THROWAWAY VERSUS REGENERATION OF CONDENSATE RESIN: RADWASTE IMPACT

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ABSTRACT

The evaluation methodology utilized in deciding to change over Oyster Creek plant operation from chemical regeneration of condensate demineralizer resin beds to throwaway of this spent resin is presented. Both the economic and operational aspects considered are discussed. The evaluation shows that potential savings in the \$1.1M range are feasible over a 5 year cycle. Cost sensitivity analysis results define the throwaway versus regeneration breakeven point to be 47 condensate demineralization beds per 5 year cycle. The evaluation also discusses the trade off between resin and evaporator concentrates burial volumes. Analyses are given which show that the burial volume cost equivalency of resin to solidified concentrates is 150 ft.^{3} of resin equals 400 ft.^{3} of concentrates. Based on one year of power operation in the throwaway mode. the savings and operational value anticipated in the initial study are being realized.

BACKGROUND

The Oyster Creek Nuclear Generating Station is a single unit facility located in southern New Jersey. The plant was placed in commercial operation on December 23, 1969. The unit's license allows operation at a maximum thermal power level of 1930 MW with a corresponding gross electrical power output of 670 MW. The unit is a Boiling Water Reactor (BWR-2). The plant is a salt water cooled unit about two miles inland from the Atlantic shoreline.

The Condensate Demineralizer System (CDS) processes water from the main turbine and the main condenser. The CDS protects the reactor from condenser tube leaks and removes condensate impurities. The CDS has seven 150 cubic foot mixed resin demineralizer beds (6 online plus 1 spare). The CDS resin can be mechanically cleaned using an Air Bump and Rinse Operation (ABRO) and/or chemically regenerated. The regeneration process involved both chemical resin regeneration and ABRO's. Waste water from these operations is analyzed and fed into the High Purity (HP) (less than 50 micromoho/cm conductivity water) or the Chemical Waste/floor drain (CW) (greater than or equal to 50 micromho/cm) radwaste processing systems. Spent resin from the CDS is slucied to radwaste for packaging in high integrity containers, dewatering and disposal.

The chemical waste/floor drain system processes water through a precoat body feed filter followed by an evaporator. The evaporator distillate is processed through the high purity system. The high purity system processes water through a precoat/body feed filter followed by a 150 ft.^{3} mixed bed demineralizer. Water from the high purity system is returned to the plant.

Filter media and evaporator concentrates are solidified and disposed of as radwaste. Solidified evaporator concentrates and filter sludge are disposed of in 170 ft.^{3} burial volume liners containing 120 ft.^{3} of radwaste. The spent resin is dewatered in 120 ft.^{3} burial volume high integrity containers holding 97 ft.^{3} of radwaste.

ECONOMIC ANALYSIS

Since 1969, Oyster Creek normally has chemically regenerated the CDS 2 cation to 1 anion by volume mixed resin beds. Prior to the start of operating fuel cycle 10 (Nov., 1984) , the decision was made to change the utilization of bead resin in the CDS. Study of the costs and benefits of throwing away spent resins, instead of continuing the practice of chemical regeneration, suggested a savings could be realized by changing over to the throwaway mode utilizing 1 cation to 1 anion stoichiometric mix CDS resin beds.

The plant cost factors for operating the CDS in the regenerative and throwaway modes are enumerated in Table I. The evaporator concentrate and spent resin costs include all radwaste processing, transportation and burial factors. The concentrates and spent resin cubic feet in Table I refer to burial volumes. The labor item covers plant personnel time for either regeneration/ABRO processing plus radwaste processing plus resin replacement or ABRO only processing plus radwaste processing plus resin replacement. The chemicals refer to 100% sulfuric acid and 50% caustic reagents used in resin regeneration and for pH adjustments during radwaste processing. The fresh resin cost and quantities refer to the purchase price of new resin for the CDS system for the five (5) year resin changeout cycle. The costs and quantities of fresh resin, spent resin, fresh filter media and filter sludge generated in the radwaste system by processing water originating from CDS treatments and the chemicals used in the CDS regeneration are also covered in Table I.

Table I presents both original and revised costs for the plant cost factors. The revision was a result of improved knowledge gained in 1985 on base line costs and incorporation of a higher yearly escalation on costs. The burial cost revisions resulted from the clarification gain as a result of the passage by Congress of the revision to the Low Level Waste Radioactive Waste Policy Act commonly referred to as the Udall Amendment.

The basis of the 5 year resin changeout cycle originates from the assumption that in a regenerative mode of operation the CDS resin beds will require changeout only every 5 years. Thus, for the regenerative mode the changeout sequence affects 6 CDS bed replacements every 5 years. The throwaway mode, on the other hand, assumes changeout of 6 CDS beds per year over the 5 year cycle.

Table II shows the five year cycle economics for the regeneration versus throwaway operational modes for both the original and revised estimate cases. The cost effectiveness of operating the CDS in the throwaway mode is shown by the anticipated \$0.6M to \$1.1M savings over the 5 year cycle. The dominating factors which determine the economics are the radwaste processing, transportation and burial costs for concentrates and spent resin plus the purchase of fresh resin over the full condensate demineralizer system resin lifetime cycle. These factors comprise in excess of 98% of the net cost. Labor costs make up some 1% of the net cost.

Table III shows the relative cost impacts of processing, transportation and burial of resin and concentrate radwaste for Oyster Creek. The comparable magnitude of these factors demonstrates that all three costs must be considered in the analysis. Furthermore, only significant change in these costs (eg, process savings, burial cost increase) will have a direct impact on the economics of regeneration versus throwaway modes.

The cost comparison in Table II is based on the key throwaway mode assumptions that the CDS resin bed changeout frequency is six (6) beds per year and the evaporator concentrates burial volume is 1400 ft.^3/yr. Thus, the margin of cost effectiveness for throwaway over regeneration is a function of these two factors. One can calculate the savings equivalency of one CDS bed changeout (A):

$$A = \frac{\text{fresh resin cost + spent resin cost}}{\text{number bed changeouts in 5 years}}$$

For the revised estimate one gets:

$$A = \frac{\$1,890,000}{6 \text{ bed/yr} \times 5 \text{ yr}} = \$63,000/\text{bed}$$

Thus, for each deviation from the six (6) CDS beds per year throwaway base, one will realizes a savings bonus (if less than 6) or a cost penalty (if greater than 6) of \$63,000

Furthermore, based on the cost factors in Tables I and II one can determine the concentrate burial volume cost equivalent to burial of one CDS resin bed (B)

$$B = \frac{A}{\text{RPTB cost}}$$

which for the revised estimate gives

$$B = \frac{\$63.000/\text{bed}}{\$158/\text{ft.}^3} = 400 \text{ ft.}^3 \text{ conc/bed}$$

Thus, for each 400 ft.^3 change from the 1,400 ft.^3/yr. throwaway base, a savings bonus (if annual concentrates volume is lower) or cost penalty (if annual concentrates volume is higher) equivalent to one CDS resin bed changeout will be realized. The A and B parameters facilitate evaluating the status of the throwaway mode of operation.

In terms of CDS resin bed changeouts, the cost breakeven point for resins (RBP) Oyster Creek operating in the throwaway mode is

$$\text{RBP} = 6 \text{ beds/yr} \times 5 \text{ yr} + \frac{\text{Savings}}{A}$$

so

$$\text{RBP} = 30 + \frac{\$1,100,000}{\$63,000/\text{beds}} = 30 + 17 = 47 \text{ beds}$$

That is, over the 5 year cycle, there can be up to 17 CDS bed changeouts made over the baseline level of 30 beds (for a total of 47 CDS beds) before the throwaway mode becomes cost ineffective.

In terms of evaporator concentrates burial volume, the cost breakeven point for concentrates (CBP) is:

$$\text{CBP} = 1,400 \text{ ft.}^3/\text{yr.} \times 5 \text{ yr.} + \frac{\text{Savings}}{\text{RPTA cost}}$$

so

$$\text{CBP} = 7,000 + \frac{\$1,100,000}{\$158/\text{ft}^3} = 7,000 + 7,000$$

$$\text{CBP} = 14,000 \text{ ft.}^3$$

Thus, there can be up to 7,000 ft.^3 of concentrates buried over the baseline level of 7000 ft^3 (for a total of 14,000 ft^3) during the 5 year cycle before the cost breakeven point is reached.

Note that both of these breakeven points are directly related as defined by parameter B. That is, utilization of the concentrates reserve reduces the resin bed changeout reserve with 400 ft.^3 of concentrates burial costing the equivalent of one resin bed. Of course reduced utilization of one of the reserve capacities relative to its baseline condition results in a proportional increase in the sister reserve.

PLANT RESULTS FOR 1985

The 1985 operation of the Oyster Creek plant in the throwaway mode resulted in seven (7) CDS resin bed changeouts and burial of 1780 ft.^3 of solidified concentrates. The corresponding baseline analysis parameters are six (6) CDS resin bed changeouts per year and burial of 1400 ft^3 of solidified concentrates per year. The seven CDS bed changeouts were a direct result of a condenser leak. A salt water intrusion occurred due to a break in the condenser system which resulted in rapid depletion of the CDS beds. Based on 1985 normal operational CDS resin performance, it is anticipated that the changeout frequency of six (6) beds per year will be found to be high. The stoichiometric mix beds have been found to have a longer useful life and to be more cost effective. Thus, barring salt water intrusion, the CDS resin usage should be consistant with the baseline analysis assumptions.

Evaluating the impact of 1985 operations on the analyses for the 5 year cycle economics, one finds the CDS bed changeout reserve has been decreased by the cost equivalent of 2 beds. That is, 7 versus 6 CDS beds for a net of 1 excess bed plus 1780 ft^3 versus 1400 ft^3 for a net of 380 ft^3 of excess concentrates which, per parameter B, is approximately equivalent in cost to 1 CDS bed. If one were to assume the remaining four years were comparable to the 1985 experience (which is overly pessimistic due to the condenser leak), the 5 year cycle economics would realize a $0.5M savings for the throwaway mode of operation.

Another aspect which is important to the present evaluation of the regeneration versus throwaway modes of operation are the operational impacts. By not operating in the regenerative mode, one realized operational benefits due to reduced handling of industrially hazardous acids and bases, equipment longevity effects due to reduced corrosive processing conditions, system performance due to simplified processing and operator availability due to reduced processing time/effort. In addition, improved reactor water and feedwater quality have been realized. These real, but hard to quantify, factors, although not incorporated into the economic analysis are nevertheless very important factors.

The evaluation, by other utilities, of regeneration versus throwaway modes of condensate demineralization system resin utilization can be facilitated by the results of the present study. As is evident from Table II, there are only three cost factors which need to be quantified to carry out an evaluation:

fresh resin costs
radwaste processing, transportation and disposal cost for concentrates.
radwaste processing, transportation and disposal cost for spent resins.

In terms of baseline parameters/assumptions, one has to decide on the corresponding quantities in Table I for these three line items. Thus, knowing these costs per cubic foot, three regeneration mode quantities and three throwaway mode quantities, one can evaluate the potential value of the regeneration versus throwaway modes of condensate demineralization system resin usage.

For Oyster Creek, the analysis results and operating experience indicate somewhere between $2.0M to $4.0M savings should result from operation in the throwaway mode for the current remaining life of the plant. This savings assumes the operating cost inflation rate and annual cost of capital rate are equal which should be conservative in view of past burial cost escalation rates for radwaste operating costs. The positive operational benefits are also being realized by Oyster Creek as a result of changing over to the condensate resin throwaway methodology.

ACKNOWLEDGMENT

The original study and evaluation of the changeover in operational methodology away from regeneration was a joint effort by the Oyster Creek Plant Chemistry Department and the Corporate Chemical Engineering Department. The radwaste aspects and impacts of the changeover were considered and reviewed by the Oyster Creek Plant Radwaste Operating Department. This multidiscipline effort involved the following key personnel:

C. Halbfoster--Manager Plant Chemistry;
B. Shumaker--Engineer; Plant Operations
T. Snider--Manager, Radwaste Operations;
J. Tangen--Senior Engineer, Chemical Eng. and
P. Zanis--Senior Engineer, Chemical Eng.

The services of Finetech, Inc. were utilized to investigate/delineate costs and document the feasibility and economics of going to the throwaway mode of operation. The Technical Data Report generated by Finetech for GPUN was authorized by L. Ryan, President and J.Giannelli, Vice President.

TABLE I

Plant Cost Factors

Item	Cost[e]	System	Quantity	
			Regeneration	Throwaway
Concentrates[a]	$\$ 119/\text{ft}^3$	RPTB	4700 ft.^3/yr.	1400 ft.^3/yr.
	$\$ 158/\text{ft}^3$*	RPTB	4700 ft.^3/yr.	1400 ft.^3/yr.
Spent resin[a]	$\$ 216/\text{ft}^3$	RPTB	1100 ft.^3/5 yr.	5600 ft.^3/5 yr.
	$\$ 210/\text{ft}^3$*	RPTB	1100 ft.^3/5 yr.	5600 ft.^3/5 yr.
Labor[b]	$\$8000$/yr.	CDS/RW	400 manhr./yr.	-
	$\$5000$/yr.	CDS/RW	-	180 manhr./yr.
Chemicals[b]	$\$ 650$/yr.	CDS	6 beds/yr.	-
Fresh filter media[b]	$\$ 432$/yr.	RW	6 beds/yr.	-
	$\$ 216$/yr.	RW	-	6 beds/yr.
Fresh resin[c]	$\$ 125/\text{ft}^3$	CDS/RW	900 ft.^3/5 yr.	4500 ft.^3/5 yr.
	$\$ 153/\text{ft}^3$*	CDS/RW	900 ft.^3/5 yr.	4500 ft.^3/5 yr.
Labor[d]	$\$9000$/yr.*	CDS/RW	400 manhr./yr.	-
	$\$5600$/yr.*	CDS/RW	-	180 manhr./yr.
Chemicals[d]	$\$ 730$/yr.*	CDS	6 beds/yr.	-
Fresh filter media[d]	$\$ 490$/yr.*	RW	6 beds/yr.	-
	$\$ 240$/yr.*	RW	-	6 beds/yr.

Abbreviations:

RW = Radwaste system
CDS = Condensate Demineralization System
RPTB = Radwaste Processing, Transporting and Burial

Footnotes:

a - lower $\$/\text{ft.}^3$ costs used 1984 based costs with 10% across the board net escalation over the last four years of the 5 year cycle. The higher $\$/\text{ft}^3$ costs are based on 1985 cost escalated 30% per year for burial and 10% per year for processing and transportation.

b - values are based on 1984 base year costs with 10% net escalation over the last four years of the 5 year cycle.

c - lower cost assumed no escalation and higher cost assumes 10% per year escalation.

d - values are based on 1985 base year costs with 10% per year escalation over the last four years of the 5 year cycle.

e - all values are averages for the five year CDS resin changeout cycle. The unmarked costs make up the original cost estimate and the costs denoted by an * form the basis for the revised cost estimate.

TABLE II

Five Year Cycle Economics

Item	Original Estimate ($x1000)		Revised Estimate ($ x 1000)	
	Regeneration	Throwaway	Regeneration	Throwaway
Concentrates	2800	830	3700	1100
Spent Resin	240	1200	230	1200
Labor	40	25	45	28
Chemicals	3	-	4	-
Fresh filter media	2	1	2	1
Fresh resin	110	560	140	690
Net Cost	3200	2600	4100	3000
Savings	-	600	-	1100

TABLE III

1985 Radwaste Relative Cost Components

		Percent of Total Cost	
	Processing	Transportation	Burial
Resin	37	31	32
Concentrates	46	16	38