# AVANTech's Advanced Polymer Solidification (APS™) for Radioactive Waste Stabilization: Case Studies


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## Overview

There have been recent developments in polymer technology as well as process improvements that simplify the process and improve efficiency for stabilizing low and intermediate level radioactive and mixed radioactive/hazardous wastes. Polymer technology has been used successfully since the early 1990s to solidify and stabilize radioactive and mixed hazardous/radioactive waste at United States (US) Department of Energy (DOE) and US Department of Defense (DOD) sites, United Kingdom government sites, and commercial nuclear power plants. Applications in Japan include resin and debris solidification. AVANTech's APS™ options include In Situ or Continuous Mixing. It is an effective, efficient, and economical means of treating waste for storage and long-term disposal.

### Proven, US Nuclear Regulatory Commission (NRC)-Approved Method of Solidification

- ✓ Produces **stable waste form** that meets 10 CFR 61.56 requirements
- ✓ **Specialized epoxy polymers** used to immobilize and encapsulate radioactive wastes
- ✓ **Mature technology** used to treat over 3,000 m³ of radioactive waste at nuclear power plants and government facilities
- ✓ **Simple and effective** technology:
  - Room temperature application
  - High waste loading (≈100%)
  - Suitable for treating varying types of waste (resins, filters, etc.)
  - Successor of "DOW Process", US Patent: 4,405,512

*Polymer Solidified Carbon and Resin*

### APS™ Advantages

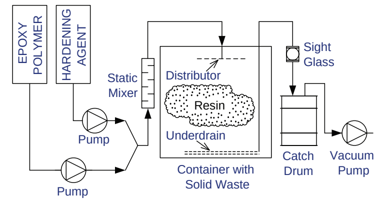
- ✓ NRC-approved Topical for stabilization of waste containing radioactivity below the limits of 10 CFR 61.55
- ✓ Eliminates the need for HIC or similar specialized high cost container
- ✓ Can be used with any type of dried powder, bead, or granular media
- ✓ Superior performance compared to traditional methods such as Portland cement: very low leachability, high compressive strength, waste loading is 4 times higher than Portland cement
- ✓ Highly predictable process – no chemical reaction between waste and polymer required
- ✓ Solidification polymer is "stable" for more than 300 years; therefore, concerns of container or vessel deterioration are eliminated
- ✓ All sizes of disposal containers are acceptable for use with APS™
- ✓ ALARA – Remote application of polymer minimizes personnel exposure
- ✓ Low equipment costs compared to traditional cementation processes
- ✓ APS™ uses relatively simple equipment that is small in size: reduced facility space requirements, may permit use of spare space in existing facility

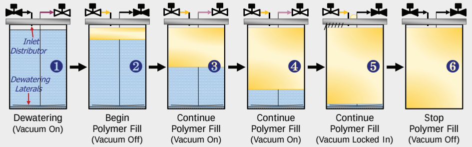
## APS™ Application Method #1: In Situ Process

- ✓ In situ: with waste in its original place inside a container or vessel (**no waste transfer required**)
- ✓ Requires an upper liquid distributor and an outlet underdrain
- ✓ Easily permeable material (ion exchange resin, carbon, etc.)
- ✓ Polymer percolates from top to bottom filling interstitial spaces, minimizing waste volume

### Process Description

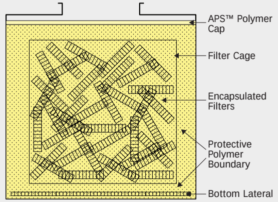
- ✓ Container is filled with waste.
- ✓ Water (if present) is removed through underdrain by vacuum pump.
- ✓ Voids and interstitial spaces of waste are filled with polymer by simultaneous operation of the Polymer Pumps and Vacuum Pump (polymer will displace any remaining water as it fills container).
- ✓ When clear polymer is seen in the sight glass, the process is stopped and curing begins.
- ✓ Typically cures to rock-hard, free-standing monolith within 24 hours.




### APS™ In Situ Filter Encapsulation (ENCAP™)

- ✓ Compatible with filters, tools, large objects
- ✓ Process steps:
  - Load filters (objects) into perforated metal cage
  - Load permeable media (resin) into interstitial space
  - Solidification proceeds in normal manner




### Typical APS™ In Situ Applications

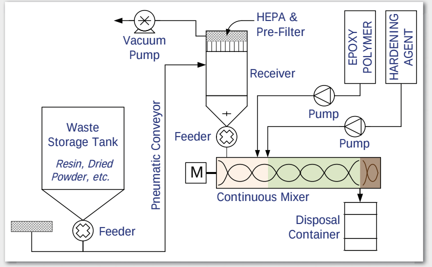
- ✓ Spent resin contained in:
  - HICs
  - Steel Containers
  - Drums (200 L, etc.)
  - Disposable ion exchange (IX) vessels
- ✓ Packaged high-dose rate components:
  - Filter elements
  - Metal parts
  - Irradiated metal
  - Radiation sources

## APS™ Application Method #2: Continuous Mixing

- ✓ Applied to fine materials with low permeability:
  - Powdered resins
  - Fine materials such as soils, sludge, dried powder, fine sand, etc.

### Process Description

- ✓ Pneumatic transfer of waste from Storage Tank to Receiver
- ✓ Waste metered into Continuous Mixer by Loss-in-Weight Feeder
- ✓ Polymer injected and homogeneously mixed with waste
- ✓ Product falls by gravity into disposal container




### Typical APS™ Continuous Mixer Applications

- ✓ Powdered ion exchange resin
- ✓ Crystalline sorbents (FeCN, CST, etc.)
- ✓ Sludge and fine debris
- ✓ Dried evaporator concentrates (bottoms)
- ✓ Dewatered ion exchange resin
- ✓ Incinerator ash and filters
- ✓ Soil and similar materials


*APS™ Continuous Mixing System*

## APS™ Polymer Experience

### US DOE Nuclear Facilities

- ✓ Bechtel Bettis Naval Reactor Facility – in situ
- ✓ Idaho National Laboratory – macro encapsulation, circuit boards
- ✓ Puget Sound Naval Shipyard – in situ, IX and GAC vessel solidification
- ✓ Paducah – macro encapsulation, uranium chip solidification
- ✓ Savannah River Site – in situ, silver coated packaging, and mixer, aqueous mercury
- ✓ Westinghouse Naval Reactors Idaho – in situ, stabilization of zircaloy swarf

### US Commercial Nuclear Plants

- ✓ Connecticut Yankee – mixer, sump sludge
- ✓ Diablo Canyon – in situ, resin and filter
- ✓ Dresden – mixer, concentrate, and in situ, resin
- ✓ Pilgrim Station – in situ, resin liner solidification
- ✓ V.C. Summer – in situ, resin

### Non-US Nuclear Facilities

- ✓ BNFL, UK – macro encapsulation
- ✓ Magnox Trawsfynydd Power Station, UK – mixer, resin solidification
- ✓ Kozloduy, Bulgaria – mixer, tank sludge/resin

## Conclusions

APS™ processes use in-container mixing, high-speed mixing, and in-container In-Situ solidification to address a wide variety of radioactive and mixed waste materials, including liquids, sludges, bead resin, granular media, and powders. The resulting polymer-solidified product forms a rock-hard monolith and meets or exceeds the 10 CFR 61.56(b) BTP requirements for a stable waste form whose integrity is assured for long-term storage, transportation, and land burial environments.

Efforts to further maximize the efficiency of the polymer solidification process have focused on pre-solidification volume reduction of the waste by use of a continuous screw dryer incorporated into the system ahead of the solidification station. Pre-drying can yield a 50%-80% volume reduction in some wastes, further reducing packaging, transport, and burial volumes.