RADWASTE DRYING: AN ENGINEERED SYSTEM FOR POWDERED AND GRANULAR MEDIA

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ABSTRACT

Low level ion exchange resins, filter media and sludges are currently dewatered or solidified prior to disposal. A waste drying system has been placed in commercial service that fully meets the regulatory requirements regarding free standing water in less than 8 hours with more volume efficient containers. The large increase in drying performance results from an engineered approach to the problem. Waste characteristics, waste container design and thermal effects were reduced to an analytic model with specific endpoints and proven with fixed tests and field operations. Not only can the amount of free standing water be predicted, but zero free standing water criteria can be confidently achieved. A patent is pending on the process and many specific aspects of the system.

INTRODUCTION

The vast majority of dewatered waste material has been, and still is, bead type ion exchange resins. Powdered ion exchange resins were predominantly solidified, or dewatered in drums, until 1981 when the first large scale dewatering containers were placed in service. Small amounts of activated carbon are found in radwaste treatment systems and inorganic zeolites are not frequently used in the commercial reactors. Powdered and bead type ion exchange resins average 130 cubic meters per year per commercial plant. They represent nearly half of the total wet wastes generated by the utilities.

Prior to the free standing water criteria specified by the State of South Carolina in 1980, dewatering containers were simply thin gauge carbon steel liners with some cartridge filters unscientifically placed on the bottom. The 1980 free standing water criteria quickly illustrated a lack of understanding of the drying mechanisms. The containers, dewatering tests and procedures changed rapidly. Bead resin containers were designed with conical bottoms and low point drains or suction configurations. Powdered resin containers were designed with several levels of cartridge filters. A diaphragm pump was used to remove free water.

Previous testing and certifications have been based on using "representative" waste media. Methods were not employed that encompassed the range of waste forms to be found in the field. When a test did not meet the vendor defined end point, the duration of the pumping cycle was simply extended until the arbitrary end point was achieved. Thermodynamic considerations, such as condensing cycles, have not been addressed by the industry. An understanding of the drying mechanisms and consistent results have not been achieved. An extrapolation of free standing water versus drainage time has been attempted using specific test results. This is mathematically unsound and unrepresentative of the variety of actual waste forms. There have been many new designs over the last several years but there has not been any real technical advances in drying in the past four years.

Provided that new techniques for resin drying are accepted, it is expected the use of resin drying will increase over the next five years. Some of the reasons are:

1. The presence of this new system means greater certainty of resin drying meeting the transportation and burial regulations than solidification.
2. Drying is less costly than solidification and effects a reduction in shipped or stored radioactive waste.
3. Many plants are finding it more cost effective to not evaporate the regenerant from their deep bed condensate polishers and directly dispose of the once used resins.
4. The volume of bead resin is increasing because portable demineralizers are being substituted for evaporators.
5. The use of powdered resins and filter media is increasing due to closer plant attention to their water chemistry.

The driving factor behind the use of waste dewatering is economics. The waste does not have to undergo waste volume expansion due to solidification and the waste fills the full volume of the container. Additionally, the drying process requires less plant floor space, capital investment and no chemicals that may be dusty, corrosive, and hazardous.

Due to a lack of understanding and the testing methods used, some of the liners punctured at Barnwell have been found with unacceptable amounts of free water. Previous dewatering systems cannot adequately address the behavior of the waste in the buried state. This is because testing has not been representative of actual site and subsequent burial conditions.

Compliance with 10 CFR 61 is difficult to demonstrate with systems that are incapable of removing interstial water from the resin matrix. An understanding of the inter-relations between the pumps, waste characteristics and internal container piping must be developed. The system described in this paper was designed to fully meet and exceed 10 CFR 61 free standing water criteria greater than a factor of 10.

PROCESS DESCRIPTION

Introduction

Nuclear Packaging, a Pacific Nuclear company, assembled the many talents required to properly dewater waste treatment media. The problem requires expertise in fluid dynamics, mechanical design, ion exchange resins, thermodynamics, other water treatment media and container design. It was recognized early that the container, pumping system, waste media and container internals were all related to each other. Compounding the problem was the shift from liquid to liquid/gas to all gas phases as a dewatering procedure progresses. Once the free water is removed, there are water condensing problems to be resolved. The fluid flow and the thermodynamics of ion exchange resins involves dozens of different factors. Initially, there were too many variables and too few relations between them. Above all, the design and testing had to realistically model the actual waste forms found at the power plants.

Despite the apparent difficulties, Nuclear Packaging took a radical departure from past dewatering certification procedures. Full scale testing resulting in a single data point and certifying the process for all field conditions was abandoned. A model of all factors was to be produced with the testing simply confirming the validity of the model. Nuclear Packaging approached the problem by requiring sequential understanding of each step and problem encountered in the drying system development.

The problem was broken down to segments in relation to unknowns and the methods required to discover those unknowns. For example, some items could be computed but others had to be derived from actual testing. Since there were so many inter-related design factors, the testing items needed resolving first. The correctness of the computational models had to be confirmed by actual test data. Nuclear Packaging's test and design engineering approach lead to many iterations of testing, calculations and equipment modifications. Figure 1 is a process diagram of the commercial system. It is fully described later.

The initial design and testing was based on ion exchange resins since they are the primary market. However, the fundamentals were kept in mind with respect to other treatment media such as activated carbon and inorganic zeolites. The models used for ion exchange resins include flow, voidage, size and shape factors that are applicable to other treatment media. The test techniques used on the ion exchange resins will be duplicated on other media since carbon, zeolites, et cetera have significantly different chemical composition and porous structure.

Nuclear Packaging's initial test approach centered around the fluid dynamics of the waste material and the container. The types of water encountered in the drying process, and described in this paper, are defined as follows:

Interstitial Water - The water that occupies the void volume of the waste media, drainable or not.

Free Standing Water - The interstitial water that is drainable over some period of time from the container.

Adsorbed Water - The water held in the waste media itself. It is adsorbed water in ion exchange media but technically pore diffused water in some other cases.

Several test and equipment modification iterations lead to the conclusion that all the interstial water was being removed by the fluid dynamics approach. However, a thermal cycling phenomena was unmasked. At that point, the engineering methods shifted to a material drying approach since it is known that dewatered ion exchange resins contain adsorbed water and also can behave like descicants.

FLUID DYNAMICS

Fluid dynamics and thermodynamic engineering analysis was used to derive the operating requirements of the drying system. There are three main areas of this approach. They are, 1) the performance through the resins, 2) the performance of the collectors and 3) the performance of the mechanical equipment. Solving the fluid dynamics problems in these three areas is to a large extent the solution to the problem of dewatering ion exchange resins. To insure the free standing water does not develop during temperature fluctuations and in the burial condition, properly flowing dry air is required for thermally drying the waste.

Application

An understanding of the relationships between velocity, kinetic energy and momentum of fluids is critical to the understanding of fluid flow in a bed of solids, pipes and orifices. These properties must be balanced in the resin, fluid collector and the mechanical equipment in order to have a system capable of meeting field drying conditions.

Using a purely fluid dynamics approach leads to the question of two phase (liquid and gas) flow in the resin and the necessity of pulling out pockets of interstitial or free standing water.

This is basically a mechanical approach. Given the hydrophobic nature of the resin surface and the chemical solution effects of the adsorbed water, there should be a definite conclusion to the mechanical drying part of the process. Any further drying would have to be a non-mechanical method such as evaporation, chemical enhancement or solvent extraction.

Unfortunately, two phase flow in a bed of solids, particularly in the size range we are concerned with, is not empirically well founded. Hence, the need for confirming test data. In fact most single phase flow is empirically more well founded in larger sized solids and higher flow rates. The problem Nuclear Packaging wanted to avoid was relying on single point testing for conclusions applied to all field conditions. This approach has not worked well in the past. On the other hand, testing all possible waste types and forms is unrealistic. After all, residual free standing water is based on a combination of the following resin characteristics:

- o Resin effective diameter
- o The shape of the resin
- o The packing or effective void volume of the resin
- o The depth of the resin bed

In the operations section, it is demonstrated how the plant operating conditions can affect these factors. The different characteristics of the resin can not be encompassed unless there is a good understanding of the container's water collector and the pumping system's hydraulic performance. The hydraulic factors to be considered are the following:

- o A uniform minimum velocity through the waste media
- o The bottom vessel collector has design limits for achieving the uniform velocity via uniform collection
- o The losses in the pump and piping system external to the container
- o Performance curves of the pumps
- o Container design effect on flow paths

The factors cited above for both resin characteristics and hydraulic factors must also be combined with the state of the motive fluid that is applying the force to the interstitial water. Therefore, the following must also be considered:

- o The fluid temperature moving through the waste media
- o The viscosity of the fluid
- o The molecular weight of the fluid
- o The compressability of the fluid

There are a total of thirteen factors affecting a fluid dynamics hypothesis. Nuclear Packaging's goal has been to find the relations between all of these factors as they apply to field conditions and use full scale test data to simply confirm the model. Nuclear Packaging has achieved that goal. The original fluids dynamics hypothesis and subsequent analytic model have proven substantially correct.

Flow Through a Bed of Solids

Standard fluid flow relationships have been developed for single phase (gas or liquid) flow in pipes, ducts and a bed of solids. Unfortunately the same relationships have not been developed for two phase flow in a bed of solids. Nevertheless, there are analytic fundamentals which can be drawn upon that have been verified through testing.

The flow of a fluid in a bed of solids is dependent on the characteristics of the solids themselves. The analytical method derived by Nuclear Packaging has been found to be very accurate for beds of solids similar to ion exchange media, zeolites and activated carbon. Nuclear Packaging's testing has shown good correlation to to the analytical model, having an error of less than 1 percent. It is important to note the significance of the solid's physical characteristics. A change in shape or size of the waste will effect many of the model's terms. A small difference in one of these terms can lead to large changes in flow rates. Therefore, the process system and container internals are sized to incorporate large differences in waste characteristics.

Powdered Media

Powdered media, such as "Powdex", "Ecodex" and "Epifloc", have granule sizes averaging 0.045 millimeters as compared to about 0.6 millimeters for bead type resins. Flow through a bed of powdered media is affected by the presence of fibrous material. The fiber is intended to enhance filterability of the precoat. The consequence in drying is a change from a rigid bed of solids to a spongy and compressible one.

Nuclear Packaging's approach has been to do the best possible job removing the interstitial water, recognizing that shrinkage during drying will cause sloughing and random cracking. To compensate for the randomness of the media sloughing, Nuclear Packaging has enhanced water removal through the use of air drying techniques. The result of this approach has been shorter and more thorough drying than previously available for powdered media.

Container Internals

There are maximum and minimum effective flow rates for a given distributor or water/air collector design. The performance characteristics of the distributor are incorporated in the analytic model for the flow through the waste media. A combined solids an distributor analysis will determine the fluid distribution criteria and the maximum fluid drawing distance of the distributor.

For example, when the media size decreases from bead resin size to powdered resin size, then the model will tell how vertically situated, horizontally oriented collector levels are required in the container. Additionally, the combined performance region of the process system and the container are partially bounded by the distributor's performance characteristics. The portion of the computer model dealing with the container's internals were very accurate with respect to test data.

Summary of Fluid Dynamics

All of the factors cited above were reduced to a computer model. The flow through the solid, the blower performance, distributor characteristics, minimum flow criteria and the distribution criteria were all integrated into the model. The results were plotted as shown in Fig. 2. The equipment was selected to incorporate both the bead and powdered waste sizes. The accuracy of the model was found to be within 1%.

THERMODYNAMICS

Confidence in drying the waste, to preclude the generation of free water due to condensation requires the use of psychrometry, heat transfer and the physical chemistry of ion exchange resins. Analogous to the fluid flow factors, these three areas of thermodynamics must be engineered together.

Ion exchange resins contain a considerable amount of absorbed water even though they have been "dewatered". They can contain 35 to 65 percent absorbed water. The absorbed water has unique chemical solution characteristics since only one of the plus or minus charged ions in the solution is free to move while the other charged ion is fixed to the plastic bead. The plastic resin itself is hydrophobic. Since the waste will experience substantial temperature changes, the ability of the absorbed water to leave the resin must be addressed.

The thermodynamics and flow of air/water vapor mixtures is very well known. The water uptake capabilities, or descicant effects, of ion exchange resins is also well known. The initial thermal hypothesis had two points. They were 1) the fluid dynamics applications were related to the thermal applications only with respect to evenly distributing the drying air through the waste and that it is more efficient to remove the truly free water by fluid flow and, 2) there is an air/water vapor to resin retained water equilibrium point that signals the desired drying endpoint. The desired dryness of the resin should correspond to not generating free water in the burial environmental conditions - this is one intent of Part 61.

Predictably drying a material depends on the state of the drying fluid and the state of the fluid to be dried. Compared to the state of the solutions in the waste media, the state of the drying air is very straight forward. Psychrometric charts and fundamental heat transfer relations can be applied to forecasting the expected generation of free water and to the drying ability of air flowing through the waste media. Specialty data must be applied to the removal of water from ion exchange resins. From that data the following factors were found to effect the drying of various resins;

- o Moisture content of the resins
- o Chemistry of the retained water
- o Capacity or number of functional exchange sites remaining on the resin
- o Amount of crosslinking of the resin's polymer structure

There are an infinite number of combinations of the factors listed above. It was recognized early in the testing that the thermodynamic aspects of the drying system would have to be oriented to the worst case scenario. Complicated resin analysis at the plant would not be feasible. An endpoint graph has been developed. The graph has several curves each indicating a broad range of waste types. An air humidity endpoint is one axis of the graph.

Mechanical Equipment Thermodynamics

The accuracy of using psychrometric charts to characterize the operating parameters of the mechanical equipment was verified with direct test measurements. Even when pressure and heat loss deviations are ignored, the results are within good design practices. The mechanical thermal cycle is shown on a partial psychrometric chart in Fig. 3.

Ion Exchange Resins

Ion exchange resins represent the worst thermodynamic case because they contain 35 to 65 percent bound or absorbed water after all of the interstitial water has been removed from around them. The bound water remains available, to varying degrees, for vaporization within the resin bed and subsequent condensation around the container wall.

Bead type resins represent a worst case for condensation because of their much greater ability to move air and water vapor within the resin bed. Current dewatering systems do not address the operating condensation problem at all, let alone in the burial condition. Under realistic plant, transportation and burial conditions, a container that has all of the interstitial water removed can generate up to 225 liters of free standing water.

If this water is generated, where is it going to go? In the Nuclear Packaging system it never forms because the dried resin re-absorbs the water before it can form. At the worst case, the dewatered and dried resin in Nuclear Packaging's containers has a saturated water/water vapor equilibrium equivalent to 55°F. - the burial condition. When the temperature drops from the maximum waste temperature of 110°F. to 55°F., the dried resin absorbs the additional moisture in the air.

EQUIPMENT AND OPERATIONS DESCRIPTION

Equipment

The NuPac Drying Unit is a portable system containing all necessary equipment and controls for removing the free water from ion-exchange resins other waste media and keeping water from forming after it leaves the job site. It consists of a dewatering fill head, a piping skid, a blower skid, a water chiller, a control system and the necessary interconnecting hoses and cables. It is designed to interface with NuPac's line of disposable containers. A process block diagram is shown in Fig. 1.

These containers are furnished with factory installed "internals" functionally identical to those used during qualification testing. The internals are free-standing and self-supporting, without protuberances which might, (in the case of polyethylene containers) damage the container.

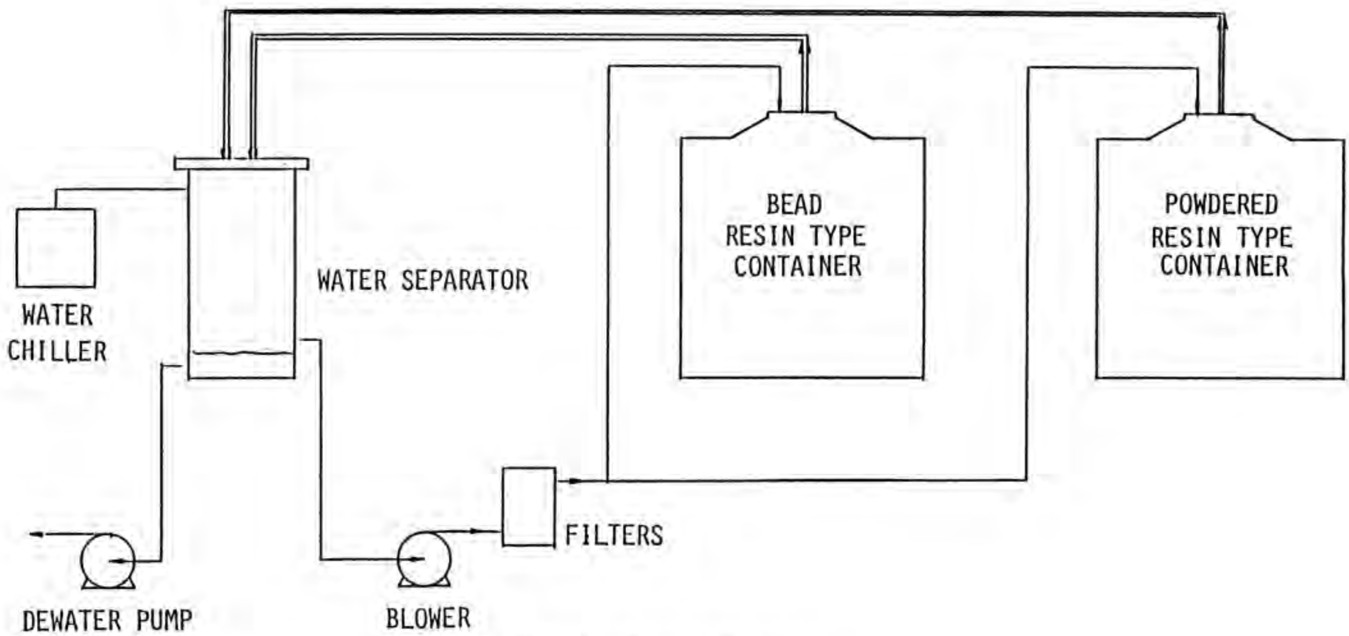

Fig. 1. Process Diagram

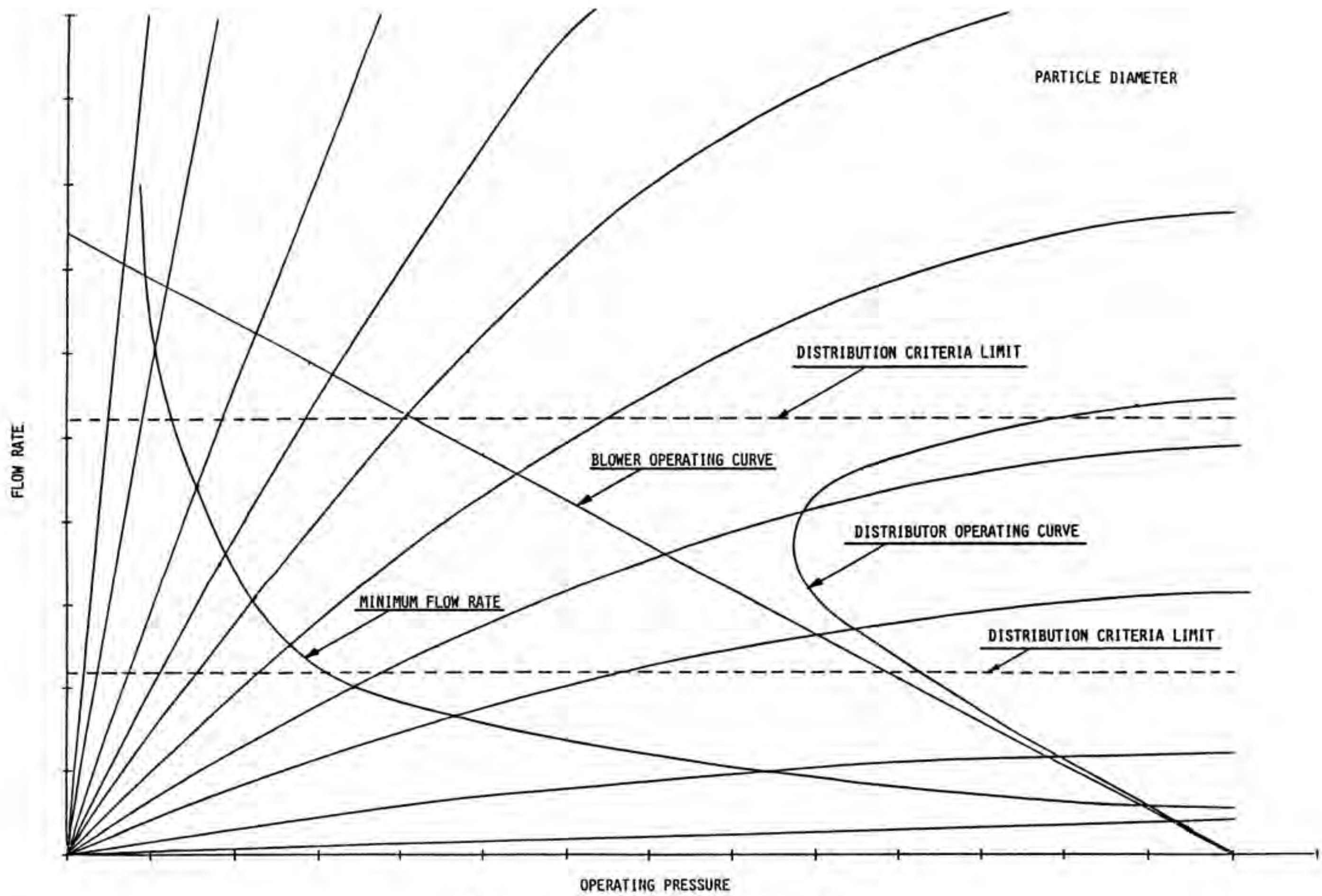

Fig. 2. Fluid Dynamics System Model.

The drying fill head serves as the interface between the drying equipment and the disposable container. The lower portion of the fill head has a set of doors which allow easy access for connecting to, and disconnecting from the container internals. The fill head seals to the upper portion of the neck of the container and is held in place by gravity.

The upper portion of the drying fill head is divided into a piping section and an enclosed electronics section. The piping section is the connection point for all hoses to and from the fillhead and includes an isolation valve for the waste line. This valve prevents any material remaining in the waste hose from spilling during movement of the fillhead to and from the container.

The electronics section is enclosed and waterproof. It houses the fillhead instrumentation and the CCTV Camera and light. It also serves to interface the control system and the container.

The piping skid houses the water separator, the dewater pump and the valve manifold. It is the interface between the drying fillhead, the blower skid, the water chiller and the plant.

The blower skid supplies the correct temperature and quantity of air to facilitate drying of the resin, and is operated after the bulk of the water has been removed by the diaphragm pump. It is equipped with temperature instrumentation, interlocked such that it will shut down automatically on high temperature. Air is continuously circulated in a loop from the blower to the container and back to the blower again through the water separator. During this process, a very small quantity of air is bled off the discharge of the blower as required to maintain atmospheric pressure on the container; this air passes through a HEPA filter prior to entering the plant ventilation system.

The water chiller is a weatherproof, free-standing unit, used to cool the air as it passes through the water separator enroute to the blower. This prevents over heating of the blower as well as serving to condense the water vapor in the air stream, aiding the resin drying process.

The control system consists of a wall hung control panel which contains all the necessary controls and interlocks for safe and efficient operation of the system. It includes a CCTV system used to monitor container operations and a radiation monitor with a detector probe mounted on the fillhead waste inlet line. The control system is designed to facilitate remote operation and surveillance of the drying system and container operations.

SPACE AND UTILITY REQUIREMENTS

Site Operations

The site's operations play an integral part in successful waste drying by Nuclear Packaging's dewatering system. The same water treatment application in several different plants can result in significantly different waste forms with respect to its dewatering ability. Additionally, different waste mixtures and handling methods can contribute to differing dewatering characteristics. Nuclear Packaging's approach is to incorporate in the drying system's operations and process controls the appropriate parts of the site operation's design and waste handling methods. The goal is to be certain that the waste forms are within the proper operating region of the drying system.

There are many waste forms suitable to Nuclear Packaging's drying system. The possible wastes are:

- Powdered ion exchange resins, "Powdex"
- Filter aids, "Celite", "Fibra-Cel"
- Powdered mixtures of ion exchange resins, activated carbon and filter aids, "Epifloc", "Envirosorb" and "Ecodex", from condensate polishers and radwaste treatment systems.
- Bead type ion exchange resins from deep bed condensate systems, radwaste treatment, borated water control, reactor water clean up, fuel pool cleaning, etc.
- Sludges from sump or pool bottoms, decon scale, abrasive cleaners, etc.
- Other liquid treatment media such as activated carbon, inorganic zeolites, filter sand, anthracite and odd forms of ion exchange resins that may occur from one time site jobs.

An overwhelming percentage of the waste currently dewatered is bead and powdered ion exchange resins. They can widely range in characteristics, especially once they have been used. New resins have the following characteristics:

TAB. 1: New Resin Characteristics

	Bead Type	Powdered Type
Size, mm	0.05 - 0.7	0.01 - 0.055
Average Size, mm	0.5	0.04
Average Shape	Nearly Spherical	Slivers
Moisture Content	38 - 70%	42 - 55%

Some plants combine bead and powdered resins. The average effective size and shape is drastically changed with the mixture. The transfer of wastes through high fluid shear pumps, long lengths of pipe and tight fittings can each considerably reduce the medias effective size and shape because of breakage.

A change in the waste hold up tank, sump or pool draw point can also change the waste characteristics. If the draw point on a waste hold tank is switched from the side to the bottom, then an accumulation of fine settled solids could significantly alter the waste's drying ability. Such mixtures and variations can be simulated in NuPac's analytic model to verify the type of container to be used. The remaining parts of the system remain the same. Prior to site operations, a waste and facility characterization is performed.

Chemical effects on the waste media can also seriously hinder the waste's drying characteristics. For example, a powdered or bead type ion exchange resin that has been severely decrosslinked from repeated regenerations or exposure to oxidizing decontamination solutions, has extremely reduced structural properties. Upon special application, these abnormal conditions can be factored into the drying application.

The waste characteristics can change due to the plant's system design and operation. The dewatering system operator shall be aware, by procedure and training, to observe the effects of plant design and operation features. The operator will note if waste media is being crushed by transfer through pumps and piping. He will also be aware of which plant system the media originates. The ion exchange resin from a reactor coolant cleaning system can be in a much different condition than the same type of resin from a condensate polisher. Historic traceability of the various resin batches originating from a plant is an important quality assurance tool that is unique to Nuclear Packaging.

System Operating Description

Competitive "dewatering" systems take many days to accomplish their goal. Sometimes it will take over two weeks. The NuPac drying system accomplishes the same level of dewatering in less than one hour. The remaining seven hours is used to dry theresin for the purpose of precluding the thermal generationof free standing water.

After the waste is transferred to the container, a diaphragm pump removes the bulk water in less than 15 minutes. At that time the pump is passing mostly air with spurts of water. The pump remains on and the blower is turned on. The blower causes the "trickle down water" to flood out into the water separator. Within an hour all of the interstitial water has been removed and adsorbed water is being removed from the waste itself. The established burial condition endpoint is usually reached within eight hours for the vast majority of plant waste forms. The worst possible case was tested and it took less than 16 hours.

ECONOMIC AND COMPETITIVE COMPARISONS

The NuPac waste drying system meets or exceeds the following items:

- Addresses the water generation due to thermal cycles specific to the waste type in the burial condition.
- Meets and exceeds by a factor of 10 current transportation and burial regulations for free standing water.
- Has the most efficient waste volume to container volume ratio available for water treatment media.
- Performs the process in less than half a day.
- The only system that is under the 0.5% or one gallon free standing water criteria, therefore, the dewatered containers can be buried at Hanford.
- Precludes biological action without chemicals.
- Dewatered ion exchange resins have lower cesium leaching qualities than cement solidification.
- Utilizes a flat bottom container that does not require tipping during processing.
- The waste to container volume percentage is greater than 95% versus less than 65% for solidification. Ideal for on-site storage.
- Does not rely on scaling up cup sized samples or direct waste sampling for the Process Control Procedures (PCPs).
- Mixtures of various media can be dried with the same confidence as single types of media.

The volumetric and processing efficiency advantages cited above translate into significant savings for the typical utility. Those savings are conservatively illustrated on Fig. 4. Additional savings are realized for plants located further than 600 miles from Barnwell. Additionally, the NuPac waste drying system does not require excessive floor space and hazardous or dusty chemicals.

TEST PROGRAM AND FIELD OPERATING RESULTS

Nuclear Packaging, Inc. has conducted extensive testing in order to qualify its drying system to the free standing water requirements of 10 CFR 61 for both bead and powdered resins. It is the only dewatering system offered by a service company that currently meets Part 61. A Topical Report is under review by the NRC.

The regulatory limit for free standing water in a high integrity container has been established at 1.0% of the waste volume by 10 CFR 61 and 0.5% for other containers. 10 CFR 61 also establishes that the test methods contained in ANS 55.1 are to be used to detect the presence of free water. Nuclear Packaging has performed testing in excess of these standards, particularly in regard to the absence of free liquid over the expected chemical and physical range of the waste material. This range in properties of the resins has been considered in the testing program, the equipment design and the operating parameters for this system.

The powdered resins used in the testing program were spent and of the Ecodex or Epifloc type. The filter aid present in these materials tends to hold water more readily than the resin, making them the most difficult of the powdered resins to dewater. In all cases the result was zero free standing water - even after cross country transportation. It was proven that transportation has no bearing on the generation of free standing water.

The bead resins used in the testing program are of two types, spent anion resins and new, off-spec. cation resins. The anion resins are representative of bead resins which have been regenerated many times. They tend to be oxidized with less crosslinking, organically fouled and are of a smaller average particle size. The cation resins on the other hand are representative of bead resins which have not been regenerated, are very spherical and are on the upper end of the scale as far as size and shape. The cation resins are more representative of the bead resins which will be encountered in the field. Again, zero free standing water developed at conditions less than those encountered in the burial state.

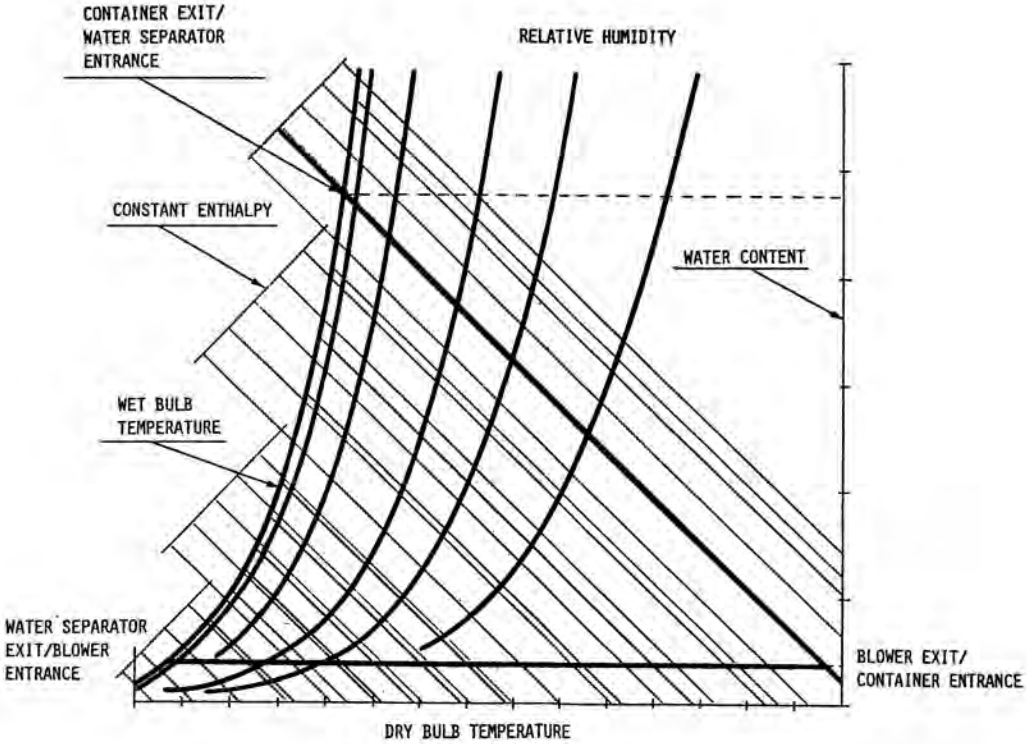

Fig. 3. Process Psychrometry.

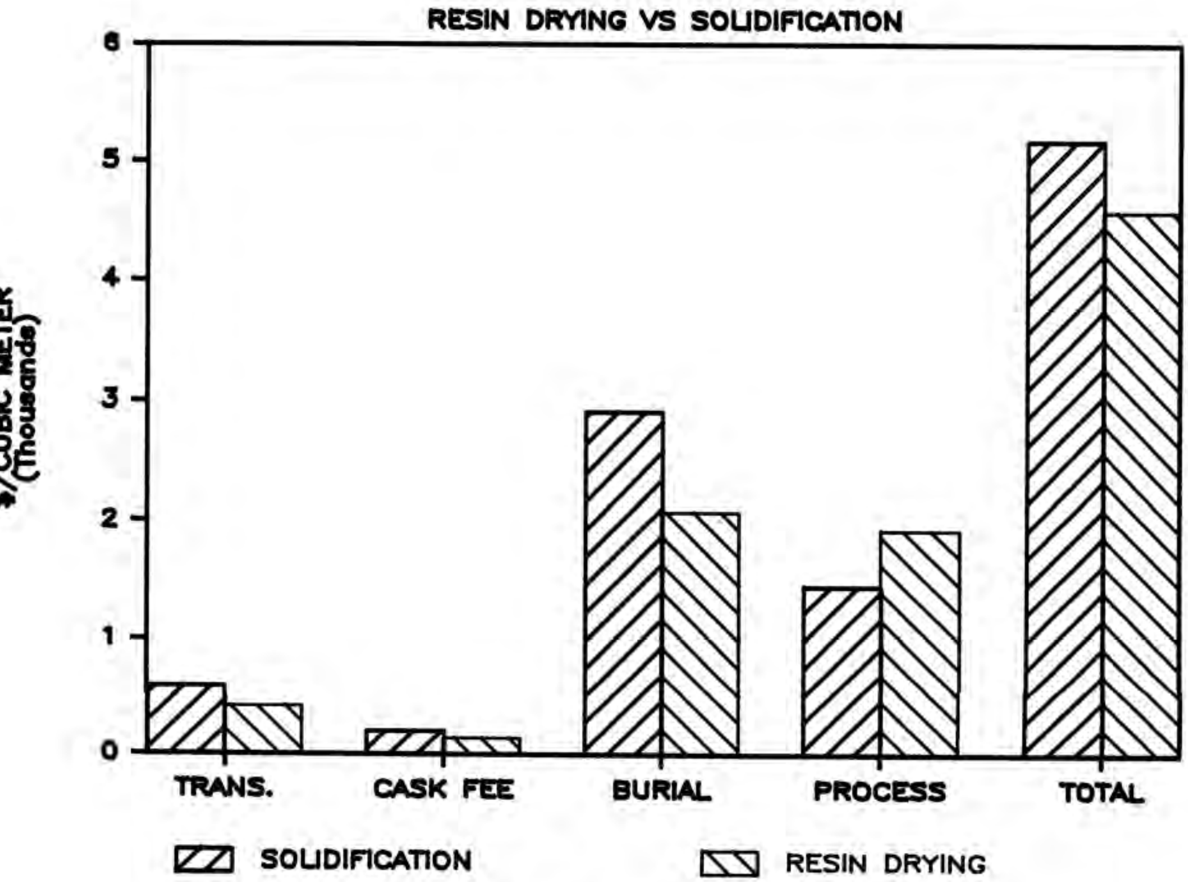

Fig. 4. Typical Utility Cost Comparison.

The physical measurements which have been taken over the course of the testing program show excellent correlation to the analytical methods developed by Nupac. The error has typically been less than 1%.

A duplicate test of a competitive dewatering system and procedures produced 41 liters of free standing water when the container was cooled from it's processing temperature.

REGULATORY COMPLIANCE

The applied research and test data from Nuclear Packaging's waste drying program significantly advanced the "drying" state-of-the-art. The NuPac system is the only dewatering system that addresses and solves the following concerns of the burial sites and Part 61:

- o Thermal condensing cycle and how it generates free standing water in the transportation and burial modes.
- o The chemical and physical effects of the waste media on the drying endpoint and on the 300 year burial conditions.
- o The entire spectrum of chemical and physical forms expected at the utilities as related to the drying process and subsequent burial.
- o Can meet the less than 1 gallon criteria for Hanford.

Given the direct application of ion exchange resin chemical and physical characteristics to the drying process and 300 year burial conditions, the NuPac drying process more confidently meets Part 61 criteria than cement solidification.

ALARA concerns include remote operating features and radiation detectors. The system is constructed in compliance with NRC Regulatory Guideline 1.143 (not in "accordance with the applicable parts thereof") per a NRC approved quality assurance program. The system is operated in accordance to the same program.

SUMMARY

The Nuclear Packaging waste drying system meets the Part 61 requirements on waste water treatment media. It is accomplished with significant operating, cost and regulatory advantages over solidification. Wastes can be dried in less than 8 hours to a waste specific endpoint.