
Thermal Destruction of Explosive Suspensions from Large-Caliber Sea-Dumped Munitions

BorDEx process concept, pre-testing and demonstrator development

authored and presented by

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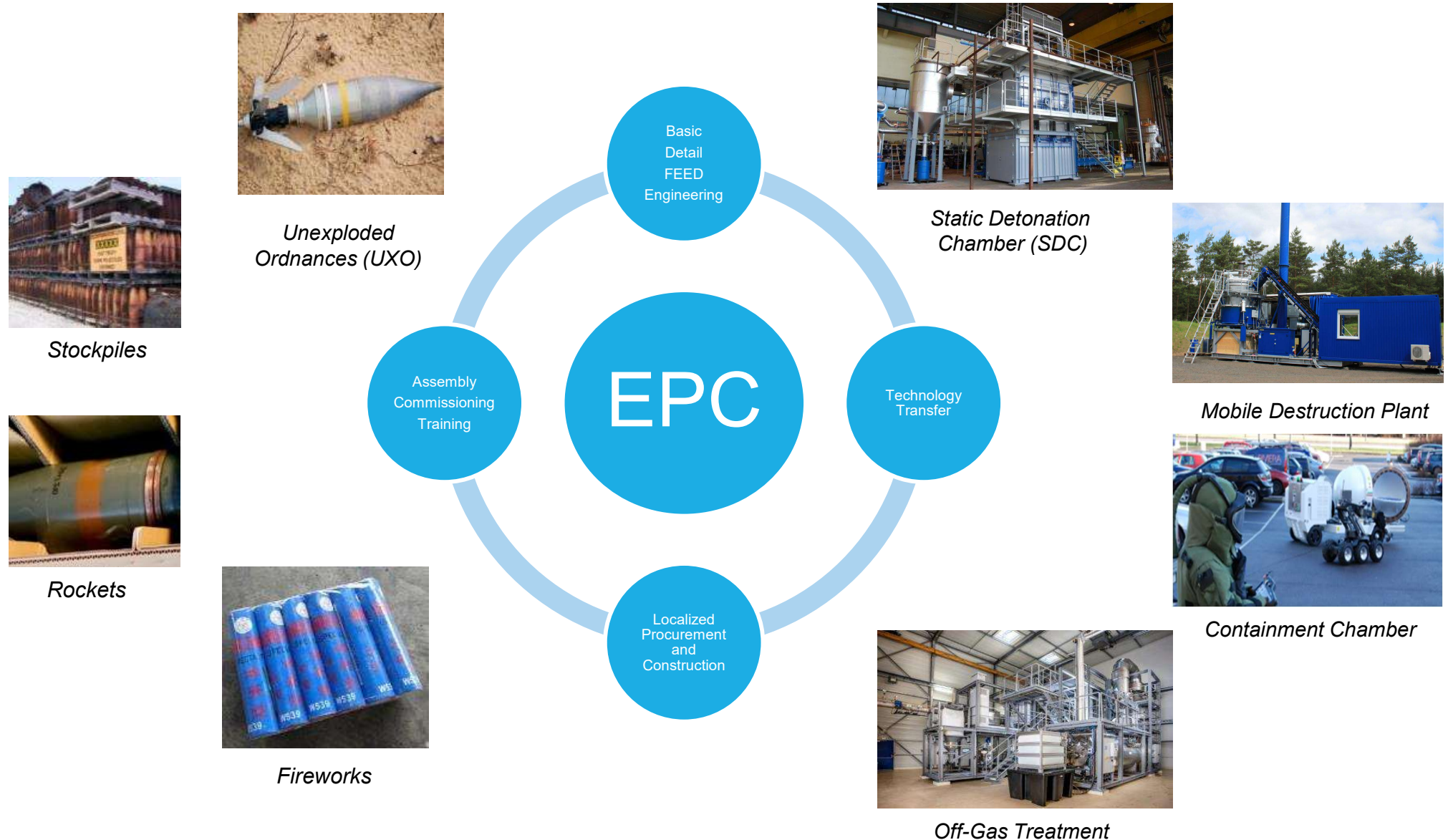
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1. Dynasafe and Demilitarization Background

Threats from explosive devices

Selected Dynasafe solutions



2. Existing Disposal Routes

- Mature disposal solutions are available for small, medium and large-caliber munitions.
- Established routes include mechanical and thermal treatment, depending on munition type and accessibility.
- The main unresolved gap concerns large sea-mines and large torpedoes.

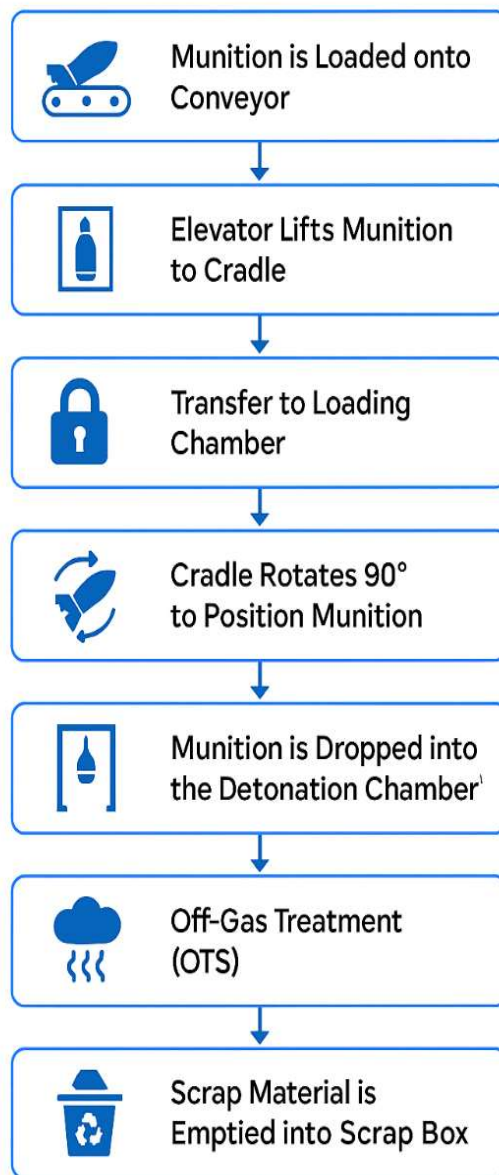


Mechanical Treatment



Thermal Treatment (SDC with OTS)

SDC Demil Process Flow



1. Munition is Loaded onto the Conveyor

- The munitions is placed on a conveyor.

2. Elevator Lifts Munition to Cradle

- A mechanical lift (elevator system) raises the munition to align with the tilting or rotating cradle mechanism.

3. Transfer to Loading Chamber

- The munition enters a gas-tight, ventilated loading chamber.
- Safety interlocks ensure the chamber is sealed before proceeding.

4. Cradle Rotates 90° to Position Munition

- The cradle securely positions the munition over the detonation chamber inlet.
- All systems are locked, and gas-tight seals are verified.

5. The munition is dropped into the Detonation Chamber,/Thermal destruction occurs.

- The munition detonates or deflagrates inside the insulated, armored chamber.
- All energetics are neutralized in one step—no disassembly needed.

6. Off-Gas Treatment (OTS) treats toxic gases

- Gases are routed through the Off-Gas Treatment System (dry or wet scrubbers) to eliminate toxic substances./Emissions comply with international environmental standards

7. Scrap Material is Emptied into Scrap Box

- Once cooled, inert scrap is dropped into a container for disposal or recycling.

3. Challenges with Large-Caliber Sea-dumped Munitions

- Large sea-dumped munitions are difficult to process using conventional disassembly methods such as sawing.
- At the same time, release of explosive chemicals to the marine environment poses a growing environmental and human risk.
- This creates a need for a safe, transportable, and scalable disposal route.



English Groundmine, Type Mark VII (front) and Mark I-IV (behind) ^[1]



German depth charge Type I ('Wasserbombe') ^[1]

4. Washout and Resulting Suspension

- One possible approach is to open the munition by water jet and wash out the explosive material in a directed process.
- The resulting explosive-water mixture is transportable and pumpable, but it introduces new challenges in mixing, temperature control, sedimentation avoidance, pumpability, and thermal decomposition.
- Particle size control is also essential before thermal treatment.



Seamine

BorDEX - Mobile Demonstrator for Thermal Disposal of Liquified Explosives

Source of explosives:

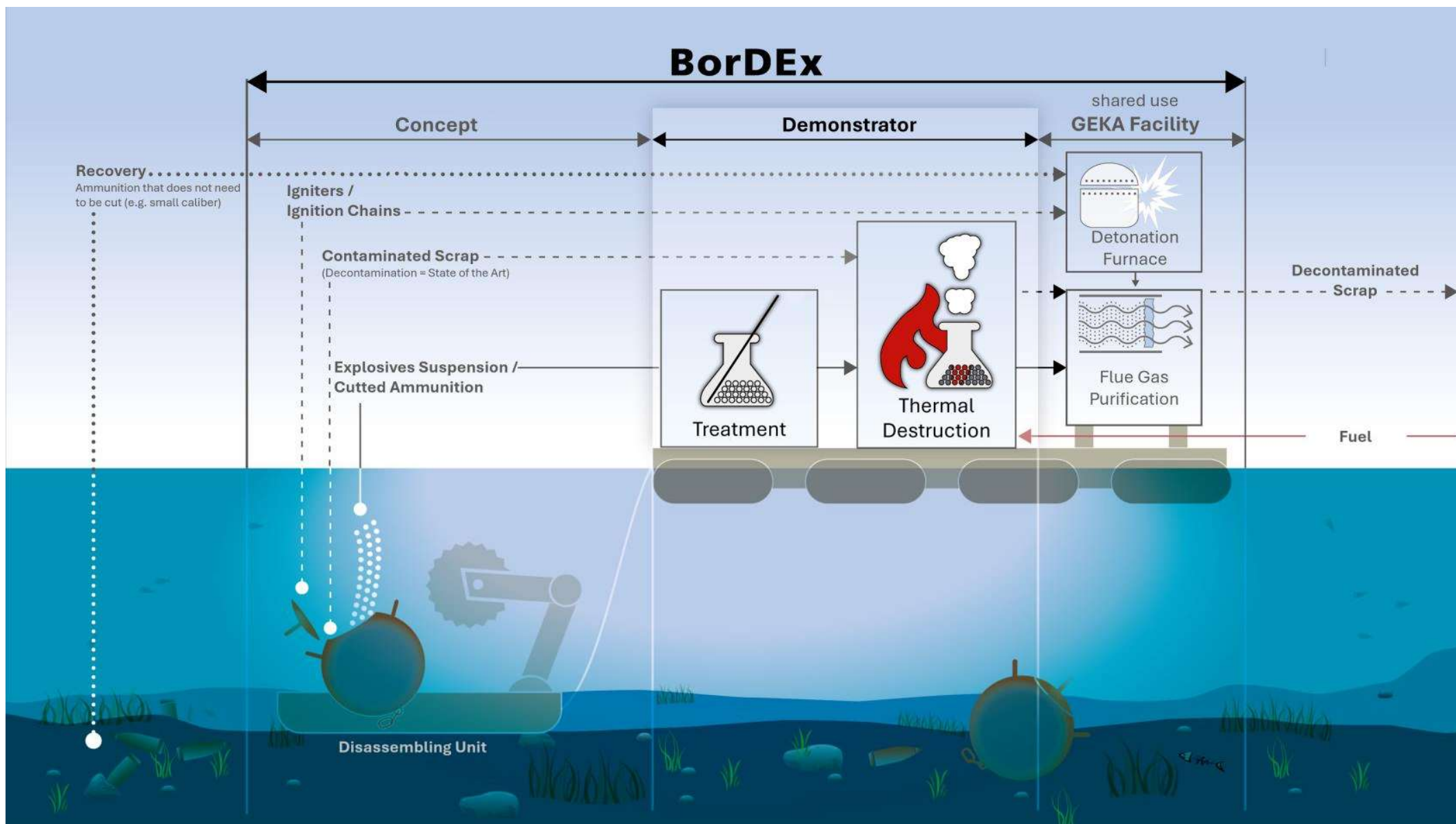
- Conventional
- Large-caliber
- Difficult-to-transport ammunition

Objectives:

- Convert explosives into an explosives-water suspension
- Safely store and transport the explosives-water suspension
- Thermal disposal without manual intervention
- Develop a safe solution for disposal of washed-out explosives from munition dumped in the sea

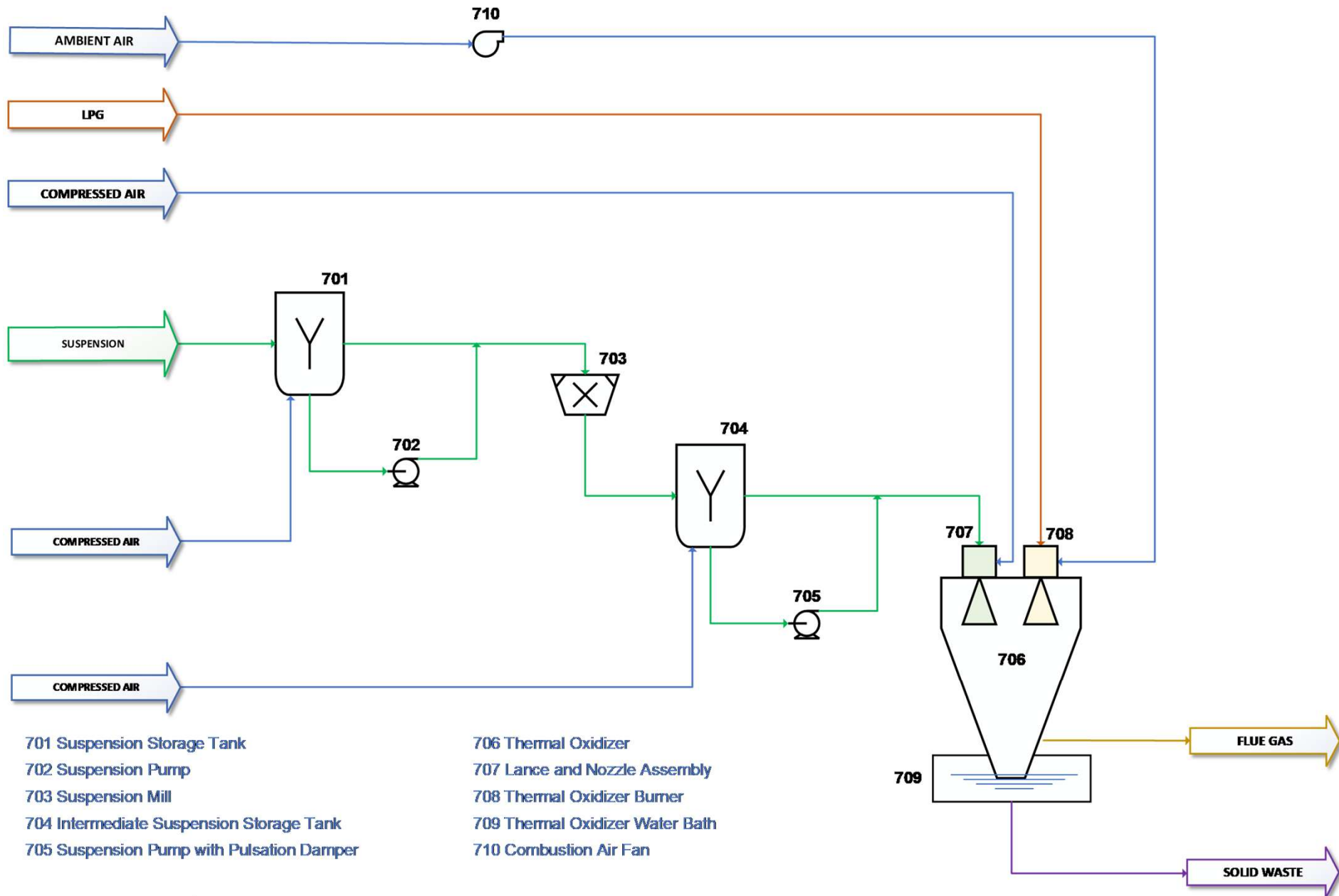
5. BorDEx Process Concept

Construction of a mobile demonstrator for thermal disposal of large-caliber munition



5. BorDEx Process Concept

Demonstrator Process Block Diagram



6. Pre-tests and First Findings at ICT

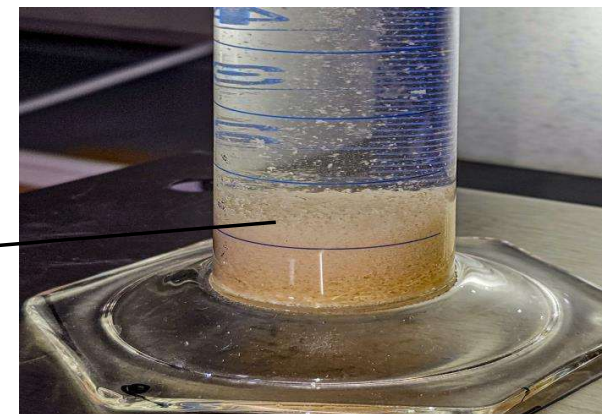
- Foam may prevent system injection
- Liquid phase mainly consists of water
- Solids may clog hoses
- Combustion process might be impaired
- Suspension might sediment out quickly



Foam



Solids

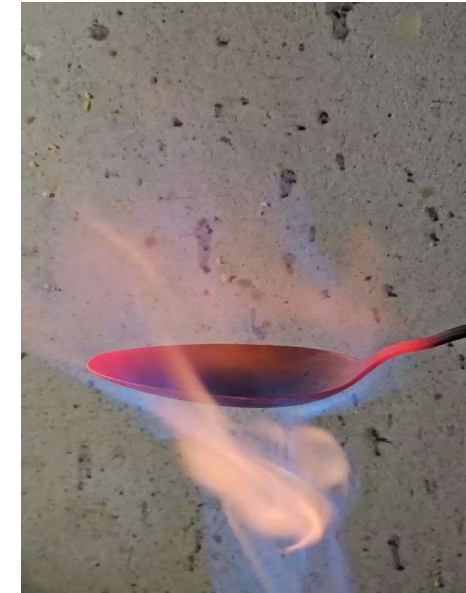




Agitator at low rpm



Agitator at higher rpm



Combustion tests on Bunsen burner

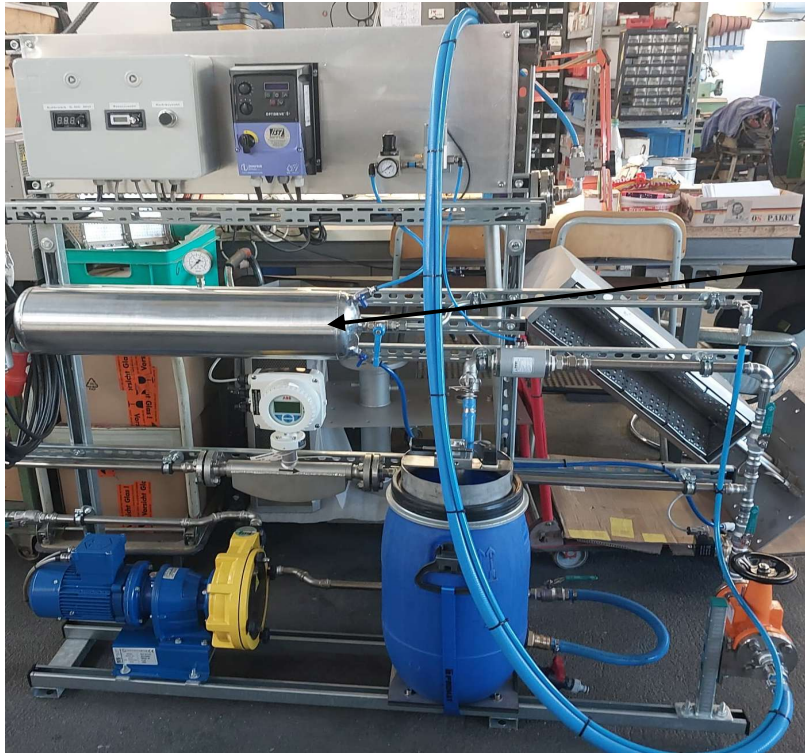
Agitator Tests in Laboratory Setup

- Little to no mixing observed at lower rpm up to 120
- Complete mixing observed at higher rpm

Combustion Tests in Laboratory Setup

- Intense combustion and spontaneous reactions observed when suspension was dropped on cold surface
- Less strong combustion and more controllable reactions observed when dropped on hot surface

7. Test Rig at Dynasafe



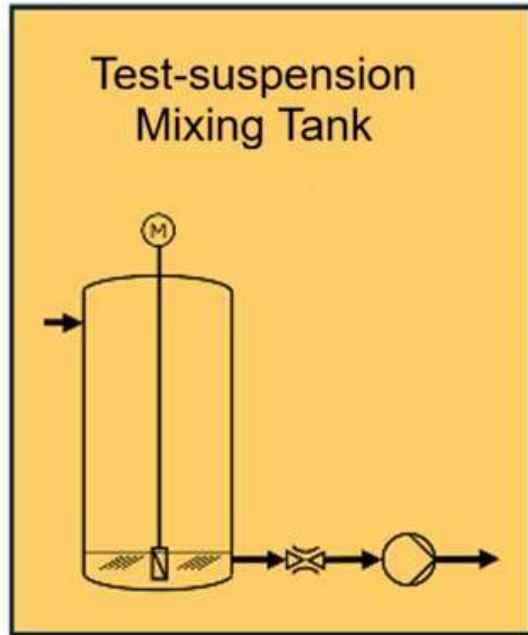
Test Rig



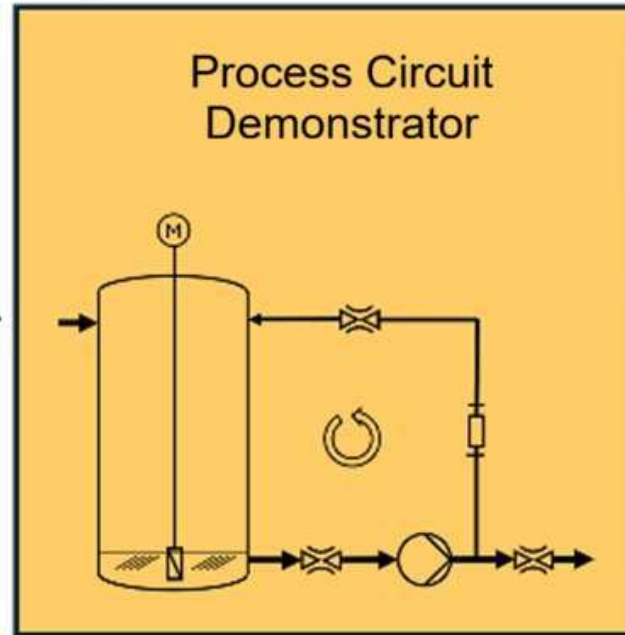
Nozzle Test

- Testing of the smaller test skid was completed in two phases at the Dynasafe partner workshop.
- The hose pump with pulsation damper showed clearly improved flow stability and the best spray pattern at 50 Hz, 3 bar, with pulsation damping.
- The electric double-diaphragm pump showed stronger pulsation, limited reproducibility of valve control behavior, and noticeable vibration during operation.
- These findings define the main focus of the ICT test campaign, in particular nozzle control behavior, pulsation effects, and stable low-flow operation.

Suspension Test



Pilot Plant Test



Component Test

Piping



Lance / Nozzle



Suspension Mill



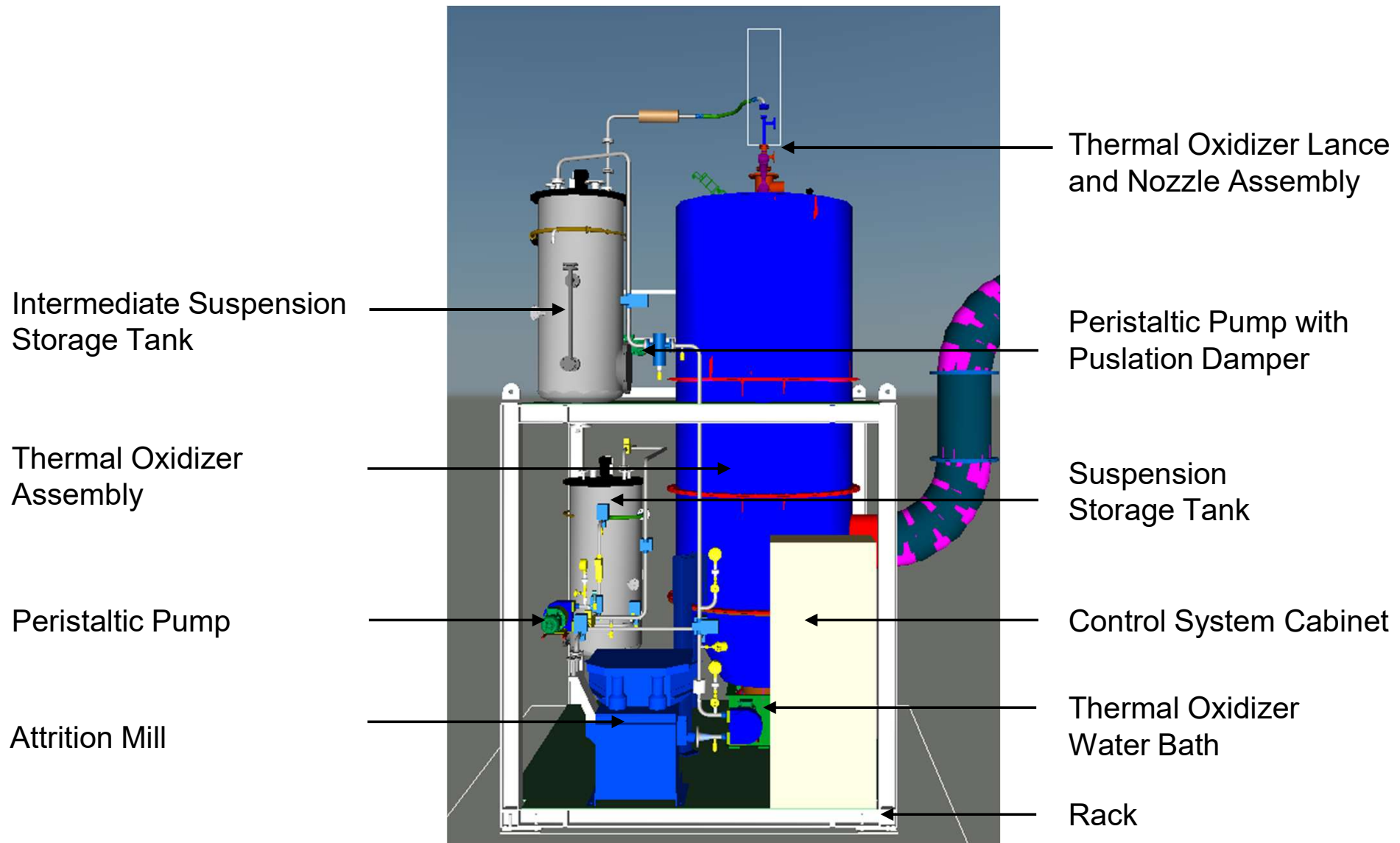
- Reproduction of the demonstrator's core loop to investigate process-safety-related questions under representative laboratory conditions.
- Planned test modules: suspension test, plant test, piping test, lance/nozzle test, and mill test.
- Transparent vessels and piping sections to visually assess suspension behavior and sedimentation.

BorDEX Demonstrator Concept

- Mixing and homogenization to avoid sedimentation.
- Pumping and recirculation loop with bypass control.
- Spray lance / nozzle system for atomization.
- Thermal Burning Chamber for destruction of the suspension.
- Interfaces to off-gas treatment and utilities.

The demonstrator combines suspension conditioning and thermal destruction in a mobile rack-type setup intended for test operations with live energetic material.

9. Demonstrator and Planned Tests



- BorDEx aims to establish a technically feasible disposal route for explosive suspensions generated during washout of large-calibre sea-dumped munitions.
- The pre-tests and ICT campaign are intended to reduce technical risk and define robust operating windows for the demonstrator.
- The demonstrator will undergo a planned test phase to validate the integrated process with live explosive material.
- In the longer term, the concept may provide a basis for scale-up towards mobile or sea-based disposal solutions.

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Thank you...questions?



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[1] Wachter, L. (2016): Gefahrenermittlung und Risikoanalyse bei der Entwicklung eines Prototyps zur Bergung und Vernichtung von Munitionsaltlasten im Meer. Bachelorarbeit, Studiengang Security and Safety Engineering, 21.12.2016.