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Examples of Disposition Alternatives for WTP Solid Secondary Waste

Roger R. Seitz

April 2018

SRNL-STI-2017-00508, Revision 0

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Printed in the United States of America

Prepared for
U.S. Department of Energy

SRNL-STI-2017-00508
Revision 0

Keywords: *Radioactive Waste, Integrated Disposal Facility*

Retention: *Permanent*

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Prepared for the U.S. Department of Energy under contract number DE-AC09-08SR22470.

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REVIEWS AND APPROVALS

AUTHORS:

R. R. Seitz, Environmental Modeling Date

TECHNICAL REVIEW:

G. P. Flach, Environmental Modeling Date

C. A. Langton, Waste Form Processing Technologies Date

APPROVAL:

D. A. Crowley, Environmental Modeling Date

C. C. Herman, Director Date
Waste Form Processing Technologies

E. E. Brown, WRPS, CTO Date

Abstract

The Hanford Waste Treatment and Immobilization Plant is planned to produce a variety of solid secondary wastes that will require disposal at the Integrated Disposal Facility on the Hanford Site. Solid secondary wastes include a variety of waste streams that are a result of waste treatment and processing activities. Four of these solid secondary wastes have been identified for more detailed consideration to support the performance assessment for the Integrated Disposal Facility:

- Spherical Resorcinol-Formaldehyde Ion Exchange Resins
- High Efficiency Particulate Air Filters
- Carbon Adsorption Beds
- Silver Mordenite.

Baseline waste forms and disposal configurations have been established for these waste streams and served as the basis for the 2017 Integrated Disposal Facility performance assessment. Initial indications are that the waste forms will be sufficient to meet the performance objectives in DOE Manual 435.1-1 for the assumed waste inventories.

Savannah River National Laboratory is providing technical support to Washington River Protection Solutions to address solid secondary wastes. A testing program is underway to obtain material properties for the baseline waste forms to confirm assumptions that were made for the Integrated Disposal Facility performance assessment. The project is also considering waste form development and qualification, including identification of potential alternatives to the baseline waste form assumptions to optimize the overall waste management strategy or provide improved performance, if waste stream assumptions change in the future.

This report includes a high-level overview of potential cradle-to-grave operational considerations and examples of waste form, container and disposal alternatives, if there is a need to seek alternatives to the baseline assumptions. Cradle-to-grave waste management considerations that could offer areas for improved efficiency include:

1. Determining whether the waste requires treatment for hazardous characteristics (i.e., if the waste is demonstrated to not have hazardous characteristics, treatment may not be required),
2. Considerations related to the need for compaction of debris (i.e., if compaction is not necessary, that treatment step and the potential for increased concentrations in final waste forms can be avoided), and
3. General perspective regarding the ability to implement a “one-touch” philosophy for any solid secondary waste streams (i.e., the waste is placed in the final disposal configuration as soon as possible, rather than going through multiple treatment or processing steps where repeated exposure to the waste can occur).

Some examples of waste form and container alternatives for solid secondary wastes are provided. United States examples include potential alternative approaches to meet Resource Conservation and Recovery Act (RCRA) requirements. International examples used for the management of radioactive waste are also provided. The primary emphasis is placed on ion exchange resins with some emphasis on HEPA filters, because of the current level of interest in those waste streams for performance assessment and potential uncertainties.

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List of Acronyms

DbD	Different by Design
DWPF	Defense Waste Processing Facility
DOE	Department of Energy
HEPA	High-Efficiency Particulate Air
HIC	High Integrity Container
IAEA	International Atomic Energy Agency
IDF	Integrated Disposal Facility
ILAW	Immobilized low-activity waste
INL	Idaho National Laboratory
K_d	Distribution coefficient
LAW	Low-Activity Waste
LLW	Low-level waste
MCC	Modular Concrete Canisters
MLLW	Mixed Low-level Waste
NNSS	Nevada Nuclear Security Site
OPC	Ordinary Portland Cement
PA	Performance Assessment
PNNL	Pacific Northwest National Laboratory
RCRA	Resource Conservation and Recovery Act
sRF	Spherical Resorcinol Formaldehyde
SRNL	Savannah River National Laboratory
SSW	Solid Secondary Waste
WCS	Waste Control Specialists
WDOE	Washington Department of Ecology
WRPS	Washington River Protection Solutions
WTP	Hanford Tank Waste Treatment and Immobilization Plant

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1.0 Introduction

Four key solid secondary waste (SSW) streams from the Hanford Tank Waste Treatment and Immobilization Plant (WTP) have been identified for more detailed consideration to support the performance assessment (PA) for the Integrated Disposal Facility (IDF) at the US Department of Energy (DOE) Hanford site (Flach et al. 2016):

- Spherical Resorcinol-Formaldehyde (sRF) Ion Exchange Resins
- High Efficiency Particulate Air (HEPA) Filters
- Carbon Adsorption Beds
- Silver Mordenite (Ag-Mordenite).

The waste streams were selected based on the concentrations/inventories of key contaminants that were deemed to have the potential to influence the conclusions of the 2017 IDF PA (Lee et al. 2018). Savannah River National Laboratory (SRNL) served as the lead for efforts related to SSW support for the IDF PA and was tasked with developing data packages used as the basis for assumptions in the IDF PA (Flach et al. 2016 and Nichols et al. 2017). SRNL is also tasked with providing recommendations for cradle-to-grave management of SSW. This includes providing examples of management practices for these waste streams with a view towards identifying potential options for waste forms/containers that may be considered based on the initial results of the 2017 IDF PA. Initial PA results suggest that, for current assumed radionuclide inventories, the baseline waste forms and disposal plans are sufficient to meet the performance objectives in DOE Manual 435.1-1. Thus, this report does not imply a need for alternatives, but is intended to provide potential options for consideration should further optimization of the management of SSW be desired (e.g., cost effectiveness, different waste loading).

SRNL (Langton 2016) has recently provided information on the design and evaluation of cementitious waste forms. Previously, Pacific Northwest National Laboratory (PNNL) also developed reports (Pierce et al. 2010 and Valenta et al. 2010) that described potential options for stabilization of SSW. This report supplements information provided in the SRNL and PNNL reports with some recent information and a focus on practices that are being or have been deployed. Although not deemed necessary at this time, such alternatives may prove useful for optimizing the management of SSW.

The SSW work scope to date has focused largely on documentation of existing information and initial testing of the assumed SSW forms from the IDF PA. This report is an initial effort to consider potential alternatives to the IDF PA baseline waste forms and introduce potential alternatives related to cradle-to-grave management of waste. This report includes a brief, high-level summary of operational considerations followed by potential alternatives for specific SSW with references for obtaining information that is more detailed. The emphasis is on examples from the United States, but some international examples are also included for global perspective. Different by Design Ltd (DbD – Brown et al. 2017) developed a detailed description of SSW management practices in the United Kingdom and provided added examples from other countries. The emphasis of this report is on HEPA filters and sRF ion exchange resins based on the significance and uncertainties in draft results from the 2017 IDF PA. Depending on the results of the final IDF PA, additional detail can be developed if other SSW are deemed to be a significant contributor to the PA conclusions.

2.0 Cradle-to-Grave Considerations

The initial focus of the IDF PA is based on assumed disposal approaches for SSW. Depending on the results and conclusions of the final IDF PA, there may be a need for improved waste forms or an opportunity for potential changes in the disposal approach to optimize operations while still meeting the objectives of the PA. When considering optimization, the complete path from waste generation to final waste disposal (cradle-to-grave) should be addressed. This section provides some potential areas for consideration in the context of efficiency of operations.

A key consideration that influences disposal options is whether a given waste stream is considered hazardous/mixed waste. It is currently assumed that the key SSW are considered hazardous, which leads to constraints for disposal practices. Table 1 includes a summary of the key SSW streams based on the IDF PA and information submitted to the Washington State Department of Ecology[1]. LLW and Mixed LLW are not currently approved for off-site disposal, but off-site options are included for completeness (Nevada National Security Site (NNSS), Federal Waste Facility (Waste Control Specialists), and Energy*Solutions* Clive Facility). Off-site disposal may provide for other, more efficient treatment/stabilization options consistent with the waste acceptance criteria and favorable disposal conditions at each facility. Note that the term, stabilization, is used in the correspondence, falls under the RCRA category of microencapsulation[2]. High Integrity Containers (HICs) are commonly used for LLW and provide a similar function to microencapsulation, but would need to be specifically approved for use for disposal of Mixed LLW.

Table 1. Key Solid Secondary Waste Streams for IDF Performance Assessment

Waste Stream	**Debris/ Non-Debris**	**Contaminants of Potential Concern***	**Treatment Options**	**Disposal****
sRF Resin	Non-Debris	Chromium, Lead, ^{99}Tc, ^{129}I, F-listed constituents	Stabilization for radionuclides and RCRA constituents	Hanford, NNSS, Federal Waste Facility
HEPA Filters	Debris	Chromium, Lead, ^{99}Tc, ^{129}I, F-listed constituents	Volume reduction, Macroencapsulation	Hanford, NNSS, Federal Waste Facility, Clive Facility
Carbon Bed Adsorber Media	Non-Debris	Mercury, organics, ^{129}I, F-listed constituents	Thermal treatment for organics and Stabilization of mercury and radionuclides	Hanford, NNSS, Clive Facility
Silver Mordenite Media	Non-Debris	Silver, ^{129}I, F-listed constituents	Volume reduction, Macroencapsulation or Stabilization	Hanford, NNSS, Federal Waste Facility, Clive Facility

* Additional detail regarding assumed contaminant inventories is provided in Prindiville (2016).
**Note that off-site disposal is included for completeness, but is not approved at this time.

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[1] Letter from K. Smith to J. Hedges, "Updated Evaluation of Waste Treatment and Immobilization Plant Secondary Dangerous Waste Treatment and Disposal For 2015 Dangerous Waste Permit Submittal," 15-ECD-0054, November 19, 2015.

[2] Treatment standards are described in 40 CFR Part 258.45. Microencapsulation (i.e., stabilization to reduce leachability) and macroencapsulation (i.e., completely surround debris with a jacket of inorganic material) are formally defined in Table 1 of that section of the regulation.

In the IDF PA, HEPA filters are assumed to require macroencapsulation and it is assumed that the non-debris waste streams are required to be blended and solidified with a grout (stabilized/immobilized). Commitments from DOE to the State of Washington include a provision where silver mordenite may be macroencapsulated[1]. If a waste stream is demonstrated to be non-hazardous (e.g., using TCLP), then additional options for disposal can be made available. This is a critical decision point in the management of SSW.

From a worker protection perspective, the concept of a “one touch” philosophy is advocated in the DOE complex, where the number of times waste is handled and total time workers are potentially exposed to a waste stream is minimized. This concept leads to considering options where the waste is placed in its disposal configuration when it is generated to avoid reopening containers and working with a waste more than once. For wastes that are not considered hazardous, and may not require treatment, this is an option that can reasonably be considered from the perspective of limiting exposures as well as cost savings and efficiency. In this case, the containers used at WTP could be selected to meet the disposal requirements at IDF. This would remove interim steps to treat wastes and then transfer wastes from one container to another.

In the case of debris that may be compacted, the benefits of volume reduction relative to costs and potential exposures associated with the added treatment step may also be considered. For relatively small volume waste streams, the benefits of compaction in terms of volume reduction relative to the capacity of the disposal facility can be compared with the costs of treatment and the potential increases in concentrations in the final waste form. It may be beneficial for smaller volume waste streams to choose to not compact the waste and avoid increases in concentrations in any given container that will result.

There may also be opportunities for improvements by considering the need to separate liquid and solid waste streams. A potential option (e.g., Brown et al. 2017) that may result in some efficiencies could involve the use of liquid waste grout as the macroencapsulation or stabilization/immobilization media for SSW. It is not clear whether this would be consistent with regulatory requirements for treatment, but given the relatively small amounts of SSW planned for disposal, there may be some advantages to considering this approach rather than potentially having separate processing for SSW and other grouted waste streams. Such an approach would be in the spirit of waste minimization as well. Factors such as compatibility of the liquid and solid wastes and the composition of the grouted liquid wastes relative to performance requirements for the SSW would need to be addressed.

A key consideration during the SRNL testing program (Flach et al. 2016, Nichols et al. 2017) has been to provide information to support flexibility in operations for treatment and packaging of waste forms. To this end, the testing program includes consideration of variations in the ratios of dry materials and water for grouted waste streams. The intent is to provide information to support development of specifications that are not overly restrictive for the acceptable ratios that will meet the performance requirements. Each of the following chapters provide some specific examples of disposition options for individual SSW streams.

3.0 Ion Exchange Resins

The sRF resins to be disposed at IDF are unusual compared to typical resins disposed as LLW in the United States because of the expected presence of hazardous constituents in the tanks wastes that are being processed at the WTP. For power plants and typical operating facilities, there is generally not a concern about hazardous constituents in the resin, so the resins are often disposed in HICs as LLW that does not require stabilization. SRNL conducted studies using simulated Hanford tank wastes to evaluate the loading of Resource Conservation and Recovery Act (RCRA) metals in sRF resin (Nash and Dowley 2007). The assumed presence of hazardous constituents in the sRF resins to be disposed at IDF leads to the need to consider treatment. From a RCRA perspective, spent ion exchange resins are considered a "non-debris" waste stream that would be managed with microencapsulation/stabilization. The potential for swelling/shrinkage of sRF resins is an important consideration when selectinging stabilization approaches and also highlights a potential benefit of considering macroencapsulation for ion exchange resins.

Two PNNL reports issued in 2010 (Pierce et al. 2010 and Valenta et al. 2010) included a brief discussion of common practices for management of ion-exchange resins. The two reports indicated that "the Class C dewatered spent resins within HICs are placed within concrete boxes to provide structural support after burial" (i.e., no stabilization within the HIC or concrete boxes). The reports also referred to an Idaho National Laboratory (INL) report by Herbst (2002) that concluded: "the best option for disposing of spent ion-exchange resins generated as a secondary waste stream from vitrification of sodium-bearing waste from the Idaho Nuclear Technology and Engineering Center was dewatering, placement in HICs, and disposal in shallow-land burial facilities." Pierce et al. (2010) also concluded that "direct disposal in either steel canisters or HICs that are placed within concrete boxes is a suitable disposal path."

During development of this report, discussions were held with personnel from PermaFix Northwest and the Energy Solutions Bear Creek facility. These discussions confirmed that a common approach for disposal of non-hazardous organic resins is dewatering (i.e., draining and/or vacuuming excess free liquids in the container) and disposal in structurally reinforced containers and/or vaults without stabilization[3]. Examples of disposal "vaults" for NRC Class B and C LLW at the Barnwell disposal facility and modular concrete canisters (MCC) used at the Waste Control Specialists (WCS) disposal facility are shown in Figure 1. Thermal treatment can also be an option for organic resins (e.g., THOR process).

Figure 1. Disposal vaults at the Barnwell disposal facility (left) and a collage of photos of one type of MCC, including grout fill, used at the WCS disposal facility (Barnwell and WCS photos).

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[3] Joe Heckman at the Energy Solutions Bear Creek Facility and Richard Grondin of PermaFix Northwest were contacted to provide perspective on current approaches in the United States.

Representatives from several DOE sites were also contacted for information on management of spent resins and the general conclusion was that spent resins were dewatered and typically disposed without stabilization. The Nevada Nuclear Security Site (NNSS) indicated that it is common to include a layer of absorbent in containers with spent resins to address any potential accumulation of moisture during transport. The INL Site currently dewaters spent resins from operations of the Advanced Test Reactor and other activities and packages them in carbon steel liners for disposal at the NNSS. An example of a resin liner used at the INL site is shown in Figure 2.

Figure 2. Liners used for disposal of spent resins from the Advanced Test Reactor at the Idaho National Laboratory Site (~6 m^3 of resin per liner) (DOE Photo).

Alternative processes are available in the United States for LLW that may not meet treatment requirements for RCRA. Energy Solutions has a process to steam reform ion-exchange resins providing for volume reduction and a stable waste form (THOR process). The THOR process is illustrated in Figure 3. Based on documentation from 2012 (see weblink in caption for Figure 3), over 350,000 ft^3 of resins have been processed in this manner prior to disposal as NRC Class A waste. The potential use of the AQUASET and PETROSET families of stabilization agents for resin immobilization has also been discussed.

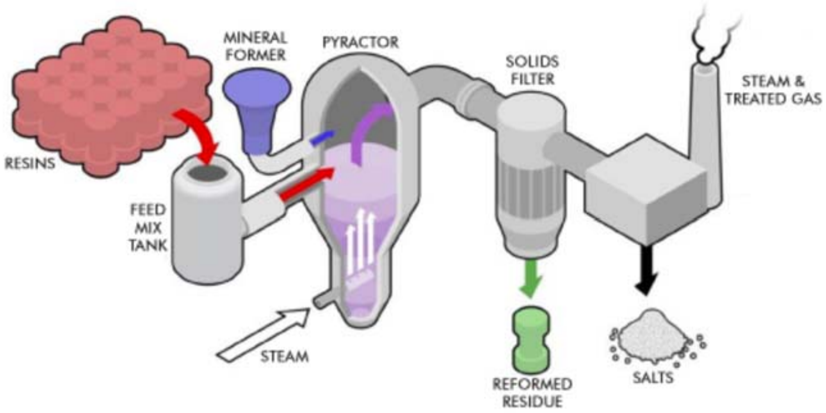


Figure 3. THOR technology for processing spent ion-exchange resins (Figure from http://ndreport.com/semprasafe-an-innovative-solution-for-spent-ion-exchange-resins/).

The use of polymers for stabilization in the United States has been described in Jensen (2007a and 2007b). For example, Jensen (2007a) summarizes Diversified Technologies Services, Inc. (DTS) use of Vinyl Ester Styrene (VES) and Advanced Polymer Solidification (APS^{TM}) processes for *in situ* immobilization of ion exchange resin and carbon filter media in decommissioned submarines and immobilization of mercury, lead and other hazardous wastes as well as other applications. Jensen describes additional details for the process and applications. Jensen (2007b) includes more specifics related to the application of APS^{TM} for management of ion-exchange resins.

From an international perspective, the International Atomic Energy Agency (IAEA) published a report addressing management of ion exchange resins with details for a variety of immobilization approaches (IAEA 2002). Table 2 is a summary of immobilization approaches from the IAEA report. More recently, the IAEA also published the results of a Coordinated Research Program on the use of cementitious materials for storage and disposal of radioactive waste (IAEA 2013). The report from that project provides several detailed examples, including applications for spent ion exchange resins from Belgium, China, Finland, Russian Federation, and Sweden. Examples were provided from the Czech Republic considering a variety of cementitious and polymer based media for stabilization of spent resins.

Valenta et al. (2010) and Pierce et al. (2010) described the use of “a new type of cement, ASC, with higher aluminum and sulfur oxide content, less silicon and calcium oxides, and a mixture of zeolites” for resin solidification in China. It was noted in the two reports that the zeolite helps in sequestering radionuclides like Cs-137 that desorb from the resins during cement hydration reactions.

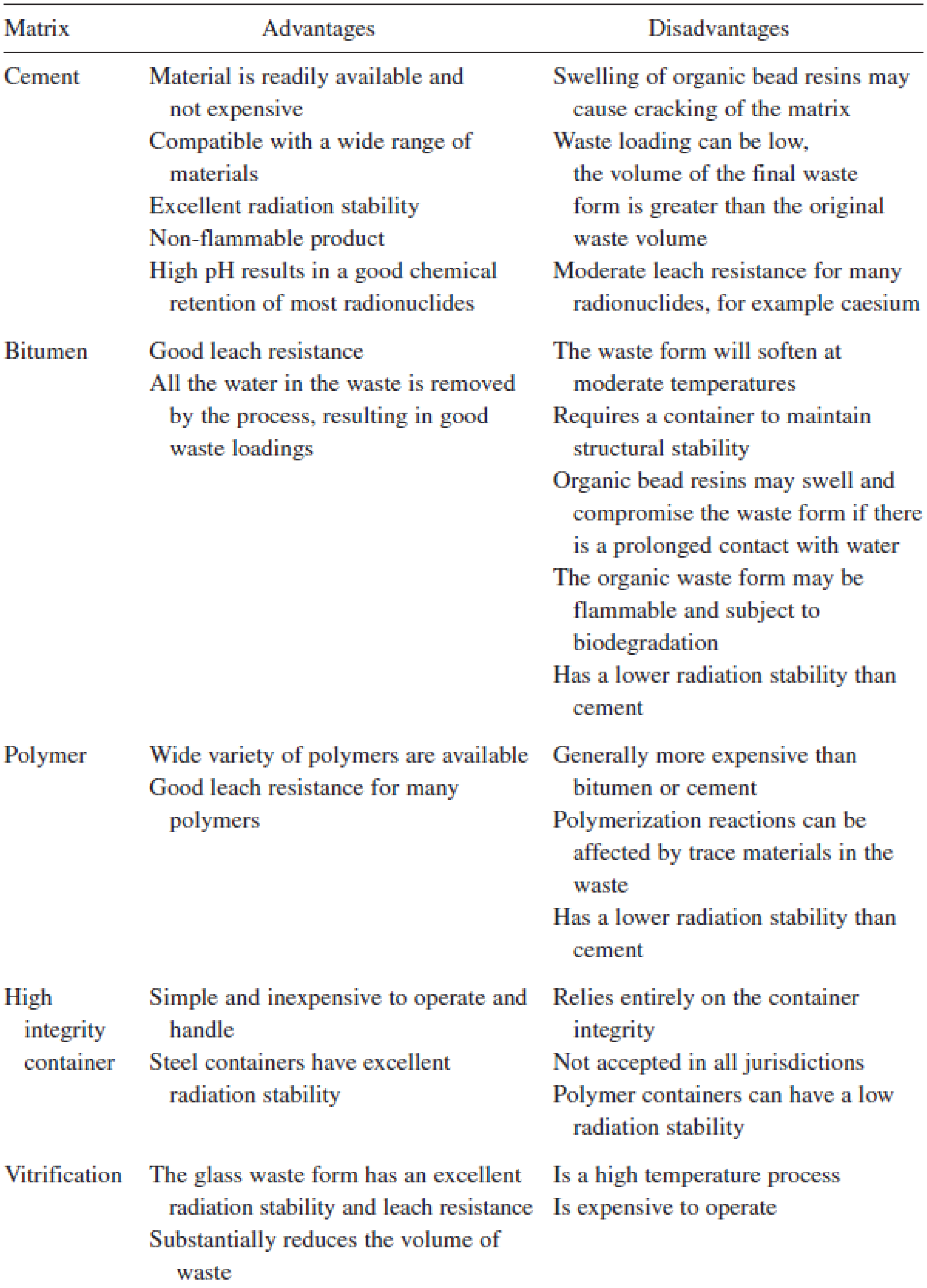
The UK Radioactive Waste Management agency has published guidance on the use of geopolymers for waste solidification and stabilization, including challenges and limitations (UK RWM 2015). The guidance includes a wide variety of potential stabilization media in addition to geopolymers. However, the exent of actual application is not clear. A specific example is also included in the guidance where a French company, Socodei, currently uses epoxy resin to stabilize ion-exchange resins. The process is illustrated in Figure 4. An example of the use of vinyl ester resin for stabilization of ion exchange resins in the UK was also provided.

Examples of the use of polymers and cementitious materials, respectively, for stabilization of spent ion exchange resins in France are provided in a report from ANDRA (2015). Notably, most wastes are disposed in robust concrete containers. Three different concepts were described, but the specific resins were not identified (see Figure 5):

1. Coating of ion exchange resin in an epoxy polymer and disposal in a concrete container,
2. Pretreatment of ion exchange resins to avoid reactions with cementitious material followed by blending with a cementitious material and placement in a steel drum for disposal, and
3. Coating of ion exchange resins in a polymerizable epoxy resin with an added hardener and placement in a steel container (excess voids from the process are filled with a cementitious material).

In the ANDRA report, it was noted that the third approach (polymerizable epoxy resin) was last used in 2003. After that time, the resins were solidified in cementitious material and disposed in drums and in some cases the drums were repacked into boxes. Currently, the third type of resin is sent for incineration (volume reduction). Lafond et al. (2013) provide a description of considerations related to addressing the potential for swelling of ion exchange resins, if a cementitious material is being considered for solidification. The potential for swelling of resins has been an emphasis of the SRNL testing program (Nichols et al. 2017). Note that use of an alternative resin (e.g., non-elutable) provides the opportunity to avoid concerns about swelling.

Table 2. IAEA Summary Comparison of Immobilization Processes for Spent Resins (IAEA 2002).



Matrix	Advantages	Disadvantages
Cement	Material is readily available and not expensive Compatible with a wide range of materials Excellent radiation stability Non-flammable product High pH results in a good chemical retention of most radionuclides	Swelling of organic bead resins may cause cracking of the matrix Waste loading can be low, the volume of the final waste form is greater than the original waste volume Moderate leach resistance for many radionuclides, for example caesium
Bitumen	Good leach resistance All the water in the waste is removed by the process, resulting in good waste loadings	The waste form will soften at moderate temperatures Requires a container to maintain structural stability Organic bead resins may swell and compromise the waste form if there is a prolonged contact with water The organic waste form may be flammable and subject to biodegradation Has a lower radiation stability than cement
Polymer	Wide variety of polymers are available Good leach resistance for many polymers	Generally more expensive than bitumen or cement Polymerization reactions can be affected by trace materials in the waste Has a lower radiation stability than cement
High integrity container	Simple and inexpensive to operate and handle Steel containers have excellent radiation stability	Relies entirely on the container integrity Not accepted in all jurisdictions Polymer containers can have a low radiation stability
Vitrification	The glass waste form has an excellent radiation stability and leach resistance Substantially reduces the volume of waste	Is a high temperature process Is expensive to operate

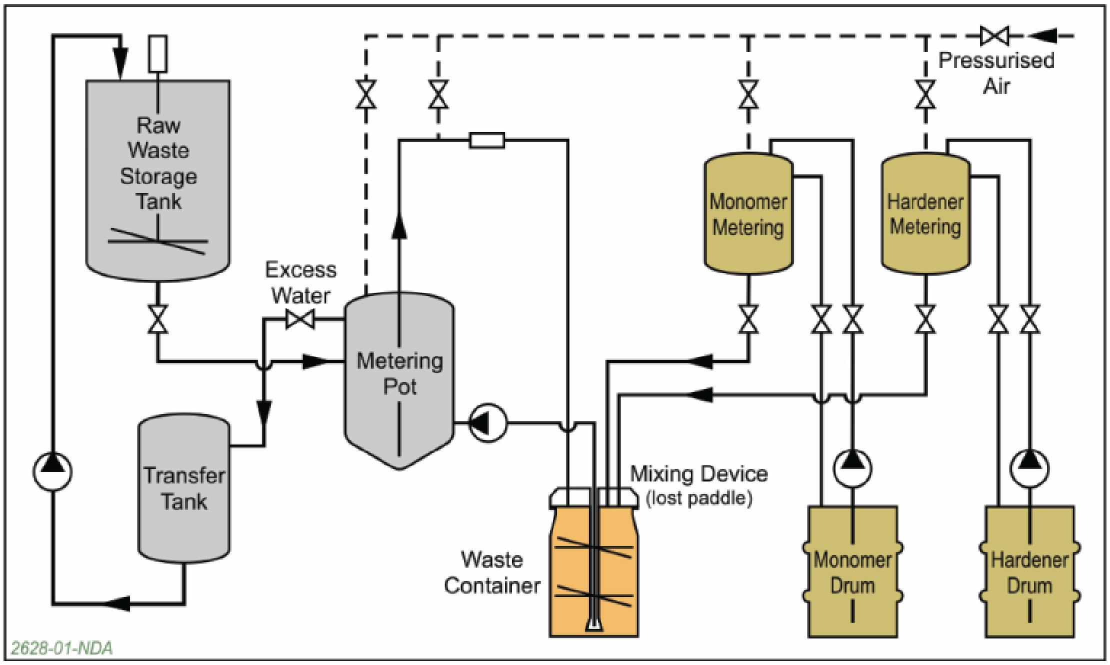


Figure 4. Schematic of Socodei epoxy resin immobilization process (UK RWM 2015).

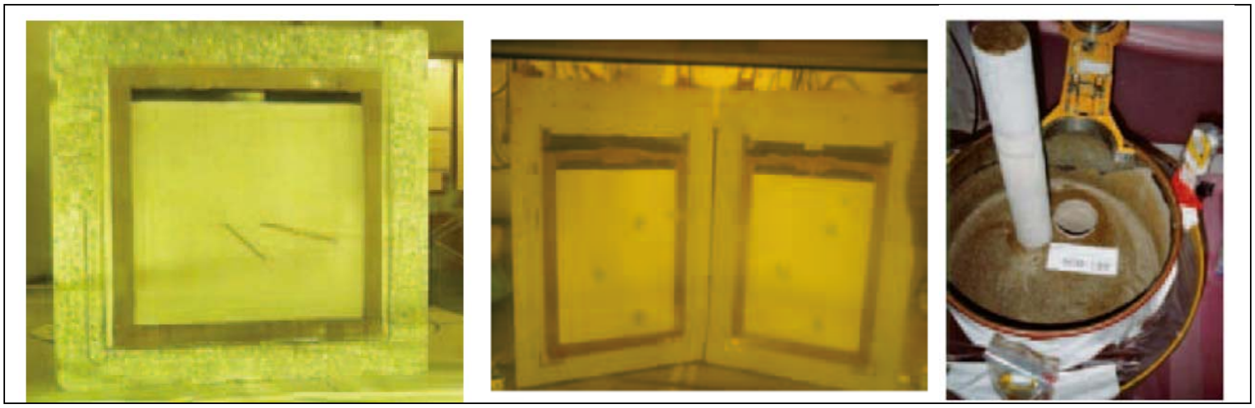


Figure 5. Examples of resin solidification in France (ANDRA 2015). (From left to right: cross-section of epoxy polymer solidification of resin in a concrete container, cross-section of cementitious solidification of ion exchange resins in a concrete container, and extraction of a core from epoxy solidified ion exchange resin in a steel drum).

4.0 HEPA Filters

High-efficiency particulate air (HEPA) filters will be used at the WTP to remove contaminants from gas systems prior to venting. Prindiville (2016) indicates that the filters that would have the highest loading of key contaminants are the radial flow design rather than more typical rectangular filters. Giffen et al. (2011) provide examples of radial flow filters. Figure 6, from Giffen et al. (2011), includes examples of different annular filters. HEPA filters are considered “debris” under RCRA and the WTP HEPA filters are currently considered MLLW. Thus, macroencapsulation is assumed to be required at the current time.

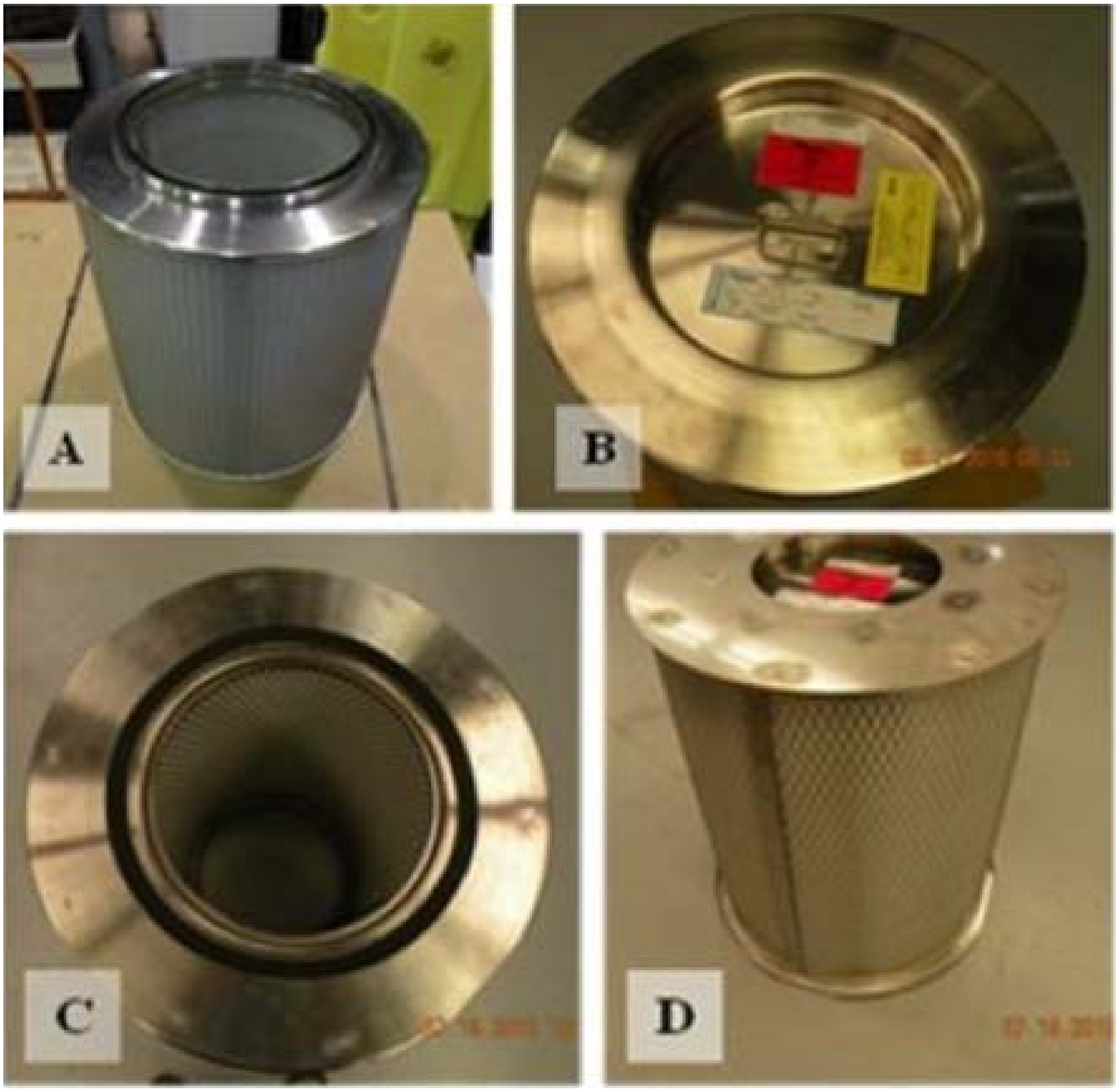


Figure 6. Examples of radial flow HEPA filters (A: Safe Change Filter Top, B: Safe Change Filter bottom, C: Remote Change Filter Top, D: Remote Change Filter Bottom). (Giffen et al. 2011)

Waste management personnel at Oak Ridge, Idaho, Savannah River Site, NNSS and Hanford were queried regarding disposal of HEPA filters and the general response was that HEPA filters typically managed are not a mixed LLW and are simply included with other LLW. HEPA filters from the Defense Waste Processing Facility (DWPF) at the Savannah River Site are mixed LLW due to Hg and are dissolved in the DWPF recycle tank and sent back to the tank farm for eventual treatment in DWPF. NNSS personnel noted that there are containers available that meet the requirements of macroencapsulation for mixed LLW debris[4]. Options for containers that qualify for macroencapsulation include liner-based containment systems from UltraTech[5] and MacroBag containment[6] from PacTec. Figure 7 is an example of the UltraTech system for disposal of drums of waste. The system includes an inner liner for encapsulation within a standard disposal container and voids are filled after loading (e.g., with foam or vermiculite). Figure 8 illustrates the MacroBag concept from PacTec, which provides flexible containers for Mixed LLW. These flexible containers provide external encapsulation and can be used over standard containers.

Figure 7. UltraTech macroencapsulation system where drums are placed in a liner within a steel container (http://www.spillcontainment.com/products/macroencapsulation/).

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[4] Discussion with Susan Krenzien from Navarro contracted to the Department of Energy, NNSA, Field Office.

[5] http://www.spillcontainment.com/products/macroencapsulation/

[6] http://www.pactecinc.com/products/llmw-flexible-packaging

Figure 8 Example of PacTec MacroBag approach applied for macroencapsulation of Mixed LLW (http://www.pactecinc.com/products/llmw-flexible-packaging)

Discussions with representatives from commercial treatment facilities indicated that the preferred approach for HEPA filters that are mixed LLW would be supercompaction to reduce the volume followed by macroencapsulation in a cementitious material in a standard disposal container. Figure 9 shows an example of supercompacted drums of waste (pucks) encapsulated in a cementitious material within a larger drum. As discussed in Chapter 2, supercompaction also increases the concentration, which needs to be considered in terms of waste loading. This approach was indicated to be preferable to alternatives that would potentially require additional sampling and testing as well as regulatory approvals. Other macroencapsulation media have been considered for commercial, DOE and defense applications. For example, Jensen (2007a) describes a test case for solidification of an annular filter using a polymer (see Figure 10).

Figure 9 Example of supercompacted drums encapsulated in a larger drum (UK AEA Photo).

Jensen (2007b) also describes an approach where filter media are mixed with resin and encapsulated. Jensen (2007b) stated that APS™ solidification of LLW, 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 using a centering 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. It is not clear if this approach is approved for mixed LLW.

Figure 10 Example of polymer solidification of an annual filter (Jensen 2007a). (Clockwise from upper left – untreated filter, solidified filter in disposal container, and cross-section of solidified disposal container that was cut in half illustrated full penetration.)

ANDRA (2015) includes an example of debris disposal, including filter media, that involves placement of debris into a robust concrete container and filling of voids with a cementitious material. Depending on the type of waste, the debris may be placed in a cage to help optimize the filling of voids. The UK RWM (2015) also cited the use of bitumen and epoxy resin as potential solidification media for filters. These approaches would have to be approved for use with mixed LLW in the United States.

5.0 Activated Carbon Beds

SSW inventory data from the Hanford Tank Waste Operations Simulator indicates that the Low-Activity Waste (LAW) Melter spent carbon adsorber beds and Ag-mordenite (see Chapter 6) are major contributors of ^{129}I (Prindiville 2016). The carbon adsorber beds are part of the LAW off-gas treatment system and contain activated carbon for Hg and halide (Cl and F) removal as well as ^{129}I abatement. Carbon adsorber beds also are currently assumed to be non-debris MLLW containing potentially problematic amounts of Hg, ^{129}I and organics. Thus, the waste would require stabilization. Thermal treatment is also considered to address the presence of organics.

Pierce et al. (2010) indicated that several options appear suitable for disposal of WTP‘s mercury-containing activated carbon waste. These options are direct disposal without treatment, solidification/stabilization in Portland cement, encapsulation in chemically bonded phosphate ceramic, or disposal after incineration (if possible based on facility permits). Macroencapsulation may also be an effective and efficient option (e.g., Figures 7 and 8), but would require approvals from the regulators. Flach et al. (2016) references studies that provide a basis for the use of a relatively large K_d for iodine release from the carbon beds reflecting the designed intent of the carbon adsorber bed to retain iodine. Activated carbon was shown to perform well over the range of K_d values assumed in the IDF PA. However, there is some uncertainty regarding the performance of activated carbon when mixed in a grout material, which highlights the potential benefits of pursuing other treatment approaches.

In discussions with PermaFix Northwest and Energy Solutions Bear Creek, potential concerns with stabilization were identified if there are significant organics retained in the carbon beds. Thus, there may be a need to drive off organics before stabilization. This is one factor that needs to be considered as the waste form is identified. Incineration is a potential option for treatment prior to disposal, however, there may be limitations related to iodine releases in the current permits for treatment facilities. Thermal treatment also seems to contradict the original purpose of the carbon beds to capture iodine from off-gas.

ANDRA (2015) provided an example for the disposal of “iodine traps” (carbon beds) in France. A steel container is used, that is designed to contain 16 iodine traps with space provided for injection of a cementitious material to fill void spaces. The iodine traps are disposed as very low-level waste in the French classification system. Figure 12 is a schematic of the container used for disposal of “iodine traps.” The containers are roughly 5 m^3 and are designed to contain roughly 4 m^3 of waste. The figure shows the outer container with the traps in a frame surrounded by a cementitious material inside the container.

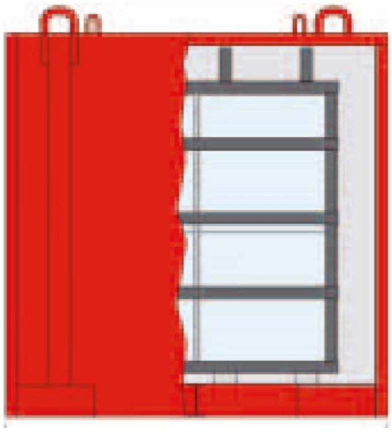

Figure 11. Container for disposal of “iodine traps” (carbon beds) in France (ANDRA 2015).

6.0 Silver Mordenite

Silver impregnated adsorbers (e.g., Ag-mordenite) are designed to capture iodine from off gas systems, and thus, are one of the primary sources of iodine in the IDF disposal inventory. The Ag-mordenite waste stream is inherently hazardous due to the use of silver and is assumed to be non-debris MLLW similar to the carbon adsorber beds. Ag-mordenite may include problematic concentrations of Hg and ^{129}I in addition to silver.

Pierce et al. (2010) provided numerous references and examples of approaches for stabilization of Ag-mordenite, including: direct disposal in a container, immobilization in cementitious material, immobilization in a CaI_2 modified cementitious material as well as other waste forms. Notably, silver proved to be the RCRA constituent of concern for the leaching tests to meet RCRA requirements for Ag-mordenite. Scheele and Wend (2015) evaluated options for solidification and stabilization of Ag-mordenite and concluded that a blend of 65 mass% ASTM Portland Type III cement, 25 mass% Ag-mordenite waste, and 10 mass% CaI_2 sufficiently addressed leaching of Ag and would yield a compliant disposal waste form.

Flach et al. (2016) also references studies that provide a basis for the use of a relatively large K_d for iodine release from the Ag-mordenite reflecting the designed intent of the carbon adsorber bed to retain iodine. Ag-mordenite was shown to perform well over the range of K_d values assumed in the IDF PA, although there is some uncertainty regarding the release of iodine from Ag-mordenite when mixed in a grout material.

7.0 Summary and Conclusion

The IDF PA was conducted using baseline assumptions for waste forms and disposal of SSW streams. Based on the initial PA results and assumed radionuclide inventories, the baseline will be sufficient to meet the performance objectives of DOE Manual 435.1-1. This report does not imply a need for alternatives, but is intended to provide potential options for consideration should further optimization of the management of SSW be desired.

This report includes a high-level overview of potential operational considerations and waste forms, containers and disposal practices for key SSW associated with the IDF PA. References were provided for more detailed information. The primary emphasis was placed on ion exchange resins with some emphasis on HEPA filters, because of the current level of interest for the IDF PA. Two other key SSW were also briefly discussed (Ag-mordenite and Activated carbon beds). A variety of different approaches have been used in the United States and internationally for management of solid secondary wastes that could be considered for use at the Hanford Site depending on regulatory approvals. This report provided potential alternatives that may be considered from the perspective of optimization of the waste management system or if assumptions regarding any of the waste streams were to change such that improved performance may be needed.

Some cradle-to-grave considerations were also introduced. The baseline SSW forms for the current IDF PA are based on the assumption that the SSW streams would require treatment to address hazardous characteristics. If individual waste streams can be shown to not require treatment, this would open up options to optimize cradle-to-grave management of those wastes. Treatment approaches have been identified by DOE to the WDOE under the assumption that treatment would be required. If testing can be conducted to demonstrate that treatment would not be required or agreements can be reached with WDOE, then different management alternatives could be available.

DOE generally recommends a “one-touch” philosophy for waste management where worker exposure to the waste is minimized by trying to place the waste in a final disposal configuration as early in the process as possible. Such an approach can also be more cost-effective. For example, it is worth considering for wastes not requiring treatment that there may be the potential to have the operating facility place the waste directly in containers destined for disposal. Examples of this were provided in this report. Likewise, the potential volume reduction benefits of compaction of selected debris waste streams can also be evaluated against the costs of treatment and potential worker exposure as well as meeting PA requirements with increased concentrations after compaction.

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Distribution:

timothy.brown@srnl.doe.gov
alex.cozzi@srnl.doe.gov
david.crowley@srnl.doe.gov
David.Dooley@srnl.doe.gov
a.fellinger@srnl.doe.gov
samuel.fink@srnl.doe.gov
Gregory.flach@srnl.doe.gov
nancy.halverson@srnl.doe.gov
erich.hansen@srnl.doe.gov
connie.herman@srnl.doe.gov
david.herman@srnl.doe.gov
Kevin.Fox@srnl.doe.gov
Christine.langton@srnl.doe.gov
john.mayer@srnl.doe.gov
daniel.mccabe@srnl.doe.gov
Gregg.Morgan@srnl.doe.gov
Ralph.nichols@srnl.doe.gov
frank.pennebaker@srnl.doe.gov
William.Ramsey@SRNL.DOE.gov
luke.reid@srnl.doe.gov
geoffrey.smoland@srnl.doe.gov
michael.stone@srnl.doe.gov
Boyd.Wiedenman@srnl.doe.gov
bill.wilmarth@srnl.doe.gov
Records Administration (EDWS)
Anthony.Howe@srnl.doe.gov
erich.hansen@srnl.doe.gov
Kevin.Fox@srnl.doe.gov
Christine.langton@srnl.doe.gov
Carol.jantzen@srnl.doe.gov
daniel.mccabe@srnl.doe.gov
david.herman@srnl.doe.gov
michael.stone@srnl.doe.gov
mhope.lee@srnl.doe.gov
naomi.jaschke@orp.doe.gov
michael.poirier@srnl.doe.gov
Amy.Ramsey@srnl.doe.gov
Elaine_N_Diaz@orp.doe.gov
David_j_swanberg@rl.gov
Elvie_Brown@rl.gov
Gary.pyles@orp.doe.gov