# General Atomics Electromagnetic Systems Group

## Title: The use of Cryofracture for Munitions Demilitarization

**Presented to: The Committee on Alternatives for the Demilitarization of Conventional Munitions**

**Presented by: John Follin, Director, Strategic Development for Demil and iSCWO Systems**

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# General Atomics

**LOCATION:** San Diego, California

**FOUNDED:** 1955

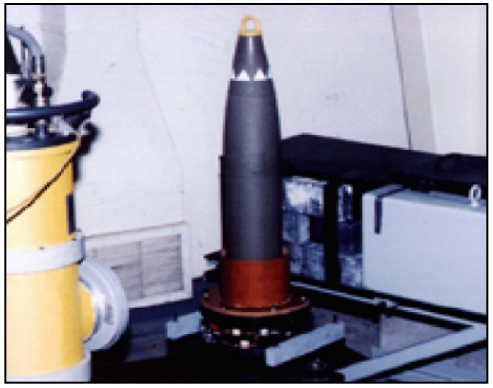
**STATUS:** Privately held corporation

**OWNERS:** Neal and Linden Blue

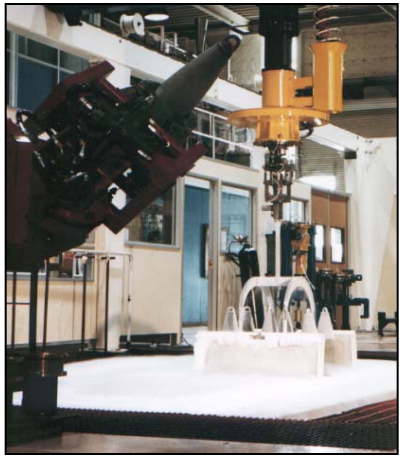
***GA is a recognized world leader in high-technology research, design, manufacturing, and production for industry and government in the U.S. and overseas***

# General Atomics Demilitarization Experience since 1982

**Munitions Inspection Systems**



**Cryofracture**



**SCWO of Energetics and Industrial Wastes**

**Energetics Incineration**

**Chemical Weapons Demil**

**Hydrolyzed Energetics**

***We apply this Experience for all Demil Projects for Success***

# Standard Munition Cryofracture Process

Munitions Loaded into Fixtures → Munitions Cooled in LN2 → Cryofracture Munitions → Thermally Treat Debris → Recycle Metal Scrap

**DESTROYS MUNITIONS EFFICIENTLY AND THOROUGHLY**

# Cryofracture Attractive Characteristics

- Cools munitions in liquid nitrogen prior to fracture/energetic accessing in a hydraulic press
- All munition handling performed by remotely controlled robots or automated conveyors (manual item feed)
- Minimum contaminated area (contained within the equipment)
- Simple system processes a wide variety of munitions
- Completely destroys the munition
- Flexible process is not sensitive to design configuration or condition (range from new to poor condition)
- High throughput/competitive cost
- Interfaces with an approved thermal treatment systems (APE-1236 or APE-2210), supercritical water oxidation, or energetic recovery systems

# Good Reasons to Use Cryofracture

- **Many munitions are excellent candidates for cryofracture**
  - **Munition items that are difficult or costly to disassemble (easy to disassemble items need not apply)**
  - **Munition items that do not have an established or demonstrated demilitarization technology (e.g., not a direct feed into an APE-1236 kiln)**
  - **Items that will cause damage if they detonate during thermal treatment**
  - **Deactivated munition bodies to be recycled that require full breakup**
  - **Cryofracture is at its best when accessing munitions without any detonator train near the stress points exerted by the cryofracture tooling (e.g., large munitions, hand grenades, BLUs, ICMs, Rockets, etc.)**
  - **The cryofracture process is very cost effective if there are a variety of different munition items for demilitarization because the process utilizes the same equipment but uses different tooling and fixtures**

# Summary – Cryofracture Item Data Base

- **Large Items**
  - **8 inch, 155mm, and 105mm Projectiles**
  - **M23 landmines, M55 Rockets (115mm), and 4.2 in. mortars**

- **Small Items**
  - **ADAM mines (QA and AP) and M16 mines**
  - **Rockeye II (MK 118) Bomblets**
  - **BLUs (BLU 63/B, BLU 86/B, BLU 61 A/B, BLU 91/B, BLU 92/B, and BLU 97/B)**
  - **M42/M46/M77/M80 ICM bomblets**
  - **40mm Cartridge Rounds (M406 and M433)**
  - **Destructors (M10, M4, MK24)**
  - **Fuzes (M379)**
  - **Bursters**
  - **Hand Grenades (M26, M61, and M59)**
  - **Landmines (M16 and M56 AT/AV)**

- **A large number of items were cryofractured in support of tests**

# Summary – Cryofracture Tests

- General Atomics – inert munitions with real configuration
- Dugway Proving Ground – real munitions (large, medium and small) with thermal treatment system
- Yuma Proving Ground – a variety of medium and small sized munitions with thermal treatment system
- Tooele Army Depot – Medium and small sized munitions with thermal treatment system

# Cryofracture Ensures Accessing of Energetics

4.2 IN. MORTARS

155 mm PROJECTILES

BOXED 4.2 IN. MORTARS

105 mm PROJECTILES

DRUMMED MINES

ROCKETS

**CRYOFRACTURE DESTROYS MUNITION BODIES**

# Some Examples of Medium to Small Sized Item Cryofracture

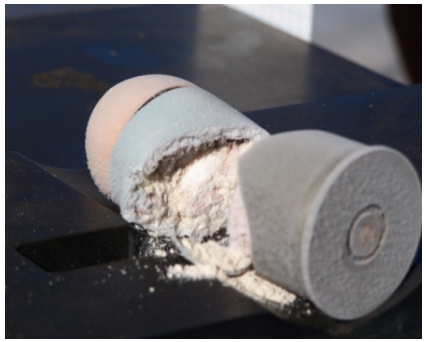
BLU 92/B
(CBU 89 A/B)

BLU 97/B
(CBU 87 A/B)

BLU 61A/B
(CBU 52B/B)

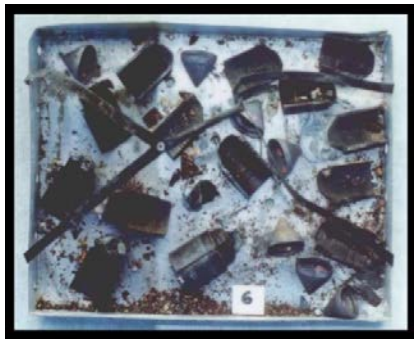
ADAM
Land Mines

Rockeye II
Bomblets



M406 and M433
40mm HEDP

M26 Hand
Grenade



ICM Shape
Charges

# Conventional Demil

## McAlester Army Ammunition Plant (MCAAP)

- GA cryofracture system with APE-1236 RKS/PAS for the destruction of ADAM AP Land Mines
- PAS upgrades – plant startup in March 2018
- System can be modified for other munitions

## Yuma Proving Ground (YPG)

- GA cryofracture system at YPG for destruction of ICM range scrap

## Crane Army Ammunition Activity (CAAA)

- GA transportable cryofracture system delivered to CAAA
- Planning underway to install/startup/test system to destroy Rockeye Bomblets

# Detonations inside the Cryofracture Press

- Detonations are not likely due to controlled orientation of the munition item (and detonator) prior to cryofracture
- Detonations are possible and the press and frame are designed to survive detonation forces (20 ms impulse loading)
- Fragment shields and tooling are designed to survive but can easily be replaced
- Press system designed to withstand multiple detonations
- Blast Isolation Valves protect downstream equipment
- Fragment/blast analysis has been performed to verify more-than-adequate design to withstand multiple detonations
- Test coupons are used inside the press to evaluate conditions after a detonation

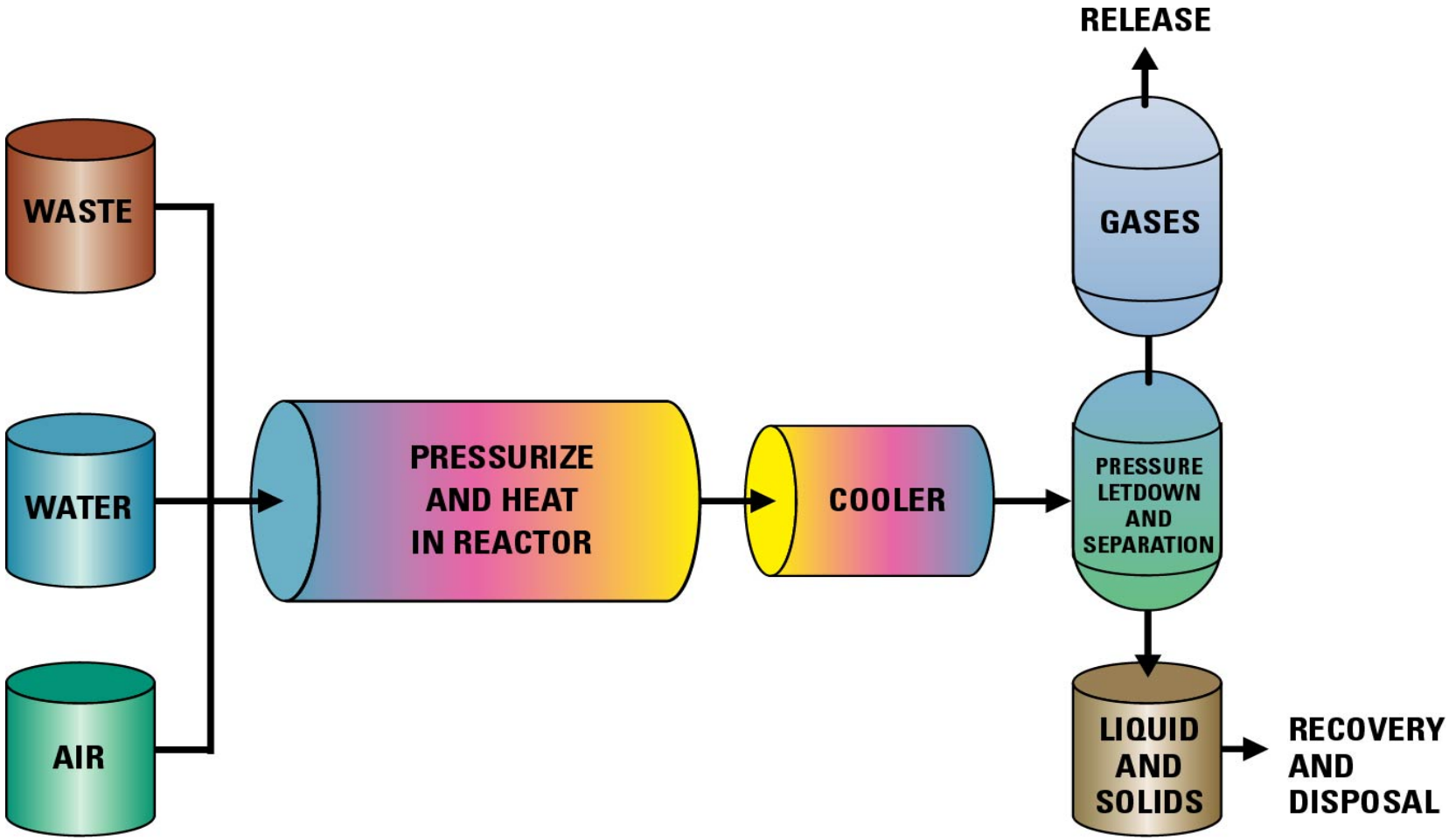
# Press Cleaning

- Press tooling is kept clean from debris by use of a tilt table to discharge the cryofracture debris and a air-blast system to clean surfaces while the press slide is in the close position
- Debris build-up is not a problem based on past cryofracture tests and operations
- If maintenance is required inside the press (e.g., tooling), procedures are in place that specify the use of a low-force sand blaster to scour the tooling. The resultant sand is discharged to the shuttle boxes where it can be thermally treated by a thermal treatment system
- Standard procedures are then followed for maintenance of equipment
- Other components such as conveyors and robots do not come into contact with exposed munitions – equipment manufacturer repair procedures are used

# Cryofracture Interfaces

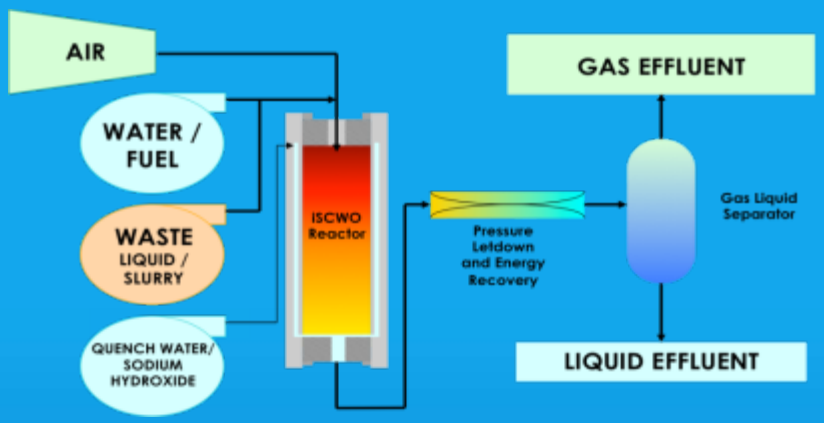
- The cryofracture process is a pre-treatment process to access energetics and destroy the munition body – does not destroy the energetics
- Thermal treatment of the energetics can be handled by an approved and permitted APE-1236 RKS/PAS incinerator
- Energetics recovery is possible by washing the cryofracture debris and then going thru additional steps to recover energetics
- If destruction of energetics is required but incineration is not supported or desired, the cryofracture debris and energetics can be washed and subsequently destroyed by using a supercritical water oxidation process

# Process Flow of a GA iSCWO System




**System operates at 650C and 3500PSI for excellent destruction of organics**

# iSCWO: Technical and Cost Advantages




- Perfect for onsite waste destruction
- Cost competitive with incineration or any other oxidation process at the site
- No airborne particulates
- No afterburner or complex secondary processing equipment
- Clean water by-product required little or no post-treatment prior to discharge to POTW
- No flame or burners used for process
- Simple design – easily maintainable
- Waste stream testing in San Diego

**Rapid, complete organic destruction with no pollution abatement system**

# Cryofracture – Commonly Asked Questions

- **Is there data to backup cryofracture of various munitions?**
  - **There is real test data that supports the use of cryofracture for the destruction of a variety of munitions (or similar types)**
  - **This data not only supports the use of cryofracture to access the munitions but also the successful thermal treatment of the cryofractured debris**
  - **For any unique munitions, GA can perform analysis to determine how to fracture the munition to access the energetics**

- **Is it safe?**
  - **The process is an automated, remote operation behind blast walls**
  - **Press has slides that give 3" of protection prior to fracture**
  - **Detonations are possible - system can withstand a detonation up to 5 lbs NEW – both within the press and thru the blast isolation discharge valves**
  - **Full HAZOP analysis has been performed on each process step**

# Cryofracture – Commonly Asked Questions

- **Can you process other munitions through the system?**
  - Within a certain size, you can change fixtures to handle different munitions (L x W)
  - Press tooling can be changed inside the press to handle different munition configurations – however, some configurations might use similar type tooling
  - Feeding method to the rotary kiln can be modified (shuttle boxes)

- **How does the use of liquid nitrogen assist with the process?**
  - Liquid nitrogen does NOT change any chemical properties (e.g., explosives or propellants)
  - Liquid nitrogen does allow for ferrous metal to reach its nil-ductility temperatures so that it fractures
  - Generally for most munition items the soak time ranges from 10 mins to 45 mins
  - Other non-ferrous metals can be used – but requires specialized tooling

# Summary

- Simple remote, automatic process that completely destroys the munition body and prepares the debris for thermal treatment
- Process can process a wide variety of munitions
- Minimum contaminated area (contained within the equipment)
- Flexible process is not sensitive to design configuration or condition (range from new to poor condition)
- Successful testing has been performed on many types of munitions
- Thermal treatment can use an incinerator (APE-1236 or APE-2210 RKS/PAS), supercritical water oxidation, or energetic recovery systems

# Contact Information

**Thank you very much for your time!**

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