Technical Memorandum

Date: May 8, 2017

To: Sylvan Source

From: Michael DiFilippo

Subject: Mobile Core System for EDTA Boiler Cleaning

Introduction

This analysis presents the economics of treating EDTA boiler cleaning wastewater using a mobile 5-stage 50,000 gal/day Core system. The mobile system, which includes a small propane-fired steam generator, would be trailer mounted and capable of treating boiler cleaning wastewater on a point-of-use basis, wherever it is needed. A large US electric power company provided a sample of boiler cleaning wastewater to Sylvan Source to demonstrate treatability and volume reduction (discussed later). They also provided typical costs to dispose of wastewater. Wastewater constituents, which are mostly heavy metals, cannot be discharged to a receiving body of water or sent to a municipal sewer; wastewater must be sent to a Class 1 disposal facility.[1] Refer to Table1.

Table 1: Summary of Disposal Volumes and Costs

	Volume gallons	Disposal Cost	Transport Cost	Total Cost	Unit Cost $/gal
Chrome Waste	124,535	$68,333	$122,200	$190,533	$1.53
Bromate Drain	84,517	$14,661	$79,900	$94,561	$1.12
Bromate Rinse	86,755	$47,500	(included)	$47,500	$0.55
Haz Waste Fee				$33,000	
Total	295,807			$365,594	$1.24

Boiler cleanings generate about 300,000 gallons of wastewater that requires offsite disposal. The unit cost of disposal for the boiler cleaning in Table 1 is $1.24 per gallon; transportation accounts for about 80% of the disposal cost.

Volume Reduction of Boiler Cleaning Wastewater

Sylvan treated EDTA boiler cleaning wastewater at their facility using their two-stage bench-scale pilot. The Core pilot reduced the volume of the sample by 90% without pretreatment. The distillate produced during the testing had a TDS of 40 mg/L. Also, testing was observed by representatives of the power company that provided the sample. Table 2 shows how disposal costs[2] (from Table 1) are decreased to $66,000 – a savings of $299,000 – when wastewater volume is reduced by 90%.

[1] Class 1 disposal facilities receive and process liquid and solid hazardous waste for disposal.

[2] Costs were proportioned based on volume and the hazardous waste fee was left as is.

Table 2: Summary of Disposal Volumes and Costs – 90% Volume Reduction

	Volume gallons	Disposal Cost	Transport Cost	Total Cost
Chrome Waste	12,454	$6,833	$12,220	$19,053
Bromate Drain	8,452	$1,466	$7,990	$9,456
Bromate Rinse	8,676	$4,750	(included)	$4,750
Haz Waste Fee				$33,000
Total	29,581			$66,259

Sylvan Mobile Core System Operating Costs

The unit cost to treat and reduce the volume of boiler cleaning wastewater using a mobile 50,000 gal/day Core system can be found in Table 3. Costs are based on a feed rate of 50,000 gallons per day (cost assumptions are embedded in the table[3]). In addition to the mobile Core system, a propane-fired steam generator will also be provided to supply steam for the Core. Equipment costs also include one-time operator training. It was assumed that a designated group of operators would be trained to operate (or oversee operation) at various sites within a company's operating fleet of plants. It is also significant that the unit operating cost of the Core is $0.013/gallon compared with the disposal cost of $1.24/gallon of boiler cleaning wastewater disposal.

Table 3: Sylvan Mobile Core Unit Operating Costs and Equipment Cost

Operating Costs (50 kgal/day basis)		
Labor	N/A	Pre-Trained operators
Power	$11	95 kWh/day @ $0.120/kWh
Propane	$493	51.2 MMBTU/day @ $7.70/MMBTU, 80% o'all eff
Chemicals	$14	pH adjustment w/NaOH (as required)
Maintenance	$137	2% of equipment cost
Total, $/day	$656	
Unit Op Cost, $/gal	$0.013	
Equipment Cost		
Mobile System	$2,500,000	
Mobile Boiler	(included)	
Op Training	$50,000	(one time)
Total	$2,550,000	

Economic Analysis of Mobile Core System

The mobile 5-stage 50,000 gal/day Core system would reduce the example boiler cleaning disposal volume by 90% from 295,807 gallons to 29,581 gallons. Refer to Table 4. Recovered water (distillate) could be used in the plant for cooling tower makeup, SO2 scrubber makeup, boiler feedwater (with additional treatment), etc. For this example, treatment time would be about 6 days (of continuous operation).

[3] The cost for pH adjustment is based on ~90 mg/L of NaOH (dry basis).

Table 4: Economic Analysis of Mobile Core System for Boiler Cleaning Wastewater

Boiler Cleaning Vol to Disposal, gal	295,807	
Mobile Core Feed Rate, gpd	50,000	
Treatment Time, days	5.92	
Watewater Volume Reduction, gal	266,226	(as distillate)
Core Brine to Disposal, gal	29,581	
Disposal Cost	$365,594	
Reduced-Vol Disposal Cost	$66,259	
Savings w/Core per Boiler Cleaning	$299,335	
Core Op Cost per Boiler Cleaning	$3,878	
Plant-to-Plant Mobilization per Cleaning	$3,000	
Net Savings per Boiler Cleaning	$292,457	
Straight Payout, Boiler Cleanings	8.5	

Disposal costs would be reduced by $299,000. The cost of Core mobile treatment is estimated to be $3,900 and includes power, propane, chemicals and a maintenance allowance. Mobilization costs were assumed to be $3,000 per cleaning to transport the system from plant to plant. The net savings per boiler cleaning is estimated to be $295,000. Using a straight-payout method[4], 8.5 cleanings would pay for the mobile Core system.

Other Technologies

Two other technologies were identified for this service: reverse osmosis (RO) and suppressed-evaporation mechanical vapor recompression (SE-MVR). RO was eliminated quickly because the wastewater generated by boiler cleanings is highly concentrated solutions of mineral acids, organic acids and EDTA; these solutions are oxidizing in nature and would not be compatible with RO membranes. Also, spent solution concentrations would exceed RO osmotic pressure limits. Lastly, iron and TSS levels are very high and significant pretreatment would be required to protect the membrane surfaces from fouling. SE-MVR was considered because there were a number of mobile systems built to treat high TDS flow-back water from Marcellus gas operations. These systems were horizontal tube heat exchangers where water to be treated was recirculated, and steam generated by vapor compression, was used to heat the circulating brine. Brine was pressurized to suppress boiling in the exchanger and vapor was flashed in a disengagement tank; flashed vapors were compressed to heat recirculating brine. The systems were large with minimal evaporative capacity. Several were built but a brief survey did not identify any remaining in service.

[4] Straight payout (number of cleanings) is calculated as follows: $Pay\ Out = \frac{Equipment\ Cost}{Cleaning\ Net\ Savings}$