

INTRODUCTION

Adventus Americas Inc. (AAI) is a USA-based environmental services company that provides various biotechnologies including those exclusive to our sister company, Adventus Remediation Technologies, Inc. (ART). ART's proprietary technologies include DARAMEND® and TERRAMEND® for treatment of soil and sediment; AQUAMEND® for wastewater; and EHC™ and mGCW systems for *in situ* groundwater treatment.

A 10-year record of successes in Adventus' application of technologies to solve complex environmental problems began within the W.R. Grace & Co. organization (NYSE:GRA). Our portfolio of remediation successes enables us to uniquely **guarantee the performance** of our products.

Adventus specializes in remedial solutions. Our business model is to support a project team by aiding in the design and selection of the most cost-effective remedial solution or strategy without predisposition or bias as to the selection of our propriety technologies. When their application is justified, however, our proven products may provide significant advantages. We subsequently rely on select consultancies to support joint projects especially from engineering and construction (oversight) perspectives.

OVERVIEW OF DARAMEND® TECHNOLOGY

DARAMEND is a bioremediation technology proven effective for treating soils and sediments containing persistent organic contaminants, including a range of organic explosive compounds. DARAMEND has been used successfully throughout the world to treat over 500,000 tons of soil, sediment, and solid wastes containing persistent organic contaminants such as chlorinated pesticides (e.g., toxaphene, DDT and dieldrin), wood preservatives and organic explosives (e.g., TNT, DNT, RDX and HMX).

DARAMEND is a patented technology (U.S. Patent No. 5,618,427) that integrates controlled-release carbon and reduced metals (e.g., zero-valent iron) to significantly accelerate destruction of targeted compounds. The technology has been successfully applied at a number of Department of Defense sites to treat soil and sediment impacted by organic explosives:

- U.S. Army's Raritan Arsenal - Edison, NJ
- U.S. Naval Weapons Station -Yorktown, VA
- Iowa Army Ammunition Plant - Burlington, IA
- Joliet Army Ammunition Plant - Joliet, IL



Application of DARAMEND (green material) at 1% (weight basis) to treat soil impacted by organic explosives; Joliet Army Ammunition Plant, Joliet, IL.



DARAMEND materials combine controlled-release carbon and microscale reduced metals into a single product.

DARAMEND treatment is **faster, better** and **more cost efficient** as compared with conventional composting. A few of the key process features are described below in more detail:

- Creation of Strong Reducing Conditions

As native soil microorganisms consume DARAMEND organic amendment particles, oxygen consumption is stimulated. In addition to microbial oxygen consumption, the inorganic amendment (e.g., powdered zero-valent iron) serves as a chemical scavenger of oxygen. This synergistic combination of oxygen consumption allows consistent attainment of redox potentials as low as -600 mV, which greatly benefits reductive dechlorination processes.

- Cycled Anaerobic and Aerobic Phases of Treatment

During very strong reducing conditions products of anaerobic microbial activity may accumulate and reduce the rate at which the biodegradation of organic explosive compounds proceeds. To manage this potential problem soil is often cycled through sequential anaerobic and aerobic phases of treatment.

- Thorough Mixing

Soil can be treated in place, in windrows, or in engineered biopiles. Where appropriate, powerful, durable tillage equipment is used to simultaneously incorporate the amendments and thoroughly breakdown soil aggregates. This prevents physical shielding of contaminants within dense, stable soil aggregates and thereby ensures that soil microorganisms have access to essentially all contaminants present.



On site DARAMEND treatment of soil and sediment impacted by organic explosives; US Naval Weapons Stations, Yorktown,



DARAMEND is proven to be faster, better, cheaper and more reliable than conventional bioremediation technologies.

® DARAMEND is a registered trademark of Adventus Intellectual Property, Inc



TABLE 1: DARAMEND® vs. Composting

DARAMEND® Bioremediation Technology	Composting Generic Process
<ul style="list-style-type: none"> • Effective on many organic compounds including all organic explosives and many pesticides • No production of toxic intermediates • No bulking <ul style="list-style-type: none"> - added at 0.5 to 3% by weight - <5% volume increase - no change in soil physical properties • No odors • No pathogens • Clean operations; DARAMEND materials are neatly packaged and stored on site • Manufactured regionally <ul style="list-style-type: none"> - reagent quality, type and grade are carefully controlled yielding a consistent product • <i>In situ</i> applications • In-place applications • Least expensive <ul style="list-style-type: none"> - \$25 to \$50 US/ton in place treatment - \$75 to \$150 US/ton for biopile treatment • Consistent performance • Guaranteed effectiveness 	<ul style="list-style-type: none"> • Not proven effective for highly chlorinated compounds; limited effectiveness on certain organic explosives (<i>i.e.</i>, DNT) • Toxic intermediates are often produced • Significant bulking <ul style="list-style-type: none"> - added at 2 to 3-times volume - 200 to 300% volume increase - modifies soil physical properties • Manure can be malodorous • Manure can harbor pathogens • Reagent stockpiles can be difficult to manage on site and they can attract rodents • Often uses local materials <ul style="list-style-type: none"> - reagent quality, quantity, type and grade are highly variable • Not practical • Not practical • More costly <ul style="list-style-type: none"> - in place treatment not possible - \$175 to \$250 US/ton for biopile treatment • Variable reagents → variable performance • Guarantee not offered

Costing based in part from: D.E. Jerger and P. Woodhull, 2000. "Applications and Costs for Biological Treatment of Explosives-Contaminated Soils in the U.S." *In: Biodegradation of Nitroaromatic Compounds and Explosives. Eds. J.C. Spain, J.B. Hughes, and H. Knackmuss, CRC Press, Boca Raton, Florida.*

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