IMEMG MURAT
EUROPEAN MANUFACTURERS GROUP

The 3rd European IM Day

Amsterdam, 18-19th May 2017

SESSION 4

PROGRAMMES / R&T

Current IM challenges

Session chair

Martin Emsenhuber

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MSIAC

Munitions Safety Information Analysis Center

Supporting Member Nations in the Enhancement of their Munitions Life Cycle Safety

MSIAC TECHNOLOGY AND PROGRAMMES: IM DESIGN

MAY 2017

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MSIAC Tools Introduction

- Large number of products and tools immediately available to MSIAC nations
  - Developed over the last 25 years
- Can be grouped under categories:
  - Insensitive Munition (IM) design
  - IM Procurement
  - Safety Requirements & Assessment
  - Use / Lessons learned
- The full list of products could be found here: https://www.msiac.nato.int/products-services/products-services

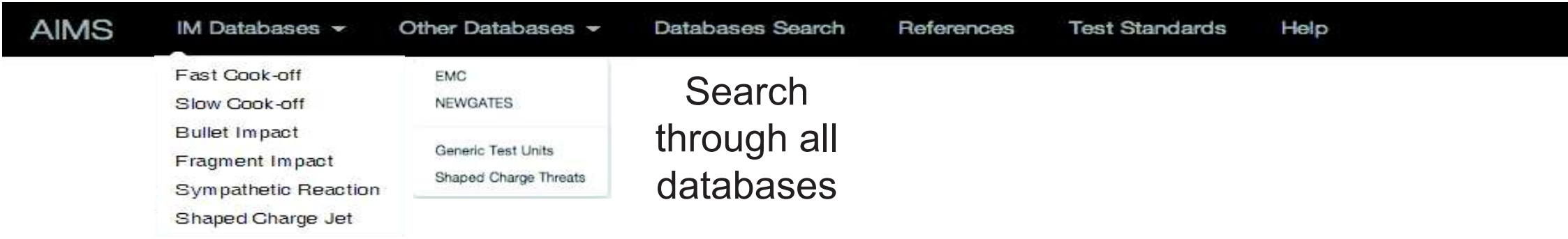
IM Design Overview

- **IM Technology: AIMS, IM SOA**
- **Energetics Choice: EMC, NEWGATES**
- **IM Warheads Design: TEMPER, NEWGATES**
  - Shock Mitigation: PIMS
  - Venting
  - Packaging: Venting & Barriers
- **IM Propulsion Design: MTM**

- **Gun Launch Setback Ignition: Setback CWG**

ADVANCED IM SEARCH - AIMS

AIMS



Search through all databases

Database of IM test results

IMSoA

- Database on Reduced Vulnerability Munitions
  - Updated Yearly
  - Based on open Literature Information
- Useful for
  - Procurement of New Munitions
  - Quick IMSoA assessment for a particular type of munitions

IMSoA: Example

WL

155/52 Artillery shell: 155-mm LU 211-IM

Performance Comparisons

	Comp B	XF-13333
Formulation	RDX/TNT (60/40)	NTO/TNT/Al/Wax
Density	1.67	1.75
VoD	7860	7150

Customers

- French Army – 5,000 rounds in 2004 plus 20,000 in 2006.

IM Technology

- IM High Explosive: XF-13333
- NTO 48%,TNT 31%, Al 14%, Wax 7%
- Embedded booster (V-350)
- Storage pallet 20-round configuration (95% of life cycle)

Not fuzed –Plugged

IM Benefits (cost analysis)

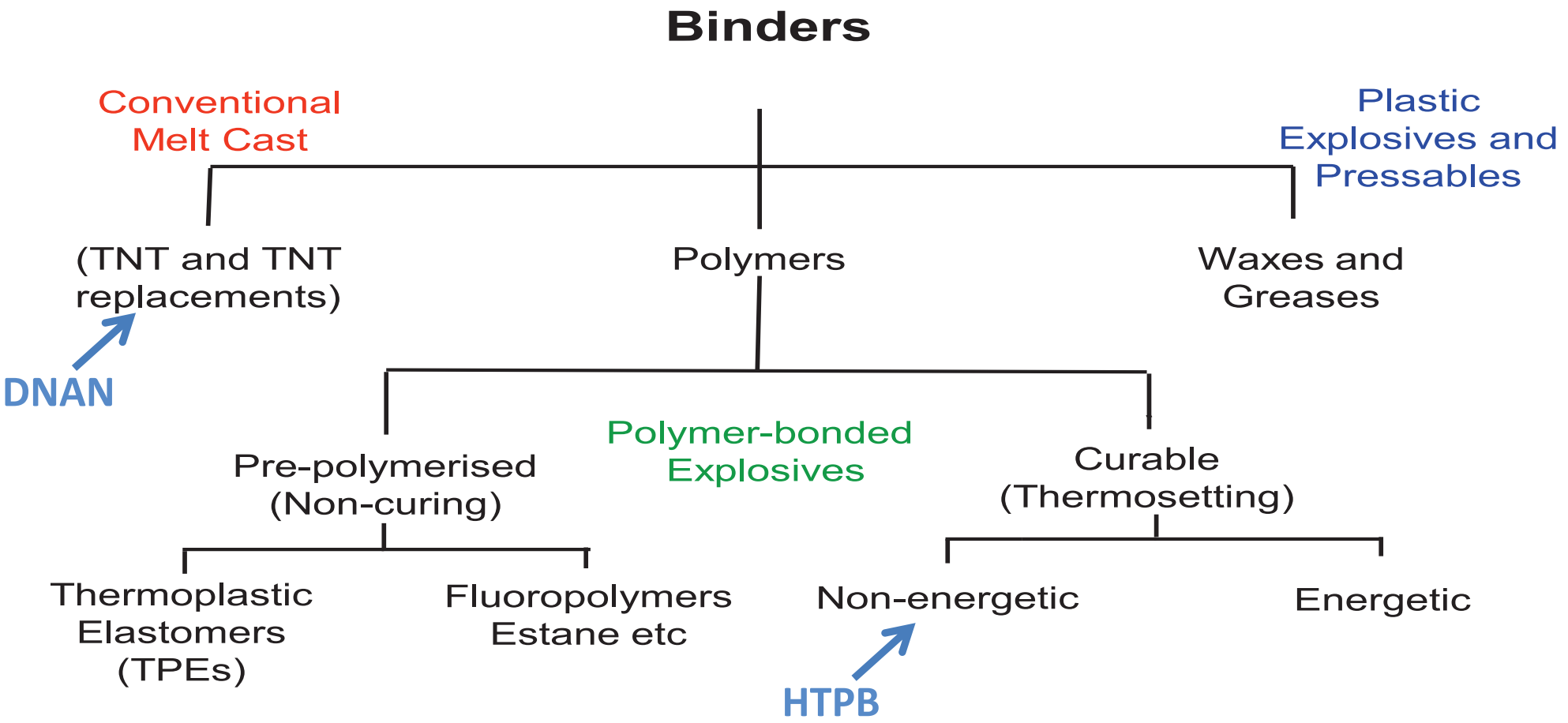
- Hexal / XF-13333 (NTO cost sensitive)
- Increased Unit Cost shell: ~ 6 %

IM Signature

	FCO	SCO	BI	FI	SR	SCJ
Hexal	I	I	I	I	I	I
LU211-IM	V	V	NR	NR	IV	IV

*Heavy Fragment Impact 250 g – 2000m/s: type III MURAT ** (Latest results suggest ***)

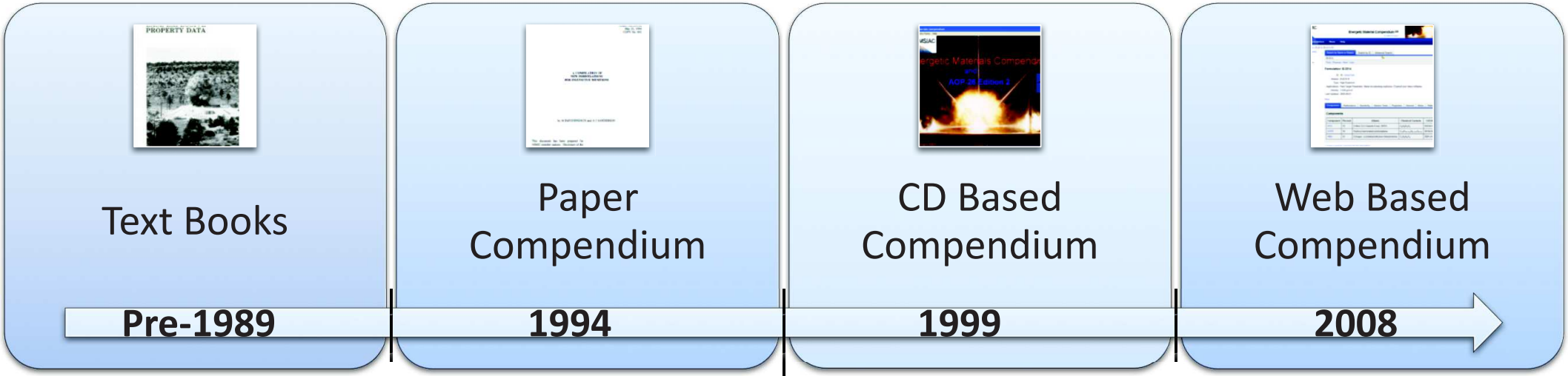
ENERGETICS CHOICE



Choice based on a balance of performance vs. sensitivity.

EMC - History

EMC



- Upgraded to web based database (v5.1.2)
  - Secure log in
  - Easy access for users
  - Updates can be performed more quickly
- Currently **1300** formulations and **686** components
  - Including pyrotechnic, rocket motor and HE formulations
- 800+ referenced documents

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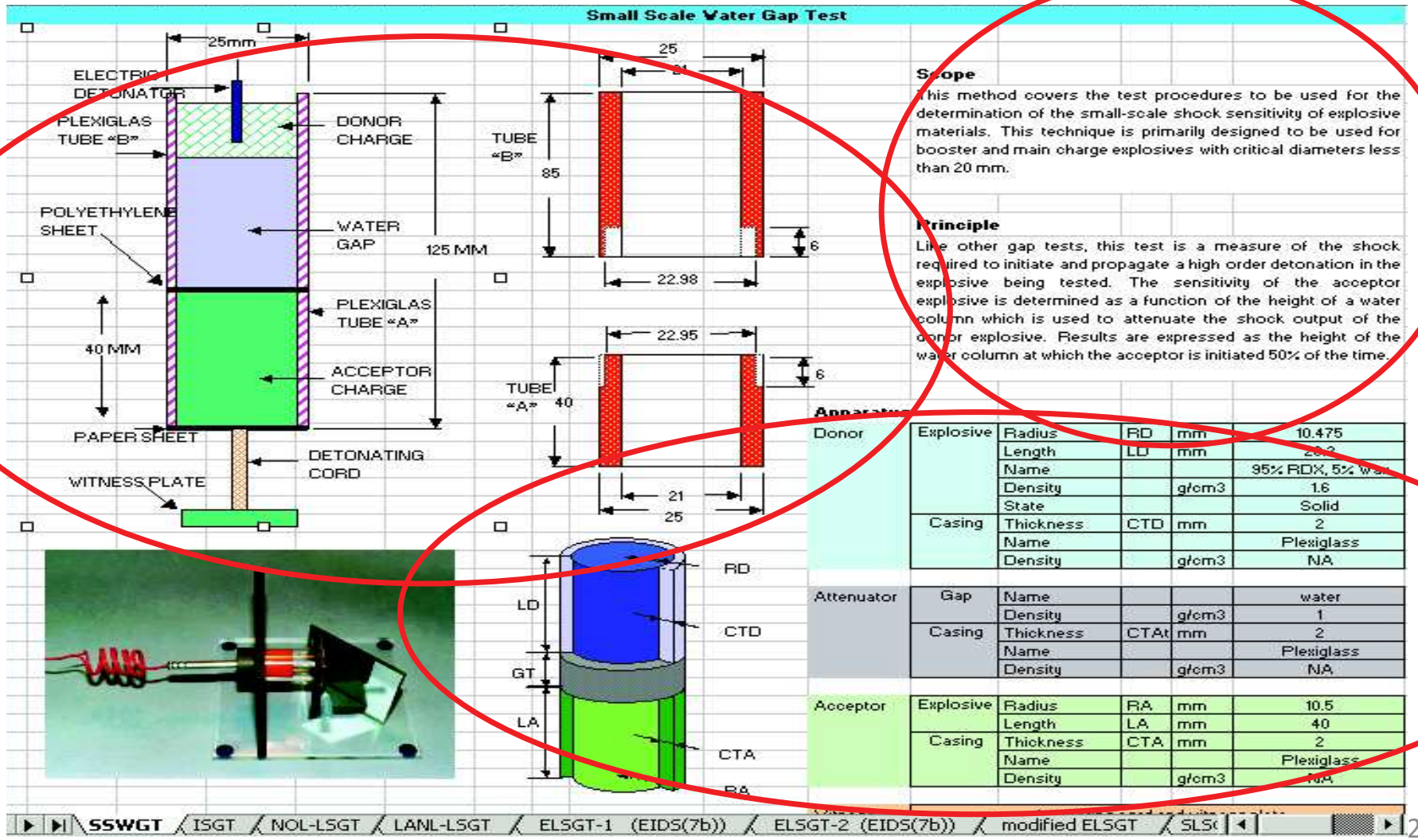
NEWGATES

DATABASE OF GAP TEST DATA

- NIMIC Excel Worksheet on Gap TESts (NEWGATES)
  - Most recent version 1.10: developed in Excel2003
  - Flexible research tool: References, data and calculations
  - 10 gap tests (dimensions, scope, principles)
  - calibration curves: pressure, time and shock curvature
  - 1455 gap test results
  - Unreacted Hugoniots & mixture Hugoniot calculation
- Wide range of:
  - Ingredients
  - Explosive composition
  - Gap tests

General Information on Gap Tests



Shock Mitigation: TEMPER

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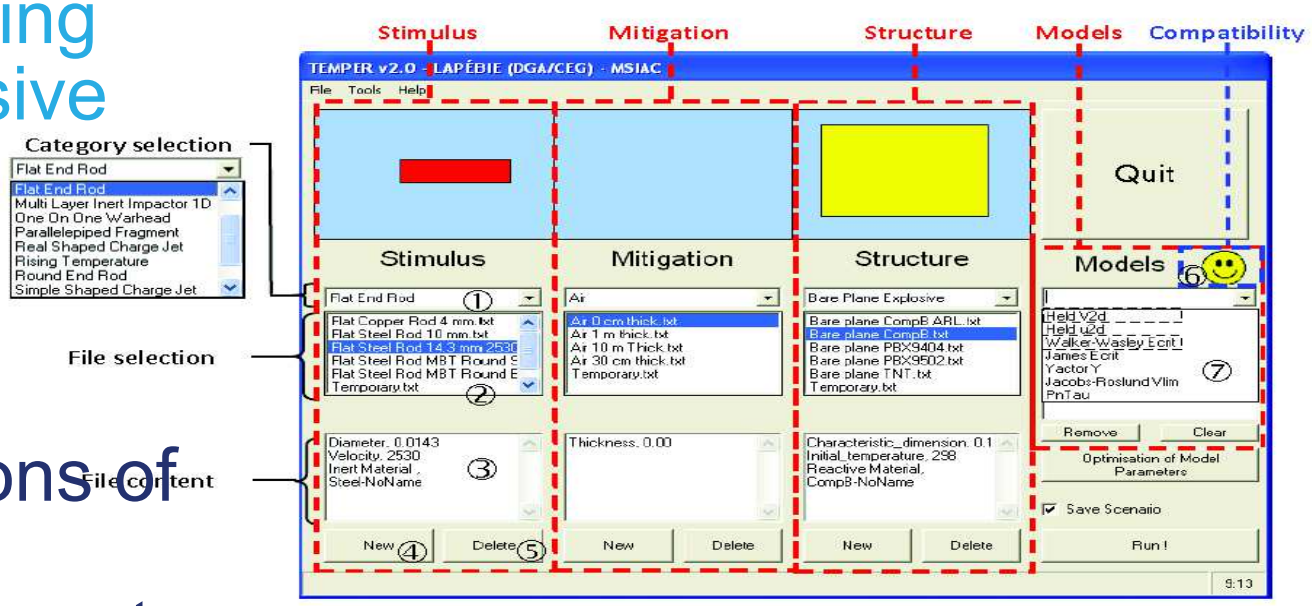
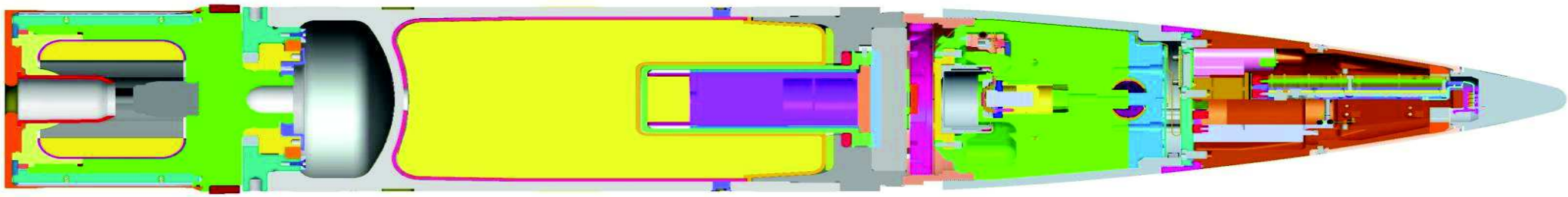
- The Toolbox of Engineering Models to Predict Explosive Reactions
  - TEMPER v2.3 is now available for use
  - Executable file
  - Runs on recent versions of Windows and Excel
  - Visual Basic 6: no support
- Replaces TEMPER v2.2.1
  - Not supported beyond Windows XP
- O-176: TEMPER Status and Recommendations



- 2017:
  - Porting TEMPER from antiquated Visual Basic 6
  - Currently scoping specs for an incremental Javascript rewrite.

PIMS

- Detonation behavior can be effected by barrier materials inserted between an incoming fragment or shock wave and an explosive material
  - Packaging materials used to ship and store munitions can be manipulated to help pass sympathetic detonation testing.
  - Low density liners around the warhead body, or between the explosive and warhead body can reduce fragment impact violence and provide a vent path for cook-off thermal events mitigation.
- As a practical application of this technology, low density liners, called Particle Impact Mitigation Sleeves (PIMS), were investigated to help reduce the violent response from fragment impact

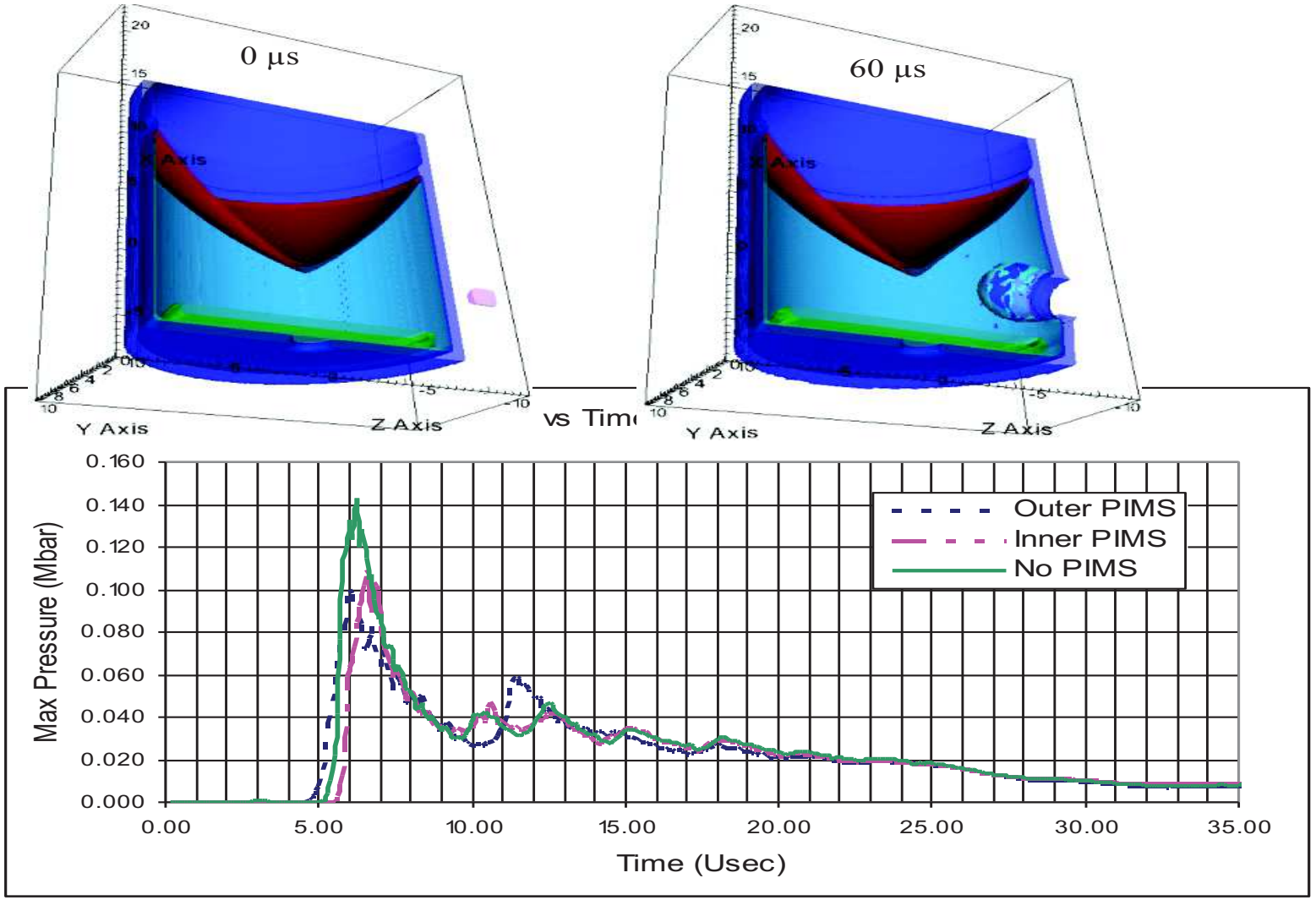


FRAGMENT IMPACT M&S

ALE3D

MAXIMUM PRESSURE PLOTS

2530 m/s



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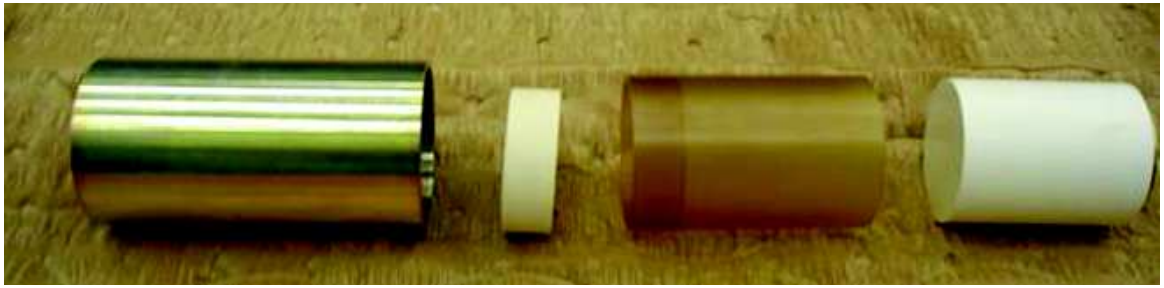
PIMS Test Results



Typical type 4 reaction showing large chunks of un-reacted explosive

Witness plate after type 4 reaction

Witness plate after type 1 reaction

WARHEAD VENTING

- Thermal threats are normally addressed using a venting technique in order to allow ignition products to escape therefore preventing over pressurization
- Venting techniques
  - Melt venting: plastics or eutechtics
  - Ignition venting: Typically 140˚ to 170˚C.
  - Pressure rupture: pressure blow-out
  - Shape memory alloys: metal or plastic
- Venting mechanisms
  - Vent plugs
  - Thread adaptors
  - Unlock mechanisms
  - Crushing or bursting

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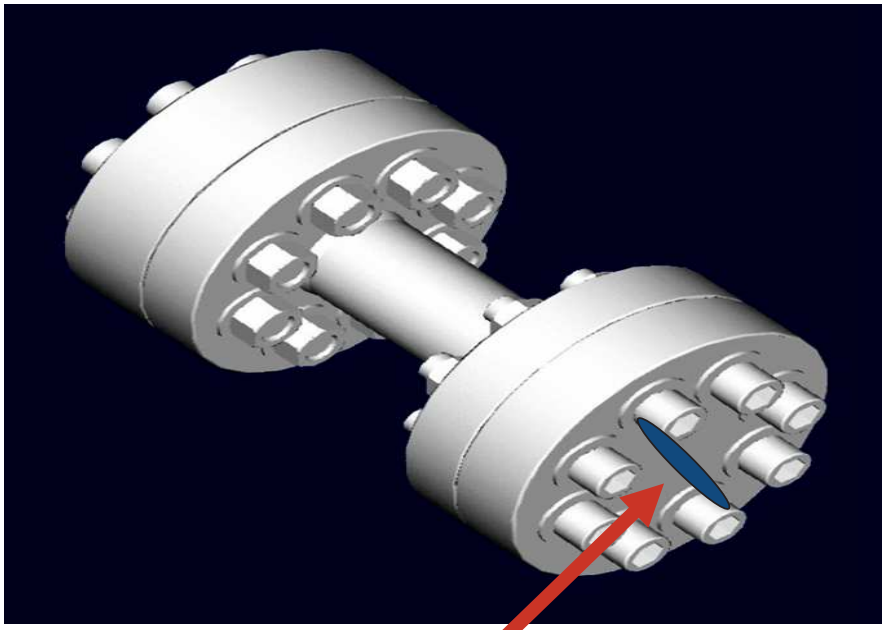
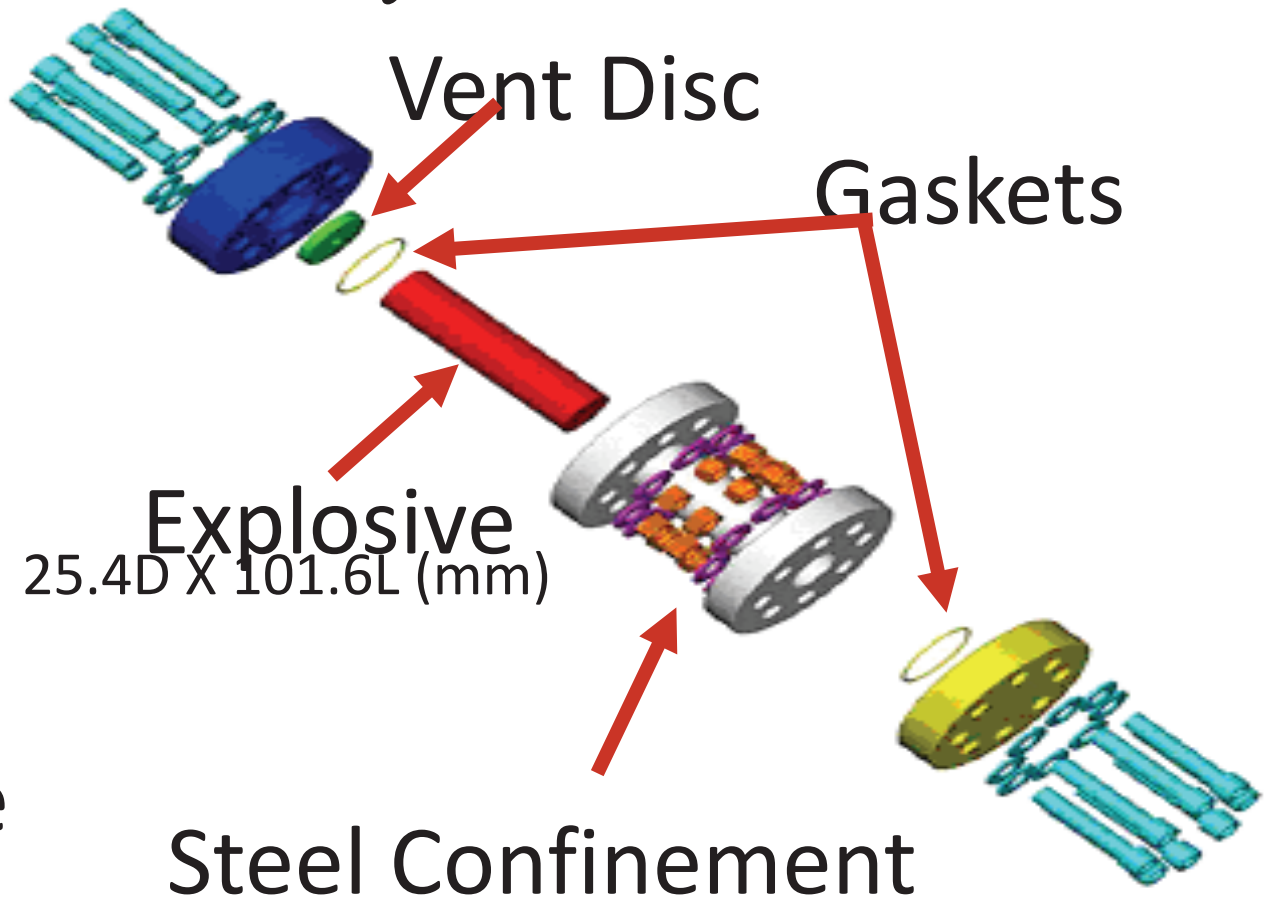
IM Warhead Venting

Small Scale Laboratory Fixture



Adjusted Vent Hole



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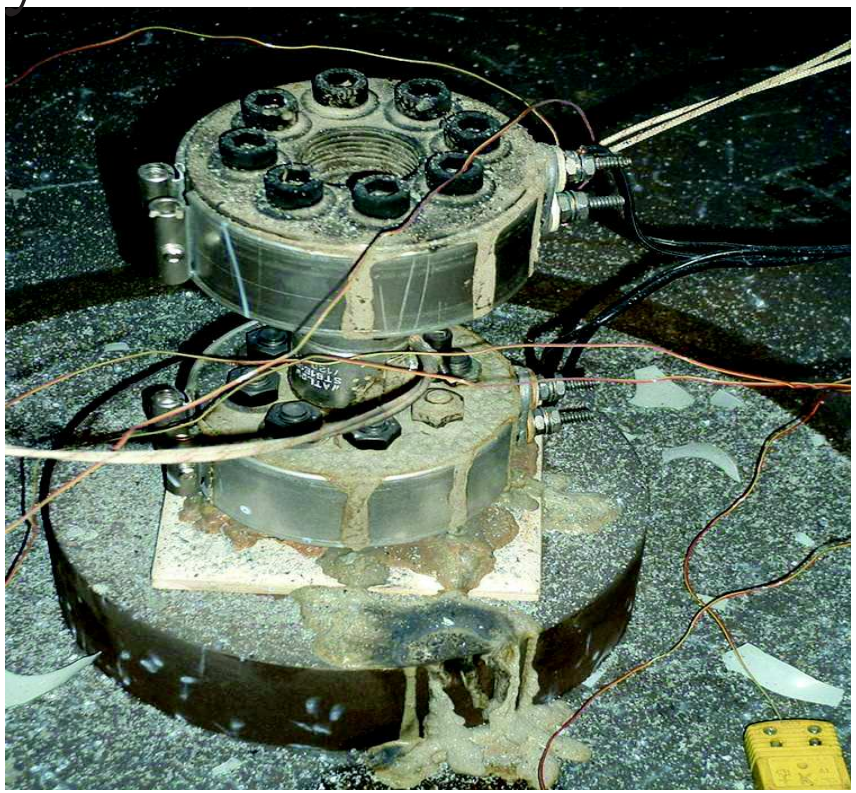
IM Warhead Venting

Small Scale Laboratory Fixture

Violent Response

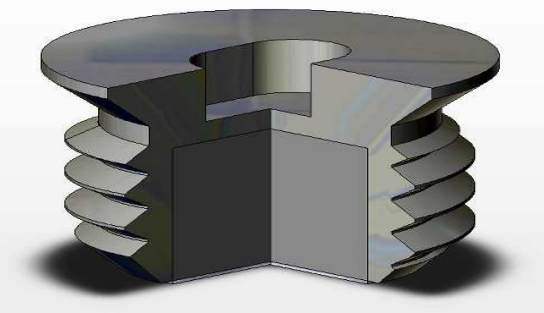


Non-Violent Response

IM Warhead Venting

155mm Venting Lifting Plug

81mm Venting Adaptor



Reactive Vent Plug

Large Scale Laboratory Fixture

PBXN-109 - AHM Liner Testing

PBXN-109 - HDPE Liner Testing

Identical single hole vent:
AHM liner: not violent
HDPE liner: violent

Less viscous melt materials work better!

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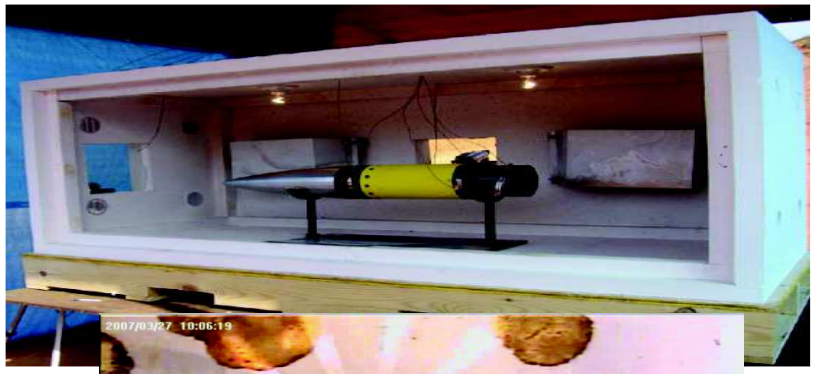
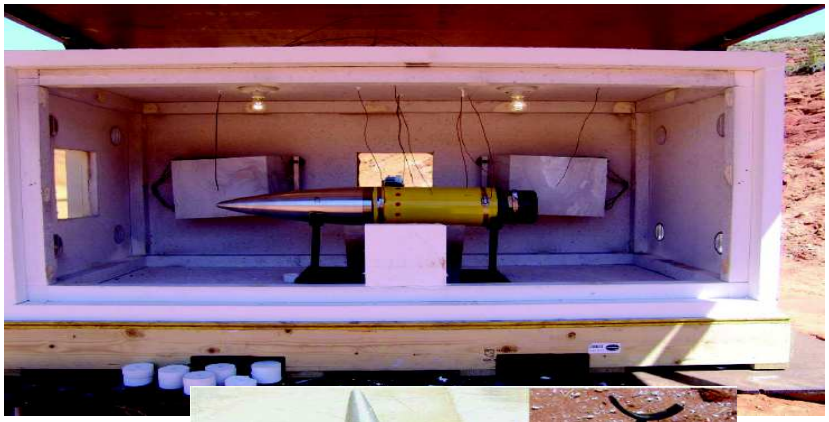
Excalibur Full Scale Test Results

28C/h: Type III & V



SETUP



RESULT

TYPE V

TYPE III

28C/hour

Excalibur Full Scale Test Results

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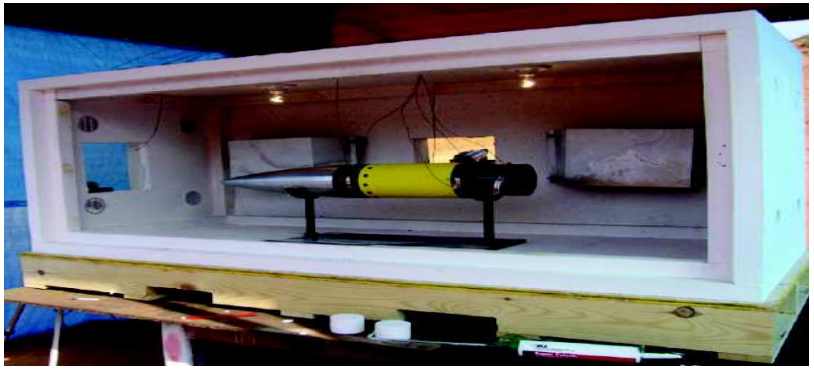
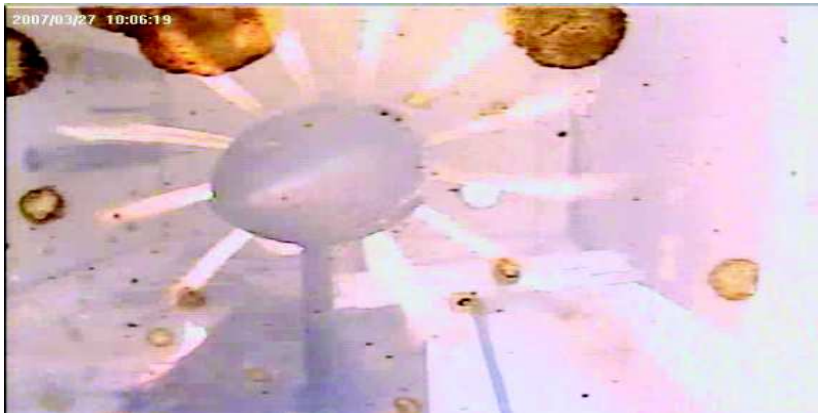


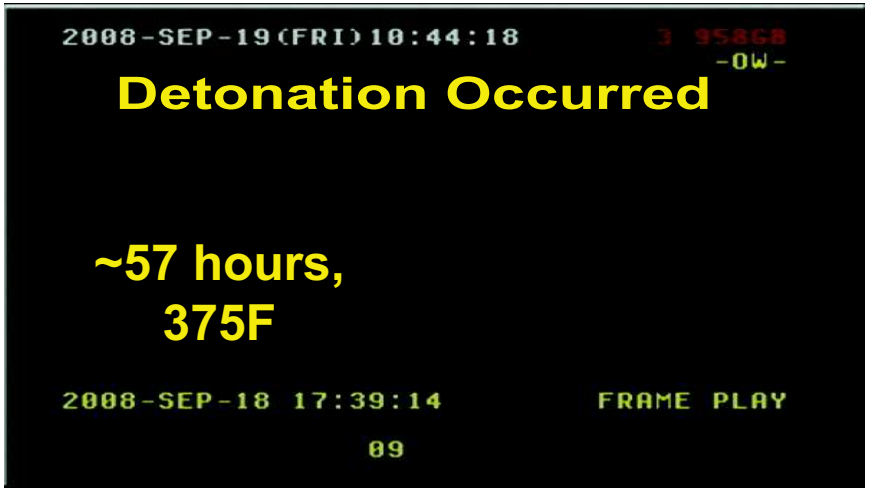
28C/hour

Type III & V



3.3C/hour

Type I



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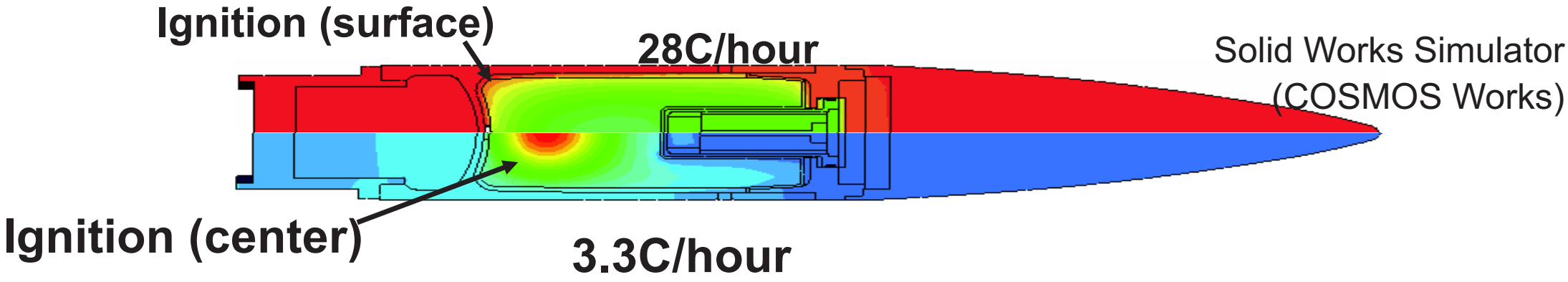
Excalibur Thermal Modeling



- Hotspot = where ignition occurs, i.e., explosive begins to burn in self sustaining reaction
- 28°C/hour
  - Hotspot forms on or near the surface
  - Surface burn allows gases to escape through vents
- 3.3°C/hour
  - Hotspot forms on billet centerline below the surface
  - Hot gases trapped inside the billet

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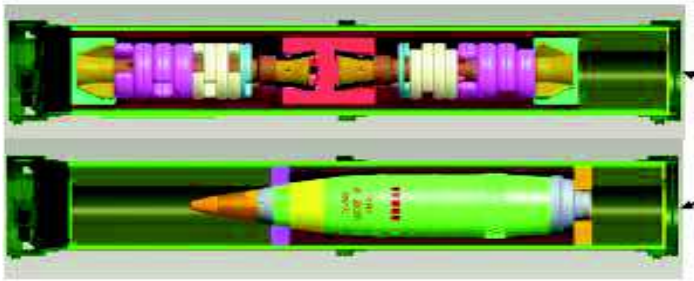
PACKAGING VENTING

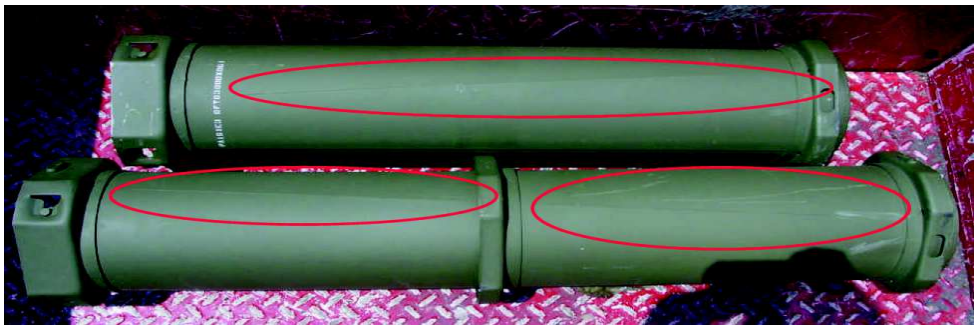


A Blowout Panel in the bottom of the container allows pressure release

120mm M829E3 Tank Cartridge
IM Container M171

Blowout Panels allow pressure release from inside the container

Foam cushions and sleeves melt and separate to prevent insulation of heat



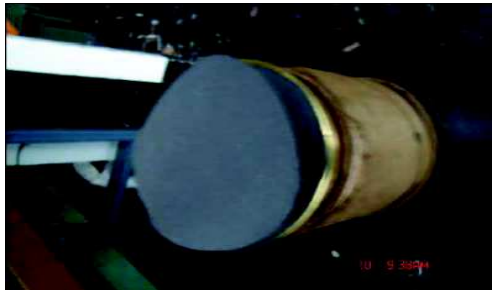
25mm IM Container

Web based application of mitigation techniques

- Migration of M3 into a web based application
- Accessible via the MSIAC Portal, on computer, tablets and smartphones
- Database centred on technologies (instead of Methods in M3)
- Improve user experience:
  - Additional information provided
  - Improved search functionalities
- Improve admin experience to add new data

CARTRIDGE VENTING

- Mitigation technology for 105 mm to mitigate thermal threat: vent holes + meltable plug + primer heat protection



- Stress riser (example: 57 mm cartridge case)

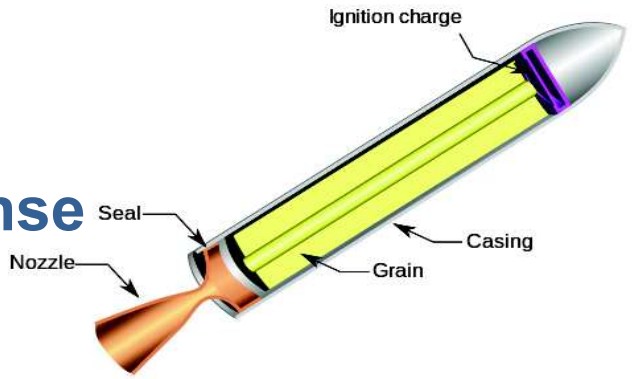
MITIGATION FOR ROCKET MOTOR

Different mitigation families

- Venting Devices — 9 technologies identified, 3 known as to be in use
- Active Mitigation — 16 technologies identified, 3 known as to be in use
- Intumescent coating — 14 painting identified, 3 known as to be in use
- Casing composition — 8 technologies identified, 5 known as to be in use
- Barrier – Packaging – Arrangement — 6 technologies identified, 3 known as to be in use

Other way to help reduce the rocket motor response

- Composition of the propellant



Solid Rocket Motor

Venting devices

To create a venting of the motor during heating. In case of ignition of the propellant it would permits a decrease of the pressure. Thus the reaction type stays a burning and does not change into a more violent reaction type.

Threat: Slow /Fast Heating

Example: Use of Shape Memory materials ; Partial insulation; Use of eutectic components…

Shape Memory Material to disengaged the end

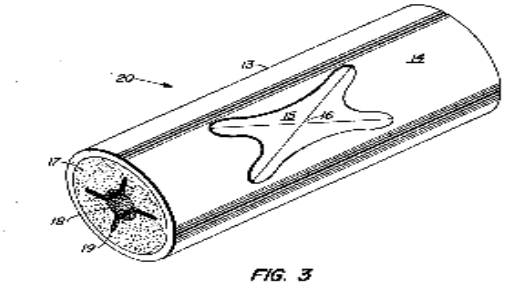


Figure 5 : Partial Insulation Technique

Online Technical Question Form

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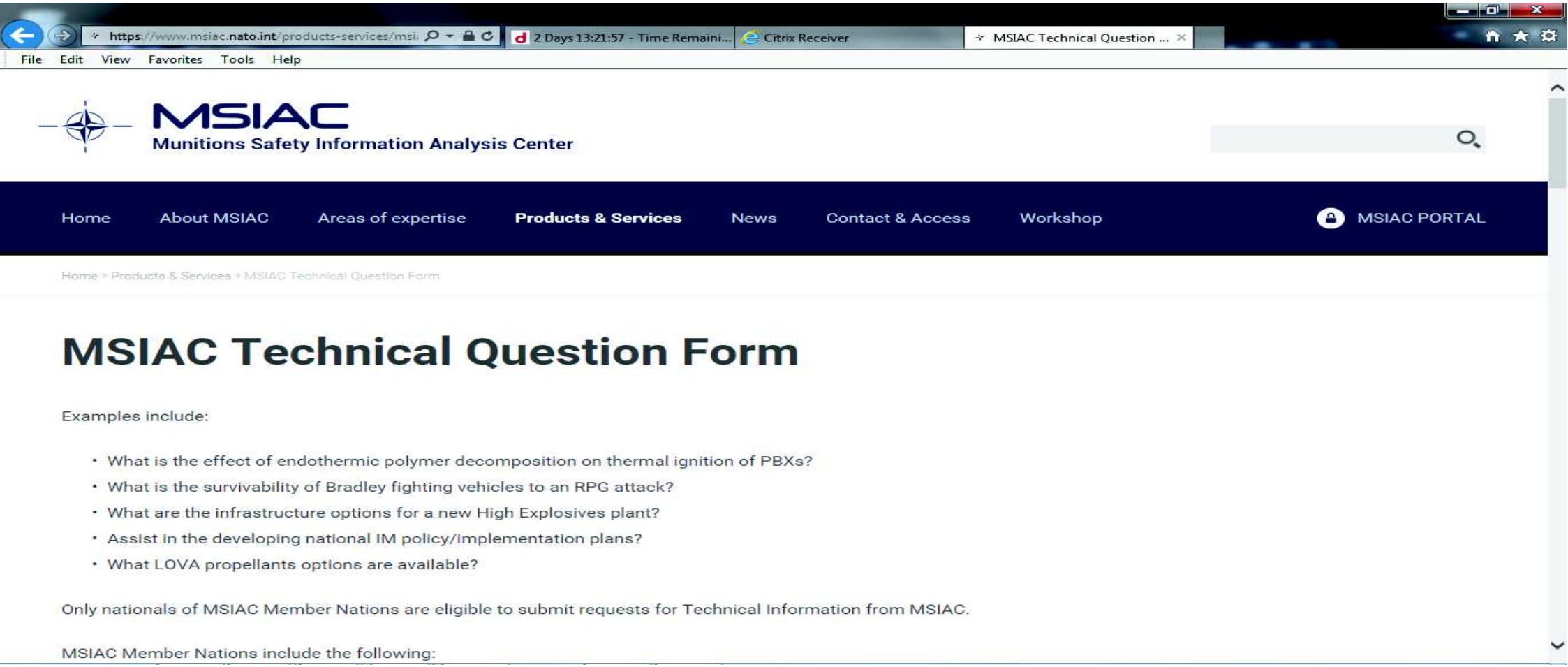

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Questions?