



MuniRem[®] Technology
Case Studies

Safer and Cost-Effective
Explosives Remediation and
Decontamination

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Safe removal of H-6 Explosives from equipment and on-site neutralization by MuniRem®

Engagement details

Client:	Confidential Private Industry Client
Site:	Explo Systems, Inc. Site. Former Louisiana Army Ammunition Plant, Camp Minden, Louisiana
Task:	Safe Recovery of H-6 Explosives from Equipment and On-site Neutralization
Date:	February 2015

Situation

H-6 (1.1D) explosives contamination was present in bulk and residual form on a Melter/Flaker machine within a building. After review of multiple solutions, the client specified the use of MuniRem Reagent for safe recovery and neutralization of the bulk explosives from the equipment. The photos below show the recovered H-6 (some chunks were 13" long) and processing with MuniRem.

Solution

Initial spray application of MuniRem solution was used to desensitize smaller pieces of the H-6 explosives instantly, enabling for safe ingress/egress for intensive recovery of large H-6 chunks. Under a continuous spray of MuniRem solution, the staff removed and transported manageable small batches of H-6 bulk material from hopper and tray assemblies to the nearby process area. This explosive material was then neutralized in reaction tanks. Solid and liquid generated waste products were tested for explosives and stored for subsequent transport as non-hazardous material.



Result

The project team safely removed bulk explosive material from the Melter/Flaker machine. Although the project plan was based on the assumption that approximately 200 lbs of H-6 was left on the Melter/Flaker unit, over 900 lbs of bulk explosive material was eventually recovered; including over 950 lbs of solids (sludge and sediment). Recovery and neutralization of the bulk H-6 enabled dismantling the Melter/Flaker machine, support structures, conveyor assembly, fume hood, ducts and wooden platform with hand tools. The generated wastewater was characterized and determined to be non-hazardous; achieving regulatory level compliance in the final disposition of waste streams (liquids and solids) for characteristics of ignitability, corrosivity, reactivity, explosivity, and toxicity.

The project team successfully adapted MuniRem application practices to overcome inclement weather conditions that were unusual for the Camp Minden region; two days of snow, freezing rain, and multiple days with temperatures below freezing.

Neutralization of Aged TNT at Former Munitions Plant

Engagement details

Client: CH2M Hill (Prime Contractor)
Site: Australian Defence Site
Task: Neutralization of Aged TNT in Pipe Using Aqueous Solution of MuniRem®
Date: May 2013

Situation

CH2M HILL was contracted by the Australian Department of Defence to perform an investigation and assessment of residual explosives capable of creating a personnel hazard within select buildings and utilities. CH2M HILL's investigation identified approximately 12 kilograms (kgs) of aged TNT in a 150 millimetre (mm) diameter, 2.6 meter (m) pipe beneath the northwest corner of one of the site buildings. CH2M HILL needed to immediately eliminate the explosive hazard from the pipe. The test site is a former military munitions production plant and has been encroached by urban development.

Solution

MuniRem Environmental was approached by CH2M HILL to provide MuniRem for use to remove the explosive hazard. MuniRem Environmental reviewed site assessment data and photos provided by CH2M HILL's UXO personnel. MuniRem Environmental custom formulated MuniRem® reagent and shipped to the project site. An exclusion arc of 500 meters was set-up around the worksite. CH2M HILL and MuniRem Environmental personnel prepared MuniRem solution and used to flush the pipe. After many flushes, the discharge end of the pipe was capped, and MuniRem® poured into the pipe from inside the building, allowing it to pool up inside the pipe, keeping it in contact with the residual explosives. Once the pipe was filled with MuniRem®, it was left alone for 18 hours. The next day the MuniRem solution was removed and the pipe was flushed a few more times. A camera was inserted into the pipe to confirm complete destruction of the TNT chunks. All of the flushing MuniRem solution was collected in three 220 liter drums. Residual explosives in the wastewater was treated by adding MuniRem® powder to the wastewater.



The 150 mm pipe (discharge end) before set up



Site preparation, outside of discharge end of pipe

Result

Visual and videos obtained by the camera inserted into the pipe confirmed that MuniRem® achieved the cleanup goal in the <48 hrs after application, which was reconfirmed by Analytical Laboratory analysis for explosives and MuniRem degradation products. MuniRem® was effective in the neutralization of the aged TNT that had accumulated inside the pipe for many years. The project goals were achieved without interrupting the activities of other contractors performing work on-site and the inhabitants in nearby residents.



Fully dissolved and neutralized TNT after treatment with MuniRem

Demilitarization of Nitrocellulose Propellant

Engagement details

Client: Department of the Army
 Site: Indiana Army Ammunition Plant ("AAP"), Indiana
 Task: Dissolution and Neutralization of Nitrocellulose ("NC") Propellant
 Date: October 2010

Situation

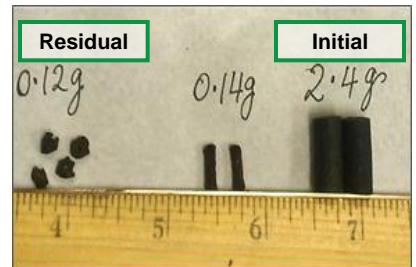
Indiana AAP extends over 10,649 acres and has been in operation since 1941. The facility produced large quantities of nitrocellulose and nitroglycerin based propellants and explosives during WWII, the Korean War, and the Vietnam War. It has been declared an excess site by the U.S. Army. The manufacturing equipment and building at Indiana AAP must first be decontaminated prior to deconstruction and transfer of land to the state of Indiana. The main challenge for decontaminating the buildings has been finding a safe and cost-effective technology to dispose of the solid NC propellants swept off the equipment and buildings.

Solution

MuniRem Environmental developed an innovative method to dissolve the different sized propellants (single, double and composite base) followed by neutralization at ambient temperature. Indiana AAP provided three sizes of double base solid NC propellant for dissolution and neutralization. The proprietary formulations were prepared to dissolve and neutralize multiple batches of the NC propellants.

Result

NC propellant pellets were dissolved and formed a dark solution. The breakdown products were sulfate and small amounts of nitrate and nitrite. The cellulose transformed to glucose and mannose primarily, with smaller amounts of arabinose and xylose. This demonstration completed at Indiana AAP confirmed that NC propellant can be neutralized and degraded to monosaccharides (sugars) that may become a potential source of raw material for cellulosic ethanol production.



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

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)

Neutralization of Chemical Warfare Agent – Bulk Mustard

Engagement details

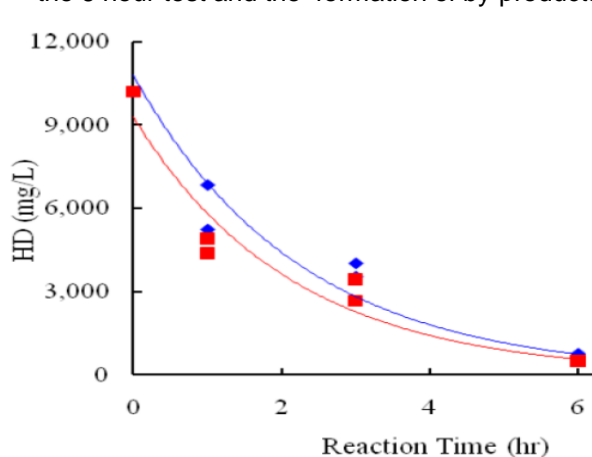
Client: Non-Stockpile and Army HQ
 Site: Non-Stockpile Edgewood, Maryland
 Task: Evaluation of MuniRem® for Neutralization of Bulk Sulfur Mustard
 Date: February - May 2010

Situation

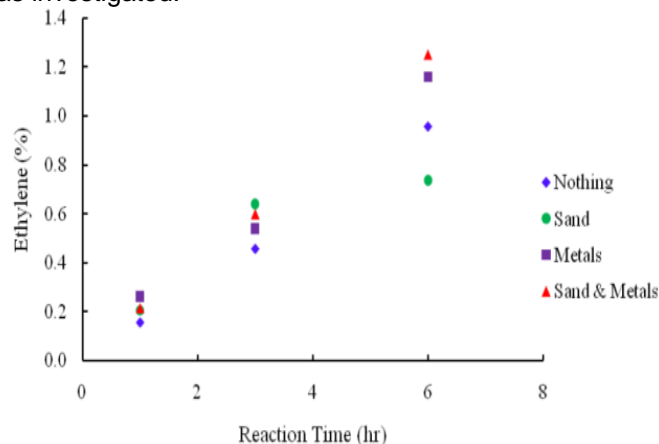
Sulfur mustard [bis(2-chloroethyl) sulfide] is the most prevalent chemical warfare agent present at Non-Stockpile Chemical Materiel (NSCM) Sites. Destruction of bulk (neat) sulfur mustard (HD) and remediation of HD contaminated soil and materials poses serious health and safety challenges. The main challenge for neutralizing CWA has been finding a safe and cost-effective technology to destroy the agents without forming and accumulating harmful by-products. MuniRem was evaluated as a cost-effective, safer and green alternative neutralant of the CWA mustard.

Solution

This project was a collaboration between the United States Non-Stockpile, an Army HQ office, Tennessee Valley Authority, SAIC, and MuniRem Environmental. All tests were performed at Non-Stockpile's Laboratory in Edgewood, MD. Multiple doses of bulk HD (93.7 wt% purity) were challenged with either MuniRem® powder or the solution at a temperature of 50 ± 2 °C for 6 hours. Additional tests were conducted with sand and metals added as impurities to simulate MuniRem® effectiveness for remediation of HD contaminated soil and empty one ton containers. The disappearance of HD during the 6 hour test and the formation of by-products was investigated.



Rate of bulk HD destruction by MuniRem® for a 6 hour test
 >95% of initial bulk HD destroyed in 6 hours



Evidence of ethylene formation as a by-product of
 MuniRem® degradation of HD, with and without impurities

Result

MuniRem® rapidly degraded bulk (neat) mustard to chloride, sulfur and ethylene gas. The breakdown products of MuniRem® reagent were sulfate and thiosulfate. No hydrogen sulfide was formed. The degradation of HD in the presence of sand and metal was more efficient than in the homogeneous samples (i.e., Nothing). This demonstration confirmed that sulfur mustard is neutralized and degraded to ethylene gas, which is known to rapidly oxidize to CO₂. MuniRem® offers a safer and easy to apply rapid neutralization approach for sulfur mustard (HD) and similar chemical warfare agents in bulk or as contaminants in soil and surfaces.

Neutralization of Picric Acid-Based Bulk Explosives

Engagement details

Client: Department of the Army, U.S. Army Corps of Engineers
 Site: ATF Approved Facility, Minnesota
 Task: Neutralization of Reclaimed and Stockpiled Explosive D (picric acid-based explosives) by MuniRem®
 Date: November 2009

Situation

The munitions item assigned to MuniRem Environmental for neutralization was a U.S. Navy projectile containing Explosive D (ammonium picrate). Explosive D is a stable, yellow-crystalline explosive once used as the standard main charge for armor-piercing bombs and projectiles. MuniRem Environmental pilot-tested the use of MuniRem® for instant neutralization of wetted picric acid reclaimed from demilitarized munitions.

Solution

MuniRem Environmental designed an explosive and chemical neutralization (ECAN) reactor with a throughput of 10 pounds per hour. An optimum dose of MuniRem® was prepared and used to neutralize multiple 10-pound batches of explosives in the reactor. The resulting solution was polished in a reactive column prior to disposal.

Result

The explosives were degraded to formate and nitrogen gas in less than one hour. The highest throughput for neutralization of bulk high explosives was achieved in a 100-gallon reactor. Using the optimum MuniRem® dosage, the Composition D was destroyed to 2 mg/L in the ECAN reactor under an hour.

MuniRem® achieved non-detectable levels (US DoD 5X) for explosives initially present on the contaminated metal casings. A protocol was developed for neutralization of bulk explosives and decontamination of metal casings with MuniRem® solution.



Preparation of projectiles for waterjet cutting and washout in Gradient's booth



Wet picric acid recovered from explosive D projectiles



Before



After

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

Decontamination of explosives contaminated equipment and building walls by MuniRem®

Engagement details

Client:	Confidential private industry client
Site:	Explo Systems, Inc. Site. Former Louisiana Army Ammunition Plant, Camp Minden, Louisiana, USA
Task:	Decontamination of equipment and building
Date:	Jan – Feb, 2015

Situation

H-6 (1.1D) explosives contamination was present in bulk and residual form on a Melter/Flaker machine within a building, as well as all fixtures within the building. After review of multiple solutions, the client specified the use of MuniRem Reagent for safe recovery and neutralization of the bulk explosives to remove the explosion hazard for safe disassembly of all equipment and decontamination of the Bay area building fixtures. The photo below shows the small footprint of MRE's decontamination set-up next to the building of interest.

Solution

An initial spray application of MuniRem solution in hallways and the Bay containing the Melter/Flaker machine desensitized H-6 contaminated surfaces and provided safe ingress/egress for staff. The sprayed MuniRem solution successfully desensitized, soaked, and cleaned loose materials in the Bay. The sprayed walls, ceiling, hood, and all equipment surfaces were rinsed after confirmation of complete explosives decontamination. Applied MuniRem solution on the floor progressively dissolved and destroyed the explosives in cracks during equipment and Bay decontamination.



Equipment and building fixtures inside bay area

Results

The project team decontaminated walls, floors, ceilings and disassembled equipment as well as achieved regulatory level compliance in the final disposition of waste streams (liquids and solids) for characteristics of ignitability, corrosivity, reactivity, explosivity, and toxicity. According to regulatory and explosive safety qualified professionals, "the Bay work area is now the cleanest and safest place within the Building." The project team successfully adapted MuniRem application practices to overcome inclement weather conditions that were unusual for the Camp Minden region; two days of snow, freezing rain, and multiple days with temperatures below freezing.

Inerting of recovered scuttled Confederate States Ship (CSS) Georgia underwater munitions by MuniRem®

Engagement details

Client: Donjon Marine as Prime for United States Army Corps of Engineers
Site: Savannah River Harbor Expansion, Savannah – Georgia, USA
Task: Inerting of recovered underwater munitions (Projectiles) on-site
Date: September – November, 2015

Situation

MuniRem Environmental (MRE) was contracted through DONJON Marine Inc., to support inerting operations for munitions and explosives of concern (MEC) removed from the Confederate States Ship (CSS) Georgia in the Savannah River. MRE's scope of work was to receive, store, inert, and dispose of munitions and explosives of concern (MEC) items recovered from the CSS Georgia wreck site. These MEC items, Civil War era cannon balls, are considered to be Discarded Military Munitions (DMM).

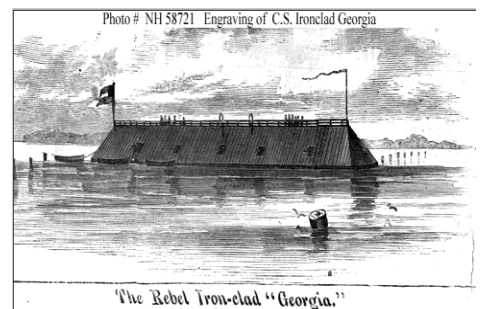
A Navy Explosives Ordnance Disposal dive team conducted an underwater UXO clearance around the sunken wreck and raised the munitions. The two primary types of munitions items recovered were 6.4 inch Brooke projectiles and 9 inch Dahlgren Mortars. Custody of 170 munitions was transferred from the US Navy to the US Marine Corps and then to the MRE team for inerting using MuniRem - a patented technology. The MRE team was composed of a Senior UXO Marine, UXO QA and Safety Navy Senior Chief, Senior Chemist and Chemical Engineer.

Solution

A MRE process was successfully applied to remove the main charge and the threat of a detonation and fragmentation of the munitions safely without disturbing the most hazardous part of the munition (the fuze). Thereafter, the amount of explosives remaining within the projectile was contained within the fuze. Subsequently, the fuze was rendered safe by unscrewing and inerting in MuniRem solution or drilling directly through the fuze body to access and neutralize the explosives again using a solution of MuniRem. All explosive material flushed from the munitions was fully neutralized with MuniRem solution for safe disposal as non-hazardous waste.

Result

An automated remote disassembly line utilizing a combined chemically enhanced hydro mine process provides a unique safe and environmentally friendly non-thermal alternative solution for demilitarization. Custody was passed back to the USACE with the munitions now safe for shipment on public roads. The munitions will be conserved by the University of Texas and distributed to museums around the country.



Inerting of breached Dahlgren ball



Fully inerted Brooke projectile and Dahlgren canon ball

Application of MuniRem® in support of large scale demilitarization contracts

Engagement details

Client: International Demilitarization Contractors performing on USDoD contracts
Site: Multiple Demilitarization Facilities, USA
Task: Non-thermal chemical destruction of explosives in support of demilitarization
Date: 2015 - 2020

Situation

In many countries, excess stockpiles of obsolete or unserviceable munitions and munitions captured during armed confrontations have reached a level requiring demilitarization on an industrial scale. In most countries, it is a race against time as the ammunition tends to become unsafe with age. Since states rarely have the capacity to demilitarize the surplus ammunition stockpiles, they often turn to the demilitarization industry.

New regulatory requirements are generally becoming more stringent and unfavorable to thermal based demilitarization. As a result, there is a growing need for safer and greener alternatives to decontaminate different types of energetic materials (EM) and energetics materials contaminated wastes (EMWC). The most desired solutions must be safe, readily available, assure a high degree of decontamination on a variety of EM and EMCW, produce little or no waste, and be cost-effective.

Solution

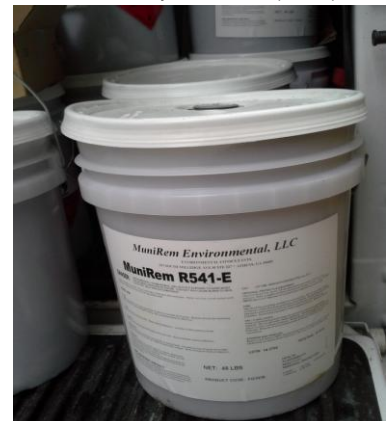
The efficacy of rapid chemical destruction of explosives by MuniRem as a viable alternative to thermal destruction of explosives in different materials has been successfully demonstrated and validated on multiple field scale projects. The MuniRem powder is shipped in United States Department of Transportation approved containers via air, land or by sea. Decontamination of bomb casings and demilitarization scrap metal is achieved either by spraying MuniRem solution on large bomb casings or soaking the scrap metals (including bombs shells, bomb fragments, breached projectiles) in MuniRem baths. The decontamination occurs when the contaminated surface is soaked in high strength MuniRem solution (>15%) and allowed to react for 2 - 4 hours. MRE has developed standard operation protocols for decontamination of explosives contaminated scrap metal and other demilitarization wastes for self-performing clients.

Result

Our MuniRem solution is flexible and scalable with a “pay-as-you-go” model, requires NO material upfront costs. Typical MuniRem costs are 30-50% less than traditional for demilitarization methods. No air permits are required to apply MuniRem in support of demilitarization.



Discarded Military Munitions (DMM)



MuniRem powder shipped via air, land and sea

Decontamination at Milan Army Ammunition Plant

Engagement details

Client: American Ordnance, LLC
Site: Milan Army Ammunition Plant, Tennessee
Task: Decontamination of Shut-down Explosives Production Lines with MuniRem®
Date: June 2012 - Present

Situation

Milan Army Ammunition Plant (MLAAP) is a government-owned, contractor-operated facility located in Milan, Tenn. The plant is currently transitioning from a munitions load, assemble, and pack facility to a commercialized industrial site known as the Milan Commercial Complex. There are numerous munitions production lines that need to be decontaminated prior to fully transitioning MLAAP to other uses. Also, MLAAP is a National Priority List site due to the presence of various contaminants including TNT and RDX in the site soils and groundwater at many Operable Units.

Solution

MuniRem Environmental visited MLAAP in June 2012 and demonstrated the efficacy of MuniRem solution to neutralize TNT, RDX and HMX at the bench scale and within the production facility. Bench scale tests involved placing explosive material into beakers and adding MuniRem solution to initiate rapid neutralization. MuniRem solution was also prepared and sprayed on explosives contaminated surfaces – equipment, drains, and floors to demonstrate the efficacy of MuniRem to destroy and decontaminate the surfaces. MuniRem reagent was also provided to the site staff to perform their independent evaluation of MuniRem.

Result

The MuniRem reagent was shown to be an effective, rapid and safe way to destroy the bulk explosives and decontaminate surfaces. No detectable concentrations of TNT, RDX and HMX were measured in solution of samples treated at the bench scale. MuniRem solution was found to be effective for instant neutralization and decontamination of the contaminated surfaces. The explosives did not recrystallise after the water dried off because the explosives were completely destroyed. MuniRem offers a non-thermal solution for decontamination of production lines at munitions production and demilitarization plants. MuniRem continues to be applied for routine decontamination at MLAAP.

Decontamination of Explosives on Multiple Media (Building, Equipment, Soil, Sludge, Wastewater, Bomb Casings) at a Demilitarization Site (Part A)

Engagement details

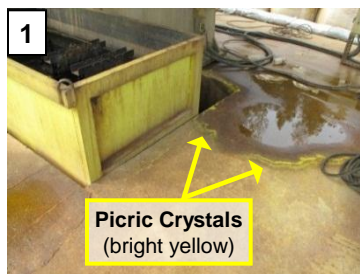
Client: Global Government Contractor
 Site: Confidential Asian Pacific Island
 Task: Decontamination of Composition-D (picric acid) Contaminated Building & Equipment and Dismantled Bomb Shells by MuniRem®
 Date: February 2012

Situation

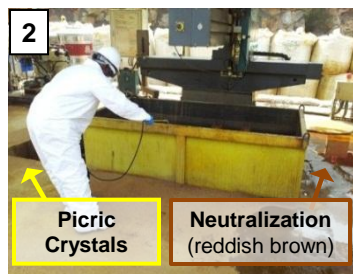
The site is a demilitarization facility for dismantling and neutralizing old unexploded ordnance (many from WWII). Decontamination was required for (i) equipment and building involved with demilitarizing old ordnance, which are contaminated with picric acid and (ii) dismantled shells, which are lined with crystallized picric acid.

Building & Equipment

MuniRem® solution is sprayed onto the equipment using a hand-held garden sprayer and is poured onto the contaminated concrete flooring to remove explosive substances.



Visible picric crystals on building surfaces (in bright yellow) before treatment.



Instant color change to reddish brown signifies neutralization reaction.



MuniRem® continues to breakdown the yellow picric crystals.



MuniRem®-treated area is left to air-dry.



24 Hours Later
 Visible and significant reduction of picric crystals.



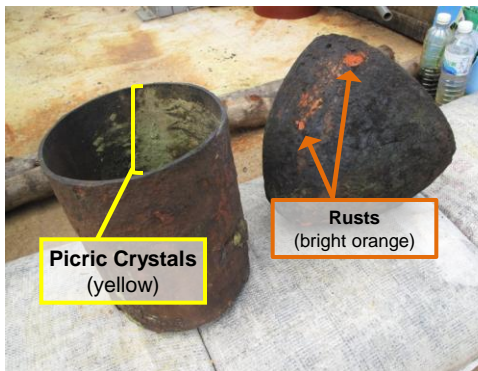
2 Weeks Later
 No re-crystallization of picric acid.

Bomb Casings

The bomb casings are submerged into a MuniRem® solution bath for half an hour until the explosive substances are dissolved.

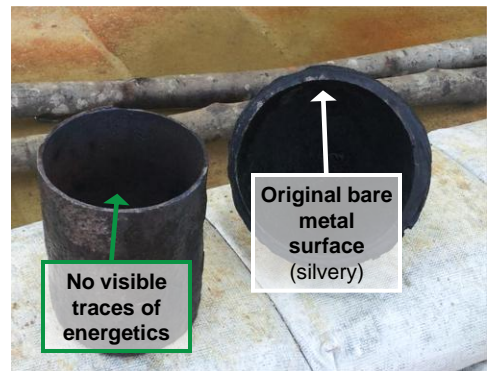
Demonstration of MuniRem® on the equipment, building and bomb casings was observed by over ten individuals, including representatives from the local military and government contractor.

Before Treatment



30-mins MuniRem® Bath

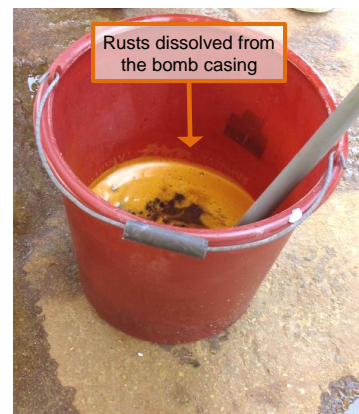
30-mins after MuniRem® Bath



30-mins MuniRem® Bath



30-mins MuniRem® Bath



Decontamination of Explosives on Multiple Media (Building, Equipment, Soil, Sludge, Wastewater, Bomb Casings) at a Demilitarization Site (Part B)

Engagement details

Client: Global Government Contractor
 Site: Confidential Asian Pacific Island
 Task: Decontamination of Composition-D (picric acid) Contaminated Soil, Sludge and Wastewater by MuniRem®
 Date: February 2012

Situation

The site is a demilitarization facility for dismantling and neutralizing old unexploded ordnance (many from WWII). Most of the surrounding soil and water involved in the demilitarization process have been contaminated with picric acid, characterized by its bright yellow color and require remediation.

Soil

MuniRem® is tilled into the explosive-contaminated soil and water is added to initiate rapid degradation. The soil then immediately turns from its bright yellow shade to a deep red/brown color. This immediate reaction signifies the instant neutralization of the picric acid. Within 24 hours, the dark red color significantly dissipates with natural oxidation. Two weeks after application, the treated soil has regained its original color, with no trace of picric acid.



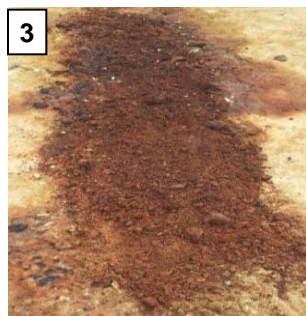
Soil contaminated with picric acid stored in bags before MuniRem® treatment



MuniRem® mixed into contaminated soil



Water immediately activates the neutralization



24 hours after MuniRem®



2 weeks after MuniRem®

Water

MuniRem® powder is directly poured into the contaminated water and allowed to dissolve and destroy the explosive. Upon contact, the chemical reaction in the water displays a vibrant red color, distinctive of the oxidation process. The picric acid is being neutralized. After 24 hours, the color fades into lighter brown. After two weeks, the vibrant red color has dissolved.



Contaminated water, before MuniRem® treatment



MuniRem® Powder reacts instantly with water...
Time: 5 secs after application



... to turn bright red:
oxidation is underway
Time: 10 secs after application

Result

MuniRem® achieved instantaneous degradation of the various picrate-contaminated media immediately after being activated by water. The bright yellow color characteristic of the picric acid instantly turned red, signifying oxidation and hence, the success of the neutralization reaction.

The efficacy of the treatment for both the soil and water sites was also monitored 24 hours and two weeks post-treatment. In both cases, the yellow and red colors had disappeared, revealing the soil's original color and clearer waters. Following MuniRem® treatment, levels of picric acid dropped considerably.

Demonstration of MuniRem® was observed by over ten individuals, including representatives from the local military and government contractor.



Lake on demilitarization site, contaminated with picric acid and requiring remediation

Decontamination at McAlester Army Ammunition Plant

Engagement details

Client: Department of the Army
 Site: McAlester Army Ammunition Plant ("AAP"), Oklahoma
 Task: Decontamination of Explosives Contaminated Demilitarization Equipment and Building
 Building: Walls by MuniRem®
 Date: October 2011

Situation

McAlester AAP manufactures and demilitarizes TNT based explosives. For decontamination, equipment and facilities are sprayed down with steam on several occasions. Unfortunately, steam dissolves the high explosives and generates large quantities of wastewater that must be treated at a dedicated explosives wastewater treatment plant. Once the steam dries off, the explosives re-crystallize on the equipment and building walls, thus posing an explosive risk. The process also produces highly explosive and contaminated sludge that collects in sumps and in wastewater collection ponds. Also, cracks and floor drains have accumulated layers of explosives over the years.

At the request of McAlester AAP, MuniRem Environmental demonstrated the safety and efficacy of decontamination of contaminated demilitarization equipment and building walls, as well as on spent Granular Activated Carbon ("GAC") and sludge using MuniRem® solution.

Solution

MuniRem Environmental prepared concentrated solutions of MuniRem® that was sprayed on the equipment and walls. The bomb shells and gaskets were soaked in MuniRem® solution baths for 24 hours. MuniRem® was added to the pink water (wastewater), spent Granular Activated Carbon and sludge to destroy dissolved explosives.

Result

MuniRem® achieved complete degradation of the explosives on the equipment and walls within four hours. Unlike steam treatment, no explosives re-crystallized on the surfaces following application. The analysis of TNT on the equipment before and after MuniRem® application was conducted by McAlester AAP chemists who certified the analytical reports. The success of MuniRem® was watched and supervised by staff from many Department of Defense divisions with military munitions mission, including the Defense Ammunition Center. McAlester AAP is currently using MuniRem® to decontaminate their equipment and treat multiple legacy explosives contamination challenges.



Photos: MuniRem® application at Hawthorne Army Depot for similar application

Decontamination at a Navy Facility

Engagement details

Client: US Navy
Site: Yorktown (Indian Head Detachment), Virginia
Task: Decontamination of Explosives Contaminated Gaskets in MuniRem®
Date: November 2010

Situation

The Naval Surface Warfare Division at Yorktown Detachment uses asbestos gaskets on the doors of some of their steam ovens used to dry explosives. This gasket is about 1-1/2" in diameter, 14 feet long and weighs about 2 lbs. Based on laboratory analytical data, the gasket has a fibrous white layer #1 (30% chrysotile, 30% cellulose fiber, 40% non-fibrous material) and a brown particulate layer #2 (100% non-fibrous material). The total percentage of asbestos present was 6%. The presence of asbestos makes an uncontained item thermally untreatable in the Indian Head Industrial Waste Processor (used to treat material posing a potential explosive hazard).

The initial percentage of explosives was unknown. The ultimate goal was to treat the container thermally and then use MuniRem® to ensure complete decontamination. There are numerous asbestos-containing items in the U.S. militarization and demilitarization program which may benefit from MuniRem® decontamination.

Solution

The contaminated gaskets were soaked in a MuniRem® solution multiple times: initially for one, then two and 48 hours to destroy the explosive contaminants that had impregnated into the gaskets. The residual (reacted MuniRem®) solution was passed through a packed reactive column to polish the reacted solution prior to disposal as non-hazardous waste.

Result

The MuniRem® treatment was shown to be an effective way to eliminate the explosive contamination on the surface and inside the asbestos gaskets prior to disposal. The polished water was analyzed and found to contain no regulated compounds before being disposed. MuniRem® offers a non-thermal solution for decontamination of gaskets prior to disposal or reuse.

Remediation of Explosives in Soil

Engagement details

Client: Department of the Army, U.S. Army Corps of Engineers
Site: Ravenna Army Ammunition Plant ("AAP"), Ohio
Task: In-situ Rapid Chemical Degradation of Munitions Constituents in Soil by MuniRem®
Date: October 2009

Situation

The test site is an inactive and unoccupied government-owned Operations Support Command site that was previously active from 1941 to 1992. The selected test area was approximately 45' x 20' in size. Based on an initial sample, primary explosives of concern (and associated baseline levels of contamination) were: TNT (383 mg/kg), RDX (180 mg/kg) and HMX (15 mg/kg). Discrete sampling (EPA Method 8330A) was utilized at target hot spots with visible evidence of explosive compounds on soil surface. The average concentration of primary explosive compounds were TNT (3,347 mg/kg), RDX (5,977 mg/kg), and HMX (640 mg/kg). Other explosive compounds were detected in the soils at much lower concentrations.

Solution

MuniRem Environmental conducted a baseline characterization of the contaminated soil to determine the type and concentration of explosives present. MuniRem® activators and main reagent were tilled into the explosive contaminated soil. Water was then added to initiate the rapid explosive degradation reaction by MuniRem® reagent. The efficacy of the treatment was monitored 24 hours following application and was confirmed two weeks thereafter.

Result

Analysis of the treated soil samples confirmed that MuniRem® achieved the cleanup goal in the 24 hours after application, which was reconfirmed two weeks later. Further analysis confirmed that the cleanup goal was achieved in two weeks for the hot spot area that had showed visible chunks of explosives. MuniRem® was effective in the remediation of low and high concentrations of explosives in soil. Blackened soil areas following MuniRem® treatment characterized the effectiveness of MuniRem® to instantly neutralize the chunks of explosives in soils within the hot spot areas. The effectiveness of MuniRem® was independently validated by a certified chemical data validator.



MuniRem® activators and main reagent are easily applied...



...before being tilled into the explosive contaminated soil



Blackened soil characterizes the neutralization of chunks of explosives in the hotspot areas

In-Situ Bioremediation of Perchlorate and Explosives

Engagement details

Client: Department of the Army, U.S. Army Corps of Engineers
Site: Longhorn Army Ammunition Plant (AAP) in Karnack, Texas
Task: In-Situ Bioremediation of Perchlorate and Explosives by SAMNAS®
Date: September 2002 to June 2004

Situation

From 2002 to 2007, MuniRem Environmental was contracted by the Army Operation Support Command to demonstrate and apply SAMNAS® to remediate perchlorate and co-contaminants, such as high explosives in soil at an open burn open detonation (OBOD) site, Longhorn AAP. This site's underlying soil had been contaminated by byproducts of incomplete combustion/detonation of ammunition or energetic materials. The application of SAMNAS® at Longhorn AAP in 2002 was the first field application of an in-situ bioremediation process to remediate perchlorate-contaminated soil at depth (i.e. in vadose zone source area).

Solution

MuniRem Environmental characterized the extent of soil contamination prior to conducting its treatment by SAMNAS®. MuniRem Environmental remediation process included tilling bacteria-rich nutrients into the contaminated top soil to stimulate the degradation of the contaminants of concern; the SAMNAS® solution were then progressively infiltrated through the ground. Traditionally expensive dig-and-treat methods are therefore not necessary. The monitoring of contamination levels was performed bi-monthly and confirmed the progressive decrease of contaminants of concern in the treated surface and deeper soils.

Result

The test carried out in 2002 confirms that SAMNAS® is effective for in-situ bioremediation of perchlorate in soil. SAMNAS® successfully met the site's objectives for remediation of perchlorate and explosives within a 10 to 12-month period. The replanting of indigenous vegetation on site was not only possible after treatment, but also contributed to "cleaning up" any residual contamination and to improve the site's environment. SAMNAS® has been approved for a further two performance based contracts by the US Department of the Army.



Irrigation system at work – treated site covered in hay



Site after treatment and revegetation

Green Solutions Engineered

**Rapid Neutralization of Explosives in
Multiple Media**

**Rapid Chemical Stabilization of Metals
in Multiple Media**

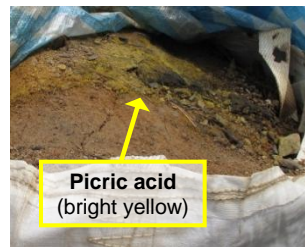
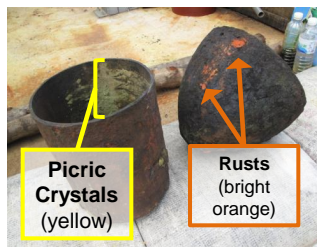
MuniRem® - Faster, Better, Safer, Cheaper

Traditional Remediation Methods

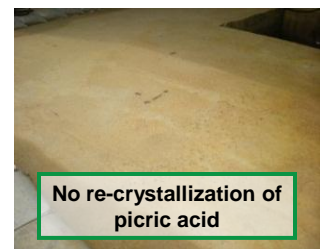
MuniRem Environmental MuniRem®

Treatment Time	<ul style="list-style-type: none"> Weeks to years Dig & haul - slow and not scalable 	<ul style="list-style-type: none"> Hours to days Simple setup and application
Treatment Effectiveness	<ul style="list-style-type: none"> Dig & haul does not remediate hazardous chemicals; only relocates Incineration & OBOD emit toxic gases and greenhouse gases 	<ul style="list-style-type: none"> Rapid, in-situ or ex-situ; 100% eco-friendly and biodegradable Generates innocuous by-product
Application Safety	<ul style="list-style-type: none"> Combustion - high pollution Alkaline hydrolysis - hazardous pH conditions Careful handling & monitoring required 	<ul style="list-style-type: none"> Safe ambient room temperature & pH process Little danger to the user or community
Cost / Capital Investment	<ul style="list-style-type: none"> High upfront plant / equipment costs High post-treatment costs Digging / transportation costs By-product remediation costs 	<ul style="list-style-type: none"> Flexible and scalable with a "pay-as-you-go" model <u>NO</u> material upfront costs Typically 30-50% less than traditional methods

Explosive contaminated munitions casing, soil and equipment



After MuniRem® treatment



MuniRem®

MuniRem® is a chemical formulation invented in the US by MuniRem Environmental's founder over a ten-year period of laboratory and field testing:

- Proven, rapid, in-situ or ex-situ chemical solution for munitions constituents (organic pollutants, heavy & toxic metals, pesticides) in soils and groundwater
- Proprietary, patented and exclusively licensed chemical formulation that can meet and exceed the most stringent remediation goals faster, better, safer and cheaper

MuniRem® consists of selected bulk reductants that:

- Degrades PCBs and explosives into nitrogen gas, formate and non-hazardous trace elements
- Reacts with toxic and heavy metals into insoluble metal sulfides

MuniRem® formulation and application is tailored to each site to ensure optimum performance and desired results:

- It can be applied as a solid or aqueous solution to achieve optimal and desirable results
- **Contaminated soils treatment** involves mixing MuniRem® into the soils and adding water to achieve in-situ or ex-situ remediation
- **Groundwater remediation** involves injection of the MuniRem® solution into the site groundwater to instantly degrade the dissolved contaminants and create permeable reactive aquifer solids for long-term treatment of the plume
- **Decontamination applications** involve spraying the MuniRem® solution on building walls, large equipment and scrap metals (including bombs shells, bomb components, projectiles); and soaking small sized equipment in MuniRem® baths

MuniRem® was voted a 2010 Better World Technology by the Association of University Technology Managers

Proven Capabilities & Field Success

MuniRem® has successfully neutralized recovered munitions fillers (bulk explosives) and decontaminated explosive residues on bomb casings, demilitarization equipment, building walls, open burn open detonation (OBOD) ash and contaminated soils including:

i. US Army:

Multiple 10-lbs batches of explosives (Composition D) recovered from Navy projectiles neutralized within 20 minutes

ii. US DoD Demilitarization Facilities:

Contaminated equipment (kettles, autoclaves, & conveyor belts), building walls, gaskets, bomb casings, OBOD ash, pink water & Granular Activated Carbon (GAC) were rapidly decontaminated to non-detect levels with no hazardous by-product and discharge to clean up

iii. Ravenna Army Ammunitions Plant:

In-situ treatment of field soils with high concentrations (>20%) of TNT, RDX and HMX and achieved cleanup goal for energetics in less than 2 weeks

Kettle lid



MDAS & 5X Munitions



MuniRem® onsite remediation on contaminated soil

MuniRem®

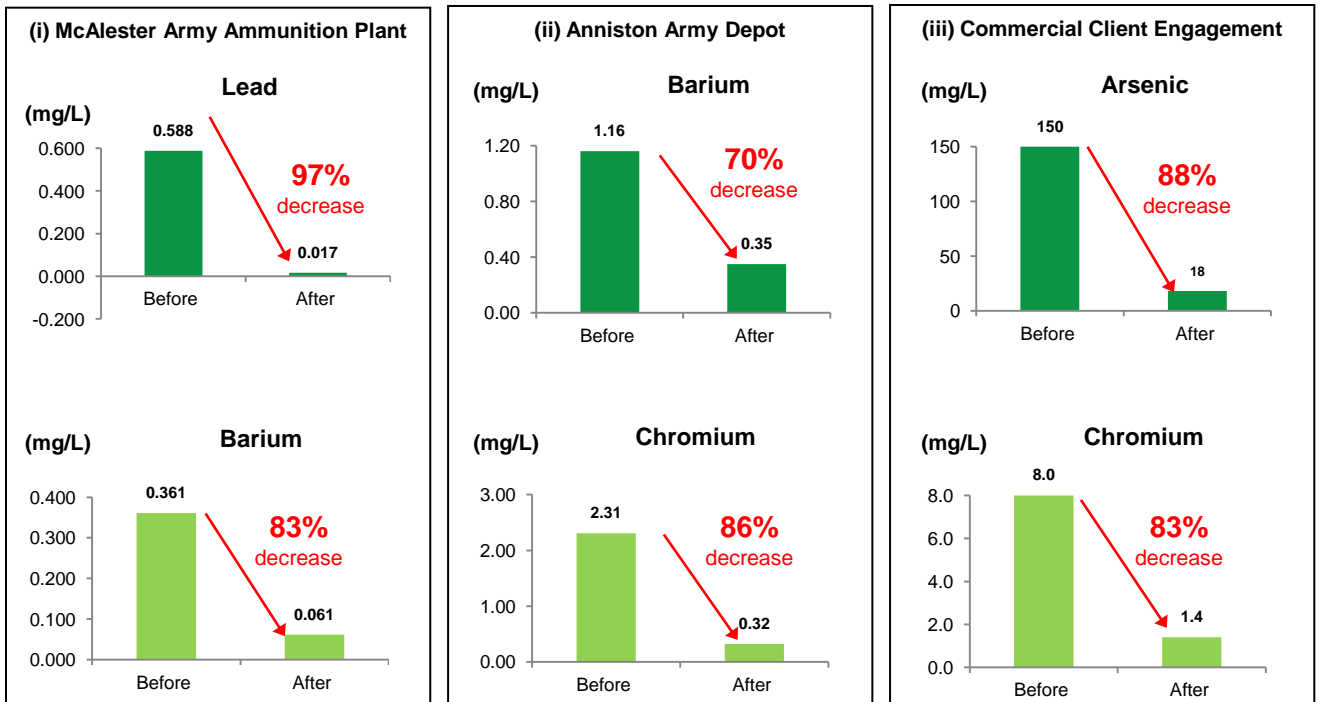
- A proprietary, patented and exclusively licensed chemical formulation
- Proven to meet and exceed the most stringent clean-up goals faster, better, safer and cheaper
- Flexible enough to be used on various media
- Every formulation and application is tailored to each site to ensure optimal performance and desired results

•MuniRem® consists of selected bulk reductants that:

- Binds with toxic and heavy metals forming insoluble metal sulfides
- Proven field and laboratory success with reactive metals commonly found at contaminated sites
- Metals treated by include: aluminum, arsenic, barium, beryllium, cadmium, chromium, lead, mercury, iron, selenium, uranium, etc.

Proven Capabilities on Treatment of Heavy Metals

Below display MuniRem Environmental TCLP successful field results from:



About MuniRem Environmental

MuniRem Environmental is a pioneer in the application of a portfolio of innovative green remediation technologies for metals, explosives, radiation, petroleum and perchlorate in various media.

Our team of experienced scientist and professionals are dedicated to making a difference by providing our clients and partners with demonstrably superior cost-effective green remediation technologies and solutions.

We provide services to Fortune 100 companies, the U.S. and international military and environmental organizations.

Contact:

Valentine Nzengung, PhD

CEO & CTO

MuniRem Environmental, LLC

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Athens, GA 30602, USA

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Email: vzengung@munirem.com

June 30, 2016

Alabama Department of Environmental Management
Permits and Services Division, 1400 Coliseum Blvd. AL 36110-2059)
P.O. Box 301463 Montgomery, Alabama 36130-1463
ATTENTION: Mr. Russell A. Kelly

**RE: Emergency Permit – Jet A Fuel and UDMH Tank Treatment Redstone Arsenal (RSA)
DSMOA Environmental Restoration Program U.S. EPA I.D. No. AL 7 210 020 742**

Dear Mr. Phillip D. Davis, Chief Land Division, ADEM

I have reviewed the above emergency permit and would like to comment on the availability of non-thermal green alternative solutions for the decontamination of multiple tanks containing residuals of unsymmetrical dimethyl hydrazine (UDMH) and Jet A fuel. For many years, NASA developed and applied Advanced Chemical Oxidation chemistry to decontaminate rocket fuel tanks that contained UDMH and NDMA. The same chemical oxidation process destroys Jet Fuels to carbon dioxide. Additionally, my company MuniRem Environmental, LLC provides a chemical destruction solution applied at the full scale to decontaminate energetics on surfaces and in different materials. A sample of my company's Case Studies performed at DoD and Industrial Client sites can be reviewed at our web site url: www.munirem.com.

Therefore, I would suggest that ADEM consider other alternative decontamination methods that have been successfully demonstrated and shown to be equally safe and cost-effective. In fact, NASA showed that Advanced Chemical Oxidation of UDMH contaminated tanks was 90% more cost effective than the alternative solutions, amongst which was thermal decontamination.

Do not hesitate to contact me if ADEM and the Department of the Army are interested in a discussion on the technical feasibility of non-thermal alternatives for the decontamination of energetics contaminated materials.

Respectfully,



Professor Valentine Nzungung, PhD
CEO/CTO, MuniRem Environmental, LLC



Projectiles



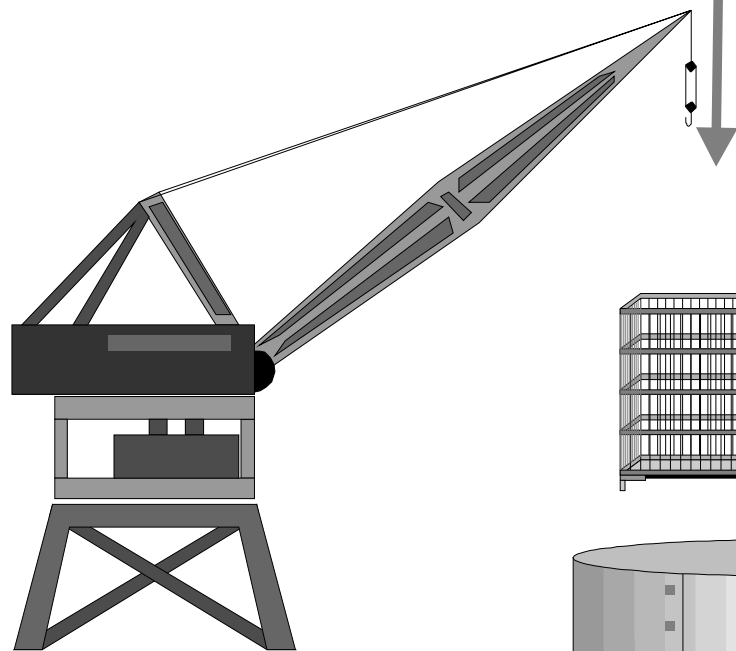
Cut Open



Explosives/Core Material



Projectile casings,
bomb casings,
scrap metal/
Shell Materials

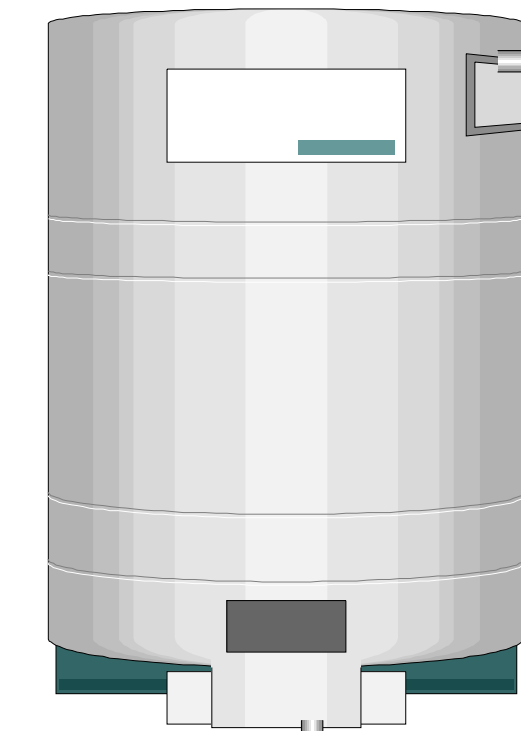


Recovered metal

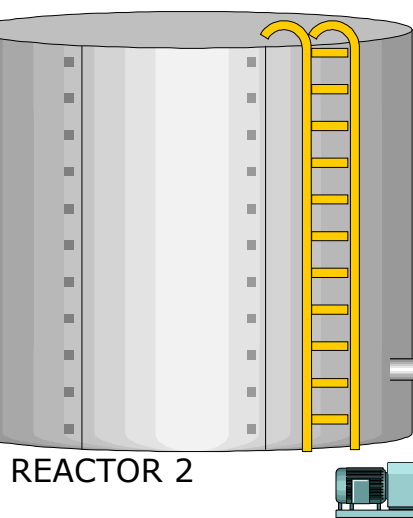


REACTOR 2

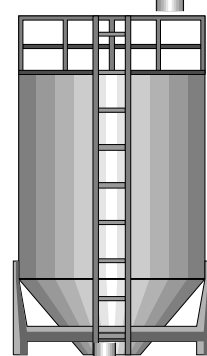
SPENT WATER STORAGE TANK



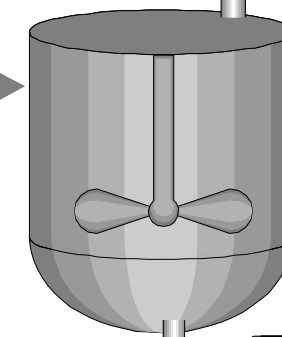
Steel
Basket



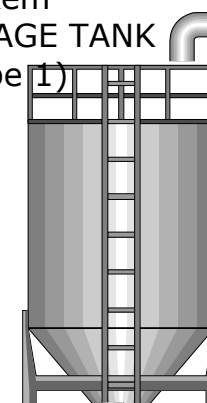
MuniRem*
STORAGE TANK
(Recipe 2)



REACTOR 1

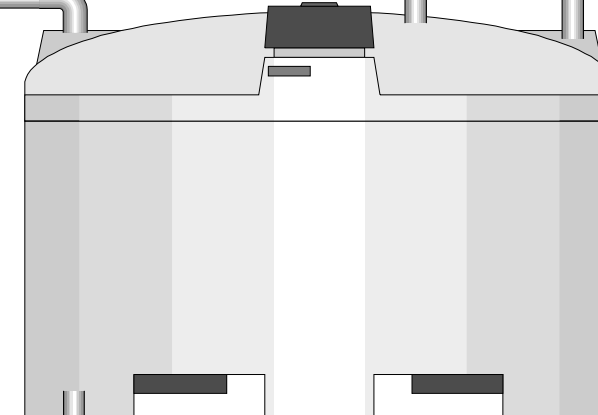


MuniRem*
STORAGE TANK
(Recipe 1)



FRESH MAKEUP
WATER

RECOVERED WATER
STORAGE TANK
FOR RECYCLE



SCRUBBING TOWERS

