DEPLOYING MUNIREM TECHNOLOGIES TO NEUTRALIZE NITROCELLULOSE PROPELLANTS AND OTHER EXPLOSIVES

Presented by

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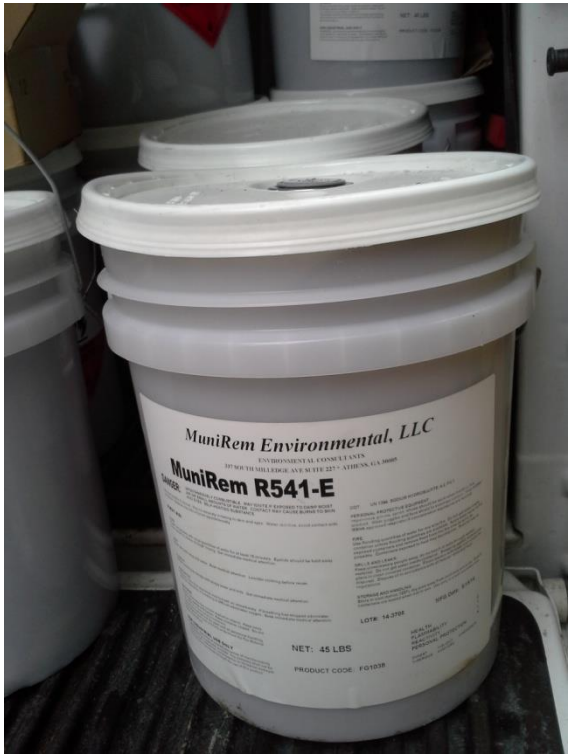
Agenda

- ✓ MuniRem Munitions Remediation Technologies
- ✓ Applications Specific to Nitrocellulose Propellants
- ✓ MuniRem Approach vs. Alternative Propellant Hydrolysis Approach
- ✓ Summary

What is MuniRem®?

- Patented technology utilizing a chemical treatment process to rapidly degrade explosives and chemical agents in various media
- Very short clean up time
- Eliminated O&M costs usually associated with other remediation technologies
- Lower treatment time and simple set-up
- Minimum risk to the user and community
- Technology and product that is flexible and scalable



Award-winning Technology

- MuniRem® selected winner of the 2010 Better World Technology
- Applied in USA, Canada, Australia and Taiwan
- Currently applied at Camp Minden, LA to safely neutralize bulk explosives, decontaminate equipment and building
- Led by a team of proven and experienced scientists and professionals

Effective for Remediation of Explosives and Munitions Constituents

Explosives, Weapons and Organics

- Mustard (CWM)
- HMX/RDX/TNT
- DNTs
- ADNTs
- NBs
- NDMA
- Nitrocellulose
- PETN
- Aluminum
- PCBs
- Others

Reliable Green Technology for Remediation of Explosives

Explosives + MuniRem®

- N_2
- CO_2
- SO_4^{2-}
- NO_2
- formate
- acetate

Reliable Green Technology for Remediation of Heavy Metals

MuniRem in Support of Demiliterization

Wet picric acid recovered from explosive D projectiles

Rapid decontamination of halved bomb casings before and after MuniRem® treatment

MuniRem Application at a Demilitarization Plant in SE Asia

Building Decontamination with MuniRem Solution to avoid Recrystallisation which Occurs after Steam Decontamination

Deluge Head

Kettle Lid

MuniRem vs. Other Munitions Destruction Technologies

Technology	Speed & Efficiency	Safety / Environmental	Mobility & Setup Times	Costs (Upfront & Recurring)
✓ **MRE Solutions: MuniRem®**	• MuniRem®'s scalable and one-step technology begins to react with energetics almost immediately and completes the process in minutes	• Safe, room temperature process requiring no safety distances • No regulatory issues, polished effluent can be dumped in municipal sewer • Satisfies criteria for Green technologies	• Simple and quick deployment and setup. Highly portable, flexible and scalable chemical process	• Low upfront costs, generally 30% - 50% lower all inclusive cost than alternatives
Alkaline / Base Hydrolysis	• Hours to days inclusive of required pH and Nitrate byproduct treatment processes	• Chemical handling safety concerns, high pH and Nitrates issues of process pose significant concerns and require further treatment and waste disposal	• General approach consists of building hydrolysis plants and long term and burdensome operations	• Immediate product costs are less expensive but high upfront plant costs, pH and nitrate remediation are costly
Open Burn / Open Detonation	• 1 hour + for setup and burn / detonation • Hours to weeks to remediate soil contamination	• Substantial physical and environmental hazards from burn / detonation reaction, heat, emissions, debris	• "Holes in the ground" can be quick initially but remediation "clean-up" burdens are enduring. • Incinerators and larger plants are not generally mobile and cumbersome	• Substantial plant capex, operations, safety, environmental compliance and contamination remediation costs
Flashing Furnaces	• 1 hour + for setup and flashing. Scale limited by furnace size	• Significant physical and environmental issues from reaction, heat, emissions	• Permanent or "portable" furnaces are required along with all support and safety infrastructure	• Substantial plant capex, operations, safety, environmental compliance costs

MuniRem Technology is Already Applied as Safe and Cost-effective Solution for Decontamination of High Explosives in Building and Equipment at Camp Minden, LA

MuniRem Environmental LLC Patented Technology for NC Propellant

Methods for Dissolution and Neutralization of Solid Nitrocellulose Propellants and Plasticized Military Munitions

Patent #: US 8,865,961 B2

MRE Past Experience on Neutralization of NC Propellants

- October 2010 MRE demonstrated the chemical destruction of NC propellant at Indiana Army Ammunition plant (INAAP) using its patented technology
- The on-site demonstration of MuniRem® was preceded by multiple bench scale tests
- The on-site tests involved the dissolution and rapid neutralization of NC propellant
- The resulting solution was analyzed for explosives and end-products by TestAmerica
- Following success of Indiana AAP demonstration, MuniRem LLC awarded a contract to produce “Propellant Destruction Kits” (PDK) for destruction of small amounts of NC propellant recovered at Maili Beach, Hawaii

Range of Propellant Sizes at INAAP

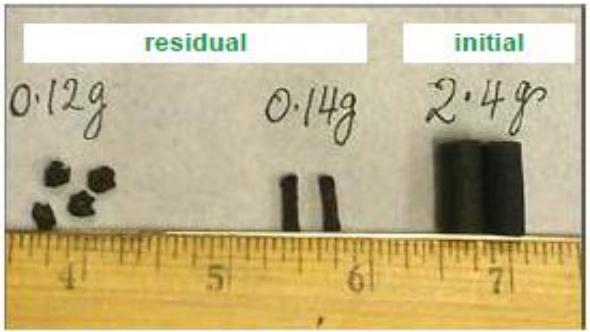
There are a range of M1 Propellants at INAAP and time to completely neutralize propellants depends on size

Propellant	Diameter	Length	Weight
1	0.44"	1.01"	59.0g
2	0.18"	0.67"	39.3g
3	0.31"	0.79"	23.5g
4	0.14"	0.33"	1.9g

Dissolution and neutralization of smallest size requires ~1 hour

Dissolution and neutralization of largest size requires ~1-2 days

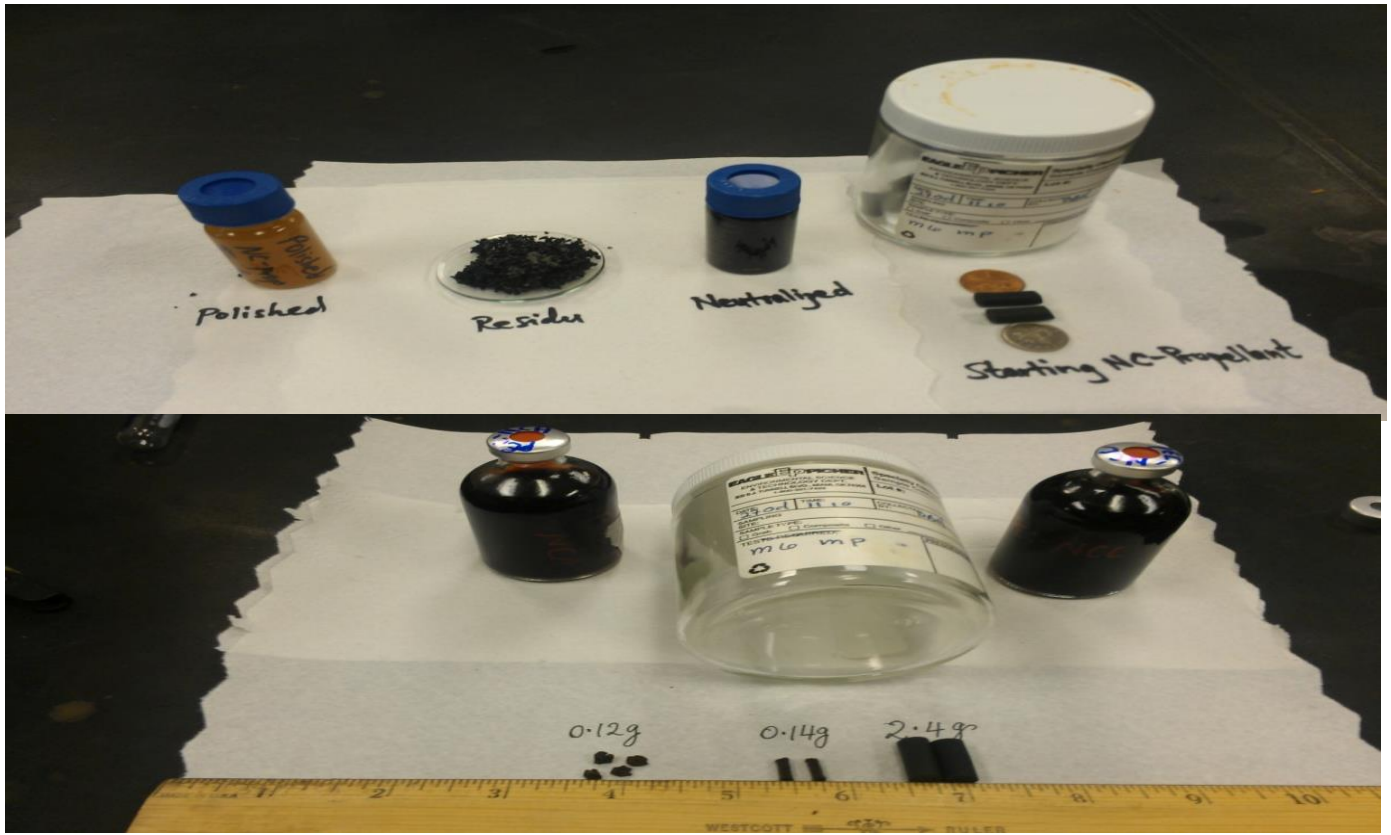
Wood-like residual (see photo) remains after complete neutralization of medium and large size propellant pellets



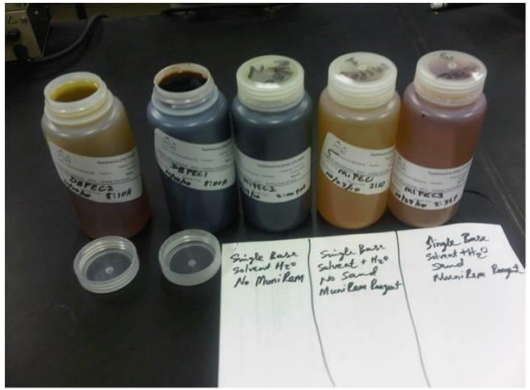
2.4 g of NC propellant residual in less than 24 hours of treatment

33g of NC propellant reduced to <5g of non-explosive residual in less than 48 hours

What remains after complete destruction of NC Propellant?



Summary of Wastewater Test Results for INAAP Test



Sample	Before Treatment	After Treatment
Nitrocellulose	Propellant grains	Non-Detectable
Sugars	N/A	Glucose, mannose, arabinose, xylose
Nitrate as N	N/A	309 mg/L
Nitrite as N	N/A	1000 mg/L
Sulfate	N/A	Non-Detectable
Total Sulfide	N/A	18.6 mg/L (lower than reporting limit)

INAAP Results for Single Base Propellant MuniRem® Reagent Added to Destroy Nitrate and Nitrite

Client Sample ID: M1PEC1

General Chemistry

Lot-Sample #...: G0K120465-001 **Work Order #...:** L90GW **Matrix.....:** WATER
Date Sampled...: 10/27/10 **Date Received..:** 10/29/10

PARAMETER	RESULT	RL	UNITS	METHOD	PREPARATION-ANALYSIS DATE	PREP BATCH #
Nitrate as N	**36.3 B,Q**	**50.0**	**mg/L**	**MCAWW 300.0A**	**11/15/10**	**0319430**
		Dilution Factor: 1000		MDL.....: 22.0		
Nitrite as N	**254 Q**	**50.0**	**mg/L**	**MCAWW 300.0A**	**11/15/10**	**0319429**
		Dilution Factor: 1000		MDL.....: 16.0		
Nitrocellulose	ND G	2000	mg/L	TAL-SOP WS-WC-005	11/13-11/15/10	0317041
		Dilution Factor: 1000		MDL.....: 475		
Sulfate	**1090 Q**	**1000**	**mg/L**	**MCAWW 300.0A**	**11/15/10**	**0319431**
		Dilution Factor: 1000		MDL.....: 49.0		
Total Sulfide	**12.5 B,G**	**50.0**	**mg/L**	**MCAWW 376.2**	**11/17/10**	**0321215**
		Dilution Factor: 1000		MDL.....: 8.8		

NOTE(S):

RL Reporting Limit

B Estimated result. Result is less than RL.

Q Elevated reporting limit. The reporting limit is elevated due to high analyte levels.

G Elevated reporting limit. The reporting limit is elevated due to matrix interference.

INAAP Results for Single Base Propellant

MuniRem ENVIRONMENTAL

Client Sample ID: DBPEC1

General Chemistry

Lot-Sample #...: G0K120465-004 **Work Order #...:** L90G5 **Matrix.....:** WATER
Date Sampled...: 10/28/10 **Date Received..:** 10/29/10

PARAMETER	RESULT	RL	UNITS	METHOD	PREPARATION-ANALYSIS DATE	PREP BATCH #
Nitrate as N	**309 Q**	**50.0**	**mg/L**	**MCAWW 300.0A**	**11/15/10**	**0319430**
		Dilution Factor: 1000		MDL.....: 22.0		
Nitrite as N	**1000 Q**	**50.0**	**mg/L**	**MCAWW 300.0A**	**11/15/10**	**0319429**
		Dilution Factor: 1000		MDL.....: 16.0		
Nitrocellulose	ND G	2000	mg/L	TAL-SOP WS-WC-005	11/13-11/15/10	0317041
		Dilution Factor: 1000		MDL.....: 475		
Sulfate	ND G	1000	mg/L	MCAWW 300.0A	11/15/10	0319431
		Dilution Factor: 1000		MDL.....: 49.0		
Total Sulfide	**18.6 B,G**	**50.0**	**mg/L**	**MCAWW 376.2**	**11/17/10**	**0321215**
		Dilution Factor: 1000		MDL.....: 8.8		

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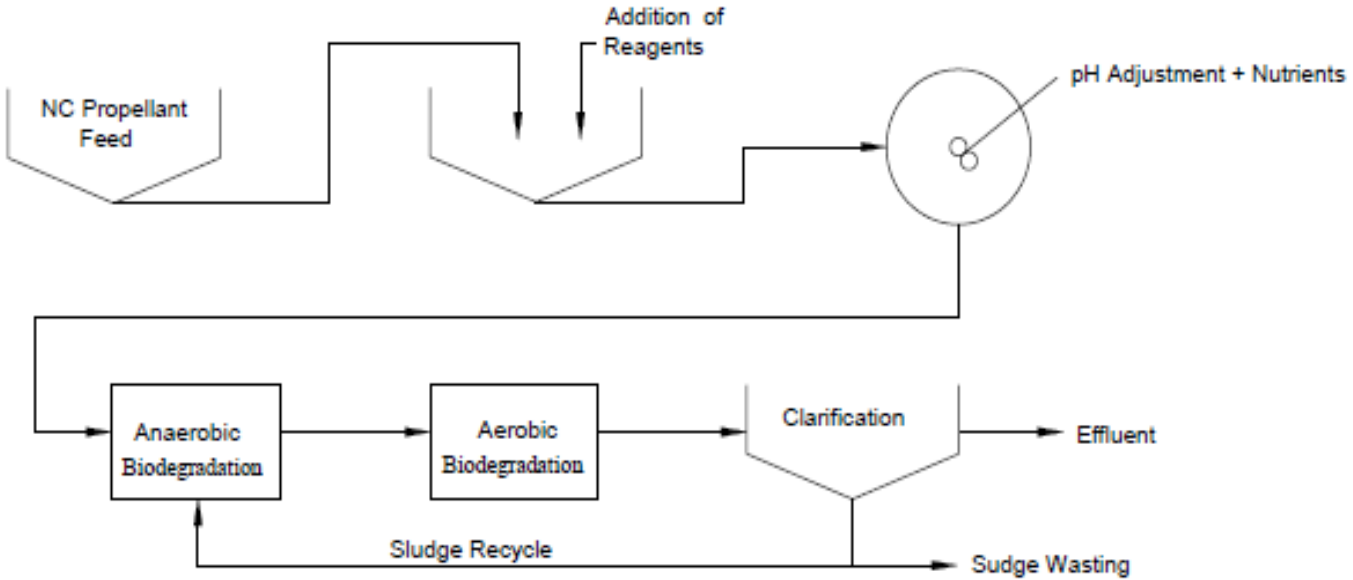
General Steps of Treating NC Propellants

1. Place NC Propellants in reactor
2. Use chemicals to pre-treat NC propellant to expose explosive compounds and hydrolyze NC
3. Use MuniRem® to degrade all nitro and amino compounds remaining in solution
4. Treat by-products from reaction and safely dispose of non-hazardous end products

MRE's Approach Couples Chemical Destruction of Bulk Propellant with Bioremediation of Effluent Wastewater



Flow diagram of NC propellant destruction with MuniRem proprietary technology and biodegradation process with denitrification (Adapted from USACERL TR-98/65)

Comparison of Two Wet Chemistry Solutions

Parameter	Alkaline Pressure Hydrolysis	MuniRem Process
Reactors (Pfaudler Hydrolysis Reactor)	• Tank farm • Main reactor with heat exchanger jacket	• Tank farm • Main reactor with heat exchanger jacket
Pre-treatment	Not a required	Not a required
Operating Conditions	✓ NaOH ✓ Temp = 150 C ✓ P < 12 bar ✓ Time <1 hour ✓ Exothermic Reaction	✓ NaOH ✓ Organic Solvent ✓ Temp = Ambient ✓ Pressure = Ambient ✓ Time <1 hour ✓ Exothermic Reaction
Wastewater Composition	✓ Nitrite ✓ Nitrate ✓ Short chain organic acids ✓ Nitroaromatics aminoaromatics	✓ Nitrite ✓ Nitrate ✓ Sulfate ✓ Short chain organic acids ✓ Sugars
Residue	Non-explosive; Depends on alkali content	Non-explosive; 5% of initial mass
Air Pollution Mitigation	Scrubber	Scrubber
Wastewater Treatment	Biodegradation	Biodegradation
Waste-to-Value	Yes, but will require time	Yes, but will require time
Handling Issues	Could be a challenge	Digests Ryon Cloth Bag

How Does an EOD Tech Move Unstable M6 from Storage to Treatment Location?

- Could Maili Beach, Hawaii have the answer?
- Will cold water ensure safety during transportation to treatment site?

Conclusions

MuniRem® and NC Propellant Technology
Neutralizes high explosives in minutes
Offers the a non-thermal rapid neutralization of NC propellants
Neutralizes other munitions and munitions components: CWM
Ensures instant neutralization of explosives to non-toxic end products
Meets the criteria for a green technology to manage explosive safety challenges

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