IMMOBILIZATION OF ROCKY FLATS PARTICULATE WASTES USING THE INERT CARRIER PROCESS

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INTRODUCTION

Rockwell International's Rocky Flats Plant, outside of Golden, Colorado, has recently completed construction of its Chemical Recovery Facility. Attached to that facility is the new Waste Treatment Facility designed to prepare the aqueous chemical wastes for shipment to an offsite repository. These wastes will be contaminated by transuranics. The repository to which the wastes will be shipped, the Idaho National Engineering Laboratory, has adopted the packaging criteria developed for the Waste Isolation Pilot Plant. These criteria have changed several times. At the time of this process design, however, the criteria for disposal included requirements that the particulate matter in the shipped waste be limited to one percent or less with diameters less than 10 microns (respirable powder) and limited to no more than 15 percent with diameters less than 200 microns (dispersible powder). Since the waste process at the new Rocky Flats facility was designed before these criteria were adopted and would have produced a dry powder that could not meet the requirements, it was desired to backfit the facility with a waste immobilization system. This paper addresses the selection and design of that immobilization equipment.

BACKGROUND

Several systems were considered for the Rocky Flats waste treatment addition. Since cement is readily available and relatively inexpensive, it was considered as the most desirable immobilization media. Standard equipment for immobilizing powders with cement was too large to fit into the existing waste product glovebox. One system considered, however, utilized a liquid conveying principle that obviated the need for dry mixing and for reliance upon gravity flow of the powder and cement; the liquid-based system permitted the use of small-scale liquid processing equipment that would fit into the available glovebox space. This process, the Inert Carrier Process marketed by the Chemical Systems Division of United Technologies Corporation in Coyote, California, was selected by Rocky Flats personnel for the waste system backfit.

The Inert Carrier Process was originally developed by North American Aviation as a means of safely mixing highly reactive solids. The process was subsequently explored by United Technologies Corporation for a variety of applications, including the volume reduction and solidification of low-level radioactive wastes from nuclear power plants, high-level wastes from reprocessing plants, and sodium wastes from the breeder reactor program. It had not, however, been tested as a means of immobilizing transuranic wastes.

The Inert Carrier Process generically consists of a closed, circulating loop of an inert liquid, as shown in Fig. 1. This liquid is recirculated through a reservoir that is designed to provide the turbulent conditions necessary for dispersing and mixing dry particles. Typically, this disperser is used for mixing a waste material with a binder. A side stream from this dispersion apparatus is passed through an in-line mixer into which a chemical reactant can be injected. This reactant can be a catalyzing agent, if a polymeric binder is used, or water, if cement is used. The waste-binder mixture begins to coagulate at this point

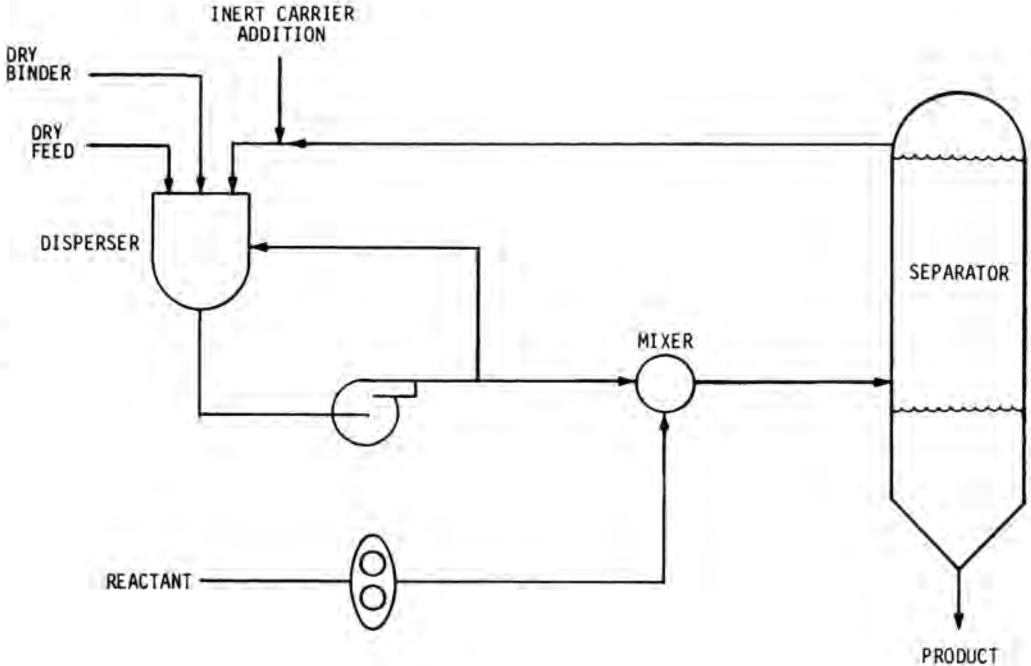

FIG. 1

GENERIC INERT CARRIER PROCESS

and settles out of the inert carrier in a separator. Product can be withdrawn from the bottom of the separator, while carrier is recycled to the disperser.

One advantage of the Inert Carrier Process is its flexibility; a wide variety of carriers and binders can be employed. For the Rocky Flats application, cement was chosen as the binder for economic and procurement considerations. Freon TF was suggested as the inert carrier, since it is non-flammable and is currently used elsewhere on the site as a solvent. To test the basic principle of the proposed process, Rocky Flats personnel simulated the mixing operation in one-liter polyethylene bottles. Non-contaminated waste from initial chemical recovery process testing was used for these "shake tests". Suspended in freon carrier, the cement, waste and water coagulated and separated into a castable product.

On the basis of these favorable results, design of a demonstration plant was authorized. This demonstration unit was designed for construction at the Rocky Flats Plant and was intended for testing with non-contaminated waste. The equipment was sized so that the demonstration unit could possibly be converted to a continuous production system in the future. The design of this demonstration unit involved a cooperative effort between Quadrex Corporation, United Technologies Corporation, and Rockwell International.

PROCESS DESIGN

This particular application of the Inert Carrier Process (ICP) utilizes freon as the inert carrier to transport dispersed waste-cement particles, mix the dispersed particles with a metered amount of water, and then transport the cementitious waste to a separator where the waste is removed. A simplified flow diagram of the transuranic waste solidification process is shown in Fig. 2.

The ICP demonstration unit was designed to permit flexibility during testing of the transuranic waste application.

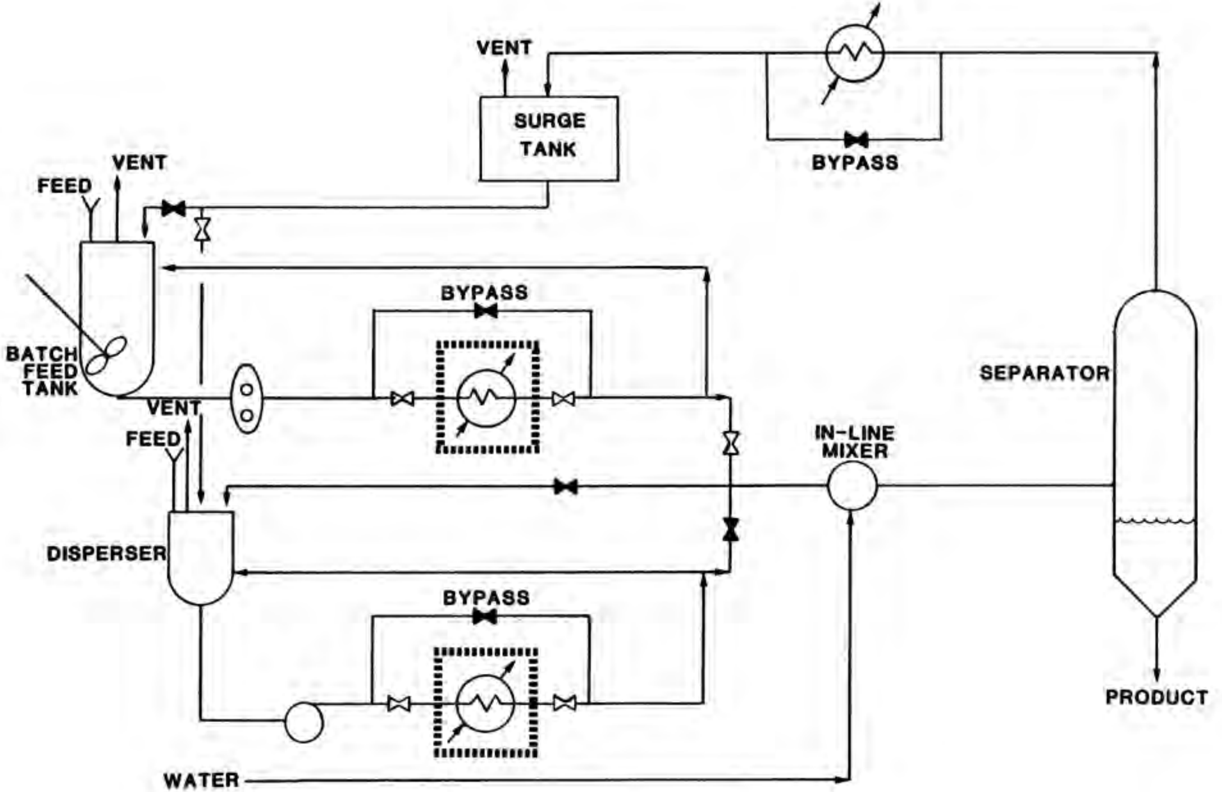

FIG. 2 Simplified Flow Diagram
ICP Demonstration Unit For Transuranic Waste Immobilization

The unit was designed to be constructed of stainless steel, which offers corrosion protection from a wide variety of test chemicals that might be used. A mechanically-agitated feed tank was provided so that a batch of waste feed and Portland cemert sufficient for experimental runs of up to 5 minutes' duration could be fed directly into the process. The ICP disperser was sized to provide for longer, semi-continuous runs. The main functions of the disperser are to break up the waste into fine particles and disperse waste and cement particles in the inert carrier. In this design, a centrifugal pump was used for recirculating the disperser contents at a high flow rate. One feed heat exchanger was provided and located for use with either the feed tank or disperser. This cooler will be used to remove both heat generated by the carrier recycling through the disperser pump and the initial heat present in any feed coming directly from the waste process dryers.

In the disperser or feed tank, cement is mixed with the waste particles. The dispersed particles are continuously recirculated or agitated, while a side stream is routed through an in-line mixer where water is injected. In the mixer, water is added as fine droplets and is mixed intimately with the dispersed waste cement particles in the turbulent inert carrier stream. The agglomerating cementitious waste mixture passes to a separator that permits gravity settling of the waste from the inert carrier, while the carrier is returned to the disperser for further mixing with the incoming waste feed and cement. Cementitious waste product is removed from the bottom of the separator into a disposal container, where it is allowed to harden.

Design of the unit was based on the use of Freon TF as the inert carrier. The volatility of this fluid necessitated the use of a completely closed system, with major equipment components vented through a condenser. In this particular application, the separator was designed to operate under pump pressure, both to reduce vaporization and improve hydraulic layout considerations. A heat exchanger was placed on the carrier recycle line to remove the heat generated by the cement-water reaction.

Because the density of water is less than the density of Freon TF, any unreacted water would flow in the recycle stream from the top of the separator back towards the disperser. To prevent water from entering the disperser and thus causing agglomeration problems, the system surge tank was redesigned to serve as a water-carrier separator. Any water carryover will remain on the top surface of the carrier, where it can be drawn off. Carrier drains from the bottom of the surge tank back into the disperser.

Process design of this unit required information on an optimum waste-cement-water mixture ratios, as well as settling and hardening characteristics of the cementitious waste. To be considered satisfactory for this transuranic waste application, the product must remain fluid long enough to be pumped from the separator into a disposal container and then form a homogeneous, solid monolith having reasonable structural integrity and no free liquid within 24 hours. Bench-scale laboratory tests were performed to obtain this information by using both simulated waste and plant waste generated before transuranics were introduced to the process. From the result of these laboratory tests, a waste-cement-water ratio of 40/40/20 percent by weight was chosen for process design. Because the mixing of cement, waste, and water occurs on a particle-size scale, less cement and water are required to form a workable concrete mixture than would be possible in a mechanical mixer. There is no net volume increase of the cement product over the powdered waste, although the weight and density approximately double.

STATUS

The major pieces of process equipment have been fabricated and are on site at the Rocky Flats Plant. Work will be commencing shortly on the interconnecting piping and the mounting of equipment on its skid base. A one-tenth scale test model has been constructed for use in developing a remote process control system. As features of this control system are developed, they will be incorporated into the full-scale demonstration unit.

Because of spatial constraints, it has been determined that two dispersers will be utilized in the production unit: one for dispersing cement and another for dispersing waste. Waste will be dropped into its disperser by gravity. Cement can be added to its disperser in an uncontaminated location and pumped with the liquid carrier into the process glovebox. This design will reduce glovebox space required and minimize operational problems that are common with remote cement systems. The cement and waste suspensions will be routed together at the in-line mixer, where water will be added.

Completion of process testing is scheduled for this summer. Final decisions regarding production unit configurations and automatic control systems will be made at that time.

SUMMARY

The Inert Carrier Process was selected for installation at the Rocky Flats Plant for several reasons, including spatial requirements and costs. Because the unit will fit inside the available glovebox space, no new facility was required and the initial capital investment was greatly reduced. The simplicity of the process and its adaptability to remote operation reduced the operating personnel and maintenance requirements from those of other systems. Although transportation and repository costs are greater for concrete than for other, lighter, binders, the overall operating cost for the ICP cement system is less than for systems employing other solidification agents.