VOLATILE ORGANIC COMPOUND EMISSION CONTROLS FOR PETROLEUM REFINERY SECONDARY WASTEWATER SEPARATORS

by

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SUMMARY

A petroleum refinery wastewater separator removes and recovers hydrocarbons from refinery wastewater. In a primary separator, this is effected through density differences. Sometimes a second stage of treatment, or secondary separator, is required to comply with air and water regulations. A separator is considered "secondary" when all entering wastewater streams have received prior treatment that has removed at least 90 percent of the hydrocarbons.

Covering the separator is the most practical control method for both primary and secondary separators. According to AP-42, covering primary separators can reduce emissions by an estimated 95 percent. Estimates also indicate that covering secondary covers will reduce VOC Emissions by 90 percent. Process modifications and improved process control also can reduce VOC emissions by reducing the quantity of hydrocarbons entering the plant wastewater stream.

The estimated control cost of retrofitting a cover onto a secondary wastewater separator is $225 per ton of VOC controlled with hydrocarbon recovery credits. Because very few refineries have secondary separators there is limited data on control costs, emission reductions, and hydrocarbon credits. Therefore, no VOC emission controls for secondary wastewater separators at petroleum refineries are presented.

1. INTRODUCTION

Over the past several years, the Office of Air Quality Planning and Standards (OAQPS) of the Environmental Protection Agency (EPA), has developed a series of Control Techniques Guidelines (CTGs) for volatile organic compounds (VOCs) to assist state and local agencies in developing regulations for VOC control. Although, the CTGs cover major VOC source categories from an overall nationwide perspective, several source categories that are not covered by CTG documents are major contributors to the ozone problem within given areas.

Air pollution control agencies in the Philadelphia Air Quality Control Region (AQCR) have requested guidance in determining whether VOC controls are available for non-CTG sources and information for use in developing appropriate regulations. Secondary wastewater separators at petroleum refineries comprise one such VOC source category.

1.1 SOURCE DESCRIPTION AND TYPES OF VOC EMISSIONS

A petroleum refinery wastewater separator is a device that separates organic material hydrocarbons from refinery wastewater. The two kinds of wastewater separators used are corrugated plate interceptors (CPIs) and American Petroleum Institute (API) separators. The smaller CPI, which is controlled by a fixed-roof cover, is effective for initial oil-water separation. The API separator has a floating-roof cover.

Contaminated wastewater originates from several sources in petroleum refineries, including leaks, spills, the cooling and flushing of pump and compressor seals sampling, equipment cleaning, and rain runoff. Although some organic contaminants that are immiscible with water can be separated rather easily, other organic constituents may dissolve or form an emulsion that

remains suspended in the water. Chemicals (e.g., ferric chloride) are frequently added to wastewater streams to achieve better separation of water and hydrocarbons.

Primary wastewater separation is often the only treatment required at a refinery. Separation is effected through differences in the densities of water and hydrocarbons. The oil that coalesces and floats on the surface of the water and the sludge that settles to the bottom of the separator are removed. Because the recovered hydrocarbons are processed in the refinery, primary wastewater separation is economically advantageous.[1]

Floating hydrocarbons in wastewater streams have a high surface-to-volume ratio that enhances evaporation and VOC emissions. According to AP-42, uncontrolled emission factors for primary oil/water separators are 5 lb/10^3 gallon (0.6 kg/10^3 liter) of wastewater or 200 lb/10^3 bbl (0.6 kg/10^3 liter) of refinery feed.[2]

The April 1, 1981, AP-42 does not give an emission factor for secondary wastewater separators.[2] An American Petroleum Institute publication estimates potential uncontrolled VOC emissions to be about 10 percent of that sustained in primary wastewater separators, which would be 0.5 lb/10^3 gallon (0.06 kg/10^3 liter) of wastewater processed or 20 lb/10^3 bbl of refinery feed (0.06 kg/10^3 liter).[1]

Because no definition currently exists for secondary separators, for the draft regulations separators will be defined as being "secondary" when all entering streams have received prior gravity separation or equivalent treatment that has removed at least 90 percent of the hydrocarbons. If any stream entering the separator has not received this prior treatment, the separator should be considered a primary separator. According to AP-42 estimates, a covered primary separator gives 95 percent control.[2]

A refinery having an API separator with multiple bays in series may define the first bay as a primary separator, the second bay as a secondary separator, etc. This is appropriate only if the first bay is sized to recover at least 90 percent of the oil entering the separator in the first bay. Otherwise, the whole unit should be considered a primary wastewater separator. A published estimate of the oil recovery from a primary separator at a 100,000 bbl/day refinery is 4,200 to 21,000 gallons/day (15,900 to 79,500 liters per day).[1]

2. EMISSION CONTROL TECHNIQUES

Primary wastewater separators can achieve reasonable control of VOC emissions if the separator is covered to minimize the amount of oily water exposed to the atmosphere. The cover may be either a sealed solid cover or one that floats on the liquid. According to AP-42, covered separators and/or vapor recovery systems achieve 95 percent control and reduce VOC emission rates to 0.2 lb/10^3 gallon (0.024 kg/10^3 liter) of wastewater or 10 lb/10^3 bbl (0.03 kg/10^3 liter) of refinery feed.[2] At least 80 percent of the petroleum refineries currently cover their primary wastewater separators.[3]

Additional control may be obtained by reducing the quantity of hydrocarbons that enter the plant wastewater treatment facility. Such reduction may be possible through improved process control or modifications that reduce the number of leaks, spills, and other upsets. A stringent fugitive leak emission control program can result in up to a 50 percent reduction of VOCs. Adding a CPI to the wastewater system can result in reductions of up to 90 percent in VOC emissions.

Covering the secondary separator is the most practical control method. Although no controlled VOC emission rate for secondary wastewater separators was found, it is estimated that the controlled VOC emission rate will be 10 percent of the uncontrolled rate for secondary separators, or 0.05 lb/10^3 gallon (0.006 kg/10^3 liter) of wastewater processed. Although AP-42 indicates that 95 percent control is achievable for primary separators,[2] only 90 percent control is achieved in most secondary separators because the more volatile, easily separated and recoverable hydrocarbons have already been removed.

3. COST ANALYSIS

This section defines the model plant, explains the assumptions made, and presents a cost analysis for control of VOC from secondary separators at refineries. Cost-effectiveness is expressed in terms of the annual control cost in dollars divided by the annual tons of VOC controlled.

3.1 MODEL PLANTS

Petroleum refineries vary considerably in size, design, age, feedstocks, and product mixes. This report presents an evaluation of retrofit controls to an existing secondary wastewater separator. Because most retrofits have enough unique characteristics to make each one a special case, attempting to cover every situation with a model plant would be impractical. Therefore, this report considers a single case of retrofitting a cover onto a secondary wastewater separator at on oil refinery with a capacity of 150,000 barrel/day (23.8 million liters/day).

3.2 ASSUMPTIONS

The annual costs for all control options include a capital recovery charge and an allowance for property taxes, insurance, and adminstrative costs. A 1977 EPA report discusses costs for primary wastewater separator covers.[4] Costs, which are expressed as a percentage of total capital costs, are:

Capital recovery factor (10-year life and 10% interest rate)	16.27
Property taxes, insurance, and administrative costs	4.00
Operating and maintenance costs	10.00

Since the equipment for covering primary and secondary separators is identical, the same cost factors were used for the latter.

Recovered hydrocarbon credits are based on a price of $23.70/barrel and a density of 8 lb/gallon. The 1977 EPA report used a value equivalent to that of light crude oil (about $32 per barrel).[4] Because the lighter, more valuable, and more easily recovered hydrocarbons have already been recovered in the primary separator, however, it is assumed that the material recovered in a secondary separator would be heavier or would have to be recovered from water emulsions. This would make it more difficult to process and therefore less valuable than the material recovered from the primary separator. The hydrocarbons recovered from a secondary separator are assumed to have a value approximately equivalent to that of No. 6 fuel oil ($23.70 per barrel).[5]

3.3 COSTS

The total capital cost for covering an existing secondary wastewater separator at a refinery producing 150,000 barrels/day is estimated to be $270,000. This is based on the average cost for installing covers on three API separators in 1982 at a refinery producing 430,000 barrels/day (personal communication from C. V. Rice, Amoco Oil Company, February 15, 1983). Costs could be higher, however, when evaluated on a site-specific basis. For example, the cost for covering an API separator at a refinery producing 380,000 barrels/day was $2 million. Installed costs were estimated to be $75 per square foot up to 1000 square feet of covered surface and $35 per square foot for up to 12,000 square feet. The cost of installing a 55,000-ft^2 cover at a refinery producing 380,000 barrels/day was $36.37 per ft^2 (personal communication from B. Roney, Petrex Company, February 16, 1983).

Annual credits for recovered hydrocarbons are estimated to be $31,400. This is based on the AP-42 controlled emission factor of 10 pounds per 1000 barrels of feed for a primary separator 90 percent control in the secondary separator, 330 days of operation per year, and a value of $23.70 per barrel for the recovered hydrocarbons.

Table 1 shows capital and annual costs for retrofitting a cover on a secondary wastewater separator. These represent typical costs; actual costs will vary on a site-specific basis. Estimated net annual costs are $50,300 with hydrocarbon recovery credits.

3.4 COST-EFFECTIVENESS

Based on net annual costs of $50,300 to control 223 tons of VOC emissions or $225 per ton of VOC emissions controlled, covering a secondary wastewater separator may be considered cost-effective from a control agency point of view, as these costs are comparable to VOC control for other source categories (e.g., pneumatic rubber tires).

TABLE 1. CONTROL SYSTEM COSTS FOR SECONDARY WASTEWATER SEPARATORS[a]
(September 1982 dollars)

Annual capital recovery factor (10 year life, 10 percent interest rate)[b]	$43,900
Taxes, insurance, and administrative costs (four percent)[b]	10,800
Operating and maintenance costs (10 percent)[b]	27,000
Total annual cost	81,700
Credit for recovered hydrocarbons	31,400
Net annual cost	$50,300
Tons of VOC controlled	223
Cost per ton of VOC controlled	$225

[a]Capital costs including installation are $270,000.
[b]Reference 4.

4. REGULATORY ANALYSIS

In this report, a wastewater separator is defined as "secondary" when all entering streams have received prior gravity separation or equivalent treatment that has removed at least 90 percent of the VOC. If any stream entering the separator has not received prior treatment, the separator is considered a primary separator and subject to all applicable regulations for primary separators.

Regulation of secondary wastewater separators is not feasible. Although a cost of $225 per ton of VOC controlled is often considered acceptable, the number of refineries with covered secondary separators is not large enough to support regulation of secondary wastewater separators.

Estimates of VOC emissions from secondary separators are based on AP-42 emission factors for primary separators[2] and an API estimate that emissions from secondary separators would be about 10 percent of that from primary separators.[1] In AP-42, the reliability of emission factors is valued on a scale of A to E and 1 to 40 points. The emission factors for primary wastewater separators received a rating of D (below average) and a numerical rating of between 6 and 15 points. A probable range of these emission factors was not estimated. Up to 20 points could have been awarded for measured emission data, up to 10 points for process data, and up to 10 points for engineering analyses. Hence, VOC emission rates from secondary wastewater separators are only estimates. Because the cost of covering a secondary separator is site-specific,[1,4] both the costs and benefits of this VOC emission control are doubtful. If field testing confirms the control costs, emission reductions, and recovered hydrocarbon credits, a regulation might be feasible.

REFERENCES

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5. Value of Residual Oil Relative to That of Crude Oil. Hydrocarbon Processing, October 1982. p. 21.