The Cryofracture Demilitarization Process:
An Evolving Technology

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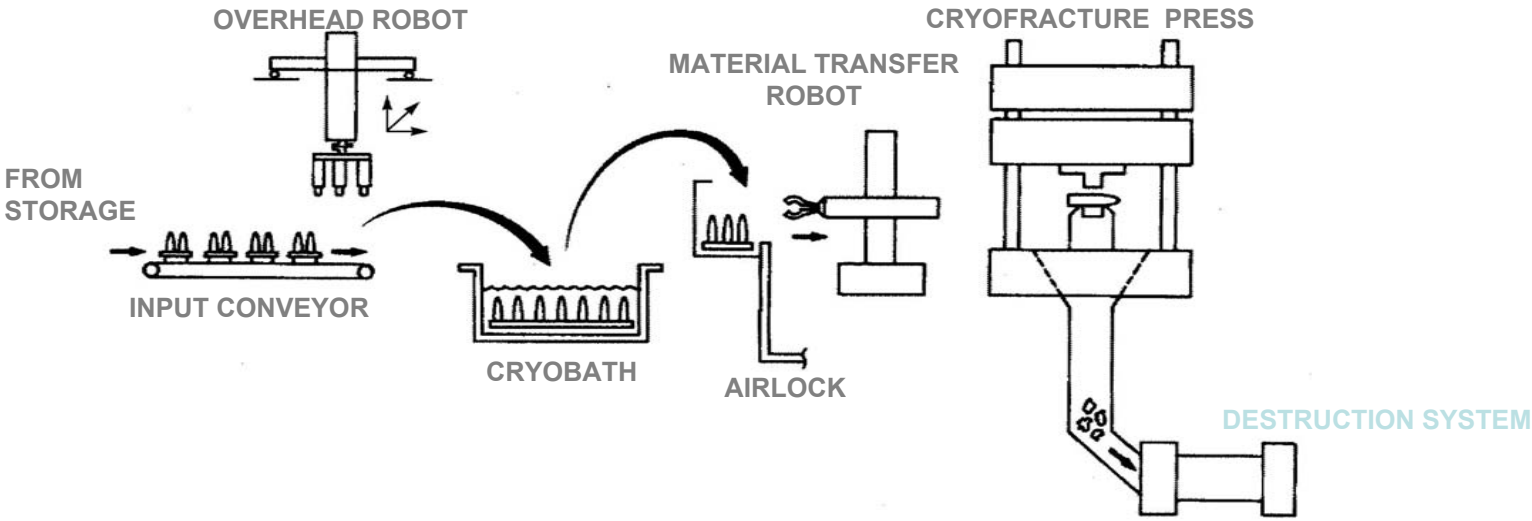
MUNITION CRYOFRACTURE PROCESS



DESTROYS MUNITIONS EFFICIENTLY AND THOROUGHLY

CRYOFRACTURE ATTRACTIVE CHARACTERISTICS

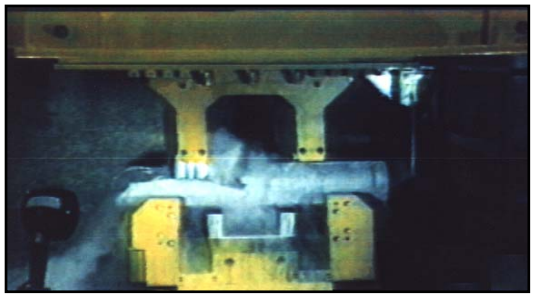
- Cools munitions in liquid nitrogen prior to fracture/energetic accessing in a hydraulic press
- All munition handling performed by remotely controlled robots or automated conveyors (manual item feed)
- Minimum contaminated area (contained within the equipment)
- Simple system processes a wide variety 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 all types of thermal treatment systems (APE-1236, APE-2210, Plasma Arc, SCWO, etc.)

GOOD REASONS TO USE CRYOFRACTURE

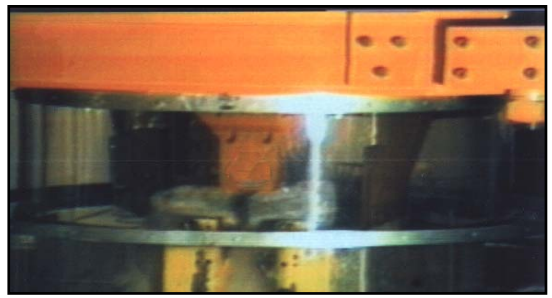
- **Many munitions are excellent candidates for cryofracture**
  - **Munition items that are difficult to disassemble (easy to disassemble items need not apply)**
  - **Munition items that do not have an established or demonstrated demilitarization technology (e.g., direct feed into an APE-1236 kiln)**
  - **Items that are likely to detonate during the demilitarization process**
  - **Items that will cause damage if they detonate inside an APE-1236 kiln**
  - **Deactivated munition items to be recycled require full breakup**
  - **The cryofracture process is very cost effective if there are a variety of different munition items for demilitarization because the process utilize the same equipment but uses different tooling and fixtures**

CRYOFRACTURE DEMONSTRATED FOR LARGE MUNITIONS

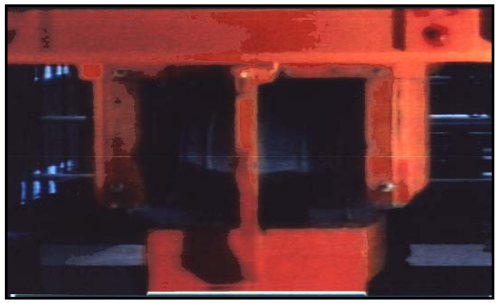
BOXED 105 mm CARTRIDGES



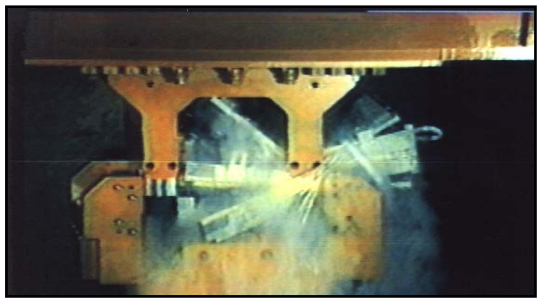
OVERPACKED MUNITIONS



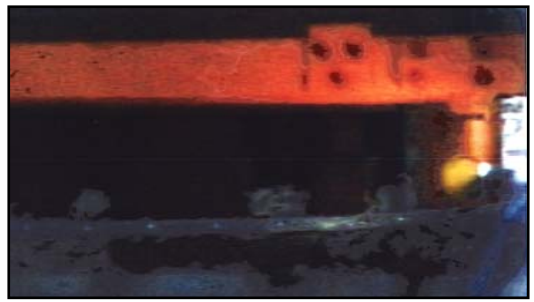
155 mm PROJECTILES



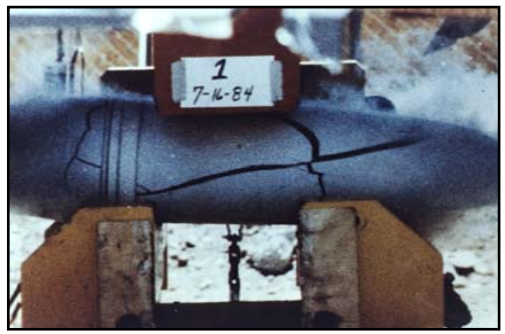
DRUMMED MINES



4.2 IN. MORTARS



ROCKETS



8 IN. PROJECTILES

OVER 4000 EXPLOSIVELY CONFIGURED MUNITIONS SUCCESSFULLY CRYOFRACTURED

CRYOFRACTURE COMPLETELY BREAKS UP MUNITION ITEM

4.2 IN. MORTARS

155 mm PROJECTILES

BOXED 4.2 IN., MORTARS

105 mm PROJECTILES

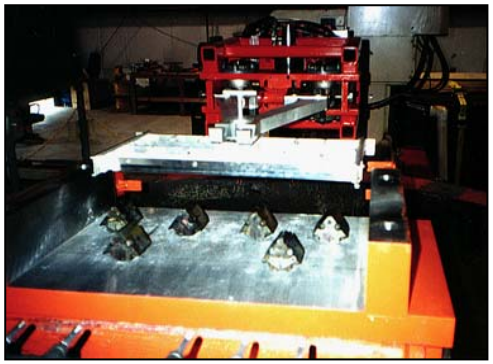
DRUMMED MINES

ROCKETS

CRYOFRACTURE ALSO DESTROYS MUNITION BODIES

DPG SMALL ITEM CRYOFRACTURE

ADAM AP Mines



Rockeye II Bomblets

M16A1 AP Mines

Items Tested at the YPG TVT

M406 and M433 40mm HEDP

M379 Fuze

M26 Hand Grenade

BLU Items Tested at the YPG TVT

BLU 63/B (CBU 58/B)

BLU 86/B (CBU 71/B)

BLU 61A/B (CBU 51B/B)

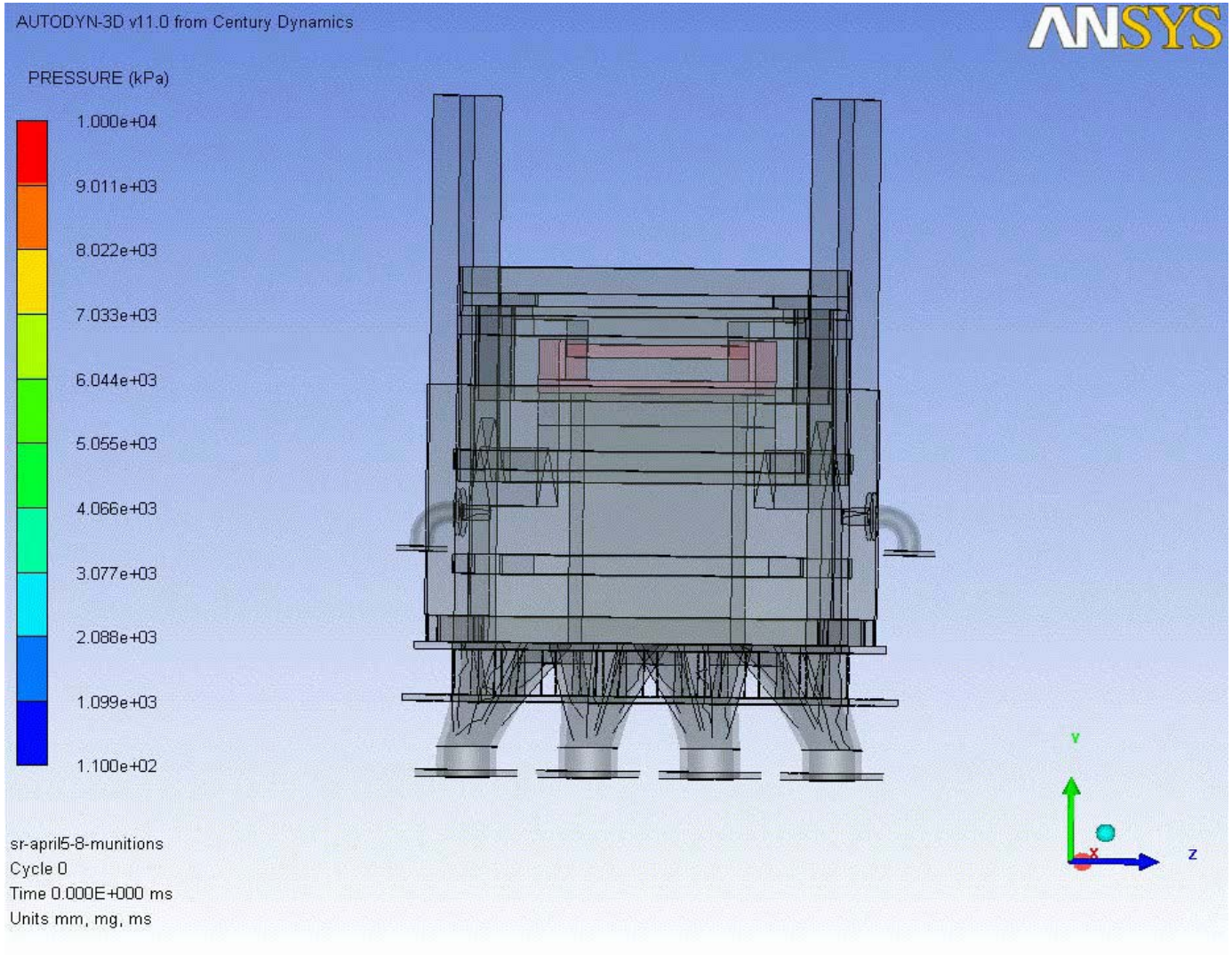
Summary – Cryofracture Item Data Base

- **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)
  - Rockeye II (MK 118)
  - BLUs (BLU 63/B, BLU 86/B, and BLU 61 A/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 total of 15,307 items cryofractured for tests**

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
- Fragment shields and tooling are designed to survive but can easily be replaced
- Press system designed to withstand multiple detonations
- Fragment/blast analysis has been performed to verify more-than-adequate design to withstand multiple detonations
  - Develop press, tooling, and fragmentation shields in solidworks
  - Perform meshing
  - Run Autodyn computer program to simulate detonation
  - Run ANSYS computer program to analyze stresses to components
  - Analyze results and update design if required

3 lbs NEW Detonation Inside Cryofracture Press



Cryofracture Customers

PM DEMIL

ARDEC

DAC

MCAAP

YPG

D&Z

HWAD

MCAAP Munitions Cryofracture Demilitarization Facility

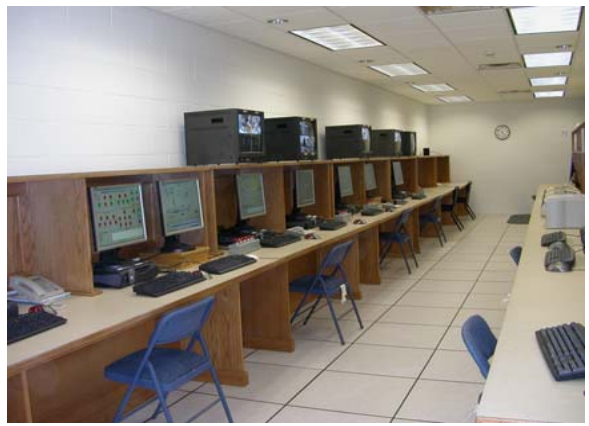
Munition Feed (manual or automatic)

Munition immersion in LN2

Automatic placement in press

Munition Cryofracture

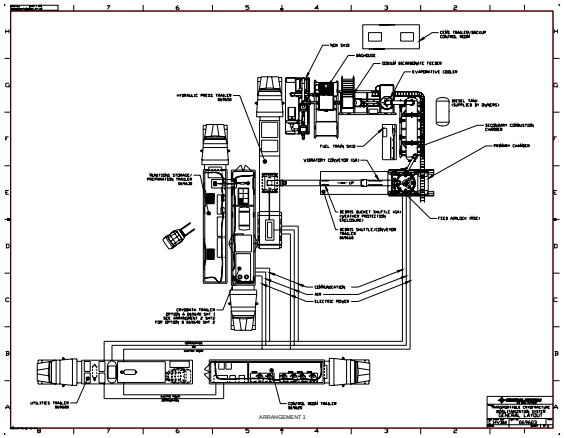
Debris discharge in RKS



Remote/Automatic Control

Processed 14,705 items – Design upgrades with plant restart planned for mid 2007

Transportable Munitions Cryofracture Plant



Equipment mounted in trailers

Transportable cryofracture system

Plasma Arc thermal treatment system

Plant village can be located anywhere

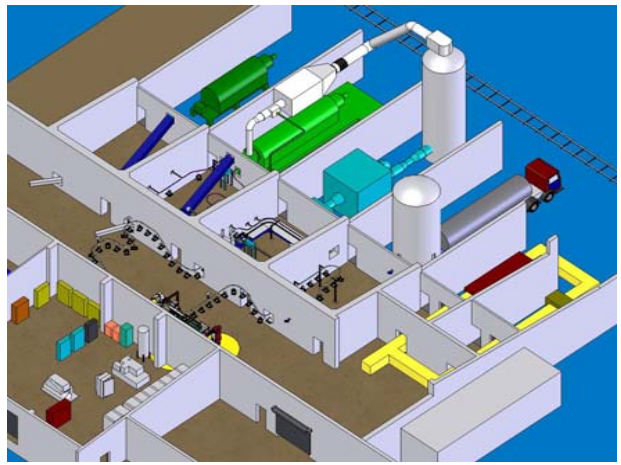
Detail design underway with procurement and truck/trailer assembly underway

Hawthorne (HWAD) Cryofracture Plant

Building to house Cryofracture System

Cryofracture Process Area

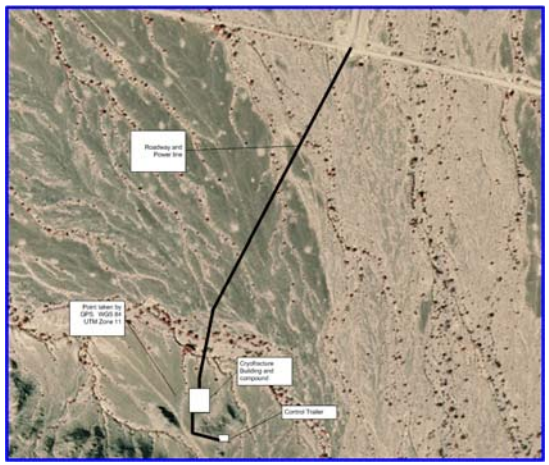
APE-2210 Thermal Treatment System



Cryofracture Equipment Arrangement

CBU Download and Cryofracture detail design underway

YPG Munitions Cryofracture Facility



Site at KOFA Firing Range

Building, LN2 Tank, Control Room

Munitions unload/load station

Munition immersion in LN2

Munitions to be fractured in press

Munitions fractured in press

Plant is processing ICMS – later to transition to 155mm projectiles

YPG Remote TVT Site for R&D

Outdoor (covered) test site

Control Room behind berm

Remote cryofracture tests

Liquid Nitrogen Cryobath

Cryofracture Tooling

Energetic Burn Pans

TVT tested 10 different unique munition items for Cryofracture

General Atomics Cryofracture Recent Experience

- **MCAAP MCDF**
  - Plant upgrades are in process
  - Planned restart summer of 2007
  - Focus on ADAM mines but can do ICMs, Rockeyes, and similar items
- **YPG Cryofracture**
  - Plant Operational – processing ICMs (80,000 so far…)
  - More ICMs, M56 Landmines, 40mm Cartridge, and 155mm Projectiles
- **HWAD Cryofracture**
  - Cryofracture design underway
  - Process BLUs from CBUs and ICMs
- **Transportable Cryofracture/Plasma Arc System**
  - Detail design currently underway – feed interface test in summer CY 2007
  - Wide variety of small (less than 3 lbs NEW) items
- **YPG Tooling Verification Test Facility**
  - Future munition item tests

Future Projects

- Cryofracture Projects in Europe
- Transportable cryofracture in Europe
- Ukrainian PFM-1 mine demil

SUMMARY

- Cryofracture technology has been shown to be an effective means for demilitarizing munitions instead of OB/OD
- The cryofracture process can accommodate a wide range of munitions – limiting factor is thermal treatment process
- Process is simple → cryocool, cryofracture, discharge, incinerate, and recycle
- Process can be complex → cryocool, cryofracture, segregate waste streams, incinerate and/or drum, and recycle
- Cryofracture technology is evolving
  - Some sites are in the implementation/test phase
  - Test site is expanding cryofracture munition data base