Spent Filter Packaging for Long Term Storage and Disposal

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ABSTRACT

This paper will discuss filter packaging experience using spent filter transfer casks, a filter shear and the NUKEM macro-encapsulation process. Marco-encapsulation of spent filters in cement has provided sufficient shielding to enable filter containers to be shipped in less expensive IP-2 casks. The lower dose rate and higher density also off-sets disposal rates at Barnwell based on mass. No re-dewatering of encapsulated filter containers is required after a period of long term storage and encapsulation eliminates the possibility of gas generation from filters during storage. Encapsulation can be performed on filters loaded into poly HICs or carbon steel liners.

INTRODUCTION

Cartridge filters have long been difficult items to process. Filter handling is dose intensive and adversely impacts station exposure goals. Packaging spent filters is rarely efficient. Efforts to increase filter packaging efficiency typically increases HIC dose rates such that they require shipment in very expensive NRC Type B casks. Finally, in an anticipated era where B and C waste disposal is no longer available, storage of spent filters in a waste form suitable for long term storage and future disposal criteria also needs to be considered.

The Nuclear Regulatory Commission’s Topical Report waste form approval process ended in the mid 1990’s. The NUKEM cement Macro-encapsulation waste form for spent filters under went the extensive NRC Branch Technical Position (BTP) testing criteria but, the testing was performed by the Idaho National Engineering and Environment Laboratory (INEEL). A report on the test results was submitted by INEEL to the E-5 Committee of the Conference of Radiation Control Program Directors (CRCPD) for approval. The CRCPD is an organization of the individual states. The E-5 Committee includes representatives from the LLW disposal site host states of South Carolina, Washington, Utah, and Texas. The E-5 Committee approved the NUKEM cement Marco-encapsulation process as a method to provide a stable waste form.[1] Although there is no guarantees that Macroencapsulation will be approved for disposal stability at the next burial site that accept Class "B & C" waste, the E-5 committee endorsement provides a very strong case for acceptance.

DISCUSSION

High activity filters have always required special handling for transfer and container loading. Filter replacement may not be a frequent task. To limit exposure to personnel, each filter transfer evolution may require an extensive ALARA review and a dry run. Since stations are always on a quest to reduce personnel exposure, minimizing filter handling is desired.

Typically, spent filters have been loaded into a large HIC in a packaging shield, stored in metal drums for future consolidation or loaded into small drum overpack HICs. Some plants use filter transfer casks or bells to limit exposure while handling high activity filters. Plants that do not have filter transfer casks use long handle tools or radio control grapples to place filters into containers relying on speed to limit exposure.

Two options are normally available to the generator to disposition filters:

1. Delivery to an off-site processor for consolidation, possibly with other waste materials. The off-site processor is responsible for meeting disposal site acceptance criteria and they ship the waste for disposal.

2. Direct disposal. The plant loads the burial container and meets the disposal site acceptance criteria before shipping for disposal by:

    - Dewatering the container or

    - Macroencapsulating the filters in the container

Sending a large container of filters or several drum sized containers of filters to an off-site processor transfers much of the packaging burden and exposure to another entity. The plant is still required to make a shielded shipment to the waste processor. If a hot spot on the large HIC exceeds 1 R/hr at 3m, a Type B cask must be used. Shipping drums or drum sized HICs of filters to a processor requires manually loading the drums onto pallets and hoisting the pallets into the shipping cask. If any of these drums exceeds 1 R/hr at 3 m, a Type B cask must be used. When Class B/C disposal site access is available, passing the responsibility of filter packaging and disposition to an off-site processor may be the preferred choice even if it is not the least cost.

If filter packaging in the disposal container is preformed on-site, maximizing efficient use of the internal available volume of the container is key. Space constraints at several plants prevent them from staging a large HIC in a packaging shield for the collection of spent filters. These plants are forced to load filters into drums or small HICs. Several plants have found that using drum overpack HICs fitted with internal tubes provides equal or better packaging efficiency to dropping filters randomly into large (120 ft3) HICs.

Several stations have filter shears. The filter shear is placed over the port in the filter packaging shield lid. The filter shear is remotely operated and works in conjunction with a spent filter transfer cask. At Diablo Canyon filters range in size from 6" to 10" OD and are 17", 23" and 30" in height. Filters are cut into 3 or 4 pieces. A volume reduction of 3 to 4 is achieved versus random loading of whole filters into HICs. When more filters are loaded into a container dose rates will increase and may require shipping in a Type B cask versus a less expensive IP-2 shielded container.

Cement Macroencapsulation is a method to stabilize Class B/C filters which also greatly reduces the dose rate on the container. Macroencapsulation involves:

- An encapsulation container (poly HIC or steel liner) prefitted with an internal expanded cage (plastic for a poly HIC, steel mesh for a liner).
- Filters are loaded directly into the container or through the use of a filter shear, volume reduced to limit void space in the container
- Cement is provided by a ready mix truck to the plant, shuttled through the RCA in drums via fork lift and pumped by an air operated diaphragm pump into the container.

In addition to filters, activated metals, contaminated valves and parts can be encapsulated. Once the cage is full the container is solidified. Cement encapsulation provides great dose reduction. Typical dose rates at the fill port are reduced from 10-15 R/hr down to 1 to 2 R/hr.

In the table below, there are three packaging examples for sheared high activity filters. Current Barnwell burial costs, excluding Curie surcharges, are calculated for a 75 ft3 encapsulated HIC, an 88 ft3 encapsulated liner and a dewatered 120 ft3 HIC.[2]

Table 1: Comparison Table of Three Packages Containing High Activity Filters

	Macro Encapsulated HIC		Macro Encapsulate Steel		Dewatered HIC	
Liner Type	NUHIC 80B (30ft3 internal basket)		Steel (60ft3 internal basket)		HIC 120 Foamed (40ft3 internal	
Burial Volume (ft3):	75		88		120	
Number of filters:	93		93		93	
Filter form	Sheared and compacted		Sheared and compacted		Sheared and compacted	
Weight of Filters	342		342		342	
Weight of Container	450		1438		765	
Weight of Cement:	5308		6220		0	
Total Wt:	6100		8000		1107	
Activity:	21 Ci		60		60	
Rad Levels	8 R/r		3.5 R/hr		10 - 25 R/hr	
Dose Rate Multiplier:	1.32		1.22		1.37	
Density (lbs/ft3)	81.33		90.91		9.225	
Weight/Density Charge:	$5.623		$5.457		$44.100	
Total:		**$45,276**		**$53,260**		**$66,882**

Disposal for both of the encapsulated containers above points to a lower burial cost than the dewatered HIC (note that the curie content of the small HIC is less than the other two containers). The added mass of encapsulated containers yield a higher density and incur a much lower $/lb charge and dose rate surcharge versus dewatered filter HICs. A further cost savings for encapsulation is the ability to ship in an IP-2 shield rather than a Type B cask which would be required for the dewatered HIC with sheared filters. Since Type B casks require leak testing, additional labor and cask rental savings is also had by use of IP-2 shielded containers.

A critical item that is not directly reflected in the table above is that the steel encapsulation liner has the largest internal volume available. It is thought that up to 200 sheared filters can fit into the 60 ft3 cage of that container. Exposure is the only limiting factor in how many filters can be placed in this container. At Diablo Canyon, the number of filters loaded has been primarily limited by exposure. The filter shear has been used to fill six 88 ft3 liners and has loaded from 93 to 158 filters per container. The actual waste filter volume (annular volume) in the containers is consistently about 30 ft3. Exposure per filter loaded has been reduced over time at Diablo Canyon down to 2.6 mRem/filter.[3]

With the expected loss of Class B/C disposal, it is time to evaluate the disposition of filters for on-site storage. Experience has shown that waste containers placed in on-site storage may be susceptible to organic growth and the resulting gas generation. Storage of filters in a dewatered form risks gas generation. Condensation will accumulate inside HICs when water vapor, from high humidity environments, passes through passive vents and undergoes fluctuating temperature swings. This is caused by storage areas that are not climate controlled. Filters stored in HICs will have to be re-dewatered prior to disposal to remove condensation which will incur associated exposure.

Macroencapsulation of filters will mitigate gas generation be it from hydrolysis or bio-growth. The cement waste form yields a low dose rate container. This will reduce exposure from container inspections required over the course of long term storage. Cement encapsulation provides a problem free waste form for storage for an unlimited period of time.

Since it can take as long as two to three years to fill a HIC with filters, it may be prudent to start using large HICs with internal cages to collect filters. In this way, the large HIC could be sent to waste processors for consolidation with other waste. Should Barnwell access be lost before the HIC can be shipped, encapsulation could be conducted to provide a suitable waste form for long term storage.

Macro encapsulation could eliminate most of the Class B/C filter inventory in the USA if the State regulators of the LLW sites adhered strictly to NRC guidance and did not impose more stringent conditions. The NRC BTP on waste classification allows waste classification to include the mass and volume of stable solidification binders in addition to the waste itself.[4] The NRC BTP on Concentration Averaging and Encapsulation explicitly allows the activity of a filter to be averaged over the volume and mass of a stable encapsulation binder.[5] Appendix C of this BTP uses the historical filter packaging method of a single cartridge encapsulated in a drum with cement as the lower limit of packaging efficiency for concentration averaging. This packaging efficiency is taken to be 13 % (1 ft3 filter / 7.5 ft3 drum), and anything less is dilutions and not allowed.

Whether filters are encapsulated whole or sheared in large containers, the packaging efficiency will typically exceed the lower limit cited in Appendix C of the BTP. The NRC has agreed that encapsulation of filters in large containers is in compliance with Appendix C of the BTP in the last Topical Report they ever approved.[6] The NRC has noted, however, that the States have regulatory authority concerning waste forms and concentration averaging at their disposal facilities. As mentioned earlier, the E-5 Committee of the CRCPD has approved the NUKEM cement Marco-encapsulation process as a method to provide a stable waste form.

Since spent filters don't collect soluble Cs-137 their classification is usually controlled by C-14 or Ni63 nuclides. If the encapsulation binder is included in waste classification calculations for filters in large containers, these containers will be found to be Class A. Condition 31 of the Barnwell license only allows filter/radioactive source activity to be averaged over the volume of the filter (envelop volume)/source not the solidification agent.[7] When the Beatty, Nevada disposal site (for those of us who remember Beatty, Nevada) was open and accepting waste, their disposal criteria did not have this condition. There is no technical justification for this condition as regards cartridge filters. In fact, all the existing technical information indicates encapsulation of spent filters should be encouraged to better protect the biosphere. The activity on filters is particulate in nature. An encapsulation agent tested to provide stability will entomb particulate activity for 300 years. The EPRI reports 1000849 and 1003066 demonstrate that after 300 years, cement encapsulation of filters is the best waste form, reducing the release of C14 by a factor of 100 versus dewatered filters.

Currently the EnergySolutions disposal site license only recognizes Class A unstable waste. If Energy Solutions were to petition and if the State of Utah were to allow Class A Stable waste, most all of the "Barnwell" defined Class B/C filters, would become Class A per NRC guidance once encapsulated in a stable binder. Similarly if a new site in Texas or elsewhere were licensed to NRC 10 CFR 61 and the existing BTP's, most all spent filters would become Class A waste if they were encapsulated in a stable binder.

CONCLUSION

Encapsulation of filters is a standard practice out side the USA (e.g., Europe, Asia, India, South America). One cement encapsulation process has been approved as a stable waste form in the USA. A solidified waste form has several advantages for on-site storage versus dewatered waste. The use of filter shears can increase the waste loading of filter containers greatly reducing storage space requirements. Encapsulation of sheared filters reduces the dose rate on the filter container easing handling issues for on-site storage. Shearing and encapsulation can be conducted off-site if space constraints, head room limitations, exposure goals or staffing levels do not permit on-site packaging.

REFERENCES:

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