
SAFETY PROPERTIES OF „SEA AGED“ EXPLOSIVES

International Symposium for sea-dumped munition and UXO

May, 2nd – 4th 2018, Berlin

Armin Keßler

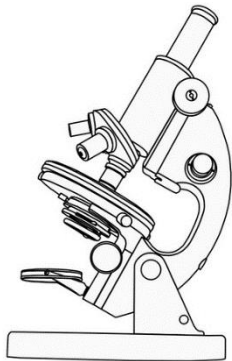


AGEING EFFECTS

Definition: „Changes in structure, composition or properties by natural or artificial ageing“ ^[1]

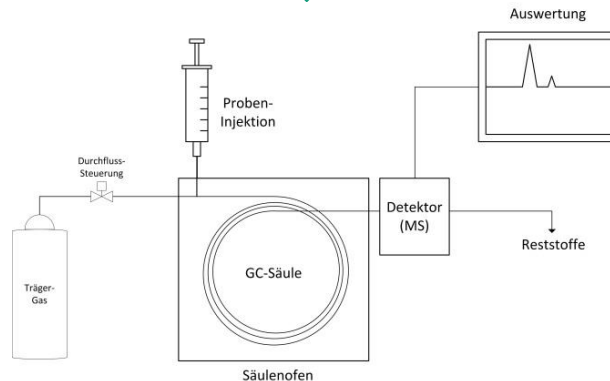
Structure

- Inner (crystalline) structure



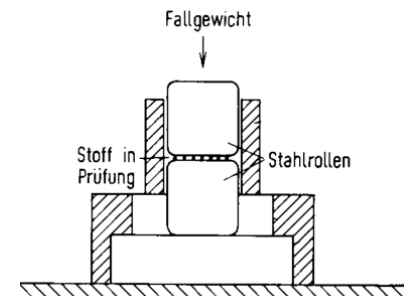
Composition

- Type and amount of components in a mixture



Properties

- Essential characteristics

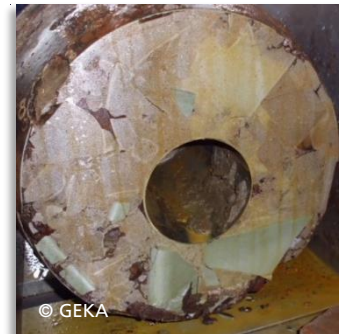


[1] Duden; URL: <https://www.duden.de/rechtschreibung/Alterung> (abgerufen am 02.02.2018)

„SEA AGEING“ EFFECT ON THE MATERIAL

Literature:	Visual appearance	Sensitiveness against impact [Nm]	Solubility in Water at 20°C [g/l] ^[1]
2,4,6-Trinitrotoluol	Slightly yellowish crystals	15	0,127
2,4-Dinitrotoluol	Yellowish needles	50	0,27
2,4,6,2',4',6'-Hexanitrodiphenylamin	Canary yellow crystal powder	7,4	<< 0,1
Ammoniumnitrat	Colourless crystals	49	1877

Reality:



[1] IFA – Gefahrstoffinformationssystem der Deutschen Gesetzlichen Unfallversicherung (GESTIS-Stoffdatenbank)

„SEA AGEING“

VARIOUS POSSIBLE CAUSES

- Autocatalytic decomposition reactions
 - Decomposition to other nitroaromatic compositions by:
 - Bacteria
 - Fungi
 - (Micro-) Algae
 - Mechanical / physical modification by:
 - Environmental influences
 - Washing out
 - Grinding
- ➡ In general: increase of specific surface
- And others...

„SEA AGEING“

WHAT CHANGED OVER THE YEARS?

→ Everything!

- **Structure & Composition**

- Investigation REM, XRD, IC

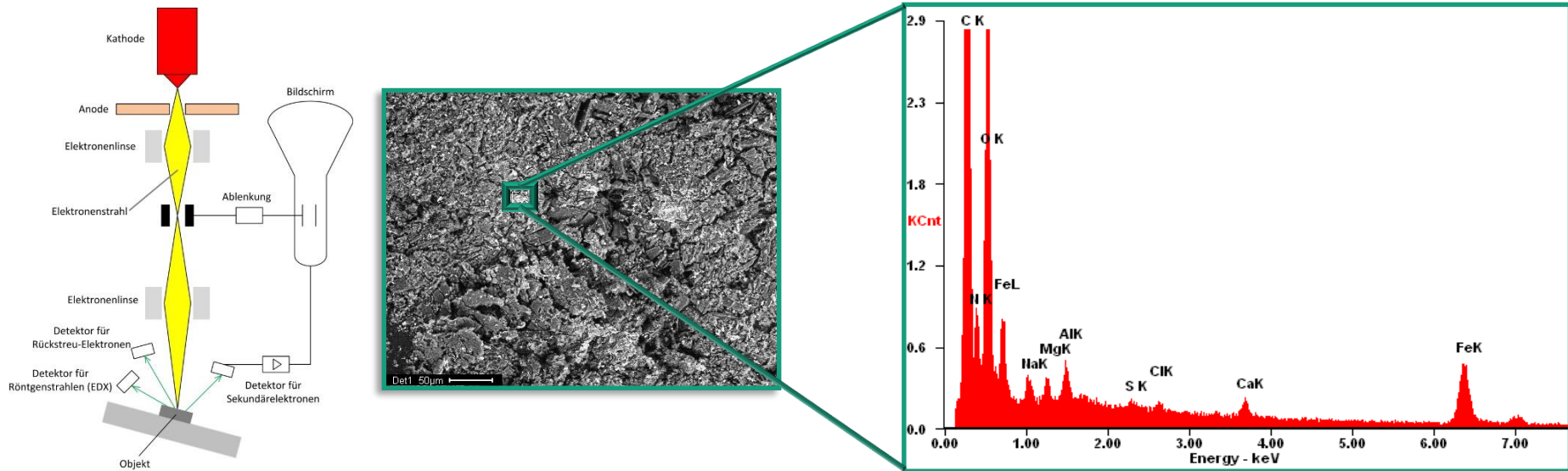
- **Characteristic Safety properties** of HE samples

- Sensitiveness to impact and friction
 - Storage Stability
 - Artificial ageing

STRUCTURE & COMPOSITION

REM / EDX

Raster Elektronen Microscopy with Electron Diffraction X-Ray

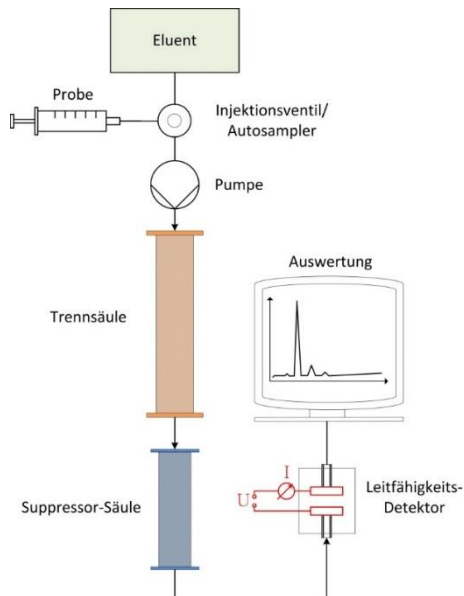


→ Local **microstructure & topography** and local **species distribution**

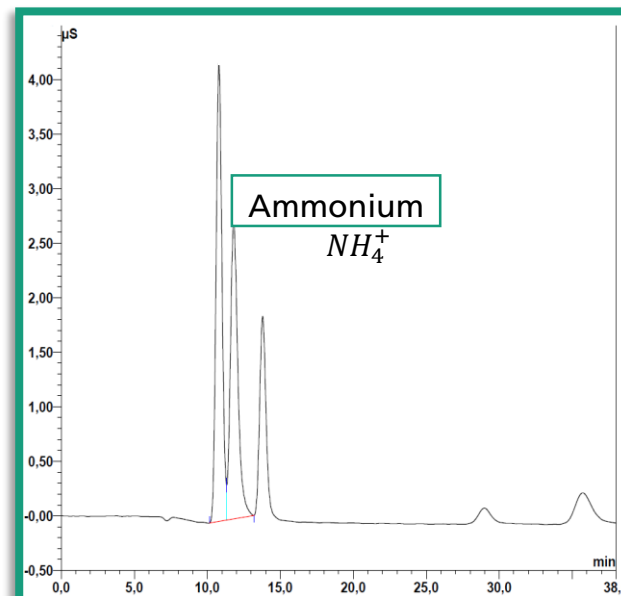
Example: german „Schießwolle 39“ investigation

STRUCTURE & COMPOSITION IC

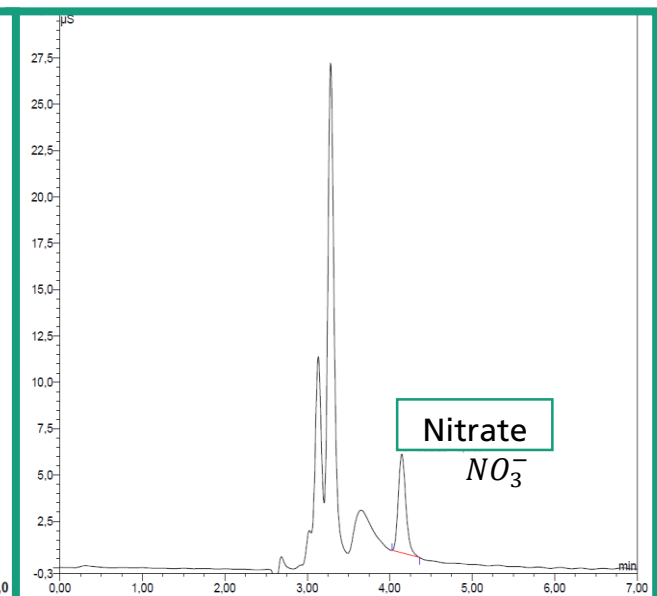
Ion Chromatography



Cation detection



Anion detection



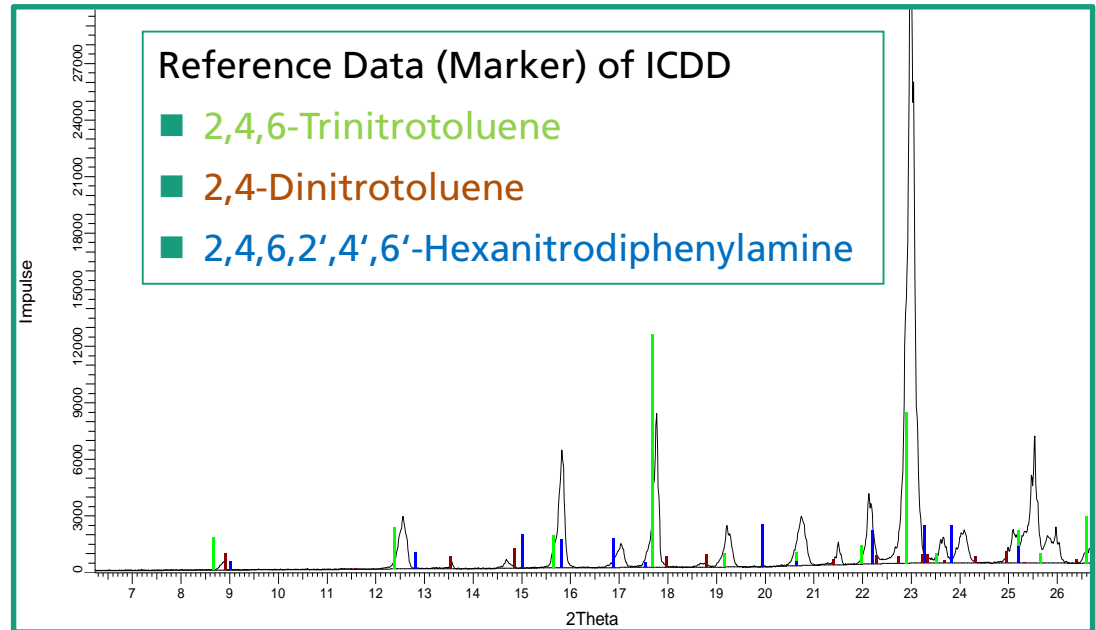
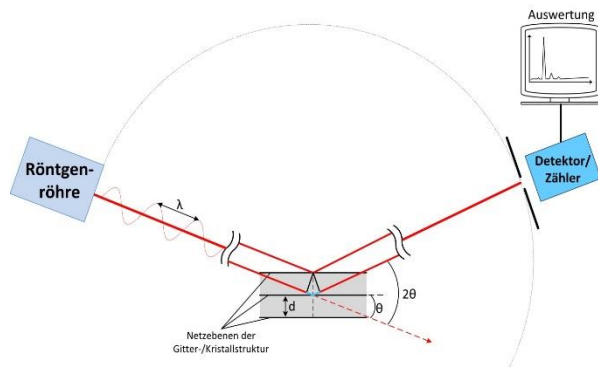
→ Analytical **separation of mixtures** of substances

Example: Torpedo warhead sample finding: Ammonium nitrate percentage: 0,1 %_{Mass}

STRUCTURE & COMPOSITION

XRD

X-Ray Diffraction



→ Identification of substances by means of their crystalline structure

Example: german „Schießwolle 39“ components

STRUCTURE & COMPOSITION INVESTIGATIONS - WHY?

Provide information on

- Real compositions
 - Percentages
 - Additional components
 - Range of variations

- HE sample conditions
 - Decomposition state

→ Understanding processes – basis for disposal process design

PROPERTIES

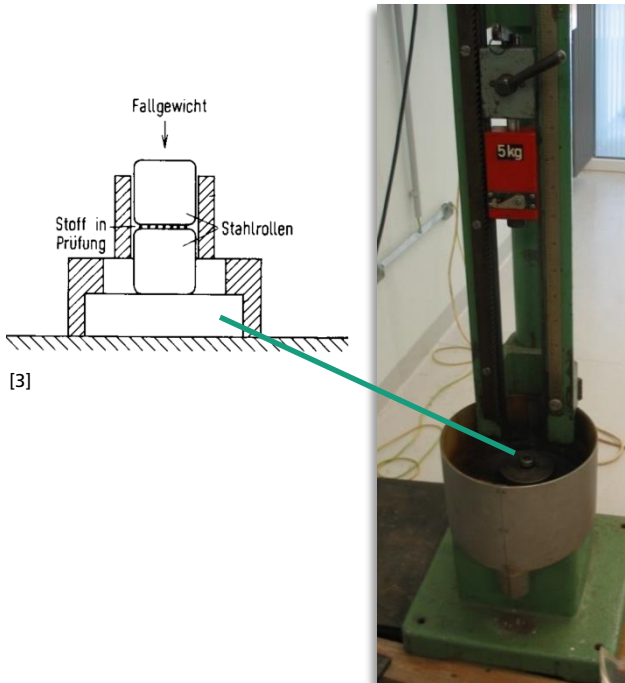
SAFETY-RELATED CHARACTERISTIC DATA

- BAM impact and friction apparatus
 - Sensitiveness against impact and friction
- Stability – max. storage time forecast
 - Artificial ageing (Holland-Test)
- „Characteristic sample“ problem
 - Where to take representative samples?
- ... and many more:
 - Shock sensitivity (modified gap test)
 - Velocity of detonation
 - Detonation propagation
 - Performance test (Plate dent)
 - Thermal impact (Koenen Test, Cook-off Test)
 - Autoignition temperatures
 - Heat of explosion
 - Thermoanalytics (DSC / TG)



© GEKA

BAM IMPACT APPARATUS GRAVITY DROP HAMMER



[2]

[2] Fraunhofer ICT – BAM - Fallhammer

[3] BAM – Empfehlungen für die Beförderung gefährlicher Güter:
Handbuch über Prüfungen und Kriterien (2015)

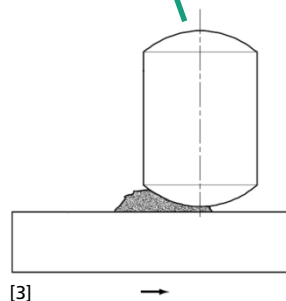
[4] Köhler; Meyer; Homburg: Explosivstoffe (2008)

	Sensitiveness against impact [Nm] ^[4]
Trinitrotoluene	15
Hexogen	7,4
PETN	3
Lead azide	2,5 - 4
Not sensitive	> 40
Sensitive	4 – 40
Very sensitive	< 4

BAM FRICTION APPARATUS



[5]

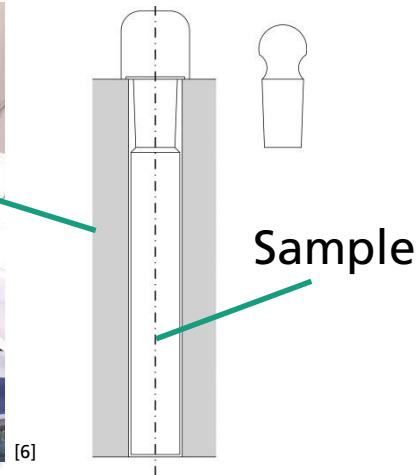


[3]

	Sensitiveness against friction [N] ^[4]
Trinitrotoluene	360
Hexogen	120
PETN	60
Lead azide	0,1 - 1
Not sensitive	> 360
Sensitive	80 - 360
Very sensitive	10 - 80

[5] Fraunhofer ICT – BAM - Reibapparat

ARTIFICIAL AGEING „HOLLAND” - TEST



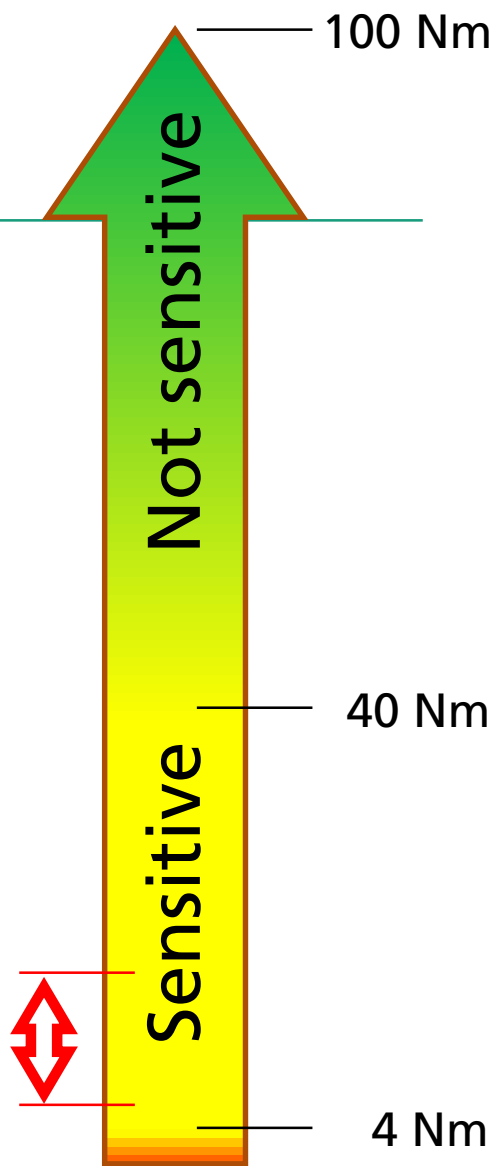
- Elevated temperature storage at 105°C / 110°C (single / double base)
 - 8h open + 64h loosely closed storage time
- Loss-in-weight measurement principle
 - Storage stability criterion: $\Delta m = m_{72h} - m_{8h} \leq 2\%$

→ Storage and service lifetime prediction

[6] Fraunhofer ICT – Holland-Test-Ofen

CONCLUSIONS

- bad statistics so far – too few samples, but:
- Strongly increased impact sensitivity (6...25Nm)
 - 6 Nm means \approx 5kg weight out of 12cm on 1cm²
- No loss of brisance and performance
- No indication for increased friction sensitivity
 - >360N (so far!)
- Large composition variation:
 - TNT content up to 155%
 - Hexyl up to 300%
- Decreased autoignition temperatures
- Stability values 6...48 months
 - According to Fh-ICT bunker storage stability rules



INVESTIGATED SAMPLES FROM PROJECT ROBEMM-SIMSE

■ Funding body

Gefördert durch:



aufgrund eines Beschlusses
des Deutschen Bundestages

■ Partner:



UNIVERSITÄT
LEIPZIG

Infrastruktur
Ressourcenmanagement

PUBLIC RELATIONS WORK

- Presentation of RoBEMM project at Hannover Fair 2018
 - Introduction to problem
 - RoBEMM approach / Link to UDEMM
 - Robotic Underwater salvage and disposal process with the technology to remove explosive ordnance in the sea

- Fraunhofer ICT responsibility: **process safety**
 - UXO handling and disassembly process
 - Offshore disposal process design