BWR PRECOAT FILTER PERFORMANCE IMPROVEMENT

Patricia J. Robinson
Electric Power Research Institute
P.O. Box 10412
Palo Alto, California 94303

Jene N. Vance
Vance & Associates

ABSTRACT

Precoat filters are typically used in BWR radwaste systems for the treatment of equipment and floor drains. The precoat materials from these filters generally contributes a sizable fraction of the total solid wastes which must be packaged and shipped to a low-level waste disposal site. Typically, these filters are not operated at or near their optimum performance point, where optimum is defined to be maximum throughput in terms of gallons per cubic foot of precoat material.

INTRODUCTION

Precoat type filters are used in the radwaste systems of virtually all BWR's for the treatment of equipment and floor drains. The filters may be precoated with a variety of precoat materials. Such materials include: Powdered ion exchange resins, diatomaceous earth and flocked cellulose fibers. Powdered ion exchange resin is the predominant precoat material used in most BWR's. The precoat dosages applied to the filters are generally in the range of 0.1 to 0.3 lbs./sq. ft. of filter area. Body feed is the addition of filter aid material (e.g. powdered ion exchange resin) during the filter processing run to increase the porosity of the suspended solids contaminant layer depositing on and within the precoat layer. This increased porosity will generally increase the filter run length. Although body feed addition equipment is installed in most BWR's, it is only being used at a few BWR's. Precoat filters in BWR radwaste systems are normally operated with a specific flow rate in the range of 0.5 to 1.5 gpm./sq. ft. They are typically operated to a differential pressure endpoint at which time they are backwashed and re-precoated.

The cost to ship and dispose of the precoat material is in the range of $200 per cubic foot and consequently there is considerable benefit in reducing the volume of waste produced by the radwaste filters. The volume of waste produced is directly proportional to the throughput efficiencies of the filters in terms of gallons per cubic foot of precoat and body feed material. The objective of this EPRI-sponsored research project is to determine those operating parameters which play a significant role in improving the throughput efficiencies of BWR radwaste precoat filters. The approach used in this effort was to perform laboratory and full-scale testing using the actual waste streams. Different precoat and body feed materials were tested at various dosage rates. The precoat and body feed materials test included: Ecodex, Ecosorb, diatomaceous earth and Ecocote. Cationic organic coagulant aids were also tested. Susquehanna and Grand Gulf were the two BWR's selected for the testing because of the operational availability of body feed equipment.

GENERAL FILTRATION PRINCIPLES

Although precoat filtration is in wide use in the nuclear industry as well as many other industries, it is difficult to predict a filter's performance in terms of effluent quality and throughput efficiency in the absence of actual test data. The reason is that a filter's performance is a function of the waste stream characteristics of:

- o Suspended solids concentration.
- o Particle size distribution.
- o The presence of colloids.
- o Particle shape.
- o Nature of the particles.

These characteristics are generally not known for a given waste stream and their role in a filtration process is not known. Different precoat and body feed materials will perform differently as a function of the above characteristics and must be assessed empirically via testing. This is likewise true for the use of coagulant aids, such as organic polymers, to destabilize colloidal suspensions to allow the particles to coagulate.

General filtration principles indicate that, generally, run lengths increase as precoat cake porosity increases, but effluent quality decreases as cake porosity increases. Body feed materials also exhibit these same general trends. For most waste streams, the use of body feed will increase filter run lengths. Depending on the body feed dosage, the throughput efficiency (gallons/cu. ft.) will also increase with the use of body feed. The use of coagulant aids such as organic polymers will generally improve effluent quality and increase filter run lengths. At lower specific flow rates filter run lengths and correspondingly throughput efficiencies will generally increase. Testing on the actual waste stream is the only way to assess the impact of the above operating parameters. Because of the significant variability in the filterability characteristics of the equipment and floor drains, plant to plant comparisons of throughput efficiencies may not be meaningful.

SUSQUEHANNA TEST RESULTS

At Susquehanna, the floor and equipment drains are collected in a common collection system and treated as a common waste stream. Because of this common collection the waste stream behaves similar to the floor drains at other BWR's which segregate the two waste streams. The liquid radwaste at Susquehanna is processed through a Schenk horizontal leaf precoat filter with a centrifugal discharge capability. Tables I and II show the Susquehanna reference data for the radwaste filter.

TABLE 1

Susquehanna Reference Data

Equipment

- Schenk Horizontal Leaf, Centrifugal Discharge
- 325 ft^2 Filter Area

Waste Stream

Influent Solids Range - 10 ppm to 300 ppm

Average Influent Solids - 45 ppm

Influent Turbidity Range 5 NTU's to 60 NTU's

Average Influent Turbidity - 21 NTU's

TABLE II

Susquehanna Reference Data

Operation (Pre-Optimization)

Filter Flow Rate - 200 gpm

Body Feed Flow Rate - 96 gph

Body Feed Rate - 6.8 lbs./hr. (dry)

Average Body Feed to Crud Ration - 1.05 to 1

Endpoint - 90 Psid

Precoat - Diatomaceous Earth with an Overlay of Powdered Resin and Ecosorb

Body Feed - Ecocote

Performance* (Pre-Optimization)

Average Run Length - 93,000 gals.

Average Throughput Efficiency - 10,4-0 gals./$ft.^3$

*Based on 171 Filter Runs in 1985

Laboratory-scale testing was conducted on a vacuum millipore filter apparatus in which the various precoat materials were precoated on a porous precoat screen. The testing was conducted using actual liquid radwaste samples from the collector tanks over the testing period. In the vacuum testing procedure, filtration times were measured for incremental waste volumes passed through the precoat cake. From the filtration times and incremental volumes, inverse filtration curves were developed. From the slope of inverse filtration rate vs. filtrate volume cake porosity values were calculated. The cake porosities were used as filter run length indices for application to the full-scale filter. From the laboratory testing it was determined that DE-Hyflo was the preferred precoat material. Ecocote and DE-545 tested comparably and were the preferred body feed material over Ecodex and Ecosorb.

In the full-scale testing, DE-Hyflo was used as the precoat material at 0.2 lbs./sq. ft. Although the body feed dosage should be varied as a function of the influent suspended solids level, the plant operating staff was reluctant to modify the body feed pump stroke because of the concerns over the line plugging. Also, the body feed tank volume is adequate for four collector tank volumes and it was not considered practical to change the body feed material quantity charged to the body feed tank for each waste collector tank volume. Therefore, the body feed material charged to the body feed tank was based on average influent suspended solids concentration to yield a 0. body feed-to-crud ratio of 0.70 to 1. It should be noted that higher body feed-to-crud ratios would produce longer filter run lengths, but could produce smaller throughput efficiencies. Table III presents the results of the full-scale testing at Susquehanna.

TABLE III

Susquehanna Full-Scale Test Results

Body Feed*	Run Length (Gallons)	Throughput Efficiency (Gallons/cu. ft.)
1985 Data	93,000	10,400
None	41,000	7,200
Ecocote	156,850	17,950
Ecodex	306,800	23,500
DE-545	344,000	26,400

*Body Feed dosages were based on 24 lbs. charged to body feed tank.

The test results shown are the average of the test runs conducted for the body feed materials. From these test data it can be concluded that the use of body feed will increase the filter run lengths and throughput efficiencies by 8.4 and 3.7 respectively over no body feed. The results of optimizing the precoat and body feed materials and dosages increased the filter run lengths and throughput efficiencies by 3.7 and 2.5 respectively over the 1985 operating parameters at the annual waste volume shipped for disposal would be reduced from approximately 2,600 cubic feet to 1,040 cubic feet. This would result in an annual cost saving of $313,000 based on $200/cu. ft. disposal cost.

GRAND GULF TEST RESULTS

At Grand Gulf, the equipment and floor drains are segregated and treated separately by their respective precoat filters. The equipment and floor drain filters are identical units. They are Funda horizontal leaf centrifugal discharge filters. Tables IV and V show the Grand Gulf reference data for the two filters.

As with Susquehanna, the laboratory-scale testing was conducted on a vacuum millipore filter apparatus. For the equipment drain filter testing, the test results indicated that a DE-Hyflo precoat would produce slightly longer run lengths with comparable effluent quality. Because the plant staff was concerned with the silica addition and potential settling problems with DE in the phase separators, the improvement in the run length did not warrant a change in the precoat material for the equipment drain filter. For a body feed material, the test results indicated that DE-545 would be preferred over Ecodex or Ecocote which were essentially equal. However, because because both filters are fed from the same body feed tank, it was decided that the floor would dictate the body feed material.

For the floor drain filter, the laboratory scale testing indicated that DE-545 was a preferred precoat material over Ecodex. However, because of the concern for settling problems in the phase separators and a concern for plugging the filter septa, the plant staff was reluctant to change precoat materials. For the body feed material the test results indicated that both Ecocote and DE-545 were preferred over Ecodex. For most of the test runs, slightly longer filter runs were indicated for the DE-545 over the Ecocote. However, because of the concerns mentioned above, it was decided to use Ecocote on the full-scale testing.

An organic cationic coagulant aid supplied by Betz Laboratories was tested on the floor drain water in combination with the Ecocote body feed and Ecodex precoat. The cationic polymer, designated as 1192, is a dimethyldiallyl ammonium chloride polymer which is a relatively low molecular weight (400,000), high charge density polymer. In the lab-scale testing, the use of the 1192 polymer indicated an improvement in run lengths of a factor 2 to 3 over the run lengths with no polymer.

In the full-scale testing of the equipment drain filter, the filter was precoated with Ecodex at a dosage of 0.24 lbs./sq. ft. which was half of the dosage previously used. Ecocote was charged to the body feed tank and the equipment drain body feed pump stroke was set at 30%. However, even at this reduced pump stroke, the body feed addition rate is too large for the suspended solids level in the equipment drain waste. Therefore, it was decided to body feed every third collector tank processed through the filter. The full-scale test results on the equipment drain filters are shown in Table VI.

The results show a reduction in the average run lengths, but a 25% increase in throughput efficiency for the use of body feed on the equipment drain filter.

For the full-scale testing of the floor drain filter, the filter was precoated with Ecodex at a dosage of 0.24 lbs./sq. ft. Ecocote was charged to the body feed tank at 36 lbs. The floor drain body feed

TABLE IV

Grand Gulf Equipment Drain Filter Test Results

Precoat	Dosage (lbs./ sq.ft.)	Body Feed	Dosage (lbs./ hour)	Average Run Length (Gallons)	Average Throughput Efficiency (Gallons/ cu.ft.)
Ecodex	0.48	None	--	256,000	42,670
Ecodex	0.24	Ecocote	0.96*	211,000	53,300

*Dosage calculated over entire run even though every third tank had body feed.

pump stroke was set at 90% for a feed rate of 9.72 lbs./hr. A series of 25 test runs was conducted at these conditions while equipment was purchased and installed for adding the 1192 polymer to the floor drain collector tank. After the installation of the hardware for the addition of polymer, additional testing was performed. Table VII presents the results of the testing on the Grand Gulf floor drain filter.

By reducing the precoat and body feed dosages and using Ecocote body feed in place of Ecodex, the run length and throughput efficiences were increased by 1.64 and 3.6 respectively. The same operating parameters in combination with the use of an organic cationic coagulant aid further improved the run lengths and throughput efficiences by 1.90 and 1.62 respectively. At the improved throughput efficiency of 5.9 over the pre-optimization parameters at Grand Gulf, the annual waste volume shipped for disposal would be reduced from approximately 6,200 cu. ft./yr. to 1,050 cu. ft./yr. This would result in an annual cost saving of $1,030,000 based on $200/cu. ft. disposal costs. By optimizing the precoat and body feed materials and dosages the run lengths and throughput efficiencies were improved by factors of 13.2 and 9.6 respectively.

TABLE VII

Grand Gulf Floor Drain Filter Test Results

Precoat	Dosage (lbs.ft.^{2})	Body Feed	Dosage (lbs./hr.)	Polymer 1192	Average Run Lengths (Gallons)	Average Throughput Efficiency (Gallons/ft.^{3})
Ecodex	0.48	None	---	No	5,400	900
Ecodex	0.48	Ecodex	39.0	No	22,000	1,470
Ecodex	0.24	Ecocote	9.72	No	36,000	5,330
Ecodex	0.24	Ecocote	9.72	Yes	71,380	8,640