



## ITF ENHANCING HUMAN SECURITY

# RASR The Regional Approach to Stockpile Reduction

10th RASR Workshop of Regional Approach to Stockpile Reduction (RASR) of Conventional Weapons and Munitions  
9-11 October 2018,  
**Tirana/Albania**



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# Outline

- Introduction to ITF
  - PSSM
  - Demilitarization
- Environmental aspects of Ammunitions & Explosives:
  - In the process of production / processing
  - Formal production facilities
  - In use
  - UEMS
  - Demilitarization
- Recommendation

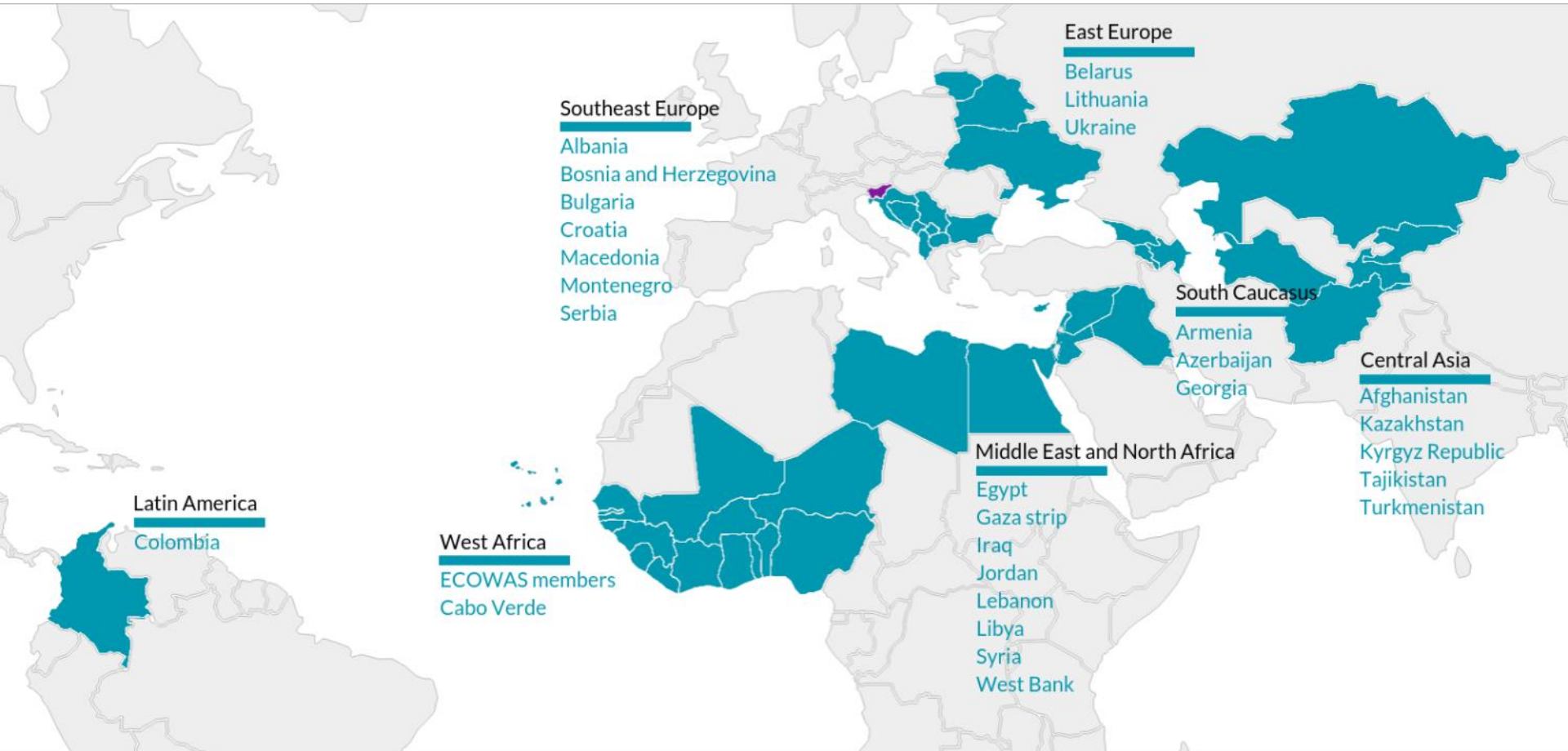
# ITF Background



- Established by the Government of the Republic of Slovenia in March 1998.
- Humanitarian, non-profit organization with headquarters at Ig, Slovenia.
- Initially operating in Bosnia and Herzegovina, later in other countries of SE Europe – support for implementation of demining projects and assistance to mine victims.
- Over the years ITF developed and expanded the scope of substantive and geographic areas of operation.



# Geographical Area of ITF Operations



## Latin America

Colombia

## Southeast Europe

Albania  
Bosnia and Herzegovina  
Bulgaria  
Croatia  
Macedonia  
Montenegro  
Serbia

## East Europe

Belarus  
Lithuania  
Ukraine

## West Africa

ECOWAS members  
Cabo Verde

## Middle East and North Africa

Egypt  
Gaza strip  
Iraq  
Jordan  
Lebanon  
Libya  
Syria  
West Bank

## South Caucasus

Armenia  
Azerbaijan  
Georgia

## Central Asia

Afghanistan  
Kazakhstan  
Kyrgyz Republic  
Tajikistan  
Turkmenistan

# Financing



**436,326,178.60**

United States dollars (USD)

managing over 3,100 programs and projects.

- More than 400 donors; 31 State donors
  1. United States of America (207 million USD)
  2. Norway (58 million USD)
  3. Germany (34 million USD)
  4. Slovenia (14 million USD)
  5. Canada (11 million USD)

# Physical security and stockpile management of weapons and ammunition

- **Croatia**

Five ammunition storage facilities have been renovated (4 x MOD, 1 x MOI), two are in the process of renovation,

- **Kyrgyzstan**

Two storage buildings are at the final stage of renovation,

# Physical security and stockpile management of weapons and ammunition



From basic ammunition  
storage renovation

To high tech multi-sensors  
integration system



## Destruction of surplus weapons and ammunition

- Over 1,300,000 items of excesses ammunition have been destroyed in Albania, Bosnia and Herzegovina, Montenegro, Croatia, Lithuania and Kyrgyz Republic.

## Urgent response to unplanned explosions in warehouses of weapons and ammunition

- 277,500 dangerous ammunition were removed and destroyed after UEMS in Albania and Bulgaria.



# Ammunition destruction

## Osh Kirgizstan - reverse engineering

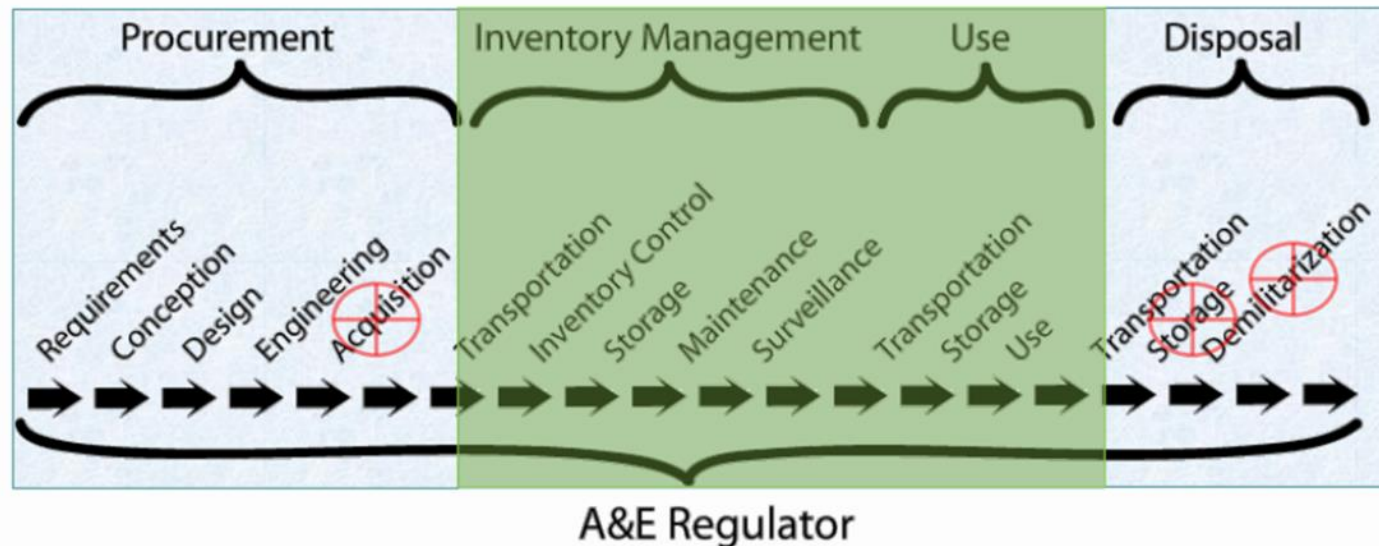


# Projects in preparation

- CWD
  - MANPADS
  - Artillery ammunition
  - Anti Tank missiles
  - WP ammunitions
  - CS riot control ammunition
- PSSM
  - Storage renovation

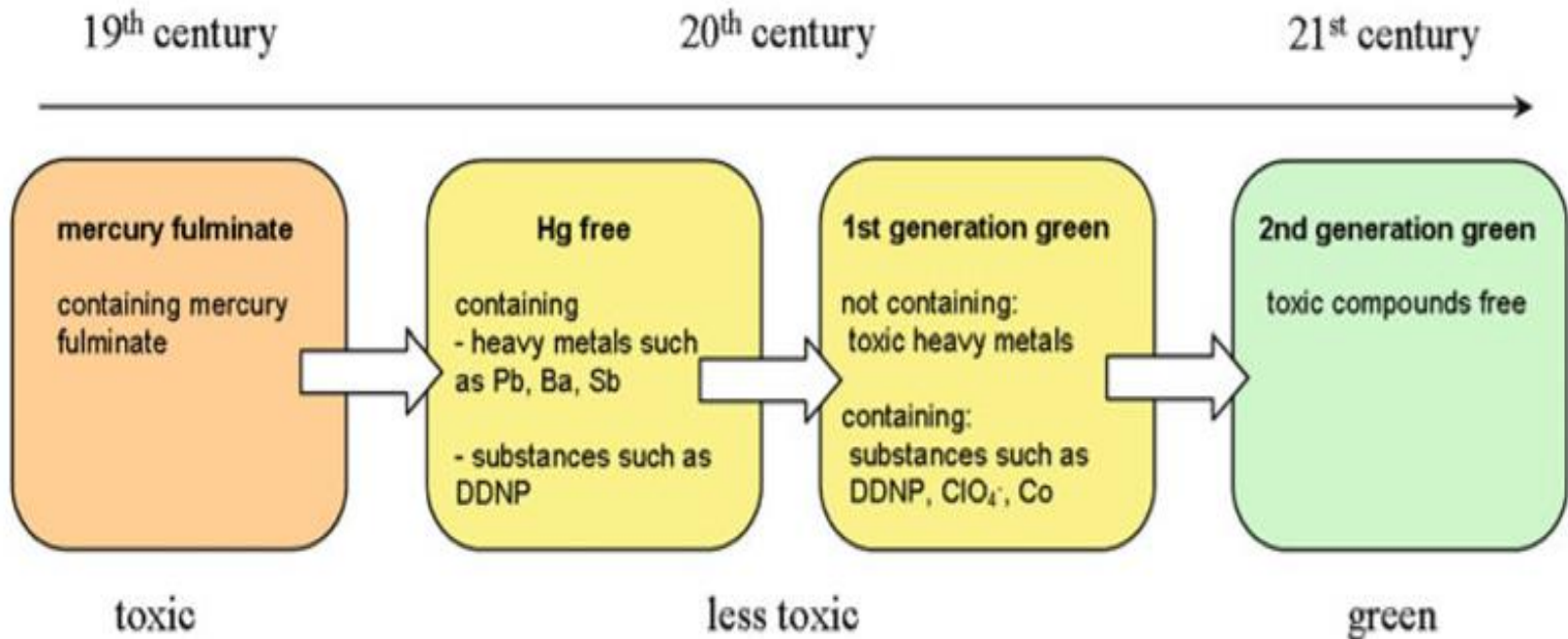
# Environmental aspects of ammunition

## Ammunition Life Cycle



- Ammunition impact on environment
  - Explosives production and ammunition loading facilities
  - Formal production facilities
  - UEMS
  - Range and battlefield areas BAC
  - Disposal/demilitarization

# Evolution of primary initial explosives and priming mixtures from perspective of toxicity



# In the process of production

TNT environmental impact at explosive production and ammunition loading and demilitarization facilities

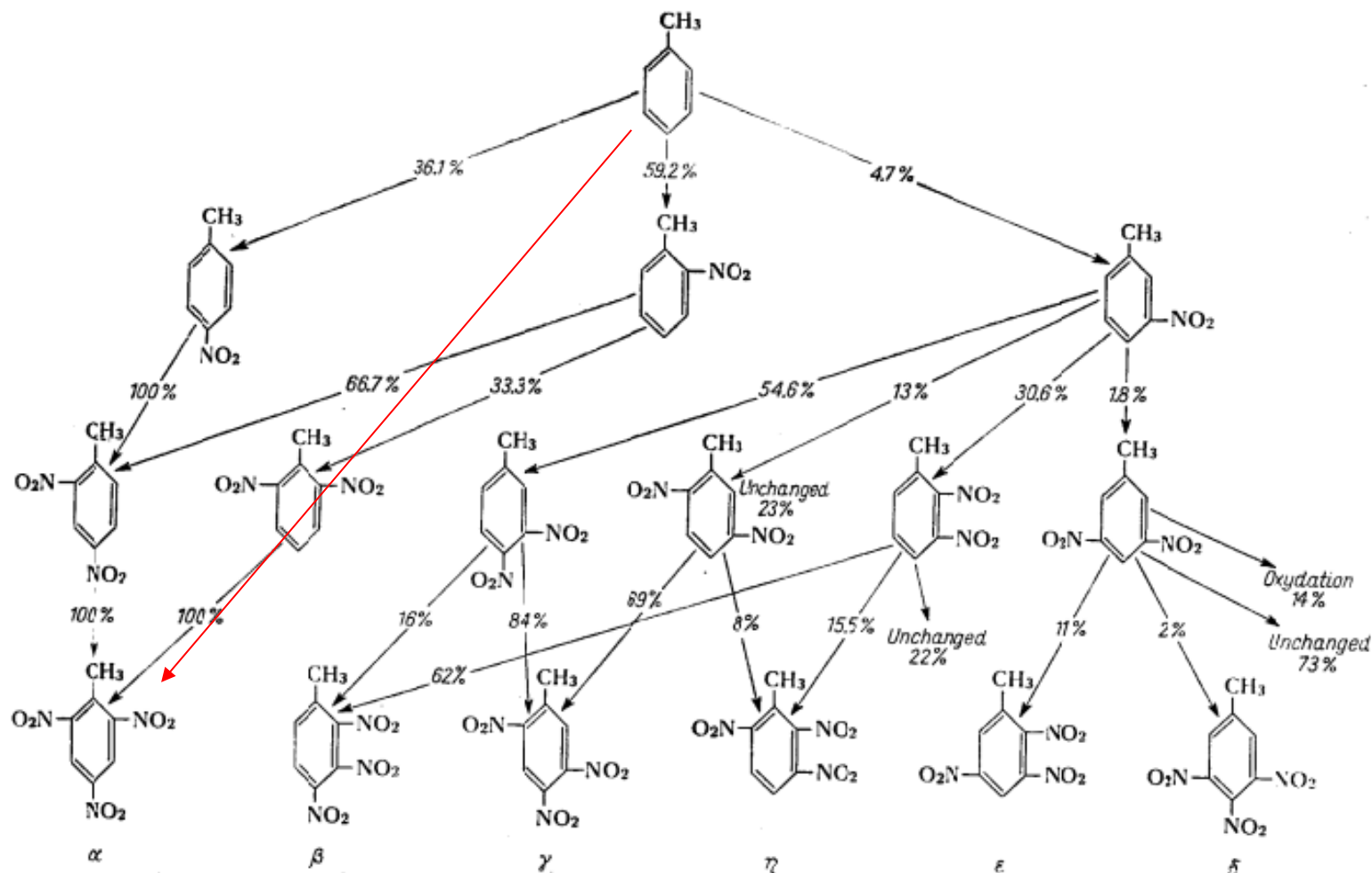


- TNT is still main military explosive
- EPA has listed TNT as a possible carcinogen, linked to disorder of the blood, such as anemia, and abnormal liver function
- TNT - to reduce impacts on improvement in the process of production
- TNT - replacement: a) develop new chemical compound or b) develop equivalent mixture



# TNT production

## Toluene nitration mechanism



Isomers formed on nitration of toluene according to de Beule.

# Traditional TNT production process

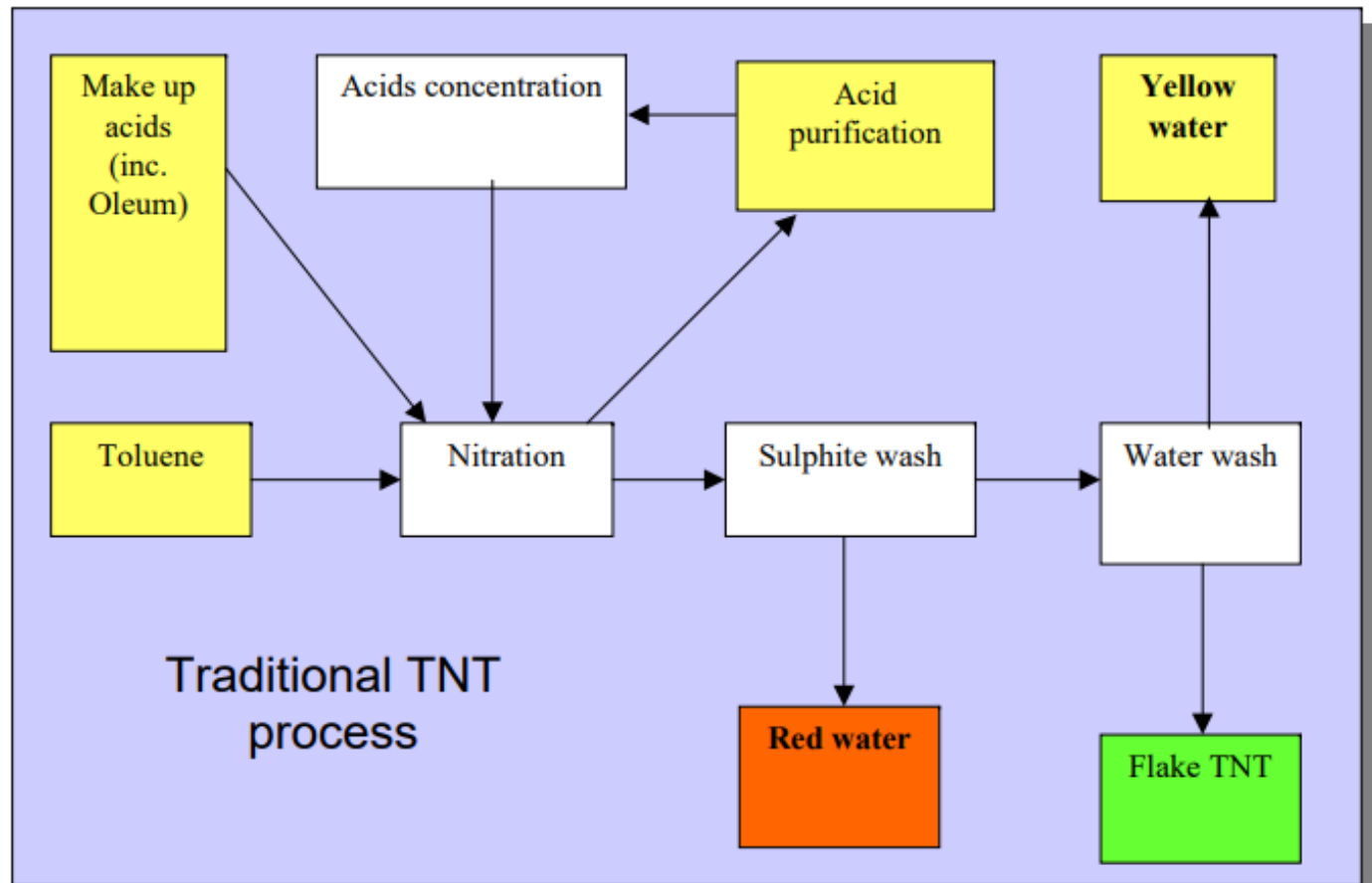


Needs oleum facilities

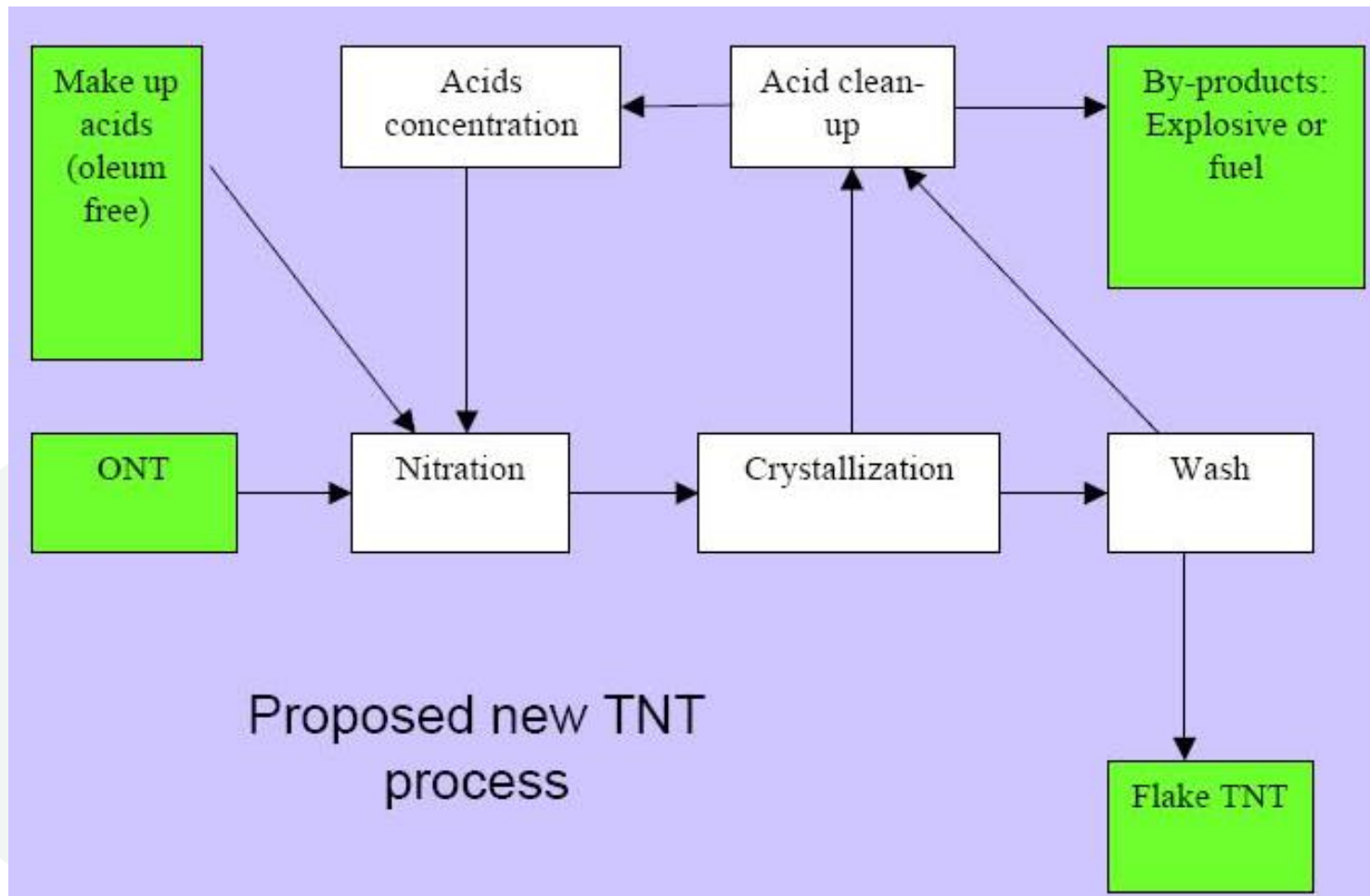
Generates yellow water

Generates red water

Requires toluene



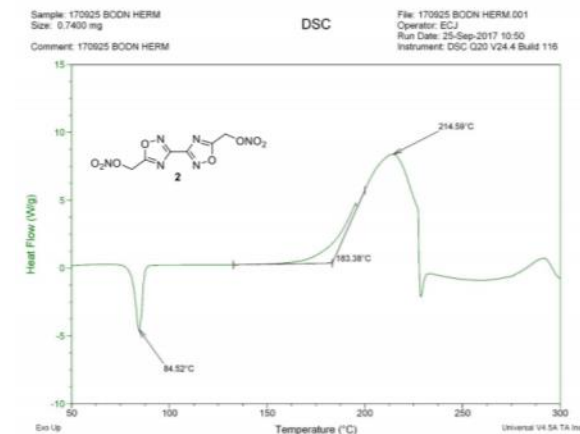
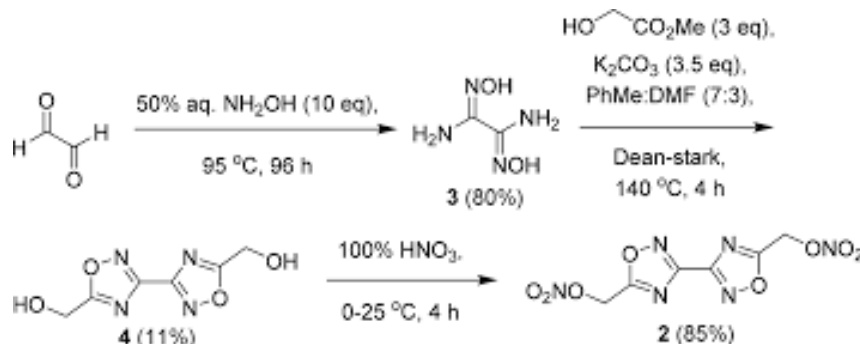
# Proposed new process of TNT production



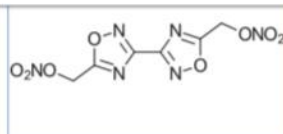
# TNT replacement:

mixture - IMX-101 mixture (DNAN + NTO + NQ) and  
chemical compound: bis(1,2,4-oxadiazole)bis(methylene)dinitrate  
both can be melt-cast loaded ( synthesized at LANL)

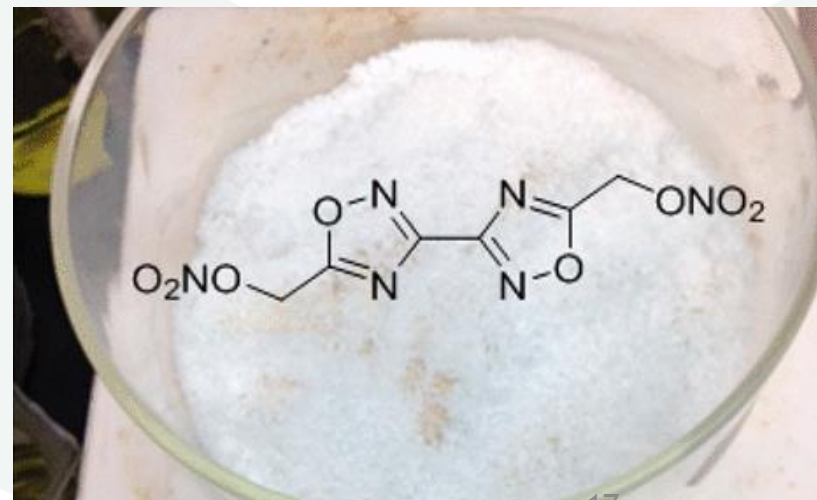
source: <https://phys.org/news/2018-06-tnt-years-job.html>



- Synthetic route
  - 4 steps (overall yield 44 %)
- Scale
  - Laboratory
- Further development
  - Environmental information
  - Compatibility
  - Ageing
- Application
  - Potential oxidiser
  - Replacement for TNT/melt cast



Formula	C <sub>6</sub> H <sub>4</sub> N <sub>6</sub> O <sub>8</sub>
M.W. (g mol <sup>-1</sup> )	292.16
ΔH <sub>f</sub> (kJ mol <sup>-1</sup> )	-79.4 <sup>1</sup>
ρ (g cm <sup>-3</sup> )	1.832 <sup>1</sup>
Ω <sub>CO<sub>2</sub></sub> (%)	-33.3
Nitrogen (%)	29.17
Melting point (°C)	84.5 <sup>1</sup>
Onset <sub>dec</sub> (°C)	183.4 <sup>1</sup>
VoD (m s <sup>-1</sup> )	8180 <sup>1</sup>
P <sub>CJ</sub> (GPa)	29.4 <sup>1</sup>
IS (→)	8.7 <sup>1</sup>
FS (N)	282 <sup>1</sup>
ESD (J)	>0.125 <sup>1</sup>

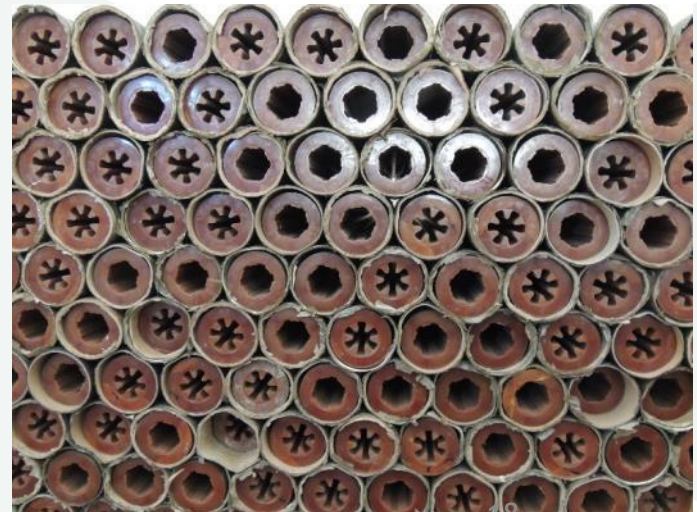
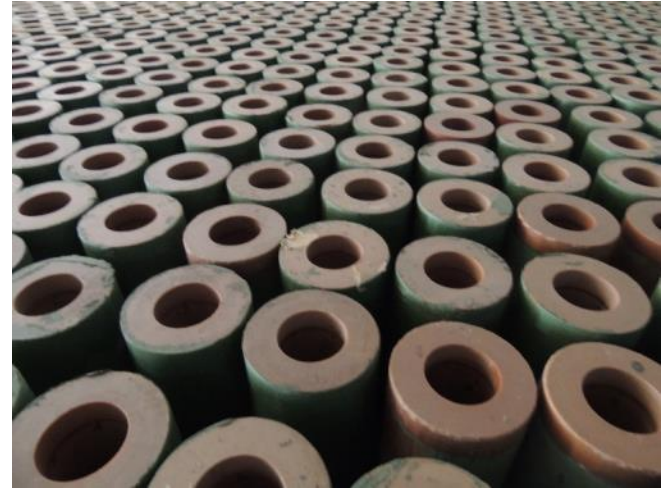


1. Johnson, E. C. et al. OPR&D, (2018)

# Abandoned explosive residual and rocket propellants in military industry



## Explosives and environmental hazards



# KIK-Kamnik, Kamnik “Ecological bomb”

<https://www.24ur.com/novice/slovenija/foto-vojska-uspesno-odstranila-652-000-kosov-eksplzivnih-sredstev-16-ton-smodnika-in-velike-kolicine-kemikalii.html>



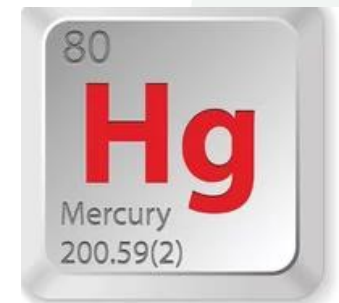
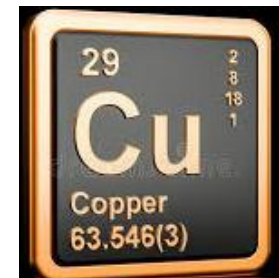
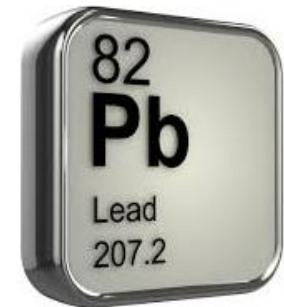
Approximately 652,000 pieces of explosives, 16 tons of black powder and a large amount of chemicals have been removed, destroyed or properly stored. With the intervention of the state, threat to people, property and environment in the area of the former company has significantly decreased



# Potential environmental impact of small arms ammunition / annual production



- Calculated to 500 Million 7.62 x 39 mm Ball rounds



Lead = 2515.000 kg (2515 t)

Brass alloys = 5385.000 kg (5385 t)

Hg in primers = 1.875 kg (1.9 t)\*

\* If primer contents mercury fulminate

# Minamata disease/Minamata convention on mercury

Effective

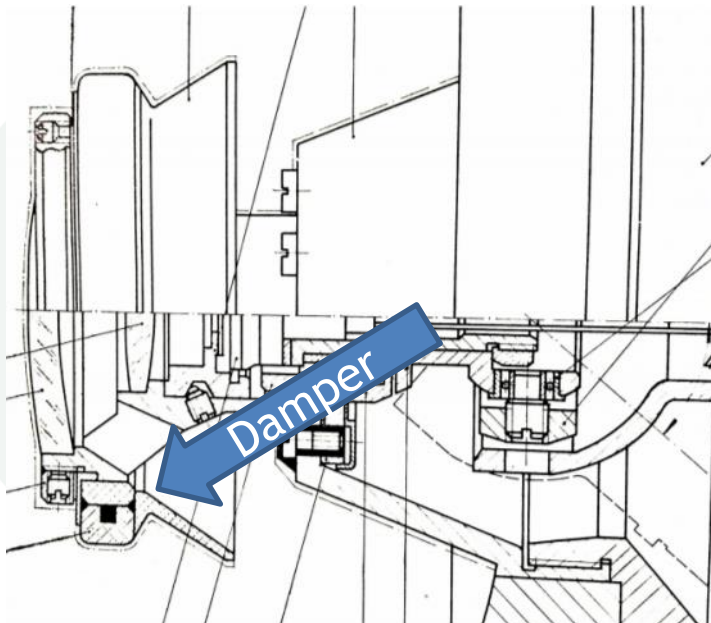
16 August 2017

Strela 2-M content liquid mercury in damper;  
“Демпфер” Russian, “dempfer” Serbian



Source: DOD.

From left to right: (A) battery, (B) gripstock, (C) launch tube, and (D) missile.



# UEMS ? in Ichnya, Chernihiv region, Ukraine Oct 09, 2018



# UEMS in Balakleya



# UEMS in Balakleya



# UEMS in Balakleya

## Ammunition storage after UEMS



# Some UEMS in Ukraine and consequences



Basic data	UEMS Place / Место нахождения				
	Артемівка Artemovka	Новобогданівка Novobogdanovka	Лозова Lozovaja	Сватово Svatovo	Балаклея Balakleja
Data of UEMS	10.10.2003 – 11.10.2003	06.05.2004 – 15.05.2004	27.08.2008 – 03.09.2008	28.10.2015 – 29.10.2015	23.03.2017 – 29.03.2017
Area of the storage ha (10.000 m2)	100	250	494	100	368
Weight of ammunitions kt	3,17	91.63	95 – 110	3,5	125 – 175
Weight of reacted ammunitions kt	1,7	18	85	3	60-90
Energy content TJ (Hiroshima)	6,7 (0,1)	190 (3,8)	200 (4)	7 (0,14)	250 – 380 (5-7)
Energy realized TJ (Hiroshima)	3,6 (0,06)	19 (1,6)	180 (3,6)	6 (0,12)	120 – 180 (2,4– 3,6)
Realized energy %	54	10	90	86	48
Number of killed (injured)	– (2)	5(4)	– (1)	4 (16)	1 (2)
Number of settles	1	250	4	1	5
Number of displaced people (thousands)	30	–	12	5	20

# UEMS in Balakleya



# UEMS in Balakleya



# Amount of aerosol, chemicals and acoustic energy released into atmosphere as a result of UEMS in Balakleya (area of the city is approx. 10 km<sup>2</sup>)



Source: <http://naukatehnika.com/katastrofa-na-ukrainskom-sklade-boepripasov.html>

Compound (radiation)	Injected mass (power)	The background value in the atmosphere		
		Above Balakleya	Above Ukraine	In atmosphere
Aerosol (dust)	0,1–1,0 kt	1–5 t	60–300 kt	50–250 Mt
Aerosol (smoke)	1 kt	80–200 kg	6–7 kt	5,5 Mt
Carbon dioxide	35 kt	40–50 kt	3,6 Gt	3 Tt
Carbon monoxide	5 kt	7–8 t	600 kt	0,5 Gt
Carbon (soot)	500 t	10–15 kg	600 t	0.5 Mt
Acoustic: due to				
- explosions;	0,2–1,4 Gw	1–10 kw	200–600 Mw	150–500 Gw
- due to fires	15 Mw	–	–	–

# UEMS environmental impact

## Lozovaja Harkovsk, Ukraine 27 august 2008

- 17.000 tones of ammunitions have been stored before UEMS
- UEMS survived 27 % amount (by weight) of small arms ammonium
- 1kg of propellants generate around 1m<sup>3</sup> of hot gasses having temperature 1500 - 2000° C
- High temperature can cause thermal dissociations and create new toxic materials
- NO<sub>2</sub> react with moisture in air and create HNO<sub>2</sub> and HNO<sub>3</sub> acid, (acid rain)

# Ammunitions stored before UEMS and destroyed in UEMS (Lozovaja)



Ammunition type	Total before UEMS		Destroyed		
	pieces	ton	pieces	ton	%
5.45 mm	466 x 10 <sup>6</sup>	6249	340 x 10 <sup>6</sup>	4497	72
7,62 mm pistol and rifle	237 x 10 <sup>6</sup>	6291	170 x 10 <sup>6</sup>	4500	73
9 mm	4,75 x 10 <sup>6</sup>	63	0,61 x 10 <sup>6</sup>	8	13
12.7 mm	3,07 x 10 <sup>6</sup>	556	2,86 x 10 <sup>6</sup>	519	93
14.5 mm	12,06 x 10 <sup>6</sup>	3446	8,69 x 10 <sup>6</sup>	2483	72
<b>Total</b>	<b>722,9 x 10<sup>6</sup></b>	<b>16607</b>	<b>518,7 x 10<sup>6</sup></b>	<b>12153</b>	<b>73</b>

Table summarized data for 37 type of ammunitions, other 20 type of ammunition content is less than 5% of total amount stored

Source: E.V Ivanov, Sostav i potencialnaja opasnost vibrosov v atmosferu produktov gorenija komponentov patronov dlja strelovoga oruzija.

- **Estimated amount of gasses released**

Average amount of propellant in cartridge is approximately 8 % by weight; what means  $M_g = 12153000 \times 0,08 = 972240 \sim 1\ 000\ 000$  kg

**1 000 000 m<sup>3</sup> or 1km<sup>3</sup> (small arms ammunitions)**

**6-7 km<sup>3</sup> (artillery ammunitions)**

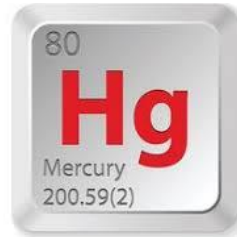
- **Estimated amount of mercury released (in small arms primers)**

Primer composition content:

Mercury fulminate  $\text{Hg}(\text{ONC})_2$

Antimony trisulfide  $\text{Sb}_2\text{S}_3$

Potassium chlorate  $\text{KClO}_3$

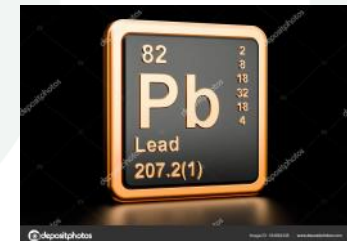


Average content of mercury fulminate in primer mixture is 20 % weight or 15 % weight of mercury. Average weight of primer mixture in cartridge is 20 mg,

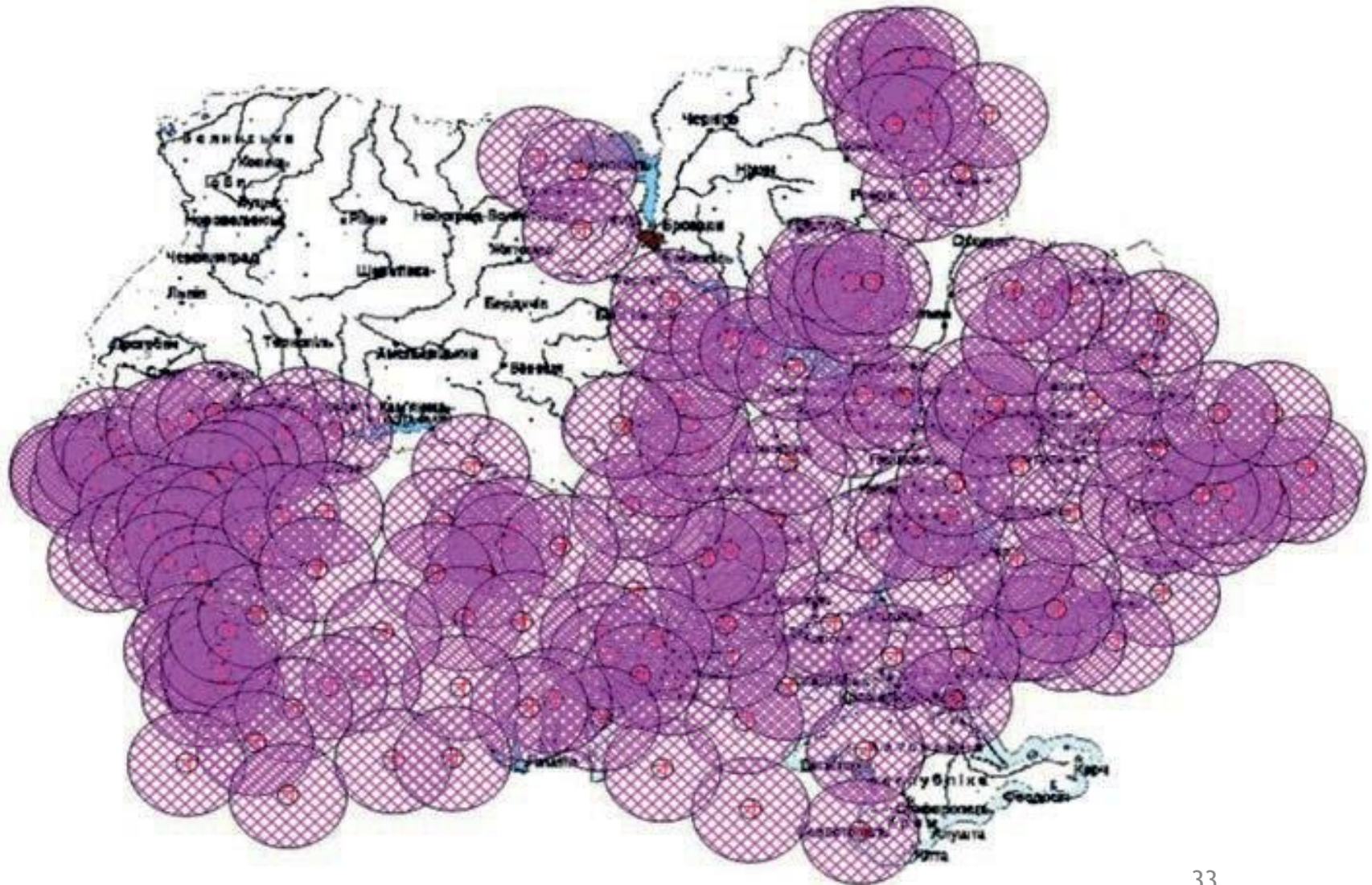
$$M_{\text{Hg}} = 518 \times 10^6 \times 3 \times 10^{-6} = 1554 \text{ kg}$$

- **Estimated amount of lead released (lead oxides are ingredient of anti-corrosion paints in artillery ammunitions) in UEMS**

$$M_{\text{Pb}} = 3500 \text{ kg}$$



The expected zones of destruction in case of UEMS in Ukraine: a small circle - a zone of partial destruction, a large circle - the zone affected by shock wave  
<http://naukatehnika.com/katastrofa-na-ukrainskom-sklade-boepripasov.html>



# UEMS probability



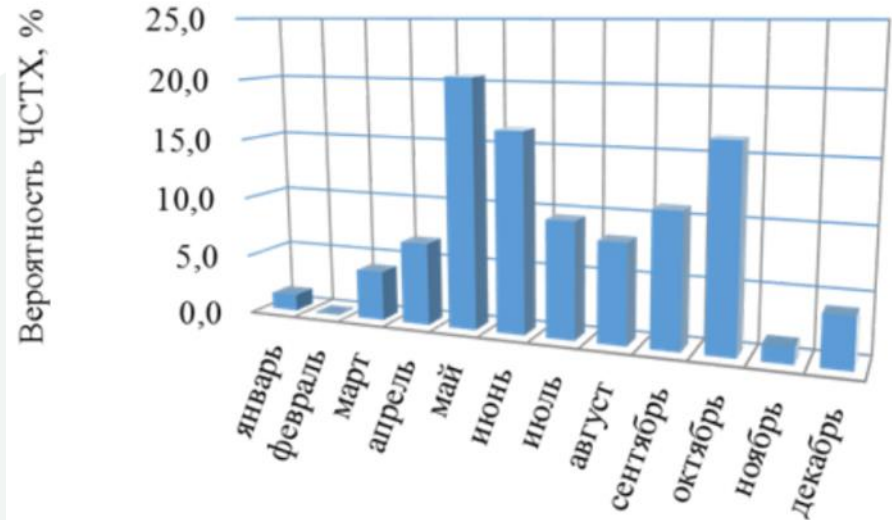
Е. В. Иванов: ЧРЕЗВЫЧАЙНЫЕ СИТУАЦИИ СО ВЗРЫВАМИ БОЕПРИПАСОВ:  
ЗАКОНОМЕРНОСТИ ВОЗНИКНОВЕНИЯ И ПРОТЕКАНИЯ

Восточно-Европейский журнал передовых технологий 1/10 ( 79 ) 2016  
<http://repositsc.nuczu.edu.ua/bitstream/123456789/1845/1/59684-122400-1-PB-2.pdf>

The most probability of UEMS is in May and October. Very likely this is due to the fact that the majority of planned works with explosives and ammunition is in the period May-October.

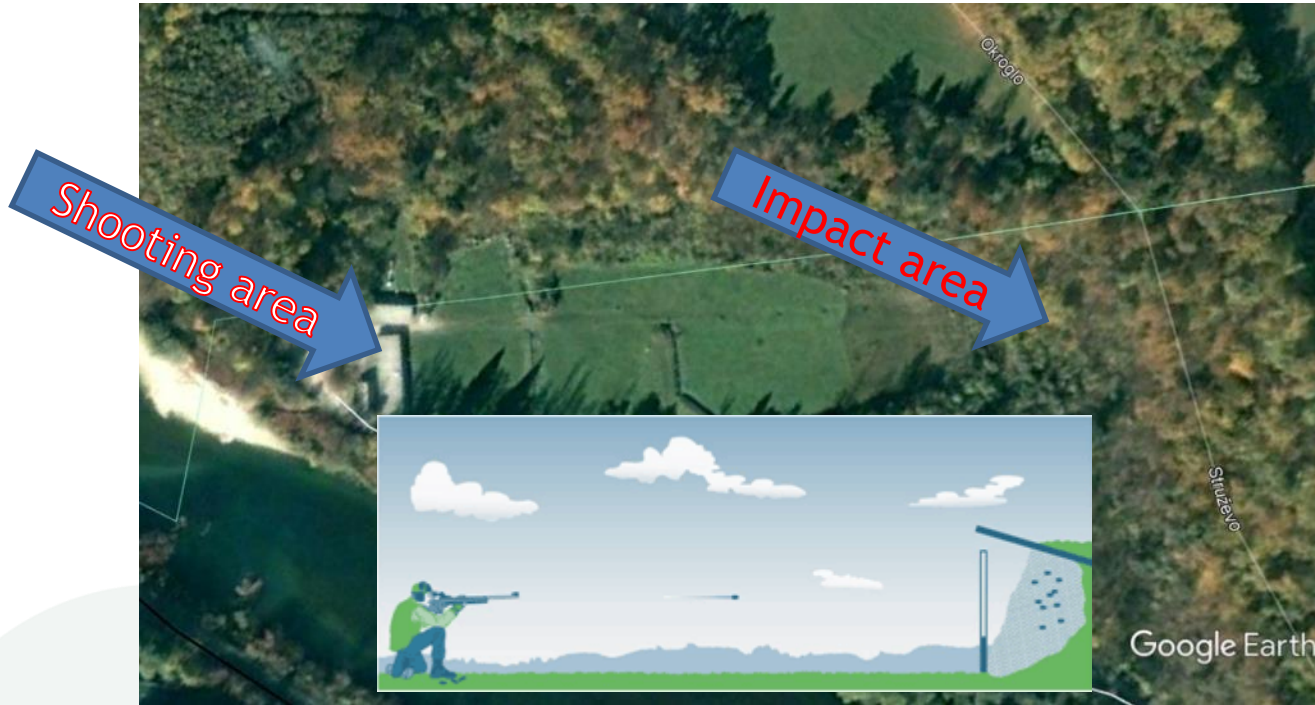
It's very important to minimize the effects of UEMS in practice. Result of analysis of the reasons that caused UEMS are:

- 45,9 % UEMS caused by fire and sequential explosion
- 40,5 % UEMS caused by poor PSSM
- 6,8 % UEMS caused by nature (light strike)
- 6,8 % UEMS unknown reason



# Small arms shooting range

Soil contaminated by Lead



# Dangerous lead levels



- As a result, soil lead concentrations above 10,000 mg per kg of soil are commonly reported at shooting ranges in New Zealand, the US, England, Germany and Scandinavia.<sup>2</sup> One site assessment in the US revealed lead concentrations ranged from 27,000 mg/kg to 233,142 mg/kg.<sup>1</sup> The ANZECC guideline limit, for Australia and New Zealand, is **300 mg/kg**, with higher levels requiring further investigation.
- Contaminants at shooting ranges may also include antimony, copper, zinc, arsenic, and polycyclic aromatic hydrocarbons (PAHs). However, lead is normally the main concern due to its range of severe toxic effects and the vulnerability of children. Lead is commonly absorbed through drinking lead-contaminated groundwater, eating contaminated foods, or breathing the dust from lead-contaminated soils.
- Typical health concerns include:
  - damage to the brain and nervous system
  - behavioral problems and learning disabilities
  - reproductive problems
  - memory and concentration problems
  - muscle and joint pain.

# Tank, mortar and gun/howitzer firing position:

- Potential contaminants:
  - Lead,
  - Bismuth,
  - Tin,
  - Propellant residuals (some propellants content carcinogenic dinitrotoluen)



# Hand grenade impact area

- Potential contaminants:
  - UXO,
  - TNT, RDX, PETN
  - Chromate,
  - Perchlorate,
  - Permanganate,
  - Lead,
  - Barium,
  - Zirconium,
  - Nickel



# Artillery, rocket and missiles impact area

- Potential contaminants:
  - UXO
  - TNT, RDX, HMX, Explosive D, Tetryl
  - Lead
  - Chromates



# Ammunition disposal Standard and Guideline



**NATO STANDARD**

**AOP-4518**

**SAFE DISPOSAL OF MUNITIONS  
DESIGN PRINCIPLES AND  
REQUIREMENTS, AND SAFETY  
ASSESSMENT**

**Edition A Version 1  
MAY 2018**



**INTERNATIONAL  
AMMUNITION TECHNICAL  
GUIDELINE**

**IATG  
10.10**

Second edition  
2015-02-01

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**Demilitarization and destruction of  
conventional ammunition**

# International instruments/legislation/standards

- International instruments (environmental)
- Supra-national legislation (environmental)
- International standards (environmental)



# International instruments (environmental)

Ammunition and explosives are considered to be hazardous or industrial waste and as such fall under the remit of international treaties that have been signed and ratified:

- a) the **London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 29 December 1972;**
- b) the **1996 Protocol to the London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (Amended 2006);** and
- c) the **Convention for the Protection of the Marine Environment of the North-East Atlantic, 1998.10 11**

Ammunition and explosives shall therefore not be dumped at sea by States that have ratified and signed the above treaties and should not be dumped at sea by non-participant States.

The United Nations shall not support any ammunition disposal activities that utilize deep sea dumping.

- d) **The Minamata Convention on Mercury is an international treaty designed to protect human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds. Effective 16 August 2017.**



# Supra-national legislation (environmental)



- Supra-national legislation that covers emissions into the atmosphere from the incineration of hazardous waste is the: European Union Council Directive 2000/76/EC **The incineration of waste**, 04 December 2000, amended by Regulation (EC) No 1137/2008 of 11 December 2008.
- European Union Council Directive 2008/98/EC Waste, 19 November 2008 contains provisions on the **management of waste**. These should be applied to industrial ammunition demilitarization processes.<sup>12</sup>
- **Industrial Emissions Directive** (Directive 2010/75/EU of the European Parliament and of the Council of on industrial emissions, dated 24 November 2010)

The directives provide a comprehensive standard and are in use by all European Union countries and those countries with associate status. States should reflect the requirements of these directives in their own national environmental legislation where it relates to the destruction of ammunition



# International standards (environmental)



- **ISO 4220:1993(E) Measurement of air pollution**

ISO 4220:1993(E), whilst not specifically legislation, lays down internationally accepted standards for the determination and measurement of air pollution from industrial processes. These standards should apply to any pollution control systems used during industrial demilitarization operations, but only in terms of the measurement of emissions. The standard does not provide any guidance on what the overall emission limits should be; this remains the responsibility of the national authority.

- **ISO 9612:2009(E) Acoustics**

ISO 9612:2009 Determination of occupational noise exposure - Engineering method may be applied to open detonation destruction operations.

# BEST AVAILABLE DEMILITARIZATION TECHNIQUE

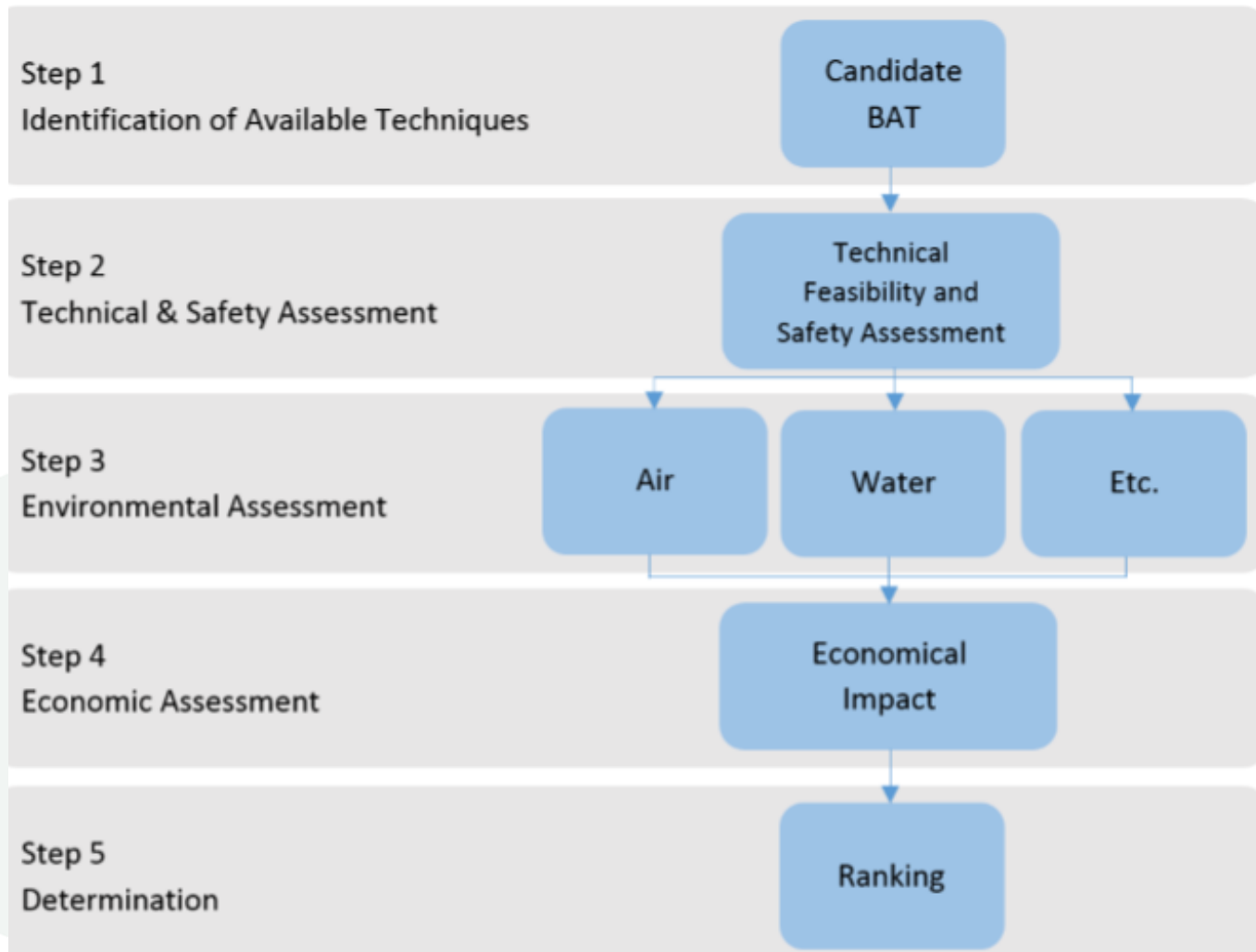
Best Available Techniques Not Entailing Excessive Costs  
(BATNEEC) principle.



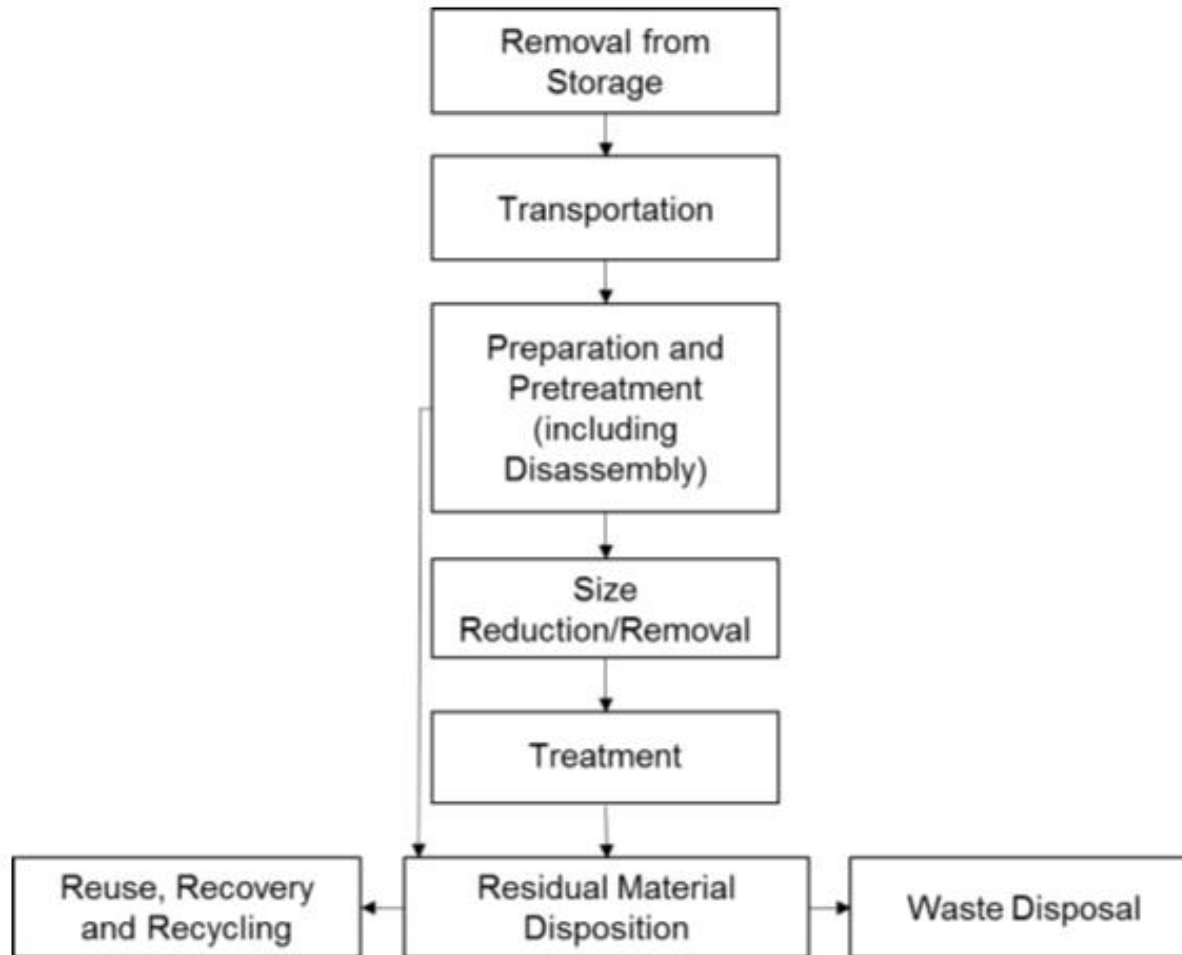
The demilitarization techniques must be subjected to a multi-criteria analysis to determine whether the technique can be considered as the BATNEEC.

- a. Best' means most effective in achieving a high level of physical and environmental protection.
- b. 'Technique' includes both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned.
- c. 'Available Technique' means those developed on a scale which allow economically and technically viable implementation.
- d. 'Not Entailing Excessive Costs' implies where the benefits gained are worth more than the costs of obtaining those benefits.

# BATNEEC Determination Process



# Typically demilitarization and disposal process



# Explosive/energetic materials removal



<b>Removal</b>				
Machining, Mechanical	Dry machining of energetic materials by contour drilling	All munition types except small munitions	In use	No waste water; Typically only removes 95% of explosive so further treatment is necessary
Washout, HP Water	Ablation of energetic material by a high pressure water jet	All munition types except small munitions	Widespread use	Moderate pressures; Generates waste water; Difficult with small munitions
Meltout, Steam	Meltout of explosive by steam or hot water jets	Melt-cast explosives	Widespread use	Generates waste water; Moderate temperature and pressures
Meltout, Autoclave	Meltout of explosive by hot water in a pressurized vessel	Melt-cast explosives	Widespread use	Reduced waste water generation; Moderate temperature and pressure

<b>Meltout, Paraffin</b>	<b>Meltout of explosive by hot paraffin</b>	<b>Melt-cast explosives</b>	<b>Widespread</b>	<b>No waste water; moderate temperature (110 °C), no pressure</b>
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# TNT melting out by hot paraffin



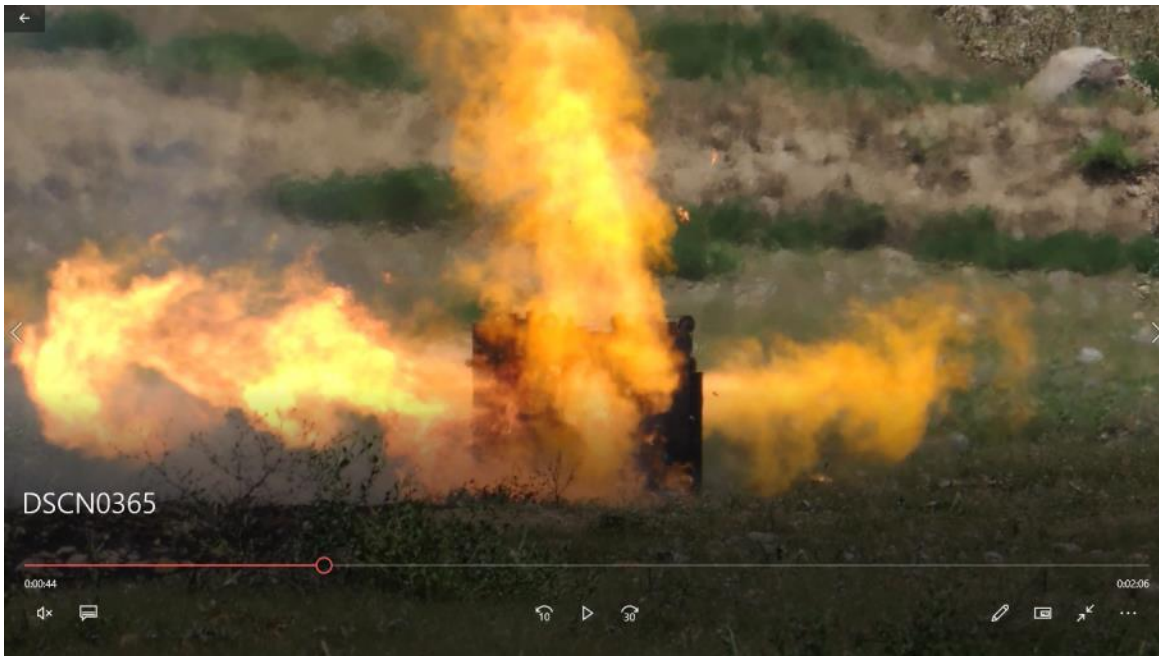
# Explosive/energetic materials Destruction



Technique	Description	Usage	Maturity	Notes
				Small capacity batch process
Incineration, Static Kiln	Incineration in a sealed chamber. Items can burn or detonate	Munitions types except large detonable items after pretreatment	In use	Pollution control; Small capacity batch process; Items may require pre-treatment such as sectioning before incineration
Incineration, Rotary Kiln	Incineration with the items slowly moved through the kiln	Non-detonable items and small detonable items	Widespread use	Pollution control; Items may require pretreatment such as sectioning before incineration
Incineration, Car Bottom Furnace	Incineration using a moveable 'car' to insert the waste	All munition types except large detonable items	Widespread use	May have pollution control; Can handle unusual shapes; Small capacity batch process

Incineration, Portable Kiln	Incineration in a semi-open chamber	Small arms ammunitions, artillery fuzes, primers and tracers	Widespread use	No pollution control, Small capacity, batch process, usually 24h
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# Portable incinerator for fuzes, tracers and primers



# Portable incinerator for small arms ammunition



# Assessing Environmental Risks of ammunition impact on environment throughout entire life cycle

Important step to keep environment clean and friendly  
for human life

