RHEINMETALL DEFENCE

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Charleston, SC

NDIA
National Defense Industrial Association

Design evolution of setback generators – based on the increased demand of energy

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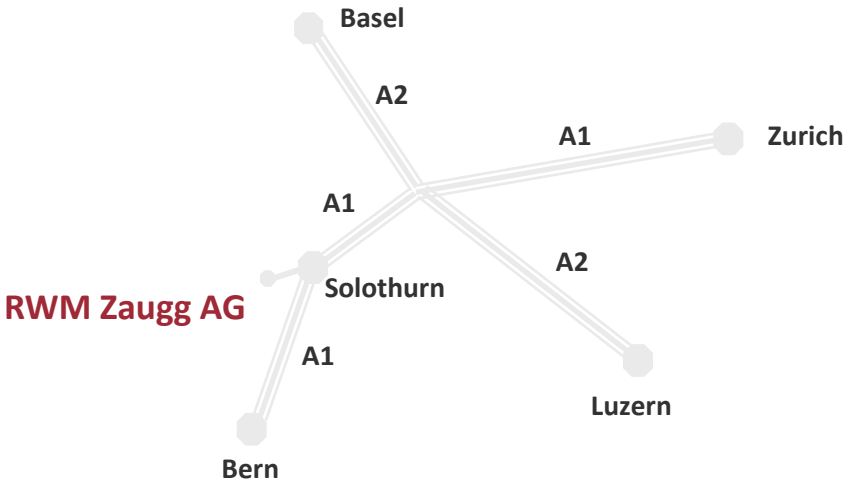
Company history RWM Zaugg AG (Switzerland)

1963	*Company founded by S. & R. Zaugg.* *Location: Derendingen*
1972	*Transformation to a Limited Company.* *Trade name is „Zaugg Elektronik AG“*
1973	*New location Lohn-Ammannsegg*
1995	*Spin-off „Motor control business“* *→ Focus on defense business*
2000	*Acquisition of the fuze division* *from EMS-PATVAG AG*
2001	*Management buy-out*
2007	*Rheinmetall acquires 100% of the company.* *New trade name is “RWM Zaugg AG”*

RWM Zaugg AG, CH-4573 Lohn Ammannsegg, Switzerland

We are located in the Heart of Swiss Watchmakers (Swatch / Breitling / Rolex)



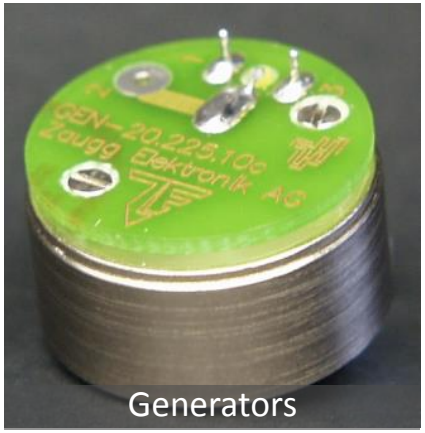
Year of construction:	1973
Floor space:	1‘340m^2
Building volume:	3‘954m^3
Covert area:	2‘000m^2
Expansion land:	1‘954m^2

Portfolio:

- High-g and energy independent fuzes
- Setback Generators
- 40 mm low, medium and high velocity fuzes
- Programmable fuzes
- High-g electronics
- Manufacturing and development competences


Programmable fuzes

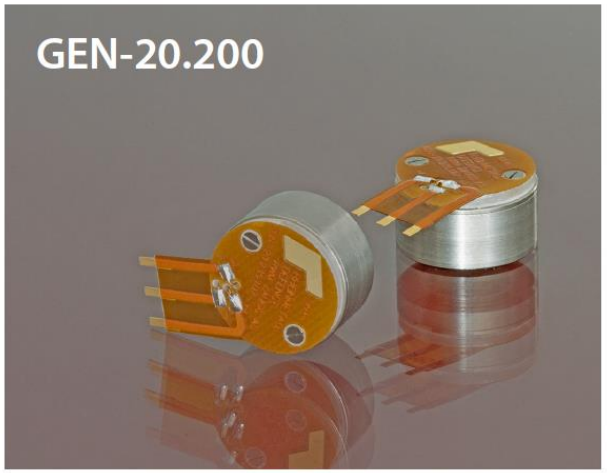
Tank- and Panzerfaust fuzes


Generators

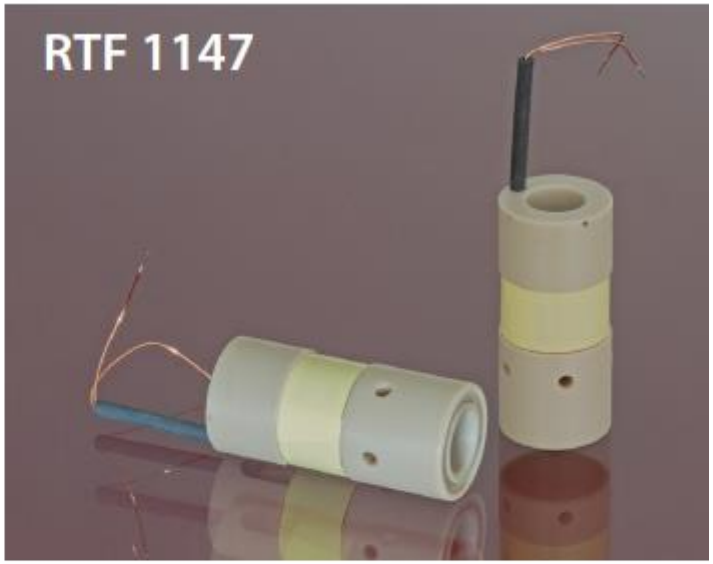

40 mm fuzes

Setback Generators for medium and large calibre

- Medium and high-g applications
- For 30-35 mm, 40 mm and 120 mm calibre
- High energy content
- No additional energy source required



Setback Generators

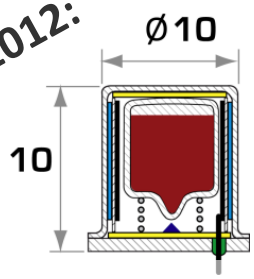


Specifications of Zaugg Set-Back Generators:

Characteristics	GEN-15.200	GEN-20.200	VELAN.270	RTF 1147
Maximum voltage [V]:	25	15 / 60	15	16
Temperature range [°C]:	-54 till +71	-46 till +63	-46 till +63	-32 till 63
Maximum energy [mJ]:	9.4	6.53	7.65	8.7
Size [mm]:	Ø 15.05 x 8.43 (15.63)	Ø 19.55 (29.8) x 12.05	Ø 10.9 x 20.8	Ø 11.9 x 26
Weight [g]:	7.156	15.62	3.38	6.6
Electrical interface:	Storage capacitor: 30 µF	Storage capacitors: 5.25 µF / 3.3µF	Storage capacitor: 68 µF	s
Mechanical interface:	Ø 6.4 mm	Ø 6.4 mm	none	none
Functional parameters:	Requested	≥ 13000 g	≥ 700 g	≥ 13'000 g
Typical applications	Customer specific	Customer specific	40mm infantery	120m tank

Need for Energy constantly claimed !

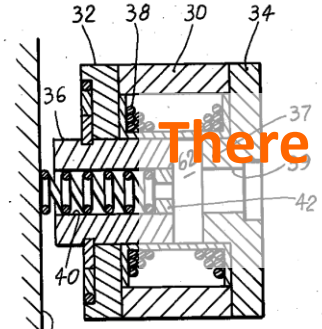
O. Clesca, Fuze Conf. 2012:
20J Battery



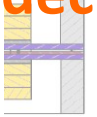
S.H. Yoon, 2005

There is a constant need for small Energy Power Systems !

There is decreasing energy consumption due to increase of low consuming electronics !

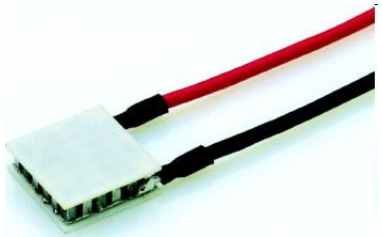


US-Patent



H. Wich, Energy Source Conf. 2014: Alternative Energy source 50-100mJ range

Fuze Conf. 2014:
„Quo Vadis Fuze (Power) ?“



A look back in ´history:

Energy sources (1977)

- low energy requirements
  - Induction - **pulse** or rotation generator
  - Piezo – pulse or rotation generator
- high energy requirements
  - Rotating generators
    Wind, airstream
  - Batteries
    with an without self-activation

From: „Handbook on Weaponry“, Rheinmetall 1977

(Capacitors Used only for load accumulation)

What is used until today ? Has something changed ?

Reserve Battery

Medium Primary Cell

Setback Generator (electromagnetic)

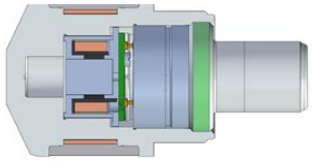
Piezo Setback Generator

Wind-Generators

→ **No ! All items mentioned in the handbock from 1980 are unchanged ! No new technologies in service.**

→ **New technologies had been worked in that decades.**
A lot of them could not be applied due to the severe environmental requirements of fuzes
or they are yet not ready for industrialization

A Renaissance for setback generators ?



Technical parameters of setback generators

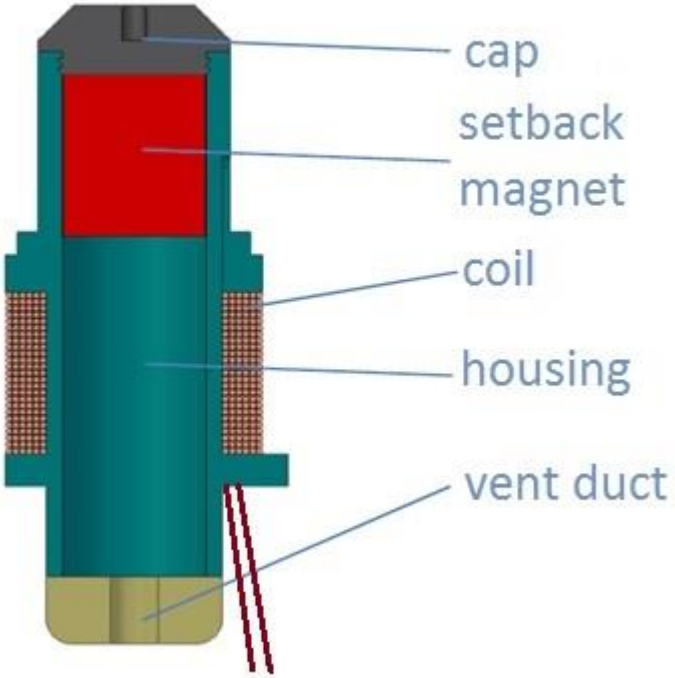
- Energy densitiy generator: <10mJ — As high as needed by electronics, sensors, ignition; setback No system known about 10mJ ! Typical: 2-3 mJ
- Space requirements — As low as possible, disadvantage: High dead volume due to displacement of magnet
- Activation mechanism — Why ? → Stanag: No „stored Energy“ → Activated by setback, advantage: reliable, disadvantage dependent on acceleration curve
- Duration of supply — energy should be provided for typical combat distances, disadvantage: energy is supplied by a short pulse -> energy storage (capacitor) is needed
- Hardness against environmental stress (esp. shock) can relative eaily be achieved
- System Safety — System Safety must not be reduced by energy source
- Maintainability — not necessary – infinitive lifetime
- Costs and availability — definitively no off the shelf product – high IPR level requ.

→ Setback Technology still provides valuable benfits !

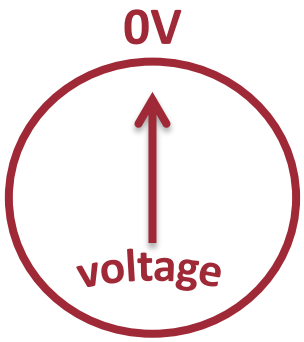
Design evolution of setback generators

Function principle of a setback generator

$$U(t) \sim -\frac{d\Phi}{dt} \sim vmag$$

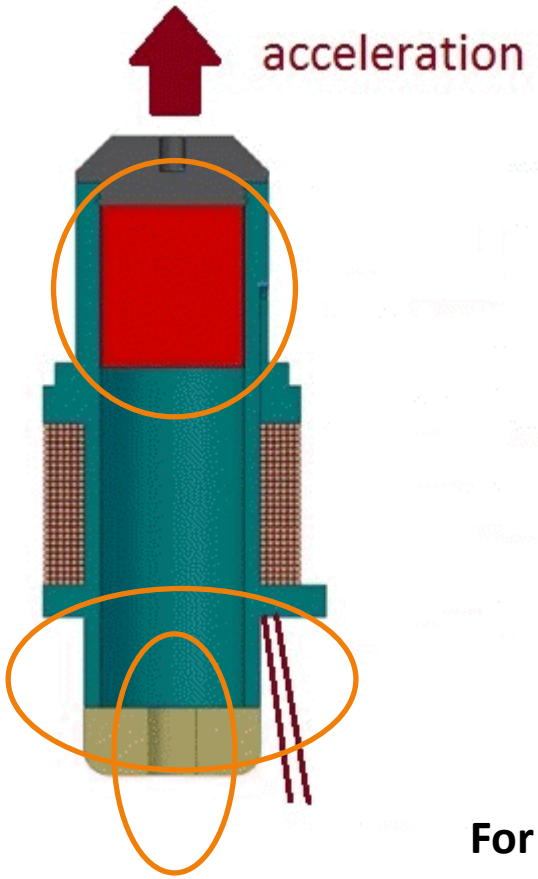


Static state: Setback magnet is hold by magnetic force.



Design evolution of setback generators

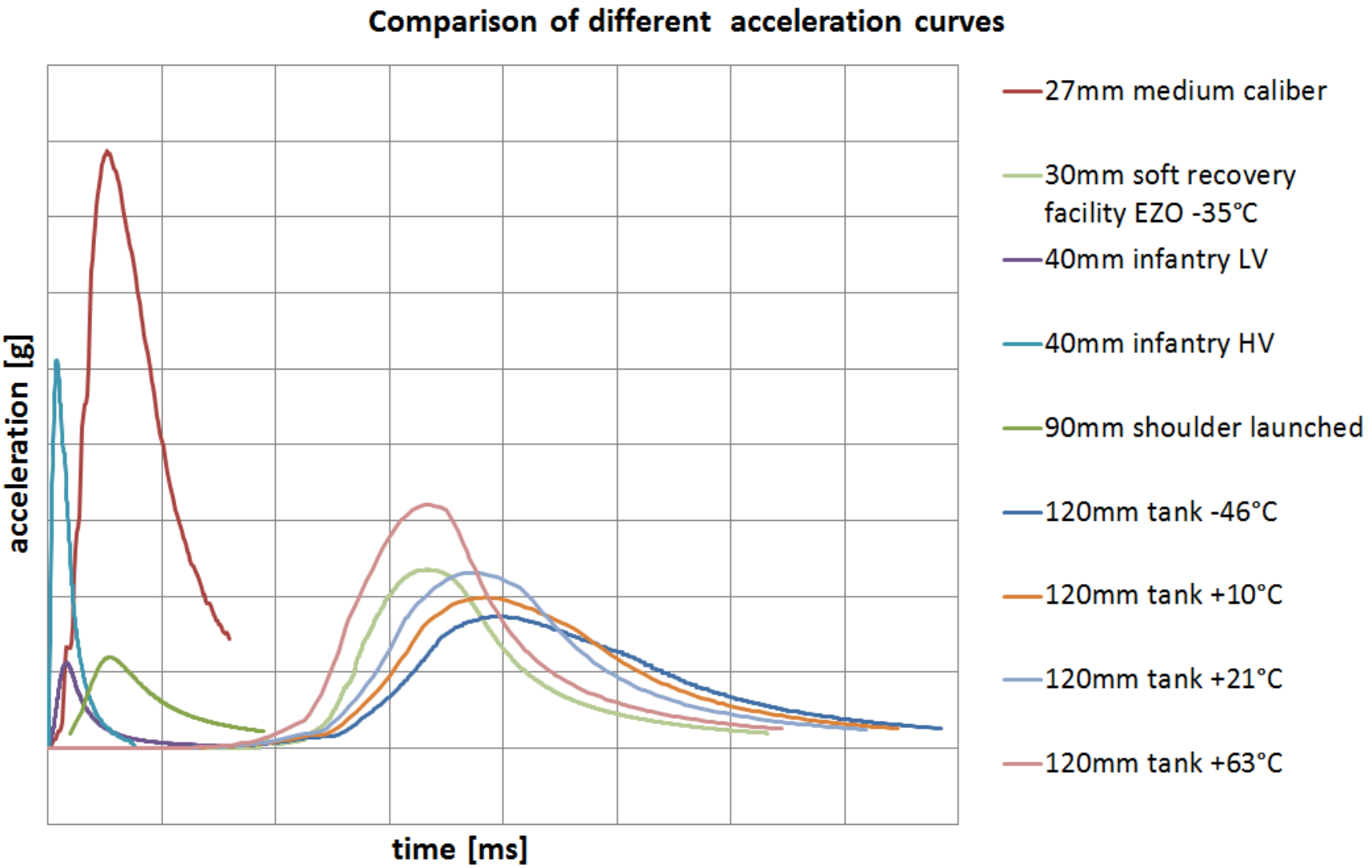
Question: How can the achieve an optimization ?



- Travel path of the magnet can be increased! In the example the magnet stops before leaving the coil completely.
- Vent duct in cap to avoid any low pressure area which retards movement of setback magnet. In the example there is only a vent duct at the end.
- Holding mechanism/retention force of setback magnet to be adapted to expected acceleration. In the example the setback magnet is hold by magnetic force.
- Adaptation of the electric circuit for storing an optimized amount of energy in the capacitors

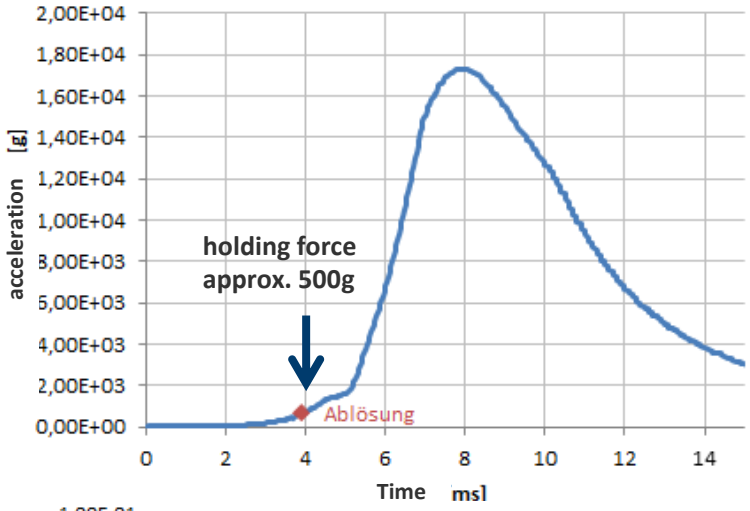
For these optimization items methods and tools were developed.

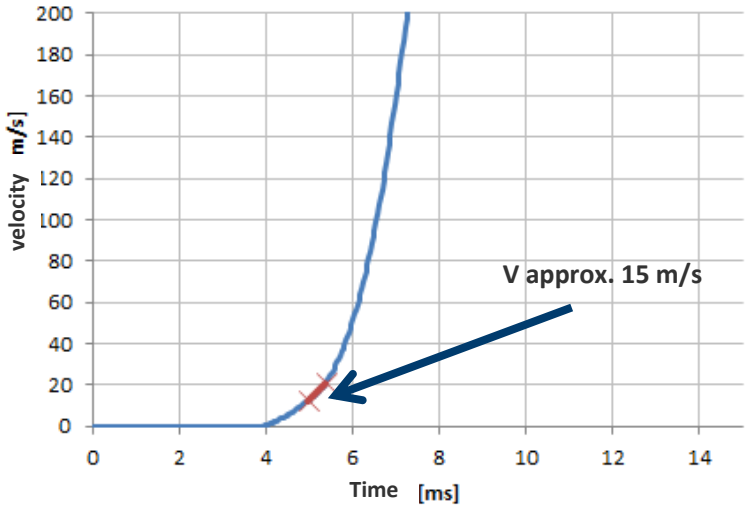
Design evolution of setback generators

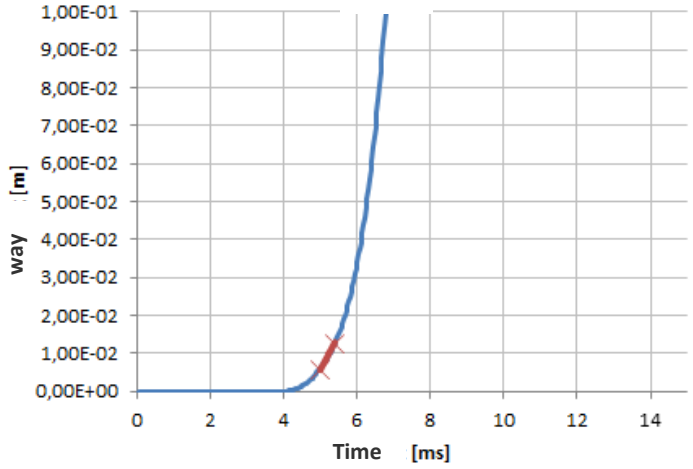


Example setback generator RTF1147 tank fuze

Energy concept: use of an specifically optimized set-back generator

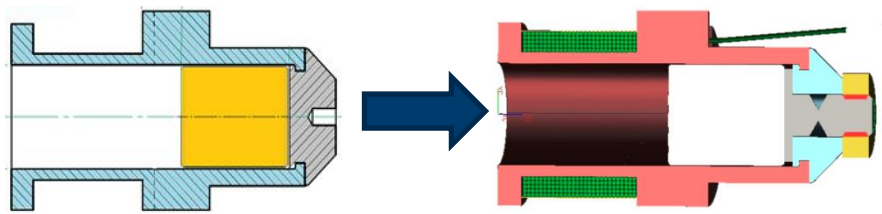






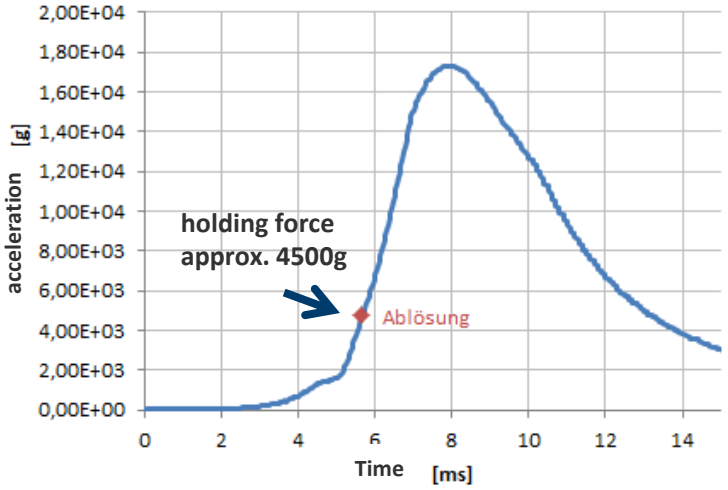
With respect to the acceleration, inertia and the rate of time distance equations the voltage achieved from a munition with shown acceleration curves is too low.

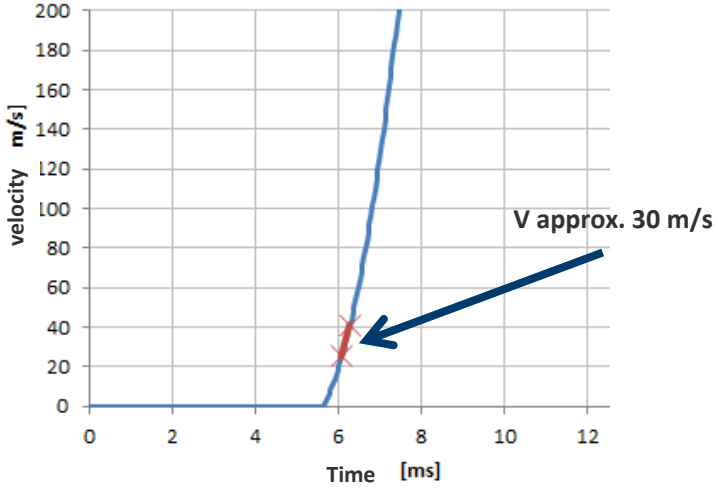
-> Optimization is necessary: Lift of holding force of magnet can bring desired effect



Optimization Setback Generator

- Significant increase of holding force by crash pin (safety bolt)
- Tool for design and calculation of setback generators was created
- Modified setback generator continuously tested in self financed development program with support of EMI and EZO





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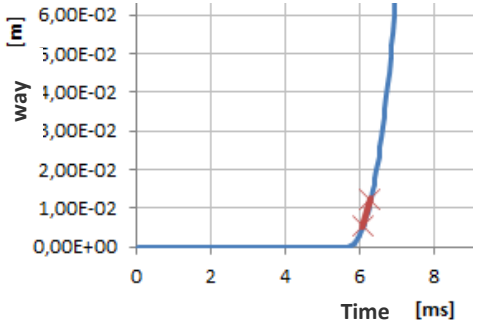
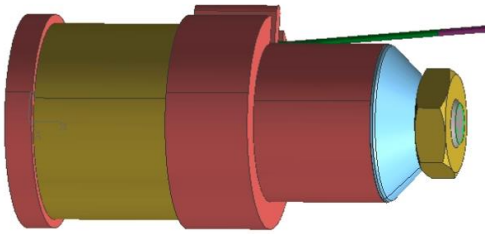


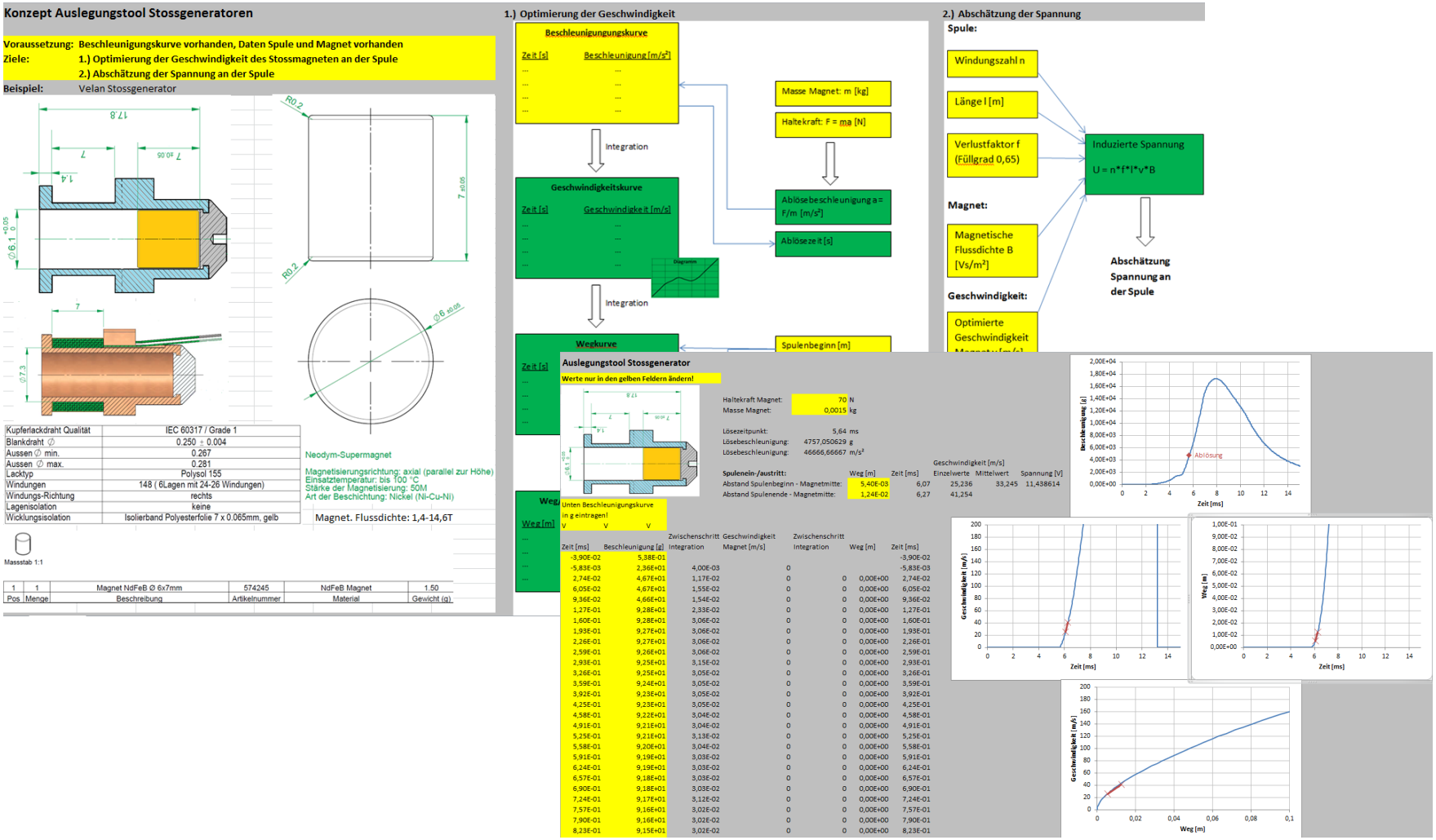


Modified setback generator

Modified magnet with holding screw

Development tools for setback generators

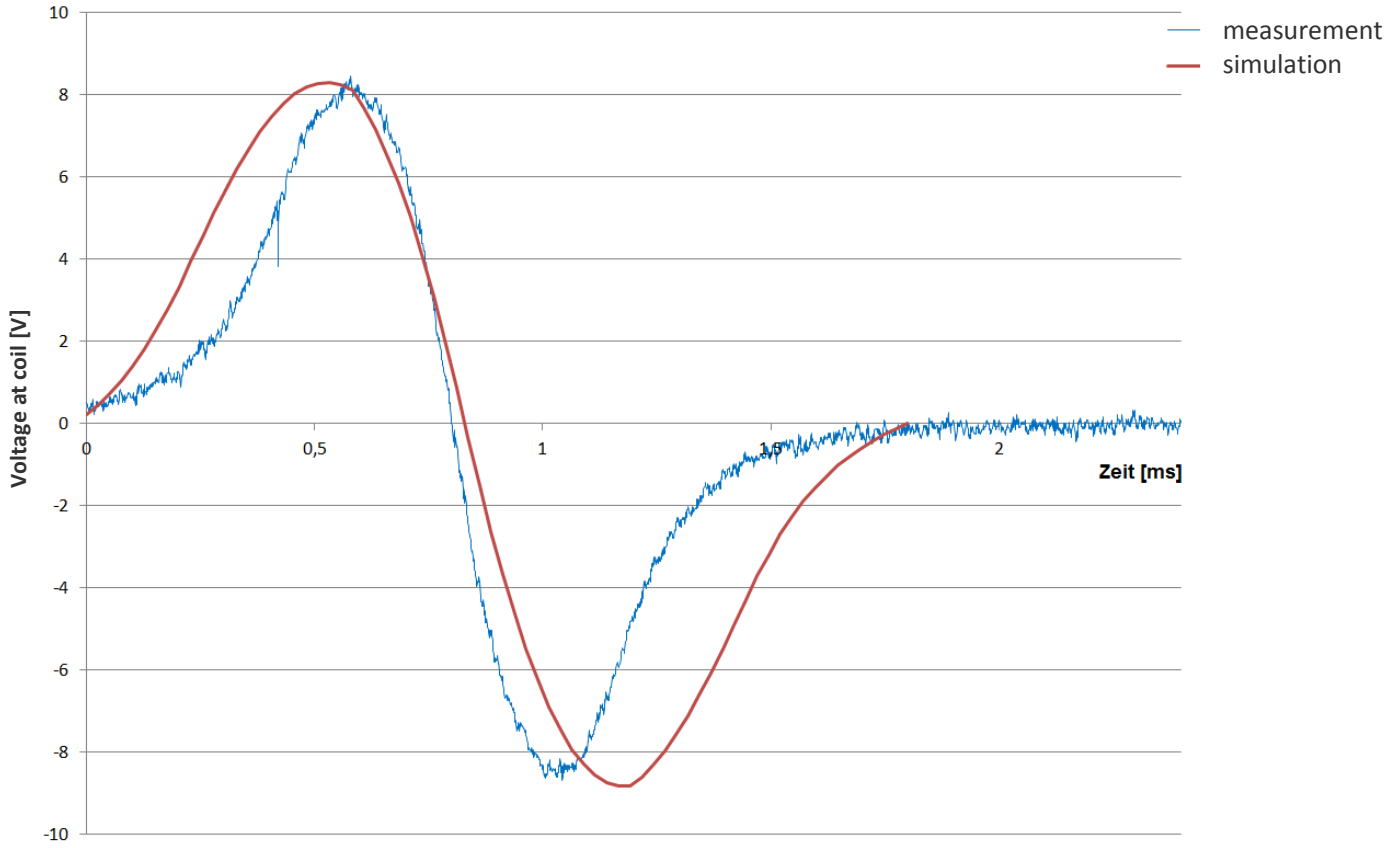
Ability to simulate design effects on setback generators **enabled quick technology push in actual running activities/projects** → easy software tool on Excel basis !



Measurements & Results

Comparision of measurements and simulation results

- small phaser shift can be observed
- amplitudes relate verv well



Result

→ An energy amount between 7-9 mJ were reached and validated under real firing.

(up to 150% more)

This is remarkable !

Summary

- Chosing or adapting any setback generator off-the-shelf only in order to fit the actual fuze design is not sufficient

- In order to obtain an optimized energy output, setback generators must be adapted to the application in relation to
  - accelaration during firing (Input)
  - Voltage Output
  - optimal design

- Tools were created to optimize these parameters with regard to the application

- Setback generators are still a viable power source for a many fuze applications

Thank you very much for your attention !

POC

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