ADVANCES IN THE DISPOSAL

OF RADIOACTIVE ION EXCHANGE RESINS

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ABSTRACT

During the last several years, more stringent regulations have been imposed on the disposal of low-level radioactive wastes. In particular, the disposal of high-activity ion exchange resins has been affected by the recent requirements intended to enhance waste stability. High-activity resins must now be either solidified or placed in a "high-integrity" container. The allowable levels of free liquids in the containers have also been reduced.

Solidification of resins has long been applied at nuclear power stations, but new designs in high-integrity containers and dewatering techniques to enhance the waste stability and ensure regulatory compliance have been developed and are being introduced for use at power stations.

REGULATORY REQUIREMENTS

During the last several years, regulatory agencies have moved to enhance the stability of concentrated (high-radioactivity) waste forms. Ion exchange resins, which are used extensively in purifying reactor coolant and radwaste waters, are one of the primary concentrators of radioactive material at nuclear power stations. Resin activities are typically 0.1 to 10 microcuries/cc for resins used in waste processing and may exceed 500 microcuries/cc in reactor coolant purification at a typical PWR. With the rapid rise in radwaste disposal prices, the use of ion exchange in processing radwaste waters is growing and replacing less efficient evaporation as the preferred method in waste processing. Hence, contaminated ion exchange resins will become an increasingly higher percentage of the waste volume which must be disposed of.

The State of South Carolina assumed the lead in developing regulations to ensure that migration of radionuclides from high-activity resins is minimized.[1] The State approached the enhancement of waste stability through the following methods:

- Solidification of high-activity resins;
- Improvement in the integrity of the waste container;
- Reduction in the amount of "free liquid" in the waste package.

By encapsulating radioactive ion exchange resins by solidification, there is less chance for the resins to be physically washed from the burial site. In addition, the surface area for contact of ground water with the resins is greatly reduced, thereby reducing the potential for exchange of radionuclides on the resin with naturally occurring minerals in the ground water. There has been concern, however, over the "regeneration" of ion exchange resins during the solidification process and the resulting dispersal of the radioactive material from the resin into the binding agent. Leachability standards are being developed but implementation is not expected for several years.

Secondly, improving the integrity of the waste container minimizes potential radionuclide migration by infiltration of ground water into the waste and prevents the flow of free liquids from the container. The State advanced the concept of a "high-integrity container" with a 300-year life to contain the longer-lived low-level isotopes Cs^{137} and Sr^{90} for ten half-lives.[2] High-integrity containers have been available for several years and are used regularly at numerous power stations.

Thirdly, reducing the volume of "free" or drainable water in the container obviously reduces the volume of contaminated water which can migrate from the disposal trench.

The Nuclear Regulatory Commission in developing 10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Waste", has adopted requirements for waste stability similar to those developed by the State of South Carolina.[3] The NRC has classified low-level wastes on the basis of specific activity for various radionuclides. However, the requirements for waste form are essentially the same as the requirements for the Barnwell site. The following table summarizes the requirements for resin disposal at the Barnwell and Hanford sites and the requirements specified in 10 CFR 61.

Table I. <u>Ion Exchange Resin Disposal - Waste Form</u>

<u>Barnwell, South Carolina</u>[1]

Free Liquids:
< 0.5% in conventional containers
< 1.0% in High-Integrity Container

Waste Activity: (long-lives isotopes)
< 1 μCi/cc - No stabilization required
> 1 μCi/cc - HIC or solidification required

<u>Hanford, Washington</u>[4]

Free Liquids:
< 0.5% or 1 gallon whichever is less

Waste Activity: (long-lived isotopes)
<1 μCi/cc - No stabilization required
>1 μCi/cc - Solidification required

10 CFR 61[3]

Class A wastes*
Free Liquids:
< 1.0%

Class B & C wastes* (solidification or HIC required)
Free Liquids:
< 0.5% for processed (solidified) wastes
< 1.0% in HIC

*Waste classifications are defined in 10 CFR 61.55. Requirements for waste form are presented in 10 CFR 61.56.

HIGH INTEGRITY CONTAINERS

Since the State of South Carolina introduced the high-integrity container concept in 1980, the use of HIC's to dispose of ion exchange resins has become fairly widespread throughout the nuclear power industry. The popularity of HIC's is understandable for several reasons:

- Resins contained in HIC's do not have to be solidified but only dewatered;
- The waste-to-volume ratio is generally higher than for solidified resins.

From an operational standpoint, HIC's are advantageous to many power stations as the need to solidify is eliminated. Many utilities are ill-equipped to solidify. The solidification equipment which was originally installed in the station often does not work, is very inefficient or requires high exposures to personnel to operate and maintain. Some power stations do not even have the space to allocate for contractor-provided mobile equipment.

The equipment and procedures required to dewater a HIC are relatively simple and compact when compared to the alternative solidification processes. Dewatering typically requires only a pump skid connected by hose to the internals of the HIC. The pump is used to pull water from the container in accordance with the specified sequence of instructions. Then the hose is disconnected and the container capped and shipped for disposal.

Solidification equipment, by comparison, is considerably more complex and expensive than a dewatering skid. Capital requirements to install equipment or rental prices for mobile equipment will reflect the relative costs of these components.

Despite the obvious operational advantages to the power station, the use of HIC's has been somewhat limited by high prices and design constraints. HIC's have been relatively expensive, primarily the result of a lack of competition in the marketplace. The price for a 200 ft^3 container, for example, could cost $7000 per container or even higher. Prices are expected to fall, however, as other manufacturers enter the market and competitive containers are made available.

The applications of the first generation HIC's have been limited by the container design. These containers have used threaded closures and have been designed to withstand a 25-foot overburden in the burial trench. By design, the threaded closures intrude into the interior of the HIC, thereby reducing the usable space inside the container for resin disposal. In addition, the threaded closures are frequently difficult to seal, resulting in high radiation exposures to personnel working over the high-activity resins.

A container designed to withstand only 25 feet of overburden can only be certified for use at South Carolina's Barnwell Site.[1] The container must be able to withstand an overburden of 45 feet for the Hanford, Washington site and to comply with 10 CFR 61 requirements.[3]

During 1983, new HIC's will be introduced which overcome the limitations of early containers. NUS Process Services Corporation will provide three generic sizes of HIC's:

- A 55-gallon drum-size container;
- An overpack to hold two carbon-steel 55-gallon drums;
- A series of cask liners from 100 ft^3 to 170 ft^3 in volume.

All three types will be provided with a heat-sealed closure to facilitate closing the container and maximize the internal volume. These containers will also be designed to withstand an overburden of 45 feet to comply with Hanford and 10 CFR 61 requirements.

ADVANCED DEWATERING TECHNIQUES

Complementing the upgrades in waste container integrity are the improvements made in dewatering the radioactive resins. As the free liquid criteria has become increasingly stringent, it has become more and more difficult to comply with these criteria. It is critical, however, for the waste generator to meet the criteria as failure in compliance can result in fines, or worse, loss of access to the disposal site.

The criteria for free liquids vary somewhat between the Barnwell and Hanford sites. At Barnwell, the amount of free liquid allowed is 0.5% by volume for resins contained in conventional containers and 1% for resins in HIC's.[1] The State of Washington, however, limits free liquids to one gallon or 1% by volume, whichever is less.[4] The NRC has essentially adopted the South Carolina criteria for inclusion in 10 CFR 61.[3]

Complying with these criteria is difficult with the conventional methods used at power stations. Typically, an air-driven, positive-displacement pump is used to draw water from the bottom of the container through an internal assembly of retention elements. The pump is run past the point at which suction is lost to pull air down through the container. Flow rates are relatively low at six to ten SCFM. Water can be readily removed from the bottom of the container but water held in the interstices of the resin is much more difficult to remove. This water can migrate during storage or shipment to form free water at the bottom of the container.

Several new methods to dewater resins are now being applied in the United States. In several power stations, the resin container is placed on a vibratory plate which assists significantly in "shaking" the interstitial water down to the bottom of the container where it is removed. In another method, nitrogen is forced through a container under pressure to strip and evaporate water from the resin.

Of the new dewatering techniques, the most effective may be that used with NUS TRANSFIX (transportable filtration/ion exchange) System. Ambient air is pulled by vacuum through a heater to increase the water capacity of the air. The air is then pulled through the resin vessel at approximately 85 SCFM to strip and evaporate water from the resins. The water-laden air is pulled from the vessel to a collection tank where free water is separated from the air by a coalescer and collected in the tank. The air is then filtered prior to entering the vacuum pump, then discharged from the pump to the station off-gas system. The results of dewatering tests have clearly indicated the success of the method. Dewatering times are relatively short (less than four hours) and no free water remains in the vessels.

CONCLUSION

Regulatory requirements for the disposal of low-level radioactive resins have become more restrictive. New high-integrity container designs and dewatering methods are being applied at power stations to comply with the new requirements and thereby improve the waste form stability. It is expected that the technology for high-integrity containers and dewatering techniques will continue the evolutionary trend of improvement and that prices will decline as new competition enters the industry.

REFERENCES

1. South Carolina Department of Health and Environmental Control Radioactive Material License No. 077 (Barnwell Site License).

2. Memorandum to Heyward G. Shealy from South Carolina Department of Health and Environmental Control, October 22, 1980.

3. 10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Waste".

4. State of Washington Radioactive Materials License No. WN-1019-2 (Hanford Site License).