A NEW CONCEPT TO PREVENT SYMPATHETIC DETONATION

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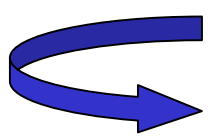
CONTENTS

➢ CHALLENGES

- **POROUS MATERIAL FOR SHOCK MITIGATION – SME PROTOCOL**
- **CALIBRATION EXPERIMENTS FOR MODEL**
- **MK82 LOGISTIC PALLET : RESULTS - DISCUSSION**
- **SUMMARY AND CONCLUSIONS**

CHALLENGES

- **Ordnance systems must be more than ever secured against accidental and terrorist threats**
- **Preventing the Sympathetic Detonation event is a priority for IM community to increase safety concern**
- **Increase logistic capabilities for closely packed systems**



Many research programs have been investigated to reduce the vulnerability of systems by optimizing properties of EM and systems

CONTENTS

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POROUS MATERIAL FOR SHOCK MITIGATION

Experience with sympathetic detonation :

- at close range, SDT due to casing impact
- at longer range, SDT or DDT induced by fragments impact or penetration

EURENCO/SME technical response for closely packed systems

A new concept based on porous concrete shields : a lightweight and low-cost material, a good candidate for shock mitigation

SME PROTOCOL (1)

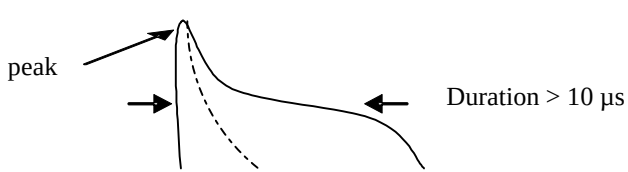
Increase density logistic capabilities = optimize shields design

- **EURENCO/SME promote laboratory tests and computer models**

- **To reach that objective, we face two major difficulties:**

  1. Physical mechanisms and mechanical behavior law of porous concrete subjected to shock waves are not well understood

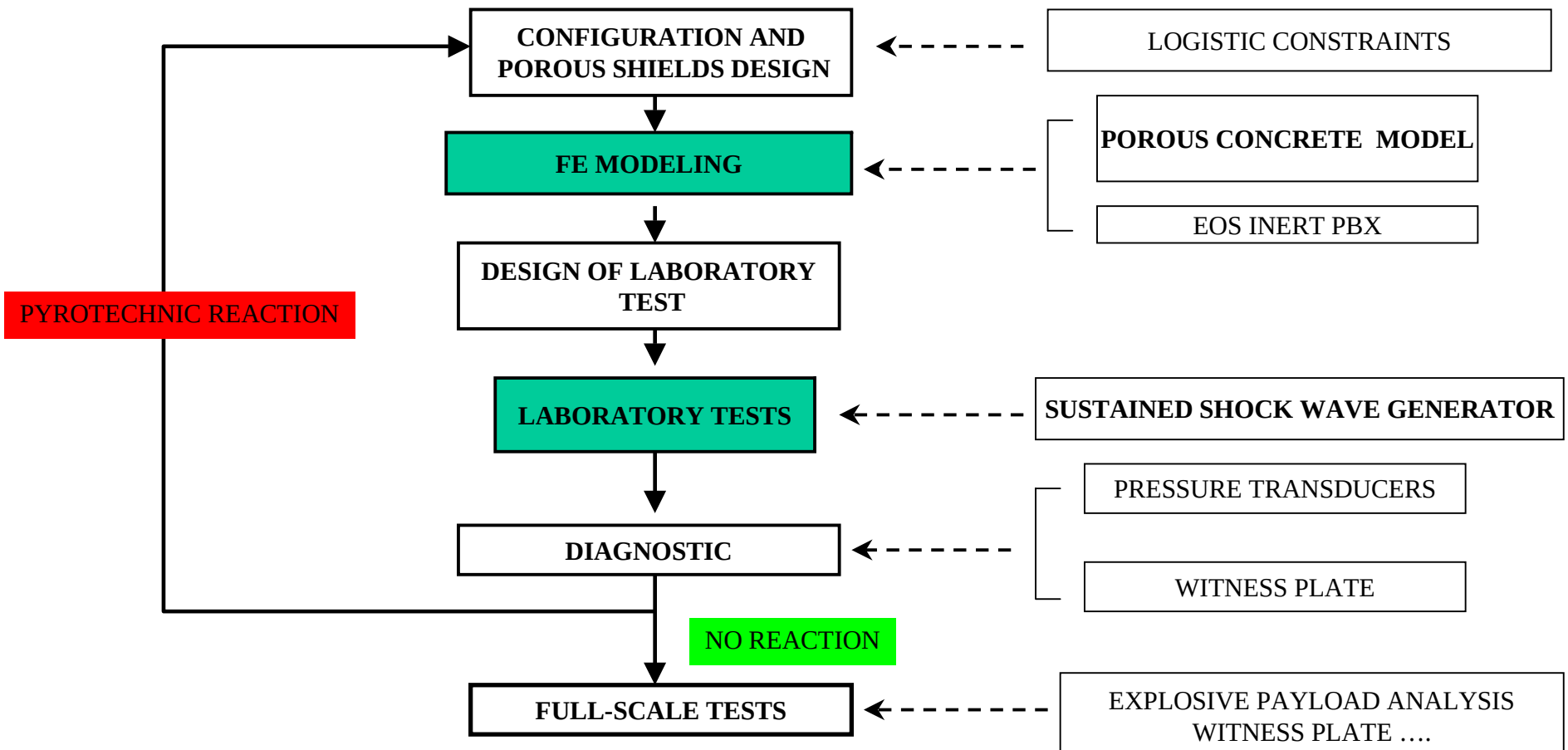
  2. Sympathetic Detonation threat induced by closely packed systems with shields is not a classical shock (short pressure pulse), but a sustained shock ("low-pressure – long duration")



➡ ***Conventional shock sensitivity tests and reactive flow models are no more accurate***

SME PROTOCOL (2)

A combined experimental / numerical approach to assess the sensitivity of PBX before operating full-scale tests



Key-steps of SME protocol

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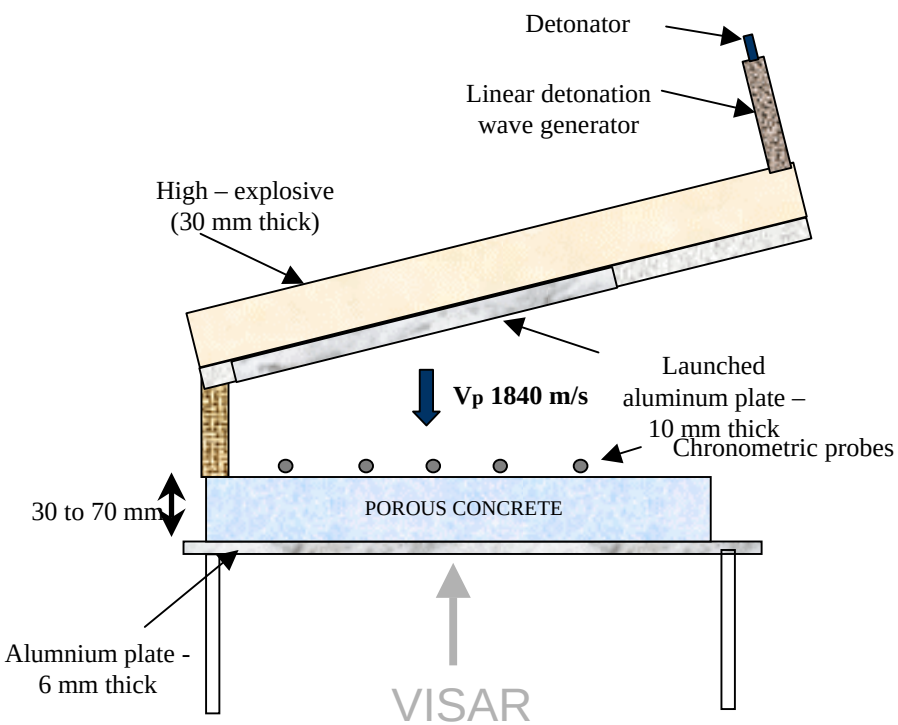
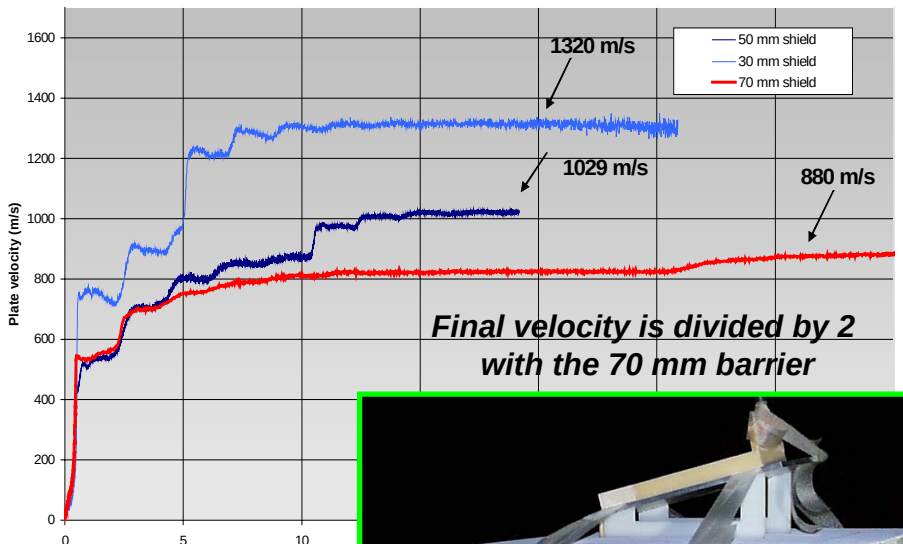
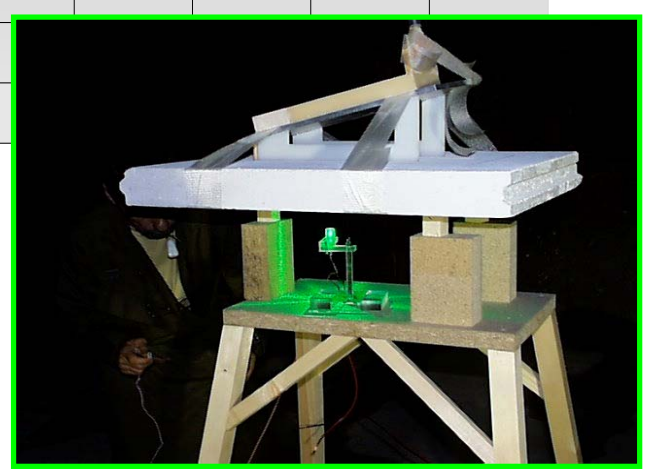
EXPERIMENTS FOR MODEL (1)

High-velocity impact tests (Calibrated Shock Test)



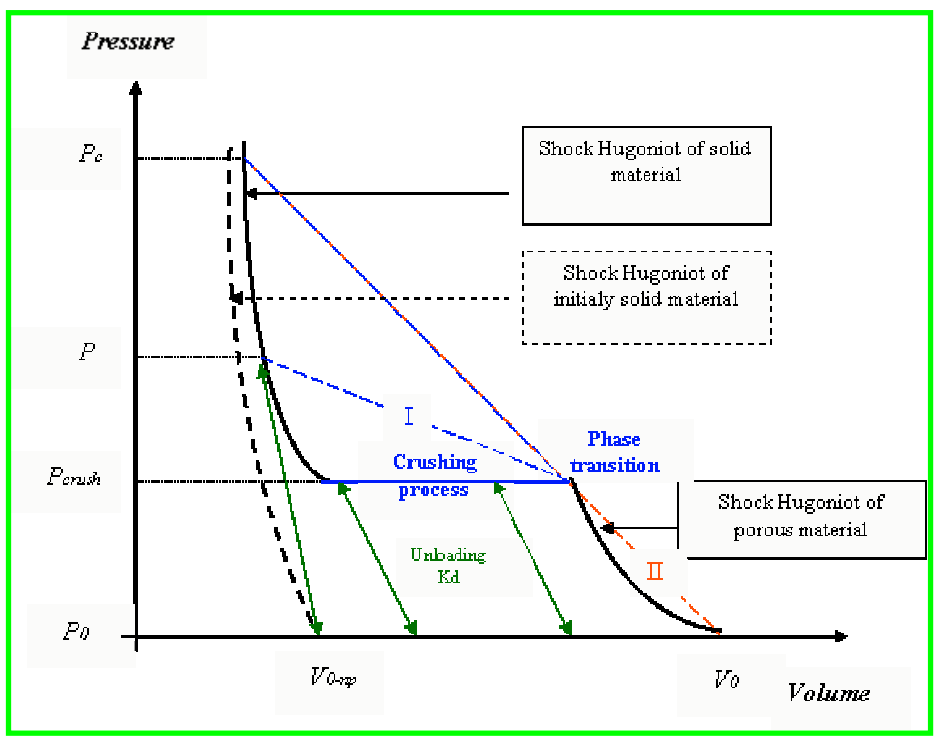


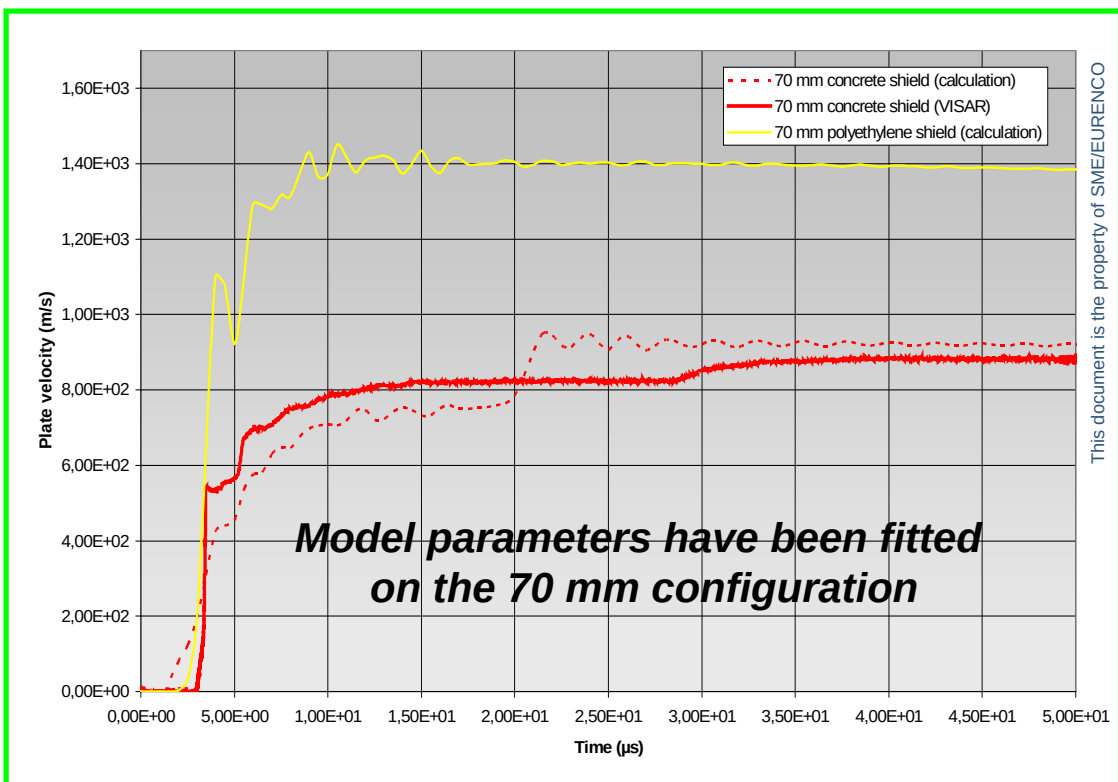


Porous concrete shields efficiency is quantified through the velocity of the aluminum plate (VISAR diagnostic)

EXPERIMENTS FOR MODEL (2)

- The physics of our model is based on high-pressures – crushing process is issued from macroscopic considerations



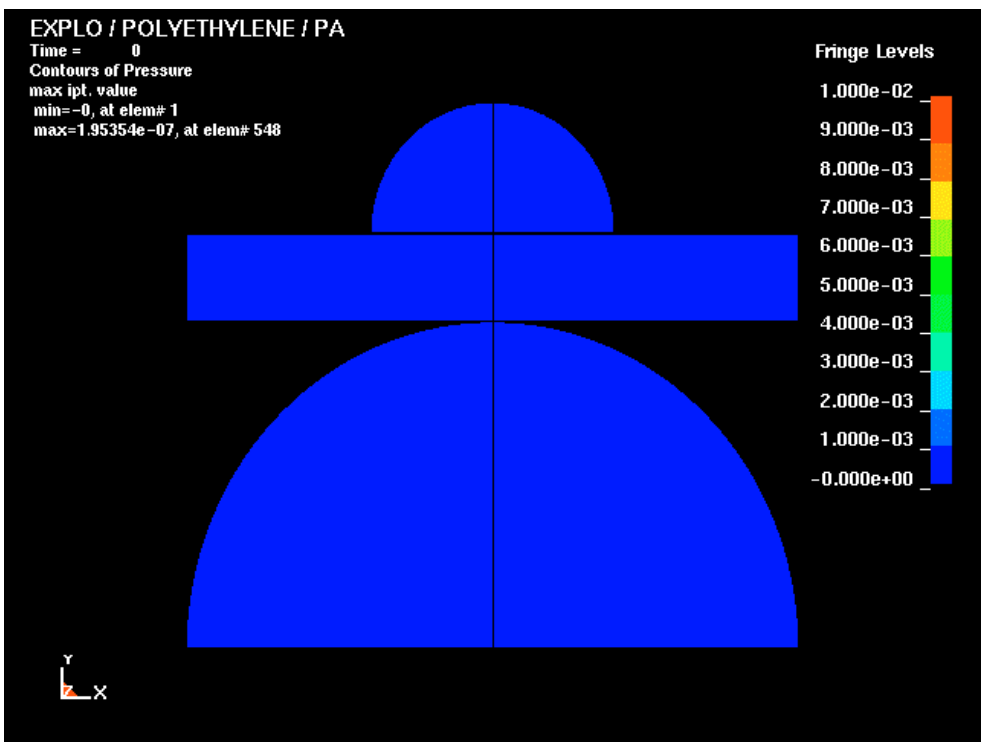


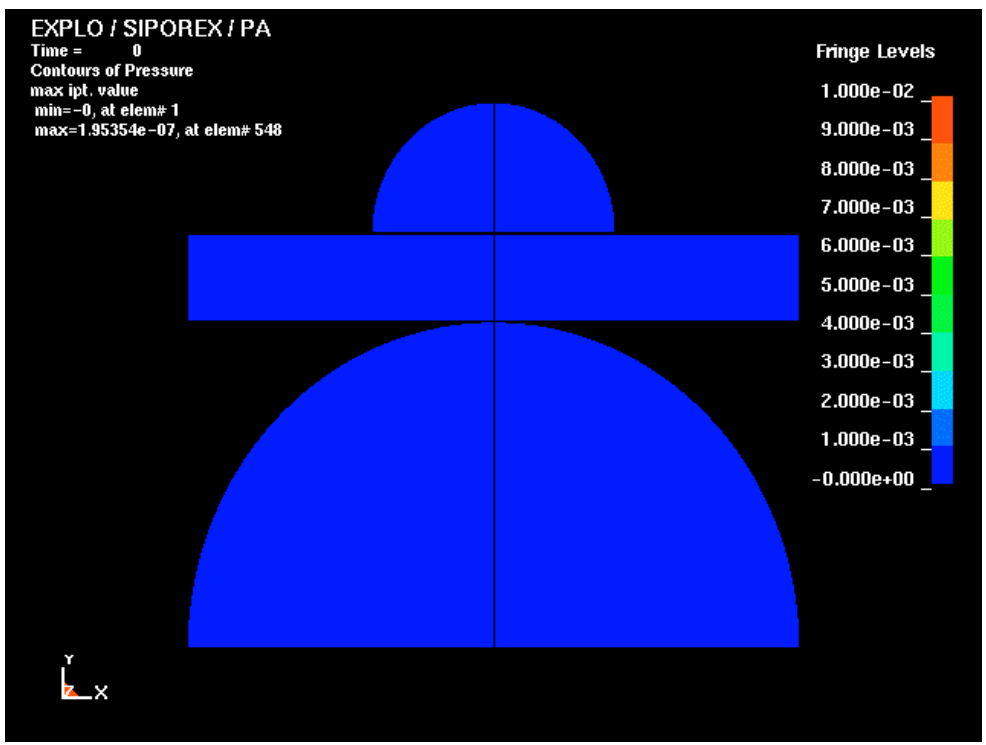
Compaction model is implemented in LS-DYNA Finite Element code

EXPERIMENTS FOR MODEL (2)

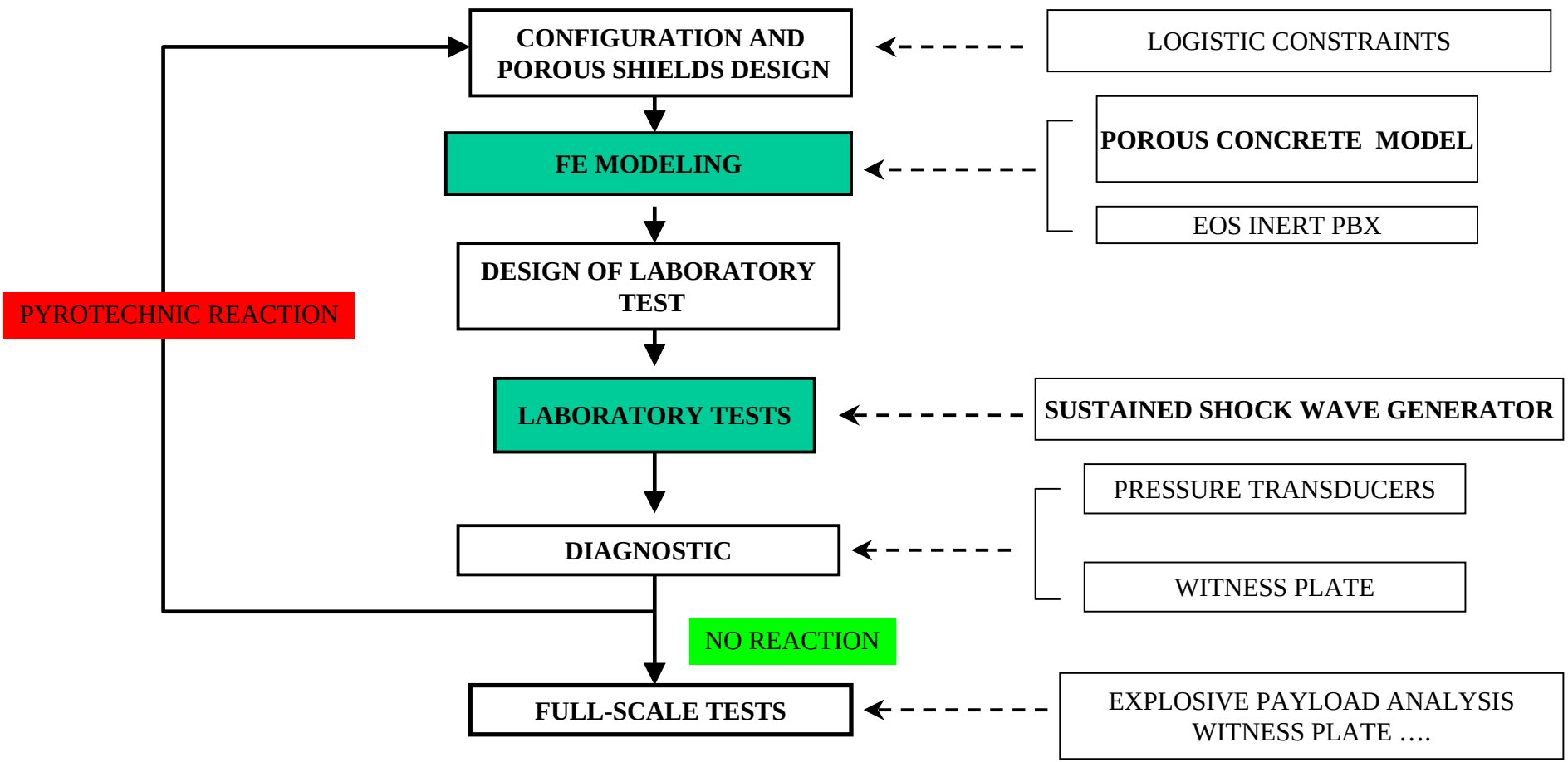
- A compaction model is implemented in LS-DYNA Finite Element code

- Shock mitigation comparison between a low impedance material and porous concrete





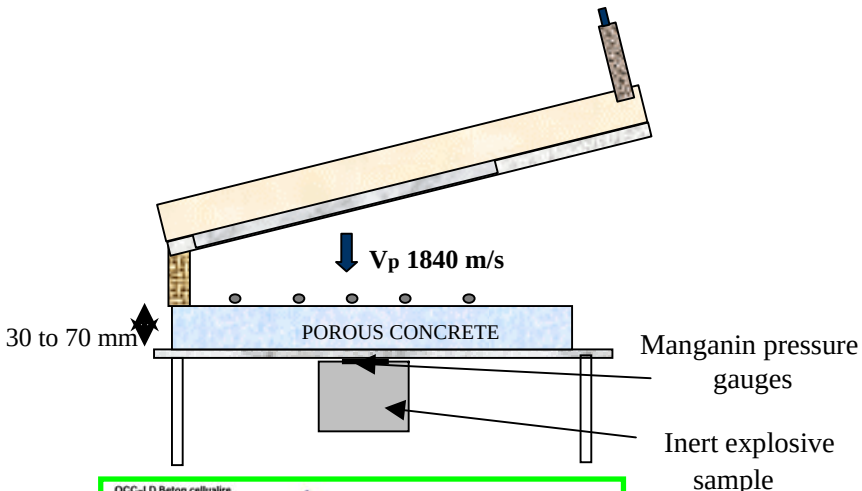
SME PROTOCOL

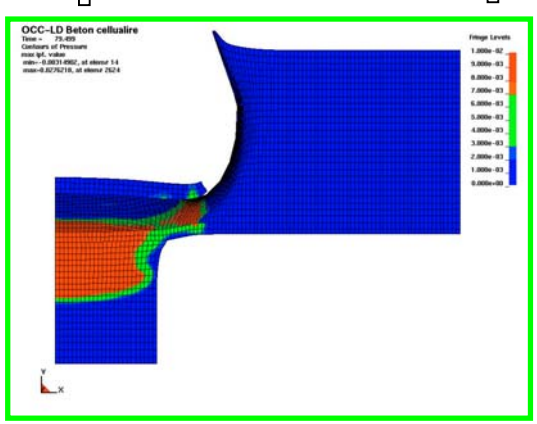


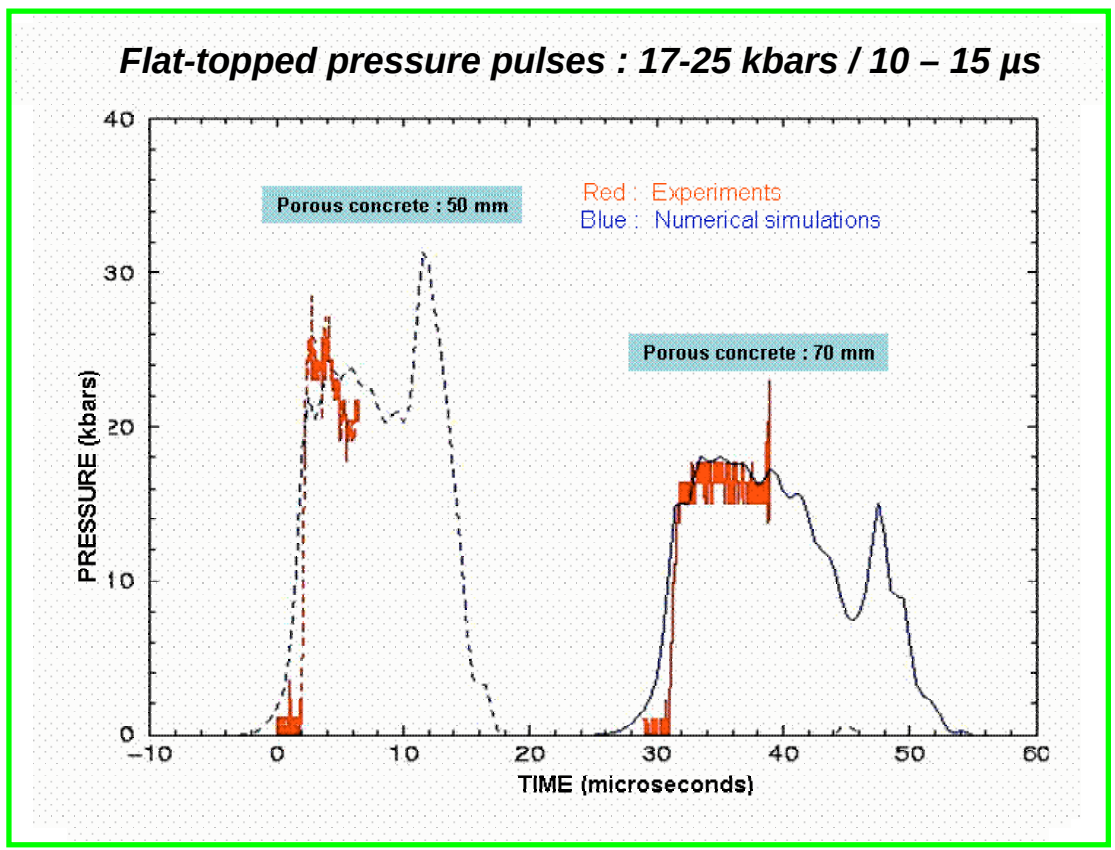
Key-steps of SME protocol

SUSTAINED SHOCK WAVE GENERATOR

Properties of porous concrete are used to generate flat-topped pulses







We can take benefit of this device for studying "low pressure – long duration" ignition of PBX

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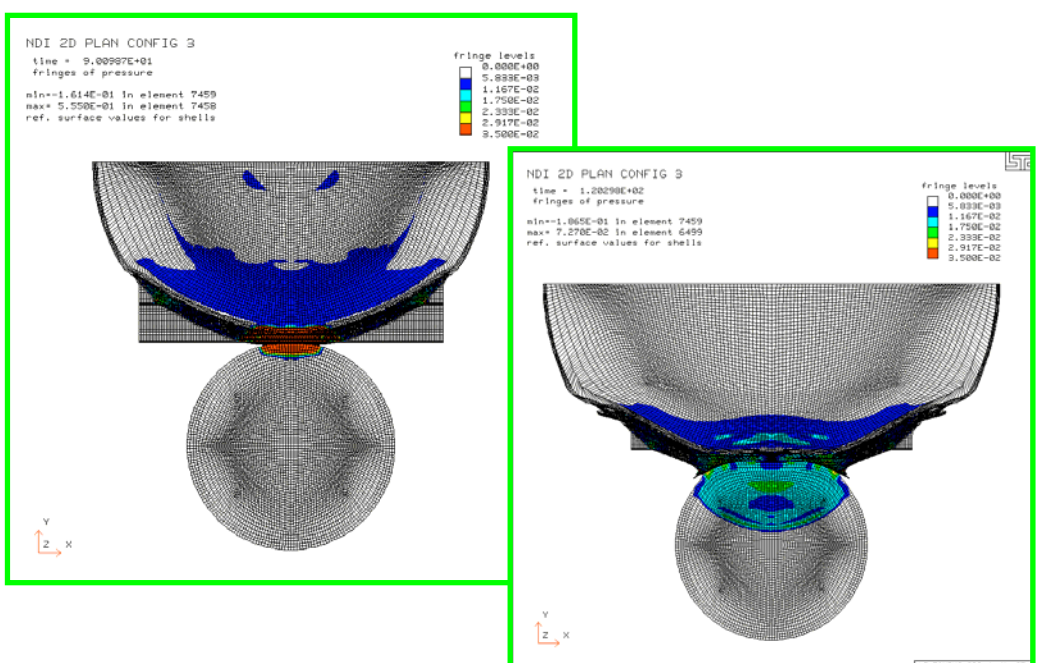
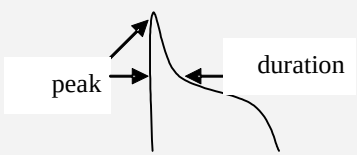
MK82 LOGISTIC PALLET (1)

- Large-scale warhead (D = 280 mm – M = 250 kg) - Strong confinement
- Energetic material : compromise between performance and sensitivity is promoted with PBXN109/EURENCO explosive (I-RDX® based)
- SME protocol has been exercised - Four arrangements have been studied : 0 – 100 – 250 and 350 mm porous concrete shields



MK82 LOGISTIC PALLET (2)

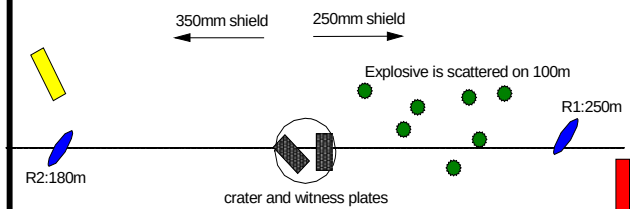
➧ **For shield thickness greater than 250 mm, acceptor weapon has demonstrated insensitivity to the detonation of a neighboring system**

CONFIGURATION	POROUS SHIELD THICKNESS (mm)	FULL-SCALE CALCULATION : PRESSURE ON THE ACCEPTOR 	SUSTAINED SHOCK WAVE GENERATOR	FULL-SCALE TEST
①	**0**	Peak : 160 kbars Duration 2 µs	**No test performed**	**DETONATION**
②	**100**	Peak : 58 kbars Duration 2 µs	**DETONATION**	**DETONATION**
③	**250**	Peak : 37 kbars Duration 20 µs	**NO DETONATION**	**NO DETONATION**
④	**350**	Peak : 20 kbars Duration > 30 µs	**No test performed**	**NO DETONATION**

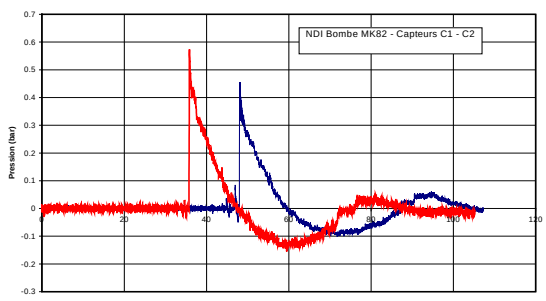
➧ **Discussion:**

- **Threshold value lies between 100 and 250 mm**
- **SME protocol has been exercised with success close to the threshold value**

MK82 LOGISTIC PALLET (3)



Projections cartography



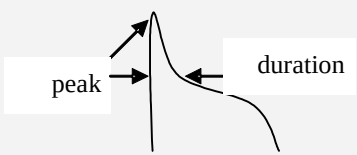
Static pressures (20 and 30 m)

Acceptor warhead and confinement item after test

NO **DETONATION**

MK82 LOGISTIC PALLET (2)

➧ **For shield thickness greater than 250 mm, acceptor weapon has demonstrated insensitivity to the detonation of a neighboring system**

CONFIGURATION	POROUS SHIELD THICKNESS (mm)	FULL-SCALE CALCULATION : PRESSURE ON THE ACCEPTOR 	SUSTAINED SHOCK WAVE GENERATOR	FULL-SCALE TEST
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SUMMARY

Studies performed by EURENCO/SME lead to valuable insight into guarantee safety requirements for MK82 logistic concern.

Outstanding results were supported by :

- The establishment of a protocol to assess at the laboratory scale the pyrotechnical reactivity of PBX, before operating full-scale tests
- The properties of porous concrete shields for shock mitigation
- The low sensitivity of PBXN109/EURENCO, I-RDX® based explosive

CONCLUSIONS

- **SME protocol has been applied with success for shells (120 and 155 mm calibers)**
- **A new program is currently performed to extend and to promote this concept for securing manufacturing processes**
- **Through this program, we developed a sustained shock wave generator that provides an insight for high-explosive ignition studies. Future works must now focus on the extension of conventional reactive models**