

APPENDIX C
COST EFFECTIVENESS ANALYSIS
FOR RULE 4695

September 17, 2009

APPENDIX C Cost Effectiveness Analysis

I. INTRODUCTION

The California Health and Safety Code (CH&SC) 40920.6(a) requires the San Joaquin Valley Unified Air Pollution Control District to conduct both an "absolute" cost effectiveness analysis and an "incremental" cost effectiveness analysis of available emission control options prior to adopting each Best Available Retrofit Control Technology (BARCT) rule. The purpose of conducting a cost effectiveness analysis is to evaluate the economic reasonableness of the pollution control measure or rule as it applies to operators in the San Joaquin Valley Air Basin. The analysis also serves as a guideline in developing the control requirements of a rule.

II. SUMMARY AND CONCLUSION

Wine Aging

An emissions capture and control system consisting of a Permanent Total Enclosure (EPA Method 204) and an emissions control device (regenerative thermal oxidizer) was found to offer a cost effectiveness of \$26,700 per ton for wine aging operations with uncontrolled Potential to Emit of 30 tons-ethanol per year or more. Since thermal oxidation offers a VOC destruction efficiency (98%) which is greater than that of the other available control technology options, an incremental cost effectiveness analysis was not applicable.

Brandy Aging

An emissions capture and control system consisting of a Permanent Total Enclosure (EPA Method 204) and an emissions control device (regenerative thermal oxidizer) was found to offer a cost effectiveness of \$24,600 per ton for brandy aging operations with uncontrolled Potential to Emit of 4 tons-ethanol per year or more. Since thermal oxidation offers a VOC destruction efficiency (98%) which is greater than that of the other available control technology options, an incremental cost effectiveness analysis was not applicable.

III. COST EFFECTIVENESS ANALYSIS

Introduction

District staff used available technical and cost information contained in technical reports, EPA's Air Pollution Control Cost Manual, District permit files for existing brandy aging operations and information supplied by equipment manufacturers and the wine and brandy aging industry to conduct a cost effectiveness analysis of the proposed requirements of Rule 4695.

A previous review of the available VOC control technologies has indicated that the following would be potentially applicable to the control of ethanol emissions from wine and brandy aging operations:

1. Thermal Oxidation (conversion of the VOC to CO₂) – 98% Control Efficiency (CE)
2. Catalytic Oxidation (conversion of the VOC to CO₂) – 95% Control Efficiency (CE)
2. Absorption ("scrubbers", which transfer the VOC in air emissions to a liquid waste stream) – 90% CE
3. Adsorption (often using activated carbon, which transfers the VOC in the air onto a solid substrate) – 95% CE
4. Condensation (conversion of the VOC gases into liquids) – 90% CE
5. Biological control systems (e.g., bio-filters or bio-scrubbers) – 90% CE

While any of the above technologies could potentially be applied for control of VOC emissions from wine and brandy aging facilities, this cost effectiveness analysis will be based only on the use of regenerative thermal oxidation (RTO) technology due to:

- All existing brandy aging facilities in the San Joaquin Valley which have been modified to install controls have used RTO technology. As of the date of this analysis, six brandy aging warehouses in the District, which represent in excess of 95% of the brandy aging capacity in the San Joaquin Valley, have been retrofit with RTO-based VOC controls.
- The wine and brandy aging industry in the San Joaquin Valley has indicated a preference for RTO technology for both wine and brandy aging operations and all cost information which has been supplied by the industry to support this analysis is based on use of an RTO.
- Thermal and catalytic oxidation, condensation, and biological control were previously found to offer similar cost effectiveness in this application while absorption and adsorption were found to be significantly more expensive due to operating costs associated with either waste water disposal or regeneration of spent activated carbon. In general, it has been found that the cost effectiveness analysis is relatively insensitive with respect to selection of the control device largely due to the significant costs associated with the PTE, ducting, induced draft

SAN JOAQUIN VALLEY UNIFIED AIR POLLUTION CONTROL DISTRICT

fan, instrumentation and other scope items which are independent of the control technology selection. No control technology was found to offer better cost effectiveness than RTO technology largely due to its low operating cost (high thermal efficiency). Therefore, the evaluation can be based on RTO technology without a loss of generality.

- An RTO provides the highest thermal efficiency and lowest collateral emissions of NO_x and greenhouse gases when compared to other types of thermal oxidation systems.

In addition, all potential control options listed above are classified as capture and control systems and therefore all share a common requirement for a capture system consisting of an enclosure for the barrel aging operation, ducting and an induced draft fan to deliver the captured emissions from the enclosure to the control device. Based on the existing brandy storage operations currently operating within the District, an enclosure that meets the criteria for a Permanent Total Enclosure (PTE), pursuant to U.S. EPA Method 204, is considered to be an Achieved-in-Practice capture system for wine and brandy aging. By definition the capture efficiency for a PTE is considered to be 100%. However, since wine and brandy aging operations (and their emissions) are a continuous 24 hour/day operation throughout the year, it would be difficult and expensive to continuously maintain the warehouse in "PTE" status due to on-going requirements to transport product into and out of the warehouse and due to requirements for maintenance during which the warehouse must be opened or the control device must be shut down. During such periods, uncontrolled emissions are delivered to the atmosphere in the absence of expensive air lock systems and redundant control devices.

As mentioned above, all existing brandy aging facilities in the District utilize an RTO for the control device. Additionally, based upon existing brandy aging operations currently permitted in the SJV, the District has determined that a PTE in this application can achieve an on-line availability of 95%, i.e., access and maintenance requirements will not exceed 5% of the total operating time for the warehouse. Annual downtime for control device maintenance is potentially 10 days per year during which time the emissions are also uncontrolled. Overall capture and control efficiency (CCE) is thus calculated as:

$$\text{CCE} = \text{CE} \times (\text{days on-line per year}) \div (\text{total days per year})$$

$$\text{CCE} = \text{CE} \times (365 - 10 - 5\% \times (365 - 10)) \div 365 = \text{CE} \times 92\%$$

Since this analysis will only consider thermal oxidation, CE = 98%. Therefore,

$$\text{CCE} = 98\% \times 92\% = 90.2\%$$

Basis and Assumptions

The following are assumptions used for the cost effectiveness analysis:

1. Existing wine and brandy aging operations are assumed to be conducted in 59 and 50 gallon wooden barrels respectively, stored in dedicated warehouses. The warehouse construction typically features concrete tilt-up walls with insulated wood-frame roof covered with composition roofing. The warehouse space is commonly conditioned with refrigerated air conditioning and humidification to minimize evaporative loss during the aging process.
2. Wine loss from barrel storage is 1.4% per year for wine aging warehouses with conditioned storage space based on data provided by industry. Average ethanol content is assumed to be 14 vol% yielding an emission factor of 0.764 lb-VOC per 59 gallon barrel per year.
3. The emission factor for brandy aging is 9.93 lb-VOC per barrel per year based on an average loss of 3 proof gallons per year per 50 gallon barrel for permitted facilities in the SJV and 3.31 lb-ethanol per proof gallon.
4. The Total Capital Investment (TCI) for installation of controls on wine or brandy aging operations is based on the following scope:
 - Modify an existing warehouse to convert it to a PTE for wine or brandy aging.
 - Install a control device equipment package consisting of the control device, a variable speed controlled induced draft fan, and stack with associated interconnecting ducting, controls and instrumentation.
 - Install ducting as required for collection of emissions and connection of the PTE to the control device package.
5. Warehouse size in square feet, as a function of the number of barrels stored, was determined based on the typical existing warehouse floor space versus barrel capacity for brandy aging operations currently permitted by the District. Based on typical industry practice, it was assumed that wine barrels are stored in metal racks in horizontal position and stacked up to 6 barrels high. For brandy, the barrels are palletized and stacked vertically up to six barrels high. A wine aging warehouse with an uncontrolled Potential to Emit of 30 tons per year was determined to consist of a 150,800 square feet warehouse space housing 78,493 barrels (59 gallons each). A brandy aging warehouse with an uncontrolled Potential to Emit of 4 tons per year was determined to consist of a 2,940 square feet warehouse space housing 806 barrels (50 gallons each).
6. Determination of the required air flow capacity per square foot of warehouse space (for estimation of electricity and fuel consumption) was made based on rated air flow

SAN JOAQUIN VALLEY UNIFIED AIR POLLUTION CONTROL DISTRICT

capacities of existing brandy aging facilities currently permitted by the District. Since the air rate is primarily set by the ability to seal the existing structure to minimize the air flow, the rated capacities as determined from the brandy operations are assumed to be applicable to wine aging as well. Using typical values, rated air flow for a 150,800 ft² warehouse was estimated at 9,950 scfm (66 scfm/1000 sq ft). Rated air flow for a 2,940 ft² warehouse was estimated at 280 scfm (95 scfm/1000 sq ft).

5. The actual detailed scope and the associated actual Total Capital Investment which was required for a previous conversion of two large existing brandy aging warehouses to PTE's and the installation of RTO-based controls on these warehouses was provided to the District by the Wine Institute as confidential information. District staff applied the "six tenths factor rule" (a commonly used estimating technique) to the industry supplied cost data to estimate the Total Capital Investment required for the specific size of operations being evaluated. Per the "six-tenths-factor rule", if a new piece of equipment is similar to one of another capacity for which cost data are available, the cost of the new unit with X times the capacity of the first is approximately $(X)^{0.6}$ times the cost of the initial unit:

$$\text{Cost of equip. } A = \text{cost of equip. } B \left(\frac{\text{cap. of equip. } A}{\text{cap. of equip. } B} \right)^{0.6}$$

Applying this equation to the two cases in this analysis yields:

$$\text{TCI (150,800 ft}^2\text{)} = \$2,469,400 \times (150,800 \text{ ft}^2 / 155,600 \text{ ft}^2)^{0.6} = \$2,423,400$$

$$\text{TCI (2,940 ft}^2\text{)} = \$2,469,400 \times (150,800 \text{ ft}^2 / 2,940 \text{ ft}^2)^{0.6} = \$228,200$$

6. Annual Cost was estimated in accordance with the cost estimation template provided in the EPA Control Cost Manual, Table 2.10 with the following exceptions:
 - Unit costs given in Table 2.10 for labor were escalated to 2009 at a rate of 3% per year.
 - Annual maintenance cost was estimated at 3% of TCI based on typical ranges given by Peters & Timmerhaus¹.
7. The Capital Recovery Factor is 0.163 based on 10-year amortization at 10% annual interest rate.
8. Electricity cost was calculated for the energy consumption by the induced draft fan, based on the rated flow of the RTO, a pressure differential of 10 "WC, fan efficiency of 65% and electric motor efficiency of 90%. A unit price of \$0.12 per kWh was applied based on published average rates for California.

¹ Peters, Max and Klaus Timmerhaus, Plant Design and Economics for Chemical Engineers, McGraw-Hill, New York, 1968, p. 132.

SAN JOAQUIN VALLEY UNIFIED AIR POLLUTION CONTROL DISTRICT

9. Natural gas requirements were estimated based on the following:
 - The RTO operates at 1,400 °F
 - Thermal efficiency is 95%
 - Ethanol is assumed to provide 50% of the thermal requirements for brandy operation and 8% is assumed for wine operations.
 - Natural gas is priced at \$8.00/MMBtu based on the average published NYMEX Henry-Hub price for 2008.

Cost Effectiveness Analysis

Table 1 presents the evaluated Total Capital Investment (TCI), Annual Cost and the Cost Effectiveness each for the wine and brandy operations. As shown, a cost effectiveness of \$26,700 per ton is applicable to the installation of VOC controls on a wine aging warehouse with an uncontrolled Potential to Emit of 30 tons per year. A cost effectiveness of \$24,600 per ton is applicable to the installation of VOC controls on a brandy aging warehouse with an uncontrolled Potential to Emit of 4 tons per year.

Table 1

Cost Effectiveness for Wine and Brandy Aging Warehouses		
Case	Wine Aging Warehouse	Brandy Aging Warehouse
Uncontrolled PE, tons per year	30.0	4
Warehouse Size ft2	150,800	2,940
Barrel Aging Capacity (bbls)	78,493	806
<u>Total Capital Investment (TCI)</u>	\$2,423,400	228200
<u>Direct Annual Costs</u>		
Operating Labor (0.5 hr/shift @ \$28.35/hr)	\$15,500	\$15,500
Supervision @ 15%	\$2,300	\$2,300
Operating Materials @ 15% of maintenance	\$10,900	\$1,000
Maintenance @ 3% of TCI	\$72,700	\$6,800
<u>Utilities</u>		
Natural Gas	\$48,700	\$700
Electricity	\$21,000	\$600
Total Direct Cost (TDC)	\$171,100	\$26,900
<u>Indirect Annual Cost</u>		
Overhead @ 60% of Operating Labor and Maintenance	\$60,800	\$15,400
Administrative Charges, 2% TCI	\$48,500	\$4,600
Property Tax, 1% TCI	\$24,200	\$2,300
Insurance, 1% TCI	\$24,200	\$2,300
Capital Recovery (CRF = 0.163)	\$395,000	\$37,200
Total Indirect Annual Cost (TIAC)	\$552,700	\$61,800
Total Annual Cost (TDC + TIAC)	\$723,800	\$88,700
Destruction Efficiency %	90.2%	90.2%
Annual Emissions Reduction - tons	27.06	3.61
Cost Effectiveness (\$ per ton)	\$26,700	\$24,600