuation rates to separate HMX and RDX crystals and keep them separated during coating of the crystals

Different solvents tested

- a proper candidate is a mix of Ethylacetate/Acetone

Work Performed, First Step (cont.)

Reduction of specific pressing pressures

- Coarse grain: HMX or RDX class 3
- Fine grain: “45 µm” crystals allow additional reduction of specific pressure compared to “15 µm” crystals

to achieve t.m.d. of more than 98 %

Result:

Required specific pressures, fine grain “45 µm”, vacuum < 1 mbar; l/d ration up to 2

diameter	kbar
22 mm	0,85
50 mm	0,70
105 mm	0,55

Note: Some values valid for harmonic trimodal mixtures, thus significant weight reduction of pressing tools possible symposium report shows values for non harmonic bimodal mixtures

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Work Performed, First Step (cont.)

Example of results from WIWEB/BWB STANAG 4170 Analyses

Versuch/Test	DXP 1380, Charge 1	DXP 1380, Charge 2
Vakuumstabilität	0,05 ml/2,5 g	0,08m1/2,5 g
Schlagempfindlichkeit	7,5 Joule schlagempfindlich	7,5 Joule schlagempfindlich
Reibempfindlichkeit	160 N reibempfindlich	240 N reibempfindlich
thermische Empfindlichkeit	#	d=2 mm, D, wenig empfindlich
Stoßwellenempfindlichkeit	R 38,80 kbar (10 mm WS), kR 30,40 kbar (13 mm WS)	R 42,20 kbar (9 mm WS), kR 35,70 kbar (11 mm WS)
Cook-Off-Verhalten	Typ 5 (Abbrand) unempfindlich	Typ 5 (Abbrand) unempfindlich
Beschuss mit 12,7 mm Munition	Typ 5 (Abbrand) unempfindlich	Typ 5 (Abbrand) unempfindlich
Verpuffungstemperatur	279°C	278°C
Entzündlichkeit	leicht entzündlich	leicht entzündlich
elektrostat. Empfindlichkeit	unempfindlich	unempfindlich
Detonationsgeschwindigkeit	- 8453 m/s	- 8402 m/s
Gurneykonstante	2,38 mm/ps	2,34 mm/ps
E-Modul (aus Druckversuchen)	41,53 MPa (20°C); 116,80 MPa (-40°C)	22,41 MPa (20°C); 83,13 MPa (-40°C)
long. Schallgeschwindigkeit v^s	2165 m/s (20°C); 2512 m/s (-30°C)	2121 m/s (20°C); 2493 m/s (-30°C)
spez. Wärmekapazität c^p [Joule/(g*K)]	0,90	0,90
thermische Längenausdehnung	*im Mittel* 6*10"$_5$ °C_1	*im Mittel 6,5*10- °C"*
Wärmeleitfähigkeit	0,47 W/m*K (bei Raumtemperatur)	0,47 W/m*K (bei Raumtemperatur)

Qualified Pressable Insensitive High Explosives of Diehl;
Qualification in accordance with STANAG 4170 and TL 1376-0800

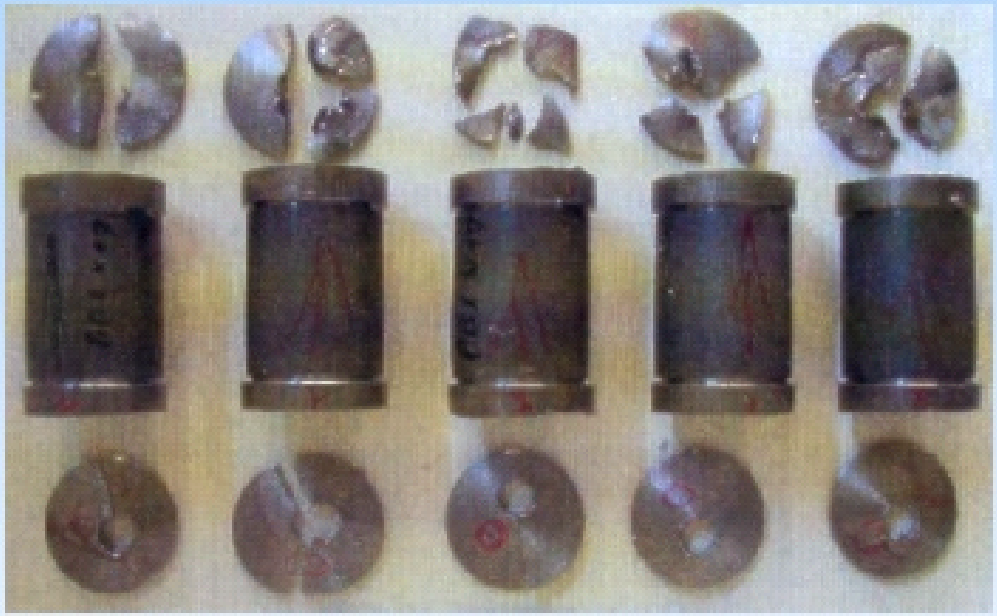
Status: 11.2001

Type		DXP 1380/1	DXP 1380/2[1)]	DXP 1340	DXP 2380	DXP 2340
Composition %	HMX	92	92	96	-	-
	RDX	-	-	-	92	96
	Al	-	-	-	-	-
	Bindersystem	8	8	4	8	4
Density	ρ (g/cm^3)	1,74	1,76	1,8	1,68	1,7
Det. Velocity.	V_o (m/s)	8450	8400	8600	8200	8350
Sensitivity GAP	(K bar) go/no go	39/31	42/36	22/20	33/28	28/24
Status		qualified		[2)]	qualified	[2)]
WIWEB Doc.-No.		410/25830/01		410/25860/01	410/25861/01	410/25818/01

[1)] differs from DXP 1380/1 by grain size distribution
[2)] fulfills at present only TL 1376-0800 standard requirements

Bullet Impact Test

Small Scale Ø 50 mm



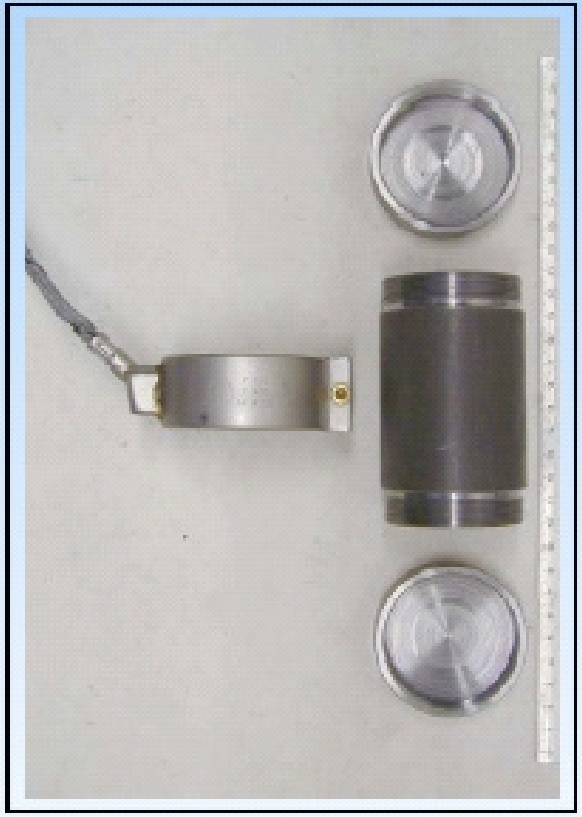
WIWEB Test Set Up:
12.7 mm soft core projectile

DXP 2380 + DXP 1380

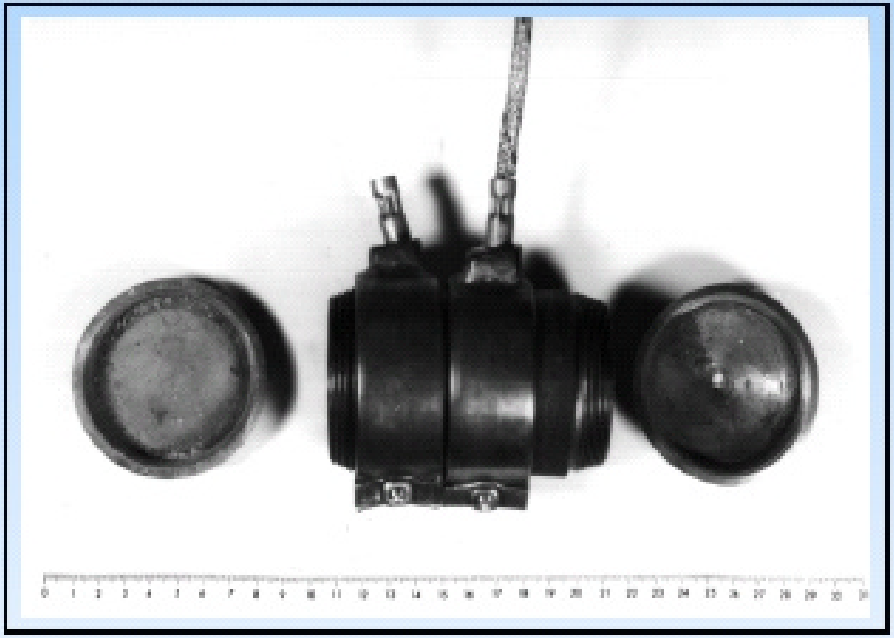
WIWEB Test Result:
Type V Reaction

Fast Cook-off Test

Small Scale Ø 50 mm



WIWEB Test Set Up



DXP 2380 + DXP 1380

WIWEB Test Result:
Type V Reaction

Work Performed , First Step

Results:

- HMX and RDX mixtures with 8 % binder meet criteria of TL 1376-0800
- HMX mixtures show reduced SSGT shock sensitivity compared to RDX

Conclusion:

Additional reduction of porosities required to improve insensitivity

- HMX: remove crystals with high risk of increased internal porosities
- RDX: as above and use of improved HE crystals type A

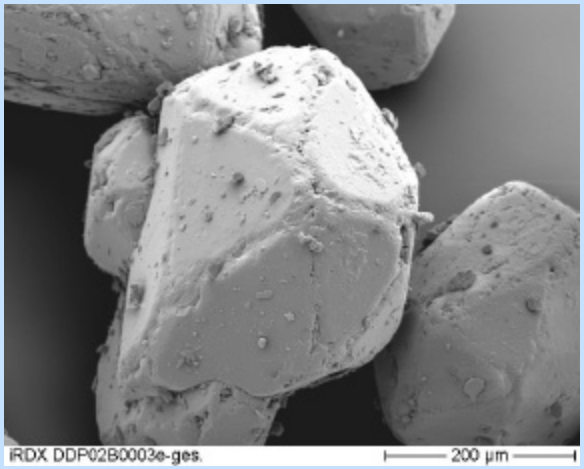
Work Performed , Second Step

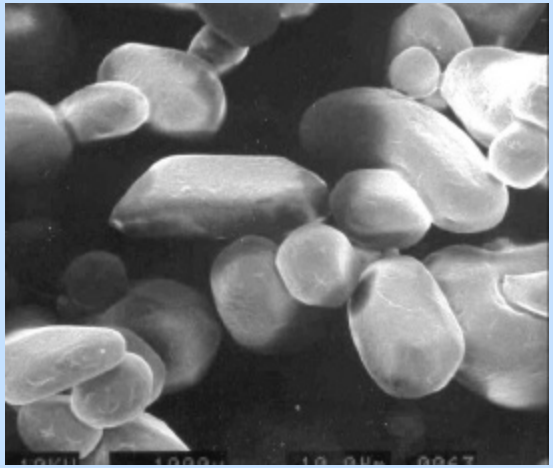
- Remove high risk crystals
  1.) maximum grain sizes 630 µm
  2.) maximum grain sizes 500 µm

Results:

- no additional improvements of RDX / 8 % binder
- HMX 4 % binder meet all criteria of TL 1376-0800 at densities 1,81 - 1,82 g/cm^3 (WIWEB-BWB results)
- HMX / 8 % binder meets “less sensitive” status of STANAG 4170 (WIWEB-BWB results)

Work Performed , Second Step (cont.)





Improved RDX Crystals Type A

- iRDX / 8 % binder failed Fast Cook Off, no significant improvement of shock insensitivity
- Fast Cook Off passed after addition of 5 % (+) HMX
- Coarse grain iRDX with milled fine grain iRDX show no improvement
- No different of SSGT results at 8 % or 6 % binder system

Insensitive RDX analyses are planned

Work Performed , Second Step -- Results:

- Further improvements on Hytemp / DOA bonded RDX and HMX by solvents process led to following results:

	HMX / 4% binder	**HMX / 8% binder**	**RDX / 4% binder**	**iRDX / 4% binder**
GAPtest (kbar)	32,9 / 26	45,2 / 42,2	32,9 / 28	32,9 / 30,4
FCO	Type V	Type V	Type V	Failed
t.m.d				* Slurry process
min 98%				

Failure of iRDX / 8% binder was not expected due to improve crystallization.

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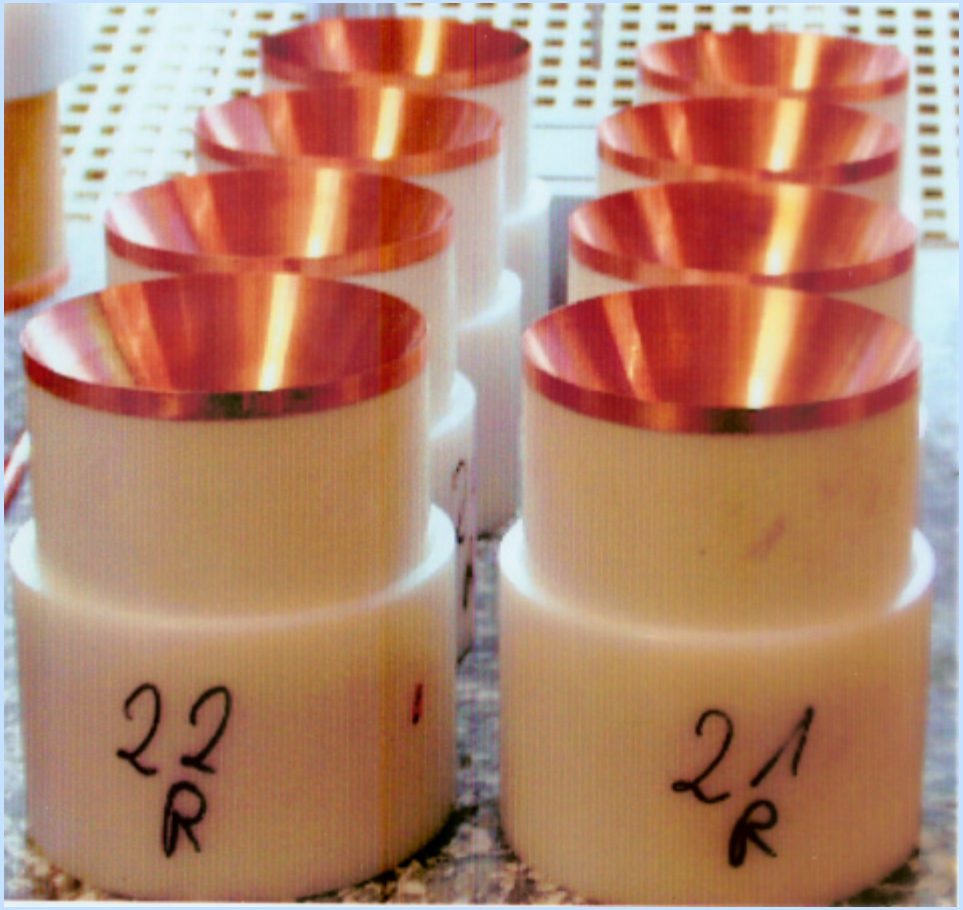
Paste Process
Advantages

- Use of type B crystals sufficient
- Significantly reduced sensitivities
- Significantly reduced specific pressures
- Complete recycling of solvents possible
- Quick improvement rework of mixtures possible
- Use of existing high shear or other composite propellant mixers possible thus avoiding additional buildings and equipment

Shaped Charge



- Shaped Charge 80mm
- DXP 1340/2, 0,9 kbar, 1,81 g/cm^3

Disadvantages

- Agglomeration of coated crystals more difficult to control
- Agglomerates tend to stick together during transportation and storage
  possible cure: dusting with Aerosil
- Standard primers e.g. K1, binder 14 to achieve sufficient wall adhesion fail
  cure: use WENKO Antirutschbeschichtung, qualification planned at WIWEB-BWB

Bomblet M77 Impact into 155 mm IHE

Conclusions

- Today's HMX crystals Type B are sufficient for acceptable insensitive HE mixtures
  Improvement of HMX crystals will result in additional insensitivity against shock stimuli
- Shock insensitivity improvement is expected to be achieved by use of Insensitive RDX crystals only
- In both cases an additional reduction of binder system seems to be possible to achieve sufficient insensitive pressable mixtures by Paste Process using organic solvents

Acknowledgements

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