Environmental Alternatives, Inc.
Rad-Release Technology

When it comes to serving the specialized decommission and decontamination needs of the nuclear power industry, few can match EAI's expertise.

EAI has years of experience addressing the full range of decontamination challenges facing nuclear power utilities, Department of Energy, Department of Defense, EPA, Homeland Security, Private Licensed Facilities and the Radiopharmaceutical Industry. We provide a comprehensive solution for projects of any size—from decontamination support for plant upgrade and refueling projects to complete Decontamination and Decommissioning (D&D).

EAI provides comprehensive radiological decontamination services for projects of any size. Our proven technologies and techniques enable us to achieve significant decontamination factors—dramatically reducing the volume of high-level waste and often allowing free release of treated objects. We have the expertise and capabilities to handle any decontamination project—from a single glovebox to an entire site decommissioning.

EAI supports the decommissioning of licensed radioactive sites with a turnkey decontamination approach. Our proven technologies and expertise — dramatically reduce the volume of contaminated waste and often allow free release of treated objects. EAI can help utilities and other nuclear facilities achieve final closure requirements for licensed termination plans.

No matter what the challenge, EAI provides a complete, turnkey solution, including:

- Site review and assessment
- Comprehensive decontamination strategy development
- Complete site preparation
- Health and safety
- Decontamination using most appropriate technologies
- Waste collection and packaging

EAI's Rad Release Chemical Extraction & Radiological Decontamination Technology

Breakthrough decontamination solution

EAI's chemical extraction technologies: Rad Release I and II, developed by the U.S. Department of Energy Idaho National Laboratory and EAI SuperGel developed by Argonne National Laboratory (all of which are licensed exclusively to EAI, Inc.) dramatically reduces the cost and risk of decontamination projects at nuclear power plants, DOE, DOD, research and weapons facilities, and other sites with radiological cleaning needs. Using this technology, EAI has achieved contaminant reduction rates of between 90% and 99%.

This technology is applicable to DOE, DOD, commercial nuclear, and private license nuclear facilities for radioactive decontamination of facilities and equipment. EAI's process can save millions in disposal costs, while enhancing worker safety and accelerating project schedules.

Overview:

EAI's technologies are effective for a range of contaminants, including:

- all radionuclides, inclusive of Transuranics
- Pcbs
- Heavy Metals

The process can be employed on a variety of surfaces and materials, including:

- Concrete, cinder block, brick, and tile
- Glass
- Asphalt
- Transite
- Wood
- Cast iron, carbon steel, stainless steel, and other metals, including exotic alloys

EAI's chemical extraction technologies are not limited to flat, horizontal surfaces—it is effective for walls, ceilings, structural beams, and irregular surfaces such as internal piping, equipment and tools. These processes can be applied as a liquid mist, foam or Gel.

Benefits:

- **Waste Minimization** - Liquid waste generated, including all chemical compounds, rinse and contaminants, is generally between 0.01 and 0.10 gallon per square foot; results as low as 0.01 to 0.03 per square foot are typical for most projects.
- **No Additional Hazards** - The process does not introduce additional hazards or disposal issues. The waste stream generated can be characterized based on the contaminants extracted.
- **Easier Disposal** - Wastes are containerized in drums, solidified and prepared for shipment to the disposal facility.
- **Reduced Liability** - By reducing the volume of waste, EAI dramatically lowers future liability. The effectiveness of the Rad Release chemical extraction process often enables permanent "de-listing" or "clean closure" status of building surfaces and materials.
- **Minimized Worker Exposure** - EAI's Rad Release chemical extraction technology minimizes or eliminates airborne contaminants, is non-hazardous and eliminates the health and safety risks to workers that are common to many other chemical processes.

Rad-Release Wins Coveted 2011 R&D 100 AWARD!

The Rad-Release Chemical Decontamination Technology (Rad-Release) has been selected by an independent judging panel and editors of *R&D Magazine* as a recipient of a 2011 R&D 100 Award. This award recognizes the 100 most technologically significant products introduced the past year. On behalf of the R&D staff, I would like to congratulate the project team on the design, development, testing, and production of this remarkable product.

Jill A Loftus

Idaho National Laboratory

Independent Validation

The technologies were originally developed after the terror events on September 11 to provide an effective means of recovering urban areas or strategic military equipment that may be affected by the use of a dirty bomb or other event using radiological materials. In an ongoing effort to validate the processes and better prepare our nation, the US EPA has been continually testing all methods of decontamination available throughout the industry and the world. These tests have been conducted independently at our national laboratories over the past several years. Various materials of construction have been tested using all major radioisotopes of concern. EAI's Rad-Release I, Rad-Release II and EAI SuperGel have ranked as the top three technologies in every test.

Decontamination Technology Testing Performed by The US Environmental Protection Agency
October 2010 - Contaminated Concrete CS137

Decontamination Technology	Technology Type (description)	Pre-Decon Activity µCi / Coupon	Post-Decon Activity µCi / Coupon	Percent (%) Removal	Decontamination Factor (DF)
EAI Rad-Release II	Chemical Extraction for both **surface and sub-surface contamination** Removal	1.02 ± 0.08	0.15 ± 0.03	85 %	7.0 ± 1.1
EAI SuperGel	Chemical Treatment designed to draw contamination into Gel **Surface and Sub-Surface Contamination**	1.03 ± 0.01	0.28 ± 0.05	73%	3.8 ± 0.7
EAI Rad-Release I	Chemical Extraction for both **surface and sub-surface contamination** Removal	1.11 ± 0.04	0.34 ± 0.14	71%	3.9 ± 1.5
RDS Liquid/ Foam	Topical Chemical surfactant for removal of loose surface contamination	1.10 ± 0.03	0.52 ± 0.09	53%	2.1 ± 0.3
INTEK ND-600 /ND-75	Chemical Process designed to remove scale and surface contamination from metals	1.08 ± 0.03	0.52 ± 0.12	52%	2.1 ± 0.4
Decon Gel 1101/1108	Strippable Coating	1.10 ± 0.03	0.60 ± 0.09	49%	1.9 ± 0.2
Water Blasting	High Pressure Water based surface removal	1.10 ± 0.02	0.85 ± 0.03	25 %	0.95 ± 0.3

Buildings and Structures

Contaminated facilities, buildings and structures can be decontaminated for reuse, de-listing or prepped for demolition quickly and effectively using our Rad-Release technology and services. All materials used in typical construction have been decontaminated with these technologies. Rad-Release works on both loose surface contamination, as well as, embedded subsurface fixed contamination.

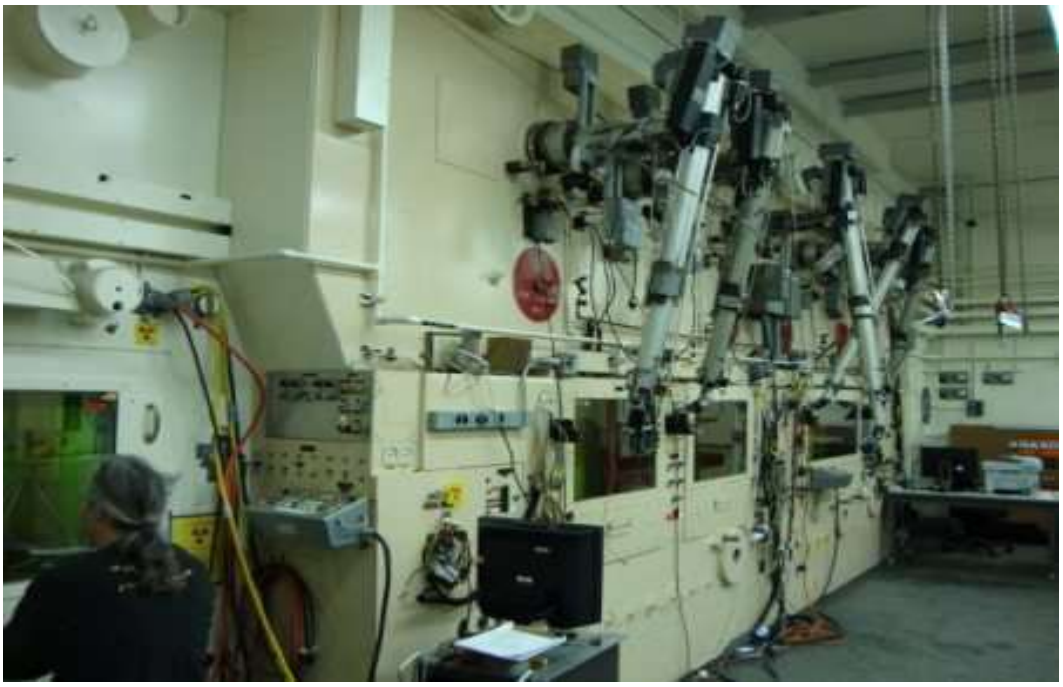
Building decontamination using Rad-Release foam to quickly cover large surface areas

Gloveboxes and Process Equipment

In support of the various US Department of Energy weapons facilities undergoing clean-up and D&D such as Rocky Flats, Hanford, Los Alamos National Laboratory, Argonne National Laboratory, EAI's Rad-Release and technical support services have played a major role in accelerating the clean-up. Gloveboxes, tanks and other process equipment that were high level TRU waste have been lowered to SCO and low level waste eliminating the labor intensive and costly size reduction and disposal at WIPP.

Manipulators

National laboratories, research facilities and hot cell operators use manipulators to carry out the work in these hostile environments. These manipulators and associated equipment fail and require routine maintenance and repairs. High contamination levels and the corresponding dose rates make these repairs difficult and dose intensive. EAI's Rad-Release has been used to quickly lower contamination levels and knock down dose rates to allow the work to take place and improve the safety and exposure to personnel.

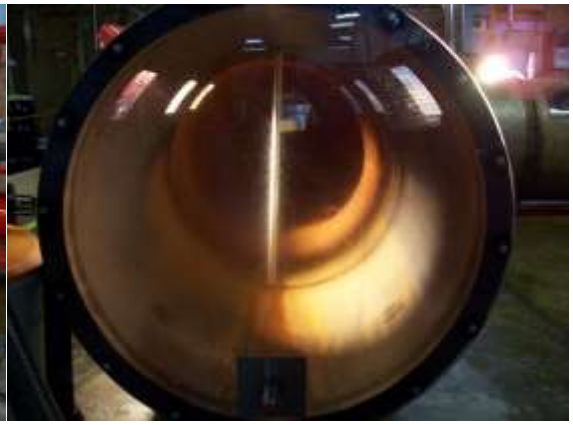


Manipulator decon at Idaho National Lab

Manipulator decon at Argonne National lab

Piping and Systems

Plant systems and piping that require decontamination for dose rate reduction can be effectively cleaned using Rad-Release foam injection, circulation and removal. Pictured below is the test set-up for removal of hold up uranium deposits from the US DOE Gaseous Diffusion cascades at Portsmouth and Paducah.



Technical Summary for Rad-Release I, Chemical Decontamination Technology

The *Rad-Release I* decontamination technology, developed and commercialized in cooperation with Idaho National Laboratory, is a chemical process that involves the topical application of a single decontamination solution to treat various substrates bearing radiological contamination. It is designed and blended to extract the contaminants via the migration pathways, pores and capillaries of the contaminated material. It is effective for both loose surface and fixed subsurface contamination and situations in which the contamination is a mixture of pure elements, oxides, and related compounds with varying solubility indices. Substrates for which the process can be used include those that are both porous and seemingly nonporous. The technology can be deployed on various geometries including walls, ceilings, equipment, structural beams, internal piping and highly irregular surfaces.

To maximize the efficacy of the extraction process, the chemistry and application are tailored to the specific substrate, targeted contaminant(s) and surface interferences. *Rad-Release I* utilizes a blend of organic and inorganic acids designed to reopen the pores and capillary pathways and cleave the electrostatic and chemical bonds binding the radiological contaminants to the substrate. The solution contains salts to promote ion exchange and surfactants to remove dirt, oil, grease and other surface interferences. Broad-target and target-specific chelants are blended into the solution to sequester and encapsulate the contaminants, keeping them in suspension until they are removed by the subsequent rinse.

The solution is applied in low volumes, as either an atomized spray or foam. Foam deployment of the solution has proven very practical for large scale applications while the spray application is beneficial for smaller applications and applications where waste minimization is a critical factor. The process can also be deployed using ultrasonic cleaning tanks for small tools, parts and equipment. After the decontamination solution is applied, light mechanical action is applied to ensure good contact with the contaminated surface. It is then left to reside for a prescribed amount of time followed by a rinse and removal. There are several options available to facilitate the removal step. The sequence of application, dwell, rinse, and removal of the decontamination solution constitutes a single iteration. It may be repeated, as needed, until the desired residual contaminant levels are achieved.

The blended solution contains no hazardous components regarding flammability or reactivity (as per 40 CFR 261) and has no components that would classify them as hazardous for disposal under TCLP testing. As a result, the waste stream from a project can be characterized based on the contaminants that were removed. Liquid waste volumes are usually 0.01 to 0.05 gal. / $ft.^2$ of contaminated substrate. Depending on the matrix and the amount of rinse applied, the liquid waste stream may have a resultant pH of less than 2. A pH neutral waste can be attained by adding sodium bicarbonate or another neutralizing agent. Waste may be handled by solidification, incineration, discharged to liquid effluent treatment systems, and / or evaporation.

Technical Summary for Rad-Release II, Chemical Decontamination Technology

The *Rad-Release II* decontamination technology, developed and commercialized in cooperation with the Idaho National Laboratory, is a chemical process that involves the topical application of project sepcific formulas to treat radiologically contaminated substrates that present challenges and/or difficult isotope matrices and stubborn surface interferences, requiring a more complex chemistry and application process. The technology is effective at removing radionuclides, including transuranics, from nearly all substrates. This process was developed to remove the contaminants by penetrating into the migration pathways, pores and capillaries of the contaminated material. It is effective for both loose surface and fixed subsurface contamination and situations in which the contamination is a mixture of pure elements, oxides, and related compounds with varying solubility indices. Substrates for which the process can be used include those that are both porous and seemingly nonporous. The technology can be deployed on various geometries including walls, ceilings, equipment, structural beams, internal piping and highly irregular surfaces.

To maximize the efficacy of the removal process, the chemistry and application are tailored to the specific substrate, targeted contaminant(s) and surface interferences. *Rad-Release II* utilizes a combination of chemical formulations that are a blend of organic and inorganic acids, as well as other chemical agents to clean dirt, oil, grease and other surface interferences. This formula is designed to penetrate the pores and capillary pathways and cleave the bonds binding the radiological contaminants to the substrate while sequestering them, preventing reattachment prior to removal. While another formula contains salts to promote ion exchange, ionic and nonionic surfactants, and additional sequestering agents to encapsulate the contaminants and keep them in suspension until they are removed.

The solutions are applied in low volumes, as either an atomized spray or foam. Foam deployment of the solution has proven very practical for large scale applications while the spray application is beneficial for smaller applications and applications where waste minimization is a critical factor. After the decontamination solution is applied, light mechanical action is applied to ensure good contact with the contaminated surface. It is then left to reside for a prescribed amount of time followed by a rinse and removal. There are several options available to facilitate the removal step. The sequence of application, dwell, rinse, and removal of the decontamination solution constitutes a single iteration. It may be repeated, as needed, until the desired residual contaminant levels are achieved. The sequence of applying, rinsing, and removing the chemical formulations constitutes a single iteration. It may be repeated, as needed, until the desired residual contaminant levels are achieved. Even with challenging matrices removal rates of 90 to 99% have been observed.

The blended solution contains no hazardous components regarding flammability or reactivity and has no components that would classify them as hazardous for disposal. As a result, the waste stream from a project can be characterized based on the contaminants that were removed. Liquid waste volumes are usually very low to minimize secondary waste. A pH neutral waste can be attained by adding sodium bicarbonate or another neutralizing agent. Waste may be handled by solidification, incineration, discharged to liquid effluent treatment systems, and / or evaporation.

Technical Summary for EAI SuperGel Chemical Decontamination Technology

The *EAI SuperGel* decontamination technology, developed and commercialized in cooperation with Argonne National Laboratory, is a chemical process that involves the topical application of a single decontamination solution to treat various substrates bearing radiological contamination. The *EAI SuperGel* can remove radioactive cesium, cobalt, strontium, actinides and other contamination from porous structures, such as brick and concrete, which are notoriously hard to clean, as well as contamination from metal surfaces. The technology focuses on rapid response—capturing as much of the contamination as possible, as quickly as possible, and filling a technology gap immediately.

The system consists of engineered nanoparticles and a super-absorbent polymer gel, which work together to clean buildings and surfaces exposed to radioactive materials. The polymer "SuperGel" that absorbs the radioactivity is similar to the absorbent material found in disposable diapers. When exposed to a wetting agent, the polymers form a kind of structural "scaffold" that allows the gel to absorb great amounts of liquid.
The amount of contamination removed depends on the characteristics of the contaminated structure—its age, type of material, whether painted or unpainted—and the radioactive isotope involved. Removal rates have ranged from roughly 80 to nearly 100 percent.

The technology follows a simple, three-step process:

1. *Application:* Spray applicators apply a wetting agent and a super-absorbent gel onto the contaminated surface.
2. *Reaction:* The wetting agent causes the bound radioactivity to re-suspend in the pores. The super-absorbent polymer gel suctions the radioactivity out of the pores and it becomes fixed in the engineered nanoparticles that sit in the gel.
3. *Cleanup:* The gel is vacuumed and dehydrated, with only a small amount of radioactive waste remaining for disposal.

A key benefit of the SuperGel technology is that it leaves structures intact. Contaminated objects were typically demolished since they could not be cleaned. Because EAI's SuperGel system preserves surfaces, monuments and buildings are not defaced during radiation removal.

The SuperGel technology can be used to:

- Reduce radiation levels to allow reoccupation or resumption of use
- Decontaminate structures for unrestricted access
- Convert liquid radioactive waste to stabilized solids suitable for direct disposal

The blended solution contains no hazardous components regarding flammability or reactivity (as per 40 CFR 261) and has no components that would classify them as hazardous for disposal under TCLP testing. As a result, the waste stream from a project can be characterized based on the contaminants that were removed. Waste may be handled by solidification, incineration or evaporation.


SuperGel before application


Applied to vertical surfaces


Removal via vacuum


After partial removal

RESULTS

The table below lists some examples of the results EAI has achieved using our Rad-Release technologies.

Project	Date of Project	Surface	Pre-Dcon Contamination	Post Decon Contamination	Primary Isotopes	Reduction (%)	Decontamination Factor
Idaho Nat'l lab	9/14/2011	Stainless Steel and Aluminum	.41 Sv/Hour .06 Sv/Hour	4.5 mSv/Hour 0.5 mSv/Hour	Sr^{90}, Cs ^{134,136,137} Y^{90}, La^{140}, Ce^{144},Pr^{144},PM^{147}, Sm^{151}	98.9% 99.2%	91 120
Oak Ridge DARPA Testing	9/21/2007	Concrete	10,200 Bq/cm²	194 Bq/cm²	Cs $^{134, 136, 137}$	99.98%	52
Oak Ridge DHA Testing	5/14/2006	Asphalt Roof shingles	12,200 Bq/cm²	189 Bq/cm²	Cs $^{134, 136, 137}$	99.85%	64
USEPA	8/25/2007	Concrete	37,700 Bq/cm²	5,550 Bq/cm²	Cs $^{134, 136, 137}$	85%	7
West Valley	8/23/2005	Spent Fuel Rack (Stainless Steel)	.4 mSv- .8mSv/Hr. 10,400 Bq/cm²	<1 µSv/Hr. 3.33 Bq/cm²	Mixed Isotopes predominantly Co^{60} & Cs^{137}	99.97%	3123
Argonne Nat'l Lab	2/11/2010	Stainless Steel and Aluminum	133,000 Bq/cm²	8,333-16,700 Bq/cm2	Am^{241}, Cs^{137}, Co^{60}	87 – 94%	8 - 16