# Post-Barnwell Disposal of Class B & C Resins and Filters

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**Abstract**

A bill seen as the best -- if not last -- hope of keeping the Barnwell disposal site open to non-Atlantic Compact generators was defeated March 2007 by a vote of 16-0. The bill, sponsored by South Carolina State Representative Billy Witherspoon, would have rescinded the 2000 pact that forced all states except South Carolina, Connecticut and New Jersey to stop sending radioactive waste to Barnwell in July 2008.

The defeat of the bill seems to ensure that as of July 1, 2008 non-Atlantic Compact members will be cut off from the current disposal pathway for Class B & C wastes. At operating power plants, these wastes consist mostly of ion exchange resin used to purify reactor coolant and spent fuel pools. A small volume of Class B & C filters is also generated. Without access to a disposal site, plants will find disposition of these wastes problematic.

This paper discusses the Advanced Polymer Solidification (APS™) process as a viable method of packaging Class B & C resins and filters for on-site storage. Advantages of this stabilization process include simplicity of process, reduction in waste handling and shipping, and elimination of the need to reprocess and repackage waste before final disposal. This process and waste form have been approved for stabilization of Class B & C wastes by the Conference of Radiation Control Program Directors (CRCPD). This approval is important for assuring that waste is accepted by future disposal facilities.

This paper compares APS™ with alternative methods of handling Class B & C resins and filters on the criteria of cost, convenience, packaging and future acceptability of waste forms. These considerations are vital for nuclear power plant planning post-Barnwell.

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## Introduction

Currently, Class B & C resins generated during clean up of reactor coolant and spent fuel pools are readily disposed of -- though at significant cost. These resins can be buried in High Integrity Containers (HIC) at the Barnwell facility, or sent to an off-site processor, such as Studsvik, for volume reduction (VR) via a thermal process. The resulting residue is commingled with that from other generators, and then buried at Barnwell.

Advanced Polymer Solidification (APS™) is a viable alternative to these methods, as has been demonstrated by Diablo Canyon Power Plant. Using the APS™ process and steel liners, Diablo Canyon stabilizes approximately a liner a year of Class B & C resin for disposal at Barnwell.

## The APS™ Process

The APS™ process involves a chemical formulation similar to that described in NRC-approved Topical Report DTI-VERI-100-NP-A: Vinyl Ester Resin In Situ Solidification Process for Low-Level Radioactive Waste, Rev 1. APS™ uses the same in situ solidification process, but a different proprietary modified polymer. The Advanced Polymer (AP), similar to the VES approved by the NRC, is chemically cured, through addition of hardening agents, to form a hard, stable monolith. The AP has been approved by the CRCPD.

The binder and the curing agents are combined in a mix tank, and the viscosity adjusted to permit optimum flow through the waste media, The mix tank is then pressurized, and the AP allowed to flow into the freeboard of a container (steel or plastic) filled with dewatered waste media. Figure 1 illustrates a typical solidification setup.

When the AP has formed a cap on top of the waste media, the same AOD pump used in the initial gross dewatering is activated, and a combination of gravity and vacuum draws the AP down through the waste media. The advancing polymer, which is hydrophobic, drives any remaining interstitial water from the media as it flows down through the container, filling voids between the beads and grains. The polymer is then allowed to cure over 24 hours, forming a liquid-free, hard, freestanding monolith inside the container. This process enables virtually 100% waste loading, since the polymer binder fills only the voids within the waste media.

Once the container is solidified, it can be moved to interim storage until a Class B & C disposal site is available.

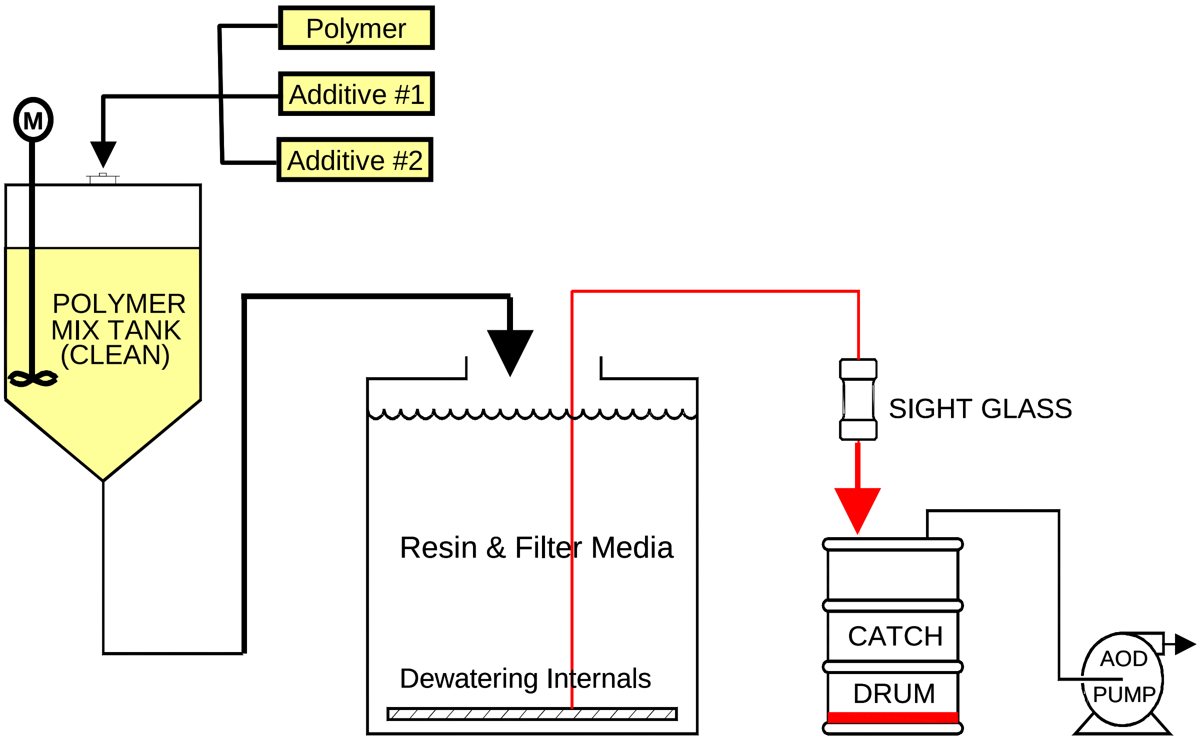


Figure 1

APS™ Simplified Process Flow Diagram

**Comparison: APS™ and Alternate Methods**

As described, an APS™ campaign consists of three simple steps: 1) sluice, 2) solidify, 3) store. However, there are complex and important underlying considerations involved in selecting APS™ as a method for stabilizing Class B & C wastes. In the following pages, we will discuss these issues, and compare APS™ to alternative methods of stabilizing Class B & C wastes in a post-Barnwell environment. The alternative methods include dewatering of resin for storage on-site, and thermal reduction of resin.

***Waste Form***

***APS™.*** The in situ polymer solidification process was approved by the NRC for VES, and VES was grandfathered by the CRCPD's E-5 Committee for Stable waste form approval. The APS™ formulation used in the in situ process was tested to NRC Branch Technical Position (BTP) on waste form criteria by DOE Idaho, and reviewed and approved by CRCPD's E-5 committee as Stable. The E-5 committee includes representatives from the States of South Carolina, Washington, Utah and Texas. This portfolio of approvals is important for ultimate disposal of the waste, when a future facility becomes available.

***Dewatering.*** Dewatering resins is the simplest -- and least effective -- way to handle them. Because dewatered resins are not (and are not likely to become) an approved waste form, some type of stable package will be required to contain them. Since poly HICs have not received a Stability approval by NRC, they will require compensatory measures (e.g., concrete overpacks) at a future Class B & C disposal site. NRC-approved metal HICs do provide stability, but are very expensive.

***Thermal Reduction.*** The VR achieved with thermal treatment is attractive, given that the number of containers of resin to be produced and the number of years they must be stored are unknown. Currently, resin residue is loaded into poly HICs. Since poly HICs themselves cannot provide stability, the container will have to be overpacked for future disposal, or the residue will have to be loaded into NRC-approved metal HICs (possible, but expensive). Resin residue could be solidified in a stable binder, but that will limit the VR benefit. Currently, only polymer solidification formulation has a Stable approval for granular media like resin residue.

***Waste Handling and Shipping***

***APS™.*** With its simple sluice/solidify/store steps, APS™ involves minimal waste handling. There are no Type B shipments to off-site processors (or return of the residue to the plant for removal from the shipping cask and placement in storage for eventual re-handling). With APS™, the waste can be solidified and moved into storage, not to be touched again until it is retrieved for disposal. APS™ can be conducted in steel containers, so the solidified waste package is non-flammable. This stabilized waste will not add to the fire load of the storage facility.

***Dewatering.*** A plant will have little choice, prior to disposal, but to retrieve the container of dewatered resin from storage, open the closure, hook up dewatering equipment, and run a recertification dewatering test. At Diablo Canyon, 3 of 4 liners failed the dewatering test after only a year in storage. Dewatering internals, whether in a poly or metal HIC, will need to function after a decade or more of storage. This may require metal internals versus the plastic ones typically in use. Should the internals fail or clog, transfer of the waste out of the HIC and repackaging on-site or off-site will be required. Finally, if the resin is stored in a poly HIC, the fire load to the storage facility will have to be considered. At Diablo Canyon, poly HICs were considered combustible, and had to be placed in metal cans prior to storage. This increased the cost of the storage containers, and the effort and exposure required to re-dewater the waste (since two lids had to be removed).

***Thermal Reduction.*** Getting waste to and from the thermal reduction facility involves multiple waste handling and shipping evolutions that result in labor, exposure and processing costs. A shipping cask must used to transport the spent resin to the off-site processor. The packaged resin residue must be returned in a Type B cask that must be opened and reassembled for return. The waste container, with a dose reading 2 to 4 times greater than when the resin was shipped out, must be transferred to the storage facility. If resin residue is loaded into a HIC, moisture will enter the HIC over time. Although the residue can absorb some water, when storage for decades may be required, dewatering provisions must be considered. If functional dewatering internals cannot be developed for the residue, then the residue will have to be solidified with a binder.

***Waste Volume***

***APS™.*** APS™ is an in situ process, and does not increase the volume of the waste (as mixing a binder with waste does). If 100 cubic feet of resin is used to fill a disposal liner to >90% full, the final stabilized waste volume will be the same. The polymer fills only the interstitial void volume, and creates a small cap of pure polymer in the freeboard of the container.

***Dewatering.*** Dewatering results in no change in volume so is, like APS™, “volume neutral.”

***Thermal Reduction.*** This process is typically represented to yield a VR of 5:1 or 6:1, which may be particularly important to a plant that has limited storage capacity. However, in accepting the smaller volume of residue to store, the plant needs to plan for dewatering the container in the future. If the residue is solidified in a binder, then the VR will be reduced.

***Waste Classification***

***APS™.*** APS™ results in a homogenous waste form that, for classification purposes, can accommodate a higher activity level of spent resin. For instance, resin that is marginally Greater than Class C (GTCC) could comply with Class B & C curie concentration limits after solidification, when the activity is averaged across the resin and binder.

***Dewatering.*** Dewatering resin will not change its waste classification, since volume and mass do not change.

***Thermal Reduction.*** Several unknowns come into play with thermal processing. If VR of 5:1 or 6:1 is achieved, the concentration of key isotopes will be increased by a like amount, potentially resulting in a GTCC waste form.

Thermal processing other low-dose resins to yield an “average” curie concentration that is less than GTCC may be effective, but will incur additional process costs, and negate much of the VR advantage. When the low-dose resin has to come from the same plant as the high-dose resin, additional shipping and scheduling will be necessary. The commingling of high/low dose resins means that low-dose resin, more economically disposed of directly, will be drawn into the thermal process. In short, the potential for forming GTCC wastes with the thermal process would seem to depend heavily on the plant and the waste stream.

***Filter Handling***

***APS™.*** APS™ solidification, when using the NRC-approved ENCAP™ encapsulation process, permits the introduction of filters, tools and other large objects into the resin monolith. Filters are disposed of by being introduced into a cage in the solidification liner. When the cage is full of filters or other objects, the liner is sluiced full of resin. The resin is then APS™ solidified, so that the Class B & C filters are fully encapsulated.

The last Topical Report approved by NRC, VERI™ ENCAP™, permits curie concentration averaging of the filters over the binder volume in accordance with the BTP’s on Waste

Classification and the Concentration Averaging and Encapsulation with the associated benefits. Accordingly, the APS™ ENCAP™ process provides a straightforward means of disposing of Class B & C filters, while still achieving 100% waste volume efficiency. APS™ ENCAP™ is currently undergoing evaluation by DOE Idaho, and is expected to be submitted to the E-5 Committee of the CRCPD for Stability approval in 2007.

**Dewatering.** Introduction of filters into a dewatered resin is problematic: the potentially unlimited combinations of filters and resins make an effective and qualified dewatering procedure difficult to develop and test. Filters can be dewatered alone in a HIC, but the void volume in the container would be as high as 70% to 80%.

***Thermal Reduction.*** Though a number of tests have been conducted for thermal or chemical destruction of filters, it remains to be seen if these processes are commercially viable. Typically, a plant design change is required to convert to incinerable filters. Plant limitations of 30 design changes per outage and 60 per year non-outage greatly decrease the likelihood that new radwaste design changes will be issued. Thermal treatment of Class B & C filters will result in GTCC waste if Ni63 or TRU are classification controlling. This result makes spent filters a DOE disposition problem (similar to used fuel).

***Cradle-to-Grave Cost***

***APS™.*** Once solidified with APS™, waste is ready for disposal. If solidified on-site, handling costs are reduced, and cask shipments (and the associated radiation exposure) are eliminated. When transshipment of waste to/from an off-site processor in casks is eliminated, transport and cask rental drop to nominally zero -- a significant cost and scheduling gain.

If activity concentration is an issue for spent filter packaging, APS™ will enjoy a distinct advantage in that, per the NRC-approved VERI™ ENCA™ Topical Report, filter activity can be averaged over the volume/mass of a stable binder, in accordance with the NRC's BTP's.

***Dewatering.*** Dewatered resins do not require use of a shipping cask until the liner is pulled from storage, redewatered, and sent off for burial (assuming waste form requirements have been met). Though dewatering resin for interim storage is the lowest-cost alternative in the short run; when the cost of retrieving the liner, re-dewatering it, transferring the resin to an acceptable container (should dewatering internals fail), and accounting for the associated exposure and future labor effort are considered; the cost advantage disappears. If poly HICs need metal overpacks to meet site fire protection requirements, there may be no cost advantage over APS™.

***Thermal Reduction***. Repeated waste handling, thermal treatment fees, container and cask rental are likely to make this a costly option. The cost to solidify the residue or provide functional dewatering internals and dewater the waste post-storage will further elevate costs.

## Conclusion

Many operational and process benefits and advantages accrue to use of the APS™ solidification to stabilize Class B & C resins and filters to an acceptable stable waste form. Among these benefits are:

- has CRCPD national waste form pre-approval for future burial;
- yields 100% waste loading with no volume increase;
- provides high packaging efficiency for Class B & C filters with spent resin (pending);
- limits on-site waste handling;
- eliminates shipments to/from off-site processor;
- eliminates costs of off-site processing;
- avoids retrieving waste from interim storage to recertify the dewatering, transferring the waste to an acceptable container should dewatering fail, or solidifying to a stable waste form;
- eliminates Type B cask shipments (except for final disposal);
- allows for higher resin activity concentration in the final package;
- yields final package that may reduce GTCC waste/objects to acceptable Class B & C waste;
- eliminates unknowns from plant planning, including:
    - what containers (if any) will be acceptable?
    - what residue or dewatered resin waste forms (if any) will be acceptable?
    - what kind of process will be available to reprocess the resin and residue to an acceptable waste form, and when will it be available?
    - what will the reprocessing cost be, and will the processing be on-site or off-site?

Effective planning eliminates as many unknowns as possible, while seeking predictable advantages. For Class B & C resins and filters, the APS™ process, proven in multiple full-scale applications, has a wide range of benefits and advantages for the post-Barnwell scenario of interim on-site storage prior to disposal.

## References


1. Miller, C.C., Jensen, C.E., "Waste Solidification Experience with Vinyl Ester Styrene at Diablo Canyon Power Plant," EPRI LLW Conference, Monterey, CA, 1993**.**

2. Miller, C.C., Jensen, C.E, et al., "Advanced Polymer Solidification (APS™) of Spent Ion Exchange Media and Activated Carbon" EPRI LLW Conference, Salt Lake City, UT, 2004**.**

3. Miller, C.C., Jensen, Werner C.E, et al., "In Situ Solidification and Encapsulation of Commercial Nuclear Power Plant, DOE and DOD wastes ," Waste Management Conference, Tucson, AZ 2007