Emerging Technologies Addressing Alternatives to Open Burn and Open Detonation

Presented to
National Academy of Sciences

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Bottom Line Up Front (BLUF)

- PM Demil manages a Budget Activity 6 Technology Program which supports the execution of Conventional Ammunition Demil (CAD) and Tactical Missile Demil for the Army and Services.
- This information brief is intended to provide a focused review of present and emerging technologies which are alternatives to Open Burning and/or Open Detonation.

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Demil Technology Focus

- Address Gaps In Execution
  - Develop Capability and Capacity
  - Develop Technology and Facilities
- Improve Existing Facilities
  - Increase Efficiency
  - Increase Effectiveness
- Investigate Emerging Technologies
- Ammunition Demilitarization Costs vary greatly
- Average Open Burn Open Detonation (OB/OD) cost $750/ton to operate
- Closed disposal operations cost vary from $2,000/ton to $20,000/ton

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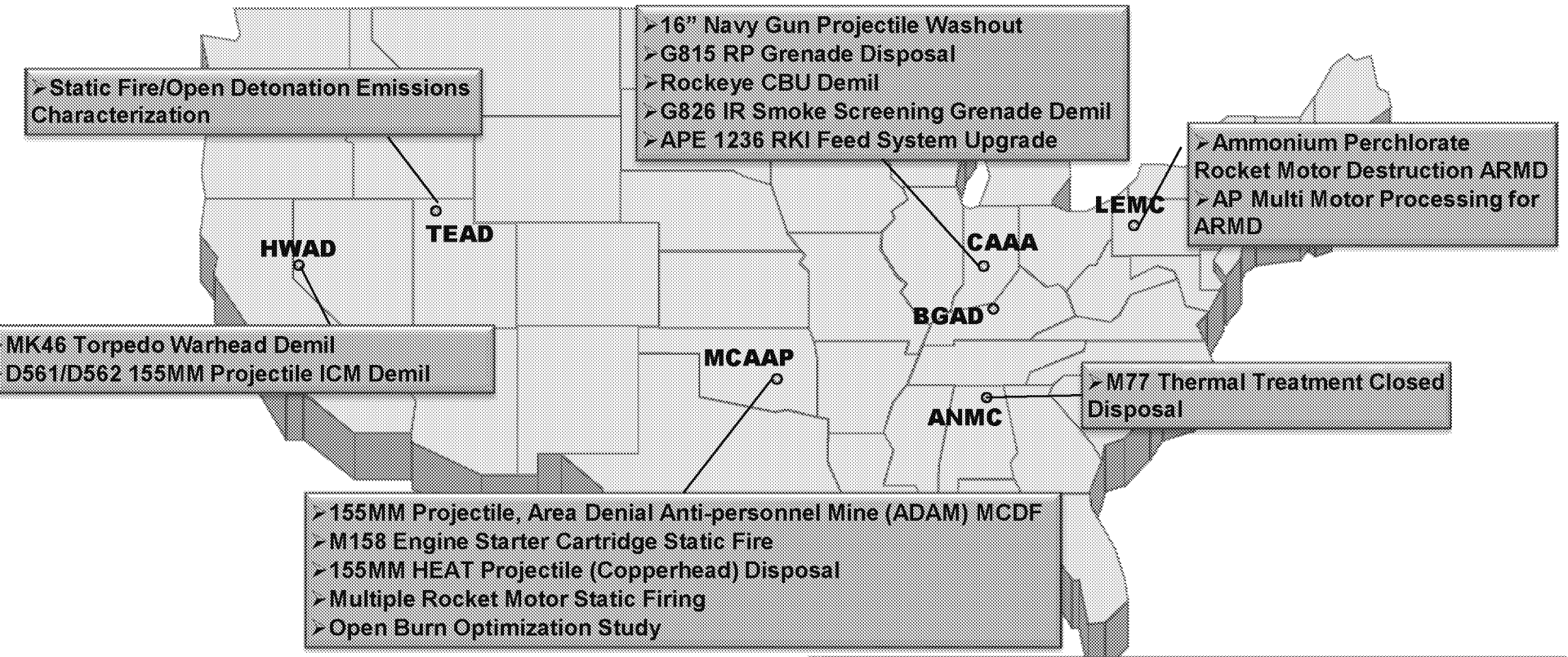
FY17 RDT&E Capability Investments



➢Non-Site Affiliated Projects
➢Castalia Capability Assessment
➢Size Reduction of Reactive Armor Tiles
➢CS Riot Agent Thermal Testing
➢Reactive Armor Tile Thermal Treatment Test

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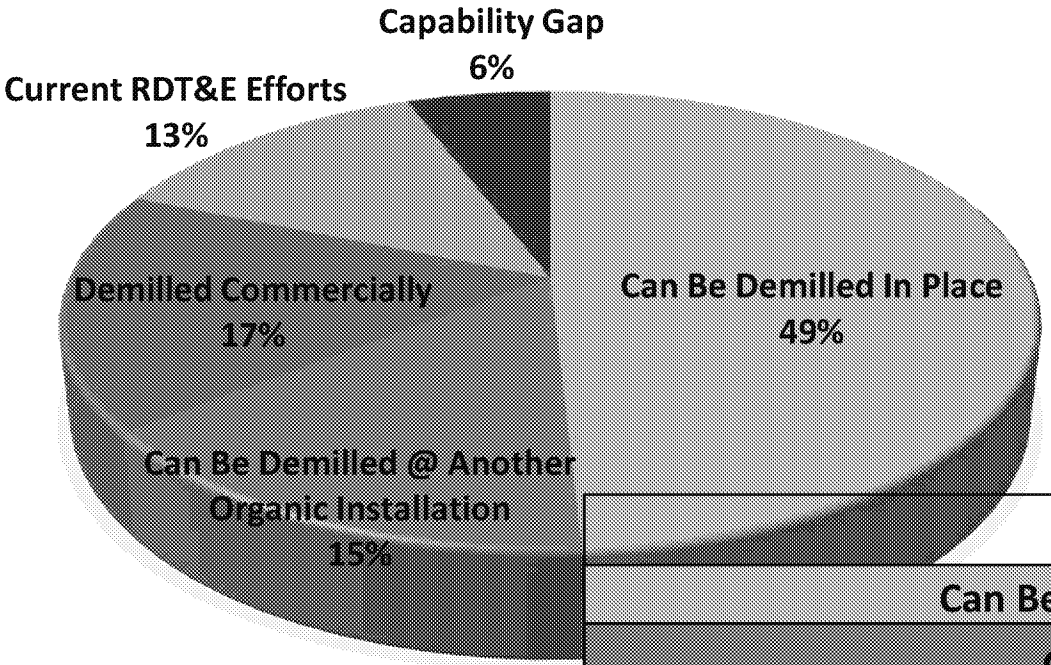
Current Top 400 Demil Capability Status

(as of EOM March 2017)



Legend	
Can Be Demilled In Place	197,771 STs
Can Be Demilled at Another Organic Installation	61,062 STs
Can Be Demilled Commercially	68,309 STs
Current RDT&E Efforts	52,474 STs
Capability Gap	22,867 STs
Total B5A Currently Analyzed	402,483 STs

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Demil RDTE Projects in Execution

#	Title	Project Start Date	Completion Date
	2004		
1	155MM Projectile, Area Denial Anti-personnel Mine	Dec 04	Jun 18
	2009		
2	Ammonium Perchlorate Rocket Motor Destruction ARMD	Sep 09	Feb 18
	2013		
3	G815 RP Grenade Disposal	Sep 13	Q1FY18
	2015		
4	16" Navy Gun Projectile Washout	Dec 15	Apr 18
5	Castalia Capability Assessment	Apr 15	Aug 17
	2016		
6	Download of Rockeye Cluster Bomb Units (CBU)	Dec 16	Oct 19
7	M77 Grenade Thermal Treatment Closed Disposal Process	Dec 13	Dec 17
8	Cryofracture of Rockeye CBU	Oct 16	Jan 23
9	155MM HEAT Projectile (Copperhead) Disposal	Mar 16	Jan 18
10	Size Reduction of Reactive Armor Tiles	Mar 16	Jun 18
11	M158 Engine Starter Cartridge Static Fire	Feb 16	Oct 17
12	Open Burn Optimization Study	Feb 16	Jun 17
13	APE 1236 RKI Feed System Upgrade	Mar 16	Aug 23
	2017		
14	CS Riot Agent Thermal Testing	Dec 16	Dec 18
15	Reactive Armor Tile Thermal Treatment	Dec 16	Mar 19
16	AP Multi-Motor for ARMD	Dec 16	Jan 19
17	Static Fire OD Emissions Characterization	Dec 16	Aug 18
18	155mm D561 ICM Projectile Demil	Dec 16	Oct 19
19	G826 IR Smoke Screening Grenade Demil	Dec 16	Apr 20
20	MK 46 Torpedo Warhead Demil	Dec 16	Jan 20

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Demil Technology
Recently Completed Activity

#	Title	Completion Date
1	Flexible Munitions Residue Inspection System (FMRIS) (HWAD)	Jun 15
2	Projectile Download Work Cell (PDWC) (MCAAP)	Jun 15
3	Rotary Kiln Incinerator Productivity Improvement (RKPI) (Non Site)	Jun 15
4	High Pressure Water Washout (HPWWO) (HWAD)	Oct 15
5	IMX 101 Autoclave Improvements (Non Site)	Jun 14
6	CBU-87 Download & OD (HWAD)	Oct 16
7	Static Detonation Chamber Testing (ANMC)	Oct 16
8	CS Gas Analysis of Alternatives	Sep 16

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Emerging Capabilities

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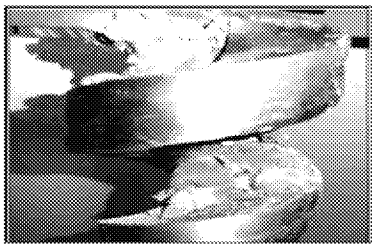
Ammunition Demilitarization Capabilities

2.5k tons



Red Phosphorous Munitions Disposal

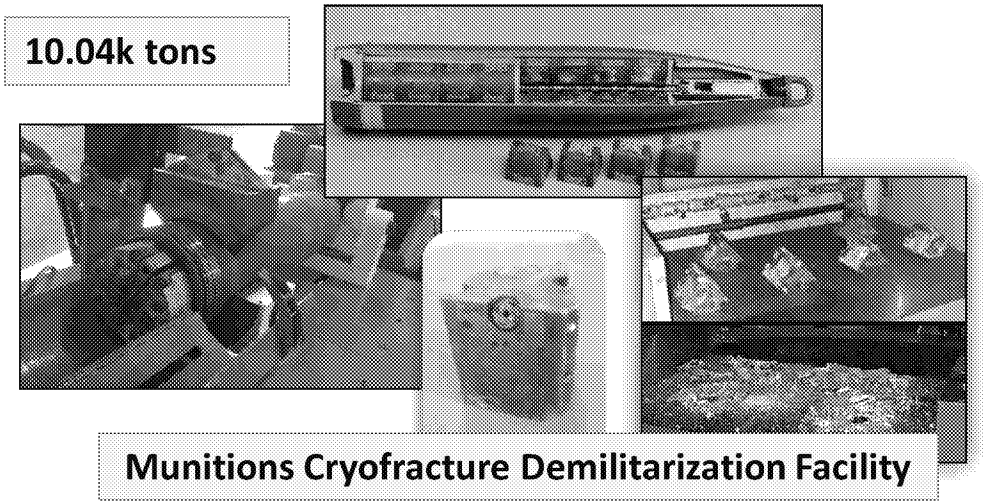
Description of the Capability: G815 RP Grenade Disposal: An automated capability for the disposal of DODCI G815, red phosphorus (RP) smoke grenades and feeds to recovered RP into the APE 1400 WP-PAC (White Phosphorus – Phosphoric Acid Conversion) See Charts.
Utilizes 2 automated disassembly stations, segmenting the grenade bodies, removing the RP filler by milling, and thermal treatment of RP in an APE 1400 WP-PAC.
The effluent is converted into a saleable product, Phosphoric Acid. The capability is located at Crane Army Ammunition Activity (CAAA).
The sale of phosphoric Acid results in a cost offset to operation of the capability.

CAAA is expected to process 400-500 grenades per day. No modification will be required to introduce RP into the APE 1400.
The DODC G815 Smoke Grenade is a significant stockpile munitions with 2,554 tons in the demil account.

Length of Project = 60 months
Operating Cost = $20,116/ ston
Operating Rate = 400 grenades / 10 hour shift

Ammunition Demilitarization Capabilities

10.04k tons



Munitions Cryofracture Demilitarization Facility

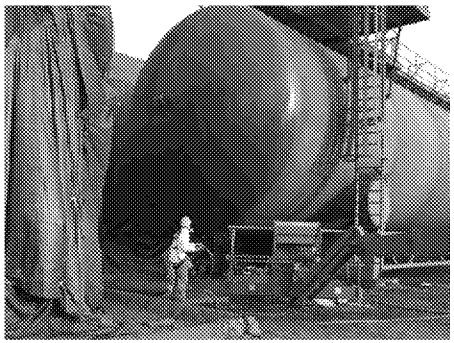
Description of the Capability: 155mm Projectile, Area Denial Anti Personnel Mine MCDF; A capability for the disposal of DODCI D501/D502 155mm, High Explosive Area Denial Munitions. The capability, located at McAlester Army Ammunition Plant (MCAAP), consists of a manual operated projectile debasing and pushout machinery, which stages the ADAM mine segments. Subsequently, the automated handling system places the mine segments on trays, transfer trays into a liquid nitrogen bath. Upon completion of the cooling cycle, munitions are transferred to a large vertically oriented pressing station, where a series of punches press the mine segment though a die to expose the explosive filler, and prevent high order detonations. The potting material for the mine housing, along with leads and dets are transferred to a drum heater for thermal treatment, while the main AP element, is transferred to an APE 1236 Hazardous Waste Incinerator to thermally treat the main explosive. The metal parts from the projectile body are sold for scrap, the HWI ash is disposed of as required, as is the baghouse waste.

The sale of scrap metal results in a cost offset to operation of the capability.

MCAAP is expected to process 50 projectiles per day. The DODC D501/D502 is a significant stockpile munitions with 10,041 tons in the demil account.

Length of Project = 60 months
Operating Cost = $10,500/ ston
Operating Rate = 50 Projectiles (1800 mines) / 10 hour shift

Ammunition Demilitarization Capabilities



Letterkenny Munitions Center Ammonium Perchlorate Rocket Motor Destruction

Description of the Capability LEMC ARMD; Closed Disposal Technology (CDT) capability for the disposition of ammonium perchlorate (AP) based composite propellant rocket motors. The intent of this program is to establish a Thermal Treatment Capability (TTC) at LEMC that can demilitarize MLRS M26 rocket motors as well as specific Other Service Missiles (OSM) AP rocket motors. The current targeted throughput threshold is 10,000 motors per year for Hazard Class 1.3 AP based rocket motors. The project is in the final stages of facilitization and live testing of the capability is currently scheduled to start in early calendar year 2018. the AP rocket motors are prepped, transferred by cart to the RAMSLIC, Loaded in the Thermal Treatment Chamber, Chamber locked, and the motors are remotely ignited. The rocket motor gasses are collected and processed through the air pollution control system, which collects the Aluminum Oxide waste as well as treating the acid gasses. The waste products generated are non-hazardous.
The rocket motor bodies are sold as scrap product.. The capability is located at Letterkenny Munitions Center (LEMC).
The sale of phosphoric Acid results in a cost offset to operation of the capability.

LEMC ARMD is expected to process up to 10,000 AP rocket motors or Segmented motors per year.

Length of Project = 60 months
Operating Cost = $8,200K per year.
Operating Rate = 16 motors / 10 hour shift

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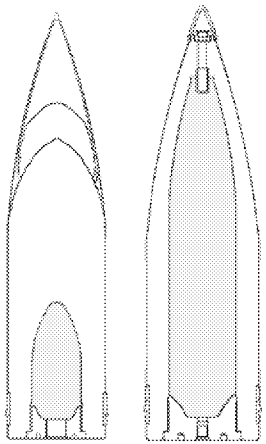
Ammunition Demilitarization Capabilities

15.6k tons



16" Navy Gun Projectile Washout

- **Description of the Capability:** Develop a capability for the disposal of 16"/50 Armor Piercing (AP) and High Capacity (HC) projectiles Navy Gun Projectiles. The capability involves physically moving projectiles which weigh up to 2700 lbs. The process removes the base fuze using water jet cutting, and washes out the explosive "D" filler for disposal (also called Ammonium Picrate). Then goals is to recover 99% of the yellow D payload and R3 all non-energetic munition components (metallic scrap). The Amor Piercing (AP) type projectiles, which contain 50 lbs nominal of Ammonium Picrate filler weigh 2700 lbs and High capacity type projectiles which contains 156 lbs nominal of Ammonium Picrate filler have a weight of 1900 lbs. The objective of this effort is for the contractor to design, build, and test a prototype capability designed to handle transfer cut washout and separate washout fluid from the metal parts of the 16" Navy Gun projectiles. The effluent is converted into a saleable product, Picric Acid. The capability is located at Crane Army Ammunition Activity (CAAA). The sale of Picric Acid results in a cost offset to operation of the capability.

- CAAA is expected to process 8 projectiles per day. The 16" Navy Gun Projectiles are a significant stockpile munitions with 15,600 tons in the demil account.

Length of Project = 48 months
Operating Cost = $2,540 / ston
Operating Rate = 8 projectiles / 10 hour shift

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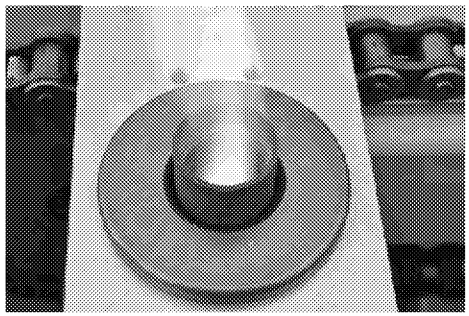
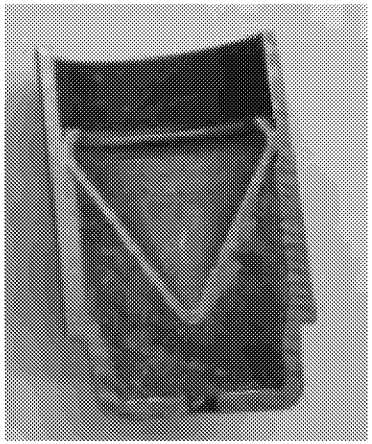
Ammunition Demilitarization Capabilities

4.8k tons





M77 Thermal Treatment Closed Disposal Capability

Description of the Capability: Developing and integrated Closed Disposal Technology (CDT) at the Anniston Munitions Center (ANMC) for the thermal treatment of M77 grenades and fuzes originating from Multiple Launch Rocket System (MLRS) M26 (H104) rocket pods. This effort is systemized with the already installed MLRS POD Download/Demate and Automated Warhead Disassembly process to provide an organic depot capability for a closed disposal process for MLRS M26 warheads.
ANMC is expected to process 2100 grenades per hour or 16,800 per day (26 MLRS Rockets). The DODC H104is a significant stockpile munitions with 4,781 tons in the demil account.

Length of Project = 60 months
Operating Cost = $4,464/ ston
Operating Rate = 16,800 grenades / 10 hour shift

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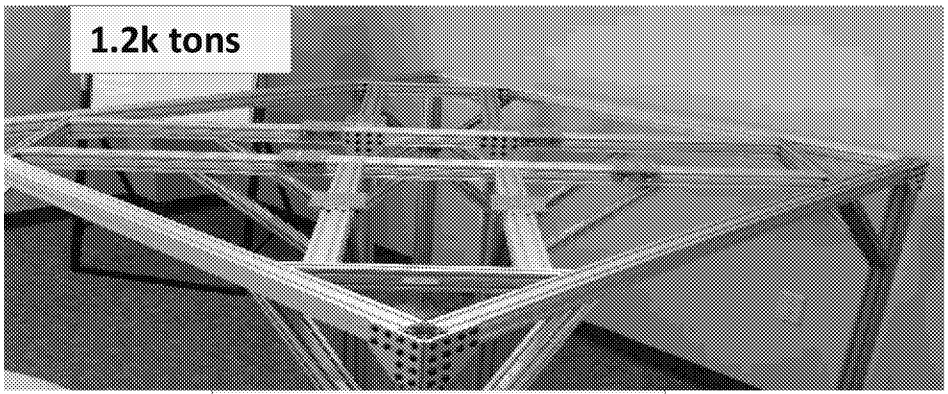
Ammunition Demilitarization Capabilities



Engine Starter Cartridge

Description of the Capability: M158 Engine Starter Cartridge Static Fire; Develop a capability to demilitarize the MXU-4A/A engine starter cartridge. The project was created to fulfill the prototype development requirement for determining a method for safely demilitarizing the asbestos-containing engine starter cartridges without liberating asbestos. Static Firing was determined through previous testing to not result in disbursement of asbestos fibers.
A test fixture was built to verify the electrical requirements of the cartridge and to determine the optimum spacing center-to-center of the cartridges based on thermal readings.
The initial test was performed December 2016. Follow on testing is planned for Oct 2017.

TEAD or MCAAP will be the site of the final capability.
The DODC M158 is a significant stockpile munitions with 1,189 tons in the demil account.

Length of Project = 24 months
Operating Cost = TBD / ston
Operating Rate = TBD / 10 hour shift

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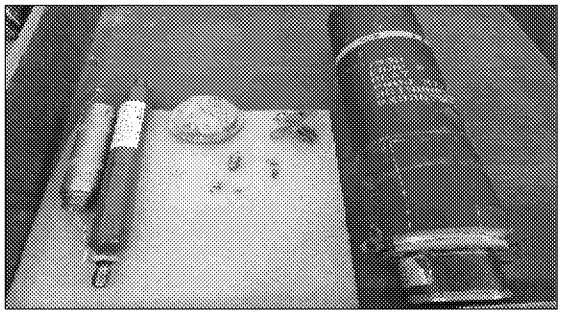
Ammunition Demilitarization Capabilities



1.9k tons

155mm Copperhead Projectile

Description of Capability 155mm Copperhead HEAT, Projectile Demil Capability McAlester Army Ammunition Plant, Oklahoma: This project develops a process to disassemble and dispose of 155mm, DODIC D510, M712, Copperhead Projectile.
The Copperhead is a 155mm, cannon-launched, laser-guided, high-explosive, anti-tank (HEAT) projectile designed for use with M109A1/A2/A3, M198, M777A2, and M114A2 howitzers.
The projectile has three major sections: guidance section, warhead section, and control section.
Each of these sections is made up of multiple assemblies and are difficult to disassemble and hazardous components prevent destruction by Open Detonation of the full up projectile.
The project involved developing a disassembly process to remove and separate the projectile into the major components, then provide final disposition for the unique hazardous components:
The disassembly process has removed and properly disposed of the Thermal batteries and the Nutation Damper which contains "Mercury Thallium" as well as the warhead and numerous small energetic items.
Explosive items; a 14.75 lbs Shaped Charge Warhead, numerous squibs and detonators.
The D510 is a significant item in the demil stockpile with 1,834 tons in the demil account and will transition for production use at McAlester Army Ammunition Plant (MCAAP). This project is currently in LRIP at MCAAP.

Length of Project = 18 months
Operating Cost = $8,900 / ston
Operating Rate = 19 Projectiles / 10 hour shift

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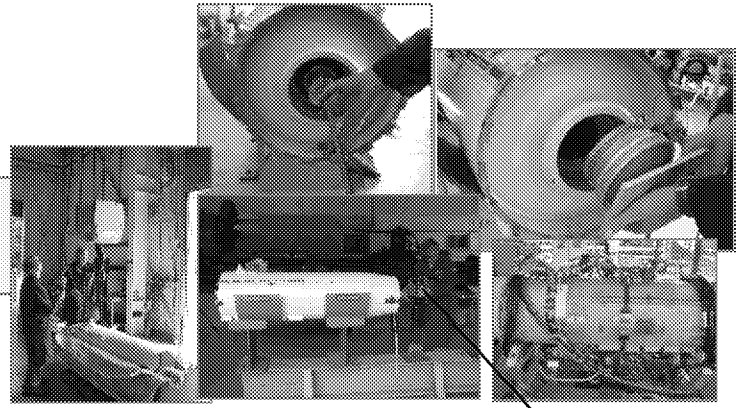
Ammunition Demilitarization Capabilities



210 items

Bullpup Liquid Fueled Motors

Description of Capability Bullpup Liquid Fueled Munitions Anniston Munitions Center, Alabama: The Bullpup rocket motors are liquid propulsion units containing 2 hazardous components; Mixed Amine Fuel (MAF-1) and Inhibited Red Fuming Nitric Acid (IRFNA).
The current funded effort developed the production capability.
The project developed the Phase III de-tanking station, which is designed to extract the liquid propellants from the Bullpup propulsion units in a safe and environmentally friendly process.
The liquid propellants are captured into DOT approved transport containers, then shipped to a disposal vendor.
The empty tanks for MAF and IRFNA components are opened via linear shaped charges, then flashed and released for scrap metal sale. The Liquid Fueled motors do not represent a large part of the stockpile, but the liquids pose a significant storage hazard, and the metallic tanks were starting to degrade.
This project will transition to Anniston Munitions Center (ANMC), and will allow for the demilitarization for 210 Bullpup Rocket Motors, and remove 81 tons of highly toxic liquids from the demil stockpile.
The Bullpup Liquid Fueled Motor project leverages contracts which were awarded for MAF and IRFNA disposal for Lance Rocket motors, another lower tonnage but higher visibility project.

Length of Project = 60 months Operating Cost = $ 36,000 / ston Operating Rate = 4 Bullpup / 10 hour shift

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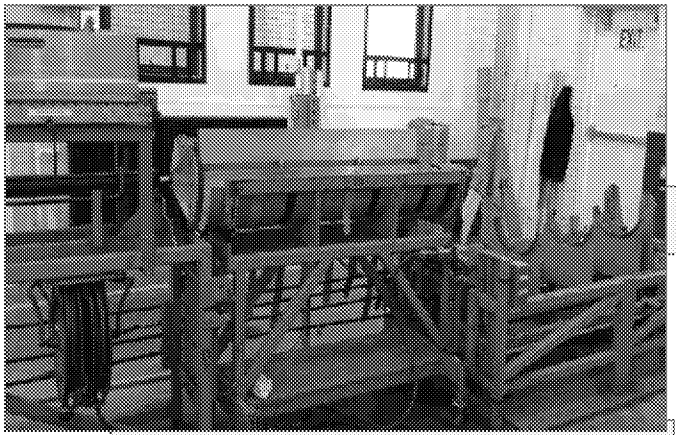
Ammunition Demilitarization Capabilities



7.6k tons

CBU-87 Download and Disposal

Description of Capability Cluster Bomb Unit (CBU) - 87 Demil and Disposal Hawthorne Army Depot, Nevada: This project provides an integrated disassembly process for the CBU-87 combined effects cluster bomb unit. This capability, which also addresses variants of the CBU-87, consists of a 2 line download line which can access the 202 BLU-97 submunitions, safe the submunitions, re package into suitable over pack and subsequently dispose of the BLU-97 submunitions payload by means of Open Detonation (OD) at HWAD. The CBU-87 Demil and OD process also helps to protect Army demil ranges from hazards associated with kick outs of the BLUs on the ranges from past attempts to demil theses munitions in the all up round configuration. CBU-87 accounts for 7658 tons in the demil stockpile. The CBU-87 capability at HWAD has been in production at HWAD since beginning of 2QFY17.

Length of Project = 60 months; Operating Cost = $1,192 .90 / ston Operating Rate = 50 CBU / 10 hour shift

Technology Studies

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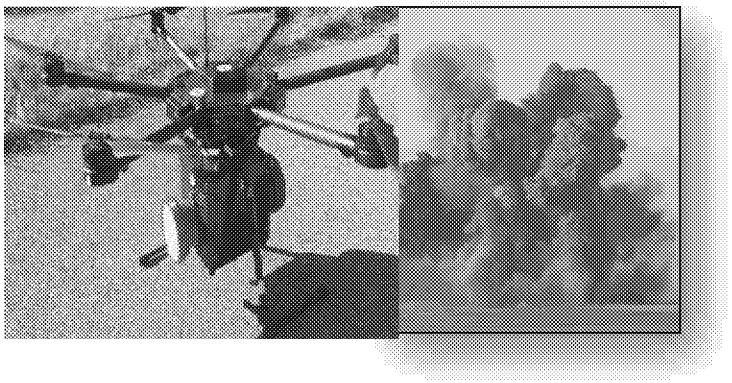
Ammunition Demilitarization Technology Studies

Open Burn Emissions Characterization Study



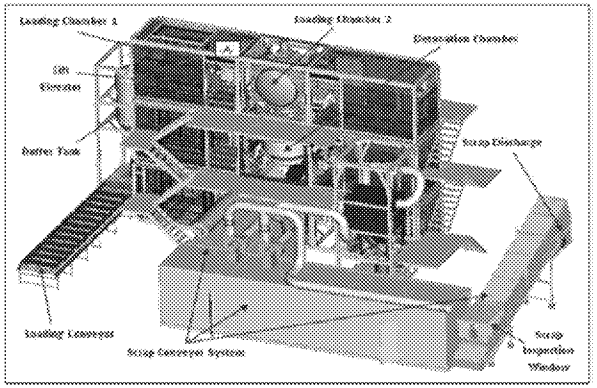
The OB Emission Characterization study:
Consisted of collection of air emissions from the open burning production operations at McAlester Army Ammunition plant during the OB of 3 different types of propellants.
The collection of emissions was accomplished by use of a drone and a sophisticated equipment skid, which was also small enough to fit on a drone.
The drone was maneuvered into the smoke plume resulting from the OB operation.
The Collected emission samples analyzed and results were compared to calculated emissions and also to plume measurements which were conducted at other installations using procedures which resulted in less residence time in the plume.
The analytical data was then used to develop models for air emissions.
The resulting air emissions models were used to develop an updated dispersion modeling software called OBODM, used to report open burn emissions to the EPA for annual air emissions reporting.
In addition to annual reporting, the OBODM information will be used to update existing Air Emission Permits at GOGO and GOCO locations.

The EPA and NASA were contractors on this effort.
OB/OD is used for 25K tons of demil per year.

Length of Project = 18 months

Ammunition Demilitarization Technology Studies

Static Detonation Chamber Assessment

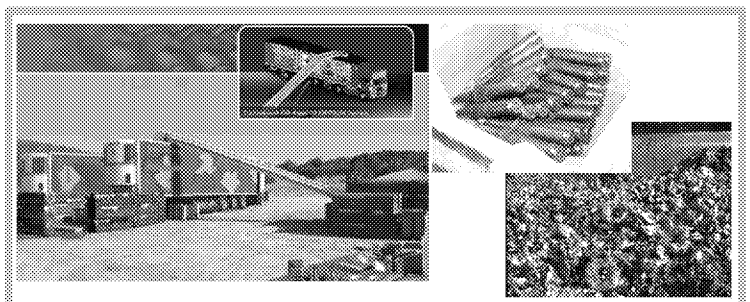


The Static Detonation Chamber Assessment:
The SDC was designed for the destruction of both conventional and chemical munitions and munition components by indirect heating in an armored detonation chamber (DC).
Destruction of the munition or energetic is achieved by heating an item above its auto-initiation temperature which results in detonation, deflagration, or burning of the energetic material contained inside the item.
Residual material from the destruction process remains in the DC until it is approximately 50% full.
The solid scrap material is emptied ready for recycle or disposal.
The process-gas generated from the SDC is thermally oxidized, neutralized and filtered in multiple stages in an Off-Gas Treatment System (OGT).
The assessment generated a final report, which documented the 12 different munitions processed.
The report also estimated processing rates in an SDC and compared the feed rate against the APE 1236 Hazardous Waste Incinerator for 4 munitions types.

Length of Project = 18 months

Ammunition Demilitarization Technology Studies

Castalia Process Assessment



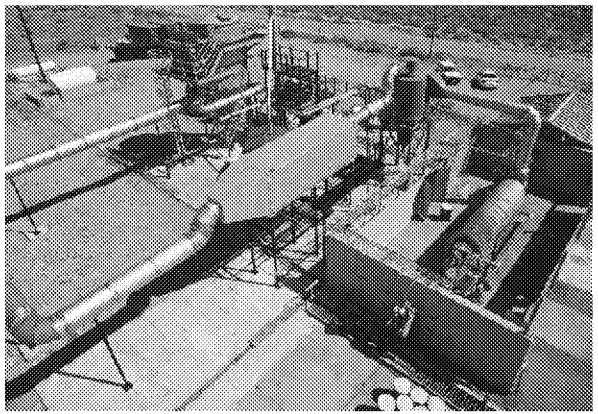
Castalia Process (Left), Cartridges and Resulting

Castalia Process Assessment:
The Castalia process, which has claimed throughputs 10 times the current closed disposal (5,000 lbs per hour) centers around munitions fed into a Destruction chamber utilizing an electromagnetic pulse generator (proprietary design) to effect break up of full up cartridges by impact to the hardened wall, with containment in an emulsion fluid.
The capability is claimed to have the ability to process shaped charge items as well as small and medium caliber cartridges, fuzes and propelling charges.
The broken up components and Energetics are contained in the emulsion and are destroyed in a downstream slurry incinerator.
Metal scrap is discharged and will likely need to be flashed (thermal treatment) to ensure small energetic components (e.g. primers) are destroyed.
The project tested 4 different types of ammunition and conducted an operational evaluation.
The outcome of the study is a final technical report assessing system performance;
The system did demilitarize ammunition, running 4.5 hours straight with only a few minutes down time and achieved sustained rate of 1,200 lb./hr. of grenades that contained a shape charge. Stoppages were encountered and the system performance at 2,000-4,000 lbs/ hour (intermittently) but did not meet government expectations for a production system.

Length of Project = 17 months

Ammunition Demilitarization Technology Studies

APE 1236 Hazardous Waste Incinerator Process Improvement Study



APE 1236 Hazardous Waste Incinerator Process Improvement Study

The comprehensive study of the APE-1236M2 Hazardous Waste Incinerator for conventional ammunition demilitarization.
The study resulted in developing productivity improvement plan to increase the capacity and efficiency HWI.
This study was structured to perform a thorough evaluation of the various constraints that govern the demilitarization capability and operating cost of the APE-1236M2 HWI divided into three phases: a current-state analysis phase, a gap analysis phase, and a future-state requirements definition phase.

The study was used to plan an IPT for the modernization of the 5 APE 1236 HWI currently operated by the Demil Industrial Base.
To date, 4 projects were started and 2 have been implemented at different CONUS locations.
The modernization projects will reduce operating costs and increase operating time between failures.

Length of Project = 24 months

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Demonstrated Capabilities in Use Ammunition Peculiar Equipment

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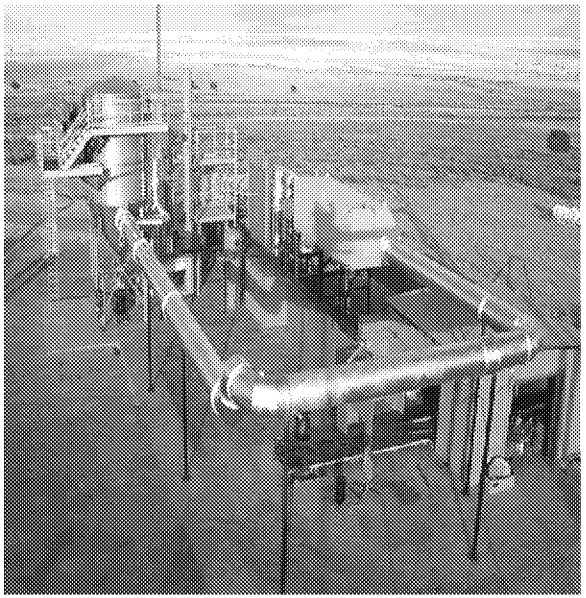
APE 1236 M2 Hazardous Waste Incinerator (HWI)

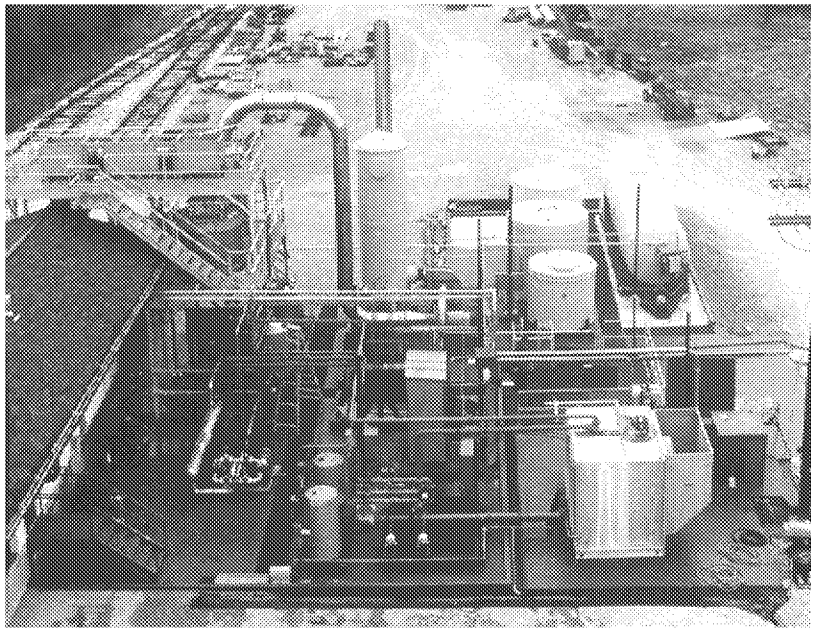


The Army's hazardous waste incinerators or APE 1236 M2 HWI, is used to demilitarize and/or dispose of ammunition items and bulk explosive wastes.
HWI Can Accomplish:

- Demilitarization of small arms ammunition, primers, fuzes, and boosters.
- Flash 75MM through 120MM projectiles after washout of explosive charge;
- Deactivate drained chemical bombs, rockets, grenades and other miscellaneous items.

APE 1236M2 consists of the following major components:
Deactivation retort
2 second afterburner
Cyclone separator
Ceramic baghouse
Induced draft fan
Control panel
gas sampling system, and connecting ducting. Additional Components includes: automatic feed system, feed and discharge conveyors, fuel oil and propane storage tanks, oil pump, and final exhaust stack. Equipment is permitted to operate following all federal, state and local environmental regulations.

APE 1400 PLANT, PHOSPHOROUS ACID CONVERSION



The APE 1400 Phosphoric Acid Conversion plant consists of two systems:
feed system
acid plant conversion system.

The two systems consist of a 115-ton punch, a converted APE 1236 furnace, hydrator, initial demister-separator, two negative pressure draft fans, a final demister, water cooling tower, acid cooling heat exchanger, acid filtering unit, acid storage tanks, rail and tanker truck acid loading stations, and an emergency generator in the event of power failure.

Downloaded munitions (fuzes, detonators and explosives removed) are punched in the 115 ton hydraulic press to expose the WP and then sent through the converted APE 1236 rotating kiln furnace for burning. The resultant smoke is drawn out of the furnace by a negative-pressure closed loop ducting system and routed into the acid plant system for conversion to phosphoric acid.

The two systems utilize automated controls for maximum efficiency.

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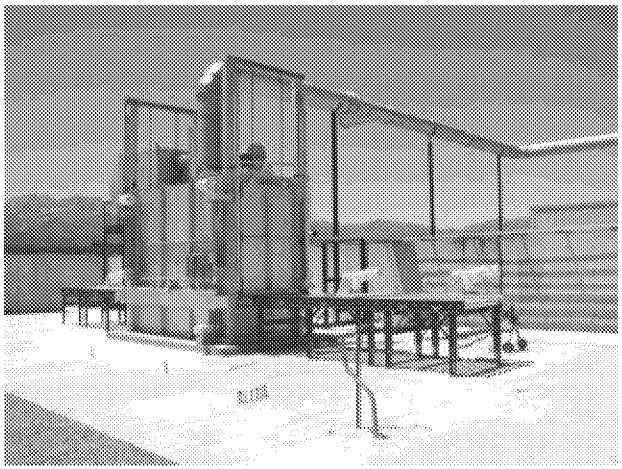
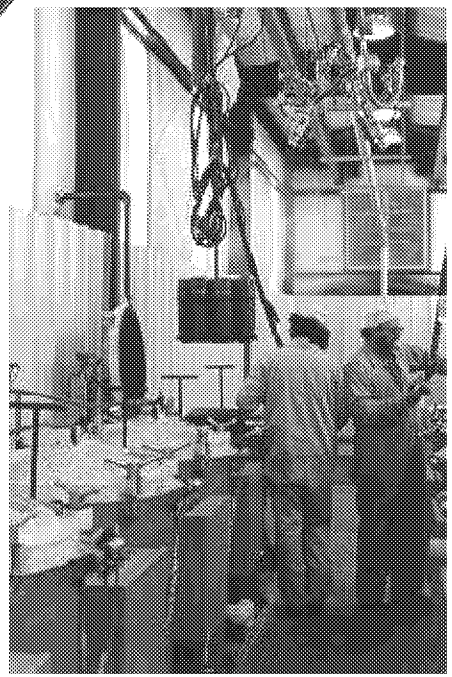
APE 2048 PLANT, Flashing Furnace System



The APE 2048 Flashing Furnace System is used to remove residual explosives from metal components, removing residual energetics to allow safe sale of scrap metal to the general public. It can be used as part of a "R3" facility to decontaminate processed munitions (105mm Cartridges to 750 pound bombs). It is not used to flash explosively contaminated waste.

The CONUS APE 2048 consists of a "continuous feed" car bottom furnace and a one second afterburner and is designed to operate under a Clean Air Permit. Metal parts are loaded onto specifically designed skids on the input conveyor, enter the flashing furnace, reside for a designated time and exit to cool on the output conveyor.

APE 1401 Autoclave Meltout



APE 1401 consists of a steam heated pressure vessel and pneumatic control panel.
Projectiles or bombs are disassembled to expose the explosive.
The item is inserted into the autoclave, the lid closed, and the steam turned on.
The molten explosive flows from the bottom of the autoclave.
After completion of the melt cycle, the steam is turned off and an integral nozzle sprays cooling water prior to removal and reloading of the next batch of items.
Reclamation of the explosives is completed by processing through collection piping, agitated melt kettles, and flaker belt or casting trays.
The Autoclave System can come in any multiple to accommodate the facilities available and the workload demand.

The autoclave meltout system is used tor remove and reclaim meltable main charge explosives such as TNT, Comp B, and Tritonal from projectiles and bombs.

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Summary

- Focus
  - Closed Disposal Technologies
  - Studies addressing capability gaps, efficiency gains and omnivorous capability.
  - RDTE ends when transition is successfully completed
- The Enterprise is Committed to reducing the Demil Stockpile
  - Adding capability and increasing execution efficiencies are our supporting goals
  - Commercial technologies funded in initial production

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Backup Slides

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Acronym List

- APE – Ammunition Peculiar Equipment
- ANMC – Anniston Munitions Center
- BGAD – Blue Grass Army Depot
- CAAA – Crane Army Ammunition Activity
- CBU – Cluster Bomb Unit
- CDC – Contained Detonation Chamber
- CPDS – Cryo/Plasma Destruction System
- DIHMES – Demil Induction Heating Meltout System
- FASCAM – Family of Scatterable Munitions
- FMRIS – Flexible Munitions Residue Inspection System
- HMX - Cyclotetramethylene-Tetranitramine
- HPWWO – High Pressure Water Washout Out
- HWAD – Hawthorne Army Depot
- ICM – Improved Conventional Munition
- iSCWO – Improved Super Critical Water Oxidation
- LEMC – Letterkenny Munitions Center
- MLRS – Multiple Launch Rocket System
- MRC – Missile Recycling Center
- MSO – Molten Salt Oxidation
- NQ - Nitro Guanidine
- OSM – Other Service Missile
- PDWC – Projectile Download Work Cell
- PI – Productivity Improvement
- PODS – Plasma Ordnance Destruction System
- RKI – Rotary Kiln Incinerator
- TEAD - Tooele Arm Depot

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