Bayern-Chemie

Solid Propellant Rocket Motor, Results of Insensitive Munitions Testing

Abstract # 15940

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MBDA MISSILE SYSTEMS

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Introduction

Bayern-Chemie/BwB IM Study&Research Programme since 2006:

1. Create a knowledge and data base on the IM behaviour of solid propellant rocket motors,

2. Improve and design new rocket-motor specific IM test set-ups/technologies and study the motor behaviour under different IM aggressions,

3. Develop computer models that are able to predict the IM behaviour of solid propellant rocket motors in order to minimize the number of large-scale tests and to reduce motor development costs,

4. Improve the IM characteristics of solid propellant rocket motors by studying the effects of motor design, propellant formulation, burn rates and mitigation.

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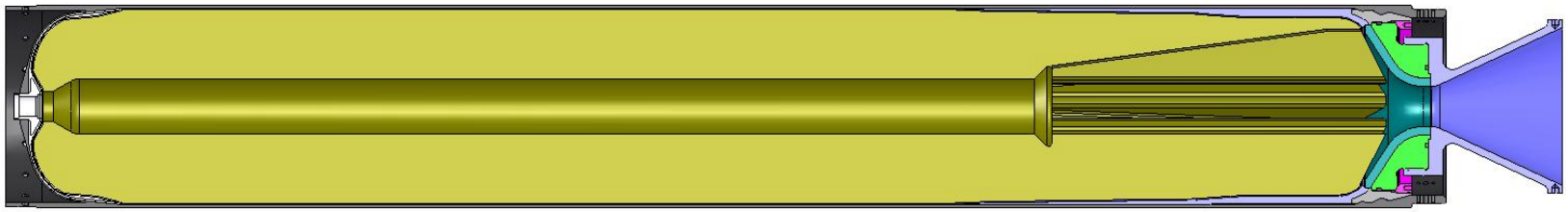
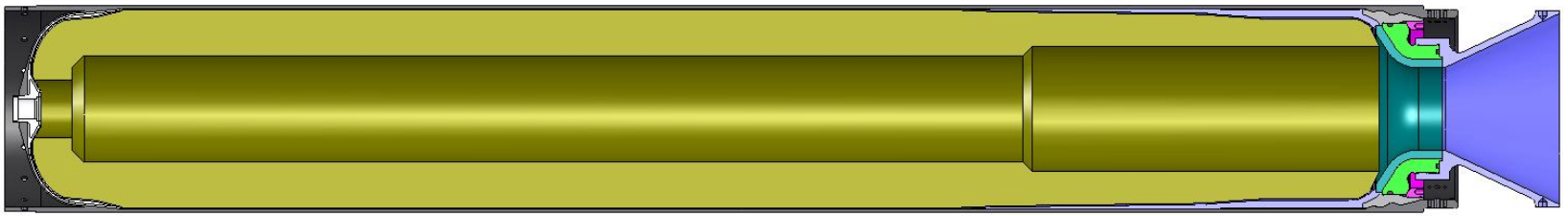
Motor Definition

- Carbon Fibre Composite (CFC) case, 168 mm caliber, 1180 mm length,
- „low“ burn-rate (LBR) propellant (20 mm/s at 100bar, +20°C), mTZ = 32 kg:



- „high“ burn-rate (HBR) propellant (40 mm/s at 100bar, +20°C), mTZ = 24 kg:



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Full Scale Motor IM Tests

IM-Aggression	Number of tests	LBR Motor	HBR Motor	Inert Motor
Bullet Attack	4	1	3	-
Fragment Attack	5	3	2	-
Shaped Charge Attack	2	1	1	-
Fast Heating, wood fire	2	1	1	-
Fast Heating, gas fire	6	3	1	2
Fast Heating, Kerosene fire	4	1	1	2
Slow Heating	7	3	4	-
Total	**30**	**13**	**13**	**4**

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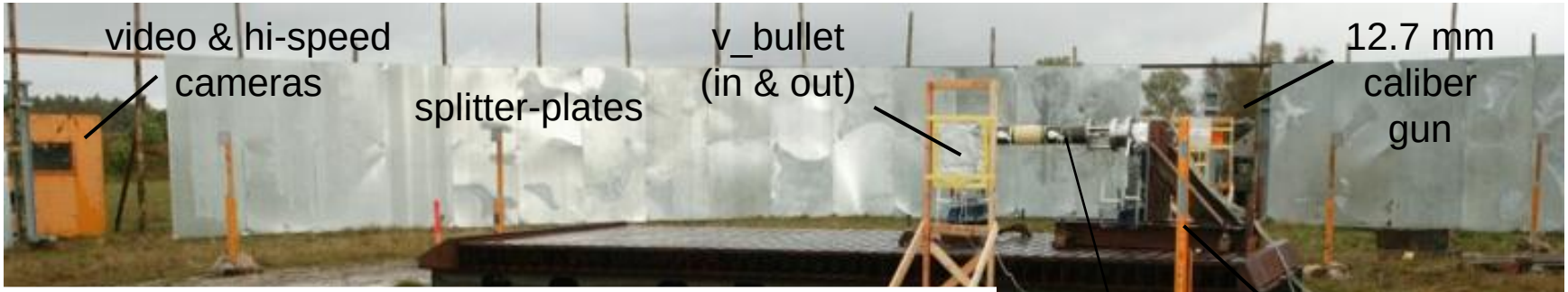
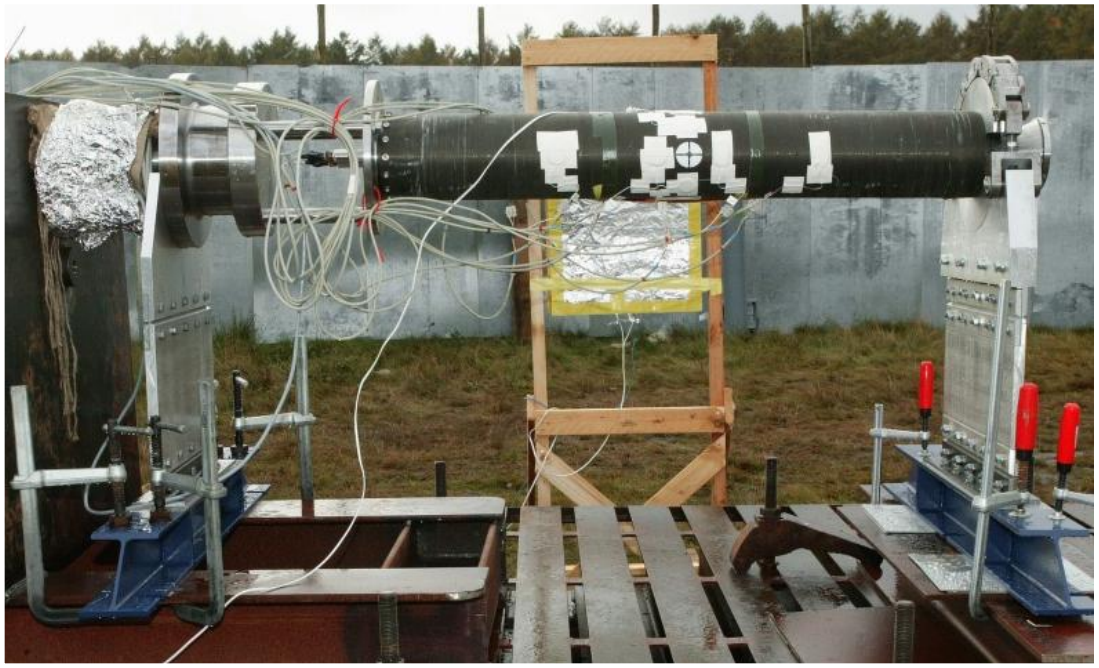
Bullet Attack Test

Test set-up:





Rocket-motor on test stand:
- pressure & thrust measurem.,
- CFC-case with strain gauges.

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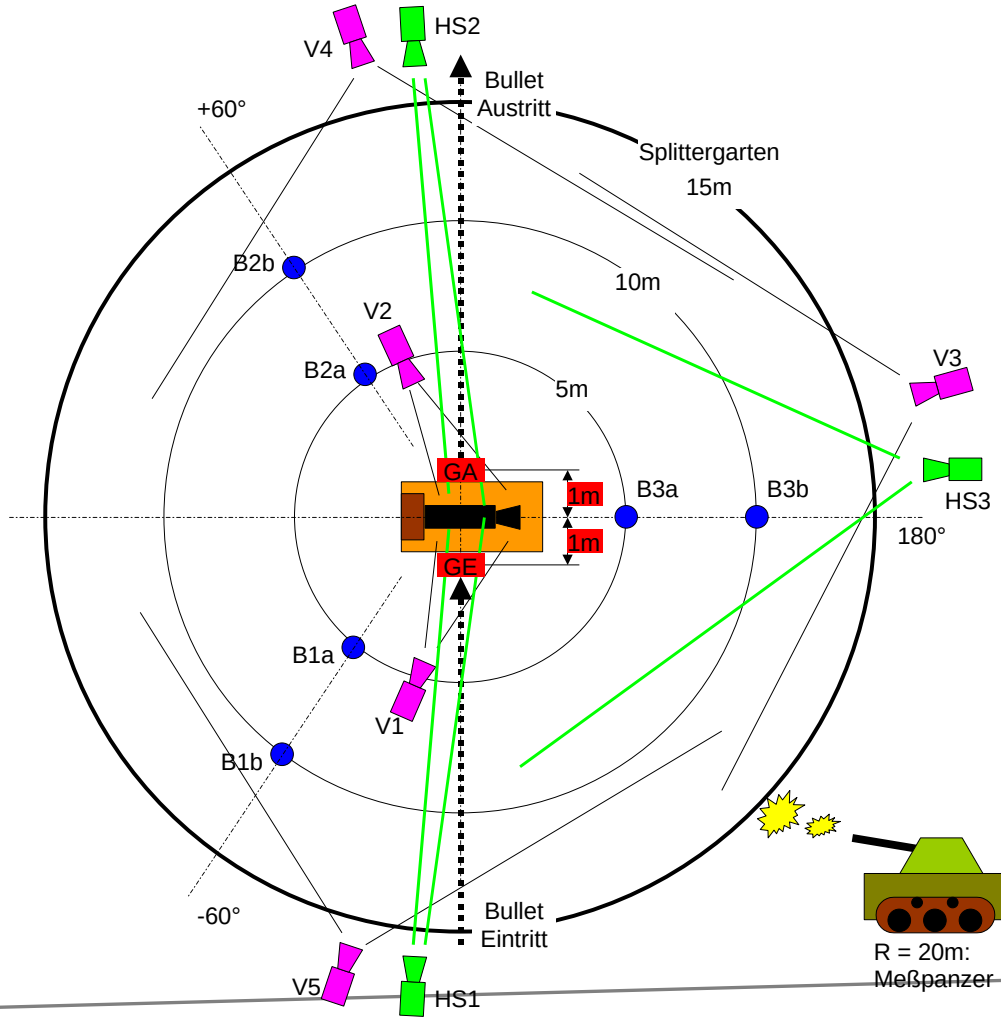
Bullet Attack Test

Instrumentation:



Legende:

- GE — Geschwindigkeitsmessung Geschoßeintritt
- GA — Geschwindigkeitsmessung Geschoßaustritt
- Blastdruckmessung (Sensoren in Höhe der Motormittelachse)
- Videokamera
- Hi-Speed Videokamera

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Bullet Attack Test

Results and „failure“ mechanism:

- target pos.: center of motor
- target size: D = 50 mm
- bullet type: M2 AP-Bullet, 0,5 Zoll
- bullet speed: 810 to 830 m/s (meas.)
  850 ± 20 m/s (requ.)

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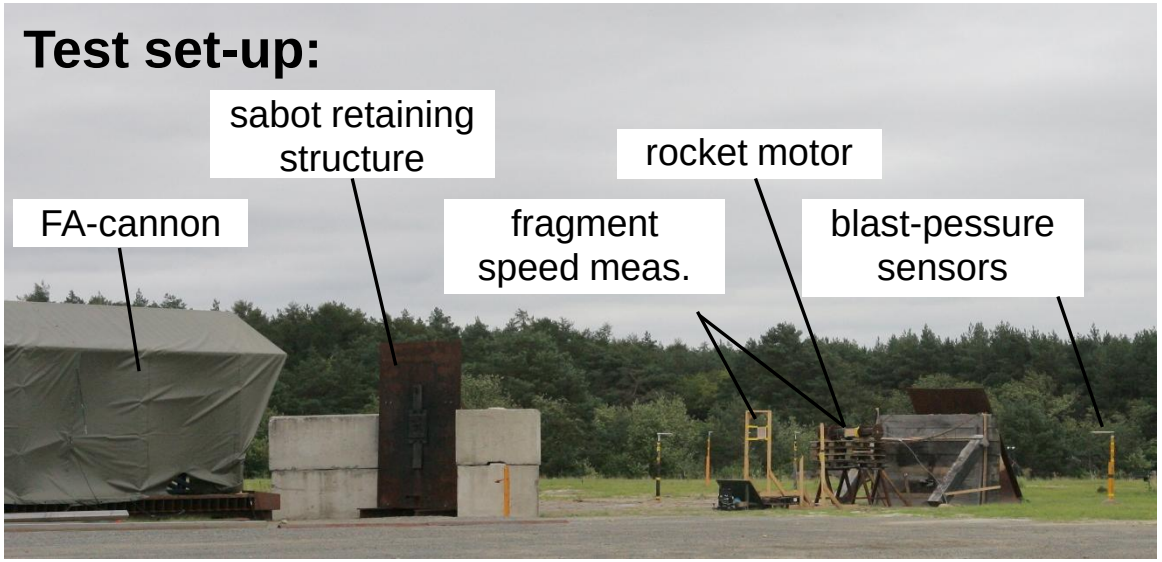
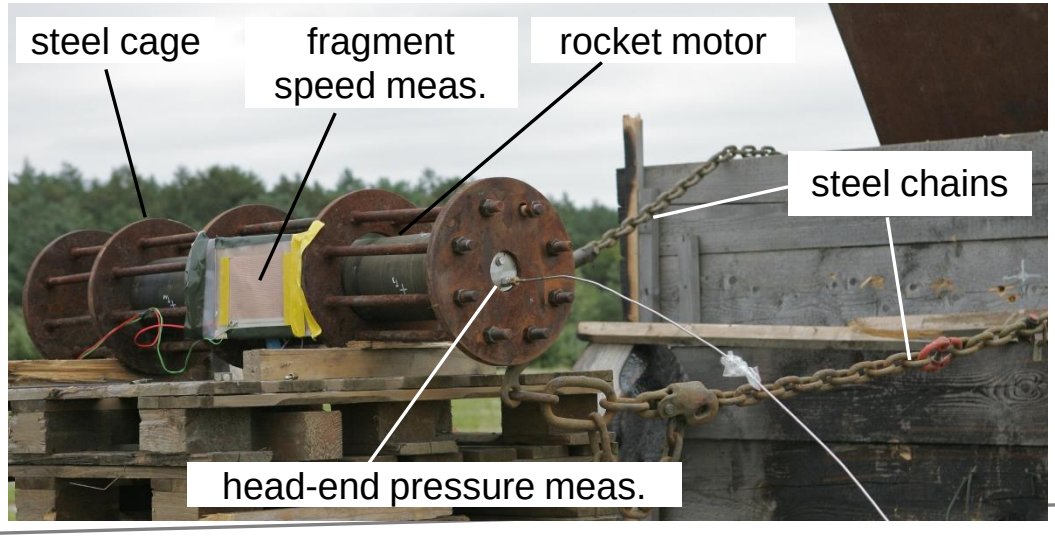
Fragment Attack Test

Test set-up:





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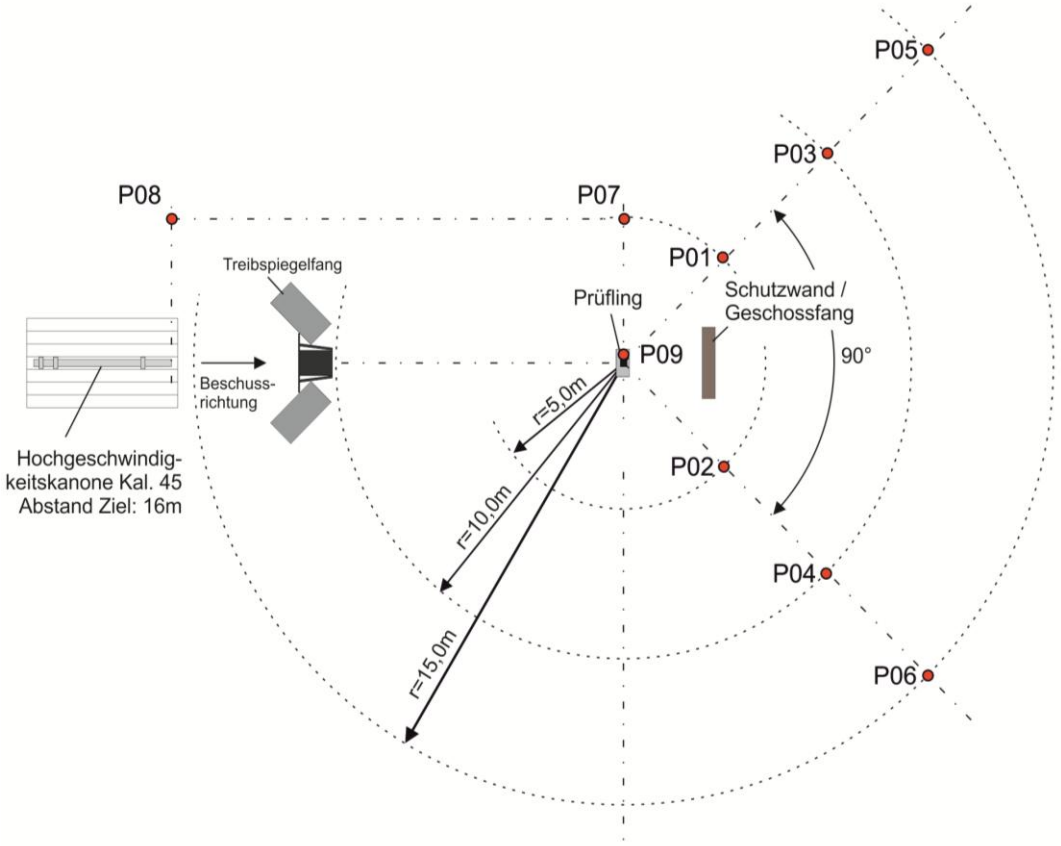
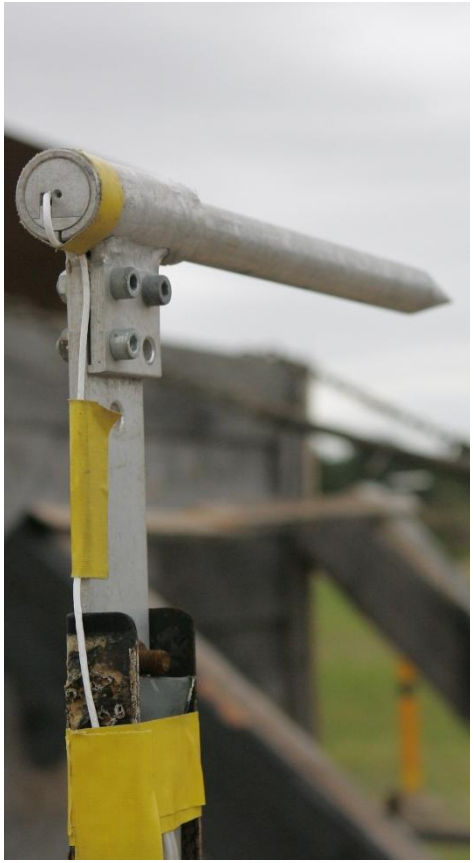
Fragment Attack Test

Instrumentation (blast & motor pressure):





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Fragment Attack Test

- target pos. : center of motor
- fragm. type : 18,1 g standard
- fragm. speed : 2530 ± 90 m/s

Results and „failure“ mechanism:

LBR-motor

HBR-motor

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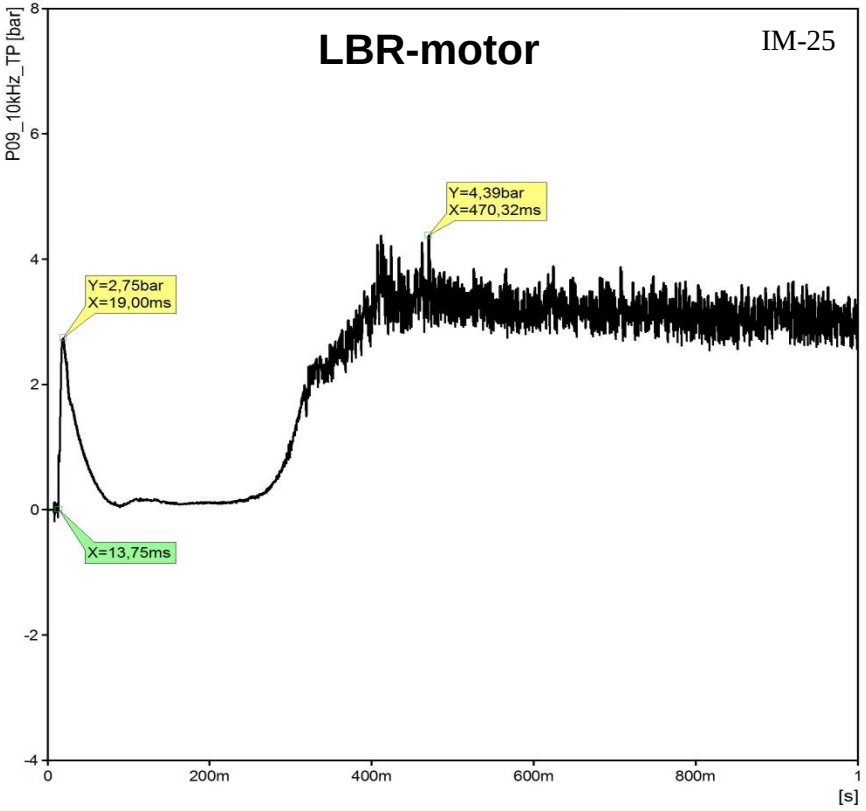
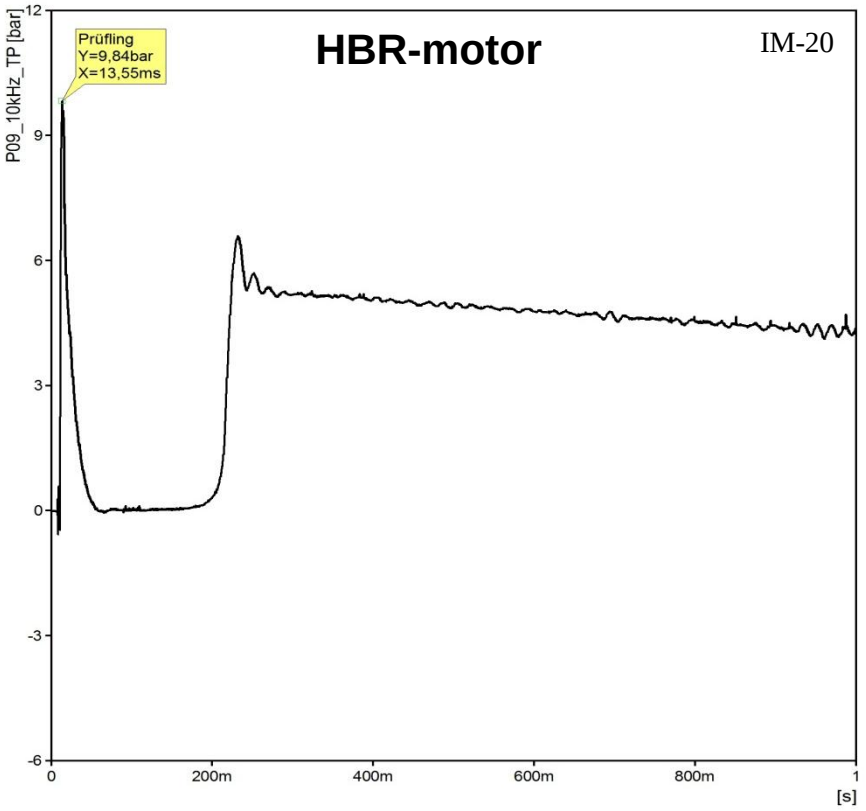
Fragment Attack Test

Measured blast pressures: r = 5 m: 87 to 106 mbar
r = 15 m: 26 to 34 mbar

Evolution of motor head-end pressures:





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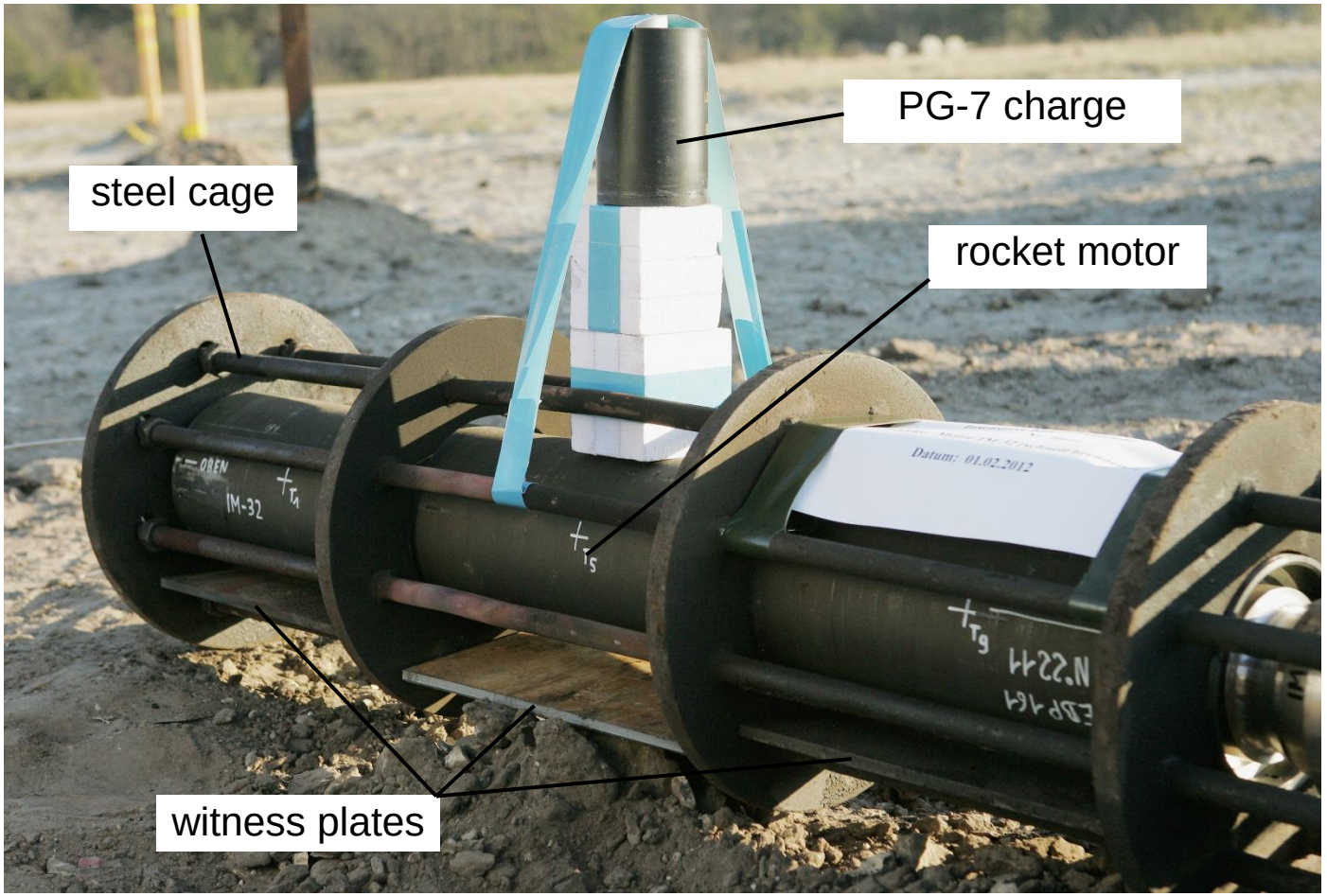
Shaped Charge Attack Test

Test set-up:



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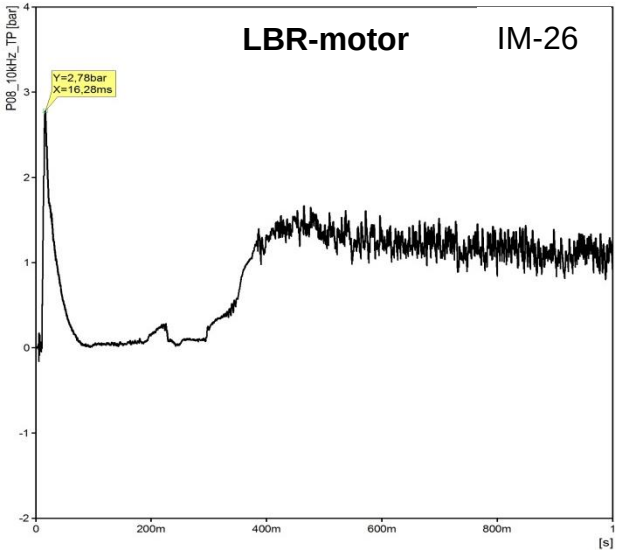
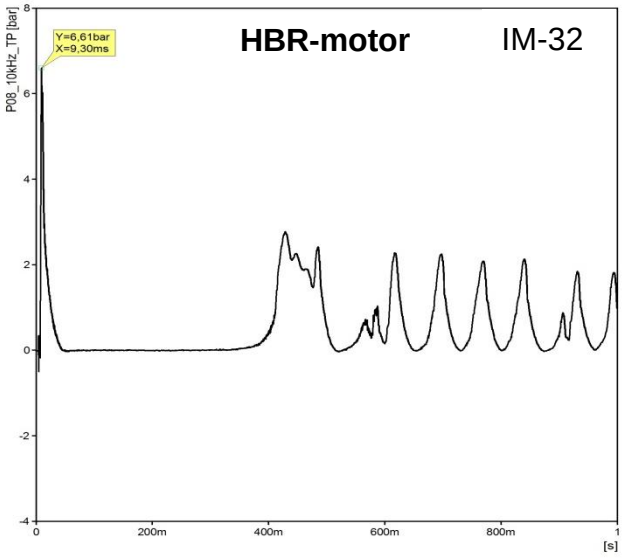
Shaped Charge Attack Test

Results and „failure“ mechanism:

- **Measured blast pressures:**
  r = 5 m: 380 mbar
  r = 15 m: 70 mbar
  Note: Caused by the shaped charge, not a motor reaction!

- **Evolution of motor head-end pressures:**





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Summary & Outlook

1. In all three types of “IM-Attack” tests, namely Bullet, Fragment and Shaped Charge Attack, the tested Carbon Fibre Composite (CFC) case structures showed the same type of failure mechanism characterized by a local destruction of the hoop layers and the loss of structural integrity of the “pressure vessel”.

2. In all attack tests and independent of the burn rate of the investigated Composite propellants the venting of the CFC case caused a favourable and relatively mild IM reaction of “Type IV with formation of thrust”.

3. The Type IV reaction is especially noteworthy in the context of Shaped Charge Attack tests where the measured blast pressures remained far below explosion- or detonation-type levels.

4. In the future, the focus of the IM work of Bayern-Chemie will be on
   - propellant ageing and high/low soak temperature effects in combination with BA, FA and SCA tests and also Fast- and Slow Heating tests,
   - continued small-scale testing such as DSC measurements and modelling of propellant reaction kinetics (e.g., fresh vs. aged material), and
   - The characteristics of Fast Heating Kerosene and Propane-gas fires.