Sensitivity and Structural Investigations on Shock Loaded and Quasi-Static Loaded KS22a HE

Dr. Helmut Muthig (*)
Dr. Werner Arnold

TDW Gesellschaft für verteidigungs-technische Wirksysteme mbH
Schrobenhausen, GERMANY

"Material & Techniques for Reducing Sensitivity"

2004 Insensitive Munitions & Energetic Materials Technology Symposium
Hilton - San Francisco, San Francisco, CA, USA
November 15 - 17, 2004

TDW ... when the payload counts ®

TDW - Gesellschaft für verteidigungs-technische Wirksysteme mbH

is the acknowledged **„Center of Excellence“**
for **Lethal Packages / Warheads** within EADS

Sensitivity and Structural Investigations on Shock Loaded and Quasi-Static Loaded KS22a

Outline:

1. Motivation
   Shock Loading of KS22a
2. TDW Gap Test
   Sensitivity Test
3. Shock Loading Mechanisms
   Static / Dynamic Loading of KS22a
4. Experimental Results
   Properties of Shock Loaded KS22a
5. Conclusion
   Summary

1. Motivation: Shock Loading of KS22a

Why Shock Loading of KS22a?

KS22a is a cost-effective, powerful but insensitive High Explosive for **penetrator applications**

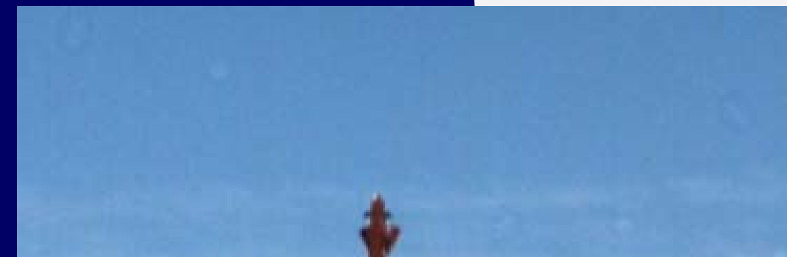
- It is RDX-based (67 % RDX)
- It is of the PBX-Type (15 % Plastic Binder)
- It is blast enhanced for improved performance in confined spaces (18 % Al)

  - It withstands high shock loads without degradation of ***performance***

  - **Question:** Will it withstand high shock loads without degradation of ***insensitivity*** as well?

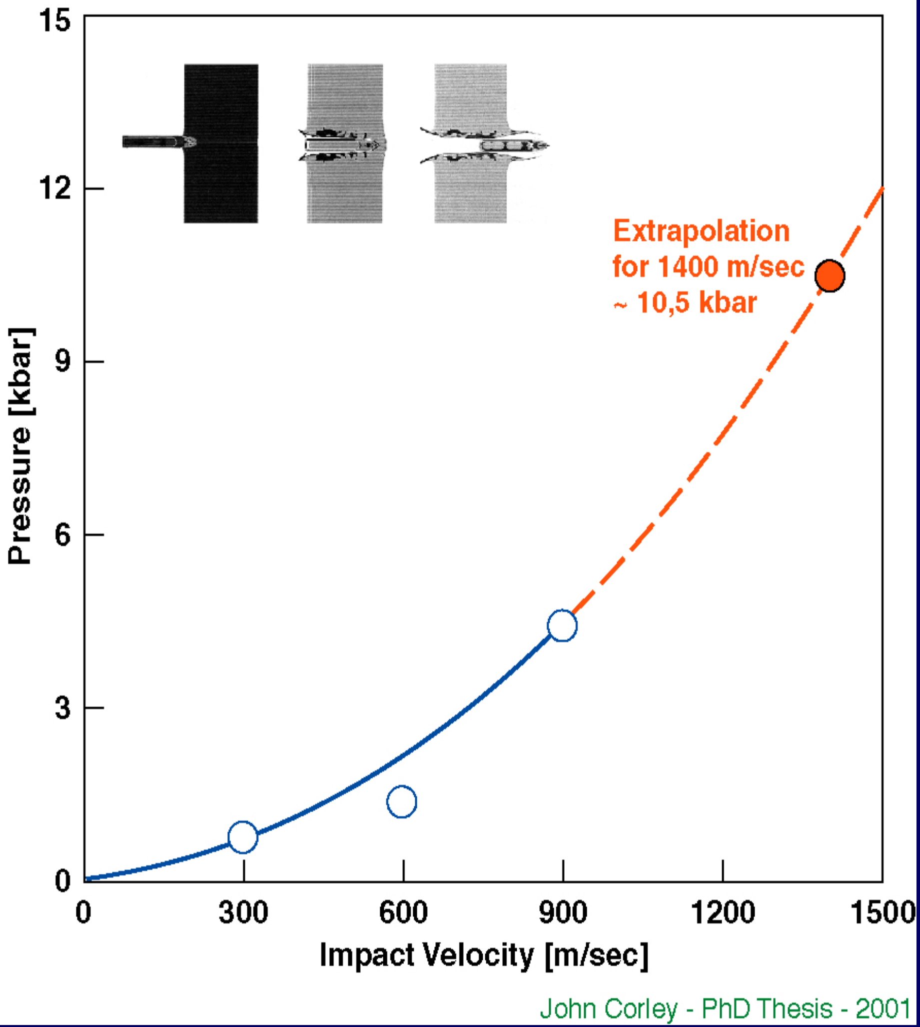
German S/O Missile Taurus KEPD 350

MEPHISTO Penetrator w/ KS22a



Future Application with higher Shock Loads

Peak Pressure in Explosive Filler (Nose)



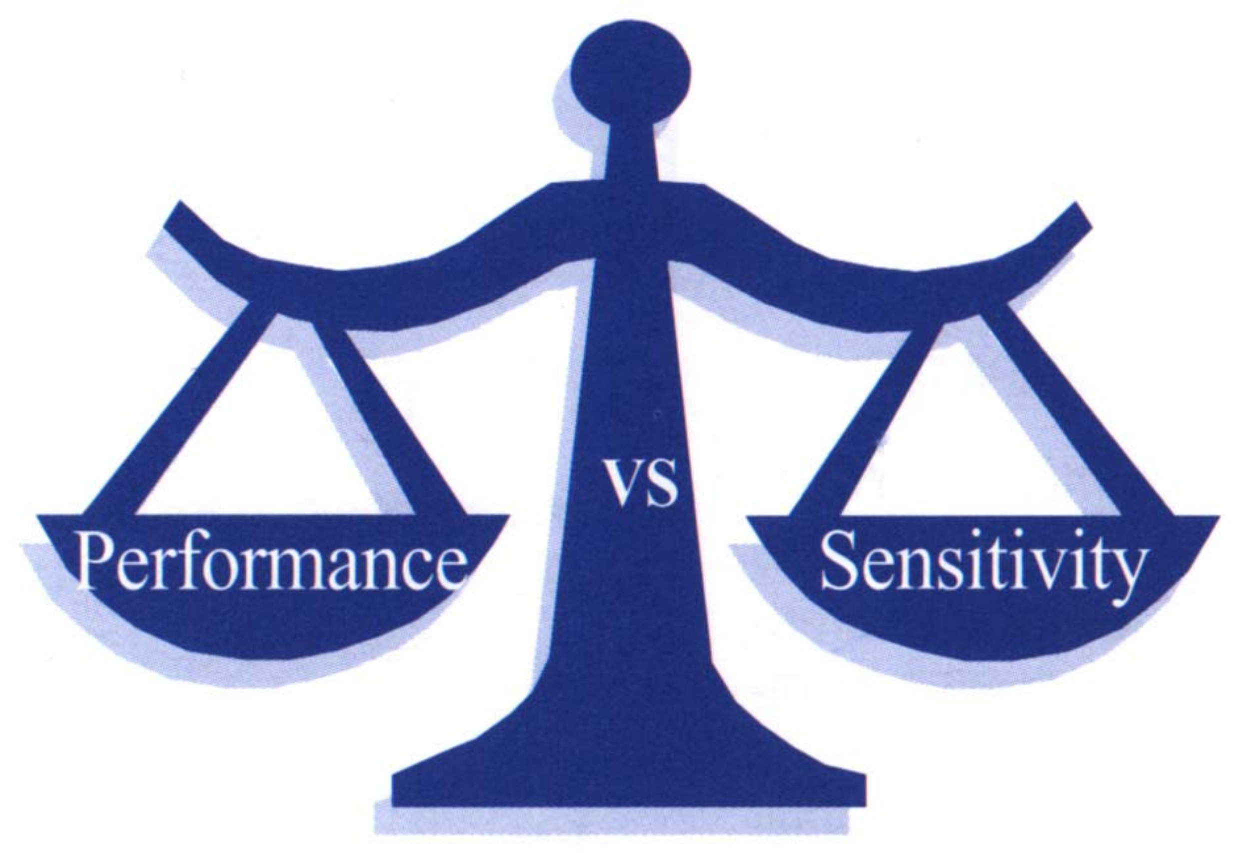
Simulation of Concrete Perforation (2 m, 35 MPa)

Question:

Will shock loads of several kbars influence the sensitivity of KS22a?

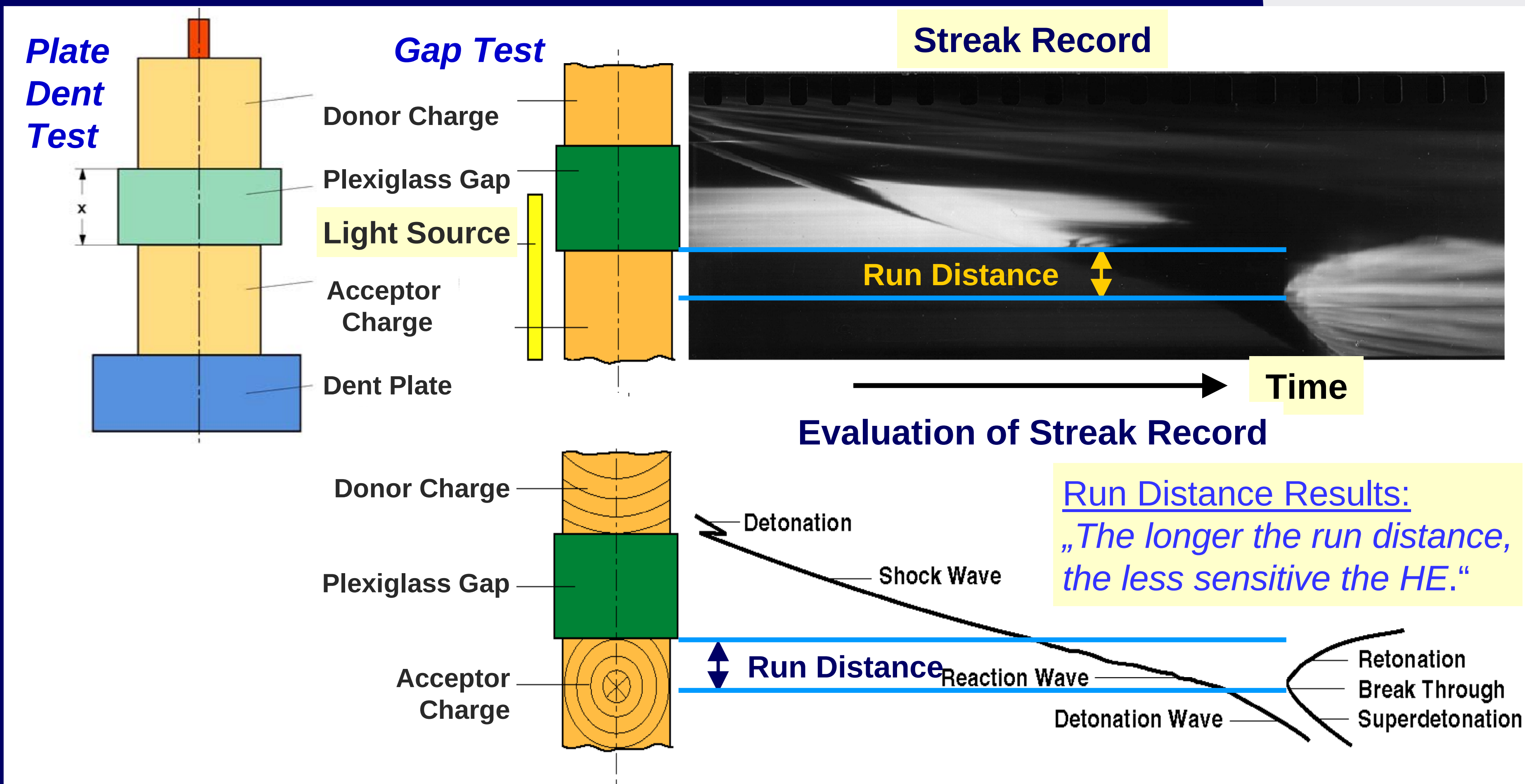
Balance between Performance vs. Sensitivity

Shock Loading of HE: Change in Sensitivity?



2. TDW Gap Test: Sensitivity Test

TDW Gap Test: Comparison between
Run Distance to Detonation and Plate Dent Depth



3. Shock Loading Mechanisms

- Quasi-Static Loading: 200 ton Press
- Dynamic Loading: Cannon Firing (IMEMTS 2003)
- Dynamic Loading: Novel Shock Wave Apparatus

3. Shock Loading Mechanisms

- Quasi-Static Loading: 200 ton Press
- Dynamic Loading: Cannon Firing (IMEMTS 2003)
- Dynamic Loading: Novel Shock Wave Apparatus

Quasi-Static Loading
TDW's 200 ton Press

Downstroke
Ram

Static shock loading with
***1 kbar* and**
***4 kbar* (axial loads)**

Pressing
Confinement
58 mm

200 ton
Static Press

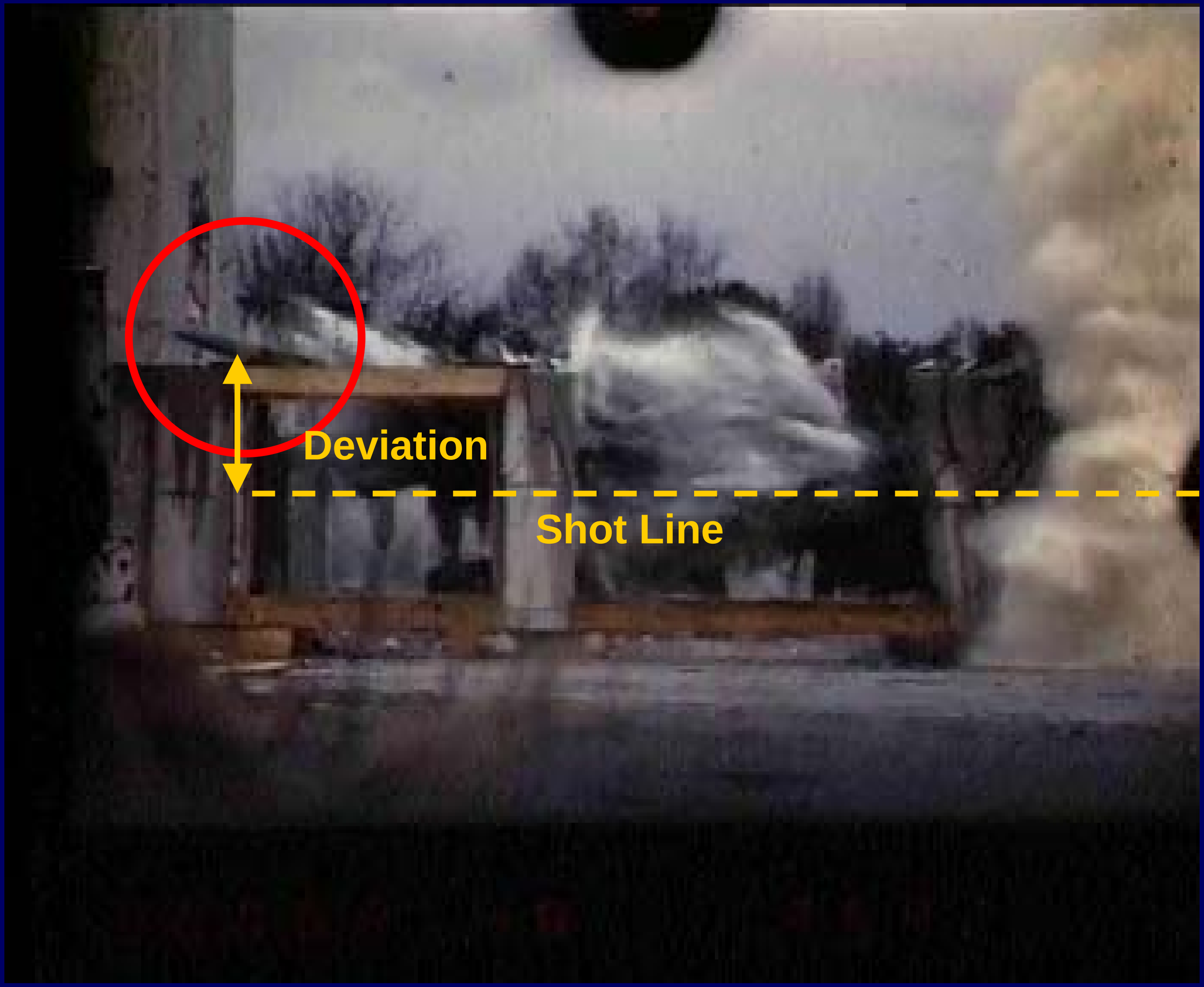
Lower
Ram

3. Shock Loading Mechanisms

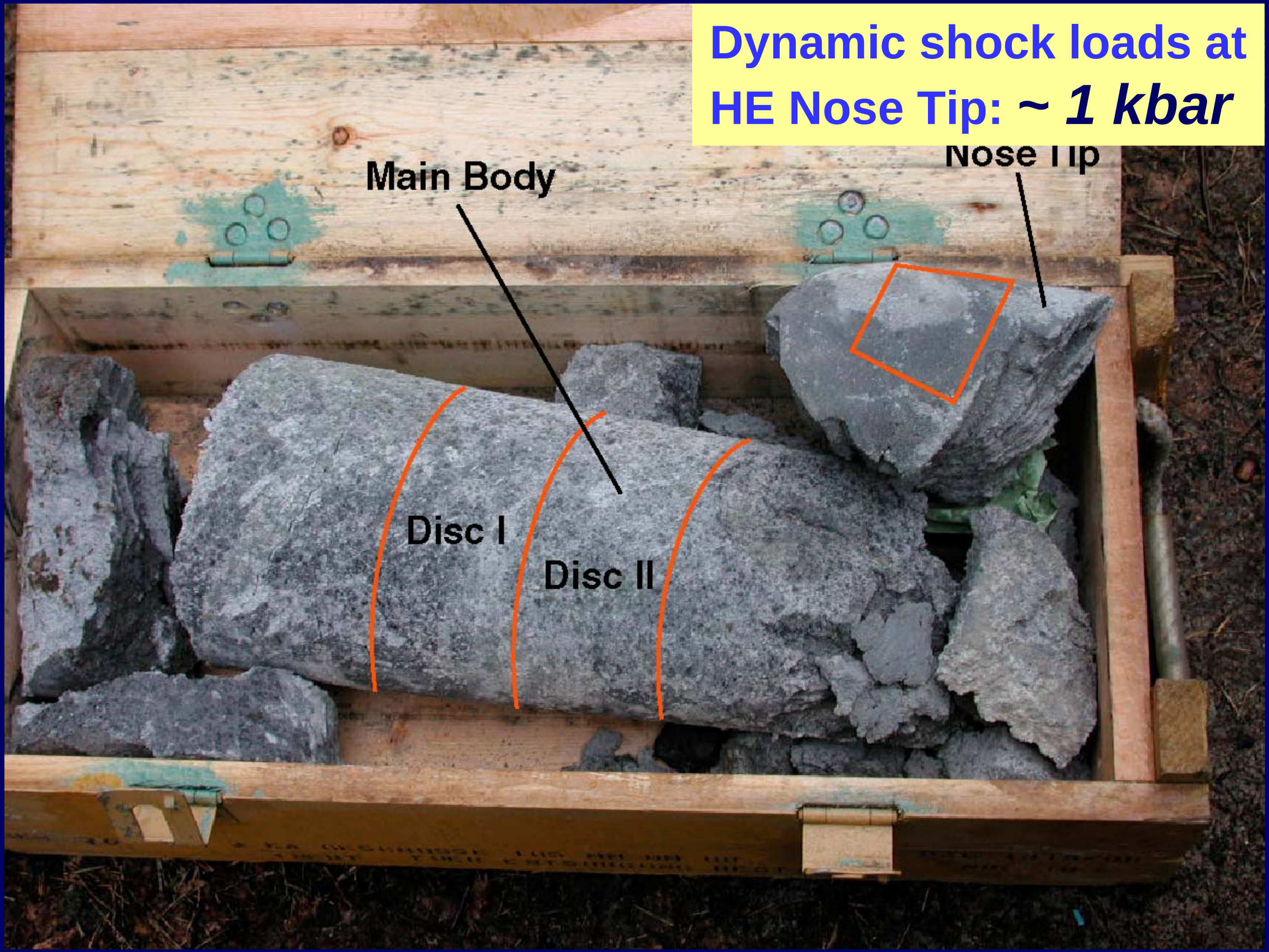
- Quasi-Static Loading: 200 ton Press
- Dynamic Loading: Cannon Firing (IMEMTS 2003)
- Dynamic Loading: Novel Shock Wave Apparatus

Dynamic Loading

Cannon Firing: Lateral Impact on Concrete Target



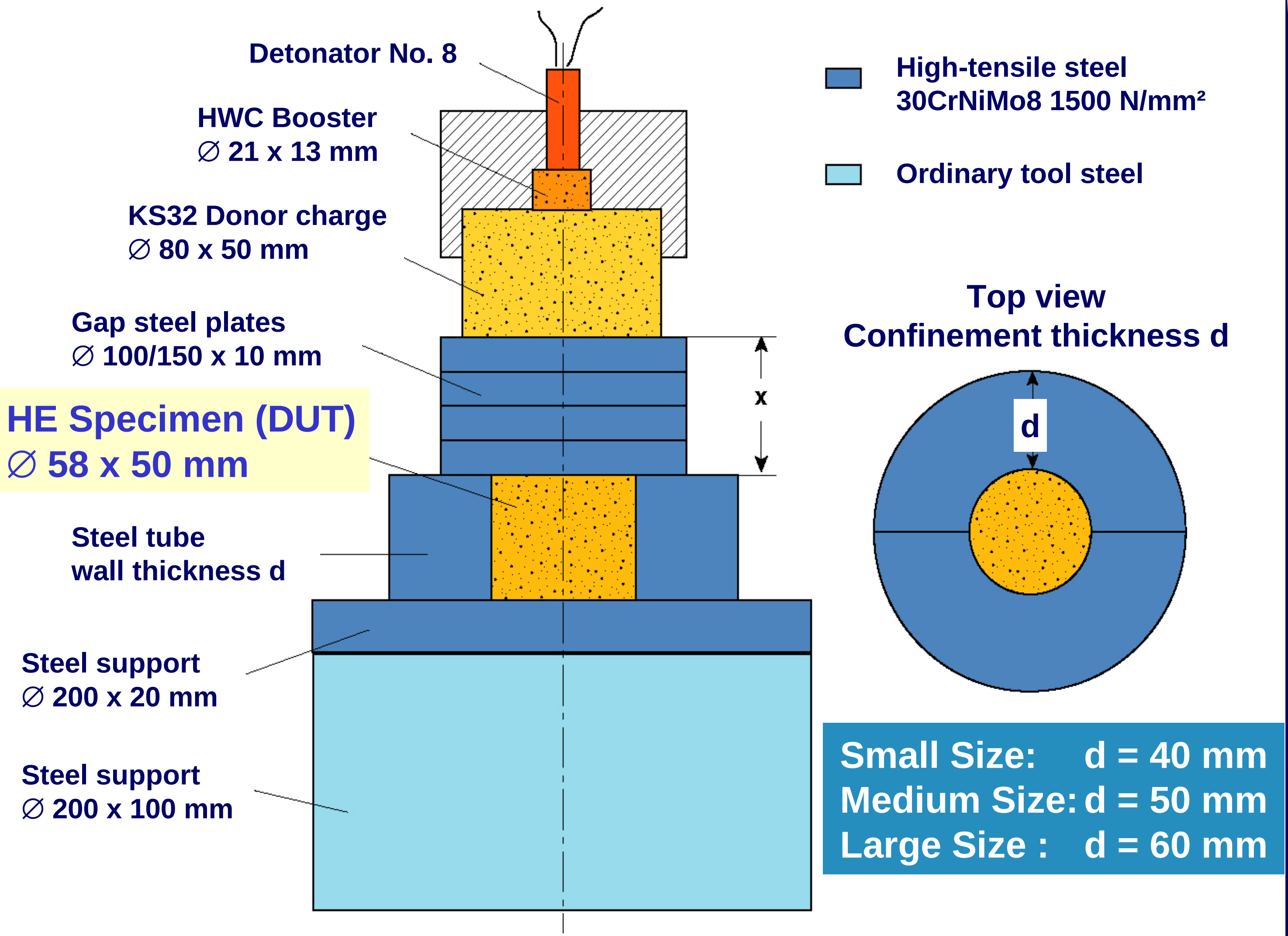
Pre-Shocked KS22a IHE Recovered after Test



3. Shock Loading Mechanisms

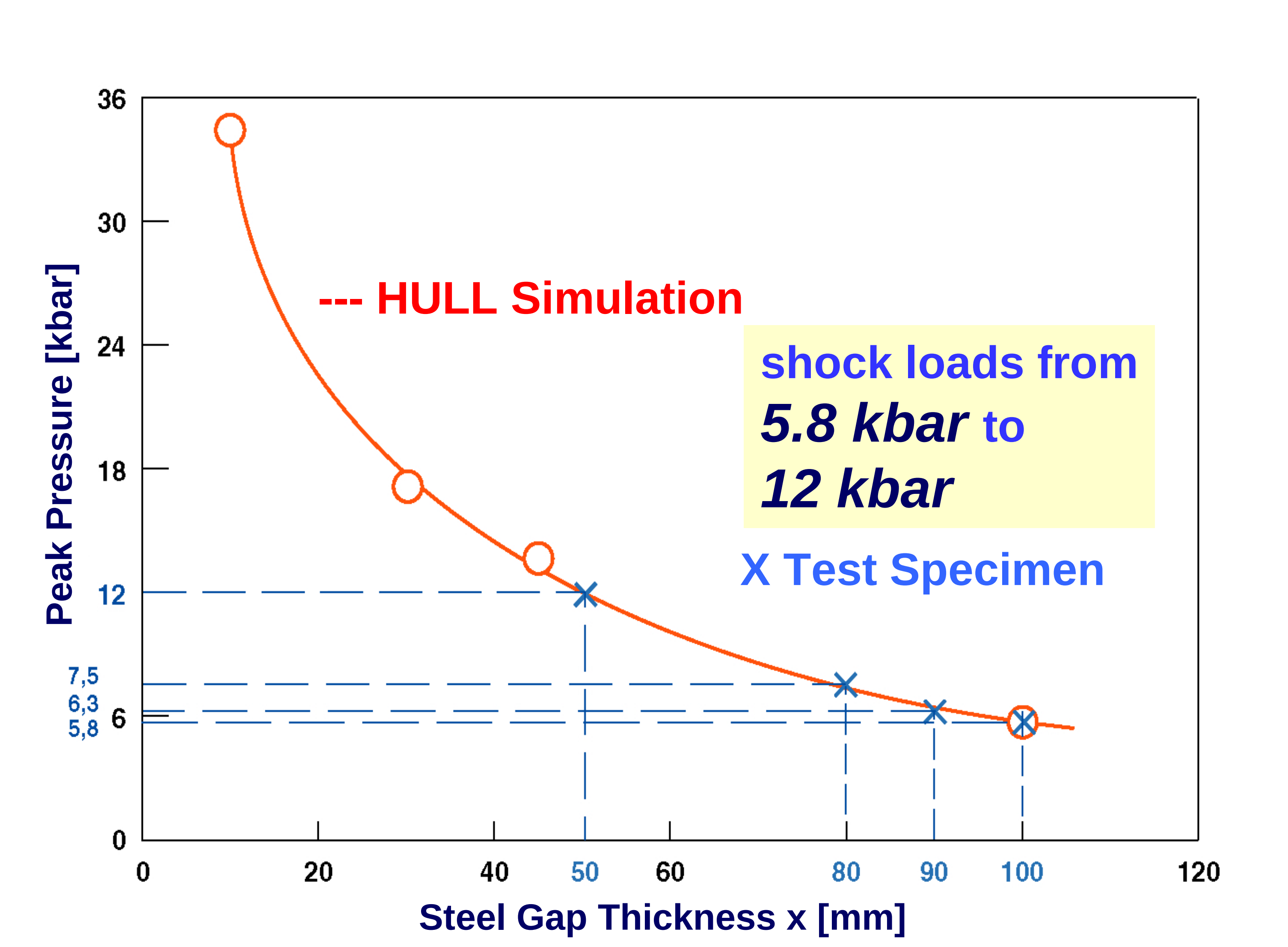
- Quasi-Static Loading: 200 ton Press
- Dynamic Loading: Cannon Firing (IMEMTS 2003)
- Dynamic Loading: Novel Shock Wave Apparatus

Novel Shock Wave Apparatus: Three Sizes



Small Size: d = 40 mm
Medium Size: d = 50 mm
Large Size : d = 60 mm

Calibration: Peak Pressure vs Gap Thickness



Shock Wave Apparatus: Test with IHE KS22a

Medium Size Variant

HWC Booster

KS32 Donor Charge

Steel Gap:
Thickness x = 100 mm

Casing of Specimen

Steel Support

Shock Wave Apparatus: Parts after Test

Medium Size Variant

Shock Wave Apparatus after Test

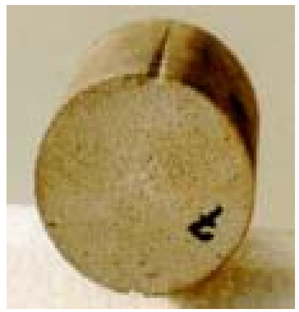
KS22a Specimen

Mechanical Limit of Shock Wave Loading

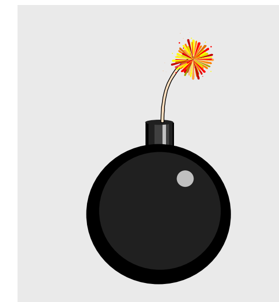
KS22a Specimen after 7.5 kbar shock wave loading

Pre-Shocked KS22a Specimens

Mechanical Limit: ~ 7 kbar; Detonation: 12 kbar; (Bare: ~ 48 kbar)



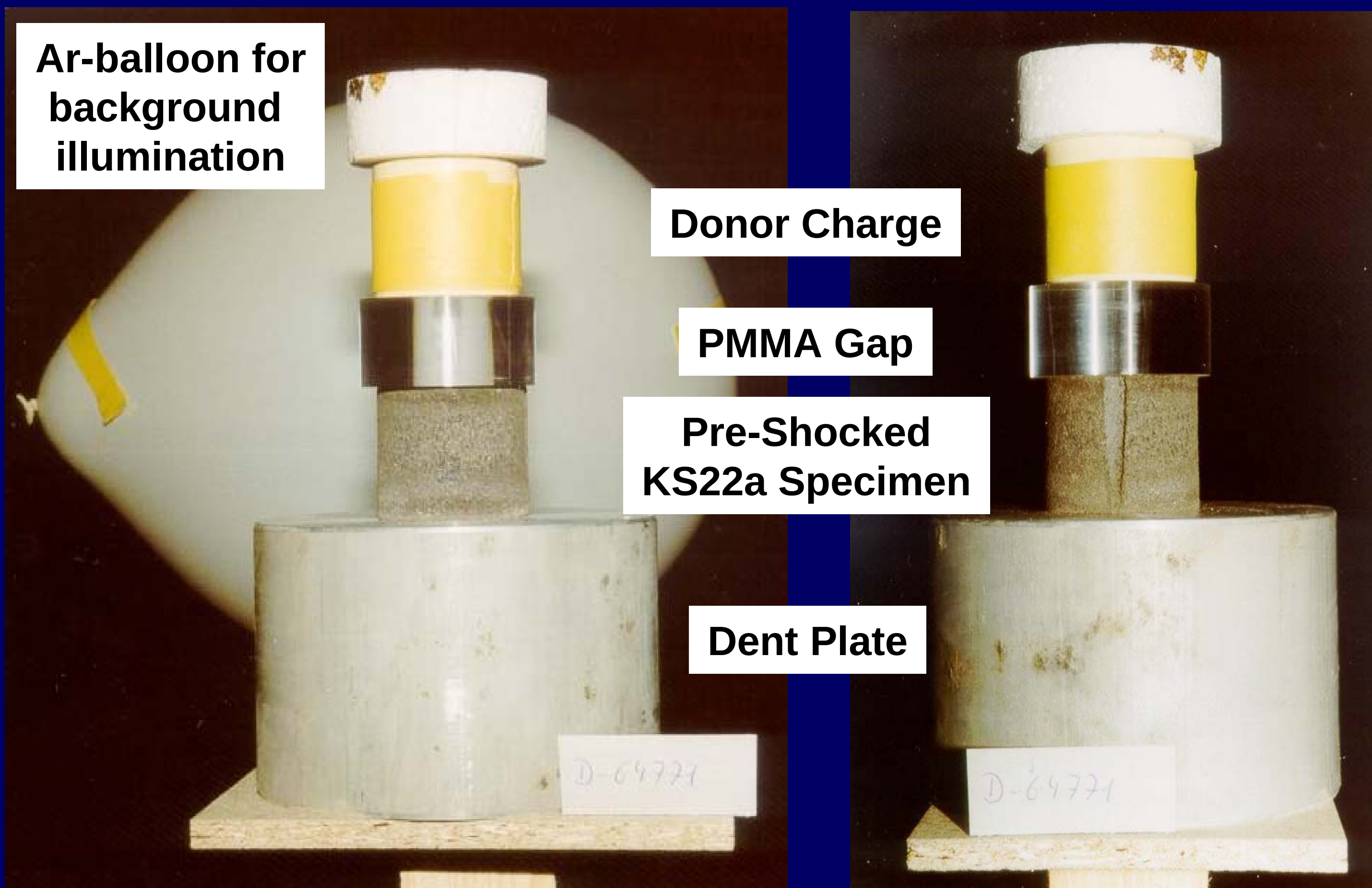




Test No.	D-64788	D-64791	D-64790	D-64789
Gap thickness ↘	100 mm	90 mm	80 mm	50 mm
Shock load ↗	5.8 kbar	6.3 kbar	7.5 kbar	12 kbar
Sample property	intact	intact	cracks	detonated !
Gap Test suitab.	possible	possible	not possible	/

Gap Test with Pre-Shocked KS22a Specimen

Experimental Set up



Front View Side View

Test Result: KS22a Residual Parts after Gap Test

Mechanical Destruction due to Shock Damage

D-64771

5.8 kbar

D-64770

6.3 kbar

Reasons for Mechanical Destruction *(No Detonation)*

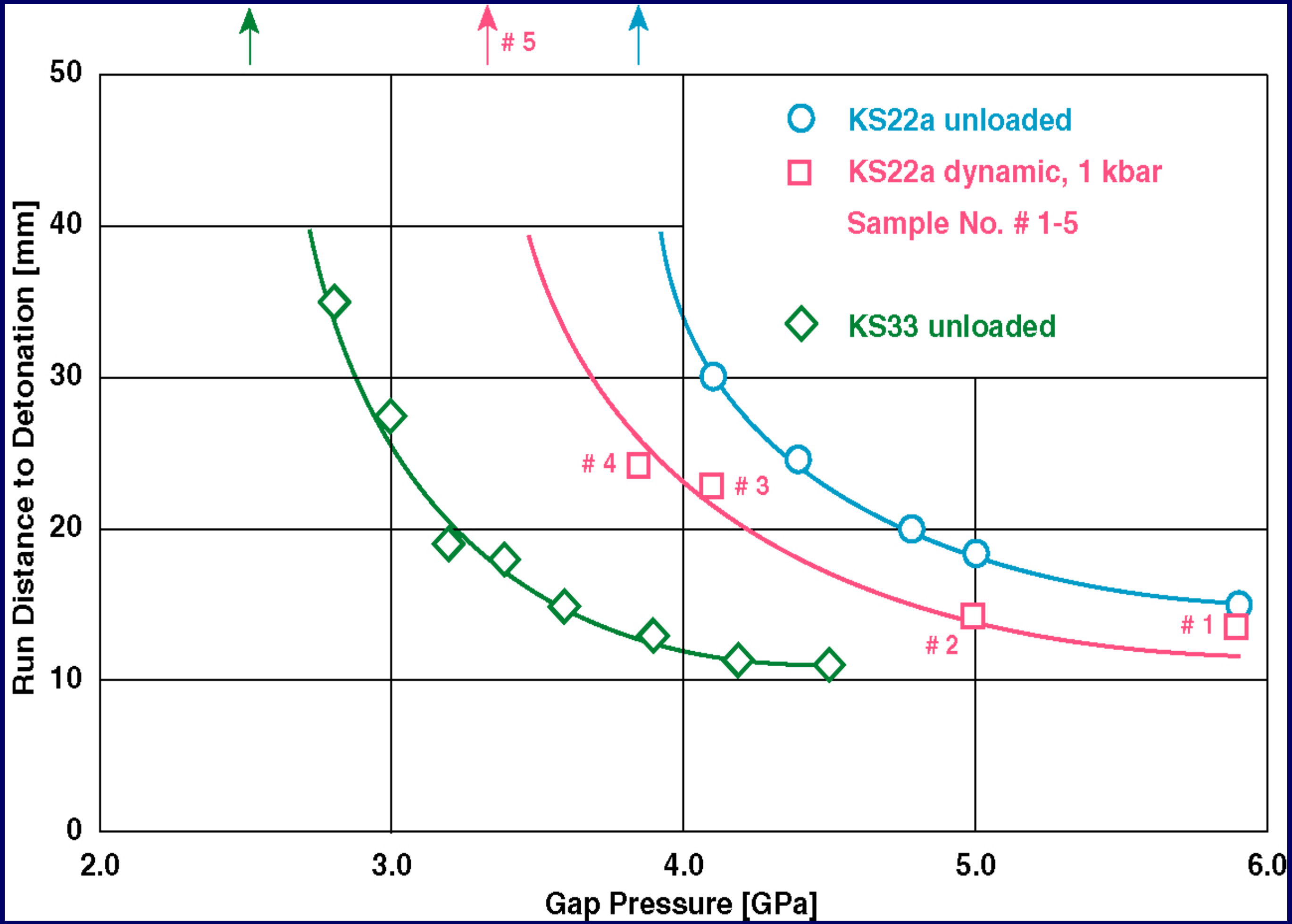
- Cracks, De-Bonding ... (reduced integrity) of specimen
- Starting of local reactions blew specimen apart
- No radial support in Bare Gap Test ...
- ... but *Detonation* within a penetrator casing to be expected

4. Experimental Results

TDW Gap Test: Run Distance to Detonation

Reference: KS33: HMX/PB 90/10 Density: 1.71 g/cc

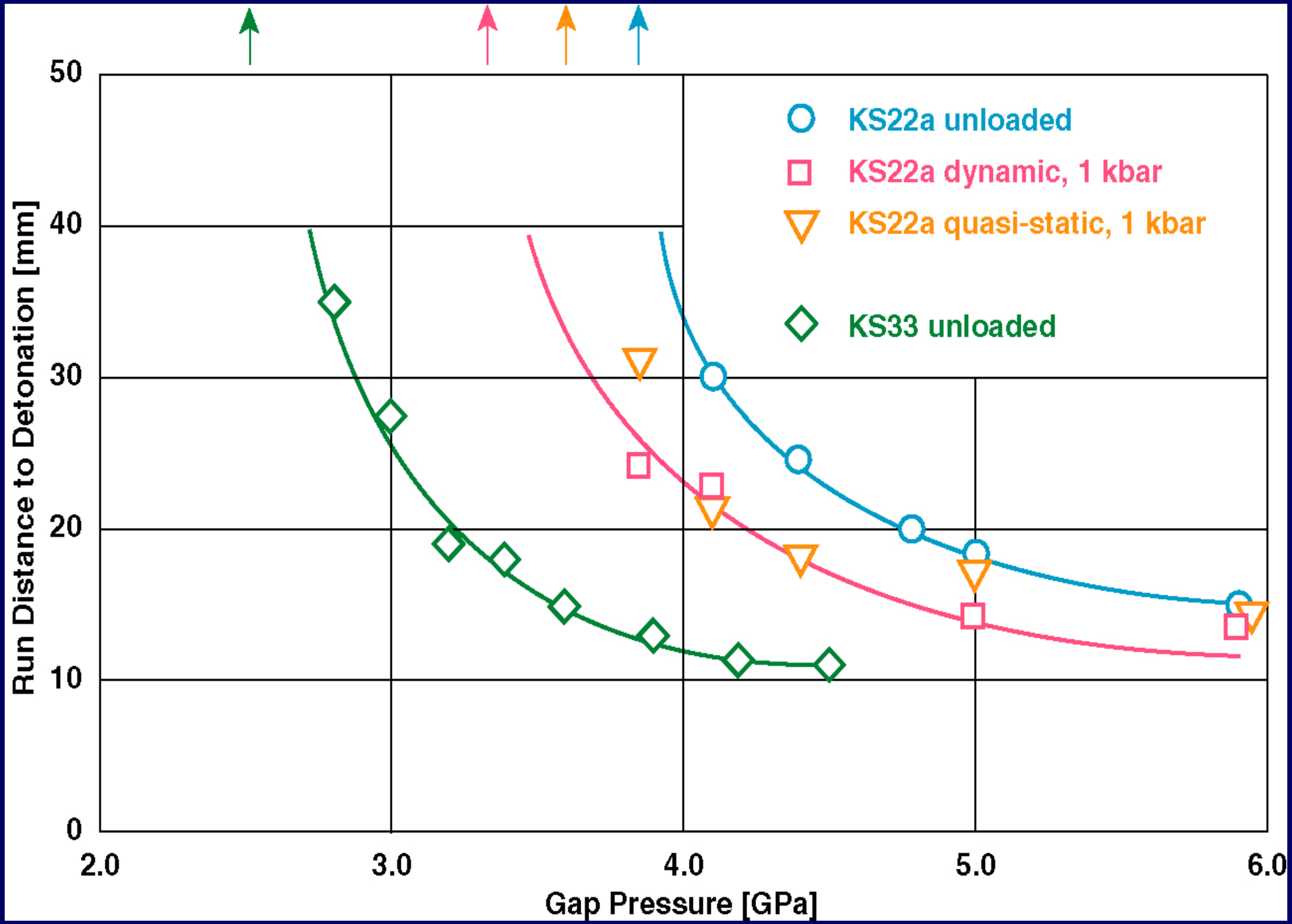
KS22a: RDX/Al/PB 67/18/15 Density: 1.64 g/cc



TDW Gap Test: Run Distance to Detonation

Reference: KS33: HMX/PB 90/10 Density: 1.71 g/cc

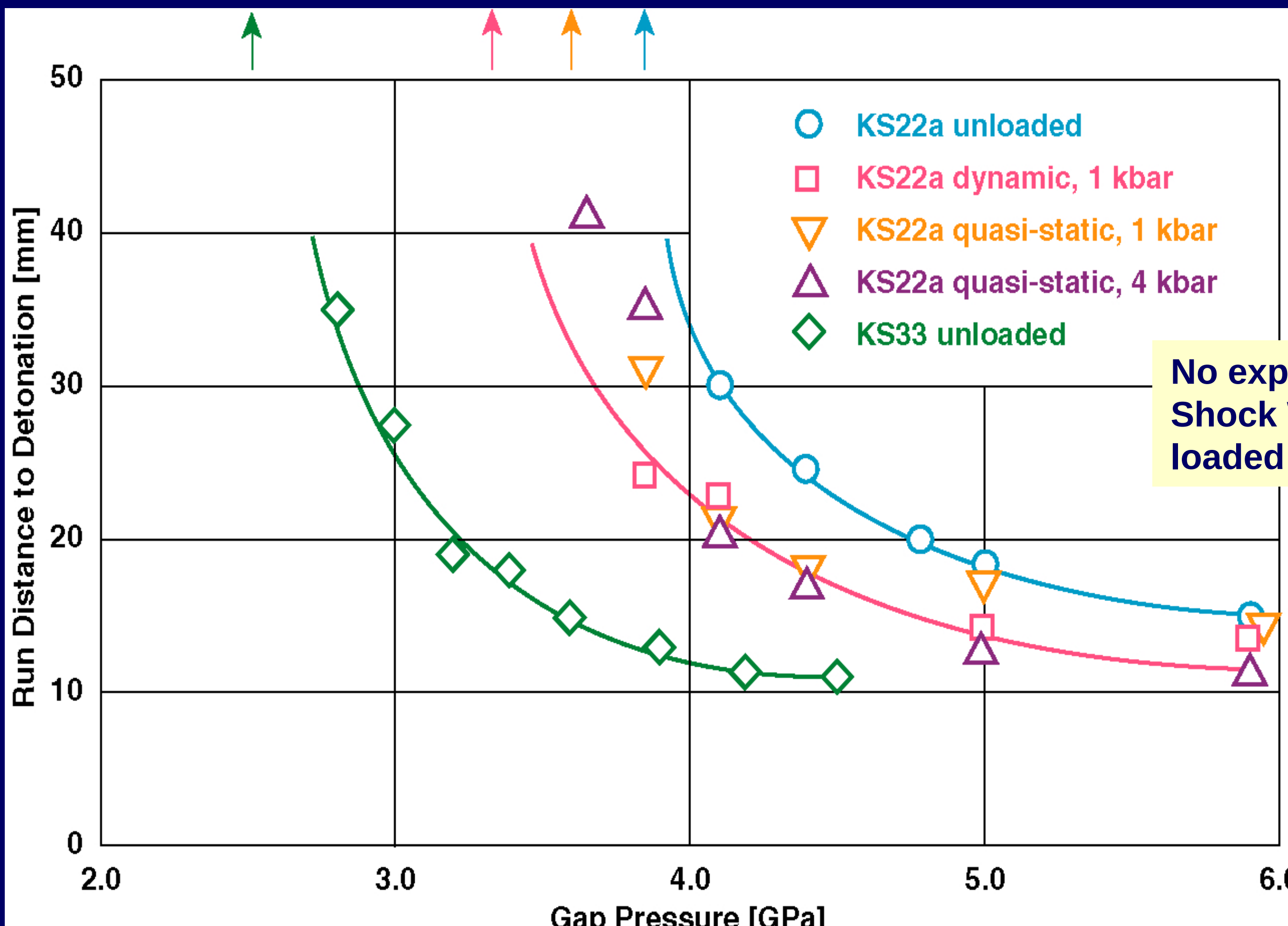
KS22a: RDX/Al/PB 67/18/15 Density: 1.64 g/cc



TDW Gap Test: Run Distance to Detonation

Reference: KS33: HMX/PB 90/10 Density: 1.71 g/cc

KS22a: RDX/Al/PB 67/18/15 Density: 1.64 g/cc

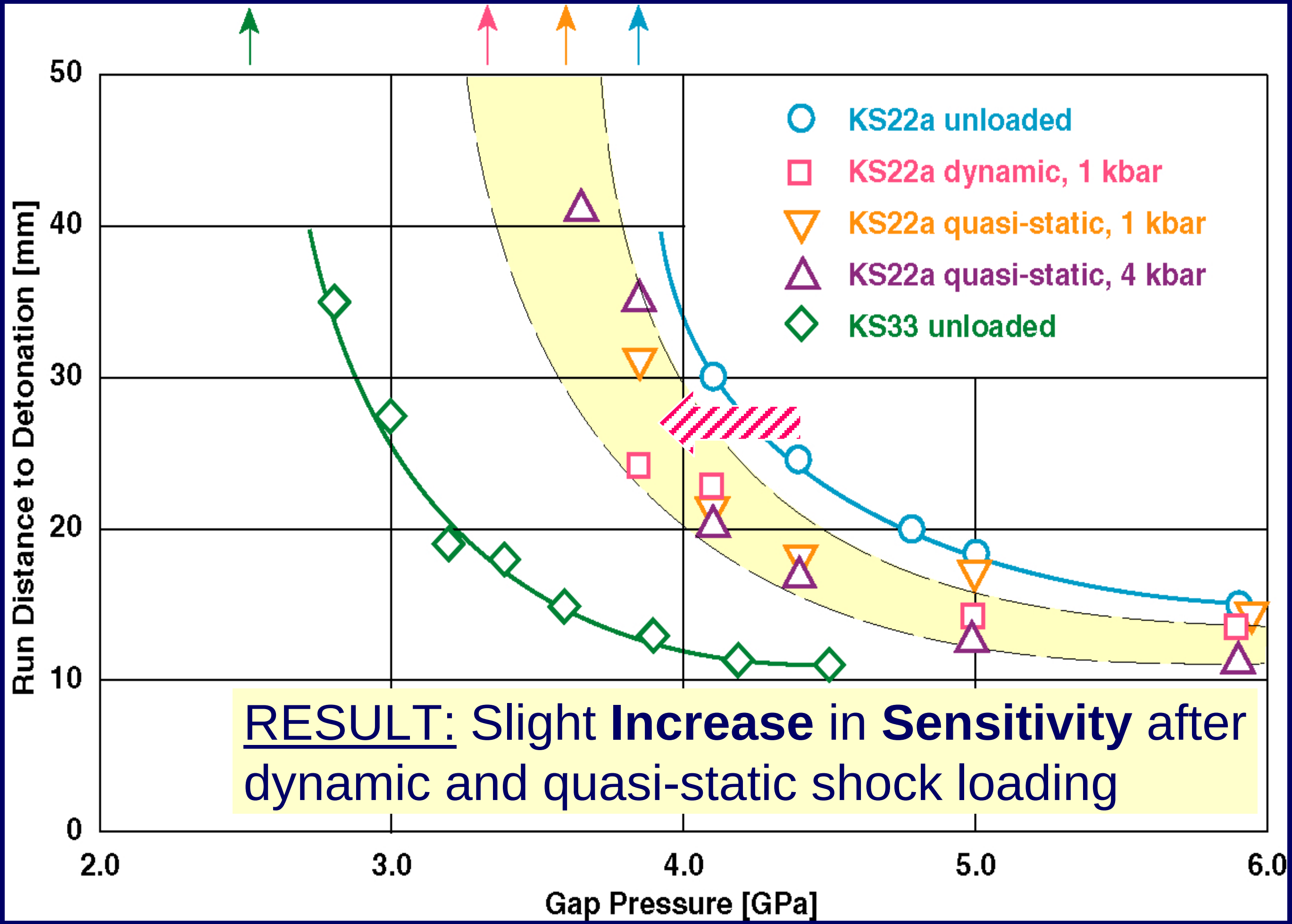


No experimental results of Shock Wave Apparatus loaded Specimen!

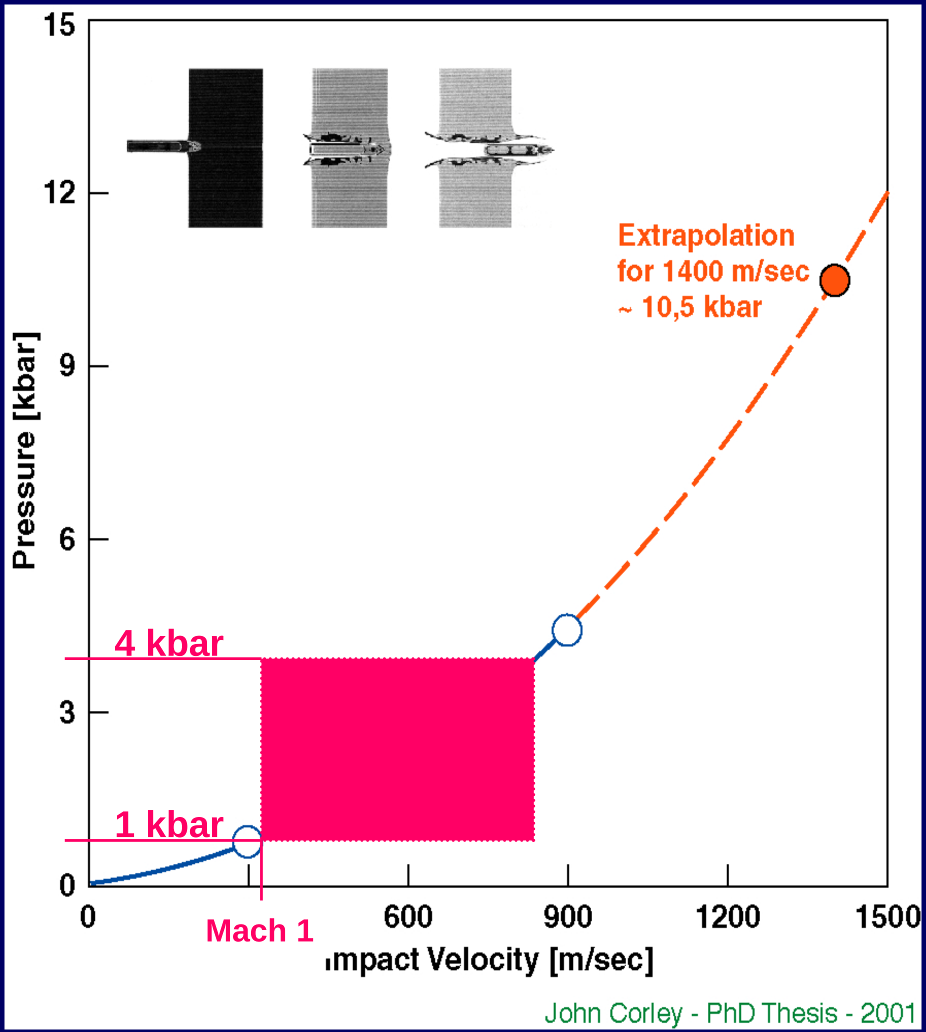
TDW Gap Test: Run Distance to Detonation

Reference: KS33: HMX/PB 90/10 Density: 1.71 g/cc

KS22a: RDX/Al/PB 67/18/15 Density: 1.64 g/cc



Relevance of these Test Results for Real World Penetrator Applications



Shock loads of more than 1 kbar correspond to supersonic impacts with more than Mach 1.

Investigations on the Structure of KS22a

Structural Investigations by

- X-Ray Refraction
- X-Ray Diffraction
- Thermal Conductivity
- Scanning Electron Microscopy (SEM)

have been carried out by WIWEB

Results: Possible Reasons for Changes of Sensitivity due to Static / Dynamic Loading

- Cracking of Grains
- Mechanical De-Bonding of Matrix / Grain Interfaces
- Local Reactions of RDX - Grains

Comparable Investigations by

A. Lefrancois et al. CEG (F): De-Bonding, Local Melting & Reaction
Dynamic Loading: RDX based HE, ~ 4 kbar, Scaled Penetrator

P. Peterson et al. LANL (USA): Cracking of HMX Crystals
Quasi-Static Loading: HMX based HE, 0.5 - 2 kbar, Press

have shown comparable results.

5. Conclusion

Observations and Conclusions

- Shock loading of HE in Supersonic Penetrators *is* an issue !
- Significant reduction of initiation thresholds due to radial confinement (48 → 12 kbar) observed
- Changes in sensitivity by quasi-static & dynamic shock loadings (Run Distance Tests) occured
- This does not mean that KS22a is not suited for Supersonic Penetrators to be an IM !
- Indications for defects like de-bonding and grain fracture are likely the reasons for sensitivity changes

EADS TDW

EADS / TDW

A MEMBER OF

IMEMG MURAT

EUROPEAN MANUFACTURERS GROUP

Thank you for your patience!

Any Questions?