

## Dissolvable Clothing: Cost-Effective, Emerging Technology for Low Level Waste management



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Management of solid waste from radiological protective clothing and its associated low level, liquid laundry waste has been a burden for the nuclear power industry for some time. A recent technological development using dissolvable clothing made from polyvinyl alcohol (PVA) and off-site processing represents a sound solution to this challenge. A new report from EPRI presents a comprehensive technical and economic evaluation of utility use of PVA clothing.

Dissolvable materials made from PVA have captured the interest of nuclear facilities for more than a decade. The development, testing, and successful demonstration of the OREX dissolution system, combined with a comprehensive line of compatible OREX PVA products, has significantly increased the level of interest and field testing. In the past 12 months, at least 16 nuclear stations, representing one-quarter of the commercial U.S. nuclear industry, have procured and tested OREX Certified Soluble™ PVA protective clothing, mops, wipers (rags), bags, and sheeting.

Given the large and growing level of interest in dissolvable PVA clothing, it became appropriate for EPRI to initiate and document a pilot study to capture the related facts and technical data. This new information will allow all member utilities to make a more informed analysis of dissolvable materials, including technical considerations, economic considerations, and worker impact and safety considerations.

TXU Corporation's Comanche Peak Steam Electric Station agreed to participate as the demonstration plant for a "cradle-to-grave" (purchase-use-disposition) PVA application study of OREX PVA garments during its spring 2002 refueling outage, under the direction of TXU's Doug Kay. The most important aspects of the study stemmed from the opportunity to capture actual plant cradle-to-grave data for PVA garments during a major plant outage. During the study, an unexpected outage at LaSalle County Station provided an opportunity to evaluate additional OREX PVA materials.

#### Vendor participation

OREX Technologies, Inc., and Eastern Technologies, Inc., the two key vendors involved with the OREX products, processes and dissolution technology in the U.S., also agreed to participate by providing access to technical data, cost parameters (generic and specific to Comanche Peak), live demonstrations of the processing equipment, and information on all previous testing and studies.

The vendors agreed to provide samples of materials and products, perform testing specified by EPRI to determine life-cycle expectations for launderable PVA materials, and arrange additional technical testing for PVA products. They also agreed to respond to all developmental,



technical, and economic questions in exchange for respecting the proprietary nature of certain data. The exceptional openness of the two key vendors made this study substantially more comprehensive and beneficial to the end user of the research results than would otherwise have been possible.

### **Objectives**

The study's objectives were to:

- Document the results of the field evaluation, economic analyses, and worker responses.
- Document the technical considerations of the OREX Technologies, Inc., PVA dissolution system and the technical considerations for OREX PVA materials.
- Develop a comprehensive and comparative economic analysis of all related cradle-to-grave contract data and associated costs. This applied to both existing materials and garments, as well as for PVA materials and garments.
- Implement and evaluate a controlled use situation for specified work activities with known and expected parameters (expected level of effort, person-hours, exposure, contamination levels, environmental conditions, and expected number of personnel contamination events).
- Develop and implement a standardized worker questionnaire to capture specific data points and to capture worker reactions, benefits, and impacts from the use of PVA materials.

### **Multiple perspectives**

The study examined the technologies and products developed by OREX from multiple perspectives, including:

- The field study of PVA product applications with a participating nuclear station to capture comprehensive and controlled data.
- A field survey questionnaire obtained from workers participating in the study.
- A site visit at the vendor facility to observe operation of the OREX dissolution system.
- A review of technical data for the OREX dissolution system, OREX PVA materials and product testing.
- Comprehensive economic analyses addressing multiple options involving OREX PVA protective clothing as potential alternatives to existing launderable cloth garments.
- The capture of summary data from other nuclear stations performing independent field trials of OREX PVA products.

### **Conclusions, recommendations**

The OREX PVA products and associated dissolution system offer a viable, efficient, and cost-effective alternative to nuclear protective clothing programs and for related combustible products (mops, rags, plastic bags, etc.). The system capitalizes on advances in polymer science to create both disposable (single-use) and launderable (multi-use) products. Following use, utilities can dissolve these products. The resulting effluent can be further treated or discharged. The technology represents a significant advance on earlier PVA applications, and is a viable process.

From an extensive list of detailed technical conclusions, the following additional, summary conclusions were drawn, along with a series of recommendations for follow-on work:

- A decision to use or ignore this emerging and viable technology should be made on a combination of factors rather than on economics alone. These include: maturity of the technology, worker safety and comfort, contamination control, and disposed waste volumes. These key items are each addressed in subsequent conclusions below.

- PVA products and the associated dissolution technology offered by OREX have matured into a viable technology offering significant economic and volume reduction benefits to the nuclear industry worldwide.
- Most workers reported that the OREX PVA products are cooler and more comfortable than cloth garments. This promotes effectiveness during the work process, in turn, promoting faster work with fewer errors.
- From a contamination control perspective, with primary focus on the potential for personnel contamination events, OREX PVA garments are at least as good as the existing cotton and poly-cotton cloth alternatives.
- OREX dissolution technologies equal or exceed the volume reduction capabilities and efficiencies for incineration, which currently exceeds the efficiencies of all other applicable volume reduction technologies.
- Moreover, the cost of procuring, installing, operating, and decommissioning the dissolution system is a fraction of the life cycle cost of other competing technologies.
- Economic analyses of nuclear protective clothing programs are exceptionally complex. Obscure, easily overlooked cost factors can have a critical impact on the end result. Yet it is clear that opportunities exist for realizing a significant economic benefit and cost savings from the use of OREX PVA garments and associated products.

### Recommended further work

The project team made the following summary recommendations for additional evaluation of dissolvable PVA clothing:

- Perform trial runs with the new products, and assess local worker acceptance of the product in terms of comfort, coolness, quality, durability, etc.
- Perform a comprehensive economic impact and benefit analysis.
- For governments, international organizations, and large utilities considering procurement of their own dissolution processing systems, review all of the technical considerations herein. Also evaluate the related regulatory, permitting, and licensing issues identified.
- If a decision is made to replace existing clothing inventories with PVA alternatives, it is recommended that a phased approach be given primary consideration.



Phased transition from an existing 100% launderable cloth garment program to a 100% launderable PVA garment program has a much lower impact than an immediate change. This is due primarily to an instant depletion of the cloth garment asset and the subsequent cost of dispositioning those garments (volume reduction and disposal costs).

For large utilities with multiple nuclear stations, a phased approach might be accomplished by switching to 100% launderable PVA garments at one or two stations and moving all existing cloth garments to other stations.

For smaller utilities and individual stations, a phased approach might best involve replacing 25% of the existing

stock each year, such that the transition would be completed within three years of the first garment replacement date.

### EPRI perspective

“A key, strategic mission of EPRI’s Low Level Waste Management Program is to provide unbiased

evaluations of emergent LLW processing technologies to our members,” says Sean Bushart, EPRI manager for low level waste. “This new report provides the technical, economic, and plant operational considerations for implementing a PVA clothing program. The report may also be of strong interest to radiation protection managers. EPRI is considering a follow-up report that will focus on the protective clothing aspects of this material.”

To order a copy of *Emerging LLW Technologies: Dissolvable Clothing* (1003435), press [here](#) or call EPRI Customer Service, 800-313-3774. For more information, contact Sean Bushart, [sbushart@epri.com](mailto:sbushart@epri.com), 650-855-2978.

**Photo captions**

Middle series: Drum-size bags of OREX soluble PVA protective clothing and other material are loaded into the processor at Eastern Technologies, Inc. (ETI), in Ashford, Alabama. After processing, all that remains from the 120-pound batch are rubber gloves and coverall zippers.

Bottom photo: OREX dissolution system installed at ETI's Alabama facility.