

LIBRARY-AIR RESOURCES BOARD

LIBRARY  
CALIFORNIA AIR RESOURCES BOARD  
P.O. BOX 2815  
SALVAMENTO, CA 95812

TECHNICAL REVIEW GROUP

A SUGGESTED CONTROL MEASURE FOR  
CONTROL OF ETHANOL EMISSIONS FROM WINERY  
FERMENTATION TANKS

TECHNICAL SUPPORT DOCUMENT

Prepared by:  
Energy Section  
Strategy Assessment Branch  
Stationary Source Division  
Air Resources Board, State of California  
for the  
Technical Review Group  
at its request

Principal Investigators:  
Nelson Chan  
Susan Kaiser  
Linda Lee

Approved by the Technical Review Group on October 7, 1986

This report has been reviewed by the staff of the California Air Resources Board and approved for publication. Approval does not signify that the contents reflect the views and policies of the Air Resources Board, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

## TABLE OF CONTENTS

|                                                                                             | <u>PAGE</u> |
|---------------------------------------------------------------------------------------------|-------------|
| I. <u>INTRODUCTION</u>                                                                      | 1           |
| II. <u>BACKGROUND</u>                                                                       | 3           |
| III. <u>CONCLUSIONS</u>                                                                     | 6           |
| IV. <u>RECOMMENDATION</u>                                                                   | 8           |
| V. <u>DESCRIPTION OF THE FERMENTATION PROCESS AND<br/>EMISSIONS FROM FERMENTATION TANKS</u> | 9           |
| A. DESCRIPTION OF THE FERMENTATION PROCESS<br>AND ASSOCIATED OPERATIONS                     | 9           |
| B. EMISSIONS FROM FERMENTATION TANKS                                                        | 15          |
| VI. <u>ETHANOL EMISSION CONTROL AND ITS COST</u>                                            | 24          |
| A. ASSESSMENT OF CONTROL TECHNOLOGY                                                         | 24          |
| B. EMISSION REDUCTIONS                                                                      | 38          |
| C. COSTS AND COST-EFFECTIVENESS OF CONTROL STRATEGIES                                       | 42          |
| VII. <u>PROPOSED SUGGESTED CONTROL MEASURE</u>                                              | 54          |
| A. SUGGESTED CONTROL MEASURE TEXT                                                           | 54          |
| B. SUMMARY OF SUGGESTED CONTROL MEASURE                                                     | 61          |
| C. DISCUSSION                                                                               | 63          |
| VIII. <u>COMMENTS AND RESPONSES</u>                                                         | 67          |
| SECTION I                                                                                   |             |
| A. GENERAL COMMENTS                                                                         | 67          |
| B. DUCTING SYSTEM                                                                           | 71          |
| C. CONTROL EQUIPMENT                                                                        | 78          |
| D. COMMENTS ON COST-EFFECTIVENESS                                                           | 84          |

|                                                                       | <u>PAGE</u> |
|-----------------------------------------------------------------------|-------------|
| SECTION II                                                            |             |
| A. GENERAL COMMENTS                                                   | 85          |
| B. DUCTING SYSTEM                                                     | 91          |
| C. CONTROL EQUIPMENT                                                  | 94          |
| D. COMMENTS ON COST-EFFECTIVENESS                                     | 105         |
| IX. <u>IMPACTS OF THE PROPOSED SUGGESTED CONTROL MEASURE</u>          | 108         |
| A. EMISSION REDUCTIONS                                                | 108         |
| B. OTHER ENVIRONMENTAL IMPACTS                                        | 108         |
| C. ECONOMIC IMPACT                                                    | 111         |
| X. <u>REFERENCES</u>                                                  | 113         |
| <u>APPENDICES</u>                                                     |             |
| A. METHODS OF COMPUTING COSTS FOR CONTROLS                            |             |
| B. STORAGE REQUIREMENTS FOR THE ETHANOL/WATER PRODUCT                 |             |
| C. CALCULATION OF TANK OPENING FOR DUCTING OF<br>FERMENTATION EXHAUST |             |
| D. SOURCE TEST METHOD                                                 |             |
| E. CONSULTATION MEETING NOTICES AND REQUESTS FOR COMMENTS             |             |
| F. COMMENTS RECEIVED FROM WINE INDUSTRY MEMBERS                       |             |
| G. OTHER CORRESPONDENCE                                               |             |
| H. NOTICE OF PUBLIC MEETING                                           |             |

## I. INTRODUCTION

This report is the Technical Support Document for a suggested control measure (SCM) to reduce ethanol emissions from winery fermentation tanks located in California air basins where air quality levels approach or exceed standards for ozone. The purpose of this SCM is to serve as a guideline for air pollution control districts which contain wineries and which have identified the need to control ethanol emissions from these sources. Currently, no rules exist for the purpose of limiting winery ethanol emissions.

Suggested control measures are developed by members of the Statewide Technical Review Group (TRG) for use by local air pollution control districts and air quality management districts in reducing emissions for the purpose of attaining the state and federal ambient air quality standards. The TRG is composed of technical representatives of the air pollution control and air quality management districts in California, the U.S. Environmental Protection Agency, and the Air Resources Board (ARB). The TRG has compiled a list of proposed suggested control measures and has designated a lead agency for developing each. The Fresno County Air Pollution Control District (Fresno County APCD) was at first designated the lead agency for the development of the winery fermentation SCM. The Fresno County APCD presented a draft SCM to the TRG recommending temperature control as the most cost-effective method of reducing ethanol emissions. Upon receiving that draft SCM, the TRG requested more detailed analyses of alternative control methods. At the request of the Fresno County APCD representative, the TRG appointed the ARB as the new lead agency, due to the lack of staff resources in the Fresno district.



The lead agency is responsible for holding consultation meetings, gathering data, writing a Technical Support Document, and presenting the suggested control measure to the TRG for its approval. If the TRG approves the suggested control measure, it is then considered for approval at a public meeting of the Air Resources Board. If the Board approves the measure, the measure is forwarded to the air pollution control and air quality management districts for their consideration of adoption.

The air quality management plan for the Fresno County APCD has identified the control of ethanol emissions from winery fermentation tanks as a measure necessary for the achievement and maintenance of state and federal standards for ozone. The need for such a measure is based on an air quality analysis conducted as part of the planning process. In addition, the air quality management plan for the Kern County Air Pollution Control District includes the control of winery fermentation tank emissions as a further study measure, to be implemented if needed for further ozone reductions. The SCM discussed in this staff report may be applicable to other districts which contain wineries and which are in need of ozone reductions.

To gather data for the development of this SCM, the ARB staff conducted a consultation meeting, visited several of the largest wineries in the state, met with wine industry representatives as a follow-up to the consultation meeting, participated in a workshop conducted by the TRG, and had many individual discussions with winery technical staff and equipment vendors. In addition, the staff reviewed information compiled by the Fresno County APCD staff.

This Technical Support Document discusses the wine making process and estimated emissions, available control technology, potential emission reductions, the suggested control measure, estimated costs, and potential adverse environmental and other impacts associated with the proposed SCM.

## II. BACKGROUND

Ethanol losses from winery fermentation operations were identified as significant sources of oxidant precursors in the San Joaquin Valley Air Basin in 1978.<sup>1/</sup> The ARB began investigation of winery ethanol emissions later that year, conducting source tests of fermentation tank exhaust gases at E. & J. Gallo Winery in Fresno.<sup>2/</sup> In 1980, the ARB performed further source testing at United Vintners (now Heublein Wines) in Reedley.<sup>3/</sup> The ARB also contracted the EAL Corporation to perform source testing of fermentation tanks at several different wineries in 1982.<sup>4/</sup>

In 1980, the TRG appointed the Fresno County APCD as the lead agency for developing a winery SCM. During that same year, the district staff conducted a survey of San Joaquin Valley wineries.<sup>5/</sup> The data reported included fermentation tank characteristics, total throughput by tank size and type of wine produced, and fermentation temperatures.

In 1982, the Fresno County APCD presented a draft SCM to the TRG for the control of ethanol emissions from winery fermentation tanks.<sup>6/</sup> The SCM would have required installation of control equipment that would reduce ethanol emissions by 90 percent on all fermentation tanks with a capacity of 100,000 gallons or more. The accompanying staff report recommended condensation as the most cost-effective control technology. In response to that proposed rule, the Wine Institute, an organization representing over 80 percent of the wineries in California, prepared an alternative proposal based on temperature control of the fermentation tanks.<sup>7/</sup> The basis for the Wine Institute proposal is the relationship between fermentation temperature and ethanol emissions - the higher the fermentation temperature, the more ethanol

is emitted. Under the Wine Institute proposal, weighted average fermentation temperatures for red wine would have been reduced from 85°F to 80°F during the 10-year period from 1985 to 1995; white wine fermentation temperatures would have been reduced from 65°F to 55°F in the same 10-year period. Overall emission reductions were estimated to be 71 percent from the baseline year of 1977, when average fermentation temperatures were reported to be 90°F for red wine and 80°F for white wine. The estimated reductions were also based on the relative production of red and white wine. Red wine has decreased in popularity since 1977, when it held 30 percent of the table wine market. By 1984, red wine had dropped to 15 percent of the market. Since red wine is fermented at higher temperatures than white wine, overall emissions decrease if less red wine is produced.

In December, 1985, Fresno County APCD staff presented a revised SCM to the TRG recommending temperature control as the most cost-effective method of ethanol emission control. The SCM required fermentation temperatures of 80°F for red wine and 55°F for white wine by 1990. The TRG, upon reviewing the proposed rule, requested that the cost estimates be evaluated by the ARB staff. The staff prepared detailed cost estimates for the various control technologies. That cost analysis showed that temperature control was not the most cost-effective method of control. Those revisions were presented to the TRG in February, 1986. Due to the lack of staff resources in the Fresno County district, the TRG then requested that the ARB take over as the lead agency in the further development of the staff report and SCM.

At an April 8, 1986, consultation meeting, the ARB staff presented the cost estimates and revised emission estimates, together with a proposed SCM, to the wine industry and other interested persons. At the conclusion of the

meeting, the ARB staff was invited to tour several different San Joaquin Valley wineries to see plant layout and operations unique to each. On April 21, ARB staff visited Gallo, Heublein Wines, Guild-Cribari, and Christian Brothers, the four largest wineries in the San Joaquin Valley. A follow-up meeting attended by Wine Institute and other wine industry representatives was held at Heublein Wines the next day, during which the ARB staff presented detailed schematics of the ducting system which the industry had requested at the April 8 meeting. At that time, the ARB staff learned that an additional 35 percent tank capacity was required as excess working capacity within each tank farm grouped for exhaust gas ducting to a control device. This requirement necessitated revision of the ARB cost estimates for the ducting system.

This Technical Support Document includes revised emissions and cost estimates, as well as descriptions of control technologies not available at the April 8 meeting. The wine industry's comments on the material presented at that meeting have been summarized and the ARB staff responses included. Finally, a revised SCM, including a demonstration program to establish the feasibility of 90 percent control, is presented.

A draft of this report was mailed to industry representatives on July 24; comments on the report and on the staff's previous responses have been summarized and the staff responses included in an expanded comments and responses section.

### III. CONCLUSIONS

Based on the information presented in this report, the TRG concludes that:

1. Winery fermentation tanks in the state emitted a total of 657 tons of ethanol in 1985, or 5.5 tons per day on a 120-day season basis (mid-August through mid-December). Fermentation tanks in the San Joaquin Valley Air Basin, where 82 percent of the state's wine is produced, emitted a total of 539 tons of ethanol in 1985, or 6.7 tons per day during the 80-day fermentation season which lasts from mid-August through early November in that air basin.

2. Ethanol emissions from fermentation tanks can be reduced by at least 90 percent using commercially available emission control equipment. The staff has evaluated four different exhaust control technologies: carbon adsorption, condensation, incineration, and scrubbing. Each requires a ducting system to channel the exhaust gases from a group of fermentation tanks to a control device. Overall estimated emissions reductions for the San Joaquin Valley Air Basin were 80 percent, when allowances for exempted tanks were considered. Temperature control also was evaluated, but was estimated to reduce overall emissions in that air basin by only seven percent.

3. The overall cost to the wine industry and the overall weighted cost-effectiveness of the control technologies cannot be determined because of the lack of detailed information on each of the wineries located in the state. Instead, costs and cost-effectiveness were estimated for specific groupings of tanks and types of wine. Each winery would group its tanks differently on a case-by-case basis. These groupings would determine the cost-effectiveness for each winery.

4. The capital cost for red wine emissions control is higher than that of white wine due to higher flow rates and emissions. However, the cost-effectiveness of red wine control is considerably better because emission reductions are greater than for white wine.

5. Of the four exhaust control technologies, capital costs are lowest for scrubbing and highest for catalytic incineration. Costs per unit decrease with increasing tank size and tank farm size. With temperature control, costs are proportional to load and there is no economy of scale. Capital costs of temperature control are lower than those of each of the exhaust control methods.

6. Of the four exhaust control technologies, cost-effectiveness is best for scrubbing and poorest for condensation. Cost-effectiveness also varies with tank size, tank farm size, and wine type. Cost-effectiveness of exhaust control ranges from \$1.15 per pound of ethanol removed to approximately \$14.00 per pound. Temperature control has a cost-effectiveness of \$4.00 to \$4.50 per pound of ethanol removed. For red wine, exhaust controls generally exhibit better cost-effectiveness than temperature control. For white wine, temperature control is more cost-effective than exhaust control in approximately 60 percent of the cases. However, because of the minimal overall emission reductions achieved with temperature control, its choice as a control technology is not recommended.

7. Application of control equipment to reduce ethanol emissions would cause a negligible adverse environmental impact.

8. To allow time to eliminate any unforeseen difficulties with the installation and operation of the exhaust control system, the proposed SCM provides for demonstration and pilot programs to be conducted during the 1988 fermentation season. Depending on the results of the demonstration and pilot programs, the 90 percent control requirement of the SCM may be modified.

#### IV. RECOMMENDATION

Based on the conclusions and discussion presented in this report, the TRG recommends that the Board endorse the proposed "Suggested Control Measure for Control of Ethanol Emissions from Winery Fermentation Tanks." It is further recommended that the approved suggested control measure be forwarded to those air pollution control districts in the state which have wineries and which are in need of further ozone reductions, with the recommendation that the approved control measure or a measure of equivalent effectiveness be considered for adoption by those districts. Because air pollution control needs vary among districts, the districts may wish to modify the requirements of the SCM as necessary.

V. DESCRIPTION OF THE FERMENTATION PROCESS AND EMISSIONS FROM FERMENTATION TANKS

A. DESCRIPTION OF THE FERMENTATION PROCESS AND ASSOCIATED OPERATIONS\*

1. General Winery Operations

Grapes for wine production in California are harvested from as early as mid-August in the interior valley to as late as December along the central coast. As the grapes ripen, sugar content increases and acidity decreases. The most commonly used indicator of maturity is the degree Brix, a measure of the sugar content of the juice expressed as total soluble solids. For the best quality wines, grapes must be harvested at optimum maturity. For red wine production, 22<sup>0</sup> Brix is considered minimum. White wine grapes are usually harvested at a lower degree Brix, between 20<sup>0</sup> and 21<sup>0</sup>, while grapes for dessert wine production are harvested at 23<sup>0</sup> to 26<sup>0</sup> Brix.

Harvested grapes are received by gondola truck from the vineyard and conveyed to a crusher stemmer which separates the grapes from the stems and ruptures the skins. (Some wineries perform the crushing operations in the vineyard and transport the crushed fruit to the winery.) From 75 to 150 mg/L of liquefied SO<sub>2</sub> is added to the crushed grape mass to control wild yeasts and spoilage bacteria. Dilution with water is permissible within certain limits to bring down the sugar content of overripe grapes, but the practice is avoided by most wine makers.

\*This information has been summarized from Amerine et al., 1/ Martini, 2/ and Skofis.3/



In red wine production, the entire mass of juice, skins, pulp, and seeds (referred to as the "must") is pumped into a fermentation tank and inoculated with yeast. Red wines are fermented for two to five days with the skins for maximum color and tannin extraction. After this period, the juice is drained from the mass of skins, pulp, and seeds (the "pomace") and pumped to storage tanks where fermentation is completed. Rose wines are fermented with the skins for 24 to 36 hours before the juice is separated. In white wine production, the pomace and juice are separated before inoculation with yeast and only the juice is fermented. A fermenting batch of juice is also called must by the wine industry. Hence, the term "must" can refer either to the mixture of juice, skins, pulp, and seeds in red and rose wine fermentation, or simply to the juice in white wine fermentation.

After the pomace is separated from the juice, it is conveyed to a press. The juice from the press is normally fermented for use as a blending wine since it is of lower quality than the "free-run" juice from the crusher stemmer. The remaining solids are either washed with water to extract any alcohol or grape sugar for distilling material or discarded. Some large wineries spread the pomace onto nearby land where it is dried and then sold as cattle feed.

The amount of time required for complete fermentation is a function of fermentation temperature. At 55°F to 60°F, wines are fermented in seven to 10 days, while at 75°F to 80°F, wines take from three to six days to ferment. If fermentation is allowed to proceed uninterrupted, all of the sugar will be converted to ethanol. If sweeter wines are desired, fermentation is arrested by chilling and centrifugation or clarification and filtration to remove the yeast. This process allows some of the unconverted sugar (residual sugar) to remain in the wine.

After fermentation to the desired degree of dryness, the wine is racked (drawn off) from the "lees" or sediment of yeast, pulp, tartrates, etc. at the bottom of the tank. The wine is then transferred to another tank and clarified with a fining agent such as bentonite or gelatin. After settling for a few weeks, the wine is racked again, filtered, and transferred to storage tanks filled to the top. Many wineries centrifuge the wine after the first racking. White wines are also often centrifuged before fermentation. The lees are used (either on-site or sold) as distilling material in the production of brandy.

The above is a summary of table wine production. By law, table wine cannot contain more than 14 percent alcohol. The alcohol content of a finished wine is related to the initial sugar content of the grape juice. An estimate of the final alcohol content can be obtained by multiplying the degree Brix by .55. Thus, grape juice of 21<sup>0</sup> Brix will yield wine with an alcohol content of 11.55 percent, assuming complete fermentation.

In addition to table wines, a number of other wine types are produced: sparkling wines, "special natural" wines, wine coolers, vermouth, dessert wines, and brandy.

Sparkling wine (wine with a visible excess of CO<sub>2</sub>) is made from blended table wine which is inoculated with yeast, sugared, and fermented a second time under pressure. "Special natural" wines are table wines flavored with fruit juices, spices, etc. They are classified according to alcohol content - either greater than 14 percent or equal to or less than 14 percent. Wine coolers are a new category of special natural wines, usually diluted with fruit juice to approximately 6 percent alcohol.

Vermouth and dessert wines are fortified wines, that is, wines to which wine spirits (see below) are added to increase the alcohol content. Vermouth is made from dry table wine fortified to 15 to 21 percent alcohol and flavored with a mixture of spices and herbs. Dessert wines are commonly produced by arresting fermentation at about 12.5<sup>0</sup> to 14<sup>0</sup> Brix to maintain sweetness and adding wine spirits to bring the alcohol content up to 18 to 21 percent. The partial fermentation usually takes from 24 to 48 hours. Some wineries prefer to ferment the wine to dryness before fortification, sweetening it with grape concentrate. Grape concentrate is produced by processing grape juice in a vacuum concentrator. California law forbids the use of sugar to sweeten dessert wines.

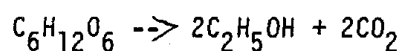
Sherries are also considered dessert wines, although dry sherry is typically consumed as an aperitif. The must is usually fermented to completion, after which the alcohol content is adjusted to 17 to 18 percent by the addition of wine spirits. The wine is then baked for nine to 20 weeks at temperatures of 130<sup>0</sup>F to 140<sup>0</sup>F. The sweeter types of sherry are produced by blending in appropriate amounts of angelica or white port, preferably after baking.

Brandy and wine spirits are both produced by distillation. Brandy is made from wine distilled at 160<sup>0</sup> to 170<sup>0</sup> proof and diluted with distilled water to 80<sup>0</sup> to 120<sup>0</sup> proof (40 to 60 percent alcohol) before aging and bottling. Brandy is measured in terms of "proof gallons," one proof gallon being the equivalent of one gallon of liquid containing 50 percent alcohol.

Wine spirits for use in vermouth and dessert wines are distilled at 185° proof. Wine spirits may be made by distilling wine, or fermented pomace washings, or fermented lees.

## 2. The Fermentation Process

Alcoholic fermentation is the metabolic process in which sugar is converted to ethanol and carbon dioxide by yeast. Gay-Lussac first reported the equation for alcoholic fermentation in 1815:



The theoretical yield of ethanol is 51.1 percent by weight of the glucose fermented, but empirical results show yields to be about 45 to 50 percent, which is 90 to 95 percent of the theoretical. This is because not all of the glucose consumed by the yeast is converted to ethanol and CO<sub>2</sub>; some is converted to yeast cell substance and other products. Moreover, some ethanol is lost through evaporation.

Fermentation is an exothermic (heat generating) process. Heat generated by fermentation and not trapped in useable form (waste heat) is manifested as an increase in temperature of the fermenting must. In a very small container, this heat is radiated to the environment, but in large or insulated fermentors there is a 2.3°F temperature rise per degree Brix drop during fermentation, and refrigeration must be applied to control the temperature. At 95°F, yeast is greatly weakened and at 100 to 105°F, most of it dies or is inactivated. Therefore, as the temperature approaches 85°F, cooling should be initiated and the must cooled by 10°F or more. (Cooling methods are discussed in Chapter VI.)

Red wines are fermented at warmer temperatures partly to enhance color extraction from the skins. For the best flavor and bouquet,

the temperature should not be allowed to rise above 85<sup>0</sup>F. In white wine fermentation, recommended temperatures are between 50<sup>0</sup>F and 60<sup>0</sup>F; temperatures above 80<sup>0</sup>F yield lesser quality wines. In both red and white wines, temperatures above the recommended maximum cause losses of aromatic constituents, lowered alcohol yield, and reduced yeast efficiency. Higher temperatures also promote the growth of bacteria and other spoilage organisms.

Most wine makers record both degree Brix and temperature two to three times daily in order to monitor the progress of fermentation and determine when to apply cooling. During red wine fermentation, the skins, pulp, and seeds rise to the surface and form a pomace cap one to several feet thick. Temperatures can be up to 18<sup>0</sup>F higher in the cap than in the liquid, and fermentation within the cap is extremely rapid. To promote the extraction of color and tannins, the cap must be submerged or pumped over from one to 10 times a day. In larger wineries, the juice is usually drawn from the bottom of the tank and pumped over the cap, but in smaller wineries the cap may be punched down manually.

According to wine industry personnel, if the temperature of a fermenting must is not carefully controlled, the juice may "foam over" and erupt through the manhole or vent in the top of the tank, apparently with considerable force. Some wineries then use anti-foaming agents to arrest the formation of foam.

Fermentation is usually conducted in stainless steel, mild steel, or concrete tanks, although some small wineries still use oak or redwood fermentors. A survey of fermentation tank characteristics by the

Fresno County APCD showed the breakdown of various tank types used in the San Joaquin Valley to be as follows: stainless steel, 54%; concrete, 27%; mild steel, 12%; and redwood, 7%.<sup>4/</sup> Tank capacity ranged from 500 to 615,000 gallons. Seventy-two percent of the tanks over 50,000 gallons are stainless steel or mild steel.

Roughly 80 percent of the tanks are closed-top with vents ranging from two inches to four feet in diameter. Of the tanks of 50,000 gallons capacity or above, 98 percent are closed-top.

#### B. EMISSIONS FROM FERMENTATION TANKS

##### 1. Ethanol Emissions and the Fermentation Process

It has long been recognized that losses of ethanol occur during fermentation and that such losses are related to the sugar content of the grapes and fermentation temperature.<sup>5,6/</sup> Until recently, the mechanism of ethanol loss was poorly understood. Early authors considered entrainment of liquid droplets of ethanol in escaping CO<sub>2</sub> bubbles to be significant, but more recent work has indicated that evaporation is the major cause of ethanol loss.<sup>7,8/</sup> Droplets are formed and leave the surface of the fermenting must, but they either impinge on the top and sides of the tank or fall back into the liquid within a second or less. The upward velocity of the CO<sub>2</sub> gas is not sufficient to sweep out the droplets. The only important mechanism for ethanol loss is the partial pressure of the ethanol in the aqueous phase.

A computer model has been developed to predict evaporative ethanol loss under any set of fermentation conditions.<sup>8/</sup> A graphical representation of the model, showing the relationship between ethanol

emissions, degree Brix, and fermentation temperature, is shown in Figure V-1. The graph shows that ethanol losses increase exponentially as fermentation temperatures increase, and the higher the initial degree Brix and the amount of sugar utilized, the greater will be the loss.

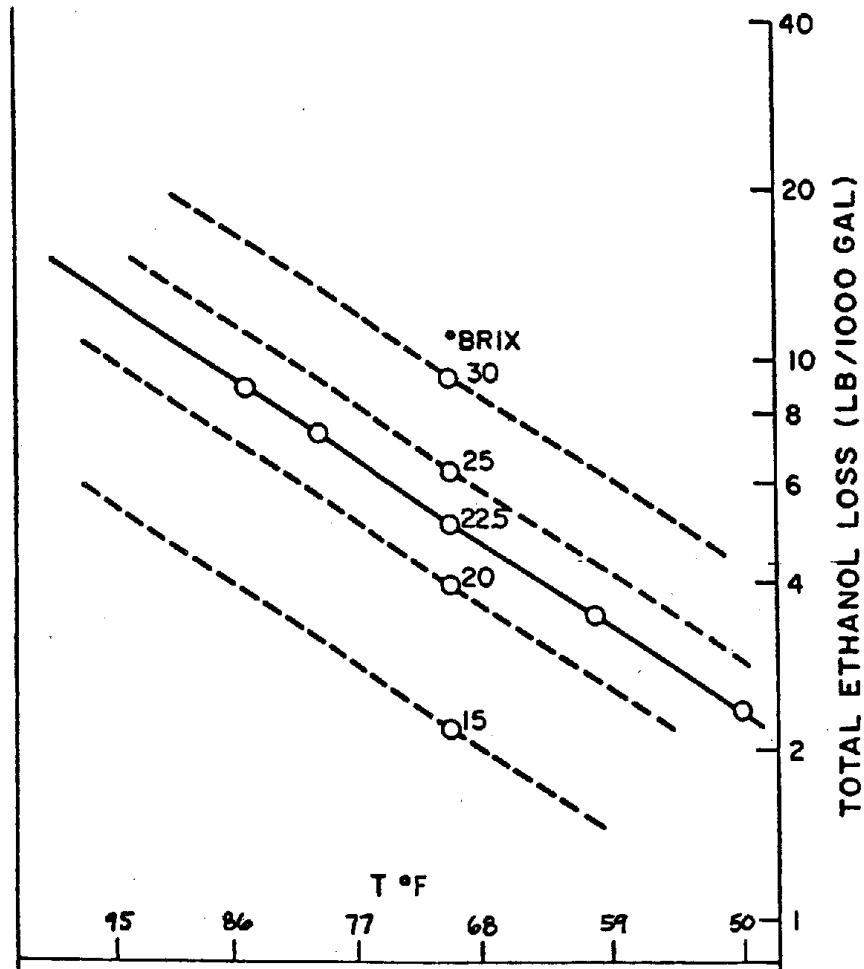
Rate curves of CO<sub>2</sub> evolution and ethanol emissions are shown for a complete fermentation cycle at 70°F in Figure V-2.<sup>8/</sup> It can be seen from the graph that sugar content of the must drops at a fairly constant rate as it is converted to ethanol and CO<sub>2</sub> by the yeast. Peak CO<sub>2</sub> evolution occurs slightly before peak ethanol emission; both are distributed as bell-shaped curves. As fermentation proceeds, the concentration of ethanol in both the liquid phase (the must) and in the vapor phase (the head space in the tank above the must) gradually increases until equilibrium is reached at the end of fermentation. Increasing temperature increases the rate of fermentation; this would be expressed graphically by more compressed curves and higher peaks.

Non-isothermal fermentation, which occurs when the capacity of the cooling system is not sufficient to maintain constant temperatures, results in greatly increased losses of ethanol. For example, temperature increases of only 9°F have been shown to increase ethanol emissions by 30 percent.<sup>8/</sup>

The presence of a pomace cap in red wine fermentations also affects ethanol losses. Cap-liquid temperature differentials can be as great as 15° to 20°F in small tanks.<sup>9/</sup> A simulation model has been developed which shows that losses almost double when the cap-liquid differential is 18°F, assuming only a 70°F fermentation temperature.<sup>8/</sup>

FIGURE V-1

RELATIONSHIP BETWEEN INITIAL DEGREE  
BRIX, FERMENTATION TEMPERATURE,  
AND ETHANOL LOSS

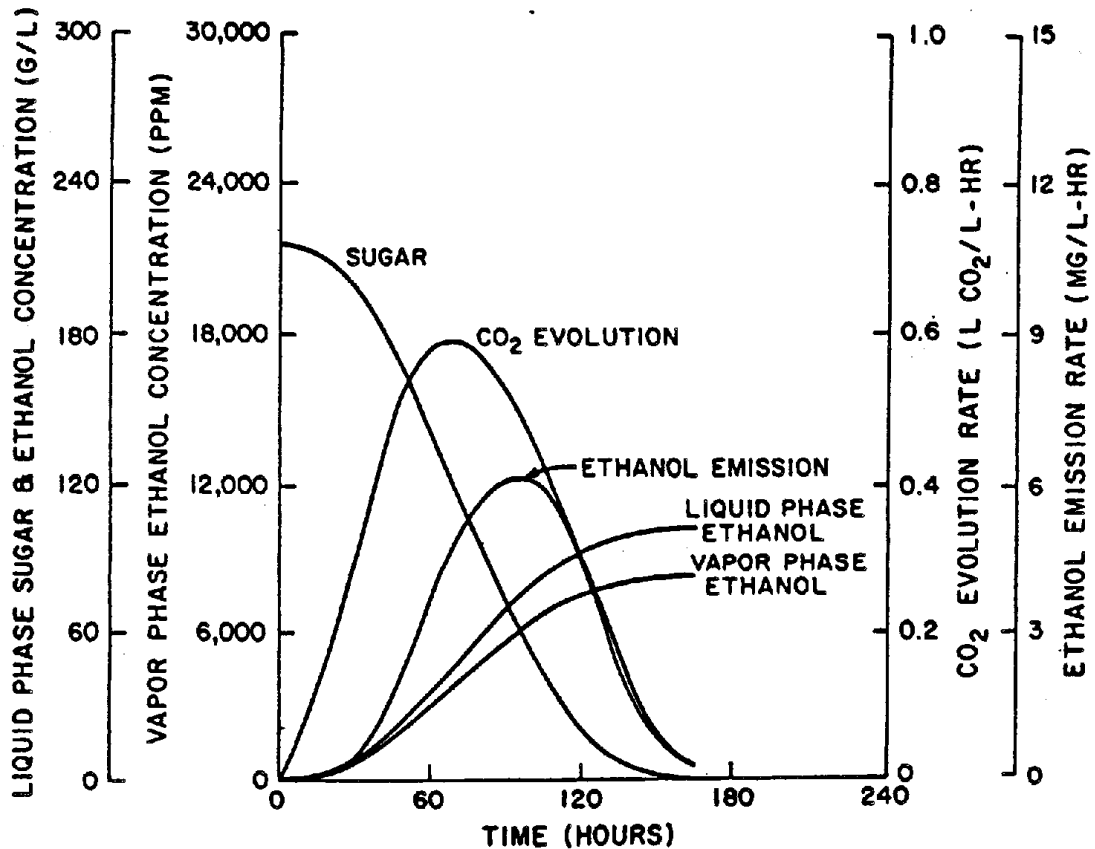


SOURCE: Williams and Boulton, 1983



FIGURE V-2

PREDICTED RATES OF CO<sub>2</sub> EVOLUTION,  
ETHANOL EMISSION, AND LIQUID AND  
VAPOR PHASE ETHANOL CONCENTRATIONS\*



\*Initial sugar content of 20° Brix, isothermal fermentation at 70°F.

SOURCE: Williams and Boulton, 1983.

## 2. Emission Factors

Emission factors expressed as pounds of ethanol lost per 1000 gallons of wine produced can be read from a plot of the computer simulation shown in Figure V-1. These were the emission factors used to estimate ethanol emissions from fermentation of wine in this report. While the developers of the model consider it to be an accurate predictor of ethanol emissions from white wine fermentation, they caution that it probably underestimates red wine emissions because of the presence of the pomace cap. Red wine emissions estimates in this staff report may therefore be on the low side.

The same workers simulated ethanol losses from red wine at various cap-liquid temperature differentials. In order to reduce evaporative ethanol emissions, they recommend more intensive cap management, including pumping over to minimize temperature differentials and separating the pomace from the juice earlier in the fermentation period.

The emission factors used to estimate emissions in this staff report are independent of tank size, construction, geometry, or vent diameter. The only variables affecting ethanol losses are fermentation temperature and the amount of sugar converted to ethanol by the yeast.

## 3. Uncontrolled Emissions from Fermentation Tanks

The staff has estimated 1985 statewide ethanol emissions from fermentation tanks based on net wine production, percentages of the various types of wine produced, average degree Brix of the grape harvest, fermentation temperatures, and the emission factors discussed above. These estimates are presented in Table V-1.

Table V-1  
California Wine Production and Ethanol Emissions Estimates  
1985

| Color grape/<br>Type of<br>Wine         | Average<br>°Brix <sup>a</sup> /<br>(millions) | Fermentation<br>Temperature <sup>c</sup><br>(°F) | Emission<br>Factor <sup>d</sup><br>(lb/1000 gal) | Ethanol<br>Emissions<br>(tons/yr) | Ethanol<br>Emissions <sup>e</sup><br>(tons/day) |
|-----------------------------------------|-----------------------------------------------|--------------------------------------------------|--------------------------------------------------|-----------------------------------|-------------------------------------------------|
| <u>Red</u>                              | <u>21.8</u>                                   |                                                  |                                                  |                                   |                                                 |
| Red Table                               | 37.3                                          | 78                                               | 6.2                                              | 115.6                             |                                                 |
| Rose Table                              | 45.5                                          | 58                                               | 2.9                                              | 66.0                              |                                                 |
| Dessert                                 | 8.2 <sup>f</sup> / <sub>f</sub>               | 78                                               | 6.2                                              | 25.4                              |                                                 |
| "SN" ≤ 14%g/                            | 6.1 <sup>g</sup> / <sub>g</sub>               | 78                                               | 6.2                                              | 18.9                              |                                                 |
| "SN" > 14%g/                            | 5.7 <sup>g</sup> / <sub>g</sub>               | 78                                               | 6.2                                              | 17.7                              |                                                 |
| <u>White</u>                            | <u>20.4</u>                                   |                                                  |                                                  |                                   |                                                 |
| White Table                             | 179.7                                         | 58                                               | 2.5                                              | 224.6                             |                                                 |
| Dessert                                 | 8.2 <sup>f</sup> / <sub>f</sub>               | 58                                               | 2.5                                              | 10.3                              |                                                 |
| Vermouth                                | 3.5                                           | 58                                               | 2.5                                              | 4.4                               |                                                 |
| Sparkling                               | 26.6                                          | 58                                               | 2.5                                              | 33.3                              |                                                 |
| "SN" ≤ 14%g/                            | 6.1 <sup>g</sup> / <sub>g</sub>               | 58                                               | 2.5                                              | 7.6                               |                                                 |
| "SN" > 14%g/                            | 5.7 <sup>g</sup> / <sub>g</sub>               | 58                                               | 2.5                                              | 7.1                               |                                                 |
| Wine Cooler <sup>h</sup> / <sub>h</sub> | 31.2 <sup>h</sup> / <sub>h</sub>              | 58                                               | 2.5                                              | 39.0                              |                                                 |
| Brandy <sup>i</sup> / <sub>i</sub>      | 69.8 <sup>i</sup> / <sub>i</sub>              | 58                                               | 2.5                                              | 87.3                              |                                                 |
| TOTAL                                   | 433.6                                         |                                                  | 3.0 <sup>j</sup> / <sub>j</sub>                  | 657.2                             | 5.5                                             |

See following page for footnotes.

Footnotes for Table V-1

- a/ Source: Reference 10.
- b/ Source: Reference 11. 1985 net wine production (excluding brandy) was 390.4 million gallons.
- c/ Source: Reference 4.
- d/ Source: Reference 8.
- e/ Assumes 120-day fermentation season.
- f/ Total production = 16.4 million gallons. Divided between red and white grapes. Includes emissions from wine fermented to produce wine spirits.
- g/ "SN" = Special natural (flavored) wines  $\leq 14\%$  ethanol and  $>14\%$  ethanol. Totals were approximately 12.2 and 11.4 million gallons, respectively, divided between red and white grapes.
- h/ Represents 11.2% wine diluted to 6% ethanol. 1985 production was 57.8 million gallons  $\times 11.2/6 = 31.2$  million gallons of wine fermented.
- i/ Represents gallons of wine fermented to yield 15.6 million proof gallons of beverage brandy. Assumes that 12 to 15 percent of the grape crush is used for brandy production.  $15.6 \text{ million proof gal} \times 4.46 \text{ gal wine/proof gal} = 69.8$  million gallons of wine. (Source: Wine Institute).
- j/ Weighted average.  $\frac{(657.2 \text{ ton/yr}) \times (2000 \text{ lb/ton})}{433.6 \text{ million gal/yr}} = 3.03 \text{ lb/1000 gal}$

Fermentation temperatures were compiled from a 1980 survey which sampled 40 percent of the wineries in the San Joaquin Valley.<sup>4/</sup> The weighted average fermentation temperature based on throughput was 78°F for red wines and 58°F for white and rose wines.\* Because these data were the best available to the staff, they were extrapolated statewide and used to estimate overall ethanol emissions for California in 1985.

As shown in the table, statewide ethanol emissions estimates for 1985 were approximately 657 tons, or 5.5 tons per day assuming the fermentation season begins in mid-August and continues through mid-December (120 days) on a statewide basis. However, the timing and length of the grape harvest varies geographically. In the interior valley, the fermentation season, which is essentially the same as the harvest period, runs from mid-August to early November, approximately 80 days.<sup>4/</sup> In the north coast region, the season runs from early September to early November, or 60 days. Thus, when calculating emissions on a tons per day basis, one must consider the seasonal nature of the fermentation operations and the length of time such operations occur in the air basin of concern.

For the San Joaquin Valley Air Basin, emissions estimates were calculated from the proportion of the statewide 1985 grape crush assigned to the air basin. The Final Grape Crush Report provides a breakdown of the crush on a grape-growing district basis.<sup>10/</sup> Since 82 percent of the grapes crushed were grown in the San Joaquin Valley, it was assumed that 82 percent of the wine produced in California was also produced in the valley.

\* Although rose wine is usually produced from red grapes, it is fermented at white wine temperatures and is therefore counted as "white" wine in emissions and cost-effectiveness estimates throughout this report.

Uncontrolled emissions for 1985 were therefore 539 tons, or 6.7 tons per day based on an 80-day season.

There are two weaknesses with the methodology outlined above. One is that the grape-growing regions generally do not correspond to the air basin boundaries; in the case of the San Joaquin Valley Air Basin, however, there was good correlation and the crush data could be used to estimate regional production. Also, wine fermented in one district is often made from grapes grown in a different district. With field crushing operations, the pulp and juice can be transported several hundred miles by tank truck.

The most accurate method of estimating emissions from fermentation tanks would be to survey the wineries in each air basin as to total throughput or production of wine. Fermentation temperatures could also be obtained through survey and weighted averages calculated.

Because of limited data, however, the method used herein was the best available to the staff.

## VI. ETHANOL EMISSION CONTROL AND ITS COST

### A. ASSESSMENT OF CONTROL TECHNOLOGY

There are five technologies available for controlling exhaust ethanol emissions from fermentation tanks: carbon adsorption, condensation, incineration, scrubbing, and temperature control. The first four technologies involve ducting the exhaust flow from the fermentation tanks to a control device. Temperature control consists of reducing the fermentation temperature in order to decrease the amount of ethanol lost to the atmosphere during the fermentation process.

Control technologies are grouped into two categories for discussion purposes: exhaust controls and temperature control.

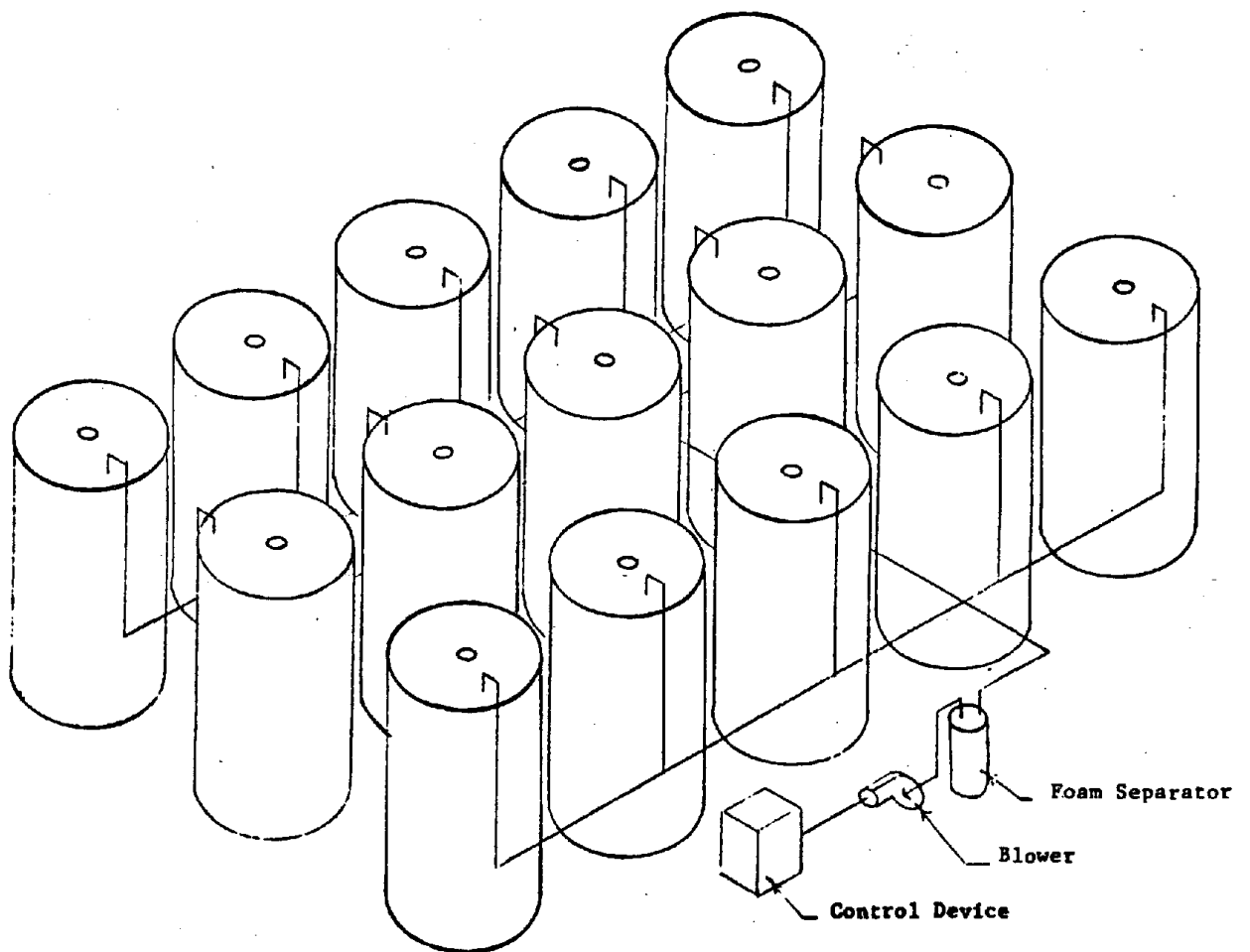
#### 1. Exhaust Controls

##### a. Ducting System

Each of the exhaust control methods requires the construction of a ducting system to transport the exhaust from a cluster of tanks to a control device. The ducting is composed of 12-gauge, 304L stainless steel piping welded together and supported above the ground to leave the area below free for production activities. A possible layout of a tank farm with exhaust ducting in place is shown in Figure VI-1.

Ducting size is based on a constant near-maximum flow rate maintained by a blower. The near-maximum flow rate is capable of handling 99 percent of the white wine and 98 percent of the red wine exhausts. Design flow rates are based on source test data of fermentation tank exhausts at 57<sup>0</sup>F for white wine and 83<sup>0</sup>F for red wine.<sup>1/</sup> Design calculations for the ductwork and associated equipment are shown in Appendix A.

FIGURE VI-1  
FIFTEEN TANKS EXHAUSTED TO  
EMISSION CONTROL DEVICE\*



\*Ducting supports not shown.

Source: ARB/SSD 12/86



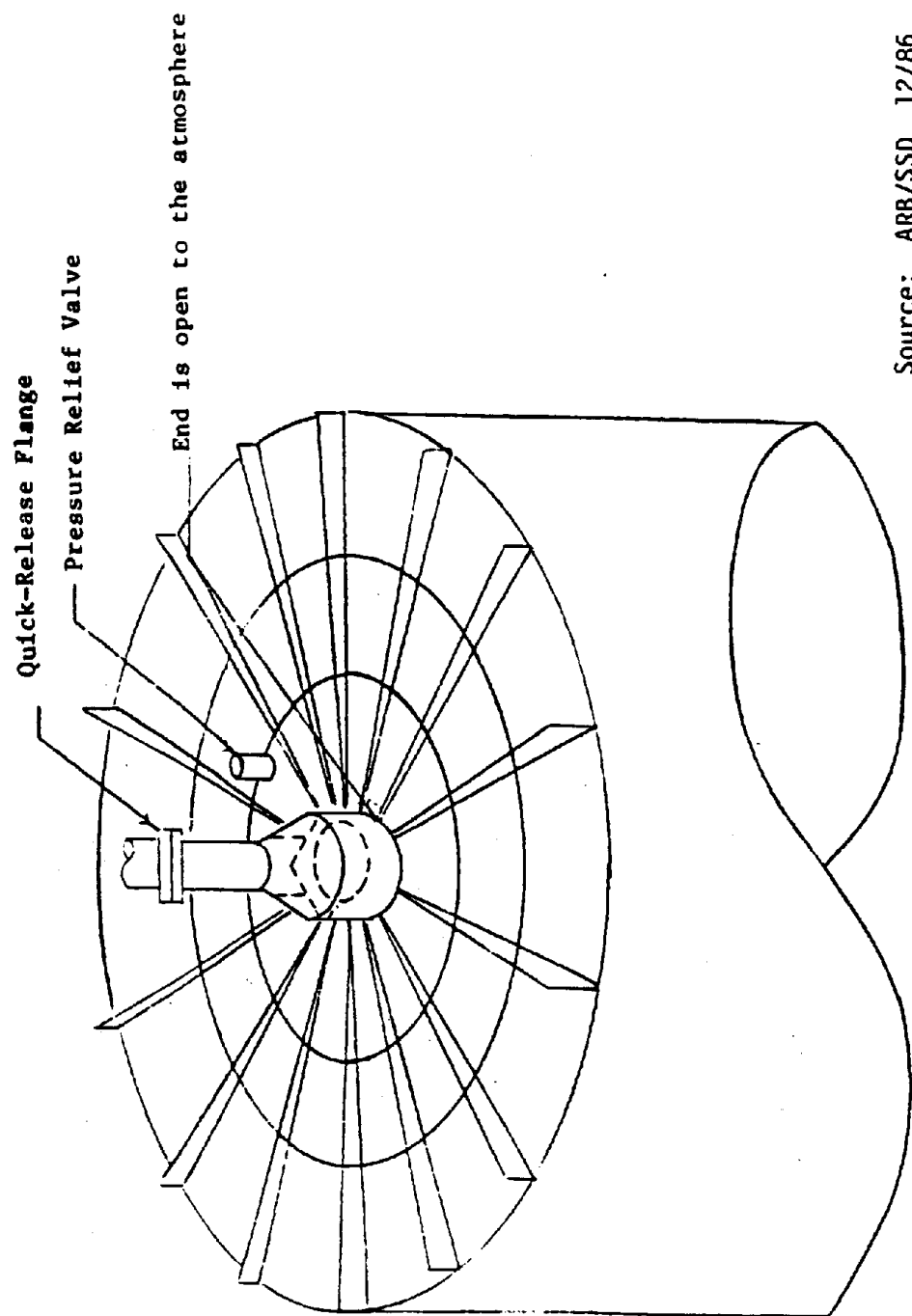
Two potential problems encountered with the use of a ducting system to transport fermentation exhaust gases are foam entering the system and contamination. To overcome these problems, a foam separator and automated clean-in-place system have been included in the ducting system cost estimates.

The foam separator selected is a centrifugal force separator suggested by R. Calvin (Heublein Wines). Incoming gases are subjected to centrifugal force and entrained liquid particles collected on the walls of the device. Liquid-free gas then passes out of the separator and onward through the ducting system. The liquid is drained into a storage vessel and held until disposal.

To facilitate cleaning, a winery could use commercially available automated clean-in-place systems for the larger ducts. It was assumed that smaller ducts (less than 8 inches in diameter) would be cleaned manually, since wineries currently use this method for their transfer lines. For easier access, a clamp-on hood with a quick-release flange is included in the design of the ducting-tank connection. Two schematics of possible hood designs are shown in Figures VI-2 and VI-3. These drawings were presented at the April 22 discussion meeting at the request of the wine industry.

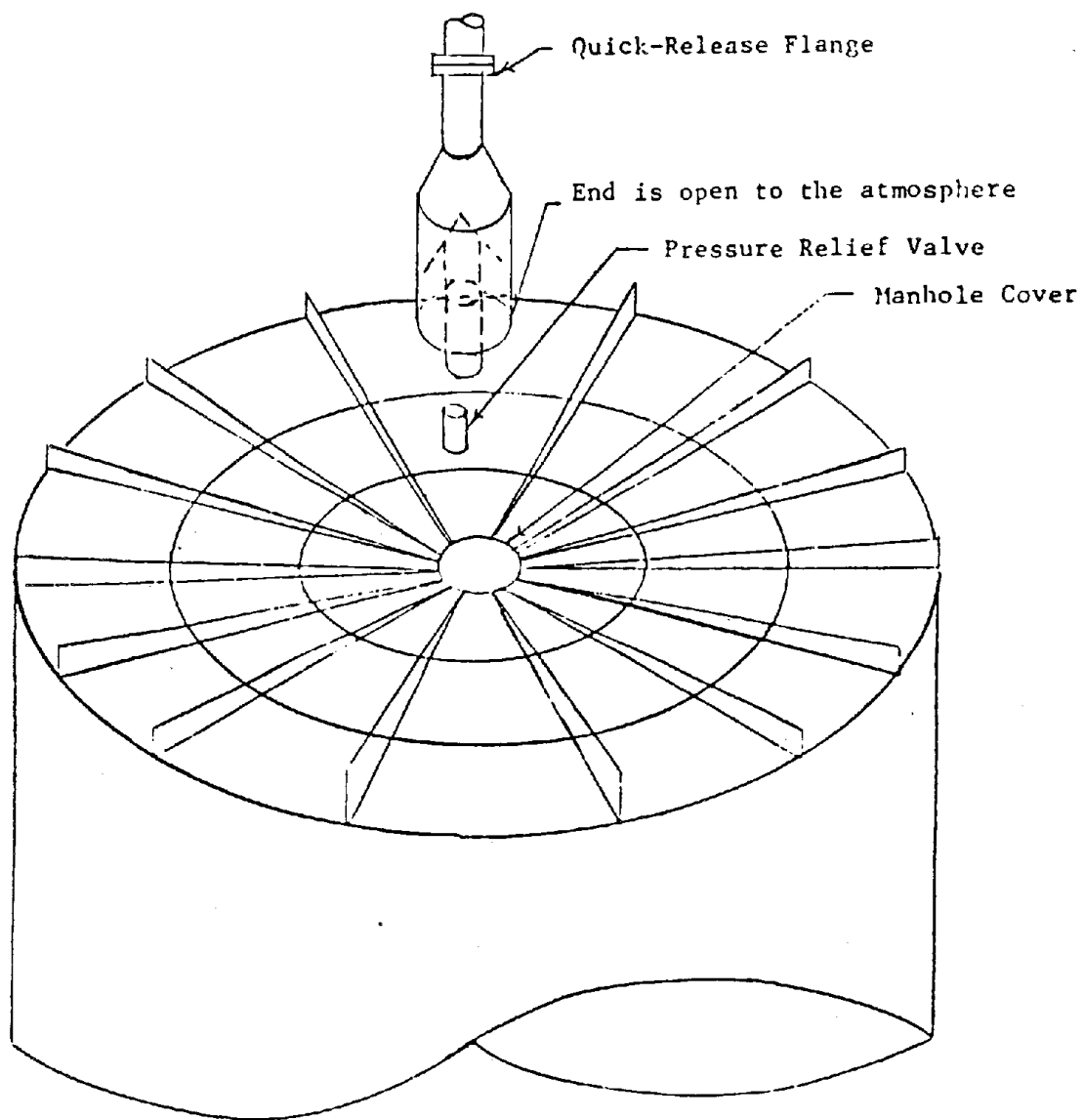
Industry representatives have indicated that the design shown in Figure VI-2, which uses the existing manhole as the exhaust gas vent, would not be feasible because of the need to have quick access to the tank in instances of foam-overs. Therefore, the design shown in Figure VI-3, which incorporates a separate exhaust vent, is more appropriate according to industry. Industry representatives have also expressed concern that any ductwork connection with the tank would cause either a build-up of pressure within the tank or development of a vacuum in the headspace of the tank, depending on the exhaust gas flow rate. At industry's request, the staff has

FIGURE VI-2  
SCHEMATIC OF POSSIBLE CONNECTION  
OF DUCTING AT TANK



Source: ARB/SSD 12/86

FIGURE VI-3  
SCHEMATIC OF POSSIBLE CONNECTION  
OF DUCTING AT TANK



Source: ARB/SSD 12/86

estimated the sizes of the collection hardware and separate exhaust vent opening which would be needed to maintain acceptable pressures in the tank. These calculations are given in Appendix C.

Currently, the manhole cover is removed during fermentation and sometimes replaced with a wide grate. It is through this opening or other vents that the exhaust gases escape. With exhaust control ducting in place, all vents and manholes would have to be covered so that exhaust gases would be channeled through the control equipment vent.

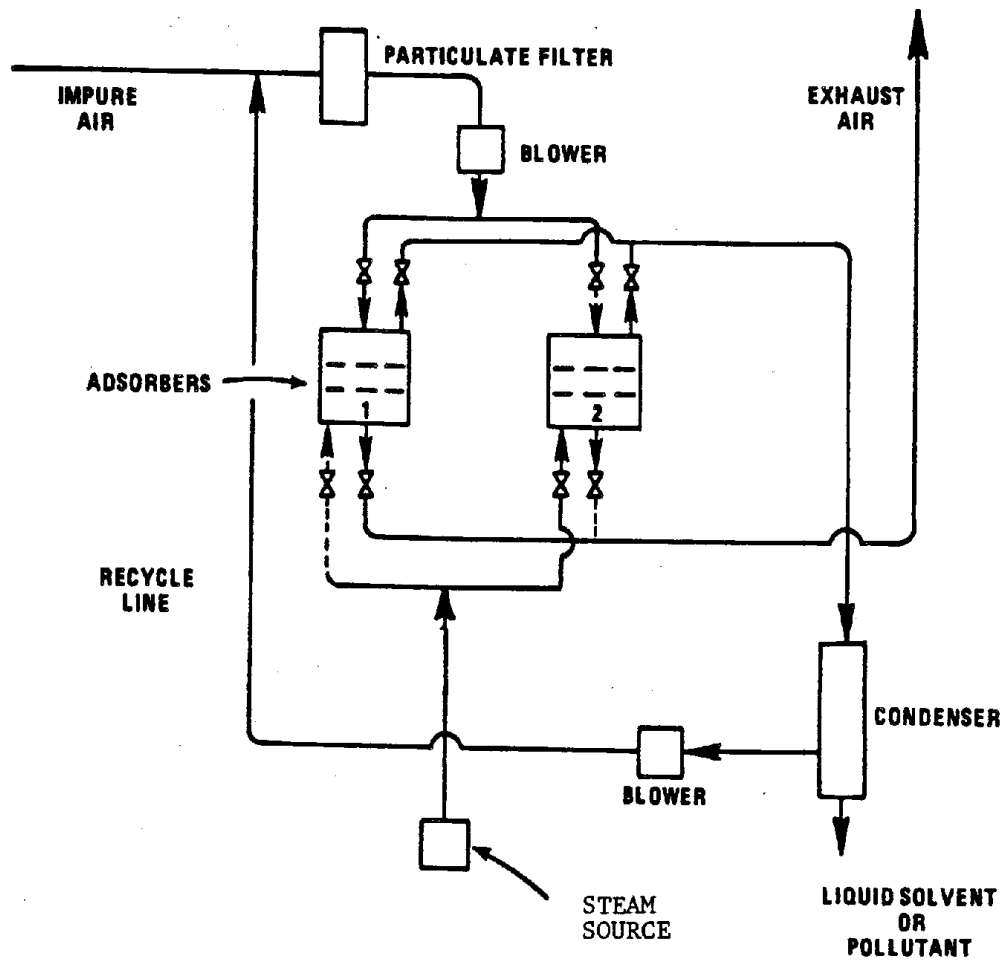
The hood design also includes a china cap mounted over the exhaust vent which would prevent any contaminants in the duct from falling back into the tank.

#### b. Carbon Adsorption

In carbon adsorption, exhaust gases are passed through a bed of granular activated carbon.<sup>2,3/</sup> The carbon granules have a very porous structure and consequently large surface area onto which the vapor molecules condense. The vapor molecules are held in the liquid state at the carbon surfaces by intermolecular forces until they are removed during the regeneration cycle and the bed reused. Continuous adsorption requires a minimum of two beds, so that one is on stream while the other is being regenerated.

A schematic of a carbon adsorption system is shown in Figure VI-4. Exhaust gases are pretreated by filtration to remove particulates and droplets which may coat the carbon and reduce the adsorptivity of the bed. Although carbon preferentially adsorbs organic compounds, CO<sub>2</sub> and water compete with organics for adsorption sites. To minimize the competition with water, relative humidity must be kept below 50 percent. This can be accomplished through the use of a heater or separate selective adsorbent (silica gel or alumina). Also, the admixture of outside

FIGURE VI-4  
SCHEMATIC OF CARBON ADSORPTION SYSTEM



SOURCE: EPA, 1973

air drawn into the exhaust stream helps to control this problem. Appropriate sizing of the carbon bed will alleviate the problem with CO<sub>2</sub> competition.

As the exhaust gases pass through the vessel containing the carbon bed, ethanol is selectively adsorbed onto the carbon surfaces and clean air is emitted from the vessel. This process continues until the carbon bed is near saturation, at which time regeneration is required.

During regeneration, the vessel is heated with low pressure steam to revaporize the ethanol. The steam is passed through the bed in a direction opposite that of gas flow during the adsorption cycle. The vaporized ethanol and steam are then passed through a water-cooled condenser and the liquid condensate stored for subsequent distillation or disposal. Any noncondensed gases are recirculated through the carbon bed.

An alternative method of disposal would be to incinerate the gases exiting the carbon beds, thus eliminating the need to distill or ship the waste product.

After desorption, clean air is passed through the carbon bed to force entrapped steam and ethanol vapors into the condenser and to cool the bed for the next cycle. Since it is not cost-effective to achieve 100 percent desorption, some ethanol (the "heel") always remains in the bed. Design of the system must, therefore, be optimized between steam costs and increased bed size to compensate for the reduced working capacity.

Sizing of a carbon adsorption system also depends on exhaust stream flow rate and ethanol concentration, as well as the adsorptivity of the carbon for the ethanol. Calculations for these conditions are shown in Appendix A.

The carbon adsorption system used in the cost analysis is designed for 95 percent control efficiency.

c. Condensation

Condensation is the process by which heat is removed from a vapor with subsequent reduction in volume.<sup>2/</sup> Any component of a vapor mixture can be condensed if it is brought to equilibrium at a low enough temperature. To achieve a sufficiently low temperature, a refrigerant is employed.

The design and cost estimates for the condenser used in this analysis were supplied to the wine industry by an equipment vendor. A copy of the letter containing the estimate is included as Attachment 2 to Appendix A. The unit is a surface condenser with fin tube coils to increase the heat-transfer area and efficiency. Coolant circulating in the tubes removes heat from the fermentation exhaust gases as they flow through the unit. The gases condense on the cold surfaces of the tubes and the liquid drips into a collecting pan. The liquid (or condensate) is then stored for later distillation or disposal. Uncondensed gases ( $\text{CO}_2$  and a portion of the ethanol) are vented to the atmosphere.

Both the water and the ethanol vapor in the fermentation exhaust gas stream condense as a function of their partial pressures. Virtually all of the water and 90 percent of the ethanol are recovered in the condensate. Because water freezes at a higher temperature than ethanol, industry representatives have expressed concern that ice may form on the coils, resulting in maintenance and efficiency problems. Staff discussions with a vendor indicate that although the vendor would not guarantee it, the vendor believes that icing would not occur. Should icing occur, a hot gas defrost system could be installed to handle the problem. This is discussed further in Chapter VIII.

Design of the system is based on heat transfer which is affected by an overall heat transfer coefficient, temperature gradients, and surface area. Calculations are shown in Appendix A.

d. Incineration

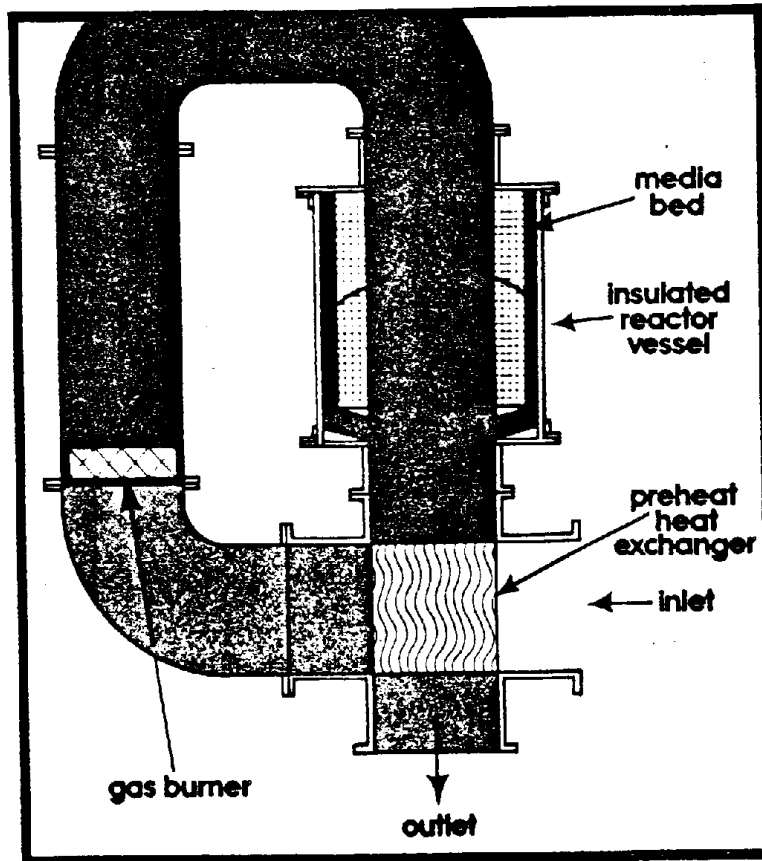
Incineration oxidizes combustible organic emissions to carbon dioxide and water.<sup>2,3/</sup> There are two types of incinerators (also known as afterburners): direct flame and catalytic. Direct flame incinerators depend upon flame contact and relatively high temperatures to oxidize the organic materials. A typical catalytic incinerator operates by preheating the exhaust gas stream and then promoting further combustion by bringing the organic material into contact with a catalyst. The catalytic unit oxidizes the organic material at lower temperatures than a direct flame unit (450<sup>0</sup> to 500<sup>0</sup>F versus 1100<sup>0</sup> to 2000<sup>0</sup>F), thus saving fuel costs. Because of these low operating temperatures, there are virtually no NO<sub>x</sub> emissions from catalytic units. For these reasons, catalytic rather than direct flame incineration was selected as a control technology for fermentation exhaust gases.

Common catalysts are platinum or other precious metals, often deposited in porous form on an inert substrate with a honeycomb configuration to maximize surface area, since catalyst effectiveness depends on the accessibility of active sites. The incinerator used in the design calculations uses a pelletized metal oxide catalyst which is lower in cost and functions at lower temperatures than precious metal catalysts. Periodic replacement of the catalyst bed is required to maintain control efficiency.

A schematic diagram of the catalytic incinerator is shown in Figure VI-5. Fermentation exhaust gases first enter a heat exchanger



FIGURE VI-5  
SCHEMATIC OF CATALYTIC INCINERATOR



SOURCE: Pillar Corporation

where they are preheated to reaction temperature. They next enter a combustion chamber fired with gas burners and finally pass through the reactor vessel containing the catalyst bed, where the remaining contaminants are combusted. Removal efficiency is rated at 95 percent.

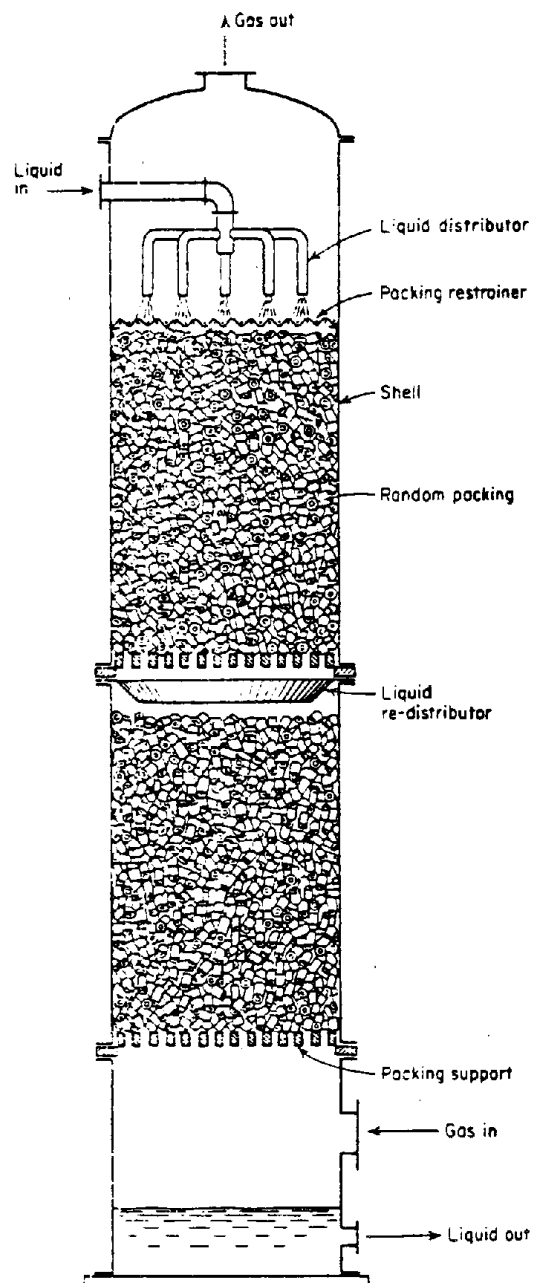
Natural gas is used to fuel the incinerator. Fuel requirements vary with the concentrations of ethanol and oxygen in the incoming stream. From 10 to 15 percent oxygen is needed to sustain combustion, but make-up air drawn into the ducting system to maintain the exhaust flow rate should minimize the requirement for supplementary combustion air. A fan is provided for supplementary air when it is needed. Design calculations for fuel requirements and sizing of the catalytic incineration unit are shown in Appendix A.

e. Scrubbing

Scrubbing is the process in which the soluble components of a gas are dissolved in a liquid.<sup>2/</sup> Thorough contact between the gas and the liquid solvent must be maintained so that interphase diffusion will occur. Effective scrubber design provides a large liquid surface area with a minimum of pressure drop. A packed tower accomplishes this through the use of chemically inert packing material through which the gas and liquid are passed in countercurrent flow. A schematic drawing is provided in Figure VI-6. Contaminated gas enters the bottom and the cleaned gas exits the top of the tower where it is vented to the atmosphere. The liquid leaving the scrubber can either be distilled to recover the ethanol or disposed of in the municipal sewage system or on land.

The scrubber chosen for this application is a packed-bed fiberglass tower which uses water as the solvent. Design is based on gas

FIGURE VI-6  
SCHEMATIC OF PACKED-TOWER SCRUBBER



SOURCE: EPA, 1970

flow rate (calculations shown in Appendix A). Efficiency of ethanol removal by scrubbing is rated at 99 percent.

## 2. Temperature Control

Temperature control as a method of reducing ethanol emissions is based on the relationship between fermentation temperature and evaporative ethanol loss. As discussed in Chapter V, ethanol emissions increase as an exponential function of increasing fermentation temperature. Because the fermentation process liberates heat, the majority of wineries cool the must at some point in the fermentation cycle.<sup>4/</sup> The three major systems employed for cooling in California are internal cooling coils in the fermentors, external shell-and-multitube coolers, and jacketed tanks. In the first two cases, water or coolant is used, often in conjunction with a cooling tower. In the jacketed tanks, ethylene glycol is the usual cooling medium. Cooling may be performed in one operation or it may be applied two or three times during fermentation so that the temperature can be lowered gradually. Temperatures which are too high or too low cause "sticking," or the cessation of fermentation. The effect of fermentation temperature on the quality of wine is discussed in detail in Chapter V.

To reduce ethanol emissions with temperature control, extra refrigeration is applied to further lower the fermentation temperature of the wine. This is accomplished by installing more refrigeration capacity. Calculations for the refrigeration requirements are shown in Appendix A. Design for the requirements is based on two scenarios: one for reducing the fermentation temperature of white wine from 65°F to 55°F and the other for red wine from 85°F to 80°F.

Efficiency of temperature control depends on the amount by which the temperature is reduced, but there are complicating factors such as the presence of a pomace cap in red wines and non-isothermal fermentation, in which the average temperature is reduced, but not maintained at a constant level. These situations are discussed in Chapter V.

#### B. EMISSION REDUCTIONS

The proposed suggested control measure would affect the emissions of ethanol from winery fermentation tanks of 50,000 gallons capacity and over in California. Because tanks under 50,000-gallons are exempted, accurate statewide emission reductions cannot be estimated without a survey of all wineries to determine annual throughput by fermentation tank capacity. The Fresno County APCD performed such a survey of San Joaquin Valley wineries in 1980.<sup>5/</sup> Data obtained by that survey were used by the ARB staff to estimate potential emission reductions for the San Joaquin Valley if the proposed SCM were implemented. Production data for 1985 were used in these estimates.

As outlined in Chapter V, 1985 statewide uncontrolled emissions were estimated to be 657 tons. The San Joaquin Valley Air Basin's share of the uncontrolled emissions was calculated at 82 percent, or 539 tons (6.7 tons per day for the 80-day fermentation season). The San Joaquin Valley tank survey showed that 89 percent of the wine produced in the valley was fermented in tanks of 50,000 gallons capacity or larger.\* Therefore, if an ethanol emission control rule were in effect, 317 million gallons of the

\* This estimate may be on the low side, because most tanks built since 1980 would probably be larger than 50,000 gallons for reasons of economy.

total 356 million gallons of wine produced in the valley in 1985 would be fermented in tanks subject to control.

Emission reductions for the San Joaquin Valley with various control technologies are presented in Table VI-1. Each of the exhaust controls is capable of achieving at least a 90 percent reduction in ethanol emissions. If a rule were adopted requiring 90 percent reduction, an 80 percent overall reduction in uncontrolled emissions would be achieved (90 percent control x 89 percent of the total wine production in the valley). This represents a reduction of 431 tons, or 5.4 tons per day (80 percent x 539 tons).

While there are over 650 wineries in the state, the largest wineries are found in the San Joaquin Valley which accounts for 82 percent of California wine production. Because most of the wineries outside of the San Joaquin Valley are relatively small, it is unlikely that these wineries would have many tanks exceeding 50,000 gallons. Thus, most of the remaining wine production in the state would be exempt from the requirements of this SCM and an 80 percent reduction would not be achieved in those regions outside the San Joaquin Valley Air Basin.

The temperature control rule proposed by the wine industry and modified by the Fresno County APCD would establish a maximum daily weighted average fermentation temperature (DWAFT) of 80<sup>0</sup>F for red wine and 55<sup>0</sup>F for white wine by the year 1990. Potential emission reductions based on 1985 production were estimated using these temperatures as endpoints. In calculating these reductions, the ARB staff assumed that the 1980 San Joaquin Valley weighted average fermentation temperatures of 78<sup>0</sup>F for red wine and 58<sup>0</sup>F for white wine were still in use in 1985. If the temperature control rule were in effect, and the average fermentation temperature for red wine

TABLE VI-1

Estimated Emissions and Emission Reductions  
for the San Joaquin Valley Air Basin  
1985

| Control Technology                                          |                            | Tons per year | Tons per day |
|-------------------------------------------------------------|----------------------------|---------------|--------------|
| Carbon adsorption, Condensation, Incineration, or Scrubbing | Emissions without controls | 539           | 6.7          |
|                                                             | Emissions with controls    | 108           | 1.3          |
|                                                             | Emissions Reduced          | 431           | 5.4          |
| Temperature Control                                         | Emissions without controls | 539           | 6.7          |
|                                                             | Emissions with controls    | 503           | 6.3          |
|                                                             | Emissions Reduced          | 36            | 0.4          |

Source: ARB/SSD 12/86

remained at 78<sup>0</sup>F and the average white wine fermentation temperature were reduced to 55<sup>0</sup>F, the estimated 1985 emission reductions for the San Joaquin Valley would be 36 tons, or 0.4 tons per day, as shown in Table VI-1. This 36-ton reduction would be achieved for white wine only, since the average fermentation temperature of red wine would not decrease.

The staff recognizes that 78<sup>0</sup>F and 58<sup>0</sup>F are average fermentation temperatures, and that a number of wineries are fermenting wine at higher temperatures. However, the temperature control rule requires a DWAF of 80<sup>0</sup>F and 55<sup>0</sup>F for red and white wine, respectively. Under this rule, some tanks could still be fermenting at higher temperatures and emitting more ethanol than the average fermentation temperatures would indicate. Also, as discussed in Chapter V, ethanol emissions are very sensitive to temperature fluctuations and cap-liquid temperature differentials. Because there is no mention in the rule of how these situations would be controlled, the staff assumes that they would not be controlled and that the emission reductions with temperature control presented in Table VI-1 may actually have been overestimated.

The cost-effectiveness of temperature control (discussed in the next section) was calculated on the basis of reducing red wine fermentation temperatures from 85<sup>0</sup>F to 80<sup>0</sup>F and white wine from 65<sup>0</sup>F to 55<sup>0</sup>F. These temperatures were used for the cost estimates because they represented the only conditions for which refrigeration costs were available to the staff. These two sets of temperatures were the basis of wine industry estimates of refrigeration needed to remove the heat generated during the fermentation process.\* These temperatures do not represent average

\*Borje Landgren, Heublein Wines, Madera.



fermentation temperatures, but their use in the cost-effectiveness calculations allows for the maximum potential emission reductions achieved with the use of temperature control. Under these conditions, emission reductions of 15 percent for red wine and 30 percent for white wine would be achieved, assuming completely isothermal fermentation and no cap-liquid temperature differential in red wine tanks. In reality, emission reductions of 15 and 30 percent would probably be achieved in only a few isolated cases.

In summary, the overall emission reductions achievable with exhaust control are much greater than with temperature control. The former approach should therefore be the basis for any proposed SCM for ethanol emission reductions from fermentation tanks. The text and further discussion of the SCM are presented in Chapter VII.

#### C. COSTS AND COST-EFFECTIVENESS OF CONTROL STRATEGIES

##### 1. Costs

With temperature control, the must is cooled to reduce the amount of emissions. The other control systems involve removing and transporting the ethanol vapor, carbon dioxide, and water vapor from the fermentation tanks' exhaust streams through exhaust ducting to a control device. Thus, the cost of the exhaust control system is shared by a set of tanks resulting in an economy of scale. Cost of temperature control is assumed to be proportional to load and does not benefit from economy of scale.

Due to the fact that no two wineries are identical, and because there is a wide variety of tank sizes, each vintner would select tank combinations for control on a case-by-case basis. Because there is no single ideal set-up, the cost analyses are based on various-sized white and red wine

tank farms. For white wine, tank sizes of 50,000, 100,000, 300,000, and 600,000 gallons for tank farms of five, 10, and 15 tanks were used. For red wine, tank sizes of 50,000, 100,000, and 300,000 gallons for tank farms of five and 10 tanks were used. During the April 22, 1986 working meeting, wine industry representatives pointed out that wineries need to maintain excess tank capacity for moving the must or juice around during fermentation. Industry representatives stated that wineries normally maintain approximately 35 percent excess tank capacity. The staff recognizes this need for excess tank capacity and has added 50 percent more tank space to each of the tank farms to accommodate the excess tank capacity.

Because each of these added tanks may be used for fermentation at some time, they need to be ducted into the control system. However, because not all of the fermentation tanks will be fermenting at a maximum rate, and because there will be at least 35 percent excess capacity, the capacities of the exhaust control equipment were not increased. The staff assumes that the fermentation capacity of the tank farms remains the same as before extra tanks were added.

Cost analyses for the control strategies are based on the assumption that white wine tanks are filled to 80 percent of tank capacity and that red wine tanks are filled to 75 percent of tank capacity. During the April 8 workshop, industry representatives agreed that it is standard practice for vintners to fill their tanks to these levels. For the exhaust control systems, ductwork and control equipment were sized on the assumption that all tanks within a tank farm reach their potential peak emissions at the same time.

Cost estimates for temperature control were obtained from wine industry representatives. Industry provided the figure of a constant \$2,000/ton of refrigeration. This estimate holds true for tanks of 100,000 gallons and over. For tanks under 100,000 gallons, there is some cut-off point where a more expensive type of refrigeration system might be used. The cut-off point could not be determined; therefore, the 50,000 gallon tanks were treated as 100,000 gallon tanks. Cost estimates for the ducting system and exhaust control systems were obtained either from vendors of the systems or from wine industry representatives.

## 2. Cost-Effectiveness

Cost-effectiveness is reported as dollars per pound and represents the cost to eliminate one pound of pollutants - in this case one pound of ethanol emissions. Cost-effectiveness is determined by dividing the cost of the control by the estimated ethanol reduction associated with that control. The cost is composed of operating and maintenance costs, fixed charges (property taxes and insurance), and fixed-capital costs. The cost-effectiveness for the control strategies was computed on an after-tax basis. The after-tax cost-effectiveness accounts for the state and federal tax benefits received by the wineries. These benefits include write-offs for depreciation and operating and maintenance expenses. The after-tax cost-effectiveness is representative of the costs that wineries will incur to implement the control strategies.

For other types of sources, cost-effectiveness has usually been determined by first converting the fixed-capital costs to an annual amount (based on an equipment life expectancy of 10 to 15 years and a selected rate-of-return on investment), then adding annual operating and

maintenance costs and deducting annual tax benefits. The sum is then divided by the annual emission reduction. However, the Wine Institute has proposed a different method based on a present value analysis rather than an annualized cost analysis.<sup>6/</sup> Because either method can be used and both give reasonably comparable results, the staff has elected to use the method suggested by the Wine Institute. We have, however, modified this method to account for all tax benefits rather than only selected benefits. The differences between the two methods are discussed in more detail in Appendix A.

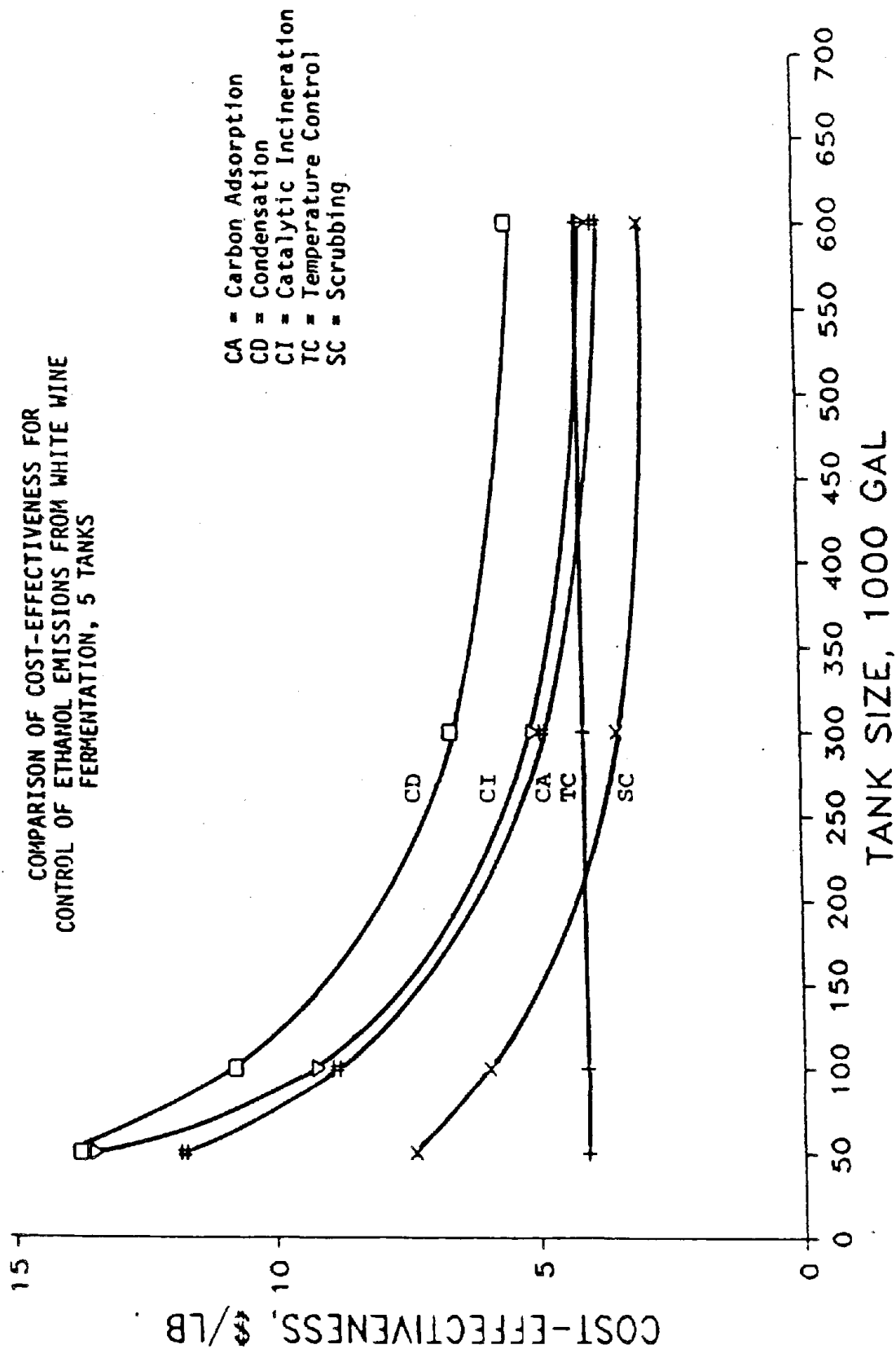
The after-tax cost-effectiveness for the different systems is shown in Figures VI-7 through VI-11. Detailed calculations of the installed capital costs, fixed-capital costs, operating and maintenance costs, and the emission reductions and cost-effectiveness estimates are included in Appendix A.

The after-tax cost-effectiveness curves for temperature control are represented by horizontal lines because, according to industry estimates, costs are proportional to load. Thus, the cost-effectiveness for temperature control is not dependent on the size of the tanks nor the number of tanks in each tank farm. White wine has a slightly better cost-effectiveness at approximately \$4.00 per pound than red wine at approximately \$4.50 per pound.

With respect to exhaust controls, the cost-effectiveness varies with tank size, number of tanks in each tank farm, and wine type. Although larger tanks require larger ducting and larger control equipment, they also benefit from economy of scale (larger systems cost less per unit of control than do smaller systems). Also, the more tanks that are ducted

FIGURE VI-7

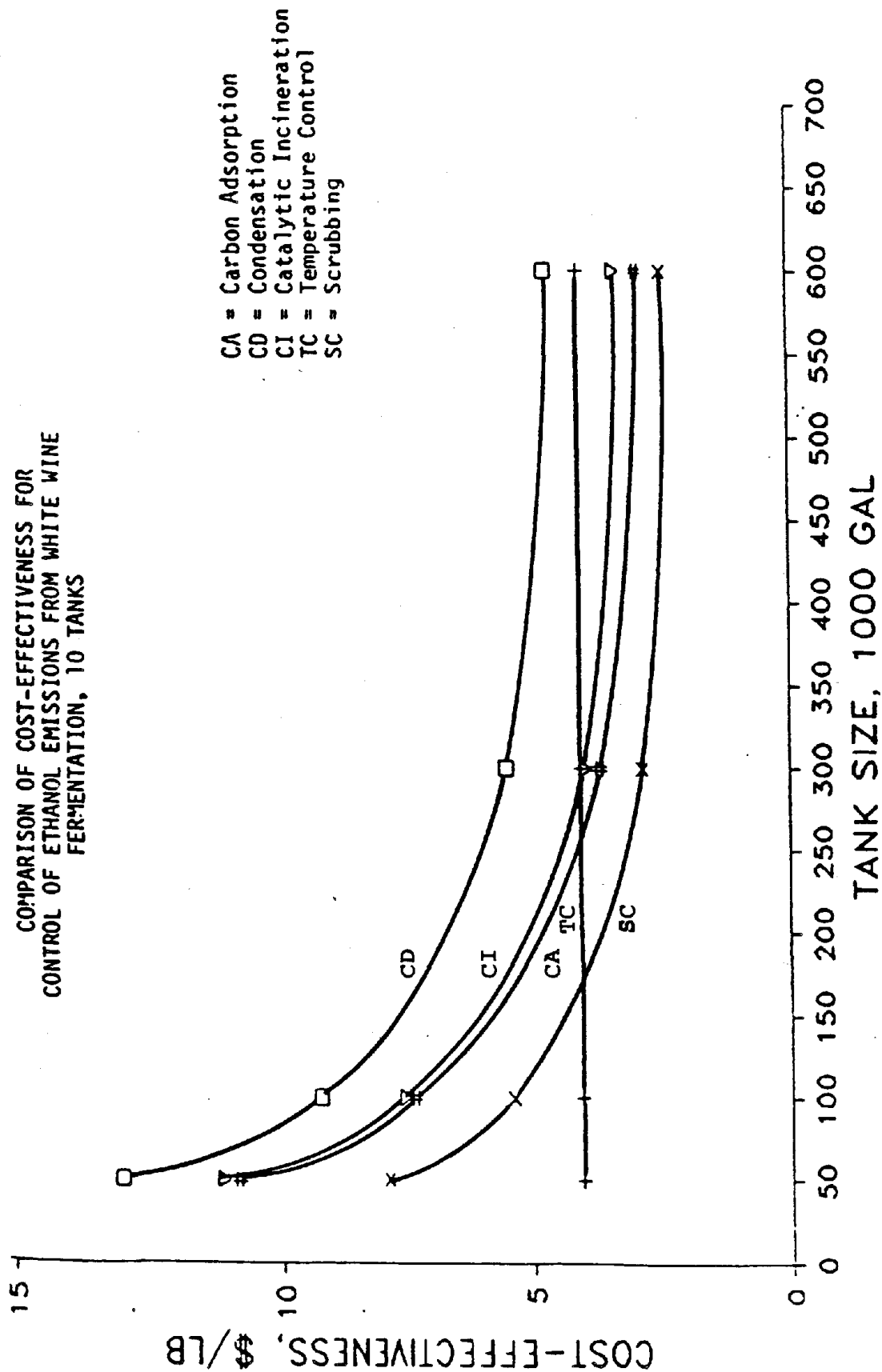
COMPARISON OF COST-EFFECTIVENESS FOR  
CONTROL OF ETHANOL EMISSIONS FROM WHITE WINE  
FERMENTATION, 5 TANKS



Source: ARB/SSD 12/86

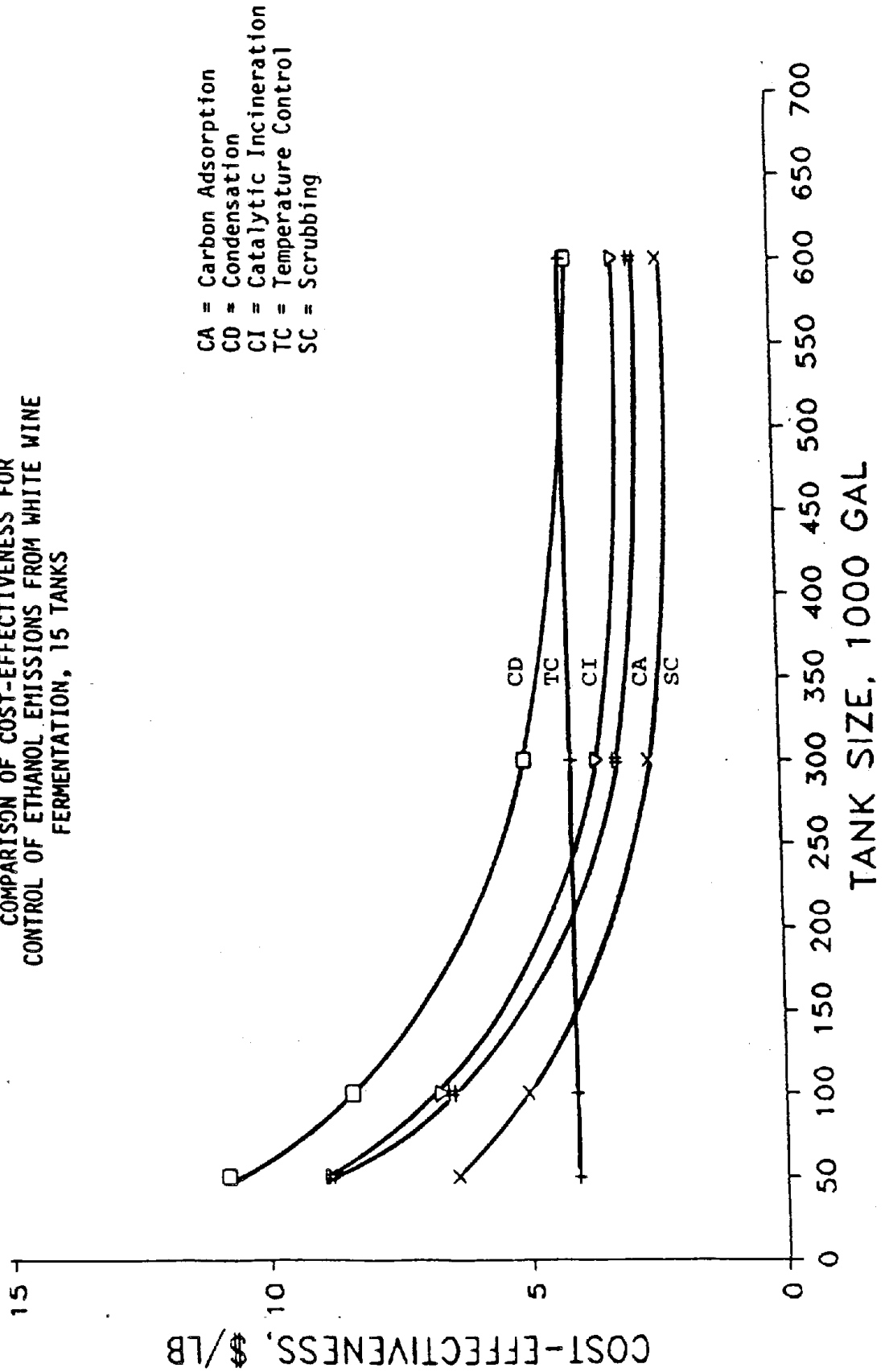
FIGURE VI-8

COMPARISON OF COST-EFFECTIVENESS FOR  
CONTROL OF ETHANOL EMISSIONS FROM WHITE WINE  
FERMENTATION, 10 TANKS



Source: ARB/SSD 12/86

FIGURE VI-9  
COMPARISON OF COST-EFFECTIVENESS FOR  
CONTROL OF ETHANOL EMISSIONS FROM WHITE WINE  
FERMENTATION, 15 TANKS

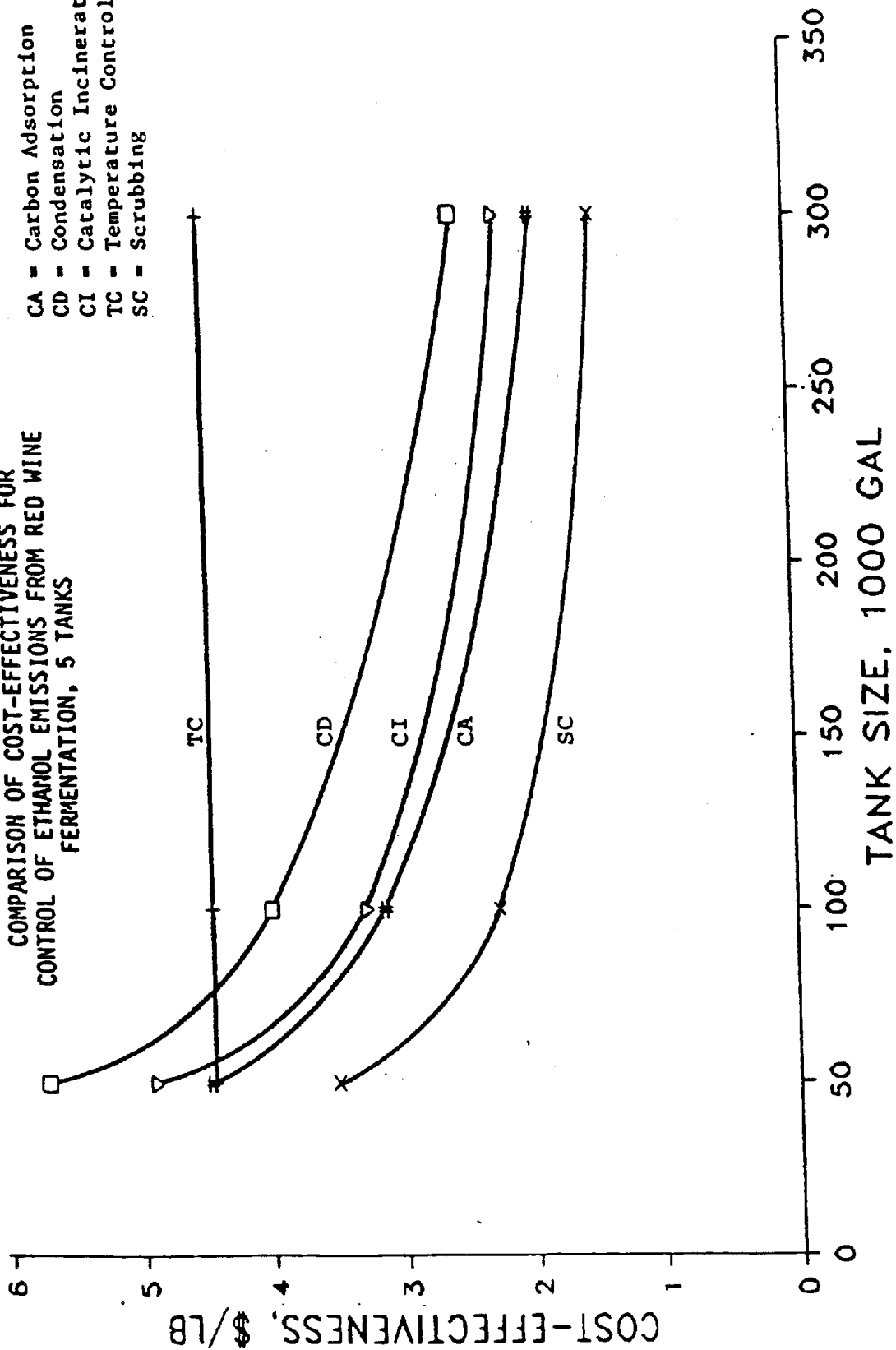


Source: ARB/SSD 12/86

FIGURE VI-10

COMPARISON OF COST-EFFECTIVENESS FOR  
CONTROL OF ETHANOL EMISSIONS FROM RED WINE  
FERMENTATION, 5 TANKS

CA = Carbon Adsorption  
CD = Condensation  
CI = Catalytic Incineration  
TC = Temperature Control  
SC = Scrubbing

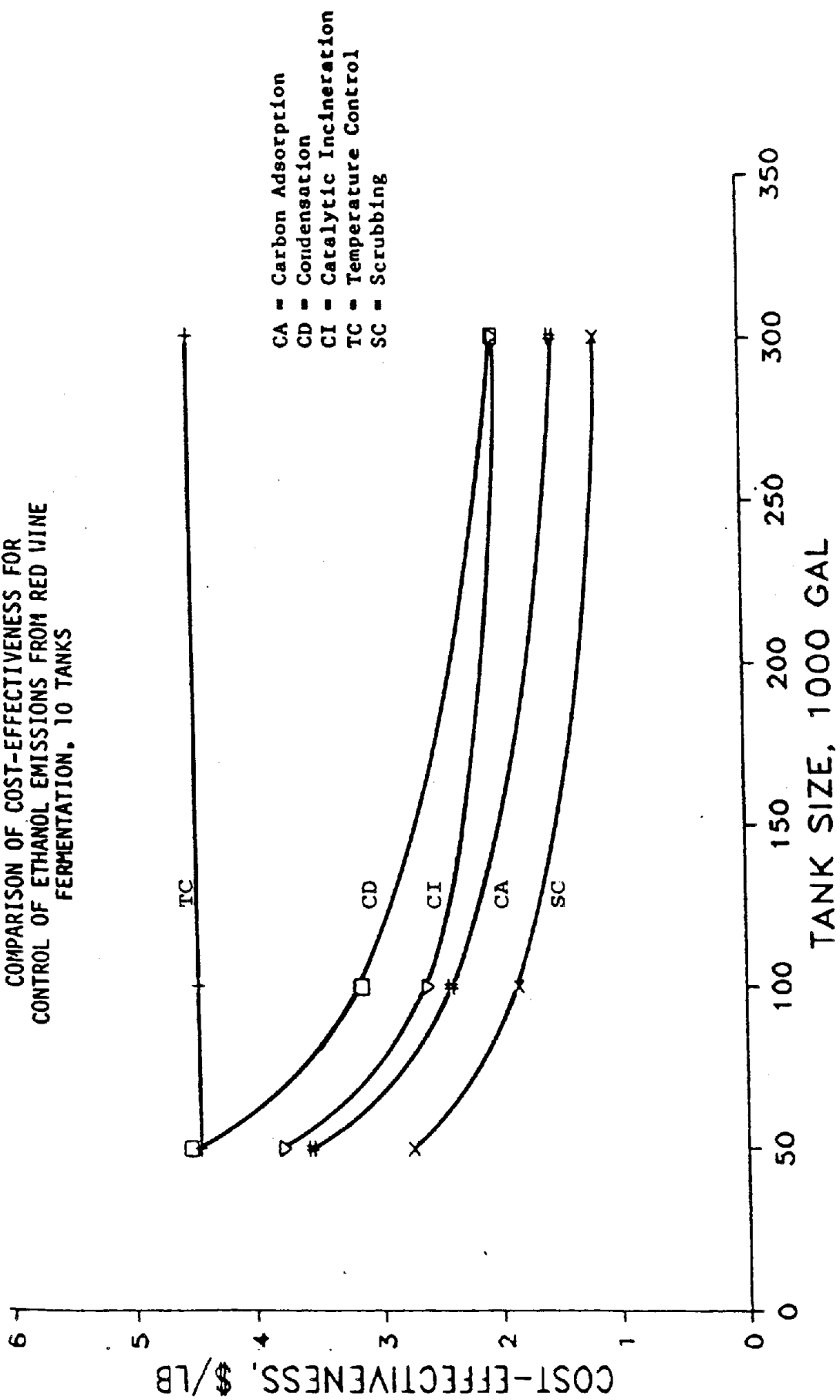


Source: ARB/SSD 12/86



FIGURE VI-11

COMPARISON OF COST-EFFECTIVENESS FOR  
CONTROL OF ETHANOL EMISSIONS FROM RED WINE  
FERMENTATION, 10 TANKS



Source: ARB/SSD 12/86

together to a single control unit, the cheaper the per-tank cost. Thus, costs per unit decrease with tank size as well as tank farm size. As shown in Figure VI-7 through VI-11, the cost-effectiveness of the red wine exhaust controls is better than the cost-effectiveness for white wine controls. Red wine fermentation emits greater amounts of ethanol than white wine fermentation, thus requiring larger control equipment; however, the emission reductions are also greater for red wine. Greater emission reductions together with economy of scale benefits produce better cost-effectiveness values.

The curves also show that red wine exhaust controls are generally more cost-effective than temperature control. This is not the case for white wines. For white wines, temperature control is more cost-effective than exhaust control in 60 percent of the tank farm scenarios. However, as pointed out in Section VI-B, the emission reductions achievable with exhaust controls are much greater than those for temperature control. Because of the minimal overall reductions associated with temperature control, its choice as a control measure is not recommended.

As noted earlier, vintners would select tank combinations for control on a case-by-case basis. The cost-effectiveness for different tank combinations can be interpreted from the cost-effectiveness curves.

### 3. Sensitivity of Cost-Effectiveness Analysis

The after-tax cost-effectiveness estimates presented in Figures VI-7 through VI-11 were based on a five-year depreciation period for equipment, a five-year life of equipment, and an after-tax rate-of-return on investment of six percent. This is identical to the Wine Institute's method. The term of five years was selected based on depreciation tax laws,

since federal tax laws allow accelerated depreciation of equipment over a period of five years. However, state tax laws require the use of straight line depreciation. While five years may be reasonable for depreciation purposes, it is not a realistic assumption for equipment life. As noted earlier, an equipment life of 10 to 15 years normally is assumed. If 10 or 15 years was assumed rather than five, the cost-effectiveness values would be considerably better. For example, the cost-effectiveness for carbon adsorption on a white wine tank farm of ten 300,000 gallon tanks is \$3.71 per pound as shown in Figure VI-8. This figure is based on a five-year accelerated depreciation for federal taxes, a five-year straight line depreciation for state taxes, and a five-year equipment life (the detailed calculations for this example are found in Appendix A). Using a five-year accelerated depreciation for federal taxes but a 10-year equipment life (and 10-year straight line depreciation for state taxes) reduces the cost-effectiveness to \$2.17 per pound. With a five-year accelerated depreciation and a 15-year equipment life (and a 15-year straight line depreciation for state taxes), the cost-effectiveness is reduced further to \$1.59 per pound. Because the staff's calculations use the same five-year equipment life basis as the Wine Institute, our estimates are conservatively higher.

As noted above, the choice of five years is based on depreciation tax laws and results in the highest value for cost-effectiveness. In reality, the equipment will last longer than five years. It is only during the first five years that the cost-effectiveness would be \$3.71 per pound. Thereafter, the only costs would be operating and maintenance costs. The result is that the cost-effectiveness of the control

equipment during the second and third five-year periods would be \$0.61 per pound and \$0.45 per pound, respectively.

Although the Wine Institute's original method partially considered tax benefits (see Chapter VIII and Appendix A for details), the Wine Institute stated in a recent letter that only a before-tax analysis should be done. The choice of doing a before-tax rather than an after-tax cost analysis has the effect of doubling the cost-effectiveness because the tax benefits to the winery are not taken into account. In the example above, the cost-effectiveness for five years would be \$7.57 per pound before-tax as compared with \$3.71 per pound after-tax. The staff believes that the standard method of after-tax analysis is the appropriate method. The Wine Institute's comments and the staff's response are discussed in more depth in Chapter VIII.

VII. PROPOSED SUGGESTED CONTROL MEASURE

A. SUGGESTED CONTROL MEASURE TEXT

(a) Definitions

For the purpose of this rule, the following definitions shall apply:

- (1) FERMENTATION TANK; any container in excess of 50,000 gallons capacity in which the juice of grapes is fermented to produce wine.
- (2) TANK FARM; any group of fermentation tanks connected via a common ducting system for purposes of channeling exhausts to a control device.
- (3) WINE; the product of the normal alcoholic fermentation of the juice of grapes, including table, sparkling, dessert, and "special natural" wines, and wine fermented for brandy production and for use as distilling material.
- (4) WINERY; any facility licensed as a bonded winery or wine cellar with the U.S. Bureau of Alcohol, Tobacco, and Firearms (BATF).
- (5) FERMENTATION SEASON; for a winery, that time of year when the winery ferments the juice of grapes to produce wine.

- (6) FERMENTATION CYCLE; that period of time beginning when yeast is added to a batch of juice and ending when either
  - a) the residual sugar of the juice falls to 3.0 percent,
  - or b) when fermentation is arrested by the addition of wine spirits; filtration or centrifugation to remove the yeast; or chilling the juice to 45<sup>0</sup>F or below to inactivate the yeast.
- (7) PEAK FERMENTATION RATE; that point in the fermentation cycle when the volumetric flow rate of the fermentation tank exhaust gases reaches its maximum value.
- (8) PILOT PROGRAM; a bench scale review of technologies to control emissions from fermentation tanks.
- (9) DEMONSTRATION PROGRAM; a program in which equipment designed and operated to reduce total emissions of ethanol by at least 90 percent is installed to control emissions of ethanol from a tank farm consisting of five or more 50,000 or more gallon capacity fermentation tanks.

(b) Requirements

- (1) The owner or operator of any winery shall reduce the ethanol content of the exhaust gases from each fermentation tank or tank farm by 90 percent.

- (2) The owner or operator of any winery shall submit to the Air Pollution Control Officer a plan for installation of ethanol emission control equipment to meet the requirements of subsection (b)(1). Such plan, which shall be subject to the approval of the Air Pollution Control Officer, shall contain as a minimum:
- (a) a list of all fermentation tanks and their respective capacities; and
  - (b) identification of the type of control to be applied to each fermentation tank or tank farm, including a construction schedule.
- (3) To determine initial compliance with the emissions limits of subsection (b)(1), source testing of emissions from all fermentation tanks or tank farms subject to control shall be conducted within 30 days after the beginning of the fermentation season, at owner/operator expense.
- (4) Compliance with this rule shall be determined thereafter by source testing the emissions from one or more fermentation tanks or tank farms during the fermentation season. No fermentation tank or tank farm shall exceed the limits set forth in subsection (b)(1).

- (5) Source testing to determine compliance pursuant to subsections (b)(3) and (b)(4) shall be conducted using ARB Method 100 or an equivalent method approved by the Air Pollution Control Officer.

(c) Compliance Schedule

The owner or operator of a winery with fermentation tanks subject to this rule shall fulfill the following increments of progress:

- (1) By May 1, 1989, submit to the Air Pollution Control Officer a control plan pursuant to subsection (b)(2) of this rule.
- (2) Upon approval of the control plan by the Air Pollution Control Officer, and by the beginning of the 1990 fermentation season, install all ethanol emission control equipment as specified in the control plan and demonstrate compliance with this rule pursuant to subsections (b)(1) and (b)(3).

(d) Demonstration Program

To allow time to eliminate any unforeseen difficulties with the fermentation tank exhaust control system, a demonstration program approved by the Air Pollution Control Officer shall be conducted for one complete fermentation season as follows:



- (1) All wineries having an annual production of 10 million gallons or more of wine shall participate in Air Pollution Control Officer approved pilot and demonstration programs. Annual production shall be determined by averaging the production for each of the three years, 1983, 1984, and 1985. The demonstration and pilot programs shall be conducted during the 1988 fermentation season. A total of at least four fermentation cycles for white wine and/or 10 fermentation cycles for red wine shall be tested.
- (2) Wineries participating in the demonstration program shall conduct a demonstration on at least one tank farm of at least five fermentation tanks, with a total capacity of at least 250,000 gallons.
- (3) Each of the four types of exhaust controls (carbon adsorption, condensation, incineration, and scrubbing) shall be reviewed in Air Pollution Control Officer approved pilot and/or demonstration programs. The pilot programs will review those techniques not reviewed in the demonstration program.

- (4) Ducting and control equipment approved by the Air Pollution Control Officer shall be installed for each tank farm or pilot tank. Ducting and control equipment shall be designed to achieve a 90 percent reduction in the ethanol content of the exhaust gases from each tank farm or pilot tank.
- (5) The owner or operator of each winery participating in the demonstration and pilot programs shall conduct or simulate fermentation operations so as to reveal any difficulties or problems in the design and/or function of the control equipment and associated ducting system.
- (6) The percent reduction of the ethanol content of the exhaust gases of each tank farm used in the demonstration and pilot programs shall be determined by source testing during the fermentation process. Such testing shall be performed by the method described in subsection (b)(5). Source tests shall be conducted at least once a week, at owner/operator expense, during the fermentation season.
- (7) The owner or operator of each winery participating in the demonstration and pilot programs shall submit a plan for the installation of ethanol emission control equipment to the Air Pollution Control Officer by July 1, 1987. Such plan shall contain as a minimum the design of the

ductwork and associated equipment, the number of tanks to be used and their respective capacities, and the type of control equipment to be used.

- (8) Each winery participating in the demonstration and pilot programs shall submit to the Air Pollution Control Officer by February 1, 1989, a report on the results of the demonstration and pilot programs. The report shall include as a minimum:

- (a) a description of the exhaust control system, including ductwork design and control equipment used;
- (b) an itemized list of costs;
- (c) a full description of the test program conditions including, but not limited to, the type of wine tested, fermentation temperatures, percentage of tank capacity filled per cycle, number of cycles tested, and a schedule of tank usage showing the times at which each tank reached its peak fermentation rate;
- (d) copies of the source test data, including but not limited to exhaust gas flow rates, fermentation temperatures, concentrations of ethanol, water and

CO<sub>2</sub> in the exhaust gases, and concentrations of ethanol and water in the waste products where applicable; and

- (e) a discussion of any problems or difficulties encountered during the installation and operation of the control system.

(e) Reevaluation of Requirements

Upon completion of the demonstration and pilot programs, the Air Pollution Control Officer shall evaluate the requirements of subsections (b)(1) and (c)(2). If the Air Pollution Control Officer determines that the requirements of subsections (b)(1) and (c)(2) are not supported by the results of the demonstration and pilot programs, a hearing shall be noticed to amend the requirements of this rule.

B. SUMMARY OF SUGGESTED CONTROL MEASURE

The suggested control measure is summarized as follows:

- o The ethanol content of the exhaust gases from each fermentation tank of 50,000 gallons capacity and over (or from each tank farm of such tanks) in which grape juice is fermented to produce wine shall be reduced by 90 percent. Storage tanks not used for fermentation are not subject to control.

o The owner or operator of each winery with fermentation tanks subject to control shall submit a control plan by May 1, 1989. The plan shall be subject to approval by the Air Pollution Control Officer and shall contain as a minimum:

1. A list of all fermentation tanks subject to control and their respective capacities. This includes storage tanks used as fermentation tanks, and excess working capacity for each tank farm regardless of frequency of use.
2. Identification of the type of control to be applied to each tank or tank farm and a construction schedule.

o All equipment identified in the control plan shall be installed by the beginning of the 1990 fermentation season.

o To determine initial compliance, source testing of the emissions from each fermentation tank or tank farm subject to control shall be conducted within 30 days after the beginning of the 1990 fermentation season.

o Thereafter, compliance with this rule shall be determined by periodic source testing of the emissions from one or more fermentation tanks or tank farms subject to control.

o Approved demonstration and pilot programs shall be conducted to identify any unforeseen problems that may be associated with the installation, operation, and maintenance of ethanol exhaust control equipment for fermentation tanks. The results of the demonstration and pilot programs shall be reported to the Air Pollution Control Officer. The adopting district will then conduct workshops in which industry is encouraged to discuss the results of the demonstration and pilot programs.

o If the results of the demonstration and pilot programs do not support the requirement of a 90 percent reduction in the ethanol content of the fermentation tank exhaust gases, a hearing will be held to amend the requirements of this rule.

#### C. DISCUSSION

##### 1. Proposed Emission Limits

The suggested control measure would limit the ethanol emissions from fermentation tanks of 50,000 gallons capacity or more (or from tank farms of such tanks) to 10 percent of their uncontrolled emissions. As discussed in Chapter VI, there are several commercially available, cost-effective control technologies capable of achieving reductions of 90 to 99 percent. Therefore, the staff believes that the requirement to reduce ethanol emissions by 90 percent from tanks subject to control is reasonable.

The cost-effectiveness curves presented in Chapter VI show that exhaust controls become less cost-effective as tank capacity decreases. The difference is most pronounced at the lower ranges of tank sizes. By exempting tanks of less than 50,000 gallons capacity, reasonable cost-effectiveness values are maintained.

## 2. Compliance Dates

The control plan required of those owners or operators of wineries with fermentation tanks subject to the suggested control measure would be due May 1, 1989, approximately two years after the anticipated date of approval of the suggested control measure.

The compliance date for the installation of all exhaust controls would be over one year after the control plan is approved by the Air Pollution Control Officer. Because the control technologies are commercially available and already in use in a number of industries for hydrocarbon emission control, most of the lead time would be needed for design and installation of ductwork. The demonstration and pilot programs should reduce the amount of time necessary for such design. The staff believes that a period of approximately 18 months following completion of the demonstration and pilot programs is adequate time for the installation of controls. Compliance would be demonstrated during the 1990 fermentation season.

## 3. Demonstration and Pilot Programs

The wine industry has expressed concerns over the use of exhaust controls on fermentation tanks. During the April 22 meeting in Madera, wine industry representatives proposed that a demonstration and pilot programs be conducted to test the control technologies in a winery situation. At the September 16 TRG workshop, this request was modified to include a full-scale demonstration and pilot programs on one of the four exhaust control technologies and pilot programs on the other three. The TRG has considered this request and has approved a SCM incorporating both demonstration and pilot programs.

The proposed SCM provides for an approximately 18-month period in which wineries with an annual production of 10 million gallons or more shall

design, install, and test ducting and control equipment on a small (250,000 gallons total capacity) tank farm. Pilot (bench scale) programs shall review the exhaust control technologies not tested in the demonstration program. The choice of the control technology to be tested in the demonstration and pilot programs will be subject to the approval of the Air Pollution Control Officer.

The control systems shall be tested during the 1988 fermentation season. Each winery participating in the demonstration and pilot programs shall submit a plan for the installation and design of the ductwork and control equipment by July 1, 1987, subject to the approval of the Air Pollution Control Officer. After completion of the demonstration and pilot programs, a report detailing design, function, and effect on wine quality shall be submitted by February 1, 1989, to the Air Pollution Control Officer.

Source testing shall be conducted during the fermentation process in order to assess the efficiency of the control equipment. If the results of the demonstration or pilot programs indicate that the requirement of a 90 percent reduction in the ethanol content of the fermentation tank exhaust gases cannot be achieved, the requirement may be modified.

#### 4. Test Method

To determine the percent reduction of the ethanol content of the fermentation exhaust gases achieved by the air pollution control equipment, fermentation exhaust gases entering and exiting the air pollution control equipment have to be tested. The values necessary to obtain the percent ethanol reduction are the flow rate, temperature, and ethanol concentration of the fermentation exhaust gases. Due to the variation of the ethanol concentration in the fermentation exhaust gases throughout the



fermentation cycle, a test method that continuously samples and analyzes the fermentation exhaust gases provides the greatest degree of accuracy.

ARB Method 100, Procedures for Continuous Emission Stack Sampling, outlines the procedures to continuously sample and analyze gaseous emissions. This method is applicable for determining emissions of oxides of nitrogen, carbon monoxide, carbon dioxide, sulfur dioxide, total hydrocarbons, and oxygen from gas streams flowing in ducts, stacks, and flues. This method could be adapted to source test the fermentation exhaust gases. An equivalent method could be used upon the approval of the Air Pollution Control Officer. Adaptations to ARB Method 100 for its application to fermentation exhaust gases are included as Appendix D of this report.

## VIII. COMMENTS AND RESPONSES

Members of the wine industry made a number of comments during the April 8 consultation meeting, during the April 21 tour of wineries and the April 22 follow-up meeting in Madera, during the September 16 TRG workshop, and in letters regarding the staff's design and cost estimates of ethanol exhaust controls. These comments, along with the staff's responses, are summarized below.

This chapter consists of two sections, the first treating comments received after the April meetings and the second treating written comments on the draft technical support document mailed to industry July 24, as well as comments made during and after the September 16 workshop. Several comments in the first section refer to an ARB staff report. These references are to a March 26, 1986, draft of a discussion of our cost and emissions estimates only. The complete staff report was not written at the time of the April 8 meeting. References to that document herein are presented in quotation marks.

### SECTION I

#### A. GENERAL COMMENTS

1. COMMENT: No ethanol emission control rule should be proposed and/or implemented prior to the outcome of the Wine Institute-sponsored smog chamber test to determine the reactivity of ethanol.

RESPONSE: The reactivity of ethanol is greater than that of ethane, which is considered by some districts to be reactive. Relative reactivity is based on the hydroxyl radical reaction rate, normalized to ethane, as determined by kinetic studies in smog chambers. Ethanol is ranked

at 6.9 relative to 1.0 for ethane on a mass basis and at 10.5 relative to 1.0 for ethane on a molar basis. While ethanol is of relatively low reactivity, it can be oxidized in the atmosphere to compounds of much higher reactivities.

The proposed suggested control measure is not a rule and would not have the force of law until adopted by a district. Both phases of the SAI smog chamber study<sup>1/</sup> will be completed before any implementation of a rule affecting winery ethanol emissions. The staff does not anticipate that the outcome of the SAI study will affect the evaluation of the proposed SCM.

2. COMMENT: Ethanol is  $\text{CH}_3\text{CH}_2\text{OH}$  and one-third of its molecular weight consists of oxygen. Thus, even if the molecule were totally reactive, it could have only two-thirds the effect of a reactive true hydrocarbon.

RESPONSE: Discussing the reactivity of organic species on the basis of mass is only a convenience for relating reactivity with emission controls that are described as reducing a certain mass of emissions. Because atmospheric reactions are really molecular phenomena, the appropriate basis for reactivity is a molecular or molar basis. Photochemical reactions proceed molecule by molecule with the mass of the reactive species an unimportant property insofar as ozone production is concerned. The mass of individual molecules does not enter into the picture when molar reactivity is considered.

Although ethanol has a lower molar reactivity than many "true hydrocarbons," it also has a greater molar reactivity than many other photochemically reactive species, including some hydrocarbons. The molecular weight is not a consideration regarding these reactivities. As mentioned in the response to the previous comment, on a molar basis, ethanol is 10.5 times as reactive as ethane.

3. COMMENT: Air quality data reflect a significant decrease in oxidant levels during the times in which winery emissions of ethanol from fermentation are occurring. Because the entire annual emissions of ethanol from winery fermentation operations occur during a small part of the year, the oxidant levels during that period ought to be affected if these emissions had any effect on air quality. Empirical evidence suggests that winery emissions of ethanol do not contribute to air pollution even at the peak of emissions.

RESPONSE: The staff disagrees with the statement that oxidant levels decrease significantly during the fermentation season. From 1982 through 1985, roughly 40 percent of the annual exceedances of the federal ozone standard of .12 ppm occurred during the fermentation season (mid-August to early November) in Fresno and Kern Counties combined.

Wineries contribute a small fraction of the total ozone precursor emissions in the San Joaquin Valley and thus would not be expected to cause significant increases in oxidant levels. However, each small source has an additive effect on air quality. Wineries are one of many candidates for control. The sum of the total reductions from all controlled sources will have a significant effect on air quality.

4. COMMENT: The ARB staff used 80<sup>0</sup>F for red wine and 55<sup>0</sup>F for white wine to depict the prevailing average fermentation temperatures in the industry. These averages may not reflect actual industry practice, but are instead based on an unrepresentative survey. At a minimum, the actual average temperatures utilized by wineries in California are probably higher than those indicated.

RESPONSE: The staff has since amended its estimates of industry-wide fermentation temperatures to 78<sup>0</sup>F for red wine and 58<sup>0</sup>F for white wine. These temperatures represent the weighted average fermentation temperatures, based on throughput, obtained through a survey of San Joaquin Valley wineries conducted by the Fresno County APCD in 1980. This information was extrapolated to statewide fermentation temperatures because it represented the most accurate data available. The staff also requested that the Wine Institute supply the weighted-average fermentation temperatures of the 10 largest wineries in California as a basis for emissions estimates, but was told that this information was unavailable.

5. COMMENT: In 1977, average fermentation temperatures were generally higher than the average fermentation temperatures mandated as a start point by the temperature control rule proposed by the Fresno County APCD. Moreover, proportionately more red wine, fermented at higher temperatures than white wine, was produced in 1977 than now. As a result, fermentation emissions of ethanol already have been reduced considerably. A fermentation temperature control rule would mandate continued low fermentation temperatures, effectively locking in place the emission reductions achieved since 1977.

RESPONSE: During both the April 8 and April 22 meetings, the staff asked for documentation of the 1977 fermentation temperatures, but has not yet received such information. The proposed Fresno County APCD temperature control rule would have established average fermentation temperatures of 80<sup>0</sup>F for red wine and 55<sup>0</sup>F for white wine. The ARB staff analysis in Chapter VI of this report shows that only a seven percent overall reduction, using 1985 production levels would be achieved if such a rule were

adopted. The staff also disagrees with the statement that a fermentation temperature control rule would lock into place the emission reductions achieved by the decreased production of red wine. The market may change in the future, and total ethanol emissions could increase if the demand for red wine increases.

B. DUCTING SYSTEM

1. COMMENT: The ARB "staff report" assumes that every tank on which ducting is installed will be used as a fermentation tank at or near capacity for the entire fermentation season during the year. This assumption is not realistic. Wineries often underutilize their fermentation tanks, because not enough grapes of each variety are available to fill the tank. Furthermore, wineries must maintain a 35 percent excess fermentation capacity in case the refrigeration to a fermentation tank breaks down and the must or juice has to be piped to a nearby tank.

RESPONSE: The staff did not assume full capacity in its estimates of fermentation tank use, but rather 80 percent capacity for red wine and 75 percent capacity for white wine which the staff understands to be standard industry practice. The staff acknowledges the need for 35 percent excess tank capacity, first disclosed by the wine industry at the April 22 meeting, and has modified its cost estimates accordingly. This is discussed in more depth in Chapter VI and in Appendix A.

2. COMMENT: The "staff report" does not describe or estimate the costs of modifying the fermentation tanks to support the ducting system and manifold on each tank. Also, the tanks would need additional catwalks and ladders to provide access to the manifold and manhole on top of the tank. Finally, an additional outlet to vent the emissions to the manifold must be

installed. This would be an extremely complicated, expensive, and time-consuming project.

RESPONSE: Based on a tour of the wineries, the staff is not convinced that additional catwalks and ladders are needed for the separate emission control vent. Such a vent would have to be offset from the present manhole by only five to 10 feet. Also, existing catwalks are supported by struts welded to the side of the tank. A similar connection can be made for the ductwork supports.

3. COMMENT: The opening to vent the fermentation tank exhaust would have to be very large if pressure build-up inside the tank is to be avoided.

RESPONSE: The staff has calculated the diameter of the opening necessary to maintain acceptable pressures (one-half ounce per square inch). The range of vent diameters was estimated to be from six inches for 50,000 gallon tanks to 18 inches for 600,000 gallon tanks. This analysis is included in Appendix C.

4. COMMENT: The "staff report" does not provide design details for the ductwork connection to the tank. A detailed schematic should be included before we can comment.

RESPONSE: A schematic, included in Chapter V of this staff report, was provided at the April 22 meeting. It is inappropriate for the staff to make detailed design of pollution control equipment. This is the responsibility of the individual winery. Qualified engineers should be employed to provide detailed equipment design.

5. COMMENT: The "staff report" does not disclose the basis for many of the estimated cost items. All of the cross-connections, valves,

dampers, and hoods will have to be custom made. As customized pieces are usually far more expensive than off-the-shelf pieces, the cost of these custom pieces could equal or exceed the materials' costs for the rest of the ducting system.

RESPONSE: The staff believes that the method of cost estimation used in the "staff report" yields a conservative figure, that is, on the high side. Contingencies were also added which should cover any costs associated with custom pieces.

6. COMMENT: The tank layout at many wineries is far from the simplified model depicted in the ARB drawings. At some wineries, tanks are spread over a relatively wide area. This would dramatically increase the cost of the ducting system at those wineries.

RESPONSE: The staff estimate is of necessity based on a simplified layout. Because of differences between wineries, it is not possible for the staff to make detailed estimates for particular wineries. In practice, wineries would group their tanks into tank farms based on the most economical combinations. In reality, some tanks may be farther apart and others closer together than assumed by the staff. The staff believes that its cost estimates are representative of potential winery costs.

7. COMMENT: The ducting cannot be placed in the open aisles because those aisles must be kept clear to allow access to the tanks by heavy equipment. The ducting systems would have to be installed in the aisles where piping is already in place, further increasing the costs and difficulties of installation.

RESPONSE: Based on the tour of wineries, the staff believes that installation of the ductwork in the aisles occupied by piping could be



accomplished without major difficulties. Retrofit installation is common practice in other industrial situations.

8. COMMENT: To achieve the 90 percent reduction of ethanol emissions mandated by the proposed SCM, the manifold must pick up virtually all of the fermentation emissions from the tank. There is no guarantee that all of the fermentation emissions will be drawn into the system unless the manifold is located so close to the tank that it is practically a closed system. The existing tank construction does not allow any higher internal pressure than one-half ounce per square inch.

RESPONSE: The staff agrees that it may be necessary to modify the SCM if not all of the fermentation tank emissions can be drawn into the system. The demonstration and pilot programs would show if all of the emissions were captured by the ducting system.

9. COMMENT: With an assumed airspeed of 34 miles per hour, the manifold will pick up large quantities of entrained sugar, dust, and insects from the air and any foam that the tank produces. Additionally, the airspeed required by the proposed design would disturb vapor pressure which would increase ethanol emissions. This could also remove flavor and aroma components from the wine.

RESPONSE: The airspeed of the fermentation gases entering the exhaust hood is not 34 miles per hour, but only seven miles per hour (approximately 10 feet per second; see Appendix C). An airspeed of 34 miles per hour is only attained once the exhaust gases bypass the hood and china cap and enter the smaller diameter ducting. The staff has calculated the diameter of the hood necessary to insure a sufficiently low airspeed so as not to disturb the vapor pressure within the tank. These calculations are presented in Appendix C.

An airspeed of seven miles per hour would not be strong enough to pick up insects from the air. As far as dust is concerned, particulate filters are used successfully in other air pollution control applications where dust levels are high. The staff does not believe that foam would enter the system, but the foam separator included in the ducting system design should be able to handle any liquid in the ducts before it reaches the control device. Finally, according to source test data, there is no sugar in the fermentation exhaust stream.<sup>2/</sup>

10. COMMENT: As the "staff report" describes the ducting system and manifolds, each group of tanks would require a control system with an axial turbofan blower operating at 40-50,000 rpm. Axial turbofans may not be operated continuously at such high speeds for long periods and are highly susceptible to mechanical breakdown or damage from intruded matter. It is likely that more than one fan will be needed for each group of tanks.

RESPONSE: The blowers would not operate at speeds of 40-50,000 rpm and the staff is not aware of how the industry representatives arrived at this value. The costs of the blowers are based on specific flow rate (capacity) requirements, in Peters and Timmerhaus, p. 562,<sup>3/</sup> which in turn are based on tank volumes. Once a capacity is known, the size and speed of the blower can be selected. However, there are many combinations of blower sizes and speeds than can be chosen to accommodate a given capacity requirement. The staff has not suggested any specific size or speed. Such detailed design specifications are more appropriately left to the wineries. The staff points out that Perry's, pp. 12-39,<sup>4/</sup> suggests that a typical turbo-blower speed would be around 3500 rpm.

11. COMMENT: Any ducting system with piping or a manifold suspended over an opening in a fermentation tank creates serious risks of contamination through solid or liquid build-up on the manifold. This build-up, which is an ideal breeding ground for molds or bacteria, could contaminate the contents of a tank if the updraft into the manifold were to drop off suddenly.

RESPONSE: One way of minimizing the possibility of any contamination would be to incorporate a "china cap" placed over the exhaust vent which would prevent any duct contents from flowing downward into the tank. The schematic for the possible hood design was provided during the April 22 meeting and is also included in Chapter V of this report. The staff believes that a properly maintained system would not increase the chances of contamination. For example, the pressure relief valves now in use on fermentation tanks seem to offer more potential for contamination than an exhaust hood, but modern winery sanitation practices prevent contamination from these sources.

12. COMMENT: Major portions of the emission collecting system will have to be bypassed on a regularly scheduled basis for cleaning. This non-productive time is in addition to downtimes for repairs and maintenance. It is likely that the emissions reduced by lowering fermentation temperatures will equal the total net ethanol recovery from any of the gas collection methods after adjustments for all downtimes due to equipment breakdowns and scheduled sanitation shutdowns.

RESPONSE: The staff's estimate of emission reductions achieved with temperature control, presented in Chapter VI, was seven percent. For exhaust control methods to fall below this level, equipment would have to be down over 90 percent of the time. The staff's design

incorporates automated clean-in-place systems which should cut down the time for cleaning. District rules and regulations include consideration of upsets and breakdowns and during such occurrences the requirement for 90 percent reduction would be waived.

13. COMMENT: Fermentation tanks which are often used for storage during the fermentation season need to remain tightly closed to prevent oxidation of the wine.

RESPONSE: During storage, the exhaust vent can be covered, just as the manhole is currently covered on fermentation tanks used for storage.

14. COMMENT: Fermentation tanks are used interchangeably for both red and white wines. If certain tanks had to be designated for red wines only, wineries would lose the versatility of fermenting red and white wines in the same tanks.

RESPONSE: The staff is not requiring that tanks be designated as red or white wine tanks. However, because of the 35 percent excess working capacity required by wineries, it would seem that some flexibility does exist for designating specific tanks at the winery's option. Even where tanks must be used for both red and white wine, the control system can be downsized by the winery if it is known that the tanks will not be filled to capacity during the fermentation of red wine, which requires the larger control system.

15. COMMENT: Noise and other safety-related issues which are of great concern to the wineries were not addressed in the staff report.

RESPONSE: The staff does not believe that a properly designed ducting system will result in unacceptable noise levels during the

fermentation season. The noise level normally encountered during that time is certainly already high due to operation of heavy equipment.

C. CONTROL EQUIPMENT

1. COMMENT: The proposed SCM is predicated on the availability of exhaust control methods with efficiencies ranging from 90 to 99 percent. If the proposed SCM were adopted, wineries would be forced to make decisions about and install exhaust control methods which will not operate with the efficiencies assumed in the "staff report."

RESPONSE: Each of the four exhaust control methods has achieved 90 percent or greater control on other emissions sources. There is little reason to believe that they will not work on winery fermentation tanks. This issue would be resolved as a result of the demonstration and pilot programs.

2. COMMENT: Some of the significant costs associated with the specific exhaust control methods, such as costs for refrigeration necessary to lower fermentation temperatures to those used by the staff to calculate ducting costs, have been ignored.

RESPONSE: The design of the exhaust control equipment is based on flow rates for white wine fermentation at 57°F and for red wine fermentation at 83°F. Source tests of fermentations conducted at these temperatures were the only data available to the staff; however, they closely approximate the average fermentation temperatures reported by the wineries in a 1980 survey. Those averages were 58°F for white wine and 78°F for red wine. Therefore, on average, no additional refrigeration will be necessary to reduce the temperature of the exhaust to the staff's design values.

3. COMMENT: Catalytic incineration is a known source of NO<sub>x</sub>, which, unlike ethanol, is unquestionably an air pollutant. Yet the staff report fails to discuss how much NO<sub>x</sub> (or for that matter, other pollutants) will be generated by catalytic incineration. The industry questions the wisdom of replacing emissions that may have no known effect on air quality with emissions that are known pollutants.

RESPONSE: The staff disagrees with the statement that ethanol is not an air pollutant. See the response to General Comment 1. Furthermore, the amount of NO<sub>x</sub> produced by catalytic incineration is insignificant due to the temperature at which the unit operates. It is not expected that any other pollutant would be generated in any significant quantity as a result of catalytic incineration of the fermentation tank exhaust gases.

4. COMMENT: The estimated annual cost for operating the incinerator is predicated on the use of pipeline natural gas. However, many wineries do not have access to natural gas. Even wineries with access to natural gas cannot rely on it. Wineries are included as industrial users of gas, and are subject to curtailment in times of shortage. Thus, each catalytic incinerator equipped for natural gas would need back-up equipment to allow use of another fuel in the event the natural gas supply is interrupted.

RESPONSE: Those wineries which do not have natural gas available could choose a different control method or could use another fuel such as propane. Under normal circumstances, if curtailment of natural gas were to occur, it would be during the cold weather months (late November through February) and not during the fermentation season. The staff is not

aware of any past curtailments that have occurred during the fermentation season. Additionally, forecasts indicate that natural gas supplies will be ample through 1995 and no curtailment to industrial users is anticipated.

5. COMMENT: In the carbon adsorption system, the carbon beds used to absorb the ethanol will be cleaned by steaming. Steaming will release the ethanol back into the atmosphere, unless the ethanol is quickly condensed. However, the condensation method described in the "staff report" is totally inadequate. Reducing the steam/ethanol mixture from 220°F to 90°F will only partially condense the ethanol. The rest will return to the atmosphere.

RESPONSE: The ethanol-steam mixture is not released to the atmosphere. It is standard practice to recirculate any noncondensed vapors through the carbon adsorption beds for further ethanol removal. Although water does compete for adsorption sites, the beds selectively adsorb ethanol versus water. The system is described in Chapter V.

6. COMMENT: To estimate the costs of scrubbing, the "staff report" assumes that municipal water will be available. However, many wineries do not have access to municipal water and must rely on their own wells. These wineries would probably be forced to install additional wells and pumps to supply the large quantities of water necessary to operate a scrubber, thereby substantially raising costs.

RESPONSE: Wineries without access to municipal water could choose a different control system if they wish to do so. The various control technologies were investigated because it is recognized that different methods may be more appropriate in different cases. Each winery needs to select the best system for its own use.

7. COMMENT: The "staff report" estimates costs for a condensation system which is not operational. The bidder was not asked to account for the unique conditions applicable to wineries. Because the emissions gases are loaded with moisture, at a condenser temperature of  $-12^{\circ}\text{F}$  the coils would ice up almost immediately, and the efficiency of condensation would drop to unacceptable levels. Any condenser system would have to have several coils, each with a defrost cycle.

RESPONSE: The staff used condensation system costs supplied by an equipment vendor to the wine industry at the specific request of the industry. There was nothing in the quotation to indicate that the system was not operational. Subsequent discussions with the vendor indicated that, although he could not be certain, he does not anticipate any problems with icing of the coils, and therefore, the system should be operational. The reason that the vendor believes that icing would not occur is that a solution of water and ethanol would condense on the refrigeration coils and this solution would probably have a freezing point below  $-12^{\circ}\text{F}$ . Because there remains some uncertainty, however, the vendor would not be able to guarantee such a system. Should icing occur, a hot gas defrost system could be installed on the condensation unit at an additional cost of about 10 percent of the uninstalled capital cost of the control unit. However, the efficiency of the unit would then decrease because no ethanol would be captured during the defrost cycle, and it might be necessary to install two smaller units rather than a single large unit.

Because of the uncertainty of this system, the staff believes that the provision for a demonstration and pilot programs is a desirable part of the SCM. Questions such as the one above should be resolved during a test program.



8. COMMENT: Carbon adsorption, scrubbing, and condensation all generate an ethanol/water solution as waste. Disposal of this waste presents problems. Distilling to recapture the ethanol can only be used by those wineries which have stills. Disposal into the municipal waste system is only possible for those wineries with access to such a system and most wineries do not have access to such facilities. Land disposal involves substantial capital expenditures and operating expenses. Also, land must be available for disposal. Both ponding and discharge into the sewer system allow for return of ethanol to the atmosphere through evaporation.

RESPONSE: The staff realizes that not all control methods are applicable to all wineries and has therefore evaluated several different control technologies. Some of these methods produce greater volumes of waste than others. Individual wineries need to select control methods based on their own resources - whether they have access to additional land or the municipal sewage system, if they own a still, if they have natural gas available, etc. The staff does not anticipate that waste disposal, if carried out properly, will cause any adverse environmental impact. This is discussed further in Chapter IX.

9. COMMENT: Appendix B appears to be in error regarding the concentration of ethanol in the condensate and the quantity of the condensate. Some previous ARB tests have shown water vapor to be greater than 3 percent and ethanol concentration less than 1 percent. The ethanol estimate of 44 percent in Appendix B seem improbable.

RESPONSE: There are several different issues covered in this comment. The first is that the ARB staff was erroneous in its calculations of the ethanol concentration of the condensate. The Wine Institute cited figures of less than 1 percent ethanol and greater than 3 percent water vapor (in the exhaust stream?) but did not state which ARB source test yielded these values. The staff assumes that the Wine Institute is referring to the source test performed at Gallo and published October 31, 1978, which recorded less than 1 percent ethanol and 3 percent water by volume in the fermentation tank exhaust stream of a white wine must. This source test was conducted during the first 24 hours of a fermentation cycle rather than for the entire cycle. The staff's calculations of the ethanol content of the condensate were based on EAL source test data for two entire fermentation cycles, one for red wine and one for white wine. From these data, the staff calculated average ethanol concentrations in the exhaust gases. These source test data were also used as the basis for control equipment and ducting design. The average ethanol and water vapor concentrations in the white wine exhaust were 0.32 volume percent and 1.57 volume percent, respectively. If 90 percent of the ethanol and all of the water vapor were condensed, the liquid condensate formed would have an ethanol and water concentration of 37 and 63 volume percent, respectively.

The average ethanol and water vapor concentrations in the red wine exhaust were 0.90 and 3.70 volume percent, respectively. The condensate formed would have an ethanol and water concentration of 44 and 56 volume percent, respectively.

If the values of 1 percent ethanol and 3 percent water vapor cited by the Wine Institute were used to calculate the concentrations in the condensate, the resulting values for ethanol concentration would be even greater than those originally reported by the staff - 52 percent by volume ethanol and 48 percent by volume water.

The Wine Institute also implies that a larger volume of waste product would be generated than that indicated by the staff. The staff does not know how the Wine Institute arrived at this conclusion. The volume of condensate is calculated by multiplying the concentration of water vapor and ethanol (volume percent) in the exhaust stream times the flow rate. Because the ethanol and water concentrations are very low, the resulting volume of condensate is also low.

#### D. COMMENTS ON COST-EFFECTIVENESS

1. COMMENT: The after-tax cost-effectiveness calculations in the "staff report" assume a benefit to the wineries from an investment tax credit on the purchase of pollution control equipment, even though Congress proposes to repeal the investment tax credit as part of the tax reform package being considered this year. This alone would increase the annualized cost of any expenditures for pollution control equipment. Furthermore, a number of wineries are losing money, are not tax payers, or are under-capitalized and therefore cannot benefit from either the investment tax credit or any deduction for depreciation of investments. The cost-effectiveness of any pollution controls must be assessed on the basis of pre-tax costs.

RESPONSE: For those wineries currently making a profit, after-tax cost-effectiveness is the appropriate method. For those wineries not making a profit, the tax benefits can be deferred for up to five years or

taken retroactively for three years. It is difficult to envision how a winery could remain in business for five additional years without showing a profit. The cost-effectiveness calculations in this report are based on the tax laws in effect at the time the staff used the most recent information available. Also see the response to Cost-Effectiveness Comment 1 in the next section.

## SECTION II

### A. GENERAL COMMENTS

1. COMMENT: "On page 9 of the Technical Support Document, the staff states that white wines 'are fermented in seven to 10 days', and red wines 'take from three to six days to ferment.'...However, on page B-7,...the staff states that the fermentation time... is 'seven days for white wine, and one day for red wine.'"

RESPONSE: The information on page 9 was taken from the literature and was included in a general description of the winemaking process. The information on page B-7 was taken from the source test data given in a report by the EAL Corporation<sup>2/</sup> and relates to specific fermentations which were monitored by that group. As explained on page A-20, these source tests were the basis of the staff's design calculations.

2. COMMENT: "...the staff errs in stating that ranges of 'recommended' fermentation temperatures exist or that temperatures above a certain level 'yield lesser quality wines'... some winemakers may still prefer to ferment some wines at higher temperatures to achieve a certain style of wine."

RESPONSE: The staff obtained the information quoted above from Technology of Wine Making by M. A. Amerine et al., pp. 208-211.<sup>5/</sup>

3. COMMENT: "...fermentation temperature control definitely works with the predicted efficiency...it does not directly threaten product quality...a fermentation control rule would help maintain the reductions in ethanol emissions that have occurred since 1977 due to the general reduction in fermentation temperature. Despite the staff's fears, no one predicts a significant shift in the market back towards red wine consumption in the foreseeable future."

RESPONSE: First, the fermentation temperature control rule proposed by the Fresno County APCD requires daily weighted average fermentation temperatures (DWAFTs) of 80<sup>0</sup>F for red wine and 55<sup>0</sup>F for white wine. As discussed in Chapter V, ethanol emissions increase with even slight fluctuations in temperature during the fermentation cycle, as well as with cap-liquid temperature differentials in red wine fermentation. Since the temperature control rule does not specify how these variables will be controlled, the staff assumes that they will not be. Therefore, emissions would be greater than the DWAFTs for red and white wine indicate. Second, the staff does not feel that exhaust controls "directly threaten product quality." The demonstration and pilot programs will resolve this issue. Finally, the staff has seen no documentation of the 1977 fermentation temperatures. We therefore assume that they were similar to temperatures used in 1980, for which we have data. These are the temperatures used as a startpoint in estimating emissions reductions with temperature control. The staff does not "fear" that the market will shift towards red wine, we simply wish to point out that temperature control does not "lock in" emissions reductions if the production of more red wine can cause emissions to increase.

4. COMMENT: "The staff states that ....based on 'smog chamber studies, ethanol is considered reactive because it is more reactive than ethane, which is considered reactive,'.... but fails to specify which ones. The two most recent prior studies of which Wine Institute is aware indicated that ethanol has low or zero reactivity."

RESPONSE: The ARB has reviewed a number of kinetics and smog chamber studies which indicate that ethanol is reactive, including the work of Campbell, McLaughlin, and Hardy (Chem. Phys. Lett. 38:362 [1976]; Shankara, Wagner, Schiff, and Davis (unpublished results, 1978); and Overend and Paraskevopoulos (J. Phys. Chem. 82:1329 [1978]).

5. COMMENT: "Since the SCM now under consideration would impose huge costs for doubtful benefits, Wine Institute submits that the SCM should not be adopted. At a minimum, the SCM should be deferred until after the effect of ethanol emissions on air quality and the costs and benefits of control have been more thoroughly evaluated."

RESPONSE: The staff does not believe that the costs imposed would be unreasonable, nor that the benefits of the SCM would be doubtful. The effect of ethanol emissions on air quality has been evaluated (see the response to Comment 4 above). Ethanol is an ozone precursor and controlling ethanol emissions will reduce the formation of ozone.

6. COMMENT: "...both the daily and hourly numbers of California and national ozone standards exceedances declined sharply in September 1985 from their August 1985 levels. Furthermore, the number of hourly and daily exceedances in September were clearly far less than the 40% of the annual total referred to by the staff."

RESPONSE: Because the 1980 San Joaquin Valley tank survey indicated that the fermentation season began in mid-August, the staff considered air

quality data from the last two weeks of August to apply to the fermentation season. When all daily exceedances of the national ozone standard from mid-August to early November, 1982 to 1985, were totaled, they accounted for 40 percent of the grand total. In 1985, 49 percent of the national and 35 percent of the California ozone standard exceedances occurred during the fermentation season.

7. COMMENT: "...the staff has not projected the impact of this rule on overall air quality in the nonattainment areas in the San Joaquin basin... Moreover, winery emissions of ethanol are seasonal and probably not substantial compared to ethanol emissions from agricultural products left to rot in the fields each year."

RESPONSE: See the response to General Comment 3 in the previous section. As for agricultural products left to rot in the fields, the costs and feasibility of controlling these sources, plus the problems involved with monitoring the fields, would not make this a practical control measure.

8. COMMENT: "...the San Joaquin Valley Air Basin Control Council intends to conduct a comprehensive study of the sources and possible solutions to air pollution in the valley air basin...sufficient doubt should exist about the efficacy and cost-effectiveness of an SCM aimed at controlling ethanol emissions to warrant deferring it until the effect of ethanol on air quality (if any) is better understood."

RESPONSE: There is an acknowledged air quality problem in the San Joaquin Valley Air Basin. The ARB staff has identified control measures which it believes are reasonable and cost-effective. To defer the development of the SCM until the results of the study are published would have the effect of prolonging the air quality problem. Furthermore, the staff does not believe that the results of the study will suggest that ethanol emissions should not be controlled in the San Joaquin Valley.

9. COMMENT: "...the proposed SCM puts an administrative burden on the local APCDs, requiring that they be given some time to set up the pilot studies."

RESPONSE: The proposed SCM does not put any greater administrative burden on a local district than many other rules. A district has the option of adopting a rule and would probably not choose to adopt one which appeared to create an overwhelming administrative burden.

10. COMMENT: "...at least one year will be required for set up after an APCD approves a winery pilot study proposal."

RESPONSE: The plan for the demonstration program would be due July 1, 1987. The actual program would not begin until the 1988 fermentation season, which presumably begins in mid-August at the earliest.

11. COMMENT: "...Due to the short length of the fermentation season, the equipment may not be properly adjusted in time to provide meaningful results during the first season of testing. The proposed SCM requires a test including at least four fermentation cycles on red wine and 10 cycles on white wine. Since a tank is typically used for at most 3-4 fermentation cycles in a season, the SCM's requirements will be impossible to meet during the first year."

RESPONSE: The demonstration program would require at least four fermentation cycles of white wine and/or 10 cycles of red wine. Through discussions with winery technical personnel, the staff learned that the cycle length is nine days for white wine and three days for red wine, including time for cleaning the tanks. The season length is 36 days for white wine and 30 days for red wine. Assuming continuous operation in the demonstration program, the requirement outlined above seems reasonable.



12. COMMENT: "Assuming that pilot studies show that emissions controls are feasible and cost-effective, all of the tanks at every winery subject to the SCM will have to be ducted and attached to control equipment. This cannot be done at once. Wineries will only be able to modify the tanks that can be emptied and will not be needed for blending or transfer of wine during the construction period...the timetables for implementation set forth in the proposed SCM are unrealistically optimistic."

RESPONSE: The staff believes that an 18-month period is sufficient for the installation of ductwork and control equipment. Modification of the tanks used in the demonstration program will indicate the length of time required to modify each tank. If more time appears to be needed to complete the installation of control equipment than is provided in the SCM, the timetable can be modified as necessary.

13. COMMENT: "...the proposed SCM does not contain sufficient flexibility in the event pilot studies indicate: (1) one or more of the proposed control methods will not work; (2) the proposed control methods will not work with the anticipated 90% efficiency; or (3) the costs of installing the control methods are significantly above the staff's estimates. If any of these applies, the SCM should be completely reevaluated, not just made the subject of a hearing in which the requirement(s) of the SCM 'may be modified'."

RESPONSE: If the 90 percent requirement is modified as a result of the demonstration or pilot programs, the cost-effectiveness of the measure would be reconsidered. The purpose of the demonstration and pilot programs is to demonstrate the technical feasibility and cost-effectiveness of the controls. The wine industry is encouraged to discuss any problems or difficulties during the programs in workshops conducted by the adopting district.

## B. DUCTING SYSTEM

1. COMMENT: "The presence of entrained sugar in emissions from fermentation tanks is a well known phenomenon...insects and dust will inevitably be sucked into the ducting system given the airspeeds at the ducting manifold that the staff contemplates."

RESPONSE: See the response to Ducting System Comment 9 in the previous section regarding airspeed. Also, the staff notes that during the September 16 workshop, Dr. Roger Boulton confirmed that sugar is not entrained in the fermentation exhaust gases.

2. COMMENT: "...the tank groupings assumed by the ARB represent the ideal situation and therefore are the most economical possible... If the staff had asked, Wine Institute would have provided tank layouts for the purpose of making cost estimates."

RESPONSE: During the April 8 consultation meeting, the staff handed out a set of questions. Question 3 on page 4 of the handout asks how the fermentation tanks are physically grouped. The staff received a total of two layouts, neither of which shows the location of existing pipelines. From these layouts, and from visual inspection of the four wineries toured on April 21, the staff does not believe that the tank farm scenarios are overly simplistic or idealized.

3. COMMENT: "The staff....claims that, on April 22, 1986, it 'presented detailed schematics of the ducting system which the industry had requested.' These drawings were neither 'detailed schematics' nor did they respond to the industry's requests."

RESPONSE: The schematics were presented to show the design concept of the ducting system - tank connection, not the actual design itself. See

the response to Ducting System Comment 4 in the previous section. That response also applies to all comments concerning the lack of specifications for equipment in the Technical Support Document.

4. COMMENT: "The staff...failed to understand that virtually every tank at a winery must be ducted and linked to a control device, substantially increasing the costs of ducting and control equipment."

RESPONSE: The staff's cost estimates were based on various tank farm layouts. There is no reason why a winery could not group every tank in the winery into such tank farms. While total costs to a winery increase as more tanks are added, the cost per tank farm remains the same.

5. COMMENT: "While some wineries use automatic clean in place systems for their large must lines, Wine Institute believes that these systems cannot automatically be extrapolated for use on the ducting systems proposed by the staff... Special valves, pumps, and cleaning solution disposal facilities would have to be installed as part of each ducting system... The staff has not considered the costs of such special cleaning facilities."

RESPONSE: The costs for the clean-in-place system were provided by Bob Calvin of Heublein Wines. The staff assumes that the price quoted was for a completely functional system.

6. COMMENT: "...the ducting systems would have to be installed in the aisles where ducting is already in place, considerably increasing the costs and difficulty of installation. The Staff Report has failed to take this into account in its cost calculations."

RESPONSE: The staff believes that, on the whole, its cost estimates are representative of the actual costs a winery would encounter in the installation and operation of the ducting system and control equipment.

7. COMMENT: "The staff has provided no basis for its opinion that the cost of customized pieces is adequately covered in its 'contingency' cost estimates."

RESPONSE: The customized pieces that are to be covered by the contingency are the cross-sections. The number of cross-sections required are one, three, and four for tank farms of five, 10, and 15 tanks, respectively. Peters and Timmerhaus<sup>3/</sup> suggest a contingency of 8 percent of the fixed capital. The staff used a contingency of 15 percent. The staff believes that the increase of the contingency will cover the cost of the cross-sections.

8. COMMENT: "...the staff proposes placing a 'china cap' over the vent. This design creates more problems than it solves. First, the proposed vent opening appears to be undersized....Second, the proposed china cap will be a source of contamination to the tank, due to solid or liquid build-up on the underside of the cap. The cap also substantially increases the chance of damage to the tank due to a catastrophic 'foam-over' incident."

RESPONSE: The analysis presented in Appendix C is not intended to be a design to be followed by a winery. The design of a connection between the tank and the ducting system would be the responsibility of the winery. The purpose of the analysis in Appendix C is to show that diameters of the tank opening would be reasonable and no adverse pressure or vacuum would occur in the tank. The staff used the empirical equation for a compressible fluid through an orifice to determine the size of the tank openings. The tank opening diameters calculated are the minimum diameters required by the various tank sizes. The underside of the china cap could be cleaned after each fermentation cycle, as presumably this is when the tank would be cleaned. The china cap would be no more of a contamination factor than the manhole cover currently used by the wineries.

9. COMMENT: "Installation of a china cap will increase substantially the costs of emissions control over the ARB staff estimates."

RESPONSE: The staff believes that the method of cost estimation used in the Technical Support Document yields a reasonable figure. The staff does not believe that the installation of a china cap would result in a substantial increase in the overall cost estimate.

10. COMMENT: "...the staff does not discuss the costs and difficulties of modifying the fermentation tanks to hold the supports."

RESPONSE: Based on a tour of the wineries, the staff does not believe that major modifications to the fermentation tanks are necessary. There are existing support struts welded to the side of the tanks. Additional supports could be added without major difficulties.

11. COMMENT: "...the staff's estimate of the typical rpm for the fans [3500 rpm] is at the low end...the staff concedes that the size and speed of the blower will depend on the number of tanks attached to it, the expected rate of gas flow, and other design specifications."

RESPONSE: The staff did not suggest any specific operating speed for the blower. The cost of the blowers is based on specific flow rate requirements. The staff stated this in response to an earlier comment (Ducting System Response 10 in the previous section) and in Appendix A of the Technical Support Document.

#### C. CONTROL EQUIPMENT

1. COMMENT: "The staff indicates that design of the carbon adsorption system must be optimized between steam costs and increased bed size to compensate for the reduced working capacity due to the ethanol 'heel.'"

However, the staff does not appear to account for this design criterion in estimating costs for the system."

RESPONSE: The staff's cost estimates did account for the reduced working capacity of the beds. It was stated on page A-49 of the Technical Support Document that only 1/3 of the adsorbed ethanol is steamed off during regeneration. The calculation for the size of the bed accounts for this fact.

2. COMMENT: "The staff states that carbon adsorption proceeds until the carbon bed is saturated and needs regeneration. Wine Institute would be interested in learning how the need for regeneration is determined and what additional equipment would be needed."

RESPONSE: Multiple-bed carbon adsorption units are commonly used in industrial applications. The price quote given by the manufacturer (Vic Manufacturing) was for a completely functional unit.

3. COMMENT: "Ethanol is both aliphatic and polar, so that information gained from typical applications of carbon adsorption is not transferable to ethanol emissions."

RESPONSE: The staff obtained cost estimates from a vendor who was asked to base his costs on carbon adsorption of ethanol. The vendor was given specific information on the fermentation exhaust gas stream for both red and white wine. Polar and non-polar solvents are equally adsorbed by activated carbon.<sup>6/</sup>

4. COMMENT: "Wine Institute attached a more recent quote for condensation equipment...as Exhibit M to its May 1986 comments. The staff did not use this more recent quote in calculating condensation costs."

RESPONSE: Before receiving the more recent price quote, the staff had scaled up the previously quoted 1982 figure of \$39,400 to \$41,800.

Because these are preliminary cost estimates, the overall accuracy of the cost-effectiveness estimates for condensation would not increase if the staff were to reevaluate the costs using the more recent quote of \$45,200.

5. COMMENT: "The staff claims that icing on condenser coils will not be a problem because the vendor did not think it would occur... In fact, icing on the condenser coils is inevitable."

RESPONSE: See the response to Control Equipment Comment 7 in the previous section.

6. COMMENT: "The staff assumes that condensation will produce a liquid that is 40-44% ethanol by volume... However, Professor Williams suggests that intermediate condensates would contain a lesser percentage of ethanol...even the most concentrated ethanol in water solution will rapidly ice up the condenser coils."

RESPONSE: The staff does not "assume" that the final concentration of the liquid will be 40-44 percent ethanol by volume; the staff's calculations are correct. See the response to Control Equipment Comment 9 in Section I. The demonstration or pilot program will resolve the issue of whether or not the intermediate condensates will ice up on the coils.

7. COMMENT: "The staff believes that a hot gas defrost system could be installed to handle icing on the coils...this system...would require additional condenser coils to be operating while other coils are being defrosted. The staff's cost estimates do not cover the cost of this defrost system or the cost of the additional condenser coils."

RESPONSE: See the response to Comment 6, above.

8. COMMENT: "The staff assumes that a catalytic incinerator will operate only one month per year, and therefore, 1% a year attrition for the

catalyst is appropriate. However, the staff concedes that the fermentation season can extend from mid-August until November. Therefore, the catalyst attrition may be greater."

RESPONSE: The staff obtained estimates from industry of approximately 30 days each as the season length for red and white wine fermentation. These seasons are staggered with some overlap. Each cost scenario was based on one season of either red or white wine fermentation. The staff stated that the fermentation season for the entire San Joaquin Valley extended from mid-August to early November. The fermentation season for individual wineries would not last this long.

9. COMMENT: "...the staff's assumptions regarding operating parameters and costs for the catalytic incinerator may be very optimistic. The ethanol...is associated with a much larger volume of non-combustible carbon dioxide... Furthermore, the staff is assuming an operating temperature of 500°F. Wine Institute believes that this is the lowest end of normal operating temperatures for catalytic incinerators... If the incineration must proceed at higher temperatures, NO<sub>x</sub> emissions may present a pollution problem."

RESPONSE: The vendor was given the conditions under which the catalytic incinerator would operate. This particular type of catalytic incinerator was chosen for the design estimates because of its low operating temperature. In order for NO<sub>x</sub> to be formed, an operating temperature of 2800°F would have to be attained.



10. COMMENT: "...the staff is also underestimating the normal costs of operating a catalytic incineration system by predicating those costs on the use of pipeline natural gas. Many wineries do not have access to natural gas in this form. These wineries would be forced to use LNG, propane, or butane delivered to them by tank truck or railcar. Not only are these fuels much more expensive than pipeline natural gas, they are also much more dangerous to handle."

RESPONSE: The staff has spoken to a supplier (Buck's Gas Service, San Jose) of liquid petroleum gas (LPG) about the cost of LPG to industrial users. The supplier informed the staff that the cost of LPG is dependent on where and when the LPG is purchased. However, he did indicate that in general, the cost of LPG is comparable to natural gas.

LPG is used by many types of industries. The handling of LPG is a common practice, and it has been proven that it can be safely accomplished with the proper precautions.

11. COMMENT: "Wineries are included as industrial users of gas, and are subject to curtailment...PG&E's contracts require customers to maintain back-up equipment. Thus, each catalytic incinerator equipped for natural gas would need back-up equipment to allow use of another fuel in the event the natural gas supply is interrupted."

RESPONSE: If a back-up fuel is required in the event that the natural gas supply is interrupted, LPG can be used as the back-up fuel. LPG could be stored in tanks leased from the LPG suppliers. The suppliers will install the required tanks and charge the LPG user an annual rental fee. The costs of maintaining this back-up system would range from 0.02 to 0.03 percent of the total costs, depending on the wine type and tank farm scenario.

Historically, curtailments have only occurred during the coldest months of the year (from late November through February). These curtailments have applied only to power generators, not to industrial users of natural gas.

12. COMMENT: "If none of the other control systems are feasible, wineries would have no choice but to incur the additional costs of installing wells and pumps to provide water for the scrubber. These costs should be taken into account in evaluating the cost-effectiveness of the proposed SCM."

RESPONSE: The staff believes that all of the exhaust control systems are feasible. The various control technologies were investigated because different methods may be more appropriate in different cases. Each winery needs to select the best system for its own use. (See the response to Control Equipment Comment 6, in the previous section).

13. COMMENT: "...the staff has not evaluated the effect on overall efficiency of shutdowns due to cleaning or equipment breakdown. To the extent that the actual level of control may be less than 90% due to such events, the staff's cost-effectiveness assumptions are not accurate."

RESPONSE: The staff's design incorporates automated clean-in-place systems which should cut down the time for cleaning. However, the staff does not know how often the ducts would have to be cleaned, nor how much time would be involved in cleaning. These questions can only be answered by a demonstration program. District rules and regulations include consideration of upsets and breakdowns, and during such occurrences, the requirement for 90 percent reduction would be waived. Upsets and breakdowns are not considered in estimating the cost-effectiveness of district rules.

14. COMMENT: "Failure to take into account actual conditions in the wine industry is a major flaw in the ARB staff's cost and feasibility analyses."

This error has affected many of the staff's assumptions and has resulted in incomplete and oversimplified specifications for the equipment suppliers that submitted quotes for control equipment...When the equipment suppliers were notified of...specific operating problems experienced in the wine industry, they could not guarantee the effectiveness of their pollution control equipment."

RESPONSE: The staff gave the equipment suppliers design parameters based on data obtained from source tests of fermentation tanks. The staff does not believe that these design parameters are incomplete or oversimplified. Based on these parameters, the equipment suppliers have provided the staff preliminary quotes for the control equipment. Equipment suppliers generally do not guarantee the effectiveness of control equipment based on preliminary design.

15. COMMENT: "...the control technologies cannot be called 'commercially available' in the wine industry..."

RESPONSE: Although the control technologies have never been used in a winery situation, the staff believes that the technologies are applicable to fermentation tank exhaust control. The only innovation required would be the design of the ducting system, the feasibility of which will be demonstrated in the demonstration and pilot programs.

16. COMMENT: "...the staff does not indicate whether its cost assumptions include the cost of personnel necessary to monitor the ducting system and emissions control equipment."

RESPONSE: These costs are included in the operating and maintenance costs (see page A-67 of the Technical Support Document).

17. COMMENT: There are a number of comments related to the fact that the control technologies have not been used in wineries before. The Wine Institute does not believe that the controls will achieve a 90 percent reduction in ethanol emissions.

RESPONSE: The staff believes that the exhaust controls will achieve a 90 percent reduction in ethanol emissions. The staff gave the vendors specific operating conditions under which the control equipment would operate. Although the control technologies have not been used in wineries before, the staff believes that with sound engineering, the control technologies could be applied to wineries and obtain the designed efficiency. The demonstration and pilot programs will resolve the issue of whether or not the control technologies are capable of achieving a 90 percent reduction in ethanol emissions.

18. COMMENT: "No consideration has been given to the costs or feasibility of the devices needed to monitor the composition of the emissions stream entering the pollution control equipment. Unlike other industries, in the wine industry, the emissions stream may vary considerably depending on the stages of fermentation and the types of wine being produced and will affect substantially the effectiveness of the pollution control equipment."

RESPONSE: Source tests would be performed routinely during the demonstration and pilot programs. The costs associated with these programs are not considered to be part of the cost of the control measure.

The schedule for compliance testing would be determined by the adopting district. The cost of compliance testing is not normally considered in estimating the cost-effectiveness of a control measure.

The control equipment was designed to obtain a 90 percent control efficiency. Without source testing the fermentation tank exhaust stream, it cannot be determined if there is a critical ethanol concentration below which the desired control efficiency cannot be obtained. The source tests performed during the demonstration and pilot programs will show if such a threshold exists. If necessary, the control requirements of the SCM can be reevaluated.

19. COMMENT: "The staff believes that carbon adsorption and condensation wastes could be distilled. However, most wineries lack stillage facilities, and those wineries with stillage facilities have little excess capacity during fermentation season. Furthermore, the alcohol distilled from this waste may not be suitable for beverage purposes."

RESPONSE: If a winery has excess storage capacity, the waste products could be stored in the fermentation tanks not used in a particular season until the still is available for use. Wineries without stills or excess storage capacity could ship the waste product to an ethanol recovery plant (see response to next comment, below). If the distilled ethanol is not suitable for beverage purposes, it, too, could be shipped to a recovery plant.

20. COMMENT: "The staff...feels that if distillation is impossible these wastes could simply be sold to 'recovery plants.' It is not clear what recovery plants the staff is talking about, and no one can predict the terms on which such plants (if they exist) could be induced to take the wastes. The transportation costs alone for the many thousands of gallons of waste that the staff anticipates would be considerable."

RESPONSE: The staff contacted Parallel Products on October 10 to confirm their interest in purchasing waste ethanol product from wineries. A representative of Parallel Products informed the staff that their plant

operation is currently limited due to the lack of available feed stock, and they would be interested in purchasing waste control products.

Parallel Products has two ethanol plants in operation. One is located in Winters, California, and the other in Rancho Cucamonga, California. Both plants are operating at approximately 40 percent plant capacity. The total capacity of these two ethanol plants is approximately five million gallons of ethanol.

The staff has calculated that a waste ethanol product containing 10 volume percent ethanol could be shipped to the Winters plant from the Fresno area without a cost to the wineries. Waste ethanol products containing more than 10 volume percent would result in a profit to the wineries.

The concentrations of ethanol in the waste products from carbon adsorption, scrubbing, and condensation are shown in Table 2, page B-7. The only controls which yield waste products feasible for shipping are carbon adsorption and condensation. Condensation yields waste products of 37 volume percent (white wine) and 41 volume percent (red wine), the shipment of which results in a net profit of approximately 0.01 to 0.03 cents per gallon of wine produced. Carbon adsorption of red wine fermentation exhaust results in a product containing 18 volume percent ethanol, which would yield a 0.02 cents per gallon profit. The only scenario which would involve a cost to the wineries would be carbon adsorption of white wine exhaust, with a waste product of 8.1 volume percent ethanol and a shipping cost of 0.004 cents per gallon. The staff based these estimates on an assumed shipping distance of 250 miles (the approximate mileage between Fresno and Winters), a shipping cost of 3 to 5 cents per gallon of waste product, and a payment of 50 cents per gallon of ethanol.

21. COMMENT: "The staff still has not addressed the problem of disposing of scrubbing wastes. Wine Institute believes that the ethanol in these wastes is likely to return to the atmosphere and that this problem alone renders scrubbing infeasible...Where municipal waste systems exist, those systems are often overloaded, and the operating agency might refuse permission for the winery to put huge additional scrubbing waste loads into the system...While the staff argues that microbial action will degrade the ethanol before more than a minimal amount evaporates, it has no support for this argument."

RESPONSE: The estimation of the evaporation rate of ethanol from an ethanol-water solution depends on many different variables. It is impossible to predict the net return of the ethanol to the atmosphere without specific information on temperature, relative humidity, wind speed, pond geometry, soil conditions affecting the infiltration rate, and the microbial degradation rate. A film or scum of organic material covering the water surface, as might be encountered in a wastewater treatment basin, also impedes evaporation.<sup>7/</sup>

The demonstration or pilot programs could, with the approval of the Air Pollution Control Officer, include an evaluation of the evaporation of ethanol from the wastewater produced by scrubbing.

As for municipal waste systems being overloaded, the staff contacted the wastewater manager for the city of Fresno (Anderson Dill). He indicated that the system would be able to handle the large amounts of scrubber wastewater generated by a winery with an annual production of roughly 40 million gallons of wine.

22. COMMENT: "Even after an ethanol/water mixture has been absorbed into the ground, ethanol would continue to volatilize into the atmosphere because of the suppression of bacterial activity by the large amount of CO<sub>2</sub> dissolved in the ethanol/water mixture."

RESPONSE: The staff has seen no data to support the above statement. As outlined in the previous response, the evaporation rate of the ethanol in the wastewater could be determined as part of the demonstration or pilot program. Evaporation of ethanol from the soil could also be monitored.

#### D. COMMENTS ON COST-EFFECTIVENESS

1. COMMENT: "...the wine industry has been going through difficult economic times. In 1975, foreign table wines constituted only 17% of the U.S. market. In 1985, foreign table wines commanded 30% of the market. Shipments of California table wine, the backbone of the industry, fell from 273.3 million gallons in 1982 to 257.4 million in 1985."

RESPONSE: The staff understands that in 1986, imports of foreign wine are down 19 percent and California wine shipments have increased 11.4 percent since 1985.<sup>8/</sup> The wine industry is not unique in the fact that economic and other conditions fluctuate. The staff does not believe that the costs of controlling ethanol emissions from large fermentation tanks will impose an undue financial burden on the wine industry.

2. COMMENT: "The staff should recognize that the tax laws are about to change...Since (some) wineries cannot take advantage of any tax benefits, and the staff's after-tax calculations are probably not meaningful anyway, before-tax costs are the appropriate measure for calculating cost effectiveness."

RESPONSE: When the staff first calculated the after-tax cost-effectiveness of the fermentation tank controls, the new tax law had not



yet been signed. It was appropriate for the staff to use the tax law in existence at the time. The Internal Revenue Service has not, at the time of this writing, promulgated regulations implementing the new tax law.

Other industries will also be subject to the new tax law and cost-effectiveness values for emission controls in those industries will also be affected. The main difference of applying the different tax law requirements in calculating cost-effectiveness lies in the applicability of the investment tax credit in tax years before 1987. However, it is worth noting that the present value of earlier year dollars invested is greater than the present value of dollars invested in 1989 and 1990, the years in which winery owners would install equipment to comply with the requirements of the SCM.

The staff, for purposes of demonstration, has calculated the after-tax cost-effectiveness of the controls based on a reduced maximum tax rate and the elimination of the investment tax credit. The result of that exercise is a 25 to 30 percent increase in the cost-effectiveness values. Cost-effectiveness in terms of dollars per pound of ethanol removed ranged from \$1.15 to \$13.70 under the conditions of the former tax law; under the new tax law, the cost-effectiveness ranges from \$1.50 to \$17.20. The staff also notes that the Wine Institute's cost-effectiveness analysis, submitted in response to a draft SCM proposed by the Fresno County APCD, was based on after-tax costs.

3. COMMENT: "...the staff is assuming that the equipment will last beyond the applicable depreciation period...operating and maintenance expenses can be expected to rise as the equipment ages. The staff's cost estimates have apparently not taken such cost increases into account."

RESPONSE: According to Tim Anglim of E. & J. Gallo Winery, winery equipment is expected to last 11 years. The operating and maintenance costs represent an overall average over the equipment life. If the equipment life is 11 years, the capital cost of the equipment would be amortized over the entire 11-year period, and the overall costs per year would be even lower than the staff's original estimates based on a five-year equipment life.

The staff has calculated the cost-effectiveness of ethanol emissions control based on an 11-year equipment life. The costs range from \$0.60 per pound of ethanol removed for a red wine tank farm of ten 300,000 gallon tanks using scrubbing to \$7.39 per pound for a white wine tank farm of five 50,000 gallon tanks using condensation. These costs compare to a range of \$1.50 to \$13.70 per pound for the same scenarios, show in Figure VI-7 and VI-11 in the Technical Support Document, based on an equipment life of five years. Thus, although operating and maintenance costs would increase as the equipment ages during an 11-year versus a five-year period, the cost-effectiveness will be lower with an equipment life of 11 years.

## IX. IMPACTS OF THE PROPOSED SUGGESTED CONTROL MEASURE

### A. EMISSION REDUCTIONS

The proposed suggested control measure would affect the emissions of ethanol from winery fermentation tanks. While potential statewide emission reductions cannot be calculated without additional information as to tank size and throughput from individual wineries, estimated overall emission reductions for the San Joaquin Valley Air Basin would be 80 percent or 431 tons per year. Because winery fermentation operations are seasonal, all of the emissions in the San Joaquin Valley Air Basin occur during an approximately 80-day period, from mid-August to early November. Therefore, on a daily basis, uncontrolled emissions of 6.7 tons per day would be reduced by 5.4 tons per day.

### B. OTHER ENVIRONMENTAL IMPACTS

#### 1. Energy Impacts

The staff has calculated the utility requirements for each of the control technologies. Of necessity, energy consumption was estimated on a tank farm basis because no two wineries are identical. Tank sizes and layout differ for each winery and individual vintners presumably would select the most economical tank groupings for exhaust ducting.

Energy requirements for each control method vary considerably according to tank size, tank farm size, and wine type. For the same amount of tank capacity, red wine control requires more energy, regardless of method, than white wine control. This is because red wine emits more ethanol during the fermentation process and has greater exhaust flow rates than does white wine.

Electricity consumption is highest for condensation and lowest for scrubbing. The worst-case scenario of a red wine tank farm of ten 300,000-gallon tanks would use 495,700 kilowatt hours of electricity per year. This would amount to 0.2 percent of the statewide wine-manufacturing industry (including bottling) electricity consumption in 1985.

Natural gas requirements for carbon adsorption are significantly higher than the requirements for catalytic incineration. The worst-case scenario (red wine tank farm of ten 300,000-gallon tanks) for incineration would require 21.5 million Btu's per year. The same scenario for carbon adsorption would require 7.11 billion Btu's per year. This latter case represents approximately 0.4 percent of the statewide wine-manufacturing industry natural gas consumption in 1985.

To estimate the industry-wide energy impacts of the proposed SCM would require data for the total number and sizes of tanks and tank farms to be controlled throughout the state. However, based on the relatively small amounts of energy required even for the highest consuming scenarios, the staff does not anticipate any significant energy impacts as a result of implementation of ethanol exhaust control.

## 2. Waste Disposal

Three of the four exhaust control technologies (carbon adsorption, condensation, and scrubbing) generate an ethanol/water solution as a waste product. Depending on the type of control technology used, wineries have several options available for the disposal of this product. As shown in Appendix B, the volume and concentration of the waste solution vary considerably. Scrubbing produces large quantities of extremely dilute (0.1 to 0.04 percent ethanol) solution. Carbon adsorption produces much lower

quantities of a 7 to 10 percent ethanol solution. Condensation produces the lowest quantities of a highly concentrated (40 to 44 percent ethanol) waste product.

Distillation to recover the ethanol is feasible for the carbon adsorption and condensation wastes. Wineries without stills could sell the waste product to recovery plants. No adverse environmental impact is anticipated from the distillation process.

The large quantities of ethanol/water solution generated by scrubbing are too dilute for cost-effective distillation, but may be disposed of by ponding or by discharge into the municipal sewage system. Ponding involves the application of the wastewater to land. The staff believes that microbial action will degrade the ethanol in the wastewater before a significant amount evaporates. Also, evaporation will be offset by infiltration of the solution into the soil. Prediction of the net return of ethanol to the atmosphere requires specific information on pond geometry, soil conditions affecting the infiltration rate, the microbial digestion rate, and weather conditions (wind speed, temperature, and relative humidity). While each of these variables differs with location and with each application, the staff believes that only a minimal amount of ethanol will evaporate. This issue could be resolved as part of the demonstration or pilot program.

Disposal of the scrubber wastewater into the municipal sewage system is expected to result in even lower quantities of ethanol returning to the atmosphere. Enhanced microbial action should degrade the ethanol very rapidly.

Because catalytic incineration generates no waste product, disposal is not an issue. The temperatures at which the incinerator operates are so low (450° to 500°F) that virtually no NO<sub>x</sub> is emitted. Therefore, no adverse environmental impact is expected from the use of this control strategy.

#### C. ECONOMIC IMPACT

Normally, economic impact is evaluated as an overall capital cost and cost-effectiveness to industry as a whole. In the case of winery fermentation tank ethanol emission control, overall costs to industry cannot be estimated. This is because costs are dependent on tank sizes, tank farm sizes, and tank layout, conditions which are unique to each winery in the state. The staff cannot predict how each winery would choose to comply with the SCM. Therefore, costs and cost-effectiveness have been calculated based on various-sized tank farms of various-sized tanks.

In exhaust control, a number of tanks connected by ductwork would share the cost of the control equipment, resulting in an economy of scale. Cost of temperature control is proportional to load and would not benefit from economy of scale.

Cost-effectiveness was calculated by dividing the cost of the control by the estimated ethanol emission reduction associated with that control. The cost-effectiveness of the control strategies was computed on an after-tax basis, which accounts for the state and federal tax benefits received by the wineries.

Because costs are proportional to load, the after-tax cost-effectiveness of temperature control does not vary with tank or tank farm size. The cost-effectiveness of white wine control is slightly better

than that of red wine control due to less refrigeration requirements during the slower white wine fermentation.

With respect to exhaust controls, the cost-effectiveness varies with tank size, tank farm size, and wine type. Because of the economy of scale, costs per unit decrease with both tank size and tank farm size. Red wine control is more cost-effective than white wine control because of the greater emission reductions achieved with the former.

In most cases, red wine exhaust control is more cost-effective than temperature control. For white wine, temperature control is more cost-effective than exhaust control in 60 percent of the cases. For larger tanks and tank farms, exhaust controls are more cost-effective than temperature control. However, even in cases where temperature control is more cost-effective than exhaust control, its choice as a control strategy is not recommended due to the minimal overall reductions achieved. Both costs and emission reductions are discussed in more depth in Chapter VI.

X. REFERENCES

REFERENCES FOR CHAPTER II

1. Organic Emissions from Wineries (draft), Fresno County Air Pollution Control District, April, 1978.
2. Source Test Report on Emissions from a Fermentation Tank at E. & J. Gallo Winery, Fresno, California, State of California, Air Resources Board, Stationary Source Control Division, Engineering Evaluation Branch Report No. C-8-050, October 31, 1978.
3. Evaluation Test to Measure Ethanol Emissions from a 106,000 Gallon Fermentation Tank, State of California, Air Resources Board, Stationary Source Control Division, Engineering Evaluation Branch Report No. C-80-071, October, 1980.
4. Characterization of Ethanol Emissions from Wineries, EAL Corporation, July 19, 1982.
5. 1980 San Joaquin Valley Wineries Fermentation Tank Characteristics Profile, Fresno County Air Pollution Control District, February, 1981.
6. Winery Emission Control in California, Fresno County Air Pollution Control District, September, 1982.
7. Rule 425 - Winery Fermentation Temperatures for Air Pollution Control, Wine Institute, December 19, 1984.

REFERENCES FOR CHAPTER V

1. M.A. Amerine, H.W. Berg, R.E. Kunkee, C.S. Ough, V. L. Singleton, and A.D. Webb, Technology of Wine Making, Fourth Edition, The AVI Publishing Company, Inc., Westport, Connecticut, 1980.
2. L.P. Martini, "Red Wine Production in the Coastal Counties of California 1960-1980," pp. 59-84 in M.A. Amerine, Editor, Wine Production Technology in the United States, ACS Symposium Series 145, American Chemical Society, Washington, D.C., 1981.
3. E. Skofis, "Production of Table Wines in the Interior Valley," pp. 123-141 in M.A. Amerine, Editor, Wine Production Technology in the United States, ACS Symposium Series 145, American Chemical Society, Washington, D.C., 1981.



4. 1980 San Joaquin Valley Wineries Fermentation Tank Characteristics Profile, Fresno County Air Pollution Control District, February, 1981.
5. H. Warkentin and M.S. Nury, "Alcohol Loss During Fermentation of Grape Juice in Closed Fermenters," *American Journal of Enology and Viticulture*, Vol. 14: 68-74, 1963.
6. H.W. Zimmermann, E.A. Rossi, Jr., and E. Wick, "Alcohol Losses From Entrainment in Carbon Dioxide Evolved During Fermentation," *American Journal of Enology and Viticulture*, Vol. 15: 63-68, 1964.
7. L.A. Williams, "Theory and Modeling of Ethanol Evaporative Losses During Batch Alcoholic Fermentation," *Biotechnology and Bioengineering*, Vol. 25: 1597-1612, 1983.
8. L.A. Williams and R. Boulton, "Modeling and Prediction of Evaporative Ethanol Loss During Wine Fermentations," *American Journal of Enology and Viticulture*, Vol. 32: 234-242, 1983.
9. J.F. Guymon and E.A. Crowell, "The Nature and Cause of Cap-Liquid Temperature Differences During Wine Fermentation," *American Journal of Enology and Viticulture*, Vol. 28: 74-78, 1977.
10. Final Grape Crush Report, 1985 Crop, California Department of Food and Agriculture, 1986.
11. "The 43rd Annual Statistical Survey," Wines and Vines, Vol. 67(7):18-41, July, 1986.

#### REFERENCES FOR CHAPTER VI

1. Characterization of Ethanol Emissions from Wineries, EAL Corporation, July 19, 1982.
2. Air Pollution Engineering Manual, Second Edition, J.A. Danielson, Editor, Environmental Protection Agency, Office of Air and Water Programs, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, 1973.
3. Control of Volatile Organic Emissions from Existing Stationary Sources - Volume I: Control Methods for Surface - Coating Operations, U.S. Environmental Protection Agency, Office of Air, Noise, and Radiation, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, November, 1976.
4. M.A. Amerine, H.W. Berg, R.E. Kunkee, C.S. Ough, V. L. Singleton, and A.D. Webb, Technology of Wine Making, Fourth Edition, The AVI Publishing Company, Inc., Westport, Connecticut, 1980.

5. 1980 San Joaquin Valley Wineries Fermentation Tank Characteristics Profile, Fresno County Air Pollution Control District, February, 1981.
6. Wine Institute Comments Regarding Fresno Air Pollution Control District Proposal to Control Winery Ethanol Emissions, January, 1983.

#### REFERENCES FOR CHAPTER VIII

1. G. Z. Whitten, D. R. Souten, M. W. Gery, and R. D. Edmond, Preliminary Final Report - Potential Impact of Ethanol Emissions on Urban Smog: A Preliminary Modeling and Smog Chamber Study, SYSAPP-86/090, Systems Applications, Inc., August, 1986.
2. Evaluation Test to Measure Ethanol Emissions From a 106,000 Gallon Fermentation Tank, State of California, Air Resources Board, Stationary Source Control Division, Engineering Evaluation Branch Report, No. C-80-071, October, 1980.
3. M. Peters and K. Timmerhaus, Plant Design and Economics for Chemical Engineers, Third Edition, McGraw-Hill, New York, 1980.
4. R. Perry and C. Chilton, Chemical Engineer's Handbook, Fifth Edition, McGraw-Hill, New York, 1973.
5. M. A. Amerine, H. W. Berg, R. E. Kunkee, C. S. Ough, V. L. Singleton, and A. D. Webb, Technology of Wine Making, Fourth Edition, The AVI Publishing Company, Inc., Westport, Connecticut, 1980.
6. Air Pollution Engineering Manual, Second Edition, J. A. Danielson, Editor, Environmental Protection Agency, Office of Air and Water Programs, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, 1973.
7. R. Vincent, Review of Evaporation of Solutes from Water, California Air Resources Board Technical Report SS-86-02, 1986.
8. L. Walker, "Despite Strike, '86 will be Great Vintage," San Francisco Chronicle, p. 27, 36, September 8, 1986.

---

APPENDIX A  
METHODS OF COMPUTING COSTS FOR CONTROLS

The calculations in this appendix are presented solely for the purpose of estimating potential costs of ethanol emissions control and are not intended to be used by a winery as a basis for control equipment design. It is the responsibility of each winery to hire qualified engineers to provide detailed design of the control systems.

## Appendix A

### METHODS OF COMPUTING COSTS FOR CONTROLS

#### TABLE OF CONTENTS

|                                  | <u>PAGE</u> |
|----------------------------------|-------------|
| I. <u>INTRODUCTION</u>           | A-1         |
| II <u>TANK FARM SCENARIOS</u>    | A-7         |
| III. <u>TEMPERATURE CONTROL</u>  | A-12        |
| A. INSTALLED CAPITAL COSTS       | A-12        |
| B. FIXED CAPITAL COSTS           | A-14        |
| C. ANNUAL UTILITY COSTS          | A-14        |
| IV. <u>DUCTING</u>               | A-18        |
| A. INSTALLED CAPITAL COSTS       | A-19        |
| B. FIXED-CAPITAL COSTS           | A-31        |
| C. ANNUAL UTILITY COSTS          | A-31        |
| V. <u>CATALYTIC INCINERATION</u> | A-37        |
| A. INSTALLED CAPITAL COSTS       | A-37        |
| B. FIXED-CAPITAL COSTS           | A-40        |
| C. ANNUAL UTILITY COSTS          | A-40        |
| VI. <u>CARBON ADSORPTION</u>     | A-47        |
| A. INSTALLED CAPITAL COSTS       | A-47        |
| B. FIXED-CAPITAL COSTS           | A-48        |
| C. ANNUAL UTILITY COSTS          | A-48        |
| VII. <u>SCRUBBER</u>             | A-55        |
| A. INSTALLED CAPITAL COSTS       | A-55        |
| B. FIXED-CAPITAL COSTS           | A-56        |
| C. ANNUAL UTILITY COSTS          | A-56        |

|                                                                                     |      |
|-------------------------------------------------------------------------------------|------|
| VIII. <u>CONDENSATION</u>                                                           | A-60 |
| A. INSTALLED CAPITAL COSTS                                                          | A-60 |
| B. FIXED-CAPITAL COSTS                                                              | A-61 |
| C. UTILITY COSTS                                                                    | A-62 |
| IX. <u>OPERATING AND MAINTENANCE COSTS</u>                                          | A-67 |
| X. <u>AFTER-TAX COST-EFFECTIVENESS</u>                                              | A-68 |
| A. EMISSIONS AND REDUCTIONS                                                         | A-68 |
| B. COST-EFFECTIVENESS                                                               | A-73 |
| XI. <u>LIST OF ABBREVIATIONS</u>                                                    | A-79 |
| ATTACHMENT 1                                                                        | A-80 |
| EVALUATION AND CALCULATIONS REGARDING PROPOSED<br>ETHANOL VAPOR CONDENSATION SYSTEM |      |
| ATTACHMENT 2                                                                        | A-83 |
| COST QUOTATION FROM L & A ENGINEERING & EQUIPMENT, INC.                             |      |

## Appendix A

### METHODS OF COMPUTING COSTS FOR CONTROLS

#### I. INTRODUCTION

This appendix presents the methodology for computing the costs and cost-effectiveness of the air pollution control equipment. Section I presents a brief overview of the cost analysis and summarizes the design parameters. Section II discusses the tank farm layout for various cost scenarios. Sections III through VIII present the calculations for capital and utility costs. Section IX discusses operating and maintenance costs. Section X presents the method for estimating the emission reductions and cost-effectiveness for each control scenario.

The methods for calculating capital costs, operating and maintenance costs, emission reductions, and the after-tax cost-effectiveness are briefly outlined below.

First, costs are determined by calculating installed capital, fixed-capital, and annual utility costs. Installed capital costs (ICCs) are the costs for purchasing and installing the hardware. Fixed-capital costs (FCCs) represent the capital necessary for the installed control equipment as well as all auxiliaries that are needed for operation. The FCC for each of the controls is made up of the same items. The breakdown of the FCC items is listed in Table I-1. Due to the different methods used to obtain installed capital costs (ICCs), on occasion some of the FCC items have been included in

Table I-1: Breakdown of Fixed-Capital Cost Items<sup>1/</sup>

Direct Costs

1. All purchased equipment and installed capital cost ICC of equipment:  
installation cost
2. Electrical and service facilities:  
Electrical equipment and labor, service facilities (i.e., water, gas, and steam).

Indirect Costs

1. Engineering and supervision:  
Engineering costs - process, design and general engineering, drafting,  
cost of engineering, consultant fees  
Engineering supervision and inspection
2. Construction expenses:  
Construction, operation and maintenance of temporary facilities
3. Contractor's fee
4. Startup expenses:  
Costs for changes made before operation of control equipment
5. Contingency:  
To cover price changes, small design changes, errors in estimation and  
other unforeseen expenses.

Fixed-Capital Cost

Sum of the direct and indirect costs

---

<sup>1/</sup> Adapted from M. Peters and K. Timmerhaus, Plant Design and Economics for Chemical Engineers, Third Edition, McGraw-Hill, New York, 1980.

the ICCs. Such instances are noted in the following text. Those items are accounted for when the FCCs are calculated, so that cost items will not be duplicated. The method of calculating the costs is outlined for each control type. The detailed calculations are covered in appropriate sections.

Second, the annual operating and maintenance costs are determined. These consist of maintenance, operating labor, property taxes, insurance, overhead, and utility costs.

Third, the emissions and emission reductions are calculated for use in the after-tax cost-effectiveness estimates. Emissions from fermentation are dependent on temperature. The emissions estimates and control equipment design for the exhaust controls are based on fermentation temperatures of 83° for red wine and 57° for white wine. Those temperatures were chosen because source test data, such as exhaust temperature and flow rate which are required for designing the exhaust control equipment, were limited to those temperatures. The emissions and design for temperature control, on the other hand, are based on reducing the baseline temperature of 85°F for red wine to a control temperature of 80°F and on reducing the baseline temperature of 65°F for white wine to a control temperature of 55°F. These temperatures were chosen because of limited design data. Ideally, if more data were available for different temperatures, then emissions and costs could have been determined for a range of temperatures for all control types.

Fourth, the after-tax cost-effectiveness is calculated by dividing the total after-tax costs by the emission reductions.

Tables I-2 through I-4 summarize the design parameters for the cost estimates. Table I-2 shows the cycle and season lengths used in this



Table I-2: Fermentation Temperature and Cycle Lengths

| Control Type        | Wine Type | Temperature °F | Cycle Length days | Season Length days | No. of Cycles |
|---------------------|-----------|----------------|-------------------|--------------------|---------------|
| Exhaust Controls    | White     | 57             | 9                 | 36                 | 4             |
|                     | Red       | 83             | 3                 | 30                 | 10            |
| Temperature Control | White     | 65             | 7                 | 28                 | 4             |
|                     | White     | 55             | 10                | 40                 | 4             |
|                     | Red       | 85             | 2 1/2             | 25                 | 10            |
|                     | Red       | 80             | 3                 | 30                 | 10            |

Table I-3: Fermentation Exhaust Flow Data and Emission Factors  
Used for the Design of the Exhaust Control

| Wine Type | Exhaust Flow Rate | Exhaust Composition*<br>(Mole Percent)                               | % of Tank Capacity Filled | Emission Factors         |                           |
|-----------|-------------------|----------------------------------------------------------------------|---------------------------|--------------------------|---------------------------|
|           |                   |                                                                      |                           | Per 1000 gallons of wine | Per 1000 gallons capacity |
| White     | See Table I-4     | Ethanol, 0.64%<br>Water, 1.57%<br>CO <sub>2</sub> , 97.79%<br>@ 57°F | 80                        | 2.55                     | 2.04                      |
| Red       | See Table I-4     | Ethanol, 1.79%<br>Water, 3.7%<br>CO <sub>2</sub> , 94.51%<br>@ 83°F  | 75                        | 7.76                     | 5.82                      |

\*At near maximum flowrate (representing 99 percent of the white wine emissions and 98 percent of the red wine emissions).

Source: ARB/SSD

Table I-4: Design Flow Rates for Exhaust  
Control Scenarios - acfm

White Wine - Tanks at 80% Full

| Number of<br>Tanks | Tank Capacity, Gal. |             |             |             |
|--------------------|---------------------|-------------|-------------|-------------|
|                    | <u>50k</u>          | <u>100k</u> | <u>300k</u> | <u>600k</u> |
| 5                  | 157                 | 314         | 942         | 1,884       |
| 10                 | 314                 | 628         | 1,884       | 3,768       |
| 15                 | 471                 | 942         | 2,826       | 5,652       |

Red Wine - Tanks at 75% Full

| Number of<br>Tanks | Tank Capacity, Gal. |             |             |
|--------------------|---------------------|-------------|-------------|
|                    | <u>50k</u>          | <u>100k</u> | <u>300k</u> |
| 5                  | 1,150               | 2,300       | 6,900       |
| 10                 | 2,300               | 4,600       | 13,800      |

Source: ARB/SSD

---

analysis. Because the temperature control scenarios have fermentation temperatures different from the exhaust control scenarios, the fermentation cycle lengths are also different. To keep production levels the same, the number of cycles was kept constant, and the season lengths were adjusted. Also, by keeping production levels constant, the emissions will reflect changes due to temperature and not reflect changes due to cycles per season. This is discussed further in Section X. Tables I-3 and I-4 summarize the data used for the exhaust control scenarios to calculate capital costs, annual utility costs and cost-effectiveness.

## II. TANK FARM SCENARIOS

Various tank farm layouts were developed for red and white wine. Tank sizes in the layouts ranged from 50k to 600k gallons and tank farm sizes ranged from 5 to 15 tanks. Tanks were assumed to be 10 feet apart. The tank ducting for the exhaust controls extended to a height of 4 feet above the tank and dropped to a low of 10 feet above the ground to connect with the mainline duct. Tank dimensions and duct lengths are summarized in Table II-1. Tank farm layouts are shown in Figure II-1 and Figure II-2.

It was assumed that Aisle 1 was filled with overhead piping. Therefore the exhaust duct work was placed in Aisle 2. The scenarios represent typical tank clusters found in larger wineries. The red wine scenarios consist of tank farms of 5 and 10 tanks of 50k, 100k, and 300k gallon tanks. The white wine scenarios consist of 5, 10, and 15 tanks of 50k, 100k, 300k, and 600k gallon tanks. The white wine scenarios were of a larger scale than the red wine scenarios because white wine production volume is much higher than red wine production volume and because white wine can be produced more cost-effectively in larger tanks than red wine. Duct work and control equipment were sized on the assumption that all tanks are fermenting full\* and that all tanks reach their maximum potential emissions at the same time.

\* Defined as 75% of capacity for red wine and 80% of capacity for white wine.

A. Excess Tank Capacity (Working Tank Capacity)

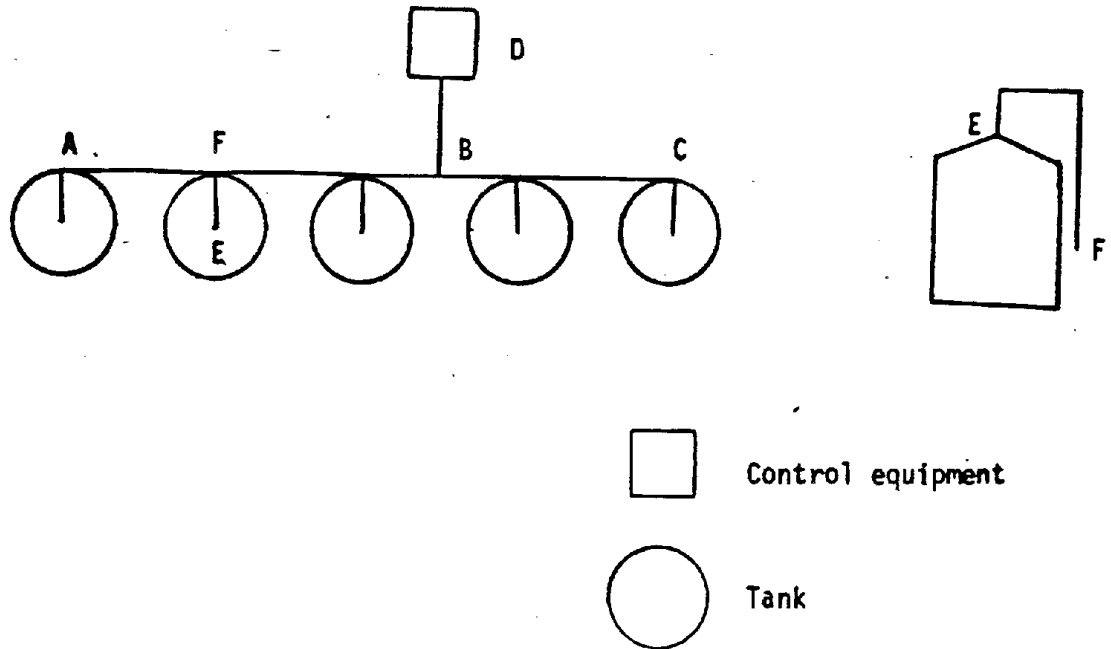
During the April 22, 1986 discussion meeting, wine industry representatives pointed out that wineries need to maintain excess tank capacity for moving the must or juice around during fermentation. Industry representatives stated that wineries normally maintain approximately 35 percent excess tank capacity. The staff recognizes this need for excess tank capacity and has added 50 percent\*\* more tank space to each of the tank farms to accommodate the excess tank capacity (this 50 percent has been added to the staff's original tank farm layouts).

Because each of the added tanks may be used for fermentation at some time, they need to be ducted into the control system. The additional ducting means that the cost of ducting increases by approximately 50 percent over the original staff estimates. Therefore, the original ICC estimates for ducting have been multiplied by 1.5. However, because not all of the fermentation tanks will be fermenting at maximum rate, and because there will be at least 35 percent excess capacity, the capacities and costs of the exhaust control equipment were not increased over the staff's original estimates. This is also true for operating and maintenance costs. Table IV-5 summarizes the ducting cost for tank farms with the 1.5 factor incorporated to account for the 35 percent excess tank capacity. The staff assumes that the fermentation capacity of the tank farms remains the same. Therefore, emission reductions continue to be based on the fermentation capacity.

$$\text{**Excess tank capacity} = \frac{0.35}{0.65} \approx 0.5$$

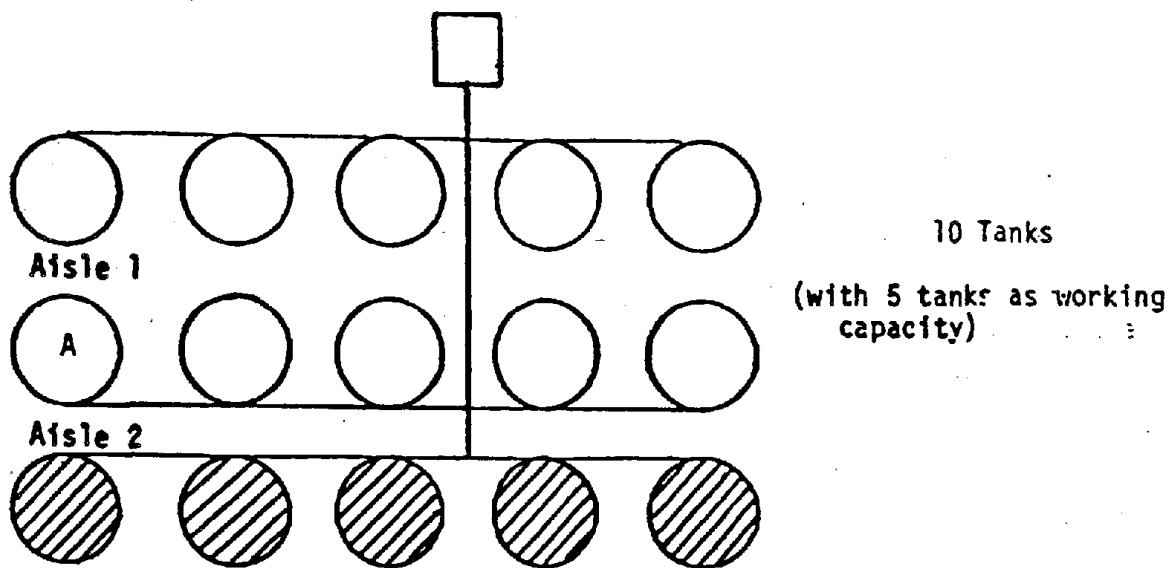
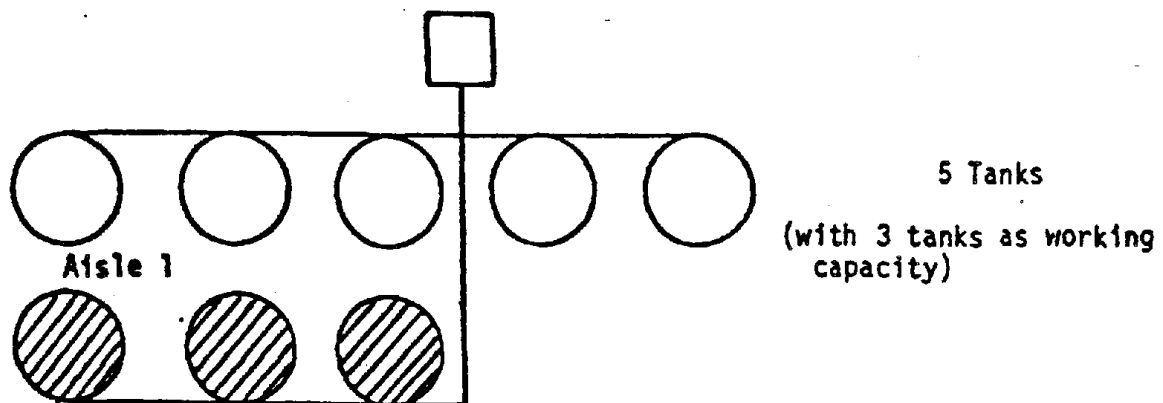
Table II-1: Tank Dimensions and Duct Lengths

| Tank                |             |             |  | Distance - Feet |            |            |            |
|---------------------|-------------|-------------|--|-----------------|------------|------------|------------|
| Size                | Diameter    | Height      |  |                 |            |            |            |
| <u>1000 gallons</u> | <u>feet</u> | <u>feet</u> |  | <u>A-B</u>      | <u>B-C</u> | <u>B-D</u> | <u>E-F</u> |
| 50                  | 21          | 20          |  | 77.5            | 46.5       | 20         | 29         |
| 100                 | 21          | 40          |  | 77.5            | 46.5       | 20         | 49         |
| 300                 | 35          | 45          |  | 112.0           | 68.0       | 20         | 61         |
| 600                 | 52          | 45          |  | 155.0           | 93.0       | 20         | 69         |

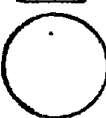


Source: ARB/SSD

Figure II-1: Tank Farm Layouts\*



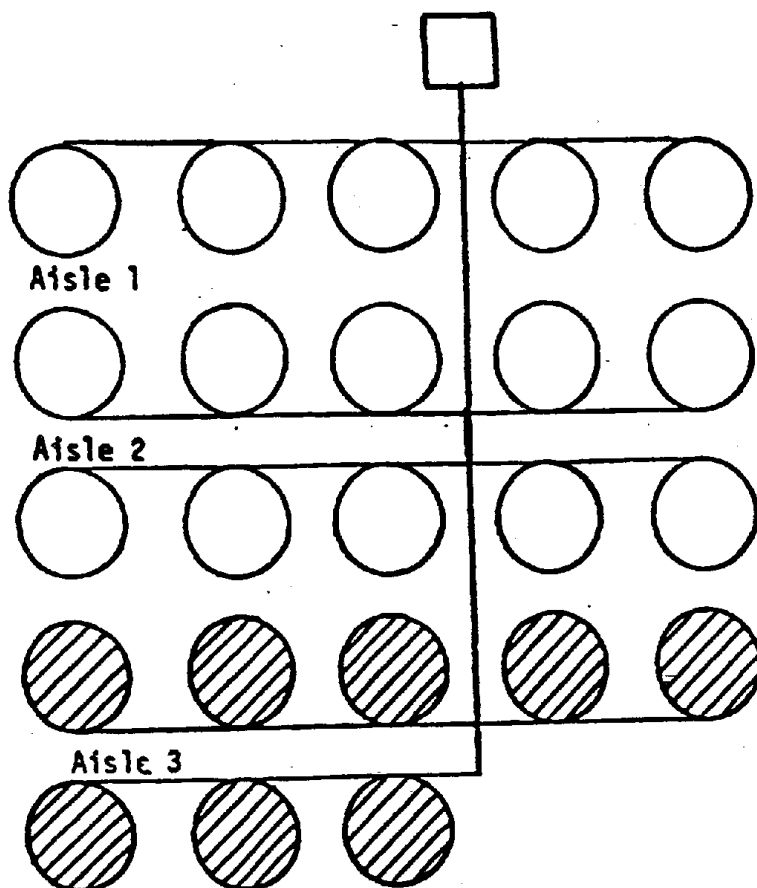

 Referenced in ducting  
utility section

 Control equipment  
 Fermentation tanks  
 Excess tanks

\*Not drawn to scale.

Source: ARB/SSD

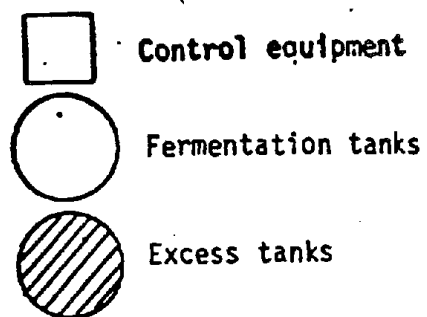
Figure II-2: Tank Farm Layouts\*



15 Tanks  
(with 8 tanks as  
working capacity)

\*Not drawn to scale.

Source: ARB/SSD





### III. TEMPERATURE CONTROL

#### A. INSTALLED CAPITAL COSTS (ICCs)

The refrigeration required was based on the assumption that the present fermentation temperatures are 65°F for white wine and 85°F for red wine and that the new limits would be 55°F for white and 80°F for red wine. The values representing the additional refrigeration required, 5,000 (Btu/hr) per 1000 gal for red and 2,479 (Btu/hr) per 1000 gal for white wine, were provided by Heublein Wines.\* These values represent the extra refrigeration required per 1000 gallons of incoming must. These values must be converted from gallons of incoming must to gallons of tank capacity in order to determine costs per tank farm size. The values were converted as follows:

$$(r) \times (1/t) \times (75 \text{ gal}^{**}/1 \text{ gal capacity}) = R$$

where r = refrigeration required, (Btu/hr) per (1000 gal/day)

t = length of fermentation cycle, days; for red wine t = 2.5, white

wine t = 7

R = refrigeration required, (Btu/hr) per 1000 gal capacity

\* Borje Landgren, Heublein Wines, Madera, CA 209-673-7071

\*\* Red and white wine tanks were considered to be full at 75% of capacity for simplicity

Using an installed cost of \$2000/ton\*, the cost of refrigeration was calculated as follows:

$$R \times \frac{1}{12000} \frac{\text{Btu}}{\text{hr-ton}} \times \$2000/\text{ton} = D$$

$$D = \$/\text{1000 gal capacity}$$

A 5-100k gallon white wine tank farm would require 11.07 tons of additional refrigeration ( $2,479 \times \frac{1}{7} \times .75/12000 \times 500\text{K gal} = 11.07$ ) costing \$22,100 ( $11.07 \times 2000 = 22,100$ ). A 5-50k gallon red wine tank farm would require 31.25 tons of additional refrigeration costing \$62,500. The costs for the other scenarios were scaled up proportionately from these two cases.

Additional fermentation capacity would be required to maintain present production levels. Costs for additional fermentation capacity were determined assuming that present storage tanks would be converted to fermentation tanks. The cost would be approximately 10 percent of the cost for a new tank, about \$.15/gal for white and \$.40/gal for red wine must tanks.\* Fermentation capacity for white wine must be increased by 43 percent ( $10/7 = 1.43$ ) because of the increase in fermentation time from 7 to 10 days. For red wine the increase is 20 percent ( $3/2.5 = 1.2$ ). The cost for the additional capacity is calculated by multiplying cost per gallon by the additional tankage. For a 5-100k gallon white wine tank farm the cost would be \$32,000 ( $500,000 \times 0.43 \times 0.15 = 32,000$ ). For a 5-50k gallon red wine tank farm the cost would be \$20,000.

---

\* Borje Landgren, Heublein Wines, Madera, CA 209-673-7071

#### B. FIXED-CAPITAL COSTS (FCCs)

The cost of \$2,000 per ton of refrigeration quoted by the wine making industry is a complete cost. The staff assumes that this cost includes all of the FCC items. Therefore, the ICC for temperature control is considered as the FCC for all tank farm scenarios. These costs are summarized in Table III-1.

#### C. ANNUAL UTILITY COSTS

The utility costs consist mainly of electricity for the compressor. The electricity required is determined by first calculating the power of compression. The following assumptions were made in determining the power required:

1. Water is available for condensing at an inlet temperature of 85°F and an outlet temperature of 95°F.
2. Ammonia is the refrigerant.
3. Heat transfer is designed for a 10°F driving differential between mediums.

The required horsepower was calculated following the example problem in the Chemical Engineer's Handbook.\* First the refrigerating effect (R.E.) was calculated:

$R.E. = h_g - h_f$ , where  $h_g$  = enthalpy of vapor leaving the evaporator, Btu/lb and  $h_f$  = enthalpy of liquid leaving the condenser, Btu/lb. Both  $h_g$  and  $h_f$  are found in the enthalpy table for ammonia. For white wine  $h_g = 624$ ,  $h_f = 161$ , and  $R.E. = 463$  Btu/lb. Next, the power of compression is calculated as follows:

\* R. Perry and C. Chilton, Chemical Engineers' Handbook, Fifth Edition, McGraw-Hill, New York, 1973, p. 12-39.

$$Hp = (hd - hg) \times \text{weight flow} / (42.4 \text{ (Btu/min)} / Hp)$$

where  $hd$  = enthalpy of compressor discharge, Btu/lb

$$\text{weight flow} = \text{tons of refrigeration required} \times 200 \text{ (Btu/min)} / R.E.$$

For white wine  $hd = 683$ ,  $hg = 624$ , and  $\text{weight flow} = (\text{tons of refrigeration required}) \times 200/463$ . Substituting the above values yields  $hp = 0.6 \times (\text{tons of refrigeration required})$ . Factoring in a 60 percent efficiency,  $hp = \text{tons of refrigeration required}$ .

Following a similar procedure for red wine results in  $hp = .554 \times (\text{tons of refrigeration required})$ . Costs are finally calculated using \$0.1/kwh for electricity costs.

A sample calculation for 5-100k gallon white wine tanks is as follows:

$$\text{Cost} = 11.07 \times .746 \text{ kw/hp} \times \$0.1/\text{kwh} \times 24 \text{ hrs/day} \times 28 \text{ days/yr} = \$555/\text{yr}$$

Annual utility costs are summarized in Table III-2.

Table III-1: Installed Capital Costs for Temperature Control\*

White Wine

Installed Capital Costs by Tank Size - \$

| No. of<br>Tanks | <u>50k</u> | <u>100k</u> | <u>300k</u> | <u>600k</u> |
|-----------------|------------|-------------|-------------|-------------|
| 5               | 27,000     | 54,000      | 162,800     | 325,600     |
| 10              | 54,000     | 108,500     | 325,600     | 651,300     |
| 15              | 81,000     | 162,900     | 488,400     | 976,800     |

Red Wine

Installed Capital Costs by Tank Size - \$

| No. of<br>Tanks | <u>50k</u> | <u>100k</u> | <u>300k</u> |
|-----------------|------------|-------------|-------------|
| 5               | 82,500     | 165,000     | 495,000     |
| 10              | 165,000    | 330,000     | 990,000     |

\*Installed capital costs represent fixed capital costs in all scenarios.

Source: ARB/SSD

Table III-2: Annual Utility Costs for Temperature Control

White Wine

Annual Utility Costs by Tank Size\* - \$/yr

| No. of<br>Tanks | <u>50k</u> | <u>100k</u> | <u>300k</u> | <u>600k</u> |
|-----------------|------------|-------------|-------------|-------------|
| 5               | 278        | 555         | 1660        | 3330        |
| 10              | 555        | 1110        | 3330        | 6650        |
| 15              | 832        | 1660        | 4990        | 9980        |

Red Wine

Annual Utility Costs by Tank Size\*\* - \$/yr

| No. of<br>Tanks | <u>50k</u> | <u>100k</u> | <u>300k</u> |
|-----------------|------------|-------------|-------------|
| 5               | 774        | 1,550       | 4,640       |
| 10              | 1,550      | 3,090       | 9,280       |

\* 28-day season

\*\* 25-day season

Source: ARB/SSD

#### IV. DUCTING

A ducting system was designed for the exhaust type controls--incineration, carbon adsorption, scrubbing, and condensation--based on the tank farm scenarios. The duct system channels the exhaust from a cluster of tanks through a foam separator and blower to a control device. All ducting eight inches and over is equipped with clean-in-place systems. The operation design is based on a constant near maximum flow rate maintained by the system blower.

It may also be possible to design a system with pressure sensitive fans that respond to the exhaust rates from each individual tank. There would then be no need for make-up air, thereby reducing the sizing and cost of the control equipment. However, the increase in cost for the exhaust system may offset the savings.

The calculation of the ICCs for the ducting systems are based on the tank farm scenarios discussed in Section II. As mentioned in Section II-A, the original estimates of the ICCs of the ducting systems have been multiplied by 1.5 to cover the additional costs for ducting the extra tanks (excess tank capacity) to the exhaust control equipment.

## A. INSTALLED CAPITAL COSTS (ICCs)

In determining installed capital costs the following were considered:

- duct size
- duct material costs
- installation costs
- cost of supports, foam separator, and clean-in-place system
- blower size and costs

The determination of each of these items is discussed in this section.

### 1. Duct Size

Duct size was based on source tests performed by the EAL Corporation on white wine and red wine fermentation tanks at United Vintners in Madera.\* Near maximum flow rates were read from the volumetric exhaust flow diagrams. The flow rates were 270 acfm for a 128,000 gallon red wine tank filled to 44,000 gallons and 220 acfm for a 350,110 gallon white wine tank filled to 280,000 gallons. During the April 8, 1986 workshop, winery representatives agreed that it is standard practice for vintners to fill their tanks to 75 percent of capacity for red wine and to 80 percent of capacity for white wine. Therefore, 44,000 gallons of red wine would be representative of a 58,667 gallon tank filled to 75 percent of capacity ( $44,000 / .75 = 58,667$ ). Likewise, 280,000 gallons of white wine would be representative of a 350,000

\* EAL Corporation, Characterization of Ethanol Emissions from Wineries,  
July 19, 1982.



gallon tank filled to 80 percent of capacity ( $280,000 / .80 = 350,000$  gallons).

Thus, the following values were chosen as design rates:

Red wine: 270 acfm for 44,000 gallons of wine (equivalent to 58,667 gallons of capacity filled to 75 percent)

White wine: 220 acfm for 280,000 gallons of wine (equivalent to 350,000 gallons of capacity filled to 80 percent)

These near maximum flow rates represent 99 percent of the white wine emissions and 98 percent of the red wine emissions.

The flow rates were then scaled to the tank capacities specified for each scenario. The flow rates for both white and red wine fermentation are summarized in Table IV-1.

Table IV-1: Design Flow Rates for Ducting System - acfm

White Wine Tanks at 80% Full

| No. of<br>Tanks | Tank Capacity, Gal. |      |       |       |
|-----------------|---------------------|------|-------|-------|
|                 | 50k                 | 100k | 300k  | 600k  |
| 5               | 157                 | 314  | 942   | 1,884 |
| 10              | 314                 | 628  | 1,884 | 3,768 |
| 15              | 471                 | 942  | 2,826 | 5,652 |

Red Wine Tanks at 75% Full

| No. of<br>Tanks | Tank Capacity, Gal. |       |        |
|-----------------|---------------------|-------|--------|
|                 | 50k                 | 100k  | 300k   |
| 5               | 1,150               | 2,300 | 6,900  |
| 10              | 2,300               | 4,600 | 13,800 |

After calculating flow rates, the ducting was sized for a stream velocity of 3000 fpm, which is above the typical 600-2800 fpm range for noise control in fan systems\* but within the rule of thumb economic velocity range.\*\*

The actual sizing of the ducting will depend on both economics and noise tolerance. The calculated diameters for all scenarios are tabulated in Table IV-2. In cases where the calculated diameter was less than 4 inches, 4 inch ducting was used to keep the pressure drop low. A sample calculation for duct size is as follows:

For white wine 10-100K gallon tanks, using the formula below, the flow rates for the different branches were substituted into V to solve for d.

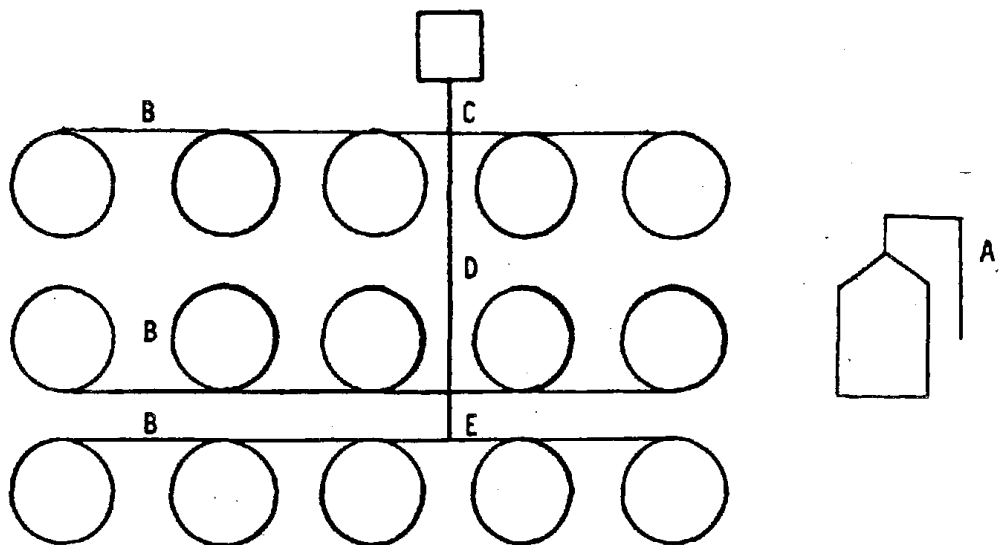
$$d = \sqrt{\frac{V \times 144 \times 4}{3000 \times \pi}} \quad \text{where}$$

\* J. Salisbury, Kent's Mechanical Engineers' Handbook, New York: Wiley Handbook Series, Power Volume, 1950, p. 12-50.

\*\* M. Peters and K. Timmerhaus, op. cit., p. 526.

Table IV-2: Duct Sizes

| Wine Type | Tank Farm Size | Flow Rate acfm | Ducting Diameter - Inches * |    |    |    |    |
|-----------|----------------|----------------|-----------------------------|----|----|----|----|
|           |                |                | A                           | B  | C  | D  | E  |
| White     | 5-100K         | 314            | 4                           | 4  | 6  | -  | -  |
|           | 10-100K        | 628            | 4                           | 4  | 8  | 6  | -  |
|           | 15-100K        | 942            | 4                           | 4  | 8  | 8  | 6  |
|           | 5-300K         | 942            | 4                           | 6  | 8  | -  | -  |
|           | 10-300K        | 1,884          | 4                           | 6  | 12 | 8  | -  |
|           | 15-300K        | 2,826          | 4                           | 6  | 14 | 12 | 8  |
|           | 5-600K         | 1,884          | 6                           | 10 | 12 | -  | -  |
|           | 10-600K        | 3,768          | 6                           | 10 | 16 | 12 | -  |
|           | 15-600K        | 5,652          | 6                           | 10 | 20 | 16 | 12 |
| Red       | 5-50K          | 1,150          | 4                           | 8  | 10 | -  | -  |
|           | 10-50K         | 2,300          | 4                           | 8  | 12 | 10 | -  |
|           | 5-100K         | 2,300          | 6                           | 10 | 12 | -  | -  |
|           | 10-100K        | 4,600          | 6                           | 10 | 17 | 12 | -  |
|           | 5-300K         | 6,900          | 10                          | 16 | 21 | -  | -  |
|           | 10-300K        | 13,800         | 10                          | 16 | 30 | 21 | -  |



\* 4-inch diameter was the minimum size used even though some flow rates were low enough to permit a smaller duct size.

Source: ARB/SSD

$d$  = diameter, inches

$v$  = volumetric flow rate, cfm

$\pi = 3.1416$

For "A" pipes  $V = 62.8$  cfm ( $314/5 = 62.8$ ),  $d = 2$  in

Use a minimum diameter of 4 inches; thus  $d = 4$  in

For "B" pipes  $V = 188$  cfm ( $62.8 \times 3 = 188$ ),  $d = 3.4$  in

Use a minimum diameter of 4 inches; thus  $d = 4$  in

For "C" pipes  $V = 628$  cfm,  $d = 8$  in

For "D" pipes  $V = 314$ ,  $d = 6$  in

## 2. Duct Material Costs

Duct material costs are based on stainless steel 304L price quotations from Felker Brothers Corporation, Marshfield, Wisconsin. Duct gauge was based on the ability to withstand a full vacuum for the ducting under 14 inches in diameter; 12 gauge duct was selected for diameters of 14 inches and over because estimates of gauge requirements for partial vacuums could not be obtained. However, the ducting would not experience a vacuum more than 5 inches of water below atmospheric pressure. Thus, 12 gauge duct would probably be adequate for ducting with diameters over 14 inches. If necessary, stiffening rings could be installed for added strength. The price quotations for the straight pipe, elbows, and tees are listed in Table IV-3. If a tee connected pipes of different diameters, then the tee price for the larger diameter was used. Felker Brothers does not carry cross connections off-the-shelf. These specialized pieces are custom made. Therefore, prices could not be obtained without a drawing. Instead, the cost of these pieces

Table IV-3: Uninstalled Capital Costs for Ducting

| Diameter<br>Inches | Gauge | Costs              |                 |               |
|--------------------|-------|--------------------|-----------------|---------------|
|                    |       | Straight<br>\$/ft. | Elbow<br>\$/ell | Tee<br>\$/Tee |
| 4                  | 14    | 5.00               | 20.40           | 48.70         |
| 6                  | 14    | 6.50               | 40.00           | 70.80         |
| 8                  | 14    | 10.00              | 75.00           | 82.70         |
| 10                 | 12    | 14.00              | 100.00          | 132.20        |
| 12                 | 12    | 20.00              | 175.00          | 220.35        |
| 14                 | 12    | 29.27              | -               | -             |
| 16                 | 12    | 32.49              | -               | 250.10        |
| 17                 | 12    | 37.32              | -               | -             |
| 19                 | 12    | 39.29              | -               | -             |
| 20                 | 12    | 41.25              | -               | -             |
| 21                 | 12    | 48.58              | -               | 525.10        |
| 30                 | 12    | 58.69              | -               | -             |

Source: ARB/SSD

as well as for valves and dampers is accounted for in the contingency factor. Material costs were estimated using Tables II-1, IV-2, and IV-3 as follows:

For 5-100k gallon white wine tanks

4 in.      369 ft    @ \$5/ft      [124 ft + (5 x 49 ft) = 369 ft]

10 ells @ \$20.40/ell

5 tees @ \$48.70/tee

Subtotal:      \$2,292

6 in      20 ft @ \$6.50/ft

1 tee @ \$70.80/tee

Subtotal      \$200

Grand Total: 2,292 + 200 = \$2,492

### 3. Installation Costs

Installation costs were estimated using Figures 13-10 through 13-13 (pp. 532-4) in Peters and Timmerhaus. The figures give installation hours for straight piping, ells, and tees. A labor cost of 40 dollars per hour was also used.

Crane costs of 800 dollars per 400 feet of ducting (\$800 minimum cost) were added to the installation costs.\* Installation costs were estimated as follows:

\* Personal Communication with Ron Hill, Department of Water Resources

For 5-100k white wine tanks

4 in. [369 ft X .28 hrs/ft + 10 ells X 6.4 hrs/ell + 5 tees X 10 hrs/tee]  
X \$40/hr = \$8,693

6 in. [20 ft X .36 hrs/ft + 16 hrs/tee X 1 tee] X \$40/hr = \$928

Crane \$800

Total Costs: 8693 + 928 + 800 = \$10,421

#### 4. Supports

In determining the cost for supports, a deflection limit was first chosen. A limit of 0.125 inches under a full load of water was suggested by Bob Calvin, an engineer for Heublein Wines. Felker Brothers supplied information on distances between supports for various deflection limits.\* The distances for a 0.125 inch deflection are listed in Table IV-4.

The number of supports was estimated by dividing the total length of ducting for each diameter by the distance between supports.

The support material used for cost estimates is 3 inch steel piping. A 10 foot steel pipe can support a 36,000 pound load which greatly exceeds the maximum load of roughly 8,000 lbs between supports for a 30 inch diameter duct filled with water (10-300k gallon red wine tanks). Furthermore, the total length, including that of vertical ducting, was included in the

\* Pipe Support Data Span - Deflection Relationship and Stress-Span & Deflection Relationship for Felkerweld Stainless Tubing (Pipe), Felker Brothers Corp., Corrosion Resistant Products, Marshfield, Wis.

Table IV-4: Distance Between Supports

| <u>Diameter<br/>Inches</u> | <u>Gauge</u> | <u>Distance<br/>Feet</u> |
|----------------------------|--------------|--------------------------|
| 4                          | 14           | 12                       |
| 6                          | 14           | 14                       |
| 8                          | 14           | 16                       |
| 10                         | 12           | 19                       |
| 12                         | 12           | 21                       |
| 14                         | 12           | 22                       |
| 16                         | 12           | 23                       |
| 17                         | 12           | 23                       |
| 19                         | 12           | 24                       |
| 20                         | 12           | 24                       |
| 21                         | 12           | 25                       |
| 30                         | 12           | 27                       |

calculation for number of supports. Vertical piping constitutes 30-40 percent of the total piping. These factors would make the estimates conservative enough to cover part of the contingency costs for the supports such as collars and labor for assembling supports.

The mass of steel piping required per support (75.8 pounds) was calculated from Table 6-4 of Simplified Engineering for Architects and Builders.<sup>\*</sup> Costs of steel are approximately \$2/lb.<sup>\*\*</sup> The cost of the supports was calculated from these data and Tables II-1 and IV-4 as follows:

For 5-100k gallon white wine tanks

Length of 4 inch duct: 369 ft

Length of 6 inch duct: 20 ft

Number of supports: 32.2  $(369/12 + 20/14 = 32.2)$

<sup>\*</sup> H. Parker, Simplified Engineering for Architects and Builders, Fifth Edition, John Wiley and Sons, New York, 1975, p. 167.

<sup>\*\*</sup> Personal Communication with Ron Hill, Department of Water Resources



Cost of supports: \$4,880 (32.2 X 75.8 lbs/support X \$2/lb = 4880)

Installation and painting of the supports are assumed to be completed by subcontractors. The costs for installing and painting the supports are estimated to be 5 percent\* of the fixed capital costs.

#### 5. Foam Separator Costs

Costs for the foam separator were scaled from the cost estimate done by Bob Calvin, for a foam separator in a ducting system for carbon adsorption, which was \$42,400 for a 4,220 cfm flow rate. The costs were scaled according to flow rate and inflated from 1983 dollars to 1985 dollars using the Chemical Engineering (CE) cost index\*\*. The following formula was used:

$$\text{Cost of equipment} = \frac{1985\$}{1983\$} \times \$42,400 \times (\text{flow rate}/4,220)^{.49} \text{ where}$$

$$1985\$/1983\$ = 324.9/316.9$$

The factor .49 is used for centrifugal separators.\*\*\*

A sample calculation is shown below to demonstrate the use of this formula.

\* Estimated by using subcontractor conversion factors, K.M. Guthrie, Process Plant Estimating Evaluation and Control.

\*\* Chemical Engineering, September 30, 1985, p.7.

\*\*\* M. Peters and K. Timmerhaus, op. cit., p. 167.

For 5-100k gallon white wine tanks

Flow rate - 314 cfm

Cost of equipment - \$12,170

$$1.025 \times \$42,400 \times (314/4220)^{.49} = \$12,170$$

#### 6. Clean-In-Place Costs

Costs for clean-in-place were scaled by ducting footage from the price quotation given by Bob Calvin in 1983. The price quote is \$83,375 for 800 feet of main ducting plus an unspecified amount of branch ducting for the 20 tanks. From the schematic attached to Mr. Calvin's letter, the length of ducting branching to each tank appeared to be about 30 feet. Thus, the total length of ducting is about 1400 feet. The clean-in-place costs for each scenario were based on the total footage of all duct work 8 inches and over. Eight inches was chosen as a cut-off because wineries are presently not using clean-in-place on fermentation tank pipelines, all of which are under 8 inches. Finally, the costs were inflated to 1985\$ using the CE cost index.

The formula used to scale costs is based on the six-tenths rule-of-thumb.

$$\text{Cost} = 1985\$ / 1983\$ \times \$83,375 \times (\text{ft. of ducting} / 1,400 \text{ ft.})^{.6}$$

For the scenario of 10-100k gallon white wine tanks the cost would be calculated as follows:

ducting length 8 inches and over: 20 ft

cost =  $1.0252 \times 83,375 \times (20 / 1,400)^{.6}$

cost = \$6,700

#### 7. Blower Costs

Blower costs were estimated using Figure 13-52 (p. 562) from Peters and Timmerhaus. Figure 13-52 gives costs for a 3 psi turboblower which should have adequate power to overcome pressure drop losses across the ducting and control equipment. After obtaining the purchase costs (in 1979\$), the values were inflated to 1985\$ using the CE cost index. Installation was assumed to be 60% of the purchase price.\* The following formula was used to estimate 1985 costs:

1985 installed cost =  $1.6 \times 1985\$ / 1979\$ \times (1979 \text{ purchase cost})$

For the 5-100k gallon white wine scenario, the 1985 installed cost is \$5,400 ( $1.6 \times 324.9 / 238.7 \times 2,500 = 5400$ ).

#### 8. Summary

The ICC is 1.5 times the sum of the costs from items 2 through 7 (the factor 1.5 is discussed in Section I-A). The ICCs do not include the cost for installing and painting the supports. The cost for installing and painting the supports is added during the calculation of the FCC. ICCs are summarized in Table IV-5.

\* M. Peters and K. Timmerhaus, op. cit., p. 169.

B. FIXED-CAPITAL COSTS (FCCs)

The following items are added to the ICCs to obtain FCCs:

|                                       |         |
|---------------------------------------|---------|
| Installation and Painting of Supports | 5% FCC  |
| Electrical and Service Facilities     | 15% FCC |
| Engineering and Supervision           | 10% FCC |
| Construction Expense                  | 7% FCC  |
| Contractor's Fee                      | 3% FCC  |
| Startup Expenses                      | 10% FCC |
| Contingency                           | 15% FCC |
| Total                                 | 65% FCC |

FCCs are calculated as follows:

$$FCC = ICC + 0.65 FCC$$

Solving for FCC

$$FCC = 2.86 ICC$$

FCCs are summarized in Table IV-1.

C. ANNUAL UTILITY COSTS

Annual utility costs consist of operating the system blower. The first step in calculating costs is to estimate pressure drops in the lines. The pressure drops for the large tank farms (15 tanks white wine and 10 tanks red

wine) were estimated to ensure that the cost estimate would be conservative. An example calculation is illustrated below:

Red wine 10-100k gallon tanks

Figure II-1 shows that Tank A experiences the highest pressure drop due to line losses. Therefore the blower must be able to handle the energy loss from Tank A. The pressure drop was estimated using the following formulas:

$$v = V_o \times 144 \times 4 / (d^2 \times \pi)$$

$$p = 3.59 \times 10^{-7} \times f \times L \times e \times v^{2*}/d$$

where  $v$  = velocity of gas, ft/min

$V_o$  = volumetric flow rate, ft<sup>3</sup>/min

$d$  = pipe diameter, inches

$\pi$  = 3.1416

$p$  = pressure drop, psi

$f$  = friction factor, approx. .015

$L$  = pipe length, 100 ft

$Q$  = density, approx. .115 lb/ft<sup>3</sup>

For simplification,  $3.59 \times 10^{-7} \times f \times L \times Q = 6.193 \times 10^{-8}$ . Thus,

$$p = 6.193 \times 10^{-8} \times v^2/d$$

Starting with the duct work leaving the tank

\* Flow of Fluids Through Valves, Fittings, and Pipe, Crane, Technical Paper No. 410, 1979, p. 3-2.

6 in X 49 ft

$$V_o = 2,300/5 = 460 \text{ ft}^3/\text{min}$$

$$v = 460 \times 144 \times 4 / (6^2 \times \pi) = 2,342 \text{ ft/min}$$

$$P = 6.193 \times 10^{-8} \times 2,342^2 / 6 = .057 \text{ psi/100 ft}$$

$$\Delta P = .057 \times .49 = .028 \text{ psi}$$

10 in X 77.5 ft

$$V_o = 2,300 \times .6 = 1,380 \text{ ft}^3/\text{min}$$

(The flow rate 1,380 is actually experienced downstream of the 3 tanks in row 2.)

$$v = 1,380 \times 144 \times 4 / (10^2 \times \pi) = 2530 \text{ ft/min}$$

$$P = 6.193 \times 10^{-8} \times 2,530^2 / 10 = 0.04 \text{ psi/100 ft}$$

$$\Delta P = 0.04 \times 0.775 = 0.031 \text{ psi}$$

12 in X 52 ft

$$V_o = 2,300 \text{ ft}^3/\text{min}$$

$$v = 2,300 \times 144 \times 4 / (12^2 \times \pi) = 2928 \text{ ft/min}$$

$$P = 6.193 \times 10^{-8} \times 2,928^2 / 12 = 0.044 \text{ psi/100 ft}$$

$$\Delta P = 0.044 \times 0.52 = 0.023 \text{ psi}$$

17 in X 20 ft

$$V_o = 4,600 \text{ ft}^3/\text{min}$$

$$v = 4,600 \times 144 \times 4 / (17^2 \times \pi) = 2,918 \text{ ft/min}$$

$$P = 6.193 \times 10^{-8} \times 2,918^2 / 17 = .03 \text{ psi/100 ft}$$

$$\Delta P = .03 \times .2 = 0.006$$

$$\text{Total } \Delta P = 0.028 + 0.031 + 0.023 + 0.006 = .088 \text{ psi}$$

The pressure drops for the four other cases were also well below 0.2 psi. Since losses from bends and merging streams were not considered, the blower load was based on 0.2 psi to cover these losses. Blower horsepower needs were approximated using the fan horsepower formula:\*

$$Hp = .000157 \times V \times P / \text{efficiency, where}$$

Hp = horsepower, hp

V = volumetric flow rate, cfm

P = pressure differential, inches of water

efficiency = blower efficiency, 0.6

For the white wine 5-100K gallon tanks,

$$V = 314 \text{ cfm}$$

$$P = 5.54 \text{ in. (0.2 psi)}$$

$$Hp = 0.455 \text{ hp } (.000157 \times 314 \times 5.54 / .6 = .455)$$

The annual utility cost is calculated as follows

$$\text{Cost} = Hp \times .746 \text{ kw/hp} \times 24 \times \text{days/yr} \times \$.1/\text{kw}$$

$$\text{Cost} = \$29.30/\text{yr } (.455 \times .746 \times 24 \times 36 \times .1 = 29.30)$$

The annual utility costs for the other white wine scenarios were scaled up from this value.

The annual utility costs for the red wine scenarios were scaled up from the annual utility cost of \$89.50 for 5-50k gallon tanks (1150 cfm)

Annual utility costs for all scenarios are summarized in Table IV-6.

\* R. Perry and C. Chilton, op. cit., pp. 6-16.

Table IV-5: Installed and Fixed-Capital Costs for Ducting System

White Wine

Installed Capital Costs by Tank Size - \$

| <u>No. of<br/>Tanks</u> | <u>50k</u> | <u>100k</u> | <u>300k</u> | <u>600k</u> |
|-------------------------|------------|-------------|-------------|-------------|
| 5                       | 39,000     | 64,100      | 110,800     | 188,900     |
| 10                      | 85,000     | 117,100     | 189,200     | 319,620     |
| 15                      | 106,000    | 166,800     | 249,900     | 424,700     |

Fixed-Capital Costs by Tank Size - \$

| <u>No. of<br/>Tanks</u> | <u>50k</u> | <u>100k</u> | <u>300k</u> | <u>600k</u> |
|-------------------------|------------|-------------|-------------|-------------|
| 5                       | 113,600    | 183,200     | 316,900     | 540,100     |
| 10                      | 245,000    | 335,000     | 541,200     | 914,100     |
| 15                      | 303,100    | 477,000     | 714,800     | 1,214,700   |

Red Wine

Installed Capital Costs by Tank Size - \$

| <u>No. of<br/>Tanks</u> | <u>50k</u> | <u>100k</u> | <u>300k</u> |
|-------------------------|------------|-------------|-------------|
| 5                       | 133,000    | 172,700     | 322,200     |
| 10                      | 212,200    | 276,900     | 498,200     |

Fixed-Capital Costs by Tank Size - \$

| <u>No. of<br/>Tanks</u> | <u>50k</u> | <u>100k</u> | <u>300k</u> |
|-------------------------|------------|-------------|-------------|
| 5                       | 380,500    | 493,800     | 921,600     |
| 10                      | 607,000    | 792,100     | 1,424,900   |

Source: ARB/SSD



Table IV-6: Annual Utility Costs for Ducting System

White Wine  
Annual Utility Costs by Tank Size\* - \$/yr

| <u>No. of<br/>Tanks</u> | <u>50k</u> | <u>100k</u> | <u>300k</u> | <u>600k</u> |
|-------------------------|------------|-------------|-------------|-------------|
| 5                       | 15         | 29          | 88          | 176         |
| 10                      | 30         | 59          | 176         | 352         |
| 15                      | 44         | 88          | 264         | 527         |

Red Wine  
Annual Utility Costs by Tank Size\*\* - \$/yr

| <u>No. of<br/>Tanks</u> | <u>50k</u> | <u>100k</u> | <u>300k</u> |
|-------------------------|------------|-------------|-------------|
| 5                       | 89         | 179         | 537         |
| 10                      | 179        | 358         | 1,070       |

\* Based on 36-day season

\*\* Based on 30-day season

Source: ARB/SSD

## V. CATALYTIC INCINERATION

The Pillar catalytic incinerator, which can operate as low as 500°F, is used in this calculation. The system consists of a preheater, fan for supplementary fuel combustion air, combustion chamber, and converter. The capital cost is based on the total flow rate of all the gases passing through the converter at start-up, which is the worst case. The utility rate is based upon fuel consumption at steady-state conditions. All equations for determining heat loads and temperature rise were obtained from Pillar Corporation.\*

### A. INSTALLED CAPITAL COSTS (ICCs)

The design concentrations are the maximum concentrations:

White wine: 6,400 ppm ethanol in CO<sub>2</sub>

Red wine: 16,000 ppm ethanol in CO<sub>2</sub>.

With the assumption that the fermentation exhaust gas does not contain air the design should be very conservative. The exhaust gas would probably contain an average of 30 to 50 percent air because not all of the tanks will be at maximum fermentation at the same time. The design capacity of the furnace is therefore greater than required.

---

\* Rob Hablewitz, Pillar Corp., 414-367-3060

Combustion requires at least ten percent oxygen present. To ensure combustion, these cases are based on fifteen percent oxygen. For white wine, using a basis of 5652 cfm\* exhaust gas (15-600k gallon tanks) from Table IV-1, the air required is y:

$$(.2) \times (y) / (y + 5652) = .15$$

$$y = 16,956 \text{ cfm}$$

The incoming stream now has a total of 22,608 cfm (16956 + 5652 = 22,608) which needs to be heated to 500°F to maintain combustion. For purposes of sizing the incinerator we take the worst case which is start-up. During start-up the heat required (Btu/hr) is

$$1.08 \times (\text{incoming stream, cfm}) \times (500^\circ - 70^\circ)^{**}$$

which is 10.5 MMBtu/hr (1.08 X 22,608 X (500-70) = 10.5 MM).

The additional volume of air required at 70°F to combust the natural gas is calculated by first determining the moles of natural gas required which is 30.5 moles/hr (10.5 MMBtu/hr / (21,495 Btu/lb X 16 lb/mole) = 30.5 moles/hr)

The mole ratio of oxygen to natural gas assuming 15% excess oxygen is 2.3 (2 X 1.15 = 2.3). Therefore the moles/hr of oxygen required is 70.2, which in turn requires 351 moles/hr of air (70.2/.2 = 351). Moles of air is converted to volume of air as follows:

$$351 \text{ moles/hr} \times 359 \text{ ft}^3/\text{mole} \times (460^\circ + 70^\circ)/492^\circ \times 1 \text{ hr}/60 \text{ min} = 2,262 \text{ cfm}$$

The total flow rate of gas for sizing the incinerator, ignoring the small flow rate of natural gas, is 25,000 cfm (22,600 + 2,300 = 24,900). The design volumes for the remaining white wine scenarios are scaled down from this

\* Assume that the temperature is 70°F which is chosen to be standard temperature for incineration. Thus acfm would equal scfm.

\*\* Pillar Corp.

Table V-1: Uninstalled Capital Costs for Incinerator Units\*

| <u>Total<br/>Flow Rate**<br/>1000 SCFM</u> | <u>Uninstalled Price<br/>(\$1000)</u> |
|--------------------------------------------|---------------------------------------|
| 1                                          | 47                                    |
| 2                                          | 53                                    |
| 3                                          | 64                                    |
| 5                                          | 77                                    |
| 8                                          | 87                                    |
| 10                                         | 104                                   |
| 15                                         | 145                                   |
| 20                                         | 168                                   |
| 25                                         | 213                                   |
| 30                                         | 249                                   |

Installation is 70 percent of the uninstalled price (60% plus 10% for resizing the ducting blower).

\* Richard E. Dunning, Consultant, 2503 N. Mountain, Claremont, CA 91711

\*\* Exhaust gas + excess air.

value. The design flow rate for the red wine scenarios is based on 60,700 cfm for 10-300k gallon tanks. The capital costs are then estimated from Table V-1. Installed capital costs are presented in Table V-2.

#### B. FIXED-CAPITAL COSTS (FCCs)

The ICCs include all of the FCC items (see Table I-1) with the exception of costs for electrical installation and contingency. Therefore, a cost for these items is to be added to the ICC. The cost for electrical installation is assumed to be 3 percent\* of the FCC. A contingency of 15 percent of the FCC is also added to cover miscellaneous costs.

The FCC is calculated as follows:

$$\text{FCC} = \text{ICC} + \text{electrical installation costs} + \text{contingency}$$

Therefore,

$$\text{FCC} = \text{ICC} + 0.03 \text{ FCC} + 0.15 \text{ FCC}$$

$$\text{FCC} = (1.22) \text{ ICC}$$

FCCs are obtained by multiplying the ICCs by 1.22. FCCs are summarized in Table V-2.

#### C. ANNUAL UTILITY COSTS

The utility costs consist of costs for natural gas for the incinerator, electricity for the fan and blower, and catalyst replenishment.

##### 1. Natural Gas Requirements

The natural gas requirements were determined for steady state operation. In this mode the incoming air and exhaust gas are preheated by the converter exhaust. However, the additional air for combusting the natural gas is not preheated. The first step is to determine the temperature rise in the converter from combusting ethanol:

$$t = H_{c,eth} \times m / (f_i \times 1.08) \text{ where}$$

$$m = f_e \times C \times 10^{-6} \times 60 \text{ min / hr} \times 46 \text{ lb/mole} \times 1 \text{ mole/359 ft}^3 \times 492 / (460 + 70)$$

t = temperature rise, °F

H<sub>c,eth</sub> = heat of combustion of ethanol, 11,954 Btu/lb

m = mass flow rate of ethanol, lb/hr

f<sub>i</sub> = incoming volumetric flow rate, cfm

f<sub>e</sub> = fermentation exhaust flow rate, cfm

C = ethanol concentration, ppm

For white wine 15-600k gallon tanks, substituting the values m = 258 lbs/hr, f<sub>i</sub> = 22,600 cfm, yields a temperature rise of 126°F. Thus, the stream temperature downstream of the converter will be 626°F.

The second step is to calculate the temperature of the incoming preheated stream. This temperature is estimated as follows:

$$(626^\circ - 70^\circ) \times .6 + 70 = 404^\circ\text{F}$$

which assumes a heat exchanger efficiency of 60 percent. Finally the heat loads of the incoming streams are calculated. The preheated stream requires 2.34 MMBtu/hr (1.08 X 22,600 X (500-404°F) = 2.34 MM) which requires 6.81 moles/hr of natural gas (2.34 X 10<sup>6</sup> / 21,495 Btu/lb X 1/16 lbs/mole = 6.81). Using the relationship between air and natural gas discussed previously yields an air requirement of 78.4 moles/hr (6.81 X 2 X 1.15/.2 = 78.4) which is 505 cfm (78.4 X 359 X (460 +70)/492 X 1/60 = 505). The heat load for this stream is 0.23 MMBtu/hr( 1.08 X 505 X (500 - 70))= 0.23. The

total heat load for both streams is 2.57 MMBtu/hr which costs \$12,213/yr (2.57 MMBtu/hr X 24 hrs/day X 36 days/yr X \$5.5/MMBtu = \$12,213/yr).

## 2. Blower and Fan Requirements

The fan requirements for the incoming streams were calculated using the fan horsepower formula\*

$$Hp = .000157 \times V \times P / \text{efficiency, where}$$

V = volumetric flow rate, cfm

P = pressure differential, inches of water

efficiency = fan efficiency

For this system, there are two incoming streams. The stream passing through the heat exchanger, combustor, converter and back through the heat exchanger experiences a 14 inch (water) pressure drop while the burner air stream experiences an 8 inch pressure drop. The total horsepower requirements for these two streams can be calculated by expanding the formula to the following form:

---

\* R. Perry and C. Chilton, op. cit., pp. 6-16.

$$Hp = .000157 \times (V_1 \times 14 \text{ in} + V_2 \times 8 \text{ in}) / .6$$
, where  $V_1$  and  $V_2$  represent the two streams. Based on this formula the 15-600k gallon white wine tank farm would require 84 hp of electricity  $(.000157 \times (22,600 \times 14 + 505 \times 8) / .6 = 83.8)$ .

The yearly cost is calculated as follows:

$$83.8 \text{ hp} \times 0.746 \text{ kw/hp} \times 36 \text{ days/yr} \times 24 \text{ hrs/day} \times \$0.1/\text{kwh} = \$5,404/\text{yr}$$

### 3. Catalyst Requirements

Catalyst requirements were scaled from the following information:

1. A 5000 cfm flow rate through the reactor requires 700 pounds of catalyst.
2. A full year of operation requires a replacement of 3-5 percent of the bed due to attrition.
3. Catalyst costs \$13/pound.

A one percent a year attrition is used for wineries because although the operating time is approximately one month a year, a conservative estimate is desired. The catalyst requirement for the 15-600k gallon white wine tanks is calculated as follows:

$$24,900 \text{ cfm} \times 700 \text{ lbs} \times .01/5000 \text{ cfm} = 34.9 \text{ lbs/yr}$$

The cost is then \$454/yr  $(34.9 \text{ lbs} \times \$13 \text{ lb} = 454)$ .

The annual utility costs for the 15-600k gallon white wine tank farm are \$18,800.



The annual utility cost for the red wine scenarios is based on the average concentrations in the incoming stream because the utility requirements for average conditions will not only be more representative of actual operating conditions, but the requirements will also be higher. Thus, the design requirements are as follows:

For 10-300k gallon tanks

Fermentation Exhaust flowrate: 9,700 cfm

Ethanol concentration: 9,000 ppm

Mixing air from dampers: 4,100 cfm

The additional air required to achieve 15 percent oxygen is calculated by the following:

$$\frac{.2 \times (y + 4,100)}{13,800 + y} = .15, \text{ where}$$

y = additional air, cfm

Solving for y yields 25,000 cfm. Thus the total incoming stream  $f_i$  contains 38,700 cfm (24,900 + 13,800 = 38,700). The remaining calculations are the same as for the white wine case. The annual utility cost for the 10-300k gallon red wine tank scenario is \$20,700.

The annual utility cost for all scenarios is scaled from these two cases. Annual utility costs are summarized in Table V-2.

Table V-2: Installed and Fixed-Capital Costs for Catalytic Incineration

White Wine

Installed Capital Costs by Tank Size - \$

| No. of<br>Tanks | <u>50k</u> | <u>100k</u> | <u>300k</u> | <u>600k</u> |
|-----------------|------------|-------------|-------------|-------------|
| 5               | 78,000     | 84,000      | 122,000     | 157,000     |
| 10              | 81,600     | 105,000     | 157,000     | 260,000     |
| 15              | 89,000     | 122,000     | 212,000     | 362,000     |

Fixed-Capital Costs by Tank Size - \$

| No. of<br>Tanks | <u>50k</u> | <u>100k</u> | <u>300k</u> | <u>600k</u> |
|-----------------|------------|-------------|-------------|-------------|
| 5               | 95,400     | 102,000     | 149,000     | 191,000     |
| 10              | 99,500     | 128,000     | 191,000     | 317,000     |
| 15              | 109,000    | 139,000     | 258,000     | 441,000     |

Red Wine

Installed Capital Costs by Tank Size - \$

| No. of<br>Tanks | <u>50k</u> | <u>100k</u> | <u>300k</u> |
|-----------------|------------|-------------|-------------|
| 5               | 131,000    | 177,000     | 423,000     |
| 10              | 177,000    | 286,000     | 850,000     |

Fixed-Capital Costs by Tank Size - \$

| No. of<br>Tanks | <u>50k</u> | <u>100k</u> | <u>300k</u> |
|-----------------|------------|-------------|-------------|
| 5               | 160,000    | 216,000     | 516,000     |
| 10              | 216,000    | 349,000     | 1,040,000   |

Source: ARB/SSD

Table V-3: Annual Utility Costs for Catalytic Incineration

White Wine  
Utility Costs by Tank Size\* - \$/yr

| No. of<br>Tanks | <u>50k</u> | <u>100k</u> | <u>300k</u> | <u>600k</u> |
|-----------------|------------|-------------|-------------|-------------|
| 5               | 525        | 1,050       | 3,140       | 6,280       |
| 10              | 1,050      | 2,100       | 6,300       | 12,600      |
| 15              | 1,575      | 3,140       | 9,420       | 18,800      |

Red Wine  
Annual Utility Costs by Tank Size\*\* - \$/yr

| No. of<br>Tanks | <u>50k</u> | <u>100k</u> | <u>300k</u> |
|-----------------|------------|-------------|-------------|
| 5               | 1,720      | 3,450       | 10,350      |
| 10              | 3,450      | 6,900       | 20,700      |

\* Based on a 36-day season

\*\* Based on a 30-day season

Source: ARB/SSD

## VI. CARBON ADSORPTION

### A. INSTALLED CAPITAL COSTS (ICCs)

The capital costs are estimated from the following information supplied by

Vic Manufacturing:\*

| <u>Exhaust<br/>Flow Rate<br/>acfm</u> | <u>Uninstalled<br/>Capital Costs<br/>\$</u> |
|---------------------------------------|---------------------------------------------|
| 300-400                               | 50,000 - 60,000                             |
| 1000                                  | 75,000                                      |
| 3000                                  | 90,000                                      |
| 5000                                  | 130,000                                     |
| 16,000                                | 225,000                                     |

The flow rates used are those developed in the Ducting Section and shown in Table IV-1.

Installation is estimated to be 75% of capital costs\*\*. Installed capital costs are presented in Table VI-1.

\* Personal Communication with Tom Cannon, Vic Manufacturing, 612-781-6601

\*\* Personal Communication with Jack Preston, Pullman Ind., 714-973-1533

#### B. FIXED-CAPITAL COSTS (FCCs)

The installation cost of 75% of the capital cost quoted by Pullman Ind. includes the following FCC items:

1. installation of the control equipment
2. electrical installation
3. engineering estimates
4. contractor's fees
5. site preparations
6. ductwork from the control equipment
7. installation of a cooling tower
8. contingency

Therefore, the installation cost would include all of the FCC items listed in Table I-1. Thus, the ICC is considered as the FCC for all control scenarios utilizing carbon adsorption. The FCCs are summarized in Table VI-1.

#### C. ANNUAL UTILITY COSTS

Annual utility costs are estimated based on the following conditions.

|                  |                    |
|------------------|--------------------|
| white wine       | red wine           |
| 1000 acfm @ 57°F | 1000 acfm @ 83°F   |
| 6400 ppm ethanol | 16,000 ppm ethanol |

Both the ethanol volume and mass flow rates can be calculated from the design conditions. All of the following calculations will be demonstrated with the white wine parameters. The ethanol volume and mass flow rates are calculated as follows:

volumetric

$$1000 \text{ acfm} \times 0.0064 = 6.4 \text{ acfm}$$

mass

$$6.4 \text{ acfm} \times 1 \text{ mole} / 359 \text{ ft}^3 \times 60 \text{ min/hr} \times 46$$

$$\text{lbs/mole} \times 492 / (460 + 57) = 46.8 \text{ lb/hr}$$

The remaining calculations are all based on the ethanol mass flow rate.

### 1. Carbon Requirements

For continuous operation, two carbon beds are required. The beds cycle between an adsorption mode and regeneration mode. The carbon beds absorb 18% of their weight in ethanol but only 1/3 of the adsorbed ethanol is steamed off during regeneration.

Size of one carbon bed:  $46.8 \text{ lbs} / (.18 \times .33) = 788 \text{ lbs/1000 acfm}$

The carbon beds were scaled down to the scenario flow rates.

Carbon requirement for 5 tanks - 100k gallons each:

$$788 \text{ lbs} \times 0.314 = 247 \text{ lbs/bed for capturing 14.7 lbs of ethanol.}$$

For 2 beds, the total carbon required is 494 lbs.

### 2. Steam Requirements

Steam is used to regenerate the bed. The ratio of steam to carbon is .35 to 1. Thus, for 247 lbs of carbon, the steam required is 86.4 lbs/hr ( $247 \times .35 = 86.4$ ).

### 3. Boiler Requirements

Boiler requirements in boiler hp are calculated by the following relationship:

$$\text{lbs of steam} \times 1 \text{ boiler hp} / 34.5 \text{ lbs steam} \times 1.6 = \text{boiler hp.}$$

The factor 1.6 represents the additional heating required to heat water from ambient to 212°F under low pressure and to account for heat losses to the environment. The boiler requirements for 81.2 lbs of steam per hour:

$$86.4 \times 1 / 34.5 \times 1.6 = 4.01 \text{ boiler hp}$$

To convert to Btu/hr multiply by 33475 Btu/hr. Thus  $1.34 \times 10^5$  Btu/hr of natural gas is required. For one season of operation, the cost is  $1.34 \times 10^5 \text{ Btu/hr} \times 24 \text{ hrs/day} \times 36 \text{ days/yr} \times \$5.5/\text{MMbtu} = \$637/\text{yr.}$

### 4. Blower Requirements

For simplification the following equation for air<sup>\*</sup> was used:

$$\text{Hp} = .0154 \times Q_1 \times P_1 \times [(P_2/P_1)^{(K-1)/K} - 1]$$

where

$Q_1$  = volumetric flow rate, cfm

$P_1$  = pressure in, psia

\* R. Perry and C. Chilton, op. cit., pp 6-16.

$P_2$  = pressure out, psia

The carbon bed has a pressure drop of 30 inches of water. Thus,  $P_1 = 14.696$  and  $P_2 = 15.779$ . Since  $K_{air} = 1.395$ ,  $(K-1)/K = 0.283$ ,

Substituting the values yields

$$Hp = 0.0154 \times 314 \text{ ft}^3/\text{min} \times 14.696 \text{ psia} [(15.779/14.696)^{.283} - 1]$$

which simplifies to

$$Hp = 1.44 \text{ for } 314 \text{ ft}^3/\text{min}$$

Assuming 60% efficiency, the hp required is 2.40 ( $1.44/.6 = 2.4$ )

and the cost of electricity per year is \$155

$$(2.40 \text{ hp} \times 1 \text{ kw} / 1.341 \text{ hp} \times 24 \text{ hrs/day} \times 36 \text{ days/yr} \times \$.1/\text{kwh} = \$155/\text{yr})$$

#### 5. Condenser Requirements

To condense 86.4 lbs of steam and 14.7 lbs of ethanol per hour from 220°F to 90°F, the cooling requirements are:

$$86.4 \text{ lbs/hr} \times 1095 \text{ Btu/lb} = 94,600 \text{ Btu/hr for steam}$$

$$14.7 \text{ lbs/hr} \times (362 \text{ Btu/lb} + .58 \text{ Btu/lb}^\circ\text{F} \times (220-90)) = 6430 \text{ Btu/hr for ethanol}$$

$$\text{Total cooling requirement: } 94,600 + 6,430 = 101,030 \text{ Btu/hr}$$

As stated in "Cost for Control Strategies," a winery would probably buy a cooling tower to supply cooling water. However, for simplification in this analysis, cooling water at a temperature of 70°F is assumed to be purchased.



Cooling water flow rate:

$$101,030 \text{ Btu/hr} / 1 \text{ Btu/lb}^\circ\text{F} \times 1/20^\circ\text{F} \times 1 \text{ gal}/8.33 \text{ lbs water} = 606 \text{ gal/hr}$$

For 1 year of operation:

$$606 \text{ gal/hr} \times 24 \text{ hrs/day} \times 36 \text{ days/yr} \times \$0.207 / 750 \text{ gal} = \$145/\text{yr}$$

## 6. Carbon Replacement

The manufacturer suggested replacement every 5-7 years for continuous operation. Since the unit will be operated for 1 month per year, the carbon bed should last 10 years. The replacement cost is \$2/lb of carbon. For two 247 lb beds the replacement cost is \$988 / 10 yrs (\$98.8/yr).

## 7. Summary

The annual utility cost is the sum of the operating costs for operating the boiler, blower, condenser, and the annual cost for carbon replacement. Annual utility costs for the white wine scenarios were calculated by scaling up the annual utility cost for 1,000 acfm. Annual utility costs for white wine scenarios are summarized in Table VI-2.

The annual utility costs for the red wine scenarios are calculated the same way except that carbon will hold 22% of its weight in ethanol for an ethanol concentration of 1600 ppm. The annual utility costs for the red wine scenarios are also presented in Table VI-2.

Table VI-1: Installed and Fixed-Capital Costs for Carbon Adsorption\*

White Wine

Installed Capital Costs by Tank Size- \$

| No. of<br>Tanks | <u>50k</u> | <u>100k</u> | <u>300k</u> | <u>600k</u> |
|-----------------|------------|-------------|-------------|-------------|
| 5               | 68,250     | 91,000      | 131,000     | 140,000     |
| 10              | 91,000     | 114,000     | 140,000     | 157,000     |
| 15              | 108,500    | 131,000     | 157,500     | 245,000     |

Red Wine

Installed Capital Costs by Tank Size - \$

| No. of<br>Tanks | <u>50k</u> | <u>100k</u> | <u>300k</u> |
|-----------------|------------|-------------|-------------|
| 5               | 122,500    | 145,000     | 262,000     |
| 10              | 145,000    | 219,000     | 359,000     |

\* Installed Capital Costs represent Fixed-Capital Costs in all scenarios for carbon adsorption.

Source: ARB/SSD

Table VI-2: Annual Utility Costs for Carbon Adsorption

White Wine  
Annual Utility by Tank Size\* - \$/yr

| No. of<br>Tanks | 50k   | <u>100k</u> | <u>300k</u> | <u>600k</u> |
|-----------------|-------|-------------|-------------|-------------|
| 5               | 520   | 1,040       | 3,120       | 6,240       |
| 10              | 1,040 | 2,080       | 6,240       | 12,500      |
| 15              | 1,560 | 3,120       | 9,370       | 18,700      |

Red Wine  
Annual Utility by Tank Size\*\* - \$/yr

| No. of<br>Tanks | <u>50k</u> | <u>100k</u> | <u>300k</u> |
|-----------------|------------|-------------|-------------|
| 5               | 5,190      | 10,400      | 31,100      |
| 10              | 10,400     | 20,760      | 62,280      |

\* 36-day season

\*\* 30-day season

Source: ARB/SSD

## VII. SCRUBBER

The scrubber design is a packed bed fiberglass absorption tower. The absorbent water is assumed to be available at municipal pipeline pressure, eliminating the need to purchase a pump. The capital and utility cost methodologies were all supplied by Croll-Reynolds.\*

### A. INSTALLED CAPITAL COSTS (ICCs)

The capital costs are based on fermentation exhaust gas flow rate.

The following guidelines and Table IV-1 were used to estimate capital costs:

| Uninstalled<br>Capital Cost<br>\$/acfm | Exhaust<br>Flow Rate<br>acfm |
|----------------------------------------|------------------------------|
| \$10-12                                | less than 500                |
| \$5-8                                  | 500-1500                     |
| \$2.5-3                                | greater than 1500            |

Installation was assumed to be 60 percent of capital costs.\*\* Because the cost guidelines are rough estimates, some adjustments were made to keep the increase in costs consistent with the increase in flow rates. Installed costs are summarized in Table VII-1.

---

\* Personal Communication with Bob Shironna, Croll-Reynolds, 201-232-4200

\*\* M. Peters and K. Timmerhaus, op. cit., p. 169.

## B. FIXED-CAPITAL COSTS (FCCs)

The ICCs include only the cost of equipment and installation. The following items are added to the ICCs\*:

|                                    |         |
|------------------------------------|---------|
| Electrical and services facilities | 15% FCC |
| Engineering and Supervision        | 10% FCC |
| Contractor's Fee                   | 3% FCC  |
| Start-up                           | 10% FCC |
| Contingency                        | 15% FCC |
| Total                              | 53% FCC |

FCCs are calculated as follows:

$$FCC = ICC + 0.53 \text{ FCC}$$

Therefore,

$$FCC = (2.13) \text{ ICC}$$

FCCs are summarized in Table III-1.

## C. ANNUAL UTILITY COSTS

### 1. Water Requirements

Water requirements were estimated according to the following guideline: 10 gpm per 100 cfm of exhaust gas. The cost of water was assumed to be 20.7 cents per 750 gallons\*\*. An exhaust flow rate of 314 cfm (white wine 5-100k gallon tanks) would require 31 gpm of water costing \$350 per year.

\*M. Peters and K. Timmerhaus, op. cit.

\*\*Water rates for City of Stockton

$$314 \text{ cfm} \times 10 \text{ gpm} / 100 \text{ cfm} = 31.4 \text{ gpm}$$

$$31.4 \text{ gpm} \times \$0.207 / 750 \text{ gal} \times 60 \text{ min/hr} \times 24 \text{ hrs/day} \times 36 \text{ days/yr} = \$350/\text{yr}$$

## 2. Blower Requirements

Blower requirements were estimated according to the following guideline:  
1 hp/1000 cfm.\* Blower hp and electricity costs for 314 cfm would be .3 hp costing \$16/yr.

$$314 \text{ cfm} \times 1 \text{ hp}/1000 \text{ cfm} = .314 \text{ hp}$$

$$.314 \text{ hp} \times .746 \text{ kw/hp} \times \$0.1/\text{kwh} \times 24 \text{ hrs/day} \times 36 \text{ days/yr} = \$15.7/\text{yr}$$

The system blower would be sized to handle this load.

Total annual utility costs for the white wine 5-100k tanks are \$366. The red wine annual utility costs were calculated the same way. The costs were then scaled to the flow rates for the remaining scenarios. Total annual utility costs are summarized in Table VII-2.

\*Based on a centrifugal blower rated at 10-20 in of water operating at 50 percent efficiency.

Table VII-1 Installed and Fixed-Capital Costs for Scrubbing

White Wine  
Installed Capital Costs - \$

| No. of<br>Tanks | 50k   | 100k  | 300k   | 600k   |
|-----------------|-------|-------|--------|--------|
| 5               | 3,014 | 5,300 | 7,200  | 9,100  |
| 10              | 5,300 | 6,400 | 9,100  | 16,000 |
| 15              | 6,500 | 7,200 | 12,800 | 22,400 |

Fixed-Capital Costs - \$

| No. of<br>Tanks | 50k    | 100k   | 300k   | 600k   |
|-----------------|--------|--------|--------|--------|
| 5               | 6,421  | 11,300 | 15,300 | 19,400 |
| 10              | 11,300 | 13,600 | 19,400 | 34,000 |
| 15              | 13,000 | 15,300 | 27,200 | 47,700 |

Red Wine  
Installed Capital Costs - \$

| No. of<br>Tanks | 50k    | 100k   | 300k   |
|-----------------|--------|--------|--------|
| 5               | 9,600  | 11,000 | 29,000 |
| 10              | 11,000 | 19,000 | 54,000 |

Fixed-Capital Costs - \$

| No. of<br>Tanks | 50k    | 100k   | 300k    |
|-----------------|--------|--------|---------|
| 5               | 20,400 | 23,400 | 61,700  |
| 10              | 23,400 | 40,400 | 115,000 |

Source: ARB/SSD

Table VII-1: Annual Utility Costs for Scrubbing

| White Wine<br>Annual Utility Costs* - \$/yr |            |            |              |              |
|---------------------------------------------|------------|------------|--------------|--------------|
| No. of<br>Tanks                             | 50k        | 100k       | 300k         | 600k         |
| 5                                           | <u>235</u> | <u>470</u> | <u>1,410</u> | <u>2,820</u> |
| 10                                          | 470        | 941        | 2,820        | 5,650        |
| 15                                          | 706        | 1,410      | 4,240        | 8,470        |

| Red Wine<br>Annual Utility Costs** - \$/yr |              |              |              |
|--------------------------------------------|--------------|--------------|--------------|
| No. of<br>Tanks                            | 50k          | 100k         | 300k         |
| 5                                          | <u>1,430</u> | <u>2,870</u> | <u>8,600</u> |
| 10                                         | 2,870        | 5,730        | 17,200       |

\* Based on 36-day season

\*\* Based on 30-day season

Source: ARB/SSD



## VIII. CONDENSATION

### A. INSTALLED CAPITAL COSTS (ICCs)

The calculation for design requirements was based on a procedure developed by the late Professor Lynn Williams\* (see part II of Attachment 1).

Attachment 1 shows that, for 90 percent control of 100,000 gallons of red fermenting must, 13.7 tons of refrigeration at -12°F is required. A similar calculation was performed for white wine must based on the following:\*\*

exhaust flow per 100k gallons of capacity - 60 cfm

ethanol concentration - 6400 ppm

temperature of exhaust - 57°F

The white wine calculations resulted in .98 tons of refrigeration at -36°F for 100K gallon capacity.

Costs for the red wine system were scaled up from an estimate given by L and A Engineering & Equipment (see Attachment 2) using the six-tenths rule:

---

\* Professor Lynn Williams, Dept. of Viticulture & Enology, University of California, Davis.

\*\* Characterization of Ethanol Emissions from Wineries, EAL Corporation, July 19, 1982.

$$\text{Cost of equipment a} = \text{cost of equipment b} \times \left( \frac{\text{capacity of a}}{\text{capacity of b}} \right)^{.6}$$

Cost of b = \$39,400 (1982\$)

Capacity of b = 13.75 tons of refrigeration

Starting with 13.7 tons of refrigeration for 100K gallons of red wine, the capacities were scaled according to tank farm size and assuming that the tanks were 75 percent full. For example 5-50K gallon tanks require 26 tons of refrigeration ( $13.7 \times .75 \times 5/2 = 25.7$ ). The cost of equipment for 26 tons is \$57,300 ( $39,400 \times (25.7/13.75)^{.6} = \$57,300$ ). The cost was then inflated to 1985 dollars using the CE plant cost index, resulting in a cost of \$59,300 ( $57,300 \times 324.8/314 = 59,300$ ). Installation hours were estimated from Figure B-7 (p. 886) in Peters and Timmerhaus. Installation costs were then calculated on the assumption of a cost of labor at 40 dollars per hour.

Capital costs and installation time for the white wine system were calculated from the same set of graphs. Installed capital costs are summarized in Table VIII-1.

#### B. FIXED-CAPITAL COSTS (FCCs)

The ICCs include only the costs of equipment and installation. The following items are added to the ICCs to obtain the FCC:

|                                   |         |
|-----------------------------------|---------|
| Electrical and Service facilities | 20% FCC |
| Engineering and Supervision       | 10% FCC |
| Construction Expenses             | 7% FCC  |
| Contractor's Fee                  | 3% FCC  |

|             |         |
|-------------|---------|
| Start-up    | 10% FCC |
| Contingency | 15% FCC |
| Total       | 65% FCC |

Solving for FCC

$$FCC = ICC + 0.65 FCC$$

$$FCC = 2.86 ICC$$

FCCs are summarized in Table VIII-1.

#### C . ANNUAL UTILITY COSTS

Utility requirements for the compressor were based on the following conditions:

1. Water is available for condensing at an inlet temperature of 85°F and an outlet temperature of 95°F.
2. R-22 is the refrigerant.
3. The heat transfer is designed for a 10°F driving differential between mediums.
4. Evaporator temperature for white wine: -36°F red wine: -12°F.

The required horsepower was calculated following the example problem in the Chemical Engineer's Handbook.\* First the refrigerating effect (R.E.) was calculated:

\* M. Peters and K. Timmerhaus, op. cit.

$R.E. = h_g - h_f$ , where  $h_g$  = enthalpy of vapor leaving the evaporator, Btu/lb, and  $h_f$  = enthalpy of liquid leaving the condenser, Btu/lb. Both  $h_g$  and  $h_f$  are found in the refrigerant tables for R-22.\* For red wine  $h_g = 103.6$ ,  $h_f = 40.9$ , and  $R.E. = 62.7$  Btu/lb. Next the power of compression is calculated as follows:

$$H_p = (h_d - h_g) \times \text{weight flow} / (42.4 \text{ (Btu/min)} / \text{hp})$$

Where  $h_d$  = enthalpy of compressor discharge, Btu/lb

$h_g$  = enthalpy of compressor inlet, Btu/lb

$\text{weight flow} = \text{tons of refrigeration required} \times 200 \text{ (Btu/min)} / R.E.$

For red wine  $h_d = 127$ ,  $h_g = 103.6$ , and  $\text{weight flow} = (\text{tons of refrigeration required}) \times (200/62.7)$ . Substituting the above values yields  $H_p = 1.76 \times (\text{tons of refrigeration required})$ . Factoring in a 60 percent efficiency  $H_p = 2.93 \times (\text{tons of refrigeration required})$ .

---

\* R. Perry and C. Chilton, op. cit., pp. 12-39.

Following a similar procedure for white wine results in  $hp = 3.6 \times$  (tons of refrigeration required). Costs are finally calculated using \$0.1/kwh for electricity costs.

A sample calculation for 5-50K gallon red wine tanks is as follows:

Cost =  $2.93 \times 25.7 \times .746 \text{ kw/Hp} \times \$0.1/\text{kwh} \times 24\text{hrs day} \times 30 \text{ days}$

Cost = \$4,040

Annual utility costs for both white and red wine scenarios are summarized in Table VIII-2.

Table VIII-1: Installed and Fixed-Capital Costs for Condensation

White Wine

Installed Capital Costs by Tank Size - \$

| No. of<br>Tanks | <u>50k</u> | <u>100k</u> | <u>300k</u> | <u>600k</u> |
|-----------------|------------|-------------|-------------|-------------|
| 5               | 31,000     | 47,000      | 92,000      | 145,000     |
| 10              | 48,200     | 73,000      | 145,000     | 252,000     |
| 15              | 61,000     | 92,000      | 208,000     | 298,000     |

Fixed-Capital Costs by Tank Size - \$

| No. of<br>Tanks | <u>50k</u> | <u>100k</u> | <u>300k</u> | <u>600k</u> |
|-----------------|------------|-------------|-------------|-------------|
| 5               | 89,000     | 134,400     | 263,100     | 414,700     |
| 10              | 137,850    | 208,800     | 414,700     | 720,700     |
| 15              | 175,000    | 263,100     | 594,900     | 852,300     |

Red Wine

Installed Capital Costs by Tank Size - \$

| No. of<br>Tanks | <u>50k</u> | <u>100k</u> | <u>300k</u> |
|-----------------|------------|-------------|-------------|
| 5               | 73,300     | 111,000     | 210,000     |
| 10              | 111,000    | 166,000     | 323,000     |

Fixed-Capital Costs by Tank Size - \$

| No. of<br>Tanks | <u>50k</u> | <u>100k</u> | <u>300k</u> |
|-----------------|------------|-------------|-------------|
| 5               | 209,600    | 317,500     | 600,600     |
| 10              | 317,500    | 474,800     | 923,800     |

Source: ARB/SSD

Table VIII-2: Costs for Condensation

White Wine

Annual Utility Costs by Tank Size\* - \$/yr

| No. of<br>Tanks | 50k   | 100k  | 300k   | 600k   |
|-----------------|-------|-------|--------|--------|
| 5               | 570   | 1,140 | 3,420  | 6,830  |
| 10              | 1,140 | 2,280 | 6,830  | 13,700 |
| 15              | 1,710 | 3,420 | 10,200 | 20,500 |

Red Wine

Annual Utility Costs by Tank Size\*\* - \$/yr

| No. of<br>Tanks | 50k   | 100k   | 300k   |
|-----------------|-------|--------|--------|
| 5               | 4,040 | 8,090  | 24,300 |
| 10              | 8,090 | 16,200 | 48,500 |

\* Based on 36-day season

\*\* Based on 30-day season

Source: ARB/SSD

## IX. OPERATING AND MAINTENANCE COSTS

In addition to the one-time fixed-capital costs (FCCs), there will be annual operating and maintenance costs (O & M) for each control device. Those items consist of maintenance and labor, insurance and property taxes, plant overhead, and utilities. Those costs are determined as follows:

|                           |                        |
|---------------------------|------------------------|
| Maintenance and labor     | 3% of FCC              |
| Insurance and local taxes | 2% of FCC              |
| Plant overhead            | 0.75% of FCC           |
| Utilities                 | From appropriate table |

Total O & M = sum of the above four items.



## X. AFTER-TAX COST-EFFECTIVENESS

In order to calculate cost-effectiveness, emissions and reductions and after-tax costs must first be calculated.

### A. EMISSIONS AND REDUCTIONS

The uncontrolled emissions for the exhaust controls are based on source tests performed by the EAL Corporation at United Vintners. The tanks tested were at 57°F for white wine and 83°F for red wine.

The emissions per cycle were 713.5 lbs for a 350,110 gallon white wine tank filled to 280,000 gallons and 341.6 lbs for a 128,000 gallon red wine tank filled to 44,000 gallons.

Emission factors of 2.55 lb/1000 gallons of white wine and 7.76 lb/1000 gallons of red wine were calculated for exhaust controls from these data. The emission factors were then converted from 1000 gallons of wine to 1000 gallons of tank capacity based on full tanks by assuming that white wine tanks were "full" at 80 percent of capacity and red wine tanks were "full" at 75 percent of capacity. During the April 8 workshop, it was agreed that it is standard practice for vintners to fill their tanks to these levels. Expressed in terms of capacity, the emission factors are 2.04 lb/1000 gallons of capacity for white and 5.82 lb/1000 gallons of capacity for red. Uncontrolled emissions per cycle were calculated for each tank farm scenario by scaling up the capacity-based emission factors.

The fermentation season lasts approximately 30 days each for red and white wines. Therefore, the season lengths chosen are the closest possible to 30 days while avoiding fractional cycles and maintaining the same number of cycles for the exhaust and temperature control scenarios. The yearly emissions are calculated by multiplying the emission factors by the tank capacities and by the number of cycles shown in Table I-2 which are 4 for white and 10 for red. The yearly uncontrolled emissions for the exhaust control scenarios are shown in Table X-1.

The uncontrolled emissions for temperature control are based on 65° for white and 85° for red wine. The emission factors for these temperatures are found by plotting the EAL emission factors 2.55 lb/1000 gal of white wine for 57° and 7.76 lb/1000 gal of red wine for 83° on the graph in Figure X-1 which is a modified form of a graph in the paper "Modeling and Prediction of Evaporative Ethanol Loss During Wine Fermentations"\* and following the constant Brix line to 65° and 85°, respectively. The emission factors read off the graph for these temperatures are 3.5 lb/1000 gallons of white wine (2.8 lb/1000 gallons of capacity) and 8.3 lb/1000 gallons of red wine (6.2 lb/1000 gallons of capacity). Yearly emissions are then calculated the same way as for the exhaust control scenarios. Uncontrolled emissions are shown in Table X-2.

Emission reductions are found by multiplying the uncontrolled emissions by the control efficiencies shown in Table X-3.

\* L. Williams and R. Boulton, "Modeling and Prediction of Evaporative Ethanol Loss During Wine Fermentations," Amer. J. Enol. Vitic., Vol. 34: p. 239, 1983.

Table X-1: Uncontrolled Emissions for Wine Fermentation - Pounds Per Year  
Exhaust Control Scenarios

| White Wine   |       |        |        |        |
|--------------|-------|--------|--------|--------|
| No. of Tanks | 50k   | 100k   | 300k   | 600k   |
| 5            | 2,040 | 4,080  | 12,200 | 24,500 |
| 10           | 4,075 | 8,150  | 24,500 | 48,900 |
| 15           | 6,110 | 12,200 | 36,700 | 73,400 |

| Red Wine     |        |        |         |         |
|--------------|--------|--------|---------|---------|
| No. of Tanks | 50k    | 100k   | 300k    | 600k    |
| 5            | 14,600 | 29,100 | 87,300  | 175,000 |
| 10           | 29,100 | 58,200 | 175,000 |         |

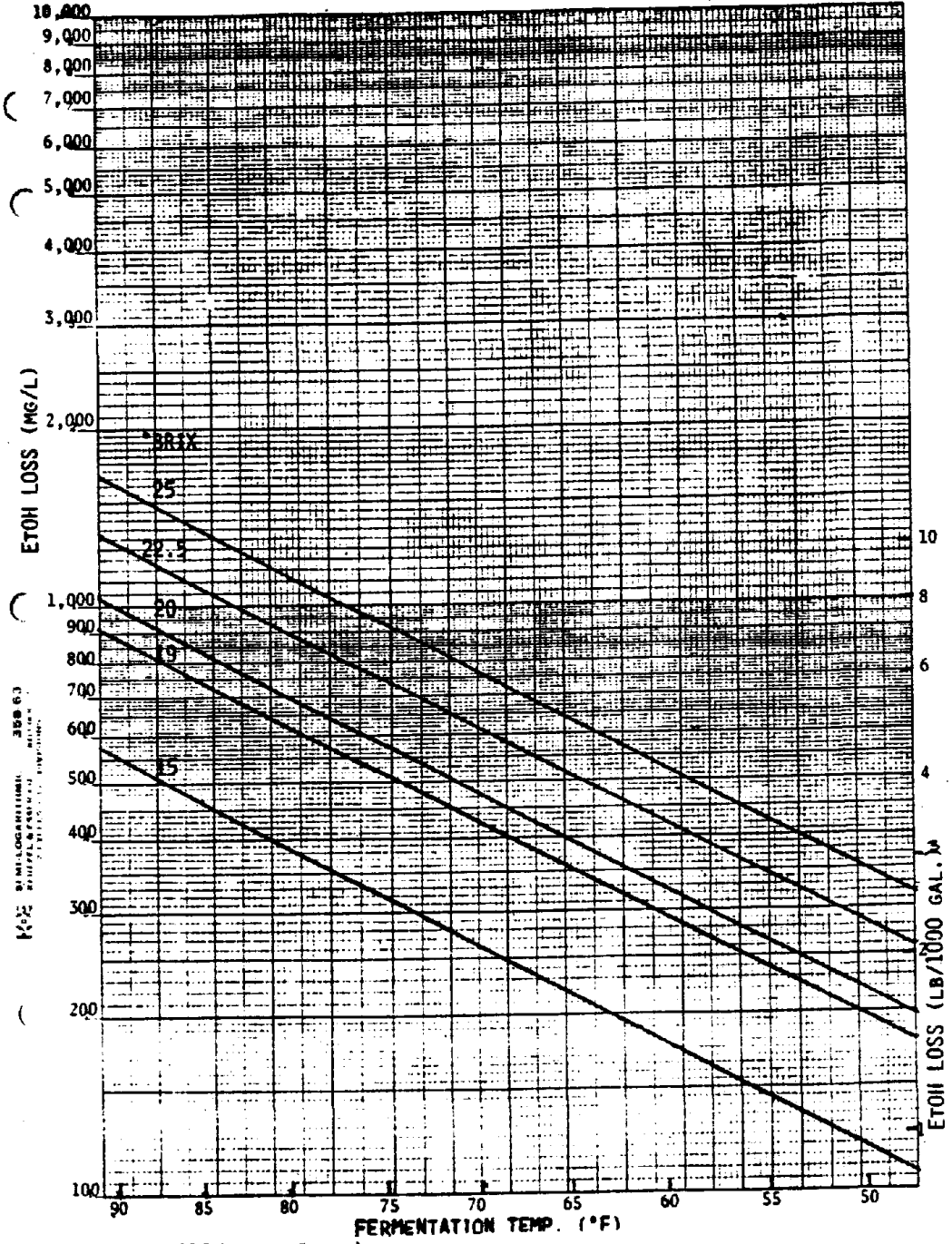
Table X-2: Uncontrolled Emissions for Wine Fermentation - Pounds Per Year  
Temperature Control Scenarios

| White Wine   |       |        |        |         |
|--------------|-------|--------|--------|---------|
| No. of Tanks | 50k   | 100k   | 300k   | 600k    |
| 5            | 2,800 | 5,600  | 16,800 | 33,600  |
| 10           | 5,600 | 11,200 | 33,600 | 67,200  |
| 15           | 8,400 | 16,800 | 50,400 | 100,800 |

| Red Wine     |        |        |         |         |
|--------------|--------|--------|---------|---------|
| No. of Tanks | 50k    | 100k   | 300k    | 600k    |
| 5            | 15,560 | 31,120 | 93,370  | 186,750 |
| 10           | 31,120 | 62,250 | 186,750 |         |

Source: ARB/SSD

Figure X-1



(Source: After Williams, 1983)

Table X-2: Control Efficiencies Used in Emission  
Reduction Cost Estimates

|             |                        |     |
|-------------|------------------------|-----|
| Temperature | Red Wine 85° to 80°F   | 15% |
| Control     | White Wine 65° to 55°F | 30% |

---

|             |            |     |
|-------------|------------|-----|
| Exhaust Gas | Red Wine   | 98% |
| Ducting     | White Wine | 99% |

|              |     |
|--------------|-----|
| Incineration | 95% |
|--------------|-----|

|                   |     |
|-------------------|-----|
| Carbon Adsorption | 95% |
|-------------------|-----|

|           |     |
|-----------|-----|
| Scrubbing | 99% |
|-----------|-----|

|              |     |
|--------------|-----|
| Condensation | 90% |
|--------------|-----|

Source: ARB/SSD

## B. COST-EFFECTIVENESS

Each point on the cost-effectiveness curves presented in Chapter VI of the report (Figure VI-7 to Figure VI-11) represents the cost-effectiveness of one control scenario. There are five control systems and eighteen tank farms. Therefore, there are 90 cost-effectiveness calculations/scenarios. However, the method of calculation is the same for each control scenario. The method used to calculate the after-tax cost-effectiveness is based on the method used by the Wine Institute in 1983\* with some modifications.

The method chosen by the Wine Institute is based on a present value cost analysis as opposed to the more traditional annualized cost analysis. Because both methods are acceptable and give reasonably close results, the staff chose to use the method advanced by the Wine Institute. However, we made some modifications to this method. The industry's method accounted for federal but not state tax write-offs and only considered depreciation write-offs when estimating the federal tax benefits, thus making that approach a partial after-tax analysis. We agree with the concept of doing an after-tax analysis; however, all tax benefits should be accounted for, not just depreciation. Therefore, our analysis differs from the industry's version as proposed in 1983 in the following ways:

\* Wine Institute Comments Regarding Fresno Air Pollution Control District Proposal to Control Winery Ethanol Emissions, January, 1983.

1. We account for state tax benefits as well as federal tax benefits while industry accounted for only federal, and
2. We account for operating and maintenance write-offs as well as depreciation write-offs while industry accounted for only depreciation. Because operating and maintenance costs are expenses, they are tax deductible.

A complete list of the assumptions used in the staff's after-tax cost-effectiveness calculations is presented in Table X-3. A sample calculation of the cost-effectiveness for a white wine tank farm of ten 300,000 gallon tanks is shown in Tables X-4 through Table X-6.

Table X-3: Assumptions for Cost-Effectiveness Calculations

1. Maintenance and labor is 3% of FCC.
2. Property taxes and insurance are 2% of FCC.
3. Plant overhead is 0.75% of FCC.
4. Maintenance and labor, local taxes and insurance, and plant overhead costs are federal and state tax deductions.
5. Investment tax credit (ITC) of 10% of FCC is claimed.
6. Basis for depreciation is FCC less one-half of the ITC.
7. For federal tax purposes, all equipment is Section 1245 5-year recovery property subject to Accelerated Cost Recovery System (ACRS).
8. Federal Corporate tax rate is 46%.
9. For state purposes, all equipment is certified air pollution control equipment and amortized over 5 years under IRS Section 169 (use straight line depreciation).
10. State Corporate tax rate is 9.6 %.
11. Interest rate is 12% before tax and 6% after taxes.

Source: ARB/SSD



Table X-4: Basis for Cost-effectiveness  
for 10 - 300,000 Gallon White Wine Tank  
Farms Using Carbon Adsorption

|     |            |
|-----|------------|
| FCC | \$ 681,200 |
|-----|------------|

|                          |            |
|--------------------------|------------|
| Ducting FCC (Table IV-5) | \$ 541,200 |
|--------------------------|------------|

|                            |            |
|----------------------------|------------|
| Equipment FCC (Table VI-1) | \$ 140,000 |
|----------------------------|------------|

|                                   |           |
|-----------------------------------|-----------|
| Operating and Maintenance (O & M) | \$ 45,585 |
|-----------------------------------|-----------|

|                              |           |
|------------------------------|-----------|
| Maintenance & Labor (3% FCC) | \$ 20,436 |
|------------------------------|-----------|

|                                |           |
|--------------------------------|-----------|
| Property Taxes & Ins. (2% FCC) | \$ 13,624 |
|--------------------------------|-----------|

|                            |          |
|----------------------------|----------|
| Plant Overhead (0.75% FCC) | \$ 5,109 |
|----------------------------|----------|

|                                        |          |
|----------------------------------------|----------|
| Annual Utility for Ducting & Equipment | \$ 6,416 |
|----------------------------------------|----------|

(Table IV-6 and Table VI-2)

|                                             |            |
|---------------------------------------------|------------|
| Basis for ACRS Depreciation (FCC - 1/2 ITC) | \$ 647,140 |
|---------------------------------------------|------------|

Source: ARB/SSD

Table X-5: Calculation of Depreciation  
and Tax Benefits

| <u>California State</u>    |         |         |         |         |         |
|----------------------------|---------|---------|---------|---------|---------|
| Year                       | 1       | 2       | 3       | 4       | 5       |
| Depreciation<br>(St. Line) | 136,240 | 136,240 | 136,240 | 136,240 | 136,240 |
| O & M                      | 45,585  | 45,585  | 45,585  | 45,585  | 45,585  |
| Tax Benefit*               | 17,455  | 17,455  | 17,455  | 17,455  | 17,455  |

| <u>Federal</u>         |        |         |         |         |         |
|------------------------|--------|---------|---------|---------|---------|
| Year                   | 1      | 2       | 3       | 4       | 5       |
| Depreciation<br>(ACRS) | 97,071 | 142,370 | 135,899 | 135,899 | 135,899 |
| O & M                  | 45,585 | 45,585  | 45,585  | 45,585  | 45,585  |
| Tax Benefit**          | 57,592 | 78,430  | 75,453  | 75,453  | 75,453  |

| <u>Totals</u>                          |        |        |        |        |        |
|----------------------------------------|--------|--------|--------|--------|--------|
| Year                                   | 1      | 2      | 3      | 4      | 5      |
| Total Tax<br>Benefits                  | 75,047 | 95,885 | 92,908 | 92,908 | 92,908 |
| Present Value of<br>Tax Benefit (i=6%) | 70,799 | 85,337 | 78,008 | 73,592 | 69,426 |

Present value of  
Total Tax Benefits for 5 years = \$377,162

\* California State Tax Benefit = (Depreciation + O & M) X (9.6/100)  
 \*\* Federal Tax Benefit = (Depreciation + O & M - California State Tax  
 Benefit) X (46/100)

Source: ARB/SSD

Table X-6: Calculation of Cost-Effectiveness

|                                                      |             |
|------------------------------------------------------|-------------|
| FCC                                                  | \$ 681,200  |
| ITC (10% FCC)                                        | \$ - 68,120 |
| Total Present Value<br>of Tax Benefits (5 yr. total) | \$ -377,162 |
| <hr/>                                                |             |
| After-Tax Capital Cost (present value)               | \$ 235,918  |
| Present Value of O & M<br>(5 yr. total, i = 6%)      | \$ +192,020 |
| <hr/>                                                |             |
| Total After-Tax cost (present value)                 | \$ 427,938  |
| Annual Emission Reductions*                          | 23,042 lb   |
| Emission Reductions for 5 yrs.**                     | 115,210 lb  |
| After-Tax<br>Cost-Effectiveness***                   | \$ 3.71/lb  |

\* .95 X .99 X uncontrolled emission (Table X-1)

\*\* 5 X 23,042 lb. = 115,210 lb.

\*\*\* \$427,382/23,042 lb. = \$3.71/lb.

Source: ARB/SSD

## XI. LIST OF ABBREVIATIONS

|      |   |                              |
|------|---|------------------------------|
| acfm | = | actual cubic feet per minute |
| Btu  | = | British thermal units        |
| cfm  | = | cubic feet per minute        |
| °F   | = | degree Fahrenheit            |
| FCC  | = | Fixed Capital Cost           |
| fpm  | = | feet per minute              |
| ft   | = | feet                         |
| gal  | = | gallon                       |
| gpm  | = | gallons per minute           |
| hp   | = | horsepower                   |
| hrs  | = | hours                        |
| ICC  | = | Installed Capital Cost       |
| in   | = | inches                       |
| K    | = | kilo -                       |
| Kw   | = | kilowatts                    |
| Kwh  | = | kilowatt-hours               |
| lb   | = | pound                        |
| min  | = | minutes                      |
| MM   | = | million                      |
| ppm  | = | parts per million            |
| psi  | = | pounds per square inch       |
| ton  | = | ton of refrigeration         |
| yr   | = | year                         |

## Attachment 1

### EVALUATION AND CALCULATIONS REGARDING PROPOSED ETHANOL VAPOR CONDENSATION SYSTEMS

By

Lynn A. Williams, Department of Viticulture & Enology,  
University of California, Davis, CA 95616

#### Part I. Errors in the original ARB proposal.

1. The calculations were based on the average vapor ethanol concentration throughout the fermentation period. To ensure the specified 90% removal at all times, design should be based on the maximum ethanol concentration in the vapor. Therefore, their system is under-designed.
2. They used a fermentation temperature of 75°F, but for proper design in all conceivable cases, 85°F would be a safer design criteria, as indicated in Table 4 of the EAL Report.
3. The ARB proposal uses a gas flow of 60 CFM from a 100,000 gallon fermentation. However, Table 5 of the EAL Report indicates a gas flow maximum (which should be the design criteria) of 6.1 CFM per 1,000 gallons. Therefore, the design value flow from a 100,000 gallon fermentation should be 610 CFM. The ARB proposal therefore underestimates the gas flow by a factor of 10.
4. Consequently, the condensation rate calculated by ARB (15 Lb/hr) is low by a factor of 10.
5. The ARB calculation of the cooling load required is erroneous in several fundamental respects, independent of the previously mentioned errors.
  - A. There was no cooling load calculated for cooling the large amount of CO<sub>2</sub>.
  - B. There was no load calculated for the actual heat of condensation of the condensate.
6. The most serious and grievous error in the ARB calculation is the nonchalant assumption that cooling to 50°F will recover 90% of the ethanol. In fact, this amount of cooling will only condense a few percent of the ethanol. The condensation process must obey the laws of vapor-liquid equilibrium thermodynamics. These laws dictate a condensation temperature well below zero °F (see below).

#### Part II. Calculation of the requirements for a functional ethanol vapor condensation system.

1. BASIS: 100,000 gallons of fermenting red wine must (the system must be designed to handle the maximum load, i.e. the worst case, and still remove 90% of the ethanol).

According to EAL Report; Tables 4 and 5 for red wine fermentation:

Temperature = 85°F = 29.4°C

Maximum gas flow = 6.1 CFM per 1,000 gallons

Maximum vapor ethanol concentration = 17,932 ppm = 1.793 mole percent  
therefore ethanol partial pressure  $p_E$  = 13.6 mm Hg

also water partial pressure at 85°F is  $p_W$  = 30.74 mm Hg or water  
content in the vapor is 4.04 mole percent.

For 100,000 gallons of must, the following may be calculated:

Gas flow 610 CFM (actual) = 550.7 SCFM

Ethanol loss rate (maximum) 75.9 lb/hr

Water loss rate (maximum) 67.0 lb/hr

Total liquid lost (potential condensate) 142.9 lb/hr

## 2. Determination of required condensation temperature.

To achieve the specified 90% removal of ethanol, it is necessary to reduce the partial vapor pressure of ethanol to 1/10 of its original value; i.e. it must be lowered to 1.36 mm Hg. This calculation depends on the ethanol and water compositions of the final condensate as well as the temperature.

The condensate composition may be estimated by assuming it contains 90% of the ethanol originally in the vapor and virtually all of the water. Therefore the condensate is:

|         |             |   |                         |
|---------|-------------|---|-------------------------|
| Ethanol | 68.3 lb/hr  | = | 50.4% w/w = 28.4 mole % |
| Water   | 67.0 lb/hr  |   | 49.6% w/w = 71.6 mole % |
|         | 135.3 lb/hr |   |                         |

Next, it is necessary to determine the temperature at which a mixture of this composition will exert an ethanol partial vapor pressure ( $p_E$ ) of 1.36 mm Hg. This is governed by the equation:

$$p_E = P_E^\circ \delta_E X_E$$

where:

$P_E^\circ$  = the pure ethanol vapor pressure (temperature dependant)

$\delta_E$  = the activity coefficient (composition and mildly temperature dependent)

$X_E$  = the liquid phase mole fraction of ethanol

The activity coefficient,  $\delta_E$ , is nearly independent of temperature at these concentrations. A value for 30°C and 0.284 mole fraction will be used. (Source: J. Chem. Thermodynamics 10:867-888, 1978).

$$\delta_E = 1.83$$

The required value of  $P_E^\circ$  may be calculated:

$$P_E^\circ = \frac{p_E}{\delta_E X_E} = \frac{1.36}{(1.83)(0.284)} = 2.62 \text{ mm Hg}$$

For the vapor pressure curves for pure ethanol, it can be determined that a temperature of  $-19^{\circ}\text{C} = -2.2^{\circ}\text{F}$  is needed to achieve a value of 2.62 mm Hg for  $P^{\circ}_E$ .

#### CONCLUSION #1

The vapor condensor must operate at  $-19^{\circ}\text{C} = -2.2^{\circ}\text{F}$ . The actual coolant temperature must be at least  $10^{\circ}\text{F}$  lower in order to provide a driving force gradient for heat transfer.

Therefore, the required coolant temperature would be about  $-12^{\circ}\text{F}$ .

The final condensate would have a freezing point of  $-37^{\circ}\text{F}$ , but intermediate condensates would have much higher freezing points and ice formation in the condenser may be a serious problem.

#### 3. Calculation of cooling loads and heat exchanger duties.

First stage cooling includes only gas cooling from  $85^{\circ}\text{F}$  to  $-2.2^{\circ}\text{F}$ .

Gas flow ( $\text{CO}_2$ ) = 550.7 SCFM = 4049.7 lb/hr

$\text{CO}_2$  heat capacity;  $C_p$  at  $0^{\circ}\text{C} = 0.205 \text{ BTU/lb-}^{\circ}\text{F}$

cooling load  $Q_1 = (\text{mass flow}) (\text{heat capacity}) (\text{temperature drop})$

$$Q_1 = (4049.7) (0.205) (87.2)$$

$$Q_1 = 72,392.4 \text{ BTU/hr}$$

Second stage cooling consists of condensation of 135.3 lb/hr of condensate at the composition specified, 50.4% w/w ethanol.

The heat of vaporization (condensation) for this condensate is:

$$\Delta H = 681.1 \text{ BTU/lb}$$

The second stage cooling load is:

$$Q_2 = (681.1 \text{ BTU/lb}) (135.3 \text{ lb/hr})$$

$$Q_2 = 92,152.8 \text{ BTU/hr}$$

#### CONCLUSION #2

The total cooling load and condenser duties required for a functional system for 100,000 gallons of fermenting red must is:

$$164,545.2 \text{ BTU/hr}$$

This corresponds to the need for 13.7 tons of refrigeration at a very low temperature of around  $-12^{\circ}\text{F}$ .

---

APPENDIX B

STORAGE REQUIREMENTS  
FOR THE ETHANOL/WATER PRODUCT



APPENDIX B  
STORAGE REQUIREMENTS FOR THE  
ETHANOL/WATER PRODUCT

I. MATERIAL BALANCE

Three out of the four exhaust controls generate an ethanol/water by-product. The three exhaust controls are scrubbing, carbon adsorption and condensation. In order to determine the storage requirement for the by-product, the amount of by-product from each type of control has to be calculated. The concentration of ethanol in the by-product is also needed to determine the method of disposal.

To calculate the concentration and amount of the by-product, a material balance is made around the control unit. Flow charts representing the process of the exhaust control systems are shown in Figure B-1.

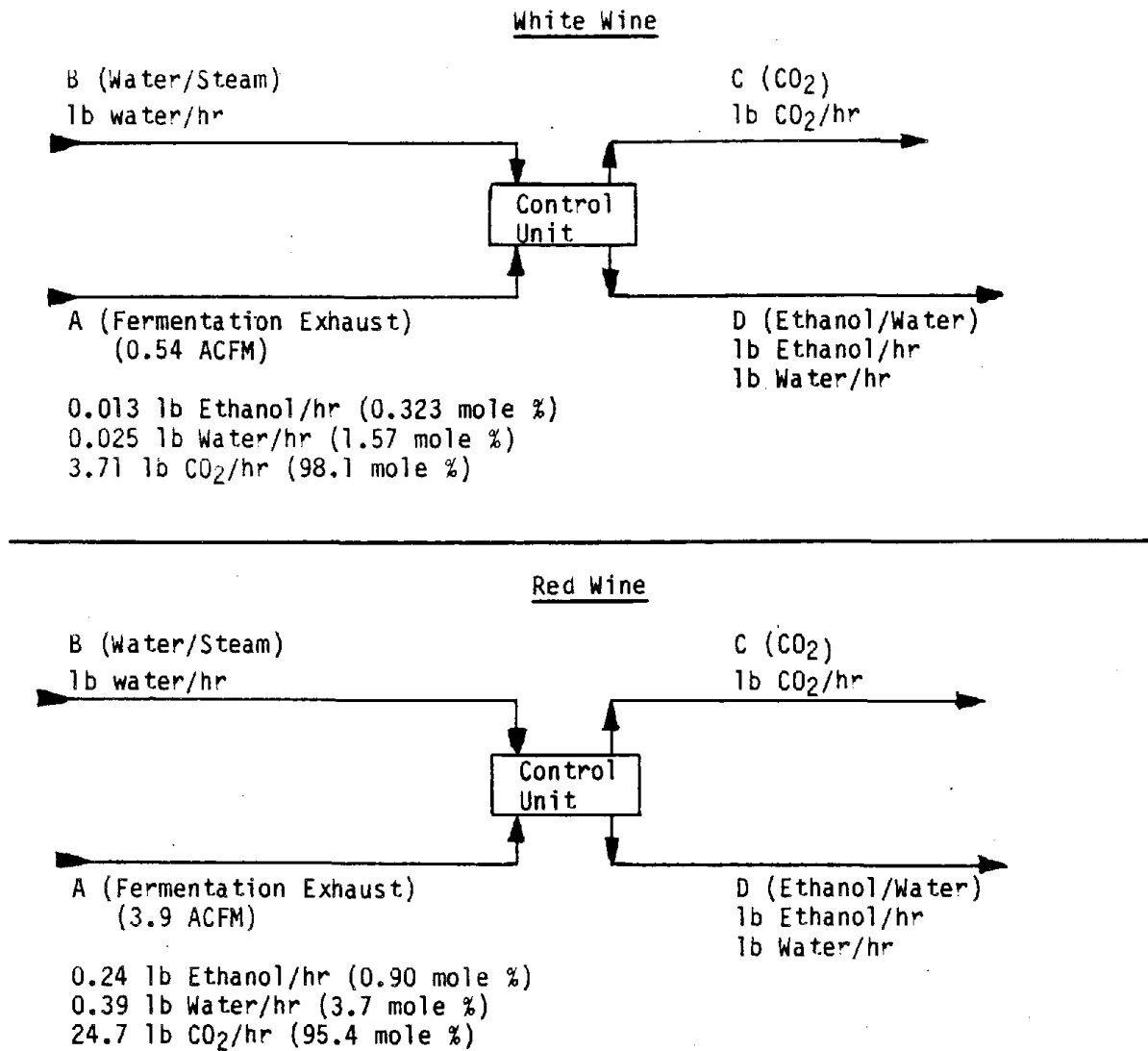
The material balance is the same for each type of control. The bases for the material balance are 1,000 gallons of juice, and one fermentation cycle.\* The fermentation cycle is treated as a continuous process. Assuming that the exhaust control system operates at steady state, then the "input" into the control unit would equal the "output." "Input" is all of the material entering the control unit and "output" is all of the material leaving the control unit.

Stream A is the fermentation exhaust. The flow rate of Stream A represents the average exhaust flow rate over one fermentation cycle. The average flow rates and the composition of Stream A are based on source tests performed by EAL Corporation. Stream B is the water/steam entering the

\*The actual fermentation time of the fermentation cycle.

Figure B-1

PROCESS SCHEMATIC OF EXHAUST CONTROLS\*



\*Based on 1,000 gallons of juice, over one fermentation cycle.

Source: ARB/SSD

control unit. The scrubbing unit uses water to absorb ethanol, and the carbon adsorption unit uses steam to remove ethanol from the carbon beds. The condensation unit does not use water. Therefore, Stream B for condensation is zero. The flow rates for Stream B can be found in Appendix A.  $\text{CO}_2$ , being an inert gas, enters and leaves the control units unchanged.  $\text{CO}_2$  enters the control unit as part of Stream A and leaves as part of Stream C. The other components in Stream C are the uncaptured ethanol and water. The amount of ethanol and water in Stream C is very small compared to the  $\text{CO}_2$  in the stream. Therefore, the amount of ethanol and water in Stream C has been neglected. Stream D is the ethanol/water product of the control unit. The amount of ethanol in this stream depends on the control efficiency of the control unit. All of the ethanol removed by the control unit leaves as part of this stream. All of the water entering the control unit is also assumed to be part of this stream. Theoretically, the water/ethanol product absorbs some  $\text{CO}_2$ , but the amount of  $\text{CO}_2$  is very small compared to the other components in the stream. Therefore, the amount of  $\text{CO}_2$  in Stream D is neglected.

Table B-1 shows the result of the material balance for both white and red wine. The mass rates and the composition of the ethanol/water product from the control units (Stream D) calculated from the material balance are used to calculate the storage requirement. Storage requirements for the ethanol/water product from a 300,000 gallon white wine tank farm of 10 tanks using condensation as the method of control are listed in Table B-2. Sample calculations are shown in the next section.

## II. SAMPLE CALCULATIONS

### 1. Conversion of mole percent to lb/hr

The equation used for converting mole percent of a component in the fermentation exhaust is

$$M = (Q) [492/(460 + T)] (X/100) (1 \text{ lb-mole}/359 \text{ ft}^3) (\text{M.W.}) \\ (60 \text{ min/hr})$$

Where M = mass flow rate of component, lb/hr

Q = Fermentation exhaust flow rate, ACFM

T = Fermentation temperature, °F

X = Mole percent of component

M.W. = Molecular weight of component, lb/lb-mole

For the ethanol in the fermentation exhaust of 1,000 gallons of white wine,  $M = (0.54) [492/(460 + 57)] (0.323/100) (1/359) (46) (60) = 0.013$  lb/hr

The mass flow rates of the components in the fermentation exhaust (Stream A) shown in Figure 1 were calculated as shown above.

### 2. Calculation of volume percent of ethanol in the ethanol/water product.

The equation for calculating volume percent of ethanol in the product (Stream D) is:

$$V\% = (Me/\rho_e) / [Me/\rho_e + Mw/\rho_w]$$

Where V% = Volume percent of ethanol

Me\* = Mass rate of ethanol, lb/hr

$\rho_e^{**}$  = Density of ethanol, lb/gal

Mw\* = Mass rate of water, lb/hr

$\rho_w^{**}$  = density of water, lb/gal

For white wine condensation the volume percent of ethanol in the ethanol/water product is

$$V\% = (0.0116/6.6)/[(0.0116/6.6) + (0.025/8.3)] = 37\%$$

3. Volume of product from one fermentation cycle. The volume of product is found by the following:

$$V = [(Me/\rho_e) + (Mw/\rho_w)] G (24 \text{ hr/day}) (\text{no. of days/cycle})$$

Where V = Volume of Product, gal

$$G = 10^3 \text{ gal of wine}$$

For a 300,000 gallon white wine tank farm of 10 tanks using condensation as the method of control,

$$V = [(0.0116/6.6) + (0.025/8.3)] (2,400) (24) (7) = 1,923 \text{ gal}$$

---

\*Mass rates are listed in Figure B-1.

\*\*The density of ethanol is 6.6 lb/gal, and the density of water is 8.3 lb/gal.

Table B-1

MASS RATE OF STREAM IN EXHAUST  
CONTROL PROCESS  
(lbs/hr)

White Wine, based on 1,000 gallons of wine

| Control<br>Type      | Ethanol | A<br>Water | CO <sub>2</sub> | B<br>Water | C<br>CO <sub>2</sub> | Ethanol | D<br>Water | Total  |
|----------------------|---------|------------|-----------------|------------|----------------------|---------|------------|--------|
| Scrubbing            | 0.013   | 0.025      | 3.71            | 26         | 3.71                 | 0.0127  | 26.023     | 26.048 |
| Carbon<br>Adsorption | 0.013   | 0.025      | 3.71            | 0.149      | 3.71                 | 0.0122  | 0.174      | 0.186  |
| Condensation         | 0.013   | 0.025      | 3.71            | 0          | 3.71                 | 0.0116  | 0.025      | 0.0366 |

Red Wine, based on 1,000 gallons of wine

| Control<br>Type      | Ethanol | A<br>Water | CO <sub>2</sub> | B<br>Water | C<br>CO <sub>2</sub> | Ethanol | D<br>Water | Total  |
|----------------------|---------|------------|-----------------|------------|----------------------|---------|------------|--------|
| Scrubbing            | 0.24    | 0.39       | 24.7            | 195        | 24.7                 | 0.233   | 195.39     | 195.69 |
| Carbon<br>Adsorption | 0.24    | 0.39       | 24.7            | 0.88       | 24.7                 | 0.223   | 1.27       | 1.49   |
| Condensation         | 0.24    | 0.39       | 24.7            | 0          | 24.7                 | 0.212   | 0.39       | 0.602  |

Source: ARB/SSD

Table B-2

VOLUME OF ETHANOL/WATER PRODUCT

10 Tanks - 300,000 Gallons Each

| <u>Control Type</u> | <u>White White</u>         |                                                      | <u>Red Wine</u>            |                                                      |
|---------------------|----------------------------|------------------------------------------------------|----------------------------|------------------------------------------------------|
|                     | <u>Gallons/<br/>Cycle*</u> | <u>Concentration<br/>of Ethanol<br/>(Avg. Vol %)</u> | <u>Gallons/<br/>Cycle*</u> | <u>Concentration<br/>of Ethanol<br/>(Avg. Vol %)</u> |
| Carbon Adsorption   | 9,198                      | 8.1                                                  | 10,100                     | 18.1                                                 |
| Scrubbing           | $1.26 \times 10^6$         | 0.061                                                | $1.27 \times 10^6$         | 0.15                                                 |
| Condensation        | 1,923                      | 37                                                   | 4,275                      | 40.6                                                 |

\*Fermentation time of one cycle.

Source: ARB/SSD



Attachment 2

# L&A ENGINEERING & EQUIPMENT, INC.

ENGINEERING SERVICES AND PROCESS EQUIPMENT FOR FOOD, BEVERAGE AND POWER ALCOHOL PROCESSING

4124 SO. SODERQUIST RD. • TURLOCK, CALIFORNIA 95380 • PHONE (209) 632-3191

GENERAL ENGINEERING LICENSE NUMBER 276910

December 20, 1982

Mr. Art Caputi, Jr.  
E & J Gallo Winery  
P.O. Box 1130  
Modesto, CA 95353

Dear Mr. Caputi:

In response to your request, we are pleased to submit our quotation for a refrigerated condenser to remove alcohol from fermentation gases. You have requested a unit with capacity of 165,000 BTU/hr with refrigerant @ -12°F, gas flow @ 551 SCFM (4050 lbs/hr). Inlet temperature is 85°F maximum, outlet temperature is -2°F.

The unit quoted uses Freon R-22 in the compressor, driven by a 50 HP motor. The condenser is of evaporative condensing design. The gas unit is a special low pressure drop fin tube coil with housing and drip pan.

These units are skid mounted and piped complete with a control panel.

The price is \$39,400.00 FOB factory plus applicable taxes.

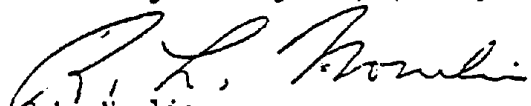
It will be necessary for you to duct the gas to the unit, bring power and water to the equipment and duct the cooled gas away, if necessary, and pipe the condensed liquid away from the unit to storage or further processing.

Installation costs will vary with site specific conditions, but an estimate of \$5,000.00 to \$10,000.00 should cover the range for most cases.

Should you have any questions, please call me.

Sincerely,

L & A Engineering & Equipment, Inc.

  
R.L. Nowlin  
President

RLN.rj  
cc: Mr. Wendell C.M. Lee



A-83

FACILITIES AT TURLOCK, GILROY, CALIFORNIA AND MINDEN, NEVADA

CARB-SBAPCD HB 000282



---

APPENDIX C

CALCULATION OF TANK OPENING FOR  
DUCTING OF FERMENTATION EXHAUST

## APPENDIX C

### CALCULATION OF TANK OPENING FOR DUCTING OF FERMENTATION EXHAUST

The four exhaust control systems require the ducting of the fermentation exhaust gas to the control unit. Each tank in the various tank farms would therefore need an opening from which the exhaust gas can be drawn. Because the existing manhole on each tank needs to be unobstructed for access, a separate vent for collecting the exhaust gases would have to be installed. Industry representatives have been concerned that any connection with the tank would either develop unacceptable pressures in the fermentation tank or would result in a vacuum being imposed inside the headspace of the tank. The purpose of the analysis below is to show that the diameters of openings would be reasonable and no adverse pressure or vacuum would occur in the tank. This analysis is not intended to be a design to be followed by a winery. The design of a connection would be the responsibility of the winery. For the purpose of this analysis the staff has estimated the size of each opening required. During fermentation, the existing manhole would have to be covered so that all gases would be funneled through the new vent.

Our concept of the tank opening would incorporate a "china cap" so that foreign matter would not fall into the tank. A diagram of our concept of a tank opening is shown in Figure C-1. The tank opening is designed on the basis that the tanks are fermenting red wine, and are at the maximum exhaust flow rate. By designing for maximum flow rate of red wine fermentation, the tank openings could handle the exhaust of both red and white wine. The design

exhaust gas temperature used is 85<sup>0</sup>F and the design exhaust flow rates for the tanks are listed in Table C-1.

The tank openings were calculated by using the empirical equation for a compressible fluid flowing through an orifice. From Unit Operations of Chemical Engineering, McCabe and Smith, pg. 212, the flow of a compressible fluid through an orifice is given by

$$\dot{M} = 0.61 (Y) (S_o) \sqrt{2g_c (P_a - P_b)} Q_a \quad (1)$$

where  $\dot{M}$  = mass flow rate, lb/sec.

0.61 = orifice coefficient

Y = dimensionless expansion factor

S<sub>o</sub> = cross sectional area of orifice, ft

g<sub>c</sub> = Newton's law proportionality factor, 32.2 ft-lbm per lbf-sec<sup>2</sup>

(P<sub>a</sub>-P<sub>b</sub>) = pressure drop across orifice

Q<sub>a</sub> = density of the fluid

The industry claims that the allowable internal pressure or vacuum of the tanks cannot exceed 1/2 oz. per in<sup>2</sup> (4.5 lb per ft<sup>2</sup>). Therefore, the maximum pressure drop through the tank opening is 4.5 lb per ft<sup>2</sup>. There are two pressure drops to be considered when the exhaust gas travels through the tank opening: the pressure drop across the orifice ( ΔP<sub>o</sub>), and the pressure drop due to losses from the 90<sup>0</sup> turn when the exhaust gas exits the tank opening ( ΔP<sub>e</sub>). ΔP<sub>e</sub> is dependent on the velocity of the exhaust gas, and can be calculated as follows:

---

\*Considered as a 90<sup>0</sup> elbow.

$$\Delta P_e = [(0.9) (U^2) / (2) (gc)] Q_a \quad (2)$$

Where  $\Delta P_e$  = Pressure drop due to 90° turn, lb/ft<sup>2</sup>

0.9 = loss coefficient for the 90° turn\*

U = exhaust gas velocity, ft/sec

However, the exhaust gas velocity is dependent on the size of the orifice. The exhaust gas velocity can be calculated as follows:

$$U = (Q/S_o) (1 \text{ min}/60 \text{ sec}) \quad (3)$$

Where U = exhaust gas velocity, ft/sec

Q = volumetric flow rate, ft<sup>3</sup>/min

Therefore, the calculation of the tank opening is an iterative procedure. To begin the procedure, a value for  $\Delta P_o$  has to be guessed. The orifice is calculated first by using the guessed value for  $\Delta P_o$ , then the velocity of the exhaust gas and  $\Delta P_e$  are calculated. This procedure is repeated until the sum of  $\Delta P_o$  and  $\Delta P_e$  is equal to or less than 4.50 lb per ft<sup>2</sup>. For a first guess, a value of 3.15 lb per ft<sup>2</sup> is used for  $\Delta P_o$  (70% of 4.5 lb per ft<sup>2</sup>). With  $\Delta P_o$  equal to 3.15 lb per ft<sup>2</sup>,  $P_b/P_a^*$  is approximately one. From McCabe and Smith, Figure 8-23, pg. 213, the value for Y is 1.0 when  $P_a/P_b$  is equal to 1.0. Because at maximum flow rate 95 percent of the exhaust is CO<sub>2</sub>, the exhaust gas is assumed to be 100 percent CO<sub>2</sub> for simplicity. Since CO<sub>2</sub> is the heaviest of the three components in the exhaust gas, and because the diameter of the opening is directly proportional to the mass flow rate, this assumption will result in a slightly larger opening than may be absolutely necessary. The difference, however, will be insignificant. The

$$*P_b/P_a = 2116.8/(2116.8 + 3.15) = 0.999$$

density of  $\text{CO}_2$  at  $85^\circ\text{F}$  is  $0.12 \text{ lb per ft}^3$ . After the substitution of known quantities, equation (1) becomes

$$\dot{M} = 3.01 \text{ So} \quad (4)$$

The diameter of the orifice (tank opening) can be calculated by using the following equation:

$$\text{So} = (\pi) (\text{Do}^2)/4 \quad (5)$$

Where  $\text{Do}$  = diameter of the tank opening, ft. Substituting equation (3) into equation (2) and solving for  $\text{Do}$  yields

$$\text{Do} = \sqrt{0.423 (\text{M})}, \text{ ft} \quad (6)$$

With  $\Delta \text{Po}$  equal to  $3.15 \text{ lb per ft}^2$ , equation (6) can be used to calculate the orifice diameters. The exhaust gas velocity corresponding to the above  $\Delta \text{Po}$  is  $25.1 \text{ ft per sec}$ . At this velocity,  $\Delta \text{Pe}$  is  $1.05 \text{ lb per ft}^2$ .

Therefore, the pressure drop through the tank opening is  $4.20 \text{ lb per ft}^2$  ( $\Delta \text{Po} + \Delta \text{Pe}$ ). Since  $4.20 \text{ lb per ft}^2$  is less than  $4.50 \text{ lb per ft}^2$ , it is not necessary to continue the iteration procedure. The diameters of the orifice for the different tanks were calculated using equation (6). The diameter of the china cap ( $\text{Dc}$ ) has to be larger than  $\text{Do}$  to provide adequate cover for the tank opening.  $\text{Dc}$  is assumed to be 25 percent larger than  $\text{Do}$ . Diameters of the tank opening and china cap for the different tanks are listed in Table C-1.

When the exhaust gas exits the tank opening, it has to flow around the china cap. The area between the china cap and the tank opening ( $\text{Scd}$ ) through which the exhaust flows can be determined by the following equation:

$$\text{Scd} = \pi (\text{Do}) (X_3) \quad (7)$$

Where  $X_3$  = distance between the china cap and the tank opening, ft

If  $S_{cd}$  is equal to  $S_o$ , then the exhaust flow rate through  $S_{cd}$  would equal the exhaust flow rate through  $S_o$ . The reason for maintaining a constant flow rate between  $S_o$  and  $S_{cd}$  is to prevent the possibility of a pressure build-up inside the fermentation tank. With  $S_{cd}$  equal to  $S_o$ ,  $X_3$  can be calculated as follows:

$$\pi (D_o) (X_3) = ( \pi /4) D_o^2$$

Solving for  $X_3$ ,

$$X_3 = D_o/4 \quad (8)$$

This is the minimum distance between the china cap and the tank opening required to prevent the development of unacceptable pressures in the fermentation tank. However, to allow for an additional margin of safety, we have selected  $X_3$  to be  $D_o/2$  (two times the minimum distance required). Values for  $X_3$  are listed in Table C-1.

The ducting system design is based on a constant flow rate maintained by the system's blower. When the fermentation exhaust flow rate drops off, outside air is taken in. The hood that covers the tank opening (see Figure 1) has to be large enough to allow the same flow rate of air to enter the ducting system as the maximum exhaust flow rate generated by fermentation. The maximum amount of air taken in by the ducting system is when the fermentation exhaust flow rate is at the minimum. Industry representatives have been concerned that the air entering the ducting system would draw off some of the substances from inside of the tank. However, the staff believes that if the area of the hood were sufficiently large, the air speed would be relatively low, thus minimizing the possibility of the loss of substances from the tank. Therefore, by selecting a cross-sectional area of the annulus between the china cap and the hood of the cross-sectional area of the tank opening three

times that of  $S_o$ , the air speed would be approximately 10 ft per second (at maximum air flow). The effect of this would be that no significant vacuum would occur in the headspace of the fermentation tank. The diameter of the hood ( $D_h$ ) can be calculated as follows:

$$(\pi/4) (D_h^2) = 3 (\pi/4) (D_o^2) + (\pi/4) (D_c^2)$$

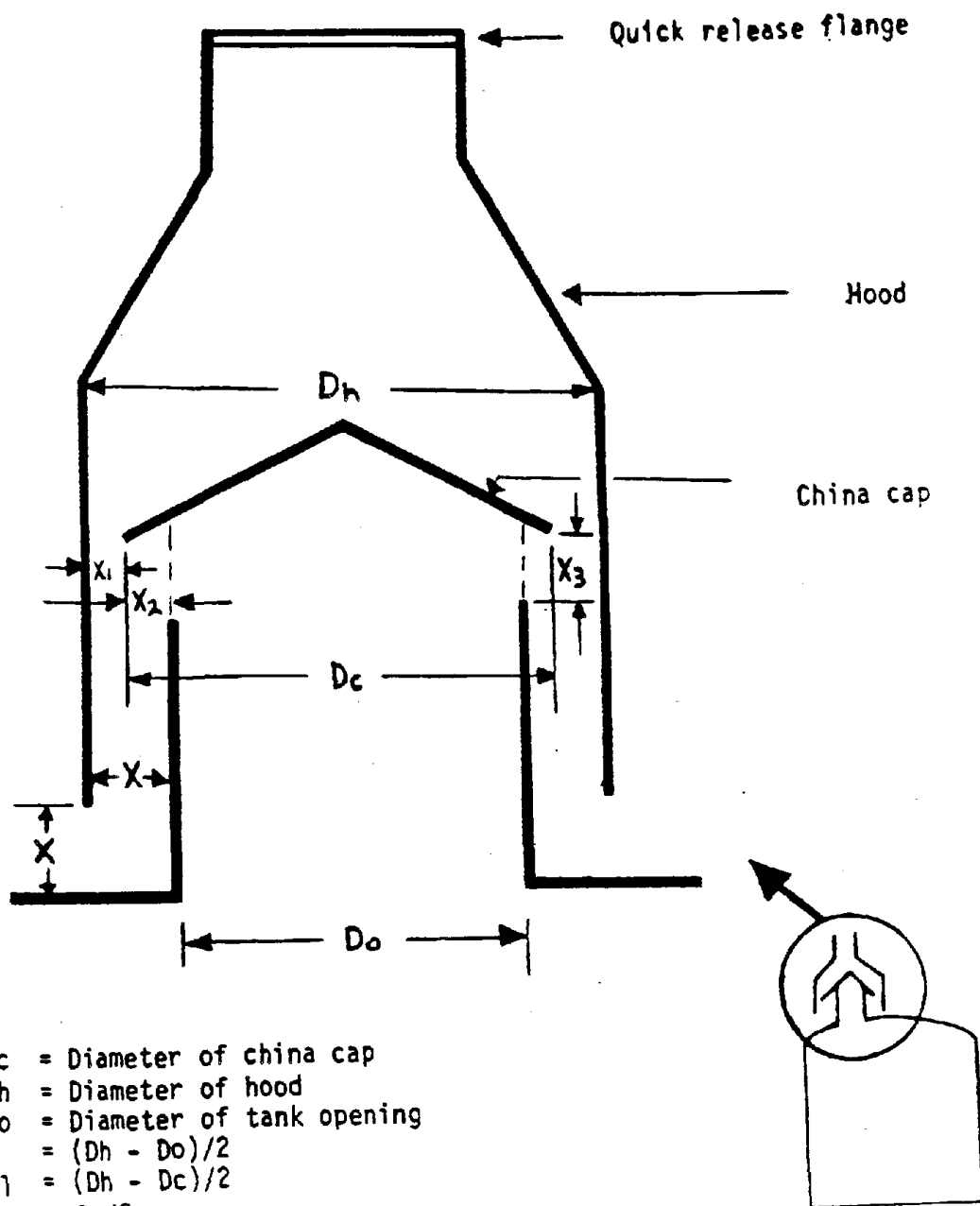
and substituting  $1.25 D_o$  for  $D_c$ ,

$$D_h^2 = 3 D_o^2 + (1.25 D_o)^2$$

$$D_h = 2.14 D_o \quad (9)$$

Values for  $D_h$  for the different tanks are listed in Table C-1.

FIGURE C-1  
EXPANDED VIEW OF TANK OPENING \*



$D_c$  = Diameter of china cap  
 $D_h$  = Diameter of hood  
 $D_o$  = Diameter of tank opening  
 $X$  =  $(D_h - D_o)/2$   
 $X_1$  =  $(D_h - D_c)/2$   
 $X_2$  =  $D_o/8$   
 $X_3$  =  $D_o/2$

\*Not drawn to scale.

Source: ARB/SSD



Table C-1: Design Exhaust Flow Rates  
and Openings by Tank Sizes

|                                                                         |      |      |      |      |
|-------------------------------------------------------------------------|------|------|------|------|
| Tank Size, 1,000 gal                                                    | 50   | 100  | 300  | 600  |
| Exhaust, Volumetric<br>Flowrate, ft <sup>3</sup> /min                   | 230  | 460  | 1380 | 2760 |
| Exhaust Mass<br>Flowrate, lbs/sec                                       | 0.46 | 0.92 | 2.76 | 5.52 |
| Diameter of<br>Opening (D <sub>o</sub> ), ft                            | 0.44 | 0.62 | 1.08 | 1.52 |
| Diameter of<br>China Cap (D <sub>c</sub> ), ft                          | 0.55 | 0.78 | 1.35 | 1.90 |
| Diameter between<br>China Cap and Tank<br>Opening (X <sub>3</sub> ), ft | 0.22 | 0.31 | 0.68 | 0.95 |
| Diameter of<br>Hood (D <sub>h</sub> ), ft                               | 0.94 | 1.33 | 2.31 | 3.25 |

Source: ARB/SSD

APPENDIX D  
Source Test Method

To determine the percent reduction of the ethanol content of the fermentation exhaust gases achieved by the air pollution control equipment, fermentation exhaust gases entering and exiting the air pollution control equipment have to be tested. The values necessary to obtain the percent ethanol reduction are the flow rate, temperature, and ethanol concentration of the fermentation exhaust gases.

This appendix outlines the procedures for sampling and testing exhaust gases from wine fermentation tanks. Due to the variation of the ethanol concentration in the fermentation exhaust gases throughout the fermentation cycle, a test method that continuously samples and analyzes the fermentation exhaust gases provides the greatest degree of accuracy. ARB Method 100, Procedures for Continuous Emission Stack Sampling,<sup>1/</sup> outlines the procedures to continuously sample and analyze gaseous emissions from gas streams flowing in ducts, stacks, and flues. However, due to the small ducts utilized by the wineries, ARB Method 2A<sup>1/</sup> shall be used to determine the exhaust gas flow rates in lieu of ARB Methods 1 and 2.

<sup>1/</sup> Stationary Source Test Methods, Volume 1, Methods for Determining Compliance with District Non-Vehicular (Stationary Source) Emission Standards, ARB, 1986.

From source tests<sup>2,3/</sup> performed by the ARB, fermentation exhaust gases were found to be composed predominantly of carbon dioxide (CO<sub>2</sub>) and ethanol. Therefore, the ethanol content can be assumed to represent the total hydrocarbon content (THC) in the exhaust gas streams. However, grab samples of the exhaust gas shall be collected and analyzed by gas chromatography (GC) to ensure that ethanol does represent the THC of the exhaust gases.

When testing for ethanol in the exhaust gases from wine fermentation tanks, the calibration gas shall be propane, and the analyzer calibrated in terms of parts per million (ppm) of propane. Prior to testing, the response factor of the analyzer has to be determined. The response factor (RF) is the ratio of the known concentration of a compound to the observed concentration when measured with an analyzer calibrated with the specified calibration gas. The RF can be determined as follows:

Calibrate the instrument with calibration gas. Obtain or prepare a known standard in air at a concentration of approximately 90 percent of the expected concentration of the compound being analyzed. Introduce this mixture to the analyzer and record the observed analyzer reading. Introduce zero gas until a stable reading is obtained. Make a total of three measurements by

- 2/ Source Test Report on Emissions From a Fermentation Tank at E.&J. Gallo Winery, Fresno, California, Report No. C-8-050, ARB, 1978.  
3/ Evaluation Test to Measure Ethanol Emissions From a 106,000 Gallon Fermentation Tank, Report No. C-80-071, ARB, 1980.

alternating between the mixture and zero gas. Calculate the response factor for each repetition and the average response factor.

Alternatively, if response factors have been published for the compound of interest for the instrument or detector type, the published response factor may be used in lieu of a factor determined by the procedure outlined above.

Due to the large amount of  $\text{CO}_2$  in the exhaust gases, there is a possibility of interference between  $\text{CO}_2$  and ethanol with respect to the analyzer's response. Therefore, a test is needed to determine any possible interference between  $\text{CO}_2$  and ethanol. Test for interference between  $\text{CO}_2$  and ethanol as follows:

Zero the analyzer with zero gas, and introduce a known standard in air to the analyzer and record the observed analyzer reading. Reintroduce zero gas until a stable reading is obtained, and introduce a known concentration of  $\text{CO}_2$  in air to the analyzer and record the analyzer reading. If the mixture of  $\text{CO}_2$  and air does not register a reading, it can be concluded that there will be no interference between  $\text{CO}_2$  and ethanol with respect to the analyzer's response. If the mixture of  $\text{CO}_2$  and air registers a reading, there will be interference between  $\text{CO}_2$  and ethanol, and the observed analyzer reading has to be corrected. The

analyzer reading due to CO<sub>2</sub> must be subtracted from the total analyzer reading of the fermentation exhaust gases. The analyzer reading due to CO<sub>2</sub> is calculated with the measured concentration of the CO<sub>2</sub> in the fermentation exhaust gases and the response factor of the analyzer to CO<sub>2</sub>.

If CO<sub>2</sub> is found to interfere with ethanol, the analyzer reading due to CO<sub>2</sub> can be calculated as follows:

$$(\text{PPM}) \text{ CO}_2 = (\text{CO}_2) / (\text{RF}) \text{ CO}_2$$

Where

$$(\text{PPM}) \text{ CO}_2 = \text{analyzer reading due to CO}_2 \text{ (ppm as propane)}$$

$$\text{CO}_2 = \text{concentration of CO}_2 \text{ in the exhaust gases, PPM}$$

$$(\text{RF}) \text{ CO}_2 = \text{response factor of analyzer to CO}_2$$

The analyzer reading is corrected for CO<sub>2</sub> interference as follows:

$$(\text{PPM}) \text{ EtOH} = (\text{PPM}) \text{ exhaust} - (\text{PPM}) \text{ CO}_2$$

Where

$$(\text{PPM}) \text{ EtOH} = \text{analyzer reading due to ethanol (ppm as propane)}$$

(PPM) exhaust = analyzer reading for fermentation exhaust  
gases (ppm as propane)

The analyzer readings obtained during the source testing are in terms of ppm as propane. The analyzer readings are corrected to ppm as ethanol by the following equation:

$$(PPM) = \text{ppm EtOH} \times (RF) \text{ EtOH}$$

Where

(PPM) = ethanol concentration in fermentation exhaust, ppm

(PPM)EtOH = analyzer reading due to ethanol (PPM as propane)

(RF)EtOH = response factor of the analyzer to ethanol

APPENDIX E  
CONSULTATION MEETING NOTICES AND  
REQUESTS FOR COMMENTS

## AIR RESOURCES BOARD

1102 Q STREET  
P.O. BOX 2815  
SACRAMENTO, CA 95812



March 10, 1986

Dear Sir or Madam:

Consultation Meeting - Ethanol  
Emissions from Winery Fermentation Tanks

The staff of the California Air Resources Board (ARB) will conduct a consultation meeting to discuss the development of a suggested control measure for controlling ethanol emissions from large winery fermentation tanks in the state.

Date: April 8, 1986  
Time: 10:00 A. M.  
Place: Library and Courts Building  
914 Capitol Mall, Room 540  
Sacramento, CA

Suggested control measures are developed by members of the Statewide Technical Review Group for use by local air pollution control districts and air quality management districts in reducing emissions for the purpose of attaining the state and federal ambient air quality standards. The Technical Review Group is composed of technical representatives of the air pollution control and air quality management districts in California, the U.S. Environmental Protection Agency and the ARB. The Technical Review Group has compiled a list of proposed suggested control measures and has designated a lead agency for developing each.

The Technical Review Group has requested that the ARB take over the lead role originally assumed by the Fresno Air Pollution Control District in the development of the winery suggested control measure. As the lead agency, the ARB is responsible for holding consultation meetings, gathering data, writing a technical support document and presenting the suggested control measure to the Technical Review Group for its approval. If the Technical Review Group approves the suggested control measure, it is then considered for approval at a public meeting of the Air Resources Board. Members of the public can present testimony at the Board meeting. If the Board approves the measure, the measure is forwarded to the air pollution control and air quality management districts for their consideration of adoption. If the district staff decides to present the measure to the district board for consideration of adoption, workshops will be held by the district and a public hearing will be held by



March 10, 1986

the district board. If the district board adopts the measure as a rule, it then, and only then, becomes law in that district. The process, from development of the suggested control measure to adoption by the local district, usually takes more than a year.

All interested persons are invited to present their views and comments on the feasibility of reducing ethanol emissions from winery fermentation tanks. Specific items to be discussed include estimation of emissions, technology of wine production, feasibility of various control technologies, and associated costs and benefits of these controls. Information received at this meeting will be used to refine ARB staff estimates of the above.

If you plan to attend the meeting, please notify Ms. Sue Kaiser at (916) 323-8475 or Ms. Linda Lee at (916) 322-8273 by March 21, 1986. We are in the process of developing a staff report on the control of winery emissions. Therefore, it is essential that we receive early notice so that we may forward portions of that report for your review prior to the meeting.

If you have any questions on the scheduled consultation meeting, please contact either Ms. Sue Kaiser or Ms. Linda Lee.

Sincerely,



Ronald A. Friesen  
Assistant Chief  
Stationary Source Division

## AIR RESOURCES BOARD

1102 Q STREET  
P.O. BOX 2815  
SACRAMENTO, CA 95812



March 26, 1986

Dear Sir or Madam:

Review Materials for Consultation Meeting -  
Ethanol Emissions from Winery Fermentation Tanks

This is a follow-up to our letter of March 10, 1986, in which we announced an April 8 consultation meeting to discuss ethanol emissions from winery fermentation tanks.

The enclosed package consists of three separate sections. The first is an estimate of uncontrolled emissions from fermentation tanks and the anticipated emission reductions from various control technologies. The second section is an analysis of the costs and benefits associated with each control technology, along with detailed appendices showing calculations and methodology. The third section is a list of questions relating to the first two sections and to the wine-making process in general. We would appreciate hearing your comments during the April 8 meeting. You also may wish to respond in writing after the meeting. We would like to receive such written comments by April 15.

If you have any questions regarding this package, please contact Ms. Sue Kaiser at (916) 323-8475 regarding the first and third sections or Ms. Linda Lee at (916) 322-8273 or Mr. Nelson Chan at (916) 322-8487 regarding the second section.

Sincerely,

A handwritten signature in cursive script that reads 'Alan Goodley'.

Alan Goodley, Chief  
Strategy Assessment Branch  
Stationary Source Division

Enclosures

### Questions

We are interested in obtaining your comments and feedback on the data presented herein. We also are interested in obtaining information relating to fermentation operations at individual wineries. If you have comments or if you can provide information in response to the questions below, we would very much like to obtain your input during the April 8 workshop or in writing by April 15, 1986. Written comments should be addressed to:

Alan Goodley

Chief, Strategy Assessment Branch

Stationary Source Division

Air Resources Board

P. O. Box 2815

Sacramento, CA 95812

A. Questions regarding Ethanol Emissions and Reductions Estimates (Section I).

1. Do the fermentation temperatures selected as the basis for calculating emissions in Table 1 represent an industry-wide average? If not, can you provide data which suggest using different temperatures?
- 2 a. What percentage of the wine produced in California is fermented in each size range of 0-50,000-gallon, 50,000-100,000-gallon,

and 100,000-gallon and larger tanks?

b. Would it be possible to obtain the above information on an Air Pollution Control District basis?

c. Would it be possible to obtain the above information on an individual winery basis?

3. a. Do you have any information on fruit wine production, specifically, gallons produced and sizes of tanks used for fermentation? If so, could this information be provided in the format(s) suggested in question 2?

b. What are the industry-wide fermentation temperatures used for fruit wine?

4. Are there any fermentation emissions that we have overlooked?

5. Are the assumptions and calculations in Section I correct? Do you have any suggestions or modifications?

B. Questions regarding Costs of Control Strategies and Method of Computing Costs for Controls (Section II).

1. How long is the red wine fermentation season? The white wine fermentation season? What is the length of an average fermentation cycle for each?

2. Are there fermentation tanks dedicated for red and white wine production, or are the tanks used interchangeably? If tanks are used interchangeably, how frequently is this done? Are dessert wines fermented in dedicated tanks?
3. How are the fermentation tanks physically grouped, i.e., by size, type of wine produced, etc.? Are there any isolated tanks?
4. Within a tank farm, is the fermentation cycle usually staggered among tanks or is it synchronized?
5. How long does it take to clean the tanks between batches?
6. For wineries using a control method which results in a byproduct of high ethanol concentration, is there adequate tank capacity to store the additional volume?
7. Do you have any comments regarding the assumptions and calculations in Section II?

## AIR RESOURCES BOARD

1102 Q STREET  
P.O. BOX 2815  
SACRAMENTO, CA 95812



July 22, 1986

Dear Sir or Madam:

Request for Comments - Ethanol Emissions  
From Winery Fermentation Tanks Technical Support Document

The staff of the Air Resources Board (ARB) has prepared a draft technical support document for a suggested control measure for ethanol emissions from winery fermentation tanks. Suggested control measures are developed by members of the Statewide Technical Review Group for use by local air pollution control districts and air quality management districts in reducing emissions for the purpose of attaining the state and federal ambient air quality standards. The Technical Review Group is composed of technical representatives of the air pollution control and air quality management districts in California, the U.S. Environmental Protection Agency, and the ARB. The Technical Review Group has compiled a list of proposed suggested control measures and has designated a lead agency for developing each.

The Technical Review Group has requested that the ARB take over the lead role originally assumed by the Fresno Air Pollution Control District in the development of the winery suggested control measure. As the lead agency, the ARB is responsible for holding consultation meetings, gathering data, writing a technical support document and presenting the suggested control measure to the Technical Review Group for its approval. If the Technical Review Group approves the suggested control measure, it is then considered for approval at a public meeting of the Air Resources Board. Members of the public can present testimony at the Board meeting. If the Board approves the measure, the measure is forwarded to the air pollution control and air quality management districts for their consideration of adoption. If the district staff decides to present the measure to the district board for consideration of adoption, workshops will be held by the district and a public hearing will be held by the district board. If the district board adopts the measure as a rule, it then, and only then, becomes law in that district.

July 22, 1986

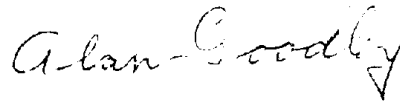
Those persons who attended the April 8 consultation meeting in Sacramento or the follow-up discussion meeting in Madera on April 22 will find a copy of the draft technical support document enclosed. Those persons who did not attend either of the meetings and would like to obtain a copy of the technical support document should contact Ms. Sue Kaiser at (916) 323-8475 or Mr. Nelson Chan at (916) 322-8487.

Please submit any comments which you may have regarding this material by August 18, 1986.

Written comments should be addressed to:

Alan Goodley, Chief  
Strategy Assessment Branch  
Stationary Source Division  
Air Resources Board  
P.O. Box 2815  
Sacramento, CA 95812

Sincerely,



Alan Goodley, Chief  
Strategy Assessment Branch  
Stationary Source Division

Enclosure

County of



Department of Health

Donald R. Rowe  
Director

Aug. 7, 1986

To: Interested Parties

From: William J. Roddy, Chairman, Technical Review Group *WR*

Subject: Suggested Control Measure (SCM) for  
Winery Fermentation Tanks

A workshop will be held to review and discuss the proposed Winery SCM on  
September 16, 1986, 10:00 a.m. at:

Department of Consumer Affairs  
1020 "N" Street, Room 102  
Sacramento, Ca 95815

The California Air Resources Board has also extended the receipt date for  
written comments on the proposed SCM from August 18th to August 29th. Any  
other information related to the proposed SCM, or to the reactivity of  
ethanol, must also be submitted by August 29th so that TRG members have  
sufficient time to review such information.

Address all comments to the Chairman, TRG, and send a copy to each individual  
member by the August 29, 1986 deadline. Attached find a listing of all TRG  
members.

If you have questions please contact me at (209) 445-3239, or Alan Goodley at  
(916) 322-6020.

WJR/mb  
cc: TRG Members



## AIR RESOURCES BOARD

1102 Q STREET

P.O. BOX 2815

SACRAMENTO, CA 95812



August 15, 1986

Dear Sir or Madam:

Notice of Meeting Location Change -  
Workshop to Review and Discuss a Suggested Control Measure  
for Winery Fermentation Tanks

It has become necessary to change the location of the workshop scheduled for September 16, 1986. The August 7th notice which you received from William Roddy of Fresno County listed the Department of Consumer Affairs, 1020 N Street, Room 102 as the meeting location. Please note that the new location is:

State Water Resources Control Board  
901 P Street, Hearing Room (First Floor)  
Sacramento, CA 95814

The meeting will commence at 10:00 a.m.

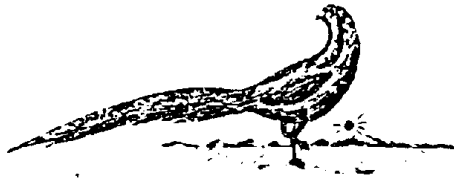
If you have any questions about the scheduling of the meeting, please contact Ms. Sue Kaiser at (916) 323-8475. We apologize for any inconvenience this may have caused.

Sincerely,

A handwritten signature in cursive script that reads "Alan Goodley".

Alan Goodley, Chief  
Strategy Assessment Branch  
Stationary Source Division

APPENDIX F  
COMMENTS RECEIVED FROM WINE INDUSTRY MEMBERS



# GIBSON WINE COMPANY

PRODUCERS OF

PREMIUM TABLE AND DESSERT WINES • FRUIT AND BERRY WINES

1720 ACADEMY • SANGER, CALIFORNIA 93657 • (209) 575-2535

RECEIVED

May 2, 1986

MAY 12 1986

Air Resources Board  
1102 Q Street  
Sacramento, Ca. 95812

Stationary Source  
Division  
Air Resources Board

Re: Winery Ethanol Emissions Control

Dear Sir or Madam:

Gibson Wine Company wishes to express some basic concerns with regard to the ARB's report issued in March, 1986.

The implementation of the proposed emission control would have a devastating effect on the wine industry in general and Gibson Wine Company in particular.

Gibson is a grower co-operative winery involving approximately 135 members who supply the winery with grapes. The winery does not purchase from outside sources. Due to the current economic situation within the industry, most wineries are operating on or below zero profit margins. A decrease in returns to Gibson Wine Company member growers of \$7.59 per ton (see attachment calculations) of grapes delivered would most certainly cause many to quit producing wine grapes, thus, increasing costs to remaining growers. This would cause economic disaster to Gibson Wine Company.

Determining the cost efficiency of ethanol recovery would be very difficult for our winery operation. Between 1980 and 1985, Gibson has crushed a high of 45,000 fresh grape tons and a low of 26,000 tons - based on vine yields. With such drastic fluctuations, it would be very difficult to figure a yearly crush tonnage figure. The cost per ton of grapes and the cost per pound of ethanol recovered would vary greatly since the cost of the recovery system would be amortized over a varying monetary base.

We also have serious concerns about utilizing a ducting system for ethanol recovery as prescribed by the ARB proposal:

- 1) Fermenting tanks which are often used for storage during the fermentation season need to remain tightly closed to prevent oxidation of the wine. Sulfur dioxide and carbon dioxide gas are used in the head space to provide an oxygen free environment.

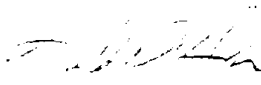
- 2) Gibson Wine Company's fermentation tanks are used interchangeably for both red and white wines. If we had to designate certain tanks for red wines only, we would lose the versatility of fermenting red and white wines in the same tanks.
- 3) Red and white varietals are fermented in small lots; therefore, requiring the use of several different size fermenting tanks. The cost of ducting all tanks utilized would be exorbitant.
- 4) An elaborate system would be very inefficient when the winery was fermenting in one tank of each module series.
- 5) The high suction on the ducting system may remove along with the ethanol other volatile components and flavors, thus changing sensory characteristics of the finished wines.
- 6) Disposal of water ethanol mixtures is a serious concern. Evaporation of said mixture would cause a secondary pollution problem.

Gibson Wine Company feels it is imperative to have the results of the Wine Institute's Smog Chamber Study to determine oxidative characteristics of ethanol, if any. Also, if the ARB insists on implementing the described emission control for ethanol, Gibson Wine Company feels the ARB should conduct a demonstration project. Wineries should not have to make a substantial capital outlay for a control system that has not been proven to be safe, efficient, reliable, or cost effective.

Gibson Wine Company requests that the Technical Review Group (TRG) carefully consider all the ramifications of its proposed Winery Ethanol Emission Control before requiring the enactment of such.

Very truly yours,

GIBSON WINE COMPANY

  
Gerald D. Homolka  
Plant Manager

GH:s  
Encl.

## Gibson Wine Company Carbon Absorption System

## Fermentation Tanks

| <b>Quantity</b>                              | <b>Size</b> | <b>Gallons</b> | <b>Modules</b> | <b>Gallons</b> | <b>Ducts</b> | <b>Carbon Equipment</b> | <b>Total</b>       |
|----------------------------------------------|-------------|----------------|----------------|----------------|--------------|-------------------------|--------------------|
| 18                                           | 131,000     | 2,358,000      | 2e10           | 2,000,000      | \$286,722    | \$228,000               | \$514,722          |
| 4                                            | 105,000     | 420,000        | 1e5            | 500,000        | 78,336       | 105,000                 | 183,336            |
| 2                                            | 54,000      | 108,000        | 1e5            | 500,000        | 78,336       | 105,000                 | 183,336            |
| 10                                           | 50,000      | 500,000        | 1e10           | 1,000,000      | 143,361      | 114,000                 | 257,361            |
| 24                                           | 23,000      | 552,000        | 2e10           | 2,000,000      | 286,722      | 228,000                 | 514,722            |
| <hr/>                                        |             |                |                |                |              |                         |                    |
| 58                                           |             | 3,938,000      | 60             | 6,000,000      | \$873,477    | \$780,000               | \$1,653,477        |
| <b>ARB Utility Cost + Carbon Replacement</b> |             |                |                |                | <b>\$353</b> | <b>\$11,816</b>         | <b>\$12,169</b>    |
| <b>Total Cost</b>                            |             |                |                |                |              |                         | <b>\$1,665,646</b> |

|                           |              |         |
|---------------------------|--------------|---------|
| After Tax Annual Cost:    | Dollars      | 208,308 |
| Ethonal Control @ 90%     | Lbs          | 15,971  |
| Cost Effectiveness        | Dollars/Lbs  | 13.04   |
| Added Cost to Wine        | Cents/Gal    | 4.1     |
| Decrease in Grower Return | Dollars/ Ton | 7.59    |

|                                       |         |
|---------------------------------------|---------|
| Fermentation Season: August - October | 91 days |
| Average White Grapes Crushed          | 28,000  |
| Red Grapes Crushed                    | 5,000   |
| Portion for White Fermentation        | 80%     |
| Red Fermentation                      | 100%    |

|                               |                        |
|-------------------------------|------------------------|
| Average White Juice Fermented | 4,144,000 Gallons/Year |
| Red Juice Fermented           | 925,000 Gallons/Year   |

|                                |                       |
|--------------------------------|-----------------------|
| White Fermentation Temperature | 57 Degrees Fahrenheit |
| Red Fermentation Temperature   | 83 Degrees Fahrenheit |

|                             |                       |
|-----------------------------|-----------------------|
| Total White Ethanol Emitted | 10,567 Lbs per Season |
| Red Ethanol Emitted         | 5,122 Lbs per Season  |

|                              |        |
|------------------------------|--------|
| Total Ethanol Emitted        | 17.745 |
| Total Ethanol Recovered @90% | 15.971 |

Heublein Wines  
12667 Road 24 P O Box 99 Madera California 93639



May 5, 1986

Mr. Alan Goodley, Chief  
Strategy Assessment Branch  
Stationary Source Division  
AIR RESOURCES BOARD  
P.O. Box 2815  
Sacramento, Ca 95812

Re: Ethanol Emissions from Winery Fermentation Tanks

Dear Mr. Goodley:

The ARB Report was received on March 27, 1986, and discussed at subsequent consultation meetings on April 8 and 22, 1986.

Due to lack of time, it is not possible to adequately study and analyze the content prior to the expiration of the comment period on May 9, 1986.

However, we have some basic comments, issues and concerns at this time.

No ethanol emission control rule should be proposed and/or implemented prior to the outcome of the Wine Institute sponsored smog changer test to determine the reactivity of ethanol. These results should be available within the next three months.

Five different methods of emission control were suggested. All but one require that tanks used for fermentation be equipped with a ducting system to collect the CO<sub>2</sub> gas with the ethanol.

It is our strong opinion that any control method employing a ducting system should be ruled out for the following reasons:

The existing tank construction does not allow any higher internal pressure than one half ounce per square inch. This pressure limitation results in large dia. ducts with high installation costs and impractical operation.

Mr. Alan Goodley  
Ethanol Emissions from  
Winery Fermentation Tanks  
May 5, 1986  
Page two

It is very doubtful that a design could be devised to make a ducting system functional relative to sanitation, safety, reliability and practical operation.

Major portions of the emission collecting system will have to be bypassed on a regularly scheduled basis for sanitation. This non-productive time is in addition to downtimes for repairs and maintenance.

There is a risk that additional ethanol is released from the surface of the liquid in the fermenter due to disturbing the normal equilibrium. This could also remove flavor and aroma components from the end product, i.e. the wine.

We also seriously question the rationale for ARB's proposed plans for the recovered ethanol. It just doesn't make good sense to spend a lot of money to collect an alleged pollutant and then let it out in the environment in the same or slightly altered form.

It is likely that the emissions reduced by lowering fermentation temperatures will equal the total net ethanol recovery from any of the gas collection methods after adjustments for all downtimes due to equipment breakdowns and scheduled sanitation shutdowns.

It should be noted that the fermentation process cannot be arrested upon demand, and that ethanol will continue to be emitted until the fermentation is completed.

In view of the above, it is our recommendation, if any ethanol emission control must be implemented, that ARB follows the lower fermentation temperature control method recommended earlier by the Fresno County Air Pollution Control District.

This control method is practical, reliable and will also improve the end product.

Mr. Alan Goodley  
Ethanol Emissions from  
Winery Fermentation Tanks  
May 5, 1986  
Page three

If ARB insists on pursuing the gas collection methods, it is imperative that a "Demonstration Project" be started to establish all the pros and the cons with the ducting system and the control devices. None of these methods has been demonstrated and proven as safe, practical and reliable to use in a food processing operation with its special public health requirements and regulations.

It should also be noted that a carbon adsorption system for the Heublein Madera Plant would show an after-tax cost effectiveness of approximately \$11/pound of ethanol controlled! The cost effectiveness without any tax benefits is approximately \$13/pound. See attached calculations. Please also find enclosed the requested plot plan and testing of tanks larger than 100,000 gallons.

These numbers were computed using ARB's capital and operating cost estimates and the ARB cost effectiveness calculation method.

The ARB cost numbers are considerably understated. This is understandable since they are based on a very simplistic layout and design, without detailed knowledge of operating conditions and winery requirements for equipment design.

In summary, the areas of concern are:

- Ethanol's reactivity classification.
- Cost effectiveness of proposed control methods.
- Net ethanol recovery from proposed ethanol recovery systems.
- Reliability of ethanol recovery systems.
- Capital cost of ethanol recovery systems.

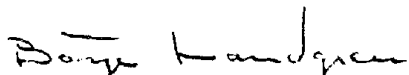


Mr. Alan Goodley  
Ethanol Emissions from Winery  
Fermentation Tanks  
May 5, 1986  
Page four

- Annual operating cost of ethanol recovery systems.
- Disposition of recovered ethanol. Secondary pollution.
- Area required to dispose of recovered ethanol.
- Size and cost of ducting system.
- Sanitation of ducting system.
- Safety of operation of ducting system.
- Additional ethanol loss from using ducting system.
- Flavor and aroma deterioration from using ducting system.
- Product integrity.
- Weakened economic position relative to competition from imported wines.

Sincerely,

HEUBLEIN WINES



BORJE LANDGREN  
Director of Engineering and Maintenance

BL/bg  
encl.

FERMENTATION SEASON AUG-SEP

40 CALENDAR DAYS

WHITE GRAPES CRUSHED

100,000 TONS/YEAR

RED GRAPES CRUSHED

3,000 "

PORTION FOR WHITE FERMENTATION

80%

PORTION FOR RED FERMENTATION

100%

WHITE JUICE FERMENTED

14,800,000 GALLONS/YEAR

RED MUST FERMENTED

660,000 "

WHITE FERMENTATION TEMPERATURE

57 DEGREES FAHRENHEIT

RED FERMENTATION TEMPERATURE

83 DEGREES FAHRENHEIT

ETHANOL EMITTED FROM WHITE JUICE

2.55 LBS/1,000 GAL. OF JUICE

ETHANOL EMITTED FROM RED MUST

7.76 LBS/1,000 GAL. OF MUST

TOTAL "WHITE" ETHANOL EMITTED

37,740 LBS PER SEASON

TOTAL "RED" ETHANOL EMITTED

5,122 "

TOTAL ETHANOL EMITTED

42,862 LBS PER SEASON

| SUMMARY                                 |            | ARB       |
|-----------------------------------------|------------|-----------|
| CAPITAL COST WHITE FERMENTERS           | DOLLARS    | 2,625,260 |
| CAPITAL COST RED FERMENTERS             | DOLLARS    | 558,660   |
| TOTAL CAPITAL COST                      | DOLLARS    | 3,183,920 |
| ANNUAL "WHITE" UTILITY COST             | DOLLARS    | 30,356    |
| ANNUAL "RED" UTILITY COST               | DOLLARS    | 22,558    |
| TOTAL ANNUAL UTILITY COST               | DOLLARS    | 52,914    |
| WHITE FERMENTERS                        |            |           |
| AFTER TAX ANNUAL COST                   | DOLLARS    | 332,150   |
| ETHANOL CONTROLLED AT 90 %              | LBS        | 33,966    |
| AFTER TAX COST EFFECTIVENESS            | DOLLARS/LB | 9.78      |
| COST EFFECTIVENESS WITHOUT TAX BENEFITS | DOLLARS/LB | 12.16     |
| RED FERMENTERS                          |            |           |
| AFTER TAX ANNUAL COST                   | DOLLARS    | 77,304    |
| ETHANOL CONTROLLED AT 90 %              | LBS        | 4,609     |
| AFTER TAX COST EFFECTIVENESS            | DOLLARS/LB | 16.77     |
| COST EFFECTIVENESS WITHOUT TAX BENEFITS | DOLLARS/LB | 22.53     |
| ALL FERMENTERS                          |            |           |
| TOTAL AFTER TAX ANNUAL COST             | DOLLARS    | 409,462   |
| ETHANOL CONTROLLED AT 90 %              | LBS        | 38,575    |
| AFTER TAX COST EFFECTIVENESS            | DOLLARS/LB | 10.61     |
| COST EFFECTIVENESS WITHOUT TAX BENEFITS | DOLLARS/LB | 13.40     |

05/12/86

## HEUBLEIN WINES CARBON ADSORPTION SYSTEM

B. LANGGREN

| ARB CAPITAL ESTIMATE FOR CARBON ADSORPTION |          |         |            |          |            |           |
|--------------------------------------------|----------|---------|------------|----------|------------|-----------|
| WHITE FERMENTERS                           | QUANTITY | SIZE    | GALLONS    | MODULES  | GALLONS    | TOTAL     |
| FERMENTATION TANKS                         | 12       | 350,000 | 4,200,000  | 1*15     | 4,200,000  | 463,500   |
| "                                          | 36       | 305,000 | 10,980,000 | 2*15+1*5 | 10,500,000 | 1,193,550 |
| "                                          | 16       | 650,000 | 10,400,000 | 1*10+1*5 | 9,000,000  | 968,202   |
| TOTAL WHITE FERMENTERS                     | 64       |         | 25,580,000 | 65       | 24,000,000 | 2,625,250 |

ARB UTILITY COST 856 29,500 30,356

| ARB CAPITAL ESTIMATE FOR CARBON ADSORPTION |          |         |           |         |           |         |
|--------------------------------------------|----------|---------|-----------|---------|-----------|---------|
| RED FERMENTERS                             | QUANTITY | SIZE    | GALLONS   | MODULES | GALLONS   | TOTAL   |
| FERMENTATION TANKS                         | 8        | 125,000 | 1,000,000 | 1*10    | 1,000,000 | 558,660 |

ARB UTILITY COST 350 22,200 22,550

[illegible]

Assume No Tax

AND

| WHITE FERMENTATION CARBON ABSORPTION |               |           |         |         |         | RED FERMENTATION CARBON ABSORPTION |                           |          |             |         |         |         |         |
|--------------------------------------|---------------|-----------|---------|---------|---------|------------------------------------|---------------------------|----------|-------------|---------|---------|---------|---------|
| CAPITAL COST                         |               | 2,425,849 |         |         |         | CAPITAL COST                       |                           | 550,649  |             |         |         |         |         |
| MAINT. AND LABOR                     | 3,805         | 79,750    |         |         |         | MAINT. AND LABOR                   | 3,805                     | 16,768   |             |         |         |         |         |
| LOCAL TAX FINE.                      | 2,805         | 52,565    |         |         |         | LOCAL TAX FINE.                    | 2,805                     | 11,173   |             |         |         |         |         |
| PUMP IN                              | 6,756         | 19,649    |         |         |         | PUMP IN                            | 6,756                     | 4,190    |             |         |         |         |         |
| UTILITIES                            |               | 30,335    |         |         |         | UTILITIES                          |                           | 82,958   |             |         |         |         |         |
| OPERATING COST                       |               | 181,388   |         |         |         | OPERATING COST                     |                           | 54,681   |             |         |         |         |         |
| BASIS FOR DEP.                       |               | 2,452,977 |         |         |         | BASIS FOR DEP.                     |                           | 538,727  |             |         |         |         |         |
| YEAR                                 | 0             | 1         | 2       | 3       | 4       | 5                                  | YEAR                      | 0        | 1           | 2       | 3       | 4       | 5       |
|                                      |               |           |         |         |         | 218                                |                           |          |             |         |         | 218     | 218     |
| DEPRECIATION                         |               | 374,879   | 544,679 | 523,739 | 523,739 | 523,739                            | DEPRECIATION              |          | 79,649      | 116,768 | 111,453 | 111,453 | 111,453 |
| OPERATING COST                       |               | 181,388   | 181,388 | 181,388 | 181,388 | 181,388                            | OPERATING COST            |          | 54,681      | 54,681  | 54,681  | 54,681  | 54,681  |
| CASH FLOW                            |               | 192,791   | 367,371 | 342,431 | 342,431 | 342,431                            | CASH FLOW                 |          | 24,958      | 62,079  | 56,772  | 56,772  | 56,772  |
|                                      |               |           |         |         |         |                                    |                           |          |             |         |         |         |         |
| CASH OUT                             | 2,625,258     |           |         |         |         |                                    | CASH OUT                  |          | 550,649     |         |         |         |         |
| LESS ITC                             | 65            | 0         |         |         |         |                                    | LESS ITC                  |          | 186         | 55,866  |         |         |         |
| PV OF COST                           | 65            | 763,737   |         |         |         |                                    | PV OF COST                |          | 65          | 238,336 |         |         |         |
| NET CASH FLOW                        | (3,384,997)   | 192,791   | 367,371 | 342,431 | 342,431 | 342,431                            | NET CASH FLOW             |          | (723,130)   | 24,958  | 62,079  | 56,772  | 56,772  |
| PV OF COST                           | 65(3,384,997) | 181,478   | 368,989 | 297,512 | 271,277 | 255,844                            | PV OF COST                |          | 65(723,130) | 23,517  | 55,298  | 47,667  | 44,969  |
| COST                                 |               | 2,865,535 |         |         |         |                                    | COST                      |          | 519,385     |         |         |         |         |
| ANNUAL COST                          |               | 413,185   |         |         |         |                                    | ANNUAL COST               |          | 183,861     |         |         |         |         |
| EMISSION REDUCTION                   |               | 33,955    |         |         |         |                                    | EMISSION REDUCTION IN LBS |          | 4,699       |         |         |         |         |
| AT                                   |               |           |         |         |         |                                    | AT                        |          | 985         |         |         |         |         |
|                                      |               |           |         |         |         |                                    |                           |          |             |         |         |         |         |
| COST EFFECTIVENESS                   | DOLLAR / PD   | 12.2      |         |         |         |                                    | COST EFFECTIVENESS        | DOLLAR / | 22.5        |         |         |         |         |

HEUBLEIN WINES MADERA  
TANKS LARGER THAN 100,000 GALLONS.

| TANK NO. | GALLONS | CONSTRUCTION |
|----------|---------|--------------|
| 1        | 128,815 | S. S.        |
| 2        | 128,815 | S. S.        |
| 3        | 128,815 | S. S.        |
| 4        | 128,815 | S. S.        |
| 5        | 128,815 | S. S.        |
| 6        | 128,815 | S. S.        |
| 7        | 128,802 | S. S.        |
| 8        | 128,860 | S. S.        |
| 31       | 266,111 | M. S. EPOXY  |
| 32       | 265,911 | M. S. EPOXY  |
| 49       | 660,328 | M. S. EPOXY  |
| 50       | 660,101 | M. S. EPOXY  |
| 51       | 658,995 | M. S. EPOXY  |
| 52       | 659,353 | M. S. EPOXY  |
| 53       | 659,353 | M. S. EPOXY  |
| 54       | 659,285 | M. S. EPOXY  |
| 55       | 659,353 | M. S. EPOXY  |
| 56       | 659,174 | M. S. EPOXY  |
| 57       | 647,141 | M. S. EPOXY  |
| 58       | 647,141 | M. S. EPOXY  |
| 59       | 647,141 | M. S. EPOXY  |
| 60       | 647,141 | M. S. EPOXY  |
| 61       | 647,141 | M. S. EPOXY  |
| 62       | 647,141 | M. S. EPOXY  |
| 63       | 647,141 | M. S. EPOXY  |
| 64       | 647,141 | M. S. EPOXY  |
| 65       | 127,629 | S. S.        |
| 66       | 127,617 | S. S.        |
| 67       | 127,582 | S. S.        |
| 68       | 127,687 | S. S.        |
| 71       | 324,517 | M. S. EPOXY  |
| 72       | 323,316 | M. S. EPOXY  |
| 73       | 322,440 | M. S. EPOXY  |
| 74       | 322,440 | M. S. EPOXY  |
| 81       | 265,052 | M. S. EPOXY  |
| 82       | 265,552 | M. S. EPOXY  |
| 83       | 265,162 | M. S. EPOXY  |
| 84       | 252,520 | S. S.        |
| 85       | 127,615 | S. S.        |
| 86       | 128,072 | S. S.        |
| 87       | 128,029 | S. S.        |
| 88       | 128,261 | S. S.        |
| 89       | 127,617 | S. S.        |
| 200      | 175,094 | CONCRETE     |
| 500      | 306,473 | M. S. EPOXY  |
| 501      | 306,473 | M. S. EPOXY  |
| 502      | 306,473 | M. S. EPOXY  |
| 503      | 306,473 | M. S. EPOXY  |
| 504      | 306,473 | M. S. EPOXY  |
| 505      | 306,473 | M. S. EPOXY  |
| 506      | 307,075 | M. S. EPOXY  |
| 507      | 307,159 | M. S. EPOXY  |

| TANK NO. | GALLONS  | CONSTRUCTION |
|----------|----------|--------------|
| 508      | 306, 473 | M. S. EPOXY  |
| 509      | 306, 473 | M. S. EPOXY  |
| 510      | 306, 473 | M. S. EPOXY  |
| 511      | 306, 473 | M. S. EPOXY  |
| 512      | 306, 861 | M. S. EPOXY  |
| 513      | 306, 473 | M. S. EPOXY  |
| 514      | 306, 473 | M. S. EPOXY  |
| 515      | 306, 854 | M. S. EPOXY  |
| 516      | 306, 473 | M. S. EPOXY  |
| 517      | 306, 473 | M. S. EPOXY  |
| 518      | 306, 473 | M. S. EPOXY  |
| 519      | 306, 473 | M. S. EPOXY  |
| 520      | 306, 627 | M. S. EPOXY  |
| 521      | 306, 682 | M. S. EPOXY  |
| 522      | 306, 523 | M. S. EPOXY  |
| 523      | 306, 473 | M. S. EPOXY  |
| 524      | 306, 473 | M. S. EPOXY  |
| 525      | 306, 473 | M. S. EPOXY  |
| 526      | 306, 473 | M. S. EPOXY  |
| 527      | 306, 473 | M. S. EPOXY  |
| 528      | 306, 473 | M. S. EPOXY  |
| 529      | 306, 473 | M. S. EPOXY  |
| 530      | 306, 473 | M. S. EPOXY  |
| 531      | 306, 473 | M. S. EPOXY  |
| 532      | 306, 473 | M. S. EPOXY  |
| 534      | 306, 924 | M. S. EPOXY  |
| 536      | 306, 473 | M. S. EPOXY  |
| 538      | 306, 473 | M. S. EPOXY  |
| 550      | 350, 136 | S. S.        |
| 551      | 350, 136 | S. S.        |
| 552      | 350, 136 | S. S.        |
| 554      | 350, 136 | S. S.        |
| 555      | 350, 136 | S. S.        |
| 556      | 350, 136 | S. S.        |
| 558      | 350, 136 | S. S.        |
| 559      | 350, 136 | S. S.        |
| 560      | 350, 136 | S. S.        |
| 562      | 350, 136 | S. S.        |
| 563      | 350, 136 | S. S.        |
| 576      | 350, 136 | S. S.        |
| 901      | 128, 177 | S. S.        |
| 902      | 128, 177 | S. S.        |
| 904      | 128, 177 | S. S.        |
| 906      | 128, 177 | S. S.        |
| 908      | 128, 177 | S. S.        |
| 909      | 128, 177 | S. S.        |
| 911      | 128, 177 | S. S.        |
| 913      | 128, 177 | S. S.        |
| 915      | 128, 177 | S. S.        |
| 917      | 128, 177 | S. S.        |
| 920      | 128, 177 | S. S.        |
| 922      | 128, 177 | S. S.        |
| 924      | 128, 177 | S. S.        |
| 926      | 128, 177 | S. S.        |
| 937      | 260, 536 | S. S.        |
| 938      | 263, 438 | S. S.        |



| TANK NO. | GALLONS | CONSTRUCTION |
|----------|---------|--------------|
| 939      | 263,911 | S. S.        |
| 940      | 260,536 | S. S.        |
| 941      | 263,241 | S. S.        |
| 942      | 260,536 | S. S.        |
| 943      | 260,536 | S. S.        |
| 944      | 260,536 | S. S.        |
| 945      | 263,454 | S. S.        |
| 946      | 260,536 | S. S.        |
| 947      | 264,037 | S. S.        |
| 948      | 260,536 | S. S.        |
| 101      | 172,945 | CONCRETE     |
| 102      | 173,460 | CONCRETE     |
| 39       | 252,795 | M. S. EPOXY  |
| 40       | 252,795 | M. S. EPOXY  |
| 41       | 252,795 | M. S. EPOXY  |
| 42       | 252,795 | M. S. EPOXY  |
| 43       | 252,795 | M. S. EPOXY  |
| 44       | 252,795 | M. S. EPOXY  |

HEUBLEIN WINES MADERA  
TANKS LARGER THAN 100,000 GALLONS.

Summary: @COUNT

Field: GALLONS

|   |                    | CONSTRUCTION |            |      |            |         |      |     |
|---|--------------------|--------------|------------|------|------------|---------|------|-----|
|   |                    | CONCRETE     | FIBERGLASS | M.S. | M.S. EPOXY | REDWOOD | S.S. | ALL |
| B | 100,000 TO 150,000 | 0            | 0          | 0    | 0          | 0       | 31   | 31  |
| A | 150,000 TO 200,000 | 3            | 0          | 0    | 0          | 0       | 0    | 3   |
| L | 200,000 TO 250,000 | 0            | 0          | 0    | 0          | 0       | 0    | 0   |
| L | 250,000 TO 300,000 | 0            | 0          | 0    | 11         | 0       | 13   | 24  |
| O | 300,000 TO 350,000 | 0            | 0          | 0    | 40         | 0       | 0    | 40  |
| N | 350,000 TO 400,000 | 0            | 0          | 0    | 0          | 0       | 12   | 12  |
| S | 400,000 TO 450,000 | 0            | 0          | 0    | 0          | 0       | 0    | 0   |
|   | 450,000 TO 500,000 | 0            | 0          | 0    | 0          | 0       | 0    | 0   |
|   | 500,000 TO 550,000 | 0            | 0          | 0    | 0          | 0       | 0    | 0   |
|   | 550,000 TO 600,000 | 0            | 0          | 0    | 0          | 0       | 0    | 0   |
|   | 600,000 TO 650,000 | 0            | 0          | 0    | 8          | 0       | 0    | 8   |
|   | 650,000 -- 700,000 | 0            | 0          | 0    | 8          | 0       | 0    | 8   |
|   | ALL                | 3            | 0          | 0    | 67         | 0       | 56   | 126 |

HEUBLEIN WINES MADERA  
TANKS QTY BY 100,000 GALLONS RANGES.

Summary: @COUNT

Field: GALLONS

|                      | CONSTRUCTION |            |      |            |         |      |     |  |
|----------------------|--------------|------------|------|------------|---------|------|-----|--|
|                      | CONCRETE     | FIBERGLASS | M.S. | M.S. EPOXY | REDWOOD | S.S. | ALL |  |
| B 0 TO 100,000       | 94           | 2          | 2    | 0          | 46      | 203  | 347 |  |
| A 100,000 TO 200,000 | 3            | 0          | 0    | 0          | 0       | 31   | 34  |  |
| L 200,000 TO 300,000 | 0            | 0          | 0    | 11         | 0       | 13   | 24  |  |
| L 300,000 TO 400,000 | 0            | 0          | 0    | 40         | 0       | 12   | 52  |  |
| D 400,000 TO 500,000 | 0            | 0          | 0    | 0          | 0       | 0    | 0   |  |
| N 500,000 TO 600,000 | 0            | 0          | 0    | 0          | 0       | 0    | 0   |  |
| S 600,000 -- 700,000 | 0            | 0          | 0    | 16         | 0       | 0    | 16  |  |
| ALL                  | 97           | 2          | 2    | 67         | 46      | 259  | 473 |  |

RECEIVED

MAY 8 1986

Stationary Source  
Division  
Air Resources Board

May 6, 1986

Mr. Ronald Friesen  
Stationary Source Division  
Air Resources Board  
1102 Q Street  
Sacramento, CA 95812

Re: Ethanol Emissions from Winery Fermentation Tanks

Dear Mr. Friesen:

Attached please find comments submitted by Guild Wineries and Distilleries which is a cooperative winery composed of some 450 California grower members.

Please note that we are one of the 80% of the California wineries who sustained operating losses in 1984 as reported in the 1985 U.S. International Trade Commission report.

We can't overstress the importance that the ARB seriously consider the temperature control as the control measure if one is to be adopted. We recommend as stated in our comments that a more comprehensive study and testing be made to insure realistic data is developed for use in any decision making, and particularly give serious consideration to the smog chamber study now under way.

Sincerely,

*E. C. Skofis*

GUILD WINE CO.

E. C. Skofis

Vice President, Production

ECS:lb

cc: G. Pasterick, President Guild Wine Co.

Comments by  
Guild Wineries and Distilleries  
Regarding California Air Resources Board  
Proposed Suggested Control Measure for  
Ethanol Emissions from Winery Fermentation  
Tanks and Supporting Materials

May 6, 1986

Guild Wineries & Distilleries  
P.O. Box 1068  
Fresno, California 93714

-----  
Guild Wineries and Distilleries is a cooperative winery composed of some 450 grower members. It has producing wineries and a bottling cellar. Its corporate headquarters are located at 1 - Winemasters' Way, Lodi, CA 95108.

First, we want to state that we concurred in the Fresno Air Pollution Control District proposal that temperature control was the only method which could be both effective and practical in ethanol emission reduction.

We have also supported Wine Institute efforts in the smog chamber study to determine real reactivity of ethanol emissions in atmosphere and whether it is a precursor to smog formation. To date there has been no convincing scientific data that ethanol emissions are actually harming the atmosphere. Our wine industry, through this Wine Institute research smog chamber study being performed by SAI of San Rafael, wants to have reliable scientific facts rather than arbitrary decisions that ethanol is a pollutant of the atmosphere.

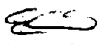
We want to also point out that before any rules are made that the ARB give our wine industry and us sufficient time to test out any suggested method for control. Methods proposed by ARB staff are not realistic and very expensive. There are no tax saving incentives, as pointed out in the ARB staff report. In our industry today over 60% of the wineries are operating at a loss due to many reasons which will be cited in Wine Institute's comments, and particularly by the cheap imported wines, whose producers will be benefited more by any requirements imposed on the California wine industry. The 1985 U.S. International Trade Commission reported that by 1984

over 80% of the wineries producing approximately 83% of American non-premium table wines were sustaining operating losses. In our case we are one of those sustaining large operating losses, and to impose on us requirements to control ethanol emissions will cause our cooperative winery with its 450 grower members to go bankrupt.

Our engineering staff has calculated (see Attachment 1) the capital cost to install a carbon adsorption system at our Cribari Winery based on ARB developed costs to be approximately \$2,791,000. This winery does primarily white wine, and the annual cost based on a peak crush of 80,000 tons is estimated to be around \$15.09 per lb. ethanol removed, using Lee graph (Fig. 2). Since we are on municipal discharge system, we don't believe we'll be able to discharge the scrubbing effluents with ethanol into this system, and must go with carbon adsorption.

We also have a medium size winery at Lodi, California which does around 28,000 tons per year. We have not calculated that cost, but believe it will exceed the \$15.09 per pound for our Cribari Winery in Fresno

We want to further state and recommend to the ARB that a more comprehensive and realistic study and testing be done to 1) insure that ethanol is a real pollutant, 2) whether the cost to control the quantities emitted are necessary, and 3) that the controls imposed will not bankrupt the grape and wine industry in California and cause great economic damage to the State of California.

Submitted by E. C. Skofis   
Vice President, Production  
GUILD WINERIES & DISTILLERIES  
May 6, 1986

GUILD WINERIES  
CRIBARI WINERY - FREDERICK  
ETHANOL RECOVERY  
BASED ON ARB DEVELOPED COSTS

| Location            | Red or<br>White | Ducting   | Carbon<br>Adsorp. | Carbon Adsorp.<br>Annual Cost per<br>Fig. 2 - Graph |
|---------------------|-----------------|-----------|-------------------|-----------------------------------------------------|
| OUTSIDE TANKS       |                 |           |                   |                                                     |
| 6-60,000 G.         | W               | 73,000    | 101,000           | 40,000                                              |
| 14-130,000 G.       | W or R          | 444,000   | 500,000           | 60,000                                              |
| 1-400,000 G         | W               | 30,000    |                   | 12,000                                              |
| 200 CELLAR          |                 |           |                   |                                                     |
| 20-50,000 G.        | W               | 215,000   | 180,000           | 140,000                                             |
| 2-200,000 G.        | W               | 40,000    | 40,000            | 16,000                                              |
| 5-60,000 g.         | W               | 58,000    | 63,000            | 35,000                                              |
| 3-122,000 G.        | W               | 53,000    | 63,000            | 30,000                                              |
| 100 CELLAR          |                 |           |                   |                                                     |
| 10-200,000 G.       | W               | 175,000   | 112,000           | 65,000                                              |
| 10-100,000 G.       | W               | 134,000   | 114,000           | 50,000                                              |
| 600 CELLAR          |                 |           |                   |                                                     |
| 20-100,000 G.       | W               | 168,000   | 228,000           | 50,000                                              |
| TOTALS              |                 | 1,390,000 | 1,401,000         | \$498,000                                           |
| CARBON              |                 |           |                   |                                                     |
| TOTAL = \$2,791,000 |                 |           |                   |                                                     |

CRUSH DATA: 80,000 TONS 13,200,000 Wg White Wine or 33,000 lbs. Ethanol  
ANNUAL COST: \$498,000  
33,000# = \$15.09/lb Ethanol Removed

ATTACHMENT 1

# WINE INSTITUTE

165 POST STREET • SAN FRANCISCO, CALIFORNIA 94108

TELEPHONE 415/986-0878

May 8, 1986

JOHN A. DE LUCA  
PRESIDENT

Mr. Ronald Friesen, Assistant Chief  
Stationary Source Division  
Air Resources Board  
1102 Q Street  
Sacramento, CA 95812

RE: ETHANOL EMISSIONS  
ARB Proposed SCM

Dear Mr. Friesen:

Wine Institute, the trade association of the California wine industry, submits the attached comments and accompanying exhibits in response to the "Proposed Suggested Control Measure for Ethanol Emission from Winery Fermentation Tanks."

We appreciate the opportunity to submit these comments and, of course, would be pleased to answer any questions which it might raise. It should be noted that additional information to supplement these comments is being developed and will be submitted in the near future.

Very truly yours,

  
John A. De Luca  
President

JAD/bk

Enclosures

cc: Alan Goodley, Chief  
Strategy Assessment Branch w/encs.



WINE INSTITUTE COMMENTS REGARDING  
CALIFORNIA AIR RESOURCES BOARD  
PROPOSED SUGGESTED CONTROL MEASURE FOR ETHANOL EMISSIONS  
FROM WINERY FERMENTATION TANKS AND  
SUPPORTING REVIEW MATERIALS

May 9, 1986  
Wine Institute  
165 Post Street  
San Francisco, CA 94108

I.        INTRODUCTION

Wine Institute, the trade association of the California wine industry, submits these comments on the "Proposed Suggested Control Measure for Ethanol Emissions from Winery Fermentation Tanks" (SCM) and the supporting Review Materials prepared by the Staff of the Stationary Source Division of the Air Resources Board ("Staff Report"). A copy of the proposed SCM is attached as Exhibit A.

The Wine Institute consists of 512 licensed California wine producers, together representing about 82 percent of all California wineries. The state of California produces about approximately 91 percent of all American wine. The proposed SCM, if adopted by local Air Pollution Control Districts, would affect the cost and methods of operation of the wineries producing most of the wine in the state of California. Consequently, Wine Institute has a direct interest in the Air Resources Board's administrative consideration of the proposed SCM.

The proposed SCM was first made available during a consultation meeting held by the ARB Stationary Source Division on April 8, 1986 for members of the industry affected by any rule to control winery fermentation emissions of ethanol. The Staff Report supporting the SCM had been made generally available only a short time before

the meeting. During the meeting, wine industry representatives were advised that the Staff Report was not complete. In fact, several revisions to the Staff Report were handed out during the meeting.

During the meeting, industry representatives expressed concerns about issues not addressed in the Staff Report. As the ARB Stationary Source Division staff was not prepared to discuss these issues in detail during the meeting, the Wine Institute Subcommittee on Ethanol Emissions arranged further meetings with the staff. On April 21, 1986, the staff was given a tour of several wineries to give them a first-hand view of the operational problems associated with control of ethanol emissions. On April 22, the Wine Institute Subcommittee and the staff held a working meeting to discuss further the issues raised. During those meetings, the staff provided some drawings to supplement the description of exhaust control ducting systems in the Staff Report. However, Wine Institute understands that the Staff Report remains incomplete and that a final version will be prepared after the Stationary Source Division staff has reviewed these comments. Consequently, Wine Institute may supplement these comments after the final Staff Report becomes available.

II. BACKGROUND OF THIS PROCEEDING / DEVELOPMENT OF  
FERMENTATION TEMPERATURE CONTROL RULE.

The ARB's proposed SCM is very similar to a draft rule proposed in September of 1982 by the Fresno Air Pollution Control District (Fresno APCD). In pertinent part, the Fresno APCD proposal, "Rule 409.7. Winery Fermentation Operations", provided that:

Fermentation tanks with a capacity of 100,000 gallons or greater require control equipment that will reduce ethanol emissions by 90%.

In January, 1983, Wine Institute submitted comments on the proposed rule. These comments are attached (without exhibits) as Exhibit B. Many of the comments made at that time apply with equal force to the SCM now proposed by the ARB.

On April 14, 1983, the Technical Review Group (TRG) considered the Fresno APCD's proposal and heard a presentation from the Wine Institute. At that meeting, the TRG recognized the points made by Wine Institute and expressed interest in using fermentation temperature control to reduce winery ethanol emissions. The TRG asked the Fresno APCD to develop a fermentation temperature control rule. Although, for reasons that are discussed below, Wine Institute did not (and still does not) concede that winery ethanol emissions contribute to air pollution, members of the Wine Institute Ethanol Emissions Subcommittee held several meetings with the Fresno APCD to develop a rule that would reduce winery ethanol emissions and guarantee that those emissions stayed low.

In 1984, while the discussions with Fresno APCD were underway, Wine Institute sponsored a study by the University of California at Davis to identify strains of yeast that could ferment wine at colder temperatures than were presently feasible. [A copy of the University's report on the study is attached as Exhibit C.] Unfortunately, despite a worldwide search, the University was unable to find any strains of yeast that were superior to the strains currently used by wineries for cold temperature fermentation.

With this information, the Fresno APCD proposed a rule to the TRG that would have limited wineries to maximum average fermentation temperatures of 80° for red wine and 55° for white wine after a five year transition period. This rule would have affected the winemaking practices of most members of the industry, by forcing them to reduce their average fermentation temperatures. Many members of the industry would have needed additional refrigeration equipment for their wineries. All wineries would have had to carefully monitor and control their fermentation temperatures.

Despite these burdens, Wine Institute supported the rule because, if winery ethanol emissions had to be reduced, fermentation temperature control could achieve this goal at a cost reasonably commensurate with the benefits. Furthermore, the refrigeration required for compliance with the rule would have some year-around utility in maintaining storage temperatures of the wine. Colder temperature fermentation was also generally conceded to have a beneficial effect on product quality for white and rose wine.<sup>1</sup>

Wine Institute is concerned that the tremendous effort and analysis that went into development of the fermentation temperature control rule is being ignored by the ARB. The Staff Report fails to discuss the development of or reasons for the Fresno APCD's fermentation temperature control proposal. Among other things, fermentation temperature control is the only suggested control method which provides a winery the flexibility to use all fermentation tanks. Despite this and other reasons, the Staff Report seems to be biased against fermentation temperature control.

---

<sup>1</sup> As noted below, over the past decade this perception has caused wineries generally to lower their average fermentation temperatures. However, without a fermentation temperature control rule, not all wineries would reach the average temperatures mandated by the rule. Some would feel that the benefits were not worth the additional cost. Others would prefer to ferment at higher temperatures as a matter of winemaking style.

For example, Figure 2 at page 2 purports to show the prevailing average fermentation temperatures in the industry. The Figure depicts averages of 80°F for red wine and 55°F for white wine, which are the ultimate goals of the proposed fermentation temperature control rule. Yet, as Wine Institute pointed out during the April 8 consultation meeting, these averages may not reflect actual industry practice but are instead based on an unrepresentative survey. At a minimum, we believe that the actual average temperatures utilized by wineries in California are higher than those indicated. Nevertheless, the Staff Report utilizes these questionable averages in their Table 1 and Table 2 on page 7 to support its conclusion that a fermentation temperature control would have no effect on emissions from wineries in California or the San Joaquin Valley.<sup>2</sup>

When evaluating the efficiency of winery ethanol emissions control, the Staff Report departs from Table 2 and presumes a reduction in fermentation temperatures from 85°F to 80°F for red wine and 65°F to 55°F for white wine, with emissions reductions of 15% and 30%, respectively. (See p. 3). However, these emissions reductions are certain, because fermentation temperature control unquestionably reduces ethanol emissions in the predicted amounts. This claim cannot be made with assurance for any of the exhaust control methods described in the Staff Report. Moreover, the Staff Report's limited focus on the incremental reduction from a fermentation temperature control rule ignores the role of such a rule in maintaining the reductions in ethanol emissions that have already been achieved through wineries reducing their fermentation temperatures.

---

<sup>2</sup> At the consultation meeting, the staff circulated some additional calculations conceding that fermentation temperature would reduce emissions if some wineries fermented above the average levels mandated by the rule.

Wineries were selected as a target for emissions control in 1977. At that time, average fermentation temperatures for red and white wine were generally higher than the average fermentation temperatures mandated as a start point by the proposed fermentation temperature control rule. Moreover, proportionately more red wine, fermented at higher temperatures than white wine, was produced in 1977 than now. As a result, as noted in Wine Institute's 1983 comments (pp. 4-5), fermentation emissions of ethanol have already been considerably reduced. At present, nothing would prevent a winery from raising its fermentation temperatures, and thereby increasing its ethanol emissions. However, a fermentation temperature control rule would mandate continued low fermentation temperatures, effectively locking in place the emissions reductions achieved since 1977.

Even though Wine Institute supported the proposed fermentation temperature control rule, it has never conceded that winery ethanol emissions present any threat to air quality. The next section discusses the reasons for the Wine Institute's position and its current study of ethanol reactivity.

### III. IS ETHANOL A PHOTOCHEMICAL OXIDANT PRECURSOR?

When winery ethanol emissions were originally targeted for control, the ARB considered ethanol to be a highly reactive smog precursor. For example, in the ARB Stationary Sources Division's 1981 report entitled "Alcohol Emissions from a Fermentation Tank", ethanol is listed as a highly reactive compound. (See Table 7 on page 24 of that report). However, this designation stemmed from limited and theoretical predictions of the behavior of ethanol in the atmosphere. As the Wine Institute pointed out in its 1983 comments, other scientific studies have indicated that ethanol is nonreactive or only marginally reactive.<sup>3</sup>

In 1983, the Wine Institute also pointed out that air quality data reflects a significant decrease in oxidant levels during the times at which winery emissions of ethanol from fermentation are occurring. More recent aerometric data is attached as Exhibit D. This data also indicates that oxidant levels decrease dramatically at approximately the same time winery ethanol emissions occur. Because the entire annual emissions of ethanol from winery fermentation operations occur during a relatively small part of the year, the oxidant levels during that period ought to be affected if these emissions had any effect on air quality. As the oxidant levels are not affected, the empirical evidence suggests that winery emissions of ethanol do not contribute to air pollution even at the peak of emissions.

Wine Institute has long been interested in conducting a study to determine whether ethanol is reactive and whether ethanol emissions contribute to air pollution. Prior to 1985, Wine Institute lacked the funds for such a study, and was led to believe that the Environmental Protection Agency or the State of California might conduct it. However, in 1985 funds became available through the Winegrowers of California, a state-authorized marketing order.

Wine Institute has retained Systems Applications, Inc. (SAI) to conduct the study in two stages. The first stage will evaluate the absolute reactivity of ethanol in the atmosphere through smog chamber tests at the Battelle Institute. This stage is underway, and final results are expected at the end of May, 1986. If ethanol is at all

---

<sup>3</sup> See Exhibit B at pp. 2-4. Ethanol is  $\text{CH}_3\text{CH}_2\text{OH}$  and one-third of its molecular weight consists of oxygen. Thus, even if the molecule were totally reactive (and there is no evidence for this), it could have only two-thirds the effect of a reactive true hydrocarbon.

reactive, Wine Institute expects to commission SAI to go to the second stage. SAI will then use the smog chamber data in a computer simulation of air conditions in Fresno County to determine the effect of unregulated winery emissions of ethanol on ozone formation. A copy of SAI's protocol is attached as Exhibit E.

The study promises to be an important addition to the body of knowledge on the reactivity of ethanol and its contribution to air pollution in California. If ethanol is not reactive, or has no effect on air quality where winery fermentation emissions occur, it would be unwise to require costly methods of ethanol emissions control. For this reason, Wine Institute recommends that the TRG delay its consideration of any ethanol emissions control rule until the study is complete and the results can be reported to the ARB.

#### IV. GENERAL CONSIDERATIONS APPLICABLE TO ALL EXHAUST CONTROLS.

The Staff Report proposes four exhaust control methods for reducing winery emissions of ethanol from fermentation: Incineration, Carbon Adsorption, Scrubbing, and Condensation. All of these exhaust control methods would require an extensive system of manifolds, ducts, and piping between the fermentation tanks and the control device.

Wine Institute's specific comments on the feasibility and costs of the ducting system and each exhaust control method proposed by the ARB appear in the following sections. In this section, Wine Institute discusses general concerns about the feasibility of exhaust controls.

First, Wine Institute notes that the exhaust control technologies described in the Staff Report have never been tested or used for the purposes proposed in the



environment of a winery. During the consultation meetings, ARB staff attempted to draw analogies between wineries on the one hand and breweries or petroleum refineries on the other. However, winery operations are unique, and cannot be compared to other industries. For example, breweries conduct fermentation in pressurized tanks to achieve carbonation of their products. The exhaust is vented through pressure valves. As a result, breweries can easily trap carbon dioxide from the valve, and many breweries have been doing this for years. On the other hand, winery fermentation tanks cannot withstand any appreciable pressure. Also, any pressurization might result in carbonation of the wine and thereby affect product quality. Design specifications are not yet available but we will forward this later.

Unlike wineries, refineries produce a product year-round that is not designed for human consumption and is essentially fungible. Consequently, refineries are far less concerned about potential effects on sanitation or product quality from emissions control methods. Furthermore, Wine Institute believes that emissions from refinery tanks generally occur as a result of the simple evaporation of volatile liquids. Winery fermentation tanks produce ethanol emissions through an active biological process, and a relatively small amount of ethanol is emitted with large quantities of carbon dioxide, moisture, as well as significant amounts of entrained sugar and other solids.

The lack of experience with exhaust controls under winery conditions leads Wine Institute to question both the feasibility of such controls and the projections of their cost effectiveness in the Staff Report. This is a serious concern, because the proposed SCM is predicated on the availability of exhaust control methods with efficiencies ranging from 90% to 99%. If none of the control methods proposed in the Staff Report can operate under winery conditions with these efficiencies, the proposed SCM cannot be implemented. Furthermore, to the extent that the efficiencies of exhaust control

methods have been overstated, the estimates of cost effectiveness for those methods have been exaggerated.

Wine Institute submits that the TRG should be extremely hesitant to approve an SCM that is predicated on the performance of totally unproven technology. If the proposed SCM were adopted, wineries would be forced to make decisions about and install exhaust control methods. As the methods will not operate with the efficiencies assumed in the Staff Report, wineries would be faced with continuing costs for altering or tearing out the ducting systems and control devices and replacing them with others that may be equally problematic. The costs imposed on the industry through this process could be astronomical and would undoubtedly be far higher than the Staff Report anticipates. At the end, Wine Institute can foresee no exhaust control method that will come anywhere near the efficiency requirements of the SCM.

Wine Institute also submits that the cost estimates for the exhaust control methods must be viewed with suspicion. Some of the significant costs associated with the specific exhaust control methods, such as costs for refrigeration necessary to lower fermentation temperatures to those used by the staff to calculate ducting costs, have been ignored. (These are discussed later in these comments.) However, even where specific cost items are accounted for, the estimates may be unreliable, because the basis for those estimates is not disclosed. For example, the Staff Report estimates the annual labor and maintenance cost for each of the exhaust control methods at three percent of the total installed cost, without advising how this estimate was derived. The same is true for many of the costs of installation listed on the "Add-Ons" page in the Staff Report. Wine Institute believes that the actual costs are undoubtedly higher than the Staff Report's unsupported estimates.

The cost effectiveness calculations on pages X-1 through X-7 of the Staff Report are very optimistic. For example, the calculations assume a benefit to wineries from an investment tax credit on the purchase of pollution control equipment, even though Congress proposes to repeal the investment tax credit as part of the tax reform package being considered this year. (See H.R. 3838 at pages 148-153 (December 3, 1985)). This alone would increase the annualized cost of any expenditures for pollution control equipment. Further, the cost effectiveness calculations fail to recognize that a number of wineries are losing money, are not tax payers, or are under capitalized and therefore cannot benefit from either the investment tax credit or any deduction for depreciation of investments. In a recent U.S. International Trade Commission (ITC) investigation, the ITC found that six out of the ten wineries which furnished usable financial data and which accounted for approximately 83 percent of domestic table wine shipments sustained operating losses in 1982. Seven of these ten reporting wineries sustained such a loss in 1983, as did eight of the ten wineries in 1984 (see page 12-13 of Exhibit F, attached).

Wineries in this state can least afford to install costly pollution control equipment in the first place. The effects of foreign wine subsidies and the artificial dollar has become evident in all aspects of the industry. The value of San Joaquin vineyards has fallen as much as 50% to 80% between 1982 - 1985. In the same period, grower returns have fallen 17% across the state from \$194.07 to \$160.95 per ton. In 1985, 57,000 acres of vineyards were either abandoned or not harvested. The consequences are major in a state where grapes are among the top four agricultural products, in terms of farm value, and where 8% of all harvested agricultural land is planted in grapes.

For these reasons, Wine Institute believes that the cost-effectiveness of any pollution controls must be assessed on the basis of pre-tax costs. Otherwise, the cost-

effectiveness calculations do not accurately depict the impact of an ethanol emissions control rule on the entire industry.

In comparing the cost effectiveness of fermentation temperature control with the exhaust controls, the Staff Report does not mention that wineries' outlays for refrigeration equipment needed for fermentation temperature control may have ancillary benefits to the wineries, while outlays for exhaust controls will not.

The general considerations alone indicate that exhaust controls are of doubtful effectiveness and will be far more expensive than estimated by the Staff Report. In the next sections, Wine Institute comments on the ducting system and each exhaust control method.

#### V. DUCTING DESIGN.

The ARB Staff Report recognizes that all exhaust control systems would require a system of manifolds, ducts and piping connecting each fermentation tank to the control device. Wine Institute believes that any such ducting system would create serious problems and would have such high costs as to call into question the feasibility of any exhaust control method.

The ducting system described in the Staff Report consists of stainless steel piping welded together and supported above the ground. The Report asserts that fermentation emissions could be drawn from several tanks by a central blower located behind a foam separator and in front of the control device. Air would be drawn into the system when fermentation emissions were low. However, the Staff Report as originally prepared contained no design or sketches of the ducting system, foam separator, or blower.

During the April 8, 1986 consultation meeting, Wine Institute representatives pointed out that the proposed ducting system could not be discussed until the ARB staff provided some information on the system design. In response, on April 22, 1986, the ARB Staff supplied the drawings that are collectively attached as Exhibit G. These drawings depict a system with as many as 15 tanks linked to each control device. The drawings also indicate that the ARB staff believes that exhaust manifolds to collect ethanol emissions could be placed over either the manholes or an additional outlet to be installed on the tanks. The drawings assume that the fermentation tanks and control devices are in the most economical layout possible. No attempt was made to show how the supports would be designed for any part of the ducting system, even where the drawings show the exhaust manifolds suspended over the tanks.

Wine Institute believes that the ducting system described in the Staff Report and depicted in the drawings represents an oversimplification of the system that would actually be required. For reasons described in more detail below, the feasibility of any such system is doubtful. However, even assuming that a ducting system like that described in the Staff Report can be designed and installed, the actual cost for the system under real conditions would be far greater than can be justified for the small amount of ethanol controlled.

1. Ducting Design Deficiencies

The Staff Report contains a hidden assumption about the ducting system that results in a significant overestimation of its cost-effectiveness. The Report assumes that every tank on which ducting is installed will be used as a fermentation tank at or near capacity for the entire fermentation season during each year. This assumption is not realistic.

At every winery, all tanks may be used for fermentation each season. Not all tanks are used at the same time during the entire fermentation season, and not all tanks operate as fermenters at or near capacity. But for several reasons, wineries must have all of their tanks available as fermenters. Any proposed emission control method proposed cannot ignore this production requirement. For example, because the amount of refrigeration available for any group of tanks is limited, wineries need to be able to move juice from freshly crushed grapes to tanks with available refrigeration capacity. Also, wineries must crush and ferment grapes as they are picked. To meet legal requirements for maintaining the varietal character of wine produced from a particular type of grape, wineries must separate that wine from other varieties. This often leads to underutilization of fermentation tanks, because not enough grapes of each variety are available to fill the tank. A number of varieties may be crushed simultaneously, and for each variety, more than one fermentor may be used. Furthermore, wineries must maintain excess fermentation capacity in case the power or refrigeration to a fermentation tank breaks down and the must or juice has to be piped to another nearby tank by gravity.

Many of these points were made in discussions with the ARB staff during the winery inspections on April 21, 1986. In addition, the staff was shown that the tank layout at many wineries is far from the simplified model depicted in the ARB drawings. At some wineries, tanks are spread over a relatively wide area. This would dramatically increase the cost of ducting systems at those wineries.

As noted in the previous section of these comments, the Staff Report does not disclose the basis for many of the estimated cost items. Of particular concern is the completely arbitrary assumption on pages IV-5, IV-6, and IV-12 that an amount equal to

20% of the assumed capital costs (before "Add-ons") will adequately cover the materials' costs for cross-connections, valves, dampers, and hoods. (It is not clear whether installation of these items is covered in that 20% or in the 5% "Add-on" for "Installation and painting of supports.") As indicated on pages IV-5 and IV-6, all of these pieces must be custom made. Since wineries differ, each will have its own specifications for these items. As customized pieces are usually far more expensive than off the shelf pieces, Wine Institute believes that the cost of these custom pieces could equal or exceed the materials' costs for the rest of the ducting system, substantially increasing its total cost.

In this connection, many installation costs for the ducting system appear to have been ignored. For example, the Staff Report does not describe or estimate the costs of modifying the fermentation tanks to support the ducting system and manifold on each tank. Among other things, the tanks would need additional catwalks and ladders to provide access to the manifold and manhole on top of the tank, since existing ladders are designed only to allow access to the manhole in the top.

Wine Institute believes that the exhaust manifold cannot be installed over the existing manhole, because this manhole must be freely available to winery personnel to inspect the progress of the fermentation and, for red wine, to punch down or hose over the cap. Therefore, an additional outlet to vent the emissions to the manifold must be installed. This would be an extremely complicated, expensive, and time consuming project.

All of the tanks could not be modified at once, because at any one time most would have to be available for wine blending and storage. Before work could begin, a tank would have to be isolated and emptied. Then, it would have to be scaffolded from the inside so that workers could have access to the top of the tank from the inside. The

scaffolding would have to be brought into the tank piece by piece through the small manhole near the bottom. Next, on insulated tanks, the insulation would have to be removed from the top of the tank. The outlet could then be cut in the top of the tank and welded from both the inside and the outside.

Once the outlet was finished, a removable cover would have to be installed so that the outlet could be closed when the tank was being used for storage. The interior of the tank would have to be recoated and, if the tank had been lined, relined. The scaffolding could then be removed and the exterior insulation repaired. Finally, the tank could be cleaned and used again, although its structural integrity might never be the same.

The design of the ducting system raises many issues. For example, to achieve the 90% reduction of ethanol emissions mandated by the proposed SCM (even given the control efficiencies assumed by the ARB), the manifold must pick up virtually all of the fermentation emissions from the tank. However, the emissions consist primarily of carbon dioxide, moisture, a small amount of ethanol, and some entrained sugar and other solids, a mixture which is heavier than air and tends to flow toward the ground once it leaves the tank. For this reason, and even with the Staff Report's assumption of an airspeed of 34 miles per hour at the manifold, there is no guarantee that all of the fermentation emissions will be drawn into the system unless the manifold is located so close to the tank that it is practically a closed system. <sup>4</sup>

With an assumed airspeed of 34 miles per hour, the manifold will pick up large quantities of entrained sugar, dust and insects from the air and any foam that the tank

---

<sup>4</sup> The Staff Report does not propose a closed system, no doubt because such a system creates unacceptable risks of product contamination and pressure and/or vacuum damage to fermentation tanks.



produces.<sup>5</sup> Wine Institute knows of no foam separator that could handle this load adequately to protect the blower and control device from these materials.<sup>6</sup> A small mesh screen would also be impractical, since it would capture entrained solids almost immediately. Without functional protections, the entire control system could be shut down frequently. Additionally, the airspeed required by the proposed design would disturb vapor pressure which would increase alcohol emissions. Noise and other safety-related issues which are of great concern to Wine Institute members were not addressed in the Staff Report.

As the Staff Report describes the ducting system and manifolds, each group of tanks would require a control system with an axial turbofan blower operating at 40-50,000 rpm. Even assuming that the cost estimate of \$5,400 for each fan is accurate, more than one will be necessary for each group of tanks. Wine Institute believes that axial turbofans may not be operated continuously at such high speeds for long periods and are highly susceptible to mechanical breakdown or damage from intruded matter.

- 
- 5 Wine Institute has repeatedly pointed out that fermentation tanks are subject to foaming over because, at peak fermentation, the must is supersaturated with carbon dioxide. Such foam-over incidents are sudden and volcanic, so they cannot be averted through an alarm system notifying winery personnel to use anti-foaming agents.

A foam-over incident was reported in the EAL Corporations's July 19, 1982 report on its ethanol emissions tests at various wineries (see pp. 12-13). During that incident, 1,000 gallons of must were lost. Afterward, EAL periodically opened the tanks, releasing ethanol into the air.

- 
- 6 The ARB Review Materials rely on cost estimates for a foam separator supplied by Heublein Wines. Heublein's estimates are based on a hypothetical closed ducting system with an entirely different design from that proposed in the Staff Report. In addition, Heublein provided the estimate for illustrative purposes only. It did not represent that the separator would work and did not consider the presence of entrained sugar. The design was proposed solely for the purpose of obtaining cost estimates and not as a functional model.

The Review Materials (IV-1, IV-11) estimate cleaning costs for the ducting system without indicating how the system is to be cleaned. In 1983, Wine Institute commented that any method of ethanol emissions control that employs a ducting system would be difficult to sanitize and could have adverse effects on product quality. The sanitation and product quality problems created by ducting systems are discussed generally in a short paper entitled "Fermentation Ethanol Emission Reduction Via Capture and Treatment — Sanitation And Product Quality Considerations" that is attached as Exhibit H. Wine Institute notes in particular that any ducting system with piping or a manifold suspended over an opening in a fermentation tank creates serious risks of contamination through solid or liquid build-up on the manifold. This build-up, which is an ideal breeding ground for molds or bacteria, could contaminate the contents of a tank if the updraft into the manifold were to drop off suddenly. In the event of even a brief power outage, this occurrence is inevitable.

The Staff Report contemplates that the ducting system will be constructed only in the clear aisles between winery tanks, because the other aisles are already congested with piping. However, the ducting cannot be placed in the open aisles because those aisles must be kept clear to allow access to the tanks by heavy equipment. The ducting systems would have to be installed in the aisles where piping is already in place, further increasing the costs and difficulties of installation.

## 2. Cost-Effectiveness of Ducting System Using ARB Assumptions

To illustrate the actual cost-effectiveness of the ducting system proposed in the Staff Report, Wine Institute ignored all of the technical problems and assumed that such

a system was installed on all of the fermentation tanks at the facility of a Wine Institute member located in Livingston, California. (A plot plan for that facility is attached as Exhibit I.) It was further assumed that control devices and ducts would be arranged in the most economical manner, even though it is unlikely that this could actually be done. The calculation of cost-effectiveness using the pre-tax costs indicated in the Staff Report is described in Exhibit J.

The actual pre-tax cost of the ducting system alone using ARB figures, without any control devices, at the Livingston facility would be \$19.37 per pound of ethanol removed.

### 3. Ducting System - Conclusion

On September 30, 1983, members of the TRG toured several wineries in the Fresno area. At that time, some TRG members expressed concern about the feasibility of any emission controls that required installation of a ducting system. These concerns still exist, and the Staff Report has not alleviated them. Furthermore, even if the ducting system were feasible, its cost would be far out of proportion to any benefits that could be realized from control of ethanol emissions. Since all of the proposed exhaust control methods require a ducting system, Wine Institute submits that none of them are an acceptable approach to controlling winery ethanol emissions.

## VI. COMMENTS ON SPECIFIC METHODS FOR EXHAUST CONTROL

The Staff Report simply assumes that four exhaust control methods — Catalytic Incineration, Carbon Adsorption, Scrubbing, and Condensation — will operate with the predicted efficiency, so that the choice between them is largely a matter of cost and each winery's preference. However, the Staff Report did not address a number of problems and issues relating to each control method:

1. Catalytic Incineration

The Staff Report describes this control method as "a catalytic incinerator [that] will oxidize the ethanol at lower temperatures than a direct flame incinerator, thus generating less NO<sub>x</sub>". (Emphasis added).

In September, 1982, the Fresno APCD report on alternatives for winery ethanol emissions control (at p. 1) rejected incineration, due to the high cost of equipment and natural gas and the potential for additional pollution problems. Catalytic incineration is a known source of NO<sub>x</sub> which, unlike ethanol, is unquestionably an air pollutant. Yet, the Staff Report fails to discuss how much NO<sub>x</sub> (or for that matter, other pollutants) will be generated by catalytic incineration. (See pp. V-1 through V-8.) Wine Institute questions the wisdom of replacing emissions that may have no known effect on air quality with emissions that are known pollutants.

The Staff Report's description of the catalytic incinerator does not reveal enough information for Wine Institute to comment specifically about the operation of the control equipment. Wine Institute requests that the ARB staff supplement the Report with a more detailed description of the incinerator, including the equipment necessary to ensure complete combustion of the ethanol, and the identity of the catalyst.

Lacking specific information, Wine Institute can make only one comment about the estimated costs of incineration at this time: The estimated annual cost for operating the incinerator is predicated on use of pipeline natural gas. However, many wineries do not have access to natural gas in this form. These wineries would be forced to use LNG, propane, or butane delivered to them by tank truck or railcar. Not only are these fuels much more expensive than pipeline natural gas, but they are also much more dangerous to handle.

Even wineries with access to natural gas cannot rely on it. Wineries are included as industrial users of gas, and are subject to curtailment in times of shortage. Thus, each catalytic incinerator equipped for natural gas would need back-up equipment to allow use of another fuel in the event the natural gas supply is interrupted.

## 2. Carbon Adsorption

The Staff Report's description of Carbon Adsorption contains estimates of the total capital costs for carbon adsorption equipment based on a communication with a supplier, but does not indicate what specifications were given to the supplier. The total cost estimates are not allocated among the types of equipment. The equipment is also not described. (See pp. VI-1 through VI-7 of the Staff Report.)

Wine Institute lacks sufficient information to comment on the design or adequacy of the equipment. Wine Institute requests that the ARB staff supplement the Report with a description of the equipment sufficient to allow meaningful comments on it.

The Staff Report states that the carbon beds used to absorb the ethanol will be cleaned by steaming. Wine Institute notes that steaming will release the ethanol back

into the atmosphere, unless the ethanol is quickly condensed. However, the condensation method described at page VII-5 is totally inadequate. Reducing the steam/ethanol mixture from 220°F to 90°F will only partially condense the ethanol. The rest will return to the atmosphere.

Carbon Adsorption, Scrubbing, and Condensation, all generate an ethanol/water solution as a waste. The Staff Report fails to address the difficulties or costs of disposing of this waste. Three methods have been proposed: distilling the ethanol from the waste, placing the waste into the sanitary sewer, and applying the waste onto land. The difficulties of land or sanitary sewer disposal are discussed in the comments on Scrubbing.

Distilling is not an adequate means of disposing of the waste. Most California wineries, even major ones, do not have stillage facilities. Some are subject to land use permits that prohibit stillage facilities.

Wine Institute also questions whether the waste from Carbon Adsorption could be adequately distilled. Appendix B of the Staff Report estimates that carbon adsorption control equipment attached to ten tanks of 100,000 gallon capacity would generate between 3,550 and 52,440 gallons per week of a 7.5% to 10% ethanol in water solution. However, this estimate does not account for the adsorption by the carbon beds of large quantities of moisture along with the ethanol from the fermentation emissions. As a result, larger quantities of a lower percentage solution would be generated, and distillation costs would be correspondingly higher.

### 3. Scrubbing

The methodology for estimating costs for Scrubbing is described in pages VII-1 through VII-3 of the Staff Report. The total costs for scrubbing equipment have been derived from estimates of capital costs in \$/acfm provided by a supplier of scrubbing equipment. However, the Report does not describe the specifications given to the supplier. The total cost for the scrubbing equipment is not allocated among the various pieces of equipment, and the equipment is not described. As a result, Wine Institute cannot comment on the design or adequacy of the equipment. Wine Institute requests that the ARB staff supplement its Report with a description of the equipment sufficient to allow meaningful comment on it.

To estimate the costs of scrubbing, the Staff Report assumes that municipal water will be available. However, many wineries do not have access to municipal water supplies and must rely on their own wells. These wineries would probably be forced to install additional wells and pumps to supply the large quantities of water necessary to operate a scrubber. The annualized cost of installing and operating these wells and pumps would be substantially greater than the annual cost of water from municipal sources.<sup>7</sup> The costs for water in certain areas may be even higher than originally projected.

The Staff Report also fails to address how wineries can dispose of the vast quantity of ethanol/water wastes that scrubbing would generate. These wastes could not be distilled, even by wineries that have stillage facilities, because the ethanol concentration (0.1% or less according to Appendix B) is far too low. The wastes would have to either must go into a sanitary waste system or be disposed of on land. Either approach is highly

---

<sup>7</sup> The Staff Report recognizes that the scrubbing water cannot be recycled. Recycling reduces the scrubbing efficiency substantially.

problematic and, among other things, poses the problem of alcohol returning to the atmosphere.

Many municipal waste systems are overloaded and have difficulty dealing with waste loads already placed on them. Consequently, some wineries might be refused permission to put the wastes in a municipal waste system. Most wineries do not have access to a municipal waste system. In any case, the wastes from municipal waste systems are usually aerated as part of the treatment process. This aeration provides an ideal avenue for return of the ethanol to the atmosphere.<sup>8</sup>

Land disposal involves substantial capital expenditures and operating expenses.<sup>9</sup> Land must be available for the disposal, and the winery must install a pump and piping system to transport the wastes onto the land. Because the applications must be done properly, at least 2 workers must be available on a 24 hour basis to oversee each application.

In this connection, Wine Institute notes that if the wastes are not properly applied to the land, the ethanol will return to the atmosphere. Wine Institute has obtained calculations from Roger Boulton of R. B. Boulton, Inc. demonstrating that a winery must have at least 4 acres of land available for each million gallons of must fermented to prevent more than 10% of the ethanol from the scrubbing wastes from returning to the atmosphere. In preliminary studies of these calculations, Mr. Boulton's figures appear to

---

8 See "Assessment of VOC Emissions from Aerated Waste Treatment Processes," Clark Allen, Research Triangle Institute.

---

9 This assumes that the respective Regional Water Quality Control Boards will permit land disposal of this waste. This permission is by no means assured.



be quite conservative (Boulton's calculations and information on Wine Institute experiments concerning Boulton's calculations are attached collectively as Exhibit K).

Boulton's calculations assume an ambient temperature of 80°F. During fermentation season, ambient temperatures are often much greater, especially in the southern San Joaquin Valley, and the loss of ethanol to the atmosphere would be correspondingly greater. Under these conditions, even more land would be required to dispose of the scrubbing wastes so that ethanol would not return to the atmosphere.

The ARB has long been aware of the serious problems associated with land disposal of scrubbing wastes. The disposal issue was identified by the Fresno APCD in its September, 1982 report on ethanol emissions control (at 2). In addition, the Wine Institute pointed out in its 1983 comments that dumping an ethanol/water solution on land would simply allow the ethanol to return to the atmosphere and would thereby be "an exercise in futility". The Fresno APCD, in its February 15, 1983 Reply Comments, agreed.

#### 4. Condensation

In September, 1982, the Fresno APCD identified condensation as the preferred method for control of winery ethanol emissions. In its January 18, 1983 comments, Wine Institute pointed out that, even if serious practical obstacles were ignored and very generous assumptions made in favor of the system, condensation would cost (after-tax) over \$9.16 for each pound of ethanol removed. Using ARB's current assumptions, pre-tax condensation costs approach \$40.00 for each pound of ethanol removed (See Exhibit L, attached).

In its look at condensation, the Staff Report accepts the conditions for a successful condensation system described by Professor Lynn Williams. (See p. VIII-1). The estimated cost for the system was adopted from a 1982 quote from L & A Engineering & Equipment. That quote does not include costs for the piping and equipment necessary for storage and disposal of the condensate. Moreover, the quote does not reflect an operational system.<sup>10</sup>

The quote was obtained from L & A by Wine Institute to illustrate that actual costs of a condenser would be far greater than had been estimated by the Fresno APCD. The bidder was not asked to account for the unique conditions applicable to wineries. For example, the emissions gases are loaded with moisture. At a condenser temperature of -12°F, the coils would ice up almost immediately, and the efficiency of condensation would drop to unacceptable levels.<sup>11</sup> Any condenser system would have to have several coils, each with a defrost cycle. Even with this feature, the efficiency of the system could not be guaranteed in advance.

Disposal of the ethanol/water solution generated by condensation would raise the same issues already discussed in connection with carbon adsorption and scrubbing. Appendix B appears to be in error regarding the concentration of ethanol in the condensate and the quantity of the condensate. Some previous ARB tests have shown water vapor to be greater than 3 percent and ethanol concentration less than one percent. The ethanol estimate of 44 percent in Appendix B seems improbable. Without

---

<sup>10</sup> A more recent quote is attached as Exhibit M.

---

<sup>11</sup> This difficulty was conceded by the Fresno APCD at page 3 of its reply to the Wine Institute comments.

further information on the concentrations and basis for calculation in arriving at this figure, Wine Institute cannot comment further on this issue.

#### CONCLUSION.

Wine Institute continues to believe that exhaust control methods should not be considered acceptable means for reducing ethanol emissions from winery fermentation tanks. These control methods would be grossly expensive and simply will not work at the efficiencies predicted by the ARB. The many other problems which such control methods would cause have also not been considered in the cost estimates.

The Staff Report does not provide any basis for a different conclusion. As noted in these comments, despite the considerable amount of work the ARB staff has put into the Staff Report, it does not answer the technical questions about the feasibility of those controls and greatly underestimates their costs. Wine Institute submits that the proposed SCM cannot be adopted, because it sets an impossible standard for compliance.

Wine Institute believes that the California wine industry has demonstrated its good faith in this proceeding by its support of a fermentation temperature control rule. This rule would impose significant costs on wineries and would restrict their freedom to use fermentation temperature as a creative variable in wine making. However, wineries were willing to accept the rule because fermentation temperature control was feasible and would guarantee that ethanol emissions were reduced and held at a low level without endangering product quality, integrity, and safe winery operation.

---

Finally, Wine Institute wishes to reserve its right to supplement these comments. The ARB Staff Report has not been completed, and Wine Institute intends to comment on the report when it is finished. In addition, Wine Institute expects to report the findings of the first stage of the study of ethanol reactivity.

PROPOSED SUGGESTED CONTROL MEASURE FOR  
ETHANOL EMISSIONS FROM WINERY FERMENTATION TANKS

(I) Definitions

For the purpose of this rule, the following definitions shall apply:

- (A) FERMENTATION TANK means any container in which the juice of grapes is fermented to produce wine.
- (B) WINE means the product of normal alcoholic fermentation of the juice of grapes, including table wine, dessert wine, sparkling wine, vermouth, and special natural wines, as well as wine produced for distillation into grape spirits and brandy.
- (C) WINERY means any facility licensed as a bonded winery or wine cellar with the U.S. Bureau of Alcohol, Tobacco, and Firearms (BATF).
- (D) FERMENTATION SEASON means that time of year when grape juice is fermented to produce wine.

(II) Requirements

- (A) The owner or operator of any winery subject to this rule shall reduce the ethanol emissions from each fermentation tank by 90 percent.
- (B) The owner or operator of any winery subject to this rule shall submit to the Executive Officer/Air Pollution Control Officer a plan for installation of ethanol emission control equipment to meet the requirements of subsection (II)(A). Such plan shall contain as a minimum:
  - (1) a listing of all fermentation tanks and their respective capacities, and
  - (2) identification of the type of control to be applied to each tank, including a construction schedule.
- (C) To determine initial compliance with the emissions limits of subsection (II)(A), source testing of emissions from all fermentation tanks shall be conducted during the fermentation season in accordance with the compliance schedule in subsection (IV)(C).
- (D) Compliance with this rule shall be determined thereafter by source testing the emissions from one or more fermentation tanks during the fermentation season. No fermentation tank shall exceed the limits set forth in subsection (II)(A).

**DRAFT**

(III) Exemptions

The requirements of section (II) shall not apply to fermentation tanks with a capacity of less than 50,000 gallons.

(IV) Compliance Schedule

The owner or operator of a winery subject to this rule shall comply with it as expeditiously as possible and shall fulfill the following increments of progress:

- (A) By \_\_\_\_\_, submit a control plan pursuant to subsection (II)(A) of the rule.
- (B) Within two years after approval of the control plan by the Executive Officer/Air Pollution Control Officer, install all ethanol emission control equipment as specified in the control plan.
- (C) Within three years after approval of the control plan, demonstrate compliance with this rule in accordance with subsection (II)(C).

**DRAFT**

**WINE INSTITUTE**  
**Comments Regarding**  
**FRESNO AIR POLLUTION CONTROL DISTRICT PROPOSAL**  
**TO CONTROL WINERY ETHANOL EMISSIONS**

January 18, 1983

Wine Institute  
165 Post Street  
San Francisco, CA 94108

John A. De Luca, President

Exhibit B  
Pages 1 - 10

WINE INSTITUTE COMMENTS  
TO FRESNO AIR POLLUTION CONTROL DISTRICT PROPOSAL  
TO CONTROL WINERY ETHANOL EMISSIONS

I. INTRODUCTION

Wine Institute, the trade association of the California wine industry, wishes to submit these comments to the Fresno Air Pollution Control District (APCD) in response to their proposed Rule 409.7 and the accompanying report by Charles E. Maskall, air quality engineer for the Fresno APCD, entitled "Winery Emission Control in California." A copy of this document is attached herewith and marked as **EXHIBIT A**.

The Wine Institute consists of 454 licensed California wine producers, together representing about 90% of all California wineries. The state of California produces approximately 90% of all American wine. Our membership was informed of the Fresno APCD proposal in September of 1982 and through our Energy and Environmental Studies Committee have undertaken the task of submitting these written comments to you.

A special subcommittee of the Energy & Environmental Studies Committee was appointed in September to carefully analyze **EXHIBIT A** and proposed Rule 409.7. This special subcommittee, as well as the full committee members, are gravely concerned with the proposal since compliance would obviously involve gross expenditures not otherwise anticipated by wineries with questionable returns and little, if any, benefits. The comments that follow reflect their concern and discuss the accuracy of certain assumptions of **EXHIBIT A**'s cost analysis.

During a time when the California wine industry faces a severe competitive threat from foreign wines and must operate under domestic economic conditions which are far from ideal, it is difficult to afford additional expenses for emission reduction. Wine Institute agrees and fully supports the legislative finding that the people of this state have a primary interest in the quality of the physical environment in which they live. Our members are truly concerned with the health, safety and welfare of the citizens of this state. However, we feel that the control of ethanol emission from wineries must be tempered with reason, and that such controls if imposed should be a proven, cost-effective means of protecting state interests. We share the position of the legislature that the benefits of reduced air contamination should justify the additional expenses involved in compliance, and feel that proposed Rule 409.7, for the reasons set forth in these comments, constitutes an unreasonable burden on the wine industry.



## **II. PROPOSED RULE 409.7 IS VAGUE AND AMBIGUOUS.**

The proposed draft Rule 409.7, entitled "Winery Fermentation Operations," states as follows:

1. Fermentation tanks with a capacity of 100,000 gallons or greater require control equipment that will reduce ethanol emissions by 90%.
  - (A) By January 1, 1984: Submit a completed application for any authority to construct necessary to comply with the provisions of this rule.
  - (B) By July 1, 1985: Be in full compliance with the provisions of this rule.

An analysis of the proposed Rule 409.7 must start with the literal provisions of the draft. The rule requires that 100,000 gallon tank fermentors be equipped with emission equipment that will reduce ethanol emissions by 90%. However, the rule fails to inform one who must comply with the rule what basis is used to determine a 90% emission reduction. We submit that the proposed rule is vague in that no base line is specified. Therefore, if wineries with such fermentation tanks are to be required to reduce ethanol emissions by a percentage figure, what figure should they use as a starting point to determine compliance? Ethanol emissions are predominant only during the eight weeks of the crushing season, and are virtually absent during the rest of the year. Without specificity, Wine Institute feels that the draft rule is so vague as to render it unenforceable. Since it is impossible to interpret from the face of the Rule what constitutes a violation, it does not give sufficient guidelines for compliance. Likewise, enforcement of such a rule is difficult if the rule is adopted as written, since it is not possible to prove a violation.

For purposes of our comments, however, we have interpreted the rule to require that 100,000 fermentation tanks must have control equipment that will reduce ethanol emissions during the crushing season by 90%. Comments below reflect this interpretation.

## **III. IS ETHANOL A PHOTOCHEMICAL OXIDANT?**

The proposed rule and the actions of the Fresno APCD in desiring winery emission control of ethanol suggests that ethanol is an ozone precursor. As a preliminary matter, it should be noted that the Wine Institute, and indeed the scientific community, is not convinced that ethanol is a photochemical oxidant. Our reviews tends to show that the classification of ethanol as a photochemical oxidant is based more on theoretical rather than empirical evidence. While we do not fully base our comments to the proposal on the issue of whether ethanol is a proven photochemical oxidant, we feel that it bears some mention at the outset of our comments.

Proceedings conducted in 1976 during the International Conference on Photochemical Oxidant Pollution and its Control, hosted by the U.S. Environmental Protection Agency, included a study entitled "Application of Reactivity Criteria in Oxidant-Related Emission Control in the U.S.A." A copy of this study is attached as EXHIBIT B, consisting of eight (8) pages, and is incorporated by reference as though fully set forth herein. Of particular interest is the fact that while EXHIBIT B gives data for

methanol, t-butanol, and i-propanol, the study is silent on ethanol data, inferring that ethanol is not reactive.

The conclusion that ethanol is only marginally reactive was reached in a Japanese study entitled "Photochemical Reactivities of Organic Solvents," conducted by Shigeru Yanigahara, Isamu Shimada, Eiichi Shinoyama, Fumitake Chisaka, Keizo Saito, and Takeshi Ishii. The conclusions reached in their study are based on actual smog chamber experiments, and reveals that ethanol ranks very low on the scale of photochemical reactivities of organic solvents. Wine Institute feels that this report is important in determining the extent of controls to be imposed on wineries for ethanol emissions, if any. A copy of this report is attached and incorporated by reference as EXHIBIT C consisting of eleven (11) pages.

EXHIBIT C bears increased significance when considered in connection with a once-proposed \$50,000 smog chamber study on ethanol reactivity which was to have been performed under the auspices of the State Energy Commission. While \$50,000 was budgeted for such a study, Wine Institute was informed that the funds were withheld because of the present financial condition of the state budget. Of interest, however, is the fact that a representative of the State Energy Commission had informed us that smog chamber studies of the kind contemplated were needed to scientifically determine the true photochemical reactivity of ethanol since available literature on the subject is far from conclusive.

Because of the absence of conclusive analytical data concerning ethanol reactivity, Wine Institute sought available atmospheric oxidant measurements from various areas within the state which might reveal a correlation with the premise that ethanol is a photochemical oxidant. If ethanol is a highly reactive ozone precursor, a pattern of increased oxidant levels should be reflected in these available measurements by a pattern of increased levels during the fermenting season. While oxidant levels can be assumed to change with various air circulation patterns and the duration and intensity of the subject which indicates reactivity, our analysis of California Air Quality data on oxidant levels disclosed some interesting findings. Air Quality data in our possession revealed no pattern of increased oxidant levels during the winery fermentation season. To the contrary, a significant decrease is evidenced. A copy of the California Air Quality information is attached as EXHIBIT D, consisting of one (1) page, and is incorporated by reference herein. Hence, available empirical data does not support winery emission control. Further, analytical data available is so inconsistent and conclusory as to render their findings extremely suspect.

For example, Table 4 of ARB Report No. 55-81-004, entitled "Alcohol Emissions from a Fermentation Tank," indicates that winery emissions during the peak of the fermenting season contribute over 50% of the estimated hydrocarbon emissions in Fresno county and virtually nothing during the rest of the year. When data from this report (attached as EXHIBIT E and incorporated by reference herein) is juxtaposed with 1979 APCD data (attached as EXHIBIT F and incorporated by reference herein) which indicates that wineries cause 3% of emission within the county, the two reports are irreconcilable. Moreover, when EXHIBIT E is compared with the data included in the EXHIBIT A with regard to the tons of hydrocarbons emitted yearly by Fresno County wineries, the validity of these reports appear suspect. While EXHIBIT E attributes Fresno County wineries with emitting 918 tons of hydrocarbons per year, EXHIBIT A states that a total of 284 tons of available ethanol emissions for the entire state is attributable to wineries per year.

If the conclusions of EXHIBIT A and EXHIBIT E are accurate, it would only be logical to assume that the disproportionately greater winery emissions in Fresno County would be manifested by extremely high oxidant readings within the vicinity of Fresno wineries. As stated earlier, based on air resources data, such is not the case.

Further, if the conclusions of EXHIBIT E are accurate, readings should indicate disproportionately elevated oxidant readings within the vicinity of wineries during the fermenting season. As stated earlier, the readings indicate to the contrary. It should be noted that also during this time, an unknown quantity of sugar-bearing crops are left to decompose in the field, and 100% of the ethanol produced by this action is released into the atmosphere.

The evidence discussed above casts serious doubt as to the validity of the premise that ethanol is a photochemical oxidant. Even if we assume that ethyl alcohol remains in the atmosphere for a period of time, sufficient to react with other substances and thus become a photochemical oxidant, the degree of reactivity is not a settled scientific fact which justifies the imposition of emission controls. Likewise, the targeting of wineries as a major source of high oxidant levels is not supported by currently available oxidant measurements.

#### IV. CURRENT PRODUCTION PRACTICES HAVE SIGNIFICANTLY REDUCED ETHANOL EMISSIONS.

The wine industry has experienced dramatic changes in the past decade which has already resulted in significant reductions of alcohol losses to the atmosphere absent the requirement of emission control regulations. There are two reasons to explain the reduction of ethanol losses. First, current production practices dictate lower temperature fermentation of all wines which decrease ethanol emissions significantly. Second, the wine market has shifted from primarily red wine to white wine consumption, which results in increased production of white wine and lower fermentation temperatures.

Experimental data submitted to the California Air Resources Board on July 19, 1982, as part of a report entitled "Characterization of Ethanol Emissions from Wineries" by the EAL Corporation, show an approximate 70% decrease in alcohol loss in the evolved CO<sub>2</sub> by lowering the fermentation temperature from 85 degrees to 55 degrees F. While in the past white wine was fermented at high temperatures, the common practice today is fermentation at 55 degrees F. A copy of the EAL data is attached as EXHIBIT G and incorporated herein by reference. It should be noted that red wines, once commonly fermented at 85 degrees F, are now commonly fermented at 75 degrees F. Roses are fermented at white wine temperatures. Further, in cold fermentation each fermentation tank has twenty to twenty-five percent headspace which in and of itself can cause a condensation of ethanol vapors during the fermentation process.

It must be emphasized that colder fermentation temperatures, which clearly reduce ethanol emissions, has not been without significant expenditures to individual wineries. Colder fermentation require additional costs estimated at between \$1,000 to \$3,000 for each ton of refrigeration used. 50 tons of refrigeration are required to maintain every 100,000 gallons of juice at 55 degrees F. The additional costs not only reflect expenditures for refrigeration, but also for the acquisition of additional tanks. At least twice as many tanks are required for cold fermentation due to the longer fermentation time necessary at reduced temperatures. A typical cost for a 100,000 gallon stainless steel fermentor is approximately \$85,000.

In response to the increasing consumer trend toward white wine came an increase in white wine production, which further reduced ethanol emissions. EXHIBIT H, attached and incorporated herein by reference, is an excerpt from the "Wine Institute 1981 Wine Industry Statistical Report." It shows that white wine, as a percentage of all California wine bottled, increased from 32% in 1974 to 64% in 1981, doubling within seven years. While the increase in white wine production is subject to change, the economic trend toward white wine consumption shows no sign of abatement and appears rather to be increasing. Further, vineyards have committed most of their recent plantings to white grapes. The recent 1981 California Grape Acreage report published by the California Crops and Livestock Reporting Service indicates that there were 58,180 non-bearing acres of white grapes in 1981, a clear indication that white wine production will be predominant in the years to come. A copy of the table is attached as EXHIBIT I and incorporated by reference herein.

The economic statistics as well as the colder fermentation temperatures clearly prove a significant reduction of ethanol emissions based solely on production techniques and market conditions. Wine Institute feels that, at considerable expense, California wineries have already accomplished significant ethanol reduction, and should not be further burdened by the imposition of additional regulation.

#### V. COST ANALYSIS OF EMISSION SYSTEMS

The proposed draft provisions of Rule 409.7, entitled Winery Fermentation Operations, establishes emissions standards for fermentation tanks with a capacity of 100,000 gallons or more, requiring control equipment which will reduce ethanol emissions by 90% by July 1, 1985. While the draft rule does not specify performance standards necessary to accomplish the 90% ethanol reduction, nor does the draft rule define the base period for determining the 90% ethanol reduction, six methods were suggested by EXHIBIT A to accomplish the reduction. These methods are as follows:

1. Incineration;
2. Charcoal adsorption;
3. Scrubbing;
4. Fractionation;
5. Refluxing; and
6. Simple condensation.

These methods are listed in what the author of EXHIBIT A believes to be the decreasing order of expense. Wine Institute has obtained research on the compliance costs required for charcoal adsorption, one of the most expensive procedures according to EXHIBIT A, and for simple condensation, the least expensive procedure according to the report.

Wine Institute agrees that charcoal adsorption involves both a high initial cost and a high operating cost. United Vintners has completed a study on the costs involved in equipping and maintaining four wineries with such a system. The total crush of these four plants is approximately 275,000 tons per year. Using the EXHIBIT A figure of 0.38

pounds of ethanol per ton of grapes, 104,500 pounds of ethanol would be lost from 275,000 tons crushed. As the letter from Robert W. Calvin, Project Engineering Manager of United Vintners indicates, (attached as EXHIBIT J and incorporated by reference herein) installation costs are approximately \$5,500,000. Yearly operating costs are estimated at about \$165,000.

A typical cost breakdown appears as follows:

**TABLE 1. COST ANALYSIS: CARBON ADSORPTION METHOD**

|                                            |                   |           |           |           |           |
|--------------------------------------------|-------------------|-----------|-----------|-----------|-----------|
| Cost:                                      | \$5,500,000.00    |           |           |           |           |
| Less one-half investment tax credit (ITC): | <u>275,000.00</u> |           |           |           |           |
| Basis for Depreciation:                    | \$5,225,000.00    |           |           |           |           |
|                                            | YEAR:             |           |           |           |           |
|                                            | 1                 | 2         | 3         | 4         | 5         |
| Depreciation*                              | 791,000           | 1,160,000 | 1,108,000 | 1,108,000 | 1,108,000 |
| Tax Benefit at 46%                         | 364,000           | 534,000   | 510,000   | 510,000   | 510,000   |
| Cash Out:                                  | \$5,500,000       |           |           |           |           |
| Less ITC:                                  | <u>550,000</u>    |           |           |           |           |
| Net Cash Flow:                             | \$4,950,000       | 364,000   | 534,000   | 510,000   | 510,000   |
| Present Value at 6%                        | 343,000           | 475,000   | 428,000   | 404,000   | 381,000   |
|                                            | \$2,919,000       |           |           |           |           |

or an average cost of \$583,800 per year or \$5.59 per lb. ethanol plus yearly operating costs of \$1.58 per lb. = \$7.17 per lb. exclusive of other cost considerations.

According to the EXHIBIT A, the least expensive method of emission control is simple condensation. Page 9 of EXHIBIT A is a calculation sheet which states that a

-----  
 \*It should be noted that there are a number of wineries that are not profitable, are not taxpayers, or are undercapitalized and in the unfortunate position of not being entitled to receive depreciation benefits. These wineries would be the most severely injured by proposed Rule 409.7. The cost to a winery not entitled to depreciation benefits would be as follows: Average cost of \$1,045,000 per year or \$10.00 per lb. ethanol plus yearly operating cost of \$1.58 per lb., for a total of \$11.58 perlb. of ethanol removed.

100,000 gallon fermentation tank equipped with a refrigeration system capable of absorbing 375 BTU/hour and which provides chilled water at 50 degrees F can condense 90% of the ethanol vapors. On cursory inspection, the figures seemed inaccurate. An important point also brought out by our members was that current refrigeration systems at wineries are used to the maximum during the crushing season and are unavailable for other uses. Further, during cold fermentation, each fermentation tank has about twenty to twenty-five percent headspace with in and of itself can cause a condensation of ethanol vapors during the fermentation process. Therefore, Wine Institute requested Dr. Lynn Williams of the University of California, Davis, to verify the accuracy of the proposed system design as described in EXHIBIT A. Dr. Williams' findings, attached and marked as EXHIBIT K, are quite inconsistent with EXHIBIT A's findings.

Wine Institute respects the high caliber of work performed in producing EXHIBIT A, "Winery Emission Control in California." However, Wine Institute adopts the position of Dr. Williams that the proposed condensation system as described in EXHIBIT A is underdesigned. EXHIBIT A calculations are based on minimum or average values. However, Dr. Williams points out that the use of such values will result in a system that is underdesigned for what it is intended to do. To design an effective system of ethanol recovery, maximum values must be used. For example, average ethanol concentrations in the vapor rather than the maximum was used in the EXHIBIT A calculations. Further, a fermentation temperature of 75 degrees F rather than 85 degrees, which may be occasionally reached, was used. Also, the gas flow of 60 CFM used in the EXHIBIT A calculations are not accurate, and peak levels of ten times that volume may be encountered.

Dr. Williams indicates that the cooling load calculation is erroneous for the following reasons: no load was attributed to CO<sub>2</sub> gas cooling (carbon dioxide being the largest component of the vapor); no condensation load was used or considered; and an incorrect condensate quantity and temperature was used to arrive at the condensate sensible heat calculation. Additionally, it appears that the condensate rate of 15 pounds per hour as stated in EXHIBIT A is low by a factor of ten.

Finally, Dr. Williams indicates that the assumption that cooling of the vapor to 50 degrees F will recover 90% of the ethanol simply defies the laws of vapor-liquid equilibrium. Dr. Williams states that a temperature well below 32 degrees F is necessary to achieve 90% recovery.

Discarding the figures in EXHIBIT A as inaccurate, Dr. Williams' calculations show that the condensation system must have a peak capacity of 164,545 BTU/hour at a temperature of minus twelve degrees F (-12 degrees F) for such a system to recover 90% of the ethanol. Using Dr. Williams' calculations, Wine Institute retained Mr. R.L. Nowlin of L & A Engineering & Equipment, Inc., a highly respected engineer familiar with wine production equipment, to render a quotation for a condensation system based on Dr. Williams' figures. A copy of Mr. Nowlin's response is attached as EXHIBIT L and incorporated by reference herein. A cost analysis of such a system for use on a single 100,000 gallon fermenter, amortized over five years, is as follows:

**TABLE 2. COST ANALYSIS FOR ONE TANK: CONDENSATION METHOD**

Cost: \$50,000.00

Less one-half ITC 2,500.00

Basis for Depreciation: \$47,500.00\*

|                             | YEAR:           |        |       |       |       |
|-----------------------------|-----------------|--------|-------|-------|-------|
|                             | 1               | 2      | 3     | 4     | 5     |
| Depreciation                | 7,125           | 10,450 | 9,975 | 9,975 | 9,975 |
| Tax Benefit at 46%          | 3,278           | 4,807  | 4,589 | 4,589 | 4,589 |
| Cash Out:                   | \$50,000.00     |        |       |       |       |
| Less ITC:                   | <u>5,000.00</u> |        |       |       |       |
| Net Cash Flow (\$45,000.00) | 3,278           | 4,807  | 4,589 | 4,589 | 4,589 |
| PV at 6% (\$45,000.00)      | 3,092           | 3,877  | 3,856 | 3,642 | 3,425 |

This corresponds to \$4,938 per 100,000 gallon fermentor per year. If a fermentor of this size contains the juice from 540 tons of grapes (which is impossible since this would fill it to the top), and 0.38 pounds of ethanol is emitted per ton (according to Maskall), then 205 pounds of ethanol is released from each fermentation. In a 70 day season a white wine fermentor may be "turned over" up to five times, so about 1,000 pounds of ethanol could be emitted in a season from such a fermentor.

The basic cost per pound of ethanol removed would be as follows:

|                |                                       |
|----------------|---------------------------------------|
| \$4,938        | for refrigeration system              |
| <u>\$3,500</u> | for power for 70 days                 |
| \$8,438        | Total to remove 900 lbs. ethanol      |
|                | (900 lbs. representing 90% reduction) |

**OR \$9.38 PER POUND OF ETHANOL REMOVED.**

-----  
 \*It should be noted that there are a number of wineries that are not profitable, not taxpayers, or are undercapitalized and in the unfortunate position of not being entitled to depreciation benefits. These wineries are the most severely harmed by the operation of proposed Rule 409.7. For such wineries, compliance costs would depend on the number of 100,000 tanks used as fermenters by such wineries. However, as an example of compliance costs for a single tank, the average cost of \$47,500 per tank and \$3,500 for power would result in a cost of \$57.00 per lb. of ethanol removed.

It should be noted that this \$9.38 figure is rather conservative, since a myriad of attendant costs are not included. Any device to adsorb or condense, or trap alcohol vapors from an active fermentation tank cannot in any case be practical or usable by wineries, not only due to inefficiency and high costs, but to insoluble sanitation problems which would jeopardize the quality of the product. Imminent problems with sanitation and costs involved in maintenance and operation, while foreseeable, cannot be accurately predicted. However, there is clearly a danger of potential damage to the quality of the product through the methods proposed.

#### VI. THE RECOVERED ETHANOL IS OF NO SIGNIFICANT VALUE.

The adoption of any of the methods suggested by EXHIBIT A for ethanol recovery would leave wineries with a dilute alcohol solution of dubious value. Wineries that do not possess distillation equipment could invest in additional equipment and adopt new procedures which involve the mounting of a condensor on each 100,000 gallon tank to reflux the solution back into the tank. The additional expenditures involved in such an operation are compounded by imminent sanitation and maintenance problems. Preliminary calculations indicate that there would not be any positive return on such an operation.

Alternatively, wineries that choose not to invest in distillation or refluxing equipment may choose simply to dispose of the solution. However, in many cases, land disposal is the only method available to wineries, and such activity would surely attract the attention of regional and local water quality authorities and health departments, and in most cases would be considered unsuitable. As to land disposal, of course, any dilute alcohol-water solution spread on the land would result in the alcohol evaporating to the air, making the entire proposal an exercise in futility.

Wineries that possess distillation equipment would similarly realize no return should they be compelled to comply with proposed Rule 409.7. Wine Institute members with such equipment at their disposal are in agreement that distilling the solution obtained by condensation would not be profitable.

\* \* \* \* \*

#### CONCLUSION

Wine Institute appreciates the efforts of the Fresno APCD in attempting to attain the National Ambient Air Quality Standard for ozone by 1987. While our position is adversarial, we must commend Mr. Bill Roddy and his staff for their cooperation and for keeping our members apprised of the development of Rule 409.7.

However, we must submit these comments in opposition to proposed Rule 409.7 because we feel that ethanol is, if reactive at all, only marginally so. Even if we assume, arguendo, that ethanol is an ozone precursor, we cannot agree with the contention that Rule 409.7 is a cost-effective means of controlling ethanol emissions. While we respect the efforts of the Fresno County Air Pollution Control District in investigating compliance costs, we cannot agree with the findings set forth in EXHIBIT A and instead contend that compliance costs for a condensation unit which would comply with the provisions of proposed Rule 409.7 would reach or exceed \$10.00 per pound of ethanol



recovered. Wine Institute feels that this figure makes compliance with proposed Rule 409.7 unreasonably burdensome.

While the wine industry in California has grown considerably in the last decade, winemaking methods currently employed have already significantly reduced ethanol emissions at considerable expense. Colder fermentation temperatures for all wines and especially for white wines have been proven to greatly reduce ethanol emissions, and with the attention that white wine has been receiving from the wine-consuming public, we can only expect further ethanol reductions based solely on the wine industry's response to market conditions and new technology.

Our membership fears that based on our figures, compliance costs would have a serious effect on the industry and may give to foreign wines the competitive edge they need to strip away even more of the market shares. Wine Institute feels that the projected cost of compliance tremendously outweigh any corresponding benefit in reducing air contaminants. It is generally conceded that the nation's economy has taken its toll on production companies. Many of our state's wineries have found themselves to be undercapitalized and unprepared for the downturn in the economy and have been forced into sale or bankruptcy. Many wineries currently operate on marginal capital, and those that have been fortunate enough to escape the nation's economic woes find themselves in a struggle to survive against the aggressive challenge from the foreign wines for market shares.

Recently given media attention, the California wine industry is faced with a very real threat from foreign wines (see EXHIBIT M, an excerpt of articles from the San Francisco Chronicle of December 27, 1982). Due to the strength of the dollar, promotion campaigns of European wine exporting countries, and foreign government subsidies, foreign wines currently enjoy a 12% annual growth rate, swiftly gaining market shares to the detriment of California's wineries. There are no quick or easy solutions to the problem of foreign wines, but it is perfectly clear that for the California wine industry to remain viable, it must not be saddled with expenditures for compliance costs which are not cost-effective, overly burdensome with no identifiable benefits, or which would practically result in the closing and elimination of lawful winery businesses.

For the above-stated reasons, Wine Institute respectfully requests that winery ethanol emissions not be the subject of regulation. Alternatively, we request an extension of time prior to any final decision on proposed Rule 407.9 to retain technical expertise and to determine photochemical alcohol reactivity in the atmosphere. An analytical study to determine the degree of reactivity of ethanol as previously budgeted, must be conducted before costly regulations are imposed. Until conclusive studies are completed, and until the best available technology is developed to economically reduce ethanol emissions, Wine Institute submits that requiring wineries to invest in emissions control equipment of the kind described in the Maskall report has no corresponding benefit in reducing air contaminants.

Exhibit B  
Page 10

## A SURVEY OF COLD TOLERANT WINE YEAST STRAINS

C. S. Ough and R. E. Kunkee

Department of Viticulture and Enology, University of California,

Davis

January 1984

Yeast strains: 1) Some 25 wine yeast strains from the UCD Enology collection will be tested. These will include strains which are known to be effective as "good" strains under normal vinification conditions. Also will be selected one or two strains which are normally not used because of their lack of vigor (because of special sensitivity to alcohol or sulfur dioxide, etc.) as negative controls and to explore the possibility that these sensitive yeast might be cold tolerant. Montrachet and Pasteur Champagne strains (UCD Enology Nos. 522 and 595) will be the positive controls. 2) Commercial yeast producers and wine research stations will also be contacted to obtain any candidate yeast strains which they might consider to be especially cold tolerant. 3) At least one mixed culture (of, say, three common vigorous wine yeast strains) fermentation will be made since one of us (REK) has some experimental (unpublished) evidence that a faster fermentation may result.

Starter culture preparation: Yeasts will be propagated as starter cultures both at 70°F (in order to obtain vigorous growth), and at one of the lower temperatures of the experiment (45 - 50°F), to determine the effect of acclimitization. The original inoculum of these starters will be  $\sim 1 \times 10^6$  cells/mL. The subsequent growth of the starters should reach at least  $1 \times 10^8$  cells/mL before they are used. Starter culture preparations and inoculation of the experimental fermentations will be made under aseptic conditions, but aseptis of the fermentations themselves will not be considered critical because of the large inoculum of starter culture and of the condition of the fermentation medium.

Problem of sulfur dioxide: The presence of sulfur dioxide (normally used in wine making) may contribute to the inhibition of the yeast in such a way that any cold tolerance may be masked. Nevertheless, it seems important to run the experiments in presence of sulfur dioxide, since the yeast strain sought must be able to perform at low temperature in presence of sulfur dioxide. [But see following paragraph]

Fermentations: For the initial experiments grape juice will be used as the fermentation medium. To insure the most vigorous vinifications, the juice will be supplemented with nutrients (yeast food, 200 mg/L and thiamine, 200  $\mu$ /L). There is a special need for this supplementation for these experiments since the juices have been stored since 1983 vintage in presence of  $\text{SO}_2$  (75 mg/L). These fermentations will be carried out as small lot fermentations: 3/4 gallon in gallon bottles (with fermentation bungs) submerged in temperature controlled water baths. The fermentations will be shaken by hand once a day. [A limited number for fermentation vessels which

are more sophisticatedly designed may be available for special candidate yeast. These have a continuous stirring mechanism and allow for flow of inert gas over the fermentation, better mimicking a natural vinification.]

Fermentation temperatures: The first experiments will be run at 55°. The best candidates from these trials will be rerun at 50°, 57° and at 45°F.

Analyses: The rates of the fermentations will be followed from time to time by removal of small samples for ethanol determination (by glc), and at the end of the fermentation by measurements of residual sugar. Microscopic examinations will also be made to insure no contamination by bacteria. Rough sensory evaluations will be made to insure no contamination by yeasts which are obviously not wine strains. In the event of contamination, the experiments will be repeated with the best strains under sterile conditions with the use of a sterile simulated-grape juice medium.

Follow up: The best candidate yeast strain(s) will be used for larger scale fermentations to allow for good sensory evaluation.

Time frame: The initial yeast will be cultured starting in the middle of January. By 1 February the water baths for the experiments will be free and the first series will be done. The baths will hold all the 25 Davis samples. In the meantime, the correspondence will be sent to request other yeast. By the third or fourth week in February, the 25 samples should be finished at 55°F. The best of them will be fermented at the three lower temperatures plus a repeat at 55°F. This could take up to two months. Then the foreign yeast samples will be treated in a similar manner. This will require another three months. This will run us close to vintage. The trials of the best yeasts then can be run in 5 gal lots on fresh juices and sensory work done. The final evaluation should be available in January or February of 1985.

## Summary

(1) Monitoring from KI (wet chemical) to Dasib1 (U.V.) in 1977 - 1978 Period

TABLE 2

41

CALIFORNIA AIR RESOURCES BOARD  
AEROMETRIC DATA SYSTEM  
1984 ANNUAL STATISTICS AND NUMBER OF OCCURRENCES OF HOURLY CONCENTRATIONS GREATER THAN OR EQUAL TO 10 PPM

## OZONE

| BASIN NAME,<br>COUNTY AND STATION<br>NAME AND ID CODES | ANNUAL STATISTICS     |              |      |      |                                           | OCCURRENCES OF HOURLY CONCENTRATIONS > OR = 10 PPM |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |      |   |      |  |  | ANNUAL<br>DY<br>OBS |
|--------------------------------------------------------|-----------------------|--------------|------|------|-------------------------------------------|----------------------------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|------|---|------|--|--|---------------------|
|                                                        | M<br>T<br>H<br>O<br>D | DAILY MAX HR |      | PPM  | ANNUAL MEANS<br>ALL DLY MAX<br>HOURS HOUR | JAN<br>DY<br>HR                                    | FEB<br>DY<br>HR | MAR<br>DY<br>HR | APR<br>DY<br>HR | MAY<br>DY<br>HR | JUN<br>DY<br>HR | JUL<br>DY<br>HR | AUG<br>DY<br>HR | SEP<br>DY<br>HR | OCT<br>DY<br>HR | NOV<br>DY<br>HR | DEC<br>DY<br>HR |      |   |      |  |  |                     |
|                                                        |                       |              |      |      |                                           |                                                    |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |      |   |      |  |  |                     |
|                                                        |                       |              |      |      |                                           |                                                    |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |      |   |      |  |  |                     |
|                                                        |                       |              |      |      |                                           |                                                    |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |      |   |      |  |  |                     |
| SAN JOAQUIN VALLEY                                     |                       |              |      |      |                                           |                                                    |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |      |   |      |  |  |                     |
| FRESNO COUNTY - 10                                     |                       |              |      |      |                                           |                                                    |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |      |   |      |  |  |                     |
| FIVE POINTS 00229-A22 UV                               | 10°                   | 09°          | 033° | 061° |                                           |                                                    |                 |                 |                 |                 |                 | 0               | 1               |                 |                 |                 |                 |      | 1 | 756  |  |  |                     |
|                                                        |                       |              |      |      |                                           |                                                    |                 |                 |                 |                 |                 | 0               | 2               |                 |                 |                 |                 |      | 2 |      |  |  |                     |
| FIVE POINTS 00229-I13 UV                               | 09°                   | 08°          | 020° | 041° | 0                                         | 0                                                  |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |      | 0 | 1284 |  |  |                     |
|                                                        |                       |              |      |      | 0                                         | 0                                                  |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |      | 0 |      |  |  |                     |
| FRESNO-CAL STATE #2 00241-I13 UV                       | 16                    | 15           | 036  | 066  | 0                                         | 0                                                  | 0               | 1               | 9               | 9               | 20              | 15              | 17              | 2               | 0               | 0               | 73              | 8087 |   |      |  |  |                     |
|                                                        |                       |              |      |      | 0                                         | 0                                                  | 0               | 2               | 46              | 38              | 92              | 50              | 66              | 5               | 0               | 0               | 299             |      |   |      |  |  |                     |
| FRESNO-OLIVE 00234-A11 UV                              | 11                    | 11           | 022  | 045  | 0                                         | 0                                                  | 0               | 0               | 1               | 1               | 2               | 0               | 1               | 0               | 0               | 0               | 5               | 7786 |   |      |  |  |                     |
|                                                        |                       |              |      |      | 0                                         | 0                                                  | 0               | 0               | 1               | 2               | 2               | 0               | 1               | 0               | 0               | 0               | 6               |      |   |      |  |  |                     |
| FRESNO-4232HERNDON- 00243-I11 UV                       | 16                    | 14           | 035  | 063  | 0                                         | 0                                                  | 1               | 1               | 7               | 11              | 18              | 13              | 11              | 1               | 0               | 0               | 63              | 7718 |   |      |  |  |                     |
|                                                        |                       |              |      |      | 0                                         | 0                                                  | 2               | 6               | 34              | 48              | 95              | 45              | 45              | 2               | 0               | 0               | 277             |      |   |      |  |  |                     |
| FRESNO-4706 E DRUMM 00244-I11 UV                       | 13°                   | 13°          | 031° | 063° |                                           |                                                    |                 |                 |                 |                 | 8               | 7               | 12              | 1               | 0               | 0               | 28              | 3356 |   |      |  |  |                     |
|                                                        |                       |              |      |      |                                           |                                                    |                 |                 |                 |                 | 23              | 19              | 40              | 2               | 0               | 0               | 84              |      |   |      |  |  |                     |
| FRESNO-5704 E BUTLE 00240-A11 UV                       | 16                    | 15           | 035  | 066  | 0                                         | 1                                                  | 1               | 1               | 9               | 14              | 8               | 18              | 15              | 1               | 0               | 0               | 68              | 7353 |   |      |  |  |                     |
|                                                        |                       |              |      |      | 0                                         | 1                                                  | 1               | 1               | 31              | 73              | 37              | 67              | 47              | 4               | 0               | 0               | 262             |      |   |      |  |  |                     |
| PARLIER 00230-I11 UV                                   | 17°                   | 14°          | 040° | 075° | 0                                         | 0                                                  | 0               | 4               | 18              | 17              | 18              | 15              | 17              | 2               | 0               | 0               | 91              | 7516 |   |      |  |  |                     |
|                                                        |                       |              |      |      | 0                                         | 0                                                  | 0               | 9               | 81              | 83              | 72              | 51              | 55              | 3               | 0               | 0               | 354             |      |   |      |  |  |                     |
| COUNTY SUMMARY -----                                   | 17                    | 16           | 033  | 062  | 0                                         | 1                                                  | 1               | 4               | 19              | 18              | 21              | 20              | 22              | 3               | 0               | 0               | 109             |      |   |      |  |  |                     |
|                                                        |                       |              |      |      | 0                                         | 1                                                  | 3               | 14              | 102             | 117             | 142             | 104             | 112             | 7               | 0               | 0               | 602             |      |   |      |  |  |                     |
| KERN COUNTY - 15                                       |                       |              |      |      |                                           |                                                    |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |      |   |      |  |  |                     |
| BKRSFLD-CHESTER ST 00203-A11 UV                        | 13°                   | 13°          | 027° | 059° | 0                                         | 0                                                  | 0               | 0               | 2               | 3               | 13              | 9               | 11              | 1               | 0               | 0               | 39              | 7415 |   |      |  |  |                     |
|                                                        |                       |              |      |      | 0                                         | 0                                                  | 0               | 0               | 6               | 7               | 39              | 23              | 23              | 3               | 0               | 0               | 101             |      |   |      |  |  |                     |
| EDISON-BKRSFLD-1EAS 00242-A11 UV                       | 17°                   | 16°          | 031° | 061° | 0                                         | 0                                                  | 0               | 0               | 0               | 0               | 8               | 25              | 21              | 3               | 0               | 0               | 57              | 7141 |   |      |  |  |                     |
|                                                        |                       |              |      |      | 0                                         | 0                                                  | 0               | 0               | 0               | 0               | 23              | 89              | 77              | 8               | 0               | 0               | 197             |      |   |      |  |  |                     |
| OILDALE-3311MANOR 00243-A11 UV                         | 14                    | 13           | 032  | 060  | 0                                         | 0                                                  | 0               | 0               | 1               | 2               | 18              | 19              | 14              | 2               | 0               | 0               | 56              | 7955 |   |      |  |  |                     |
|                                                        |                       |              |      |      | 0                                         | 0                                                  | 0               | 0               | 4               | 3               | 75              | 79              | 43              | 6               | 0               | 0               | 210             |      |   |      |  |  |                     |
| COUNTY SUMMARY -----                                   | 17                    | 16           | 030  | 060  | 0                                         | 0                                                  | 0               | 0               | 2               | 4               | 24              | 27              | 21              | 3               | 0               | 0               | 81              |      |   |      |  |  |                     |
|                                                        |                       |              |      |      | 0                                         | 0                                                  | 0               | 0               | 6               | 8               | 103             | 125             | 85              | 10              | 0               | 0               | 337             |      |   |      |  |  |                     |
| KINGS COUNTY - 16                                      |                       |              |      |      |                                           |                                                    |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |      |   |      |  |  |                     |
| HANFORD 00701-I11 UV                                   | 12                    | 11           | 031  | 057  | 0                                         | 0                                                  | 0               | 0               | 4               | 2               | 9               | 2               | 3               | 0               | 0               | 0               | 20              | 8344 |   |      |  |  |                     |
|                                                        |                       |              |      |      | 0                                         | 0                                                  | 0               | 0               | 8               | 8               | 35              | 3               | 5               | 0               | 0               | 0               | 59              |      |   |      |  |  |                     |
| COUNTY SUMMARY -----                                   | 12                    | 11           | 031  | 057  | 0                                         | 0                                                  | 0               | 0               | 4               | 2               | 9               | 2               | 3               | 0               | 0               | 0               | 20              |      |   |      |  |  |                     |
|                                                        |                       |              |      |      | 0                                         | 0                                                  | 0               | 0               | 8               | 8               | 35              | 3               | 5               | 0               | 0               | 0               | 59              |      |   |      |  |  |                     |
| SAN JOAQUIN COUNTY - 39                                |                       |              |      |      |                                           |                                                    |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |      |   |      |  |  |                     |
| STOCKTON-HAZELTON S 00252-A11 UV                       | 14                    | 13           | 021  | 049° | 0                                         | 0                                                  | 0               | 0               | 0               | 0               | 6               | 5               | 8               | 0               | 0               | 0               | 19              | 7104 |   |      |  |  |                     |
|                                                        |                       |              |      |      | 0                                         | 0                                                  | 0               | 0               | 0               | 0               | 13              | 7               | 15              | 0               | 0               | 0               | 35              |      |   |      |  |  |                     |
| STOCKTON-13521 E MA 00267-A11 UV                       | 15°                   | 15°          | 033° | 076° |                                           |                                                    |                 |                 | 4               | 5               | 20              | 7               | 10              | 0               |                 |                 | 46              | 4218 |   |      |  |  |                     |
|                                                        |                       |              |      |      |                                           |                                                    |                 |                 | 12              | 10              | 92              | 14              | 34              | 0               |                 |                 | 162             |      |   |      |  |  |                     |
| COUNTY SUMMARY -----                                   | 15                    | 15           | 026  | 058  | 0                                         | 0                                                  | 0               | 0               | 4               | 5               | 20              | 10              | 10              | 0               | 0               | 0               | 49              |      |   |      |  |  |                     |
|                                                        |                       |              |      |      | 0                                         | 0                                                  | 0               | 0               | 12              | 10              | 92              | 19              | 36              | 0               | 0               | 0               | 169             |      |   |      |  |  |                     |
| STANISLAUS COUNTY - 50                                 |                       |              |      |      |                                           |                                                    |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |      |   |      |  |  |                     |
| MODESTO-7007 JENNIN 00570-H11 UV                       | 14°                   | 12°          | 027° | 065° |                                           |                                                    |                 |                 | 4               | 3               | 11              | 2               | 5               | 0               |                 |                 | 25              | 4176 |   |      |  |  |                     |
|                                                        |                       |              |      |      |                                           |                                                    |                 |                 | 8               | 3               | 37              | 3               | 13              | 0               |                 |                 | 64              |      |   |      |  |  |                     |

ART CAPUTI, JR.

Exhibit D

MAY 5 - 1986

CARB-SBAPCD HB 000376



TABLE 3  
OZONE  
JANUARY 1985 THRU MARCH 1985  
MAXIMUM HOURLY CONCENTRATIONS  
PARTS PER HUNDRED MILLION

| NORTH BASIN NAME<br>COUNTY AND STATION<br>NAME AND ID CODES |   | METHOD |   | PARTS PER HUNDRED MILLION |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  | MEAN<br>OF DLY HIGHEST<br>MAX VALUE DAY |  |
|-------------------------------------------------------------|---|--------|---|---------------------------|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|--|--|--|--|-----------------------------------------|--|
| FEBRUARY 1985 (CONT.)                                       |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| 1                                                           | 2 | 3      | 4 | 5                         | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |  |  |  |  |                                         |  |
| NORTHEAST PLATEAU                                           |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| SISKIYOU COUNTY - 47                                        |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| YREKA 00861-122 UV                                          |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| SACRAMENTO VALLEY                                           |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| BUTTE COUNTY - 64                                           |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| CHICO-MANZANITA 00430-111 UV                                |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| SACRAMENTO COUNTY - 34                                      |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| CITRUS MTS-SUNRISE 00283-111 UV                             |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| FOLDS-HIGHLANDS-OLA 00284-111 UV                            |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| NORTH HIGHLANDS-OLA 00285-111 UV                            |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| SACRAMENTO-DEL PASO 00293-111 UV                            |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| SOLANO COUNTY - 48                                          |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| VACAVILLE-MERCHANT 00881-111 UV                             |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| YOLO COUNTY - 37                                            |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| BRODERICK-105 3RD 00376-122 UV                              |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| WOODLAND-W MAIN ST 00545-111 UV                             |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| SAN JOAQUIN VALLEY                                          |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| FRESNO COUNTY - 10                                          |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| FRESNO-CAL STATE #2 00243-113 UV                            |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| FRESNO-OLIVE 00234-111 UV                                   |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| FRESNO-1124-MORRIS 00243-111 UV                             |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| FRESNO-1124-MORRIS 00243-111 UV                             |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| FRESNO-1124-MORRIS 00243-111 UV                             |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| PARLER 00230-111 UV                                         |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| KERN COUNTY - 15                                            |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| BERSELO-CHESTER ST 00103-111 UV                             |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| EDISON-BERSELO-1145 00143-111 UV                            |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| DIILOALE-3311MARON 00143-111 UV                             |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| KINGS COUNTY - 14                                           |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| HANFORD 00701-111 UV                                        |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| SAN JOAQUIN COUNTY - 36                                     |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| STOCKTON-HAZELTON S 00232-111 UV                            |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| STANISLAUS COUNTY - 80                                      |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| MODESTO-114 14TH ST 00346-111 UV                            |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| TULARE COUNTY - 34                                          |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| VISALIA-CHURCH STRE 00348-111 UV                            |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| GREAT BASIN VALLEYS                                         |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| MONO COUNTY - 24                                            |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| MAMMOTH LAKE-GATEW 00783-111 UV                             |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| SOUTHEAST DESERT                                            |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| IMPERIAL COUNTY - 13                                        |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| EL CENTRO-STATE ST 00649-111 UV                             |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| LOS ANGELES COUNTY - 70                                     |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| LANCASTER 00662-111 UV                                      |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| RIVERSIDE COUNTY - 33                                       |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| BARRING-ALLESANDRO 00130-111 UV                             |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| INDIO-OASIS ST 00130-111 UV                                 |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |
| PALM SPRINGS-FIRE S 00137-111 UV                            |   |        |   |                           |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |  |                                         |  |





TABLE 1  
OZONE  
APRIL 1985 THROUGH JUNE 1985  
MAXIMUM HOURLY CONCENTRATIONS  
PARTS PER HUNDRED MILLION

| MOUNTAIN BASIN NAME<br>COUNTY AND STATION<br>NAME AND ID CODES |    | METHOD |    | APRIL 1963 (CONT.) |    | DAY OF MONTH |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     | MEAN<br>OF DAY<br>MAX<br>VAL - E DAY |       |        |        |
|----------------------------------------------------------------|----|--------|----|--------------------|----|--------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|-----|--------------------------------------|-------|--------|--------|
| 1                                                              | 2  | 3      | 4  | 5                  | 6  | 7            | 8  | 9  | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |     |                                      |       |        |        |
| SACRAMENTO VALLEY                                              |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| BUTTE COUNTY - 04                                              |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| CHICO-MANZANITA 00620-111 UV                                   |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| 5                                                              | 6  | 4      | 4  | 4                  | 6  | 7            | 6  | 6  | 7  | 5  | 5  | 4  | 7  | 7  | 4  | 4  | 5  | 4  | 4  | 4  | 4  | 4  | 5  | 5  | 4  | 7  | 5  | 5  | 6  | 5.3 | 7.6A                                 |       |        |        |
| SACRAMENTO COUNTY - 24                                         |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| CITRUS MTS-SUNRISE 00203-111 UV                                |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| 7                                                              | 5  | 5      | 3  | 6                  | 7  | 5            | 6  | 7  | 3  | 5  | 5  | 5  | 9  | 11 | 6  | 4  | 4  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 7  | 4  | 4  | 5   | 5.4                                  | 11.14 |        |        |
| FOLDS 00204-111 UV                                             |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| 10                                                             | 7  | 4      | 6  | 8                  | 6  | 7            | 4  | 7  | 6  | 7  | 6  | 6  | 7  | 6  | 6  | 4  | 4  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 7  | 4  | 6  | 6.1 | 10.14                                |       |        |        |
| NORTH HIGHLANDS-BLA 00204-111 UV                               |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| 8                                                              | 6  | 6      | 4  | 10                 | 6  | 5            | 5  | 5  | 6  | 7  | 6  | 14 | 13 | 6  | 4  | 4  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 7  | 4  | 5  | 7   | 6.6                                  | 13.14 |        |        |
| SACRAMENTO-DEL PASO 00205-111 UV                               |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| 10                                                             | 8  | 7      | 4  | 8                  | 8  | 6            | 6  | 6  | 6  | 6  | 5  | 6  | 10 | 12 | 5  | 4  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 7  | 3  | 4  | 6   | 4.1                                  | 12.14 |        |        |
| SACTO-MEADOWVIEW RD 00206-111 UV                               |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
|                                                                |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     | 4.8                                  | 6.13  |        |        |
| SHASTA COUNTY - 45                                             |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| REDDING-1415 CONTIN 00504-111 UV                               |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| 4                                                              | 6  | 5      | 4  | 5                  | 9  | 6            | 7  | 5  | 5  | 5  | 5  | 5  | 7  | 7  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 5  | 5  | 5  | 5  | 5  | 4  | 5  | 4  | 5   | 4.8                                  | 6.13  |        |        |
| SOLANO COUNTY - 48                                             |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| VACAVILLE-MERCHANT 00681-111 UV                                |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| 5                                                              | 5  | 5      | 2  | 3                  | 3  | 4            | 5  | 2  | 3  | 3  | 4  | 4  | 7  | 4  | 2  | 2  | 2  | 3  | 3  | 3  | 1  | 2  | 2  | 2  | 2  | 2  | 1  | 1  | 2  | 2.8 | 7.14                                 |       |        |        |
| YUBA COUNTY - 57                                               |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| BROOKLYN-101 00706-111 UV                                      |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| 5                                                              | 5  | 4      | 2  | 6                  | 5  | 4            | 6  | 4  | 5  | 3  | 3  | 4  | 12 | 8  | 3  | 2  | 4  | 5  | 4  | 4  | 4  | 4  | 5  | 5  | 5  | 4  | 5  | 4  | 5  | 4.6 | 12.13                                |       |        |        |
| WOODLAND-W MAIN ST 00569-111 UV                                |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| 6                                                              | 6  | 5      | 5  | 7                  | 6  | 5            | 6  | 6  | 5  | 5  | 5  | 5  | 6  | 6  | 7  | 4  | 4  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5   | 5.3                                  | 9.13A |        |        |
| SAN JOAQUIN VALLEY                                             |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| FRESNO COUNTY - 10                                             |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| FRESNO-CAL STATE #2 00242-111 UV                               |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| 8                                                              | 6  | 7      | 12 | 11                 | 10 | 7            | 11 | 12 | 5  | 4  | 6  | 14 | 12 | 6  | 6  | 5  | 7  | 3  | 5  | 7  | 5  | 8  | 9  | 8  | 7  | 7  | 7  | 5  | 7  | 7   | 7.9                                  | 14.13 |        |        |
| FRESNO-OLIVE 00236-111 UV                                      |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| 10                                                             | 6  | 12     | 13 | 10                 | 6  | 11           | 10 | 4  | 3  | 5  | 5  | 8  | 9  | 7  | 5  | 5  | 7  | 3  | 5  | 7  | 5  | 8  | 9  | 8  | 7  | 7  | 7  | 6  | 4  | 5   | 6.4                                  | 13.5  |        |        |
| FRESNO-OLIVE 00243-111 UV                                      |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| 4                                                              | 2  | 6      | 11 | 10                 | 7  | 5            | 10 | 5  | 4  | 3  | 4  | 3  | 4  | 3  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4   | 4                                    | 4.4   | 13.5   |        |
| FRESNO-OLIVE 00243-111 UV                                      |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| 6                                                              | 10 | 5      | 13 | 11                 | 7  | 9            | 9  | 5  | 4  | 3  | 4  | 3  | 4  | 3  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4   | 4                                    | 4.4   | 13.5   |        |
| FRESNO-OLIVE 00243-111 UV                                      |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| 10                                                             | 10 | 8      | 12 | 11                 | 12 | 10           | 12 | 13 | 7  | 5  | 10 | 10 | 12 | 10 | 6  | 5  | 4  | 7  | 6  | 7  | 6  | 7  | 5  | 7  | 7  | 7  | 7  | 7  | 7  | 7   | 7                                    | 7     | 8.5    | 16.13  |
| KERN COUNTY - 15                                               |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| BEEFLO-CHESTER ST 00303-111 UV                                 |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| 8                                                              | 6  | 10     | 9  | 10                 | 7  | 10           | 10 | 12 | 11 | 9  | 6  | 11 | 11 | 12 | 9  | 7  | 5  | 2  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7   | 7                                    | 8.2   | 12.0A  |        |
| EDISON-BEEFLO-LEAS 00342-111 UV                                |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| 7                                                              | 7  | 7      | 7  | 8                  | 8  | 7            | 8  | 9  | 8  | 6  | 6  | 10 | 10 | 9  | 7  | 4  | 5  | 5  | 3  | 6  | 5  | 7  | 4  | 5  | 5  | 5  | 7  | 6  | 5  | 7   | 7                                    | 7.8   | 12.8   |        |
| GILDALE-331MANOR 00343-111 UV                                  |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
|                                                                |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      | 6.8   | 10.13A |        |
| KINGS COUNTY - 16                                              |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| HANFORD                                                        |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| 8                                                              | 9  | 6      | 6  | 7                  | 6  | 6            | 7  | 8  | 5  | 4  | 6  | 3  | 6  | 3  | 6  | 4  | 4  | 5  | 5  | 5  | 5  | 5  | 4  | 5  | 4  | 7  | 6  | 5  | 6  | 5   | 9                                    | 9.2   |        |        |
| SAN JOAQUIN COUNTY - 39                                        |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| STOCKTON-HAZELTON S 00332-111 UV                               |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| 6                                                              | 7  | 5      | 6  | 6                  | 5  | 7            | 6  | 4  | 4  | 4  | 5  | 12 | 10 | 6  | 5  | 3  | 3  | 5  | 4  | 4  | 5  | 6  | 5  | 4  | 6  | 5  | 3  | 3  | 5  | 5   | 5                                    | 5.4   | 12.10  |        |
| STANISLAUS COUNTY - 50                                         |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| MORFITT-ALVIN ST 00568-111 UV                                  |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| 7                                                              | 8  | 6      | 5  | 6                  | 7  | 5            | 7  | 6  | 4  | 4  | 5  | 11 | 9  | 5  | 4  | 1  | 4  | 5  | 4  | 4  | 4  | 5  | 4  | 5  | 4  | 5  | 4  | 2  | 7  | 5   | 11.10                                |       |        |        |
| TUNLOCK-MONTE VISTA 00337-111 UV                               |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| 10                                                             | 8  | 9      | 2  | 8                  | 10 | 7            | 9  | 10 | 6  | 6  | 7  | 10 | 11 | 9  | 6  | 4  | 6  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5   | 5                                    | 5     | 5.5    | 11.10  |
| TULARE COUNTY - 54                                             |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| VISALIA-CHURCH ST 00568-111 UV                                 |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| 7                                                              | 7  | 8      | 6  | 9                  | 6  | 8            | 10 | 8  | 6  | 6  | 6  | 10 | 9  | 7  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5   | 5                                    | 7.0   | 10.0A  |        |
| GREAT BASIN VALLEYS                                            |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| MONO COUNTY - 26                                               |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| MAMMOTH LAKES-GATEWAY 00789-111 UV                             |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| 5                                                              | 3  | 3      | 3  | 4                  | 4  | 4            | 5  | 5  | 5  | 5  | 5  | 3  | 4  | 4  | 5  | 4  | 4  | 5  | 2  | 5  | 5  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4   | 4                                    | 4.2   | 6.24   |        |
| SOUTHEAST DESERT                                               |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| IMPERIAL COUNTY - 19                                           |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| EL CENTRO-STATE ST 00465-111 UV                                |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| 3                                                              | 4  | 6      | 5  | 5                  | 6  | 7            | 5  | 5  | 4  | 6  | 7  | 4  | 5  | 4  | 5  | 4  | 4  | 6  | 4  | 6  | 4  | 6  | 7  | 7  | 5  | 6  | 4  | 4  | 4  | 4   | 5.2                                  | 9.30  |        |        |
| LOS ANGELES COUNTY - 70                                        |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| LANCASTER                                                      |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| 4                                                              | 7  | 7      | 11 | 8                  | 8  | 9            | 10 | 9  | 10 | 9  | 10 | 7  | 6  | 6  | 13 | 11 | 8  | 5  | 5  | 5  | 5  | 5  | 6  | 6  | 6  | 6  | 6  | 11 | 13 | 7   | 6                                    | 16.10 |        |        |
| RIVERSIDE COUNTY - 35                                          |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| BANNING-ALLESANDRO 00180-111 UV                                |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| 3                                                              | 4  | 6      | 13 | 11                 | 14 | 9            | 9  | 13 | 6  | 14 | 13 | 11 | 8  | 4  | 4  | 3  | 3  | 3  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 3  | 7  | 10  | 19                                   | 8.2   | 19.30  |        |
| PHOTO-ODIS ST 00339-111 UV                                     |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| 4                                                              | 4  | 10     | 11 | 10                 | 10 | 10           | 9  | 12 | 12 | 11 | 4  | 6  | 5  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4   | 4                                    | 4     | 4.5    | 12.11A |
| PALM SPRINGS-FIRE S 00137-111 UV                               |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| 4                                                              | 4  | 10     | 11 | 10                 | 10 | 8            | 9  | 14 | 10 | 9  | 11 | 5  | 6  | 4  | 5  | 4  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5   | 5                                    | 5     | 5.6    | 18.30  |
| SAN BERNARDINO COUNTY - 36                                     |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| BARSTOW                                                        |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| 3                                                              | 4  | 5      | 4  | 4                  | 6  | 4            | 6  | 7  | 8  | 5  | 5  | 3  | 3  | 3  | 3  | 3  | 3  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4   | 4                                    | 4     | 4.5    | 11.0A  |
| PRONA-MARRET ST 00180-111 UV                                   |    |        |    |                    |    |              |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |                                      |       |        |        |
| 5                                                              | 5  | 5      | 5  | 5                  | 5  | 5            | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5   | 5                                    | 5     | 5.3    | 9.10A  |

OZONE  
 APRIL 1985 THRU JUNE  
 MAXIMUM HOURLY CONCENTRATIONS  
 PARTS PER HUNDRED MILLION

| NAME AND ID CODES                  | MAY 1983 (CONT.) |    |    |    |   |   |   |   |   |    |    |    | DAY OF MONTH |    |    |    |    |    |    |    |    |    |    |    | MEAN OF DLY HIGHEST MAR VALUE DAY |    |    |    |    |    |     |      |   |  |  |  |
|------------------------------------|------------------|----|----|----|---|---|---|---|---|----|----|----|--------------|----|----|----|----|----|----|----|----|----|----|----|-----------------------------------|----|----|----|----|----|-----|------|---|--|--|--|
|                                    | 1                | 2  | 3  | 4  | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13           | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25                                | 26 | 27 | 28 | 29 | 30 | 31  |      |   |  |  |  |
| SOUTH COAST (CONT.)                |                  |    |    |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| SAN BERNARDINO COUNTY - 34         |                  |    |    |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| CHINO-1321 CENTRAL 00190-111 UV    | 18               | 12 | 11 | 11 |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| LAKE-1321 CENTRAL 00191-111 UV     | 19               | 12 | 12 | 15 |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| LAKE-1321 CENTRAL 00192-111 UV     | 20               | 12 | 12 | 15 |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| REDLANDS-1321 CENTRAL 00193-111 UV | 21               | 12 | 12 | 15 |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| REDLANDS-1321 CENTRAL 00194-111 UV | 22               | 12 | 12 | 15 |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| REDLANDS-1321 CENTRAL 00195-111 UV | 23               | 12 | 12 | 15 |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| REDLANDS-1321 CENTRAL 00196-111 UV | 24               | 12 | 12 | 15 |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| REDLANDS-1321 CENTRAL 00197-111 UV | 25               | 12 | 12 | 15 |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| REDLANDS-1321 CENTRAL 00198-111 UV | 26               | 12 | 12 | 15 |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| REDLANDS-1321 CENTRAL 00199-111 UV | 27               | 12 | 12 | 15 |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| REDLANDS-1321 CENTRAL 00200-111 UV | 28               | 12 | 12 | 15 |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| REDLANDS-1321 CENTRAL 00201-111 UV | 29               | 12 | 12 | 15 |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| REDLANDS-1321 CENTRAL 00202-111 UV | 30               | 12 | 12 | 15 |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| REDLANDS-1321 CENTRAL 00203-111 UV | 31               | 12 | 12 | 15 |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| SAN DIEGO                          |                  |    |    |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| SAN DIEGO COUNTY - 80              |                  |    |    |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| ALPINE-VICTORIA 00120-111 UV       | 14               | 12 | 10 |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| CHULA VISTA 00121-111 UV           | 15               | 12 | 10 |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| DEL MAR-MIRACOSTA C 00122-111 UV   | 16               | 12 | 10 |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| EL CAJON-REDWOOD AV 00123-111 UV   | 17               | 12 | 10 |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| ESCONDIDO-VALLEY PK 00124-111 UV   | 18               | 12 | 10 |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| ESCONDIDO-VALLEY PK 00125-111 UV   | 19               | 12 | 10 |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| ESCONDIDO-VALLEY PK 00126-111 UV   | 20               | 12 | 10 |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| ESCONDIDO-VALLEY PK 00127-111 UV   | 21               | 12 | 10 |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| ESCONDIDO-VALLEY PK 00128-111 UV   | 22               | 12 | 10 |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| ESCONDIDO-VALLEY PK 00129-111 UV   | 23               | 12 | 10 |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| ESCONDIDO-VALLEY PK 00130-111 UV   | 24               | 12 | 10 |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| ESCONDIDO-VALLEY PK 00131-111 UV   | 25               | 12 | 10 |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| ESCONDIDO-VALLEY PK 00132-111 UV   | 26               | 12 | 10 |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| ESCONDIDO-VALLEY PK 00133-111 UV   | 27               | 12 | 10 |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| ESCONDIDO-VALLEY PK 00134-111 UV   | 28               | 12 | 10 |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| ESCONDIDO-VALLEY PK 00135-111 UV   | 29               | 12 | 10 |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| ESCONDIDO-VALLEY PK 00136-111 UV   | 30               | 12 | 10 |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| ESCONDIDO-VALLEY PK 00137-111 UV   | 31               | 12 | 10 |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| NORTHEAST PLATEAU                  |                  |    |    |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| SISKIYOU COUNTY - 47               |                  |    |    |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| YAREA 00861-122 UV                 | 4                | 6  | 4  | 6  | 5 | 5 | 4 | 5 | 5 | 5  | 5  | 5  | 5            | 5  | 5  | 6  | 6  | 7  | 5  | 5  | 6  | 6  | 4  | 3  | 3                                 | 4  | 3  | 4  | 4  | 4  | 5.0 | 7.17 |   |  |  |  |
| SACRAMENTO VALLEY                  |                  |    |    |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| BUTTE COUNTY - 84                  |                  |    |    |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| CHICO-MANFARITA 00828-411 UV       | 4                | 6  | 5  | 4  | 6 | 6 | 5 | 5 | 4 | 5  | 5  | 5  | 5            | 5  | 5  | 6  | 6  | 7  | 5  | 5  | 5  | 5  | 5  | 5  | 5                                 | 5  | 5  | 5  | 5  | 5  | 5   | 5    |   |  |  |  |
| COLUSA COUNTY - 85                 |                  |    |    |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| ARBUCKLE HILLGATE 00845-411 UV     | 7                | 5  | 5  | 5  | 6 | 5 | 5 | 4 | 5 | 5  | 5  | 5  | 5            | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5                                 | 5  | 5  | 5  | 5  | 5  | 5   | 5    |   |  |  |  |
| COLUSA-FAIRGROUNDS 00843-411 UV    | 6                | 4  | 5  | 5  | 6 | 5 | 5 | 5 | 5 | 5  | 5  | 5  | 5            | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5                                 | 5  | 5  | 5  | 5  | 5  | 5   | 5    |   |  |  |  |
| CLEONE COUNTY - 11                 |                  |    |    |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| WILLOWS-VILLA AVE 00873-411 UV     | 6                | 4  | 5  | 5  | 4 | 6 | 5 | 5 | 5 | 5  | 5  | 5  | 5            | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5                                 | 5  | 5  | 5  | 5  | 5  | 5   | 5    |   |  |  |  |
| SACRAMENTO COUNTY - 34             |                  |    |    |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| CITREUS HILLS-SUNRISE 00289-411 UV | 6                | 4  | 5  | 5  | 7 | 3 | 5 | 5 | 5 | 5  | 5  | 5  | 5            | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5                                 | 5  | 5  | 5  | 5  | 5  | 5   | 5    |   |  |  |  |
| FOULSON 00287-111 UV               | 7                | 5  | 7  | 6  | 6 | 5 | 5 | 5 | 5 | 5  | 5  | 5  | 5            | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5                                 | 5  | 5  | 5  | 5  | 5  | 5   | 5    |   |  |  |  |
| WILSON RICHARDS-BLA 00294-111 UV   | 7                | 5  | 7  | 6  | 6 | 5 | 5 | 5 | 5 | 5  | 5  | 5  | 5            | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5                                 | 5  | 5  | 5  | 5  | 5  | 5   | 5    |   |  |  |  |
| WILSON RICHARDS-BLA 00295-111 UV   | 8                | 6  | 6  | 7  | 6 | 5 | 5 | 5 | 5 | 5  | 5  | 5  | 5            | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5                                 | 5  | 5  | 5  | 5  | 5  | 5   | 5    |   |  |  |  |
| SACRAMENTO-DEL PASO 00293-111 UV   | 6                | 4  | 5  | 5  | 6 | 5 | 5 | 5 | 5 | 5  | 5  | 5  | 5            | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5                                 | 5  | 5  | 5  | 5  | 5  | 5   | 5    |   |  |  |  |
| SACRAMENTO-DEL PASO 00296-111 UV   | 3                | 4  | 4  | 5  | 4 | 5 | 4 | 5 | 4 | 5  | 4  | 5  | 4            | 5  | 4  | 5  | 4  | 5  | 4  | 5  | 4  | 5  | 4  | 5  | 4                                 | 5  | 4  | 5  | 4  | 5  | 4   | 5    | 4 |  |  |  |
| SNOW COUNTY - 45                   |                  |    |    |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| REDDING-1815 CONTIN 00534-111 UV   | 8                | 6  | 5  | 5  | 7 | 6 | 5 | 5 | 5 | 5  | 5  | 5  | 5            | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5                                 | 5  | 5  | 5  | 5  | 5  | 5   | 5    |   |  |  |  |
| SOLANO COUNTY - 48                 |                  |    |    |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| VACAVILLE-MERCHANT 00881-111 UV    | 1                | 2  | 2  | 2  | 3 | 2 | 3 | 4 | 1 | 1  | 1  | 2  | 1            | 1  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3                                 | 3  | 3  | 3  | 3  | 3  | 3   | 3    | 3 |  |  |  |
| SUTTER COUNTY - 51                 |                  |    |    |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| PLEASANT GROVE-45W 00897-422 UV    | 9                | 3  | 3  | 6  | 7 | 4 | 5 | 5 | 5 | 5  | 5  | 5  | 5            | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5                                 | 5  | 5  | 5  | 5  | 5  | 5   | 5    |   |  |  |  |
| YUBA CITY-AC BLDG 00895-422 UV     | 7                | 6  | 5  | 6  | 7 | 4 | 5 | 5 | 5 | 5  | 5  | 5  | 5            | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5                                 | 5  | 5  | 5  | 5  | 5  | 5   | 5    |   |  |  |  |
| YUBA COUNTY - 57                   |                  |    |    |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| BRIDGE-122 UV                      | 5                | 4  | 4  | 5  | 6 | 4 | 5 | 4 | 5 | 5  | 6  | 4  | 5            | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5                                 | 5  | 5  | 5  | 5  | 5  | 5   | 5    |   |  |  |  |
| DAVIS GULF-125 JRD 00576-122 UV    | 5                | 4  | 4  | 5  | 6 | 4 | 5 | 4 | 5 | 5  | 6  | 4  | 5            | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5                                 | 5  | 5  | 5  | 5  | 5  | 5   | 5    |   |  |  |  |
| DAVIS GULF-125 JRD 00577-122 UV    | 5                | 4  | 4  | 5  | 6 | 4 | 5 | 4 | 5 | 5  | 6  | 4  | 5            | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5                                 | 5  | 5  | 5  | 5  | 5  | 5   | 5    |   |  |  |  |
| WOODLAND-W MAIN ST 00849-111 UV    | 7                | 5  | 5  | 6  | 6 | 5 | 5 | 5 | 5 | 5  | 5  | 5  | 5            | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5                                 | 5  | 5  | 5  | 5  | 5  | 5   | 5    |   |  |  |  |
| SAN JOAQUIN VALLEY                 |                  |    |    |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| FRESNO COUNTY - 10                 |                  |    |    |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |
| FRESNO-0111 STATE #2 00241-113 UV  | 4                | 4  | 2  | 4  | 7 | 8 | 5 | 3 | 3 | 3  | 3  | 3  | 3            | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3                                 | 3  | 3  | 3  | 3  | 3  | 3   | 3    |   |  |  |  |
| FRESNO-0111 STATE #2 00242-113 UV  | 11               | 5  | 4  | 7  | 8 | 5 | 3 | 3 | 3 | 3  | 3  | 3  | 3            | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3                                 | 3  | 3  | 3  | 3  | 3  | 3   | 3    |   |  |  |  |
| FRESNO-0111 STATE #2 00243-113 UV  | 10               | 7  | 6  | 4  | 8 | 7 | 7 | 7 | 7 | 7  | 7  | 7  | 7            | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7                                 | 7  | 7  | 7  | 7  | 7  | 7   | 7    |   |  |  |  |
| FRESNO-0111 STATE #2 00244-113 UV  | 10               | 7  | 6  | 4  | 8 | 7 | 7 | 7 | 7 | 7  | 7  | 7  | 7            | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7                                 | 7  | 7  | 7  | 7  | 7  | 7   | 7    |   |  |  |  |
| FRESNO-0111 STATE #2 00245-113 UV  | 10               | 7  | 6  | 4  | 8 | 7 | 7 | 7 | 7 | 7  | 7  | 7  | 7            | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7                                 | 7  | 7  | 7  | 7  | 7  | 7   | 7    |   |  |  |  |
| FRESNO-0111 STATE #2 00246-113 UV  | 10               | 7  | 6  | 4  | 8 | 7 | 7 | 7 | 7 | 7  | 7  | 7  | 7            | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7                                 | 7  | 7  | 7  | 7  | 7  | 7   | 7    |   |  |  |  |
| FRESNO-0111 STATE #2 00247-113 UV  | 10               | 7  | 6  | 4  | 8 | 7 | 7 | 7 | 7 | 7  | 7  | 7  | 7            | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7                                 | 7  | 7  | 7  | 7  | 7  | 7   | 7    |   |  |  |  |
| FRESNO-0111 STATE #2 00248-113 UV  | 10               | 7  | 6  | 4  | 8 | 7 | 7 | 7 | 7 | 7  | 7  | 7  | 7            | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7                                 | 7  | 7  | 7  | 7  | 7  | 7   | 7    |   |  |  |  |
| FRESNO-0111 STATE #2 00249-113 UV  | 10               | 7  | 6  | 4  | 8 | 7 | 7 | 7 | 7 | 7  | 7  | 7  | 7            | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7                                 | 7  | 7  | 7  | 7  | 7  | 7   | 7    |   |  |  |  |
| FRESNO-0111 STATE #2 00250-113 UV  | 10               | 7  | 6  | 4  | 8 | 7 | 7 | 7 | 7 | 7  | 7  | 7  | 7            | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7                                 | 7  | 7  | 7  | 7  | 7  | 7   | 7    |   |  |  |  |
| FRESNO-0111 STATE #2 00251         |                  |    |    |    |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                   |    |    |    |    |    |     |      |   |  |  |  |

TABLE 1

APRIL 1983 THRU JUNE 1983  
OZONE  
MAXIMUM HOURLY CONCENTRATIONS  
PARTS PER HUNDRED MILLION

| MONTH, BASIN NAME<br>COUNTY AND STATION<br>NAME AND ID CODES | METHOD | DAY OF MONTH |   |   |   |   |   |   |   |   |    |    |    | DAY OF MONTH |    |    |    |    |    |    |    |    |    |    |    | MEAN<br>OF DLY HIGHEST<br>MAX VALUE DAY |    |    |    |    |     |     |     |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
|--------------------------------------------------------------|--------|--------------|---|---|---|---|---|---|---|---|----|----|----|--------------|----|----|----|----|----|----|----|----|----|----|----|-----------------------------------------|----|----|----|----|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|---|
|                                                              |        | 1            | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13           | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |                                         | 25 | 26 | 27 | 28 | 29  | 30  |     |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| SACRAMENTO VALLEY                                            |        |              |   |   |   |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                         |    |    |    |    |     |     |     |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| CHICO COUNTY - 04                                            |        |              |   |   |   |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                         |    |    |    |    |     |     |     |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| CHICO-MARZARITA 00618-ALL UV                                 |        | 5            | 5 | 5 | 4 | 5 | 5 | 5 | 5 | 6 | 4  | 4  | 7  | 4            | 4  | 5  | 6  | 10 | 9  | 9  | 9  | 10 | 8  | 7  | 4  | 4                                       | 7  | 10 | 9  | 6  | 7   | 6.1 | 10  | 17A |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| COLUSA COUNTY - 06                                           |        |              |   |   |   |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                         |    |    |    |    |     |     |     |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| ARBUCLE MILLCREEK 00645-ALL UV                               |        | 4            | 5 | 5 | 4 | 5 | 4 | 5 | 5 | 5 | 5  | 6  | 6  | 5            | 4  | 5  | 5  | 9  | 11 | 9  | 8  | 8  | 8  | 5  | 5  | 5                                       | 5  | 5  | 5  | 4  | 5   | 6   | 8.2 | 11  | 16  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| COLUSA-FAIRGROUNDS 00643-ALL UV                              |        | 5            | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 6 | 6  | 6  | 6  | 6            | 4  | 5  | 5  | 9  | 10 | 9  | 9  | 10 | 8  | 5  | 5  | 5                                       | 5  | 5  | 5  | 5  | 5   | 5   | 8.2 | 10  | 11A |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| GLYNN COUNTY - 11                                            |        |              |   |   |   |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                         |    |    |    |    |     |     |     |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| WILLOWS-VILLA AVE 00673-ALL UV                               |        | 4            | 5 | 5 | 5 | 4 | 5 | 5 | 5 | 6 | 6  | 5  | 6  | 4            | 5  | 6  | 10 | 9  | 9  | 9  | 9  | 10 | 8  | 6  | 5  | 5                                       | 5  | 7  | 9  | 5  | 5   | 6.2 | 10  | 17A |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| SACRAMENTO COUNTY - 34                                       |        |              |   |   |   |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                         |    |    |    |    |     |     |     |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| CITRUS WIS-SURREIS 00763-ALL UV                              |        | 5            | 5 | 7 | 5 | 5 | 5 | 5 | 5 | 6 | 6  | 5  | 6  | 13           | 7  | 10 | 13 | 9  | 12 | 5  | 8  | 8  | 5  | 8  | 8  | 4                                       | 8  | 12 | 6  | 5  | 6   | 7.5 | 17  | 18  |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| COLSON-CHANDLER 00787-111 UV                                 |        | 5            | 5 | 6 | 5 | 5 | 5 | 5 | 5 | 7 | 7  | 7  | 13 | 7            | 8  | 8  | 10 | 10 | 16 | 4  | 10 | 9  | 5  | 10 | 10 | 5                                       | 10 | 12 | 10 | 5  | 7   | 7.2 | 15  | 18  |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| COLSON-CHANDLER 00787-111 UV                                 |        | 5            | 5 | 6 | 5 | 5 | 5 | 5 | 5 | 6 | 6  | 6  | 10 | 13           | 9  | 13 | 5  | 10 | 16 | 4  | 10 | 9  | 5  | 10 | 10 | 5                                       | 10 | 12 | 10 | 5  | 7   | 7.2 | 15  | 18  |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| SACRAMENTO-OEL PASO 00793-111 UV                             |        | 5            | 5 | 5 | 5 | 5 | 5 | 4 | 4 | 6 | 4  | 5  | 7  | 5            | 5  | 5  | 5  | 10 | 16 | 4  | 10 | 9  | 5  | 10 | 10 | 5                                       | 10 | 12 | 10 | 5  | 7   | 7.8 | 15  | 18  |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| SACRAMENTO-MADONNEN RD 02186-111 UV                          |        | 5            | 5 | 5 | 5 | 5 | 5 | 4 | 4 | 4 | 4  | 5  | 7  | 5            | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 6  | 6  | 5                                       | 7  | 11 | 8  | 6  | 6   | 5.8 | 11  | 17  |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| SHASTA COUNTY - 45                                           |        |              |   |   |   |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                         |    |    |    |    |     |     |     |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| BREDDING-TAIS CORTIN 00844-111 UV                            |        | 4            | 5 | 4 | 5 | 4 | 5 | 4 | 5 | 5 | 5  | 5  | 5  | 5            | 3  | 4  | 6  | 12 | 9  | 8  | 9  | 8  | 5  | 4  | 7  | 6                                       | 9  | 6  | 5  | 5  | 6.0 | 12  | 16  |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| SOLANO COUNTY - 48                                           |        |              |   |   |   |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                         |    |    |    |    |     |     |     |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| VACAVILLE-MERCHANT 00881-111 UV                              |        | 1            | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1  | 2  | 2  | 2            | 0  | 2  | 3  | 2  | 1  | 2  | 1  | 1  | 1  | 2  | 2  | 2                                       | 2  | 4  | 2  | 3  | 2   | 1.8 | 4   | 9A  |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| SUTTER COUNTY - 51                                           |        |              |   |   |   |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                         |    |    |    |    |     |     |     |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| PLEASANT GROVE-45M 00847-A22 UV                              |        | 5            | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 6 | 5  | 7  | 11 | 8            | 7  | 6  | 9  | 12 | 6  | 10 | 8  | 5  | 8  | 7  | 5  | 9                                       | 18 | 9  | 6  | 6  | 7.1 | 12  | 18  |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| YUBA CITY-AC BLOC 00845-A22 UV                               |        | 5            | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5  | 5  | 5  | 5            | 5  | 5  | 6  | 10 | 7  | 8  | 10 | 6  | 7  | 8  | 7  | 5                                       | 9  | 10 | 6  | 6  | 6.3 | 10  | 70A |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| YOLCO COUNTY - 57                                            |        |              |   |   |   |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                         |    |    |    |    |     |     |     |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| BRODERICK-365 PAD 00576-122 UV                               |        | 5            | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5  | 5  | 5  | 7            | 4  | 5  | 6  | 6  | 4  | 4  | 5  | 5  | 3  | 7  | 7  | 4                                       | 7  | 9  | 7  | 5  | 4   | 5.6 | 9   | 32  |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| DAVIS GOLF COURSE 00575-A22 UV                               |        | 5            | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5  | 5  | 5  | 5            | 5  | 5  | 9  | 11 | 6  | 7  | 6  | 7  | 6  | 5  | 4  | 5                                       | 6  | 10 | 7  | 6  | 6   | 5.6 | 11  | 16  |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| WOODLAND-M MAIN ST 00365-111 UV                              |        | 5            | 5 | 5 | 5 | 5 | 5 | 4 | 5 | 5 | 5  | 6  | 10 | 6            | 4  | 5  | 9  | 11 | 7  | 7  | 8  | 7  | 8  | 5  | 5  | 9                                       | 11 | 6  | 6  | 6  | 6.5 | 11  | 16A |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| SAN JOAQUIN VALLEY                                           |        |              |   |   |   |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                         |    |    |    |    |     |     |     |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| FRESNO COUNTY - 10                                           |        |              |   |   |   |   |   |   |   |   |    |    |    |              |    |    |    |    |    |    |    |    |    |    |    |                                         |    |    |    |    |     |     |     |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| FRESNO-CAL STATE #2 00241-113 UV                             |        | 6            | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 10 | 13 | 16 | 11           | 7  | 6  | 11 | 13 | 10 | 10 | 8  | 10 | 9  | 12 | 9  | 9                                       | 11 | 9  | 6  | 8  | 8   | 8   | 8   | 9   | 16  | 12 |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| FRESNO-OLIVE 00234-ALL UV                                    |        | 5            | 5 | 6 | 5 | 5 | 5 | 5 | 5 | 6 | 4  | 12 | 14 | 14           | 13 | 9  | 5  | 12 | 16 | 11 | 10 | 9  | 9  | 9  | 10 | 8                                       | 9  | 9  | 9  | 5  | 6   | 6   | 6   | 5   | 16  | 17 |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| FRESNO-ADZEMENGO 00245-111 UV                                |        | 5            | 6 | 7 | 5 | 5 | 5 | 5 | 5 | 5 | 6  | 9  | 10 | 10           | 6  | 9  | 10 | 11 | 10 | 7  | 9  | 9  | 9  | 9  | 9  | 8                                       | 10 | 11 | 9  | 5  | 6   | 6   | 6   | 8   | 13  | 12 |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| FRESNO-706 E DRUM 00246-111 UV                               |        | 5            | 6 | 7 | 5 | 5 | 5 | 5 | 5 | 5 | 5  | 13 | 12 | 13           | 11 | 9  | 9  | 12 | 14 | 11 | 10 | 8  | 9  | 9  | 8  | 8                                       | 10 | 11 | 10 | 8  | 9   | 9   | 9   | 9   | 13  | 12 |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| FRESNO-9704 E BUTLE 00240-ALL UV                             |        | 6            | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 7  | 11 | 11 | 11           | 9  | 8  | 11 | 11 | 10 | 9  | 8  | 9  | 9  | 9  | 9  | 9                                       | 9  | 9  | 9  | 5  | 5   | 5   | 7   | 10  | 11  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |
| PARLER 00270-111 UV                                          |        | 6            | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 10 | 14 | 11 | 14           | 12 | 12 | 12 | 13 | 13 | 11 | 6  | 10 | 11 | 11 | 9  | 10                                      | 9  | 10 | 6  | 8  | 10  | 10  | 10  | 10  | 10  | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 1 |

Research Proposal

SMOG CHAMBER AND PHOTOCHEMICAL  
MODELING OF ETHANOL EMISSIONS TO CRITICALLY  
REVIEW THE NEED FOR IMPENDING STATE OF  
CALIFORNIA AIR RESOURCES BOARD REGULATIONS

6 September 1985

Prepared for

Winegrowers of California  
1849 Old Bayshore Hwy, #213  
Burlingame, CA 94010

Prepared by

Systems Applications, Inc.  
101 Lucas Valley Road  
San Rafael, CA 94903

Exhibit E  
Pages 1 - 6

110200 ep 85141

## INTRODUCTION

This research proposal, entitled "Smog Chamber and Photochemical Modeling of Ethanol Emissions to Critically Review the Need for Impending State of California Air Resources Board Regulations," is presented to the Wine-growers of California in the manner requested in the "Format for Research Proposals." The research is proposed to be carried out by Systems Applications, Inc., a private sector research firm located in San Rafael, California, specializing in state of the art research in photochemical smog and by the University of North Carolina, which has state of the art laboratory facilities necessary to support this research.

Appended to the main body of this research proposal is valuable information for the reviewers regarding the qualifications of the personnel and organization proposed for this work, as well as a listing of related research.

### Project Title

Smog Chamber and Photochemical Modeling of Ethanol Emissions to Critically Review the Need for Impending State of California Air Resources Board Regulations

### Principal Investigators (Resumes Appended)

David R. Souten  
Gary F. Whitten  
Systems Applications, Inc.  
101 Lucas Valley Road  
San Rafael, CA 94903

and

Harvey E. Jeffries  
Kenneth G. Sexton  
University of North Carolina

## Status of Proposal

This is a new proposal to the Winegrowers of California.

## Objectives

The California Air Resources Board (CARB) and certain Air Pollution Control Districts (APCD), such as Fresno County APCD, have shown a strong interest in requiring the wine industry to place controls on the fermentation process to reduce or eliminate emissions of ethanol into the atmosphere. The premise of the need for such controls is that ethanol is a hydrocarbon which, through atmospheric chemical reactions, plays a role in the formation of photochemical ozone or "smog." The purpose of this research is to explore the degree to which this premise is correct and, therefore, the degree to which the regulatory agencies are justified in requiring the wine industry to assume this additional financial liability. Although there have been some smog chamber experiments indicating that ethanol would be moderately photochemically reactive in the atmosphere, there have been no experiments showing how ethanol would participate in the complex urban smog chemistry of episodic days. Therefore, we propose to conduct a combined experimental and modeling study to determine the reactivity of ethanol as it might participate in urban smog chemistry (Phase I) and to use these results to assess the impact of varying levels of ethanol emissions on ozone concentrations (Phase II).

The first of two objectives in Phase I is to use a smog chamber experiment to test the potential ozone formation of ethanol when mixed with a surrogate mixture of hydrocarbons. Secondly, through the simulation of the smog chamber results by computer models, we plan to validate an appropriate chemical mechanism for further use in an atmospheric model.

The assessment of emission controls impact, Phase II, is dependent upon the results of Phase I: should ethanol be determined to be "unreactive" photochemically, further analyses would be unnecessary. However, if ethanol is determined to be reactive, the assessment of ethanol emissions on ozone concentrations would include three objectives.

- (1) To select and apply the most appropriate atmospheric model, incorporating the chemical kinetics developed in Phase I.
- (2) To rerun the model with alternative emission control levels and present the results in isopleths of ozone increases and decreases.

- (3) To rank alternative representative control measures available to the CARB and APCD for other hydrocarbon emission sources (i.e., not related to the wine industry) with respect to their effectiveness in smog reduction.

#### Procedures

The smog chamber experiment used to determine the reactivity of ethanol in an urban smog environment will be run in the outdoor smog chamber at the University of North Carolina.

The experiments to be performed in the chamber, and subsequently modeled, would use a surrogate blend of hydrocarbons which is designed to closely resemble a typical urban smog mixture and has been used for updating chemical mechanisms for the U.S. Environmental Protection Agency (EPA). The composition of the surrogate blend is shown in Table 1. The surrogate mixture would be used at three overall hydrocarbon to nitrogen oxide ratios. At each ratio, three sets of experiments would be performed: one with the full mixture, one with only two-thirds of the concentration, and one at two-thirds plus the remaining carbon concentration substituted by ethanol.

If ethanol substitution produced results similar to the two-thirds level without ethanol, then one could assume that ethanol was inert. If the substitution experiments were the same, or more reactive, than the full concentration experiments, then one could assume that the ethanol was as reactive or more reactive than the urban mixture.

The nine experiments would then be modeled by Systems Applications using computer techniques developed over the last ten years under EPA and other contracts. Successful simulation of the smog chamber data would then show that the chemical mechanism for the atmospheric chemistry of ethanol in an urban smog environment was validated and therefore acceptable for use in an atmospheric model.

Before an appropriate model can be selected for use in the assessment of the ethanol emission control impact, the emissions inventory data for the wineries of interest and other significant sources must be ascertained. Also, a meteorological, air quality, and emissions scenario will be selected which the Fresno County APCD agrees best represents the situation to be modeled. An appropriate atmospheric model will then be chosen on the basis of a number of study characteristics which include the terrain and area to be modeled and the kind and amount of data to be acquired.



TABLE 1. Composition of synthetic urban mixtures.

| COMPOUND               | SYNURBAN |
|------------------------|----------|
| N-BUTANE               | 0.1000   |
| N-PENTANE              | 0.1367   |
| ISOPENTANE             | 0.0801   |
| 2-METHYLPENTANE        | 0.0538   |
| 2,4-DIMETHYLPENTANE    | 0.0467   |
| 2,2,4-TRIMETHYLPENTANE | 0.1340   |
| ETHYLENE               | 0.0630   |
| PROPYLENE              | 0.0238   |
| 1-BUTENE               | 0.0137   |
| CIS-2-BUTENE           | 0.0169   |
| 2-METHYL-1-BUTENE      | 0.0187   |
| 2-METHYL-2-BUTENE      | 0.0171   |
| BENZENE                | 0.0331   |
| TOLUENE                | 0.1304   |
| M-XYLENE               | 0.0633   |
| O-XYLENE               | 0.0296   |
| 1,2,4-TRIMETHYLBENZENE | 0.0347   |
| FORMALDEHYDE           | 0.0200   |
| TOTAL PARAFFIN         | 0.5404   |
| TOTAL OLEFIN           | 0.1546   |
| TOTAL AROMATIC         | 0.2854   |

Since the reduction of emissions does not always have a linear relationship to the reduction of the ozone concentration in the atmosphere, a number of simulations will be made for alternative emission control levels. Isopleths will be generated in order to determine which emission control scenario would be appropriate for the desired reduction in ozone.

### Justification

Substantial equipment, capital, and operating costs would be incurred by the wine industry if the ARB or APCDs were to require the elimination of fermentation emissions. At the present time, there is insufficient technical information available regarding the role of ethanol emissions in smog formation to effectively, and scientifically, critique the proposed ARB and APCD actions. This research would address that need at a small fraction of the potential cost to the wine industry of the proposed regulations.

### Research Timetable

The following table presents the schedule for the proposed work:

TABLE 2. Proposed project schedule.

| Study Task                                             | Elapsed Study Time<br>(Months) |   |   |   |   |   |   |
|--------------------------------------------------------|--------------------------------|---|---|---|---|---|---|
|                                                        | 1                              | 2 | 3 | 4 | 5 | 6 | 7 |
| <u>Phase I</u>                                         |                                |   |   |   |   |   |   |
| Task 1 - Smog Chamber<br>Simulation & Report           |                                |   |   |   |   |   |   |
| Task 2 - Chemical<br>Mechanism<br>Development & Report |                                |   |   |   |   |   |   |
| <u>Phase II</u>                                        |                                |   |   |   |   |   |   |
| Task 3 - Model Selection                               |                                |   |   |   |   |   |   |
| Task 4 - Model Application                             |                                |   |   |   |   |   |   |
| Task 5 - Control Strategy<br>Assessment & Final Report |                                |   |   |   |   |   |   |

### Budget

The total cost for the proposed work is estimated to be less than \$95,000. Phase I, including the smog chamber experiments and the development of a mathematical model of the smog chamber results, is estimated to cost \$55,000. Phase II, if necessary, is estimated to cost \$40,000, depending in part on the Phase I results.

In order to expedite this proposal, we have solicited a preproposal from the University of North Carolina. Our cost estimates are contingent upon final negotiations with UNC, but we are confident that such negotiations will result in a project cost within the estimated amount. Of course, we would expect any award made by the Winegrowers of California as a result of this proposal to have a "not-to-exceed" value.

The breakdown of costs is shown in Table 3. Labor rates are in accordance with the attached fee schedule.

**CERTAIN TABLE WINE FROM THE  
FEDERAL REPUBLIC OF GERMANY,  
FRANCE, AND ITALY**

**Determinations of the Commission in  
Investigations Nos. 701-TA-258-260  
(Preliminary) Under the Tariff Act of  
1930, Together With the Information  
Obtained in the Investigations**

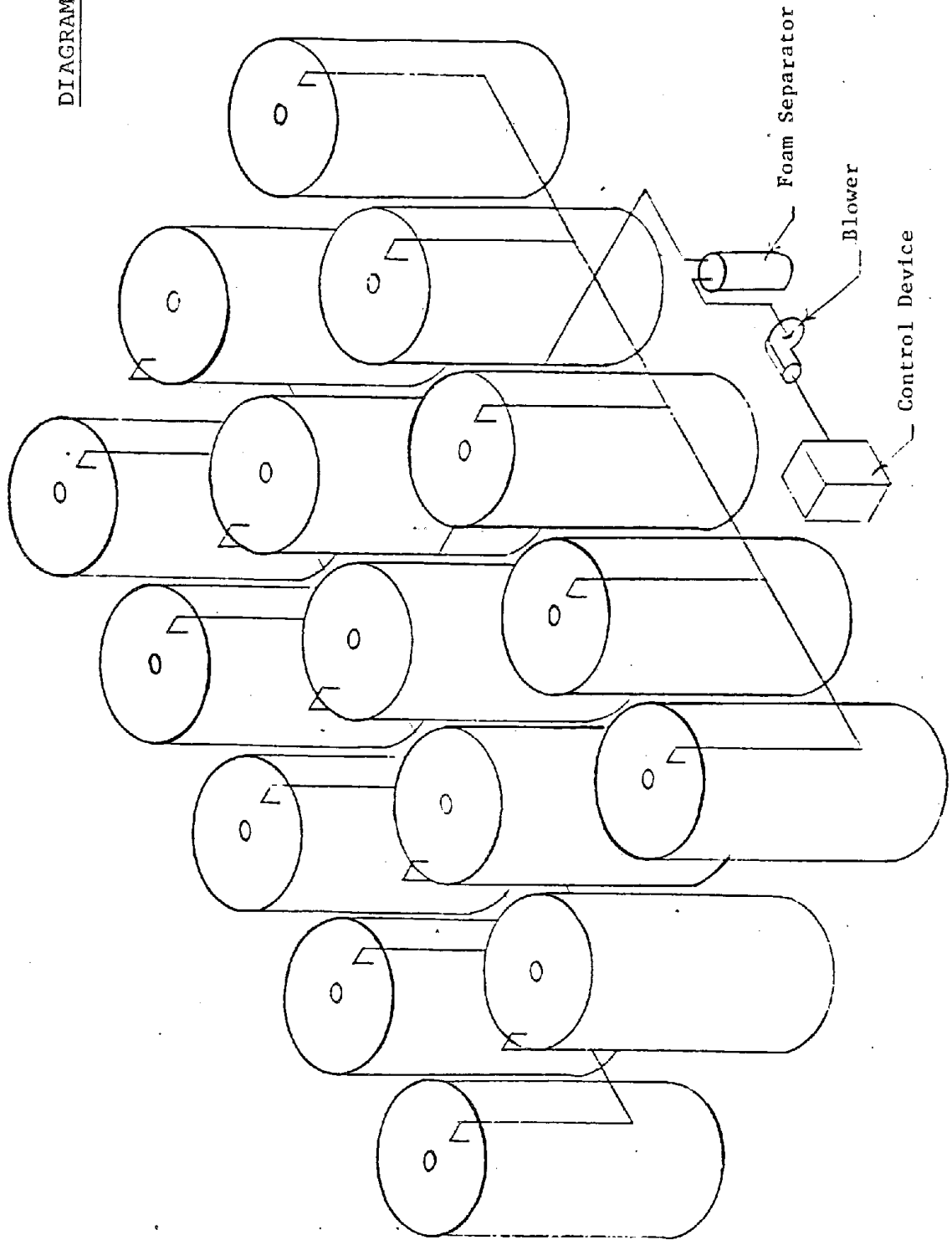
**USITC PUBLICATION 1771**

**OCTOBER 1985**

● *Exhibit F*

**Determinations of the Commission in  
Investigations Nos. 731-TA-283-285  
(Preliminary) Under the Tariff Act of  
1930, Together With the Information  
Obtained in the Investigations**

DIAGRAM #1



15 TANKS EXHAUSTED TO EMISSION CONTROL DEVICE

(Ducting supports not shown)

DIAGRAM #2

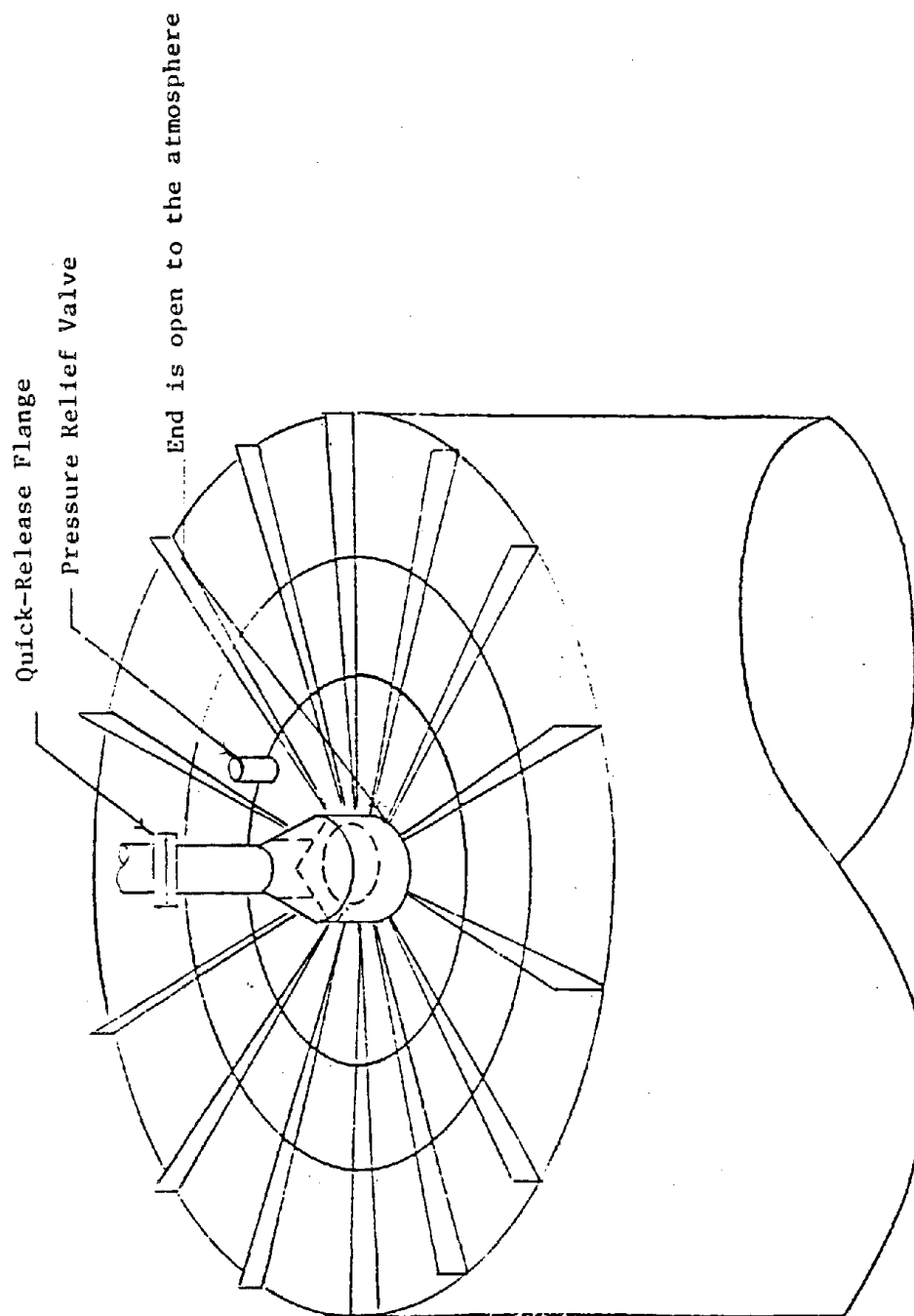
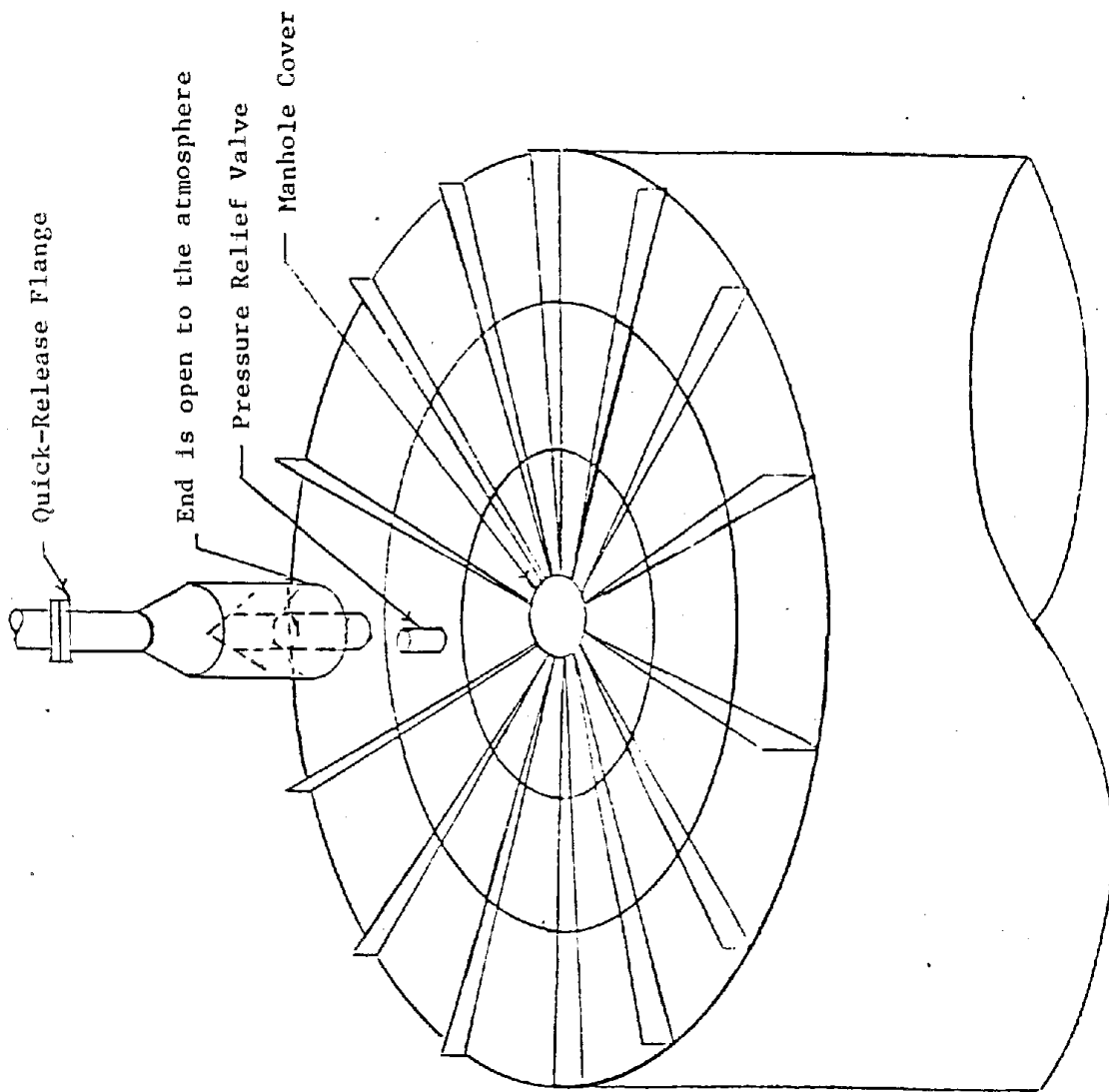


DIAGRAM #3



SCHEMATIC OF POSSIBLE CONNECTION OF DUCTING AT TANK

FERMENTATION ETHANOL EMISSION REDUCTION VIA CAPTURE AND TREATMENT--  
SANITATION AND PRODUCT QUALITY CONSIDERATIONS

Several fermentation ethanol emissions control technologies have been evaluated by the California Air Resources Board. The majority of them involved some method of capturing the emissions by incorporating a ducting scheme connecting all of the fermentors to a central location, where the ethanol vapors would be removed prior to releasing the gaseous emissions to the atmosphere.

Depending on fermentation temperature, one will expect to accumulate a volume of condensation liquid from fermentation vapors. Furthermore, the inside of the ducting network will always be damp during the harvest season. We can expect this liquid to be very close to a dilute, vinegary sweet wine in composition. Ethanol concentration should not be very high; perhaps in the range of 0.10 - 0.50%, depending on fermentation temperature. Accumulation of this fermentation broth will be heavier and higher in alcohol for red musts due to higher fermentation temperatures.

The sanitation of such a ducting system, whether directly connected to the fermentors, or suspended above the tank top openings is of great concern. To sanitize the ducting and keep it sanitized during the harvest season would be a veritable nightmare. It is very easy to contaminate non-fermenting musts with resistant wild yeasts, malolactic bacteria, etc. In the off-season, the molds will present the biggest problem, as they are quite thermoresistent and need little more than moisture of any type to proliferate.

Previous experience with inside fermentor CO<sub>2</sub> venting systems has shown us how a good idea can go wrong. The system fills up with fermentation foam, the foam ferments down to a foul smelling anaerobic liquid that has a potential to infect the fermentation tanks by running back through the duct system. In fact, what happens primarily involves the vent system draining this liquid within the cellar, causing a smell problem, and the same infection potential from another direction.

I think that a system designed not to vent excess CO<sub>2</sub> but to process or scrub it would have the same problems multiplied many times.

Because of the great need to utilize the fermentors constantly, it is highly unlikely that sufficient time could be made available to sanitize the ducting after each fermentation cycle. Fermentation foam therefore can accumulate and be returned to a fermentor with a high level of volatile acid (acetic acid and ethyl acetate), quite possibly contaminating the complete tank. The severe smell associated with the accumulated fermentation foam could possibly impart negative characteristics into fermenting juice and subsequent wine.



April 3, 1986

The best means of sanitizing this proposed ducting would be to fill completely with a hot, chlorinated caustic for some period of time, followed by a thorough hot water rinse. This procedure would be very difficult to perform during the vintage season and would require a large amount of hot water. Steam could also be used as a sanitizer, but it is doubtful that sufficient steam could be supplied to sanitize an entire ducting system, due to the distances that would be encountered in a large ducting system.

The attached page lists microorganisms likely to thrive in the ducting network. I could list considerably more molds and bacteria, but am confining myself to species confirmed to have thrived, when unchecked, in winery-type environments. I have included all these names just to give you an idea of how likely it is that we will have a large sanitation issue to address, should ethanol emission standards be implemented involving the use of ducting arrangements.

Tom Johnson  
Director of Engineering  
West Coast Operations  
Seagram Wine Company

TJ/pv

Exhibit H  
Page 2

YEASTS:

Brettanomyces: \* Bruxell ensis  
Claussenii  
Intermedius  
Lambicus

Pichia: \* Alcoholphila  
\* Farinosa  
\* Fermentans  
\* Membranae Faciens

Candida: Acuta  
Albicans  
Apicola  
Diversa  
\* Ethanolica  
Intermedia  
\* Mycoderma  
Pelliculosa  
Pulcherrima  
Rugosa  
Stellatoida  
\* Vinaria

Saccharomyces: \* Acidifaciens  
\* Bayanus  
\* Cerevisiae (32  
other variations of minor  
consequence)

Schizosaccharomyces:  
\* Acidodevoratus  
Malidevorans  
\* Pombe  
Liquefaciens  
Zygosaccharomyces  
Rouxi

Dekkera: Bruxellensis  
\* Intermedia

Filobasidium: Capsuligenum

Hansenula: \* Anomala

NOTE: \* Indicates species most likely to be present.

BACTERIA: (most common wine bacteria listed only)

Acetobacter  
Azobacter Aceti  
Lactic Acid bacteria such as Leuconostoc and other, less desirable  
Malolactic Cocci.  
Pedidcoccus (slime-forming. Form Diacetal and Histamine)

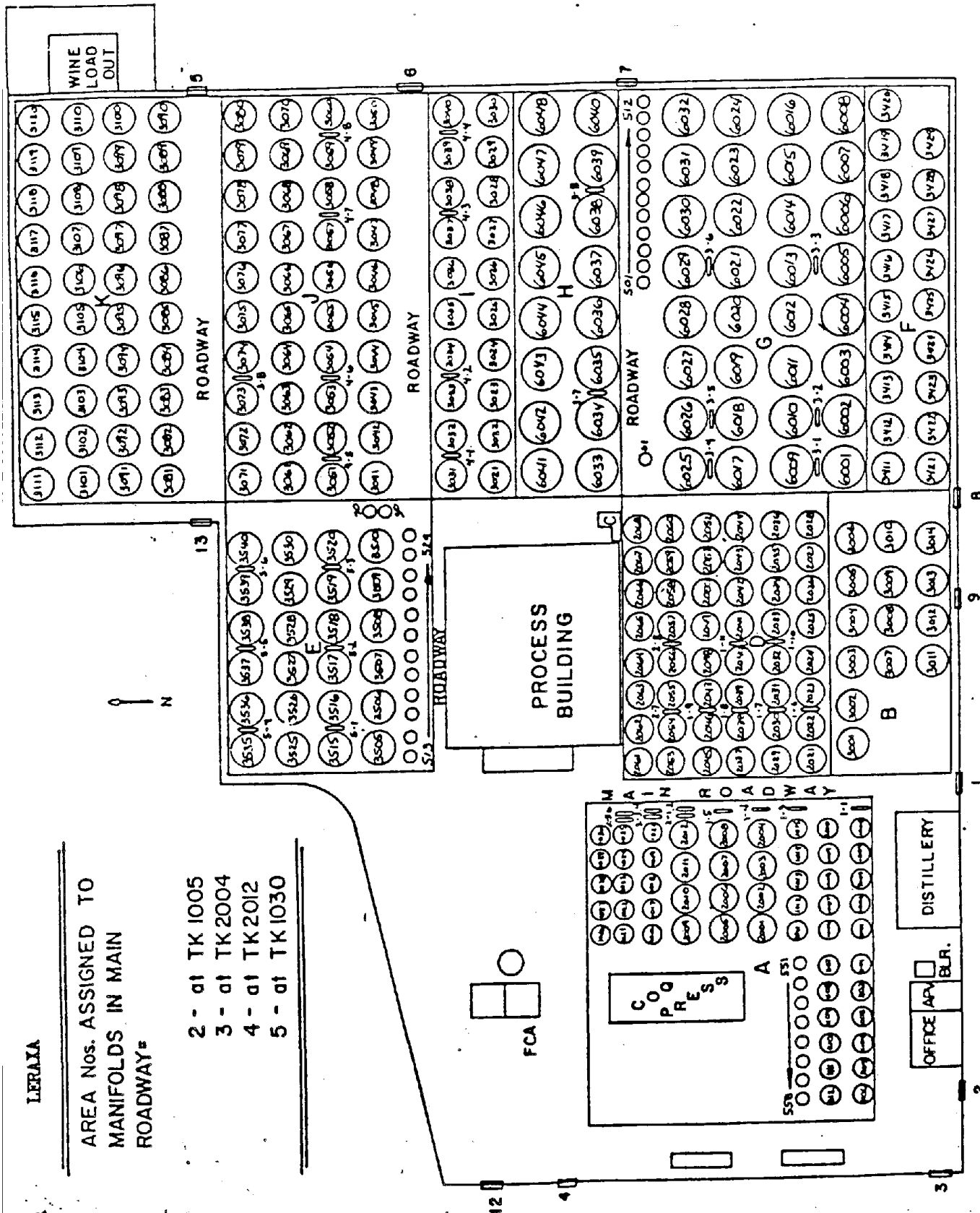
MOLDS: (most likely to be encountered; all have very high thermal resistance)

Paecilomyces Simplex  
Paecilomyces Varioti  
Byssochlamis Fulva  
Byssochlamis Nivea  
Aspergillus Niger

LERAXA

AREA NOS. ASSIGNED TO  
MANIFOLDS IN MAIN  
ROADWAY=

- 2 - at TK 1005
- 3 - at TK 2004
- 4 - at TK 2012
- 5 - at TK 1030



### Livingston Duct Costs

| <u>Tank Size</u> | <u>Number</u> | <u>Group Size</u> | <u>Annual Duct Cost (Lee Graph)</u> |
|------------------|---------------|-------------------|-------------------------------------|
| 100 K            | 12            | 12                | \$ 125,000 x 1.2 = \$ 150,000       |
| (red)            | 30            | (6) 5             | 75,000 x 6 = 450,000                |
| 200 K            | 12            | 12                | 175,000 x 1.2 = 210,000             |
| (red)            | 48            | (6) 8             | 175,000 x 4.8 = 840,000             |
| 335 K            | 19            | 10 & 9            | 90,000 x 1.9 = 171,000              |
|                  | 14            | 12 & 2            | 95,000 x 1.4 = 133,000              |
| 350 K            | 24            | (2) 12            | 95,000 x 2.4 = 228,000              |
|                  | 80            | (10) 8            | 95,000 x 8 = 760,000                |
|                  | 20            | (2) 10            | 95,000 x 2 = 190,000                |
| 600 K            | 48            | (3) 16            | 192,000 x $\frac{48}{15}$ = 614,400 |
|                  |               |                   | \$ 3,746,400                        |

### 1985 Crush Data

Total white production:

$$353,313 \text{ tons} \times 165 \text{ gallons/ton} = 58,297,000 \text{ gallons}$$

Total red production (incl. DM & dessert):

$$59,811 \text{ tons} \times 165 \text{ gallons/ton} = 9,869,000 \text{ gallons}$$

Total Emissions:

White wine @ 19°B and 60°F =

$$2.31 \text{ lbs EtOH/1,000 gallons} \times 58,297 = 134,666 \text{ lbs}$$

Red wine @ 23°B and 82.5°F =

$$8.13 \text{ lbs EtOH/1,000 gallons} \times 9,869 = \frac{80,235 \text{ lbs}}{214,901 \text{ lbs}}$$

$$\text{At 90 \% efficiency, } 0.9 \times 214,901 = 193,411 \text{ lbs EtOH removed}$$

$$\$ 3,746,400 / 193,411 \text{ lbs} = \underline{\$19.37/\text{lb EtOH removed}} \text{ using L. Lee graph.}$$

Exhibit J

THE ESTIMATION OF ETHANOL EVAPORATION RATES FROM  
WATER SOLUTIONS TO THE ATMOSPHERE

Roger Boulton  
R.B. Boulton Inc.  
Davis, California

For The ethanol Emissions SubCommittee  
Energy and Environmental Studies Committee  
Wine Institute  
San Francisco, California

31st March, 1986

Exhibit K  
Pages 1 - 4

## I. Introduction:

One of the alternatives being considered for the reduction in ethanol emissions from wine fermentors is to scrub the exit vapor with water in an absorption column. The stream so produced would contain approximately 1.1% mole/mole in ethanol for red wine and 0.4% mole/mole in ethanol for white wine and it has been suggested that this be pumped to fields where the solution would drain through the soil, allowing soil organisms to degrade the ethanol. Alternatively, the stream might be discharged in municipal sewer systems.

The purpose of this report is to calculate the evaporation rates of ethanol from this ethanol stream in order to determine to what extent evaporation would compete with microbial degradation as the mechanism by which the ethanol or its products would return to the atmosphere.

## II. Calculations:

This report has been broken into the following sections:

- A) Calculation of the water flow and ethanol content of the discharge stream.
- B) Calculation of the ethanol evaporation rate in stagnant air
- C) Calculation of the ethanol evaporation rate into laminar evaporation rate into a laminar boundary layer of air.

## III. Comments:

Comments on these results as they apply to the natural evaporation rates from flooded fields.

## II. A. Scrubber Discharge Stream

The basis of this calculation is the maximum expected ethanol emission rate of a 100,000 gal. fermentor at 85°F. The average rather than the maximum gas rate is combined with the final vapor ethanol content to provide a situation that reflects the maximum ethanol emission condition. Typical ethanol emission curves have been calculated for this situation (1).

The fermentor would produce approximately 5,590 ft.<sup>3</sup>/hour based on a 5 day fermentation at 85°F. The ethanol content of this vapor would be approximately 17,500 MM (ppm). This corresponds to a column loading of 11.32 lb/hour of ethanol per 100,000 gal. of fermentation. Based on a stripping factor (L/mG) = 1.6 (2) the water rate would be 672 mole/hour or 12,120 lb/hour per 100,000 gal. of fermentation.

## II. B. Evaporation Into A Laminar Boundary Layer

Assuming an air speed of 10 mph (14.7 ft./sec.), the mass transfer from a liquid film was calculated for the case of a laminar boundary layer. The layer that develops is approximately 0.6" thick, but the controlling resistance to transfer is confined to this layer.

Two cases have been evaluated (1) for red wines a slab 28 ft. x 28 ft. (2) for white wines a slab 44 ft. x 44 ft.

The initial evaporation rates have been used to calculate the minimum times and likely times of evaporation.

|     |                      | <u>Evaporation Time (days)</u> |                 |
|-----|----------------------|--------------------------------|-----------------|
|     | <u>Surface Shape</u> | <u>Minimum</u>                 | <u>Expected</u> |
| (1) | 28 x 28 (red wine)   | 4.5                            | 13.5            |
|     | 44 x 44 (white wine) | 5.4                            | 16.2            |

Clearly the most likely situation of the square surface, results in essentially complete evaporation in 18 days. The more likely situations of higher wind speeds and a turbulent boundary layer would produce even faster evaporation rates.

### III. Comments

The above calculations are conservative in many aspects, but still show that the evaporation times are of the same order as the times required for seepage and drainage.

The evaporation would be expected to continue from the soil after the liquid has drained. In this case, the available surface area would be greatly enhanced, favoring higher evaporation rates. The evaporation may, however, become diffusion controlled within the soil aggregate.

The calculation based on a laminar boundary layer is also conservative in that it assumes an average wind speed of 10 mph. The laminar boundary layer would almost certainly be disturbed by air turbulence, resulting in still higher evaporation rates, but correlations for turbulent mass transfer from flat surfaces do not appear to have been published.

The calculations of the absorption column lead to elevated temperatures due to ethanol absorption. The resulting solution would probably be 5 to 10°F higher than assumed in this calculation 68°F (20°C). This would lead to even higher evaporation rates than calculated. In a similar manner, the effect of solar radiation on solution temperature has been neglected, yet it is likely to be significant, leading to warmer solution temperatures.

In terms of microbial digestion of the ethanol there is an important aspect that should be well understood. This factor involves the inability of most yeasts, not to mention bacteria, to metabolize ethanol under anaerobic conditions. The absorber stream would contain between 1 to 1.5 g/L of dissolved carbon dioxide, and this would provide a very anaerobic atmosphere in the upper layers of the soil.

The land area (776 square ft. for red wines and 1940 square ft. for white wines) would be required for each 100,000 gallons of fermenting wine each hour.



## References

- 1) Williams, L.A. and R. Boulton. "Modeling and Prediction of Evaporative Ethanol Loss During Wine Fermentations" Am.J.Enol.Vitic. 32:234-242, (1983).
- 2) Treybal, R.E. "Mass Transfer Operations" 2nd Edition, McGraw Hill p. 257-262 (1968).
- 3) Bird, R.B., W.E. Stewart and E.N. Lightfoot. "Transport Phenomena" Wiley Toppan, p. 594-596 and p. 610-619. (1960).

An experiment was performed to give an example of the rate of evaporation of ethanol-water solutions projected by L. Lee's data to be 0.4% for white wine scrubbing and 0.1% for red wine scrubbing. Two plastic trays, approximately 11" x 14" were filled to a depth of 1" with the two solutions. The trays were set in filtered sunlight, and samples were taken periodically for ethanol analysis (which was performed by HPLC), and the total volume of the liquids was recorded at the same time. The attached table gives these data.

It can be seen from this information that, even under these mild conditions, only about an hour is required for 10% of the ethanol to evaporate into the atmosphere and that in five hours, almost 50% is lost. This loss would occur at much greater rates during the fermenting season in the San Joaquin Valley where the average temperatures exceed these by 20°-30°F, and the relative humidity is much lower. (These tests were conducted with R.H. of 38% or higher). As a result, no more than one hour infiltration time could be tolerated to avoid the loss of more than 10% of the scrubbed ethanol to the atmosphere. It should be noted that there is no guarantee that soil micro-organisms will decompose the ethanol in this length of time.

| Time | Temp.<br>°F | % Of<br>initial volume | % Ethanol      |                | Total % ethanol lost |                |
|------|-------------|------------------------|----------------|----------------|----------------------|----------------|
|      |             |                        | 0.04% solution | 0.10% solution | 0.04% solution       | 0.10% solution |
| 0900 | 55          | 100                    | 0.038          | 0.100          | 0.0                  | 0.0            |
| 1010 | 59          | 98                     | 0.035          | 0.093          | 9.7                  | 8.9            |
| 1100 | 61          | 97                     | 0.034          | 0.090          | 13.2                 | 12.7           |
| 1200 | 67          | 95                     | 0.031          | 0.083          | 22.5                 | 21.2           |
| 1330 | 69          | 91                     | 0.023          | 0.063          | 44.9                 | 42.7           |
| 1445 | 74          | 86                     | 0.018          | 0.050          | 59.3                 | 57.0           |
| 1550 | 73          | 85                     | 0.017          | 0.046          | 62.0                 | 60.9           |

Exhibit K - 2  
Page 2

# weather

## Modesto weather data

**LOCAL FORECAST:** Sunny and warmer. Highs 70 to 80. North to northwest winds increasing to 10 to 20 mph in the afternoon. Fair tonight. Lows in the mid 40s to low 50s. Sunny Friday. Highs in the 70s to mid 80s.

**EXTENDED OUTLOOK:** Fair except partly cloudy over the Sierra. Highs at lower elevations in the 60s along the coast to 70s and lower 80s inland. Lows in the upper 40s to lower 50s along the coast and the upper 30s to 40s inland.

**TEMPERATURES:** Wednesday's minimum 41, maximum 74, mean 57.5.

## MODESTO HOURLY TEMPERATURE READINGS:

|          |    |         |    |
|----------|----|---------|----|
| Mid-high | 48 | Noon    | 67 |
| 1 a.m.   | 47 | 1 p.m.  | 67 |
| 2 a.m.   | 46 | 2 p.m.  | 71 |
| 3 a.m.   | 46 | 3 p.m.  | 74 |
| 4 a.m.   | 47 | 4 p.m.  | 72 |
| 5 a.m.   | 46 | 5 p.m.  | 72 |
| 6 a.m.   | 45 | 6 p.m.  | 72 |
| 7 a.m.   | 48 | 7 p.m.  | 64 |
| 8 a.m.   | 50 | 8 p.m.  | 62 |
| 9 a.m.   | 55 | 9 p.m.  | 58 |
| 10 a.m.  | 66 | 10 p.m. | 58 |
| 11 a.m.  | 61 | 11 p.m. | 57 |

## AREA TEMPERATURES:

|           |    |    |
|-----------|----|----|
| Ceale AFB | 71 | 40 |
| Sonoma    | 66 | 29 |
| Stockton  | 76 | 42 |
| Turlock   | 72 | 47 |

**RECORD EXTREMES:** Temperature extremes on record for Modesto for May 7 since 1947: Highest, 83 in 1962; lowest, 33 in 1971.

**PRECIPITATION IN INCHES:** 24 hours ending Wednesday 6 p.m., .00; season beginning July 1, 17.83; last year this date, 11.08; normal to date, 11.43.

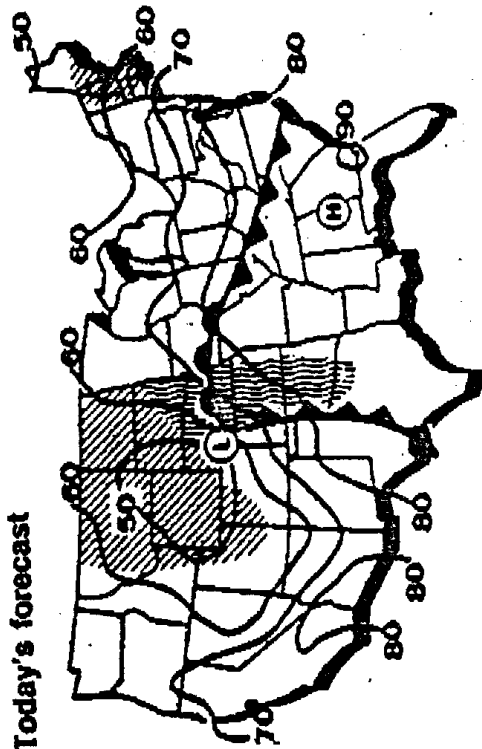
**RELATIVE HUMIDITY:** Wednesday's minimum 38, maximum 87.

**AGRICULTURAL BURN INFORMATION:** Phone 571-6044.

## River/reservoir reports

**STANISLAUS RIVER/NEW MELONES:** Storage 2,108,000 acre-feet. Elevation 1,061 feet. Inflow 2,000 second-foot. Release 1,000 second-foot.

## Today's forecast



## Forecasts

**MOTHER LODGE:** Sunny and warmer. Highs in the upper 60s to low 70s. Lows in the upper 30s to low 40s. Gusty winds.

**SAN FRANCISCO BAY AREA:** Sunny and warmer with highs in the mid 60s and 70s. Northwest afternoon winds 10 to 20 mph. Fair tonight with lows in the 40s to low 50s. Sunny Friday. Highs in the mid 60s to the low 80s.

**SALINAS VALLEY:** Sunny and warmer today. Highs in the upper 60s to near 80. Northwest winds increasing to 10 to 20 mph in the afternoon. Fair tonight. Lows in the upper 30s and 40s. Sunny Friday. Highs in the upper 60s to low 80s.

**SACRAMENTO VALLEY:** Sunny and warmer today. Highs in the 70s to lower 80s. North to northwest winds 10 to 20 mph. Fair tonight. Lows in the 40s to low 50s. Sunny Friday. Highs in the mid 70s to mid 80s.

**NORTHERN SIERRA/LAKE TAHOE:** Sunny and warmer through Friday.

**YOSEMITE:** Sunny and a little warmer through Friday.

**MONTEREY BAY AREA:** Sunny today with highs in the mid 60s to low 70s. Fair tonight. Lows in the upper 40s to low 50s.

## The nation's weather

**SUMMARY:** Up to half a foot of snow fell Wednesday in the northern and central Rockies, prompting travelers' advisories and a warning to cattlemen to shelter young livestock from the foot or more of additional snow expected by morning. Warm temperatures prevailed from the middle and south Atlantic Coast states across the lower half of the Mississippi Valley to the southern Plains. Early afternoon readings were mainly in the 80s, with temperatures in the lower 90s over eastern parts of the Carolinas. Showers and thunderstorms were scattered over New England, eastern parts of the Tennessee Valley, the southern Plains and the middle Missouri Valley. Rainshowers were scattered over the southern Rockies.

**FORECAST:** Today's forecast calls for rain, with snow in the northern and central Rockies. Showers and thunderstorms are likely over the northern Plains. Scattered showers and thunderstorms should occur over New England and upstate New York and from the southern Rockies across the upper and middle Mississippi Valley to parts of the lower Ohio Valley. Widely scattered showers and thunderstorms should develop during the afternoon of the 14th.

Livingston Condensation Costs

| <u>Tank Size</u> | <u>Number</u> | <u>Group Size</u> | <u>Annual Cost (Lee Graph)</u>        |
|------------------|---------------|-------------------|---------------------------------------|
| 100 K            | 12            | 12                | \$ 247,000 x 1.2 = \$ 296,400         |
| (red)            | 30            | (6) 5             | 150,000 x 6 = 900,000                 |
| 200 K            | 12            | 12                | 360,000 x 1.2 = 432,000               |
| (red)            | 48            | (6) 8             | 360,000 x 4.8 = 1,728,000             |
| 335 K            | 19            | 10 & 9            | 146,000 x 1.9 = 277,400               |
|                  | 14            | 12 & 2            | 200,000 x 1.4 = 280,000               |
| 350 K            | 24            | (2) 12            | 200,000 x 2.4 = 480,000               |
|                  | 80            | (10) 8            | 200,000 x 8 = 1,600,000               |
|                  | 20            | (2) 10            | 200,000 x 2 = 400,000                 |
| 600 K            | 48            | (3) 16            | 405,000 x $\frac{48}{15}$ = 1,296,000 |
|                  |               |                   | <hr/> \$ 7,689,800                    |

\$ 7,689,800/193,411 lbs = \$ 39.76/lb EtOH removed using  
L. Lee graph.

Exhibit L



2548 Paulson Rd.  
P.O. Box 2997  
Turlock, CA 95381  
(209) 668-8107  
TELEX 88-1183

Serving the Food, Beverage and Processing Industries

April 2, 1986

Mr. Art Caputi, Jr.  
E & J GALLO WINERY  
P. O. Box 1130  
Modesto, CA 95353

Dear Mr. Caputi:

Based on your inquiry of 3-14-86, we at L & A Engineering & Equipment, Inc., are pleased to submit the following:

| <u>ITEM</u> | <u>QUANTITY</u> | <u>DESCRIPTION</u>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|-------------|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A           | 1               | <p>L &amp; A Condenser Scrubber System designed to remove ethanol from Fermenter off gasing stream based on a gas flow of 551 SCFM using an R-22 Refrigerant system operating at a suction pressure of -12°F with a rating of 165,000 BTU/HR to include:</p> <ol style="list-style-type: none"><li>1. One (1) ethanol condenser (evaporative design)</li><li>2. One (1) compressor package (approx. 50 HP) with integral refrigerant fin tube condenser.</li><li>3. Skid mounting with control panel</li></ol> <p>Price (budget - each).....\$ 45,200.00<br/>F.O.B.: Point of Origin<br/>Delivery: Sixteen (16) weeks</p> |

Applicable taxes must be added. Terms and Conditions on page 2 and our General Conditions of Sale, Form GC1172, hereto attached, are applicable.

We appreciate this opportunity to offer the above proposal for your consideration and look forward to working with you further on this project. If you should have any questions, please do not hesitate to contact me directly.

Sincerely,  
L & A Engineering & Equipment, Inc.

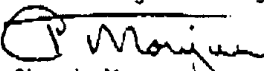
  
Chuck Morgan  
Sales Engineer

EXHIBIT M

State of California  
Air Resources Board

Received 5/8/86  
by Board Secretary

THE CHRISTIAN BROTHERS,

WINERY

MONT LA SALLE VINEYARDS  
P.O. BOX 57 REEDLEY, CALIFORNIA 95224-0057

May 8, 1986

Air Resources Board  
1102 Q Street  
Sacramento, Ca. 95812

RECEIVED

MAY 9 1986

Stationary Source  
Division  
Air Resources Board

Re: ARB Proposed Control Measure for Ethanol Emissions  
from Winery Fermentation Tanks

Dear Sir or Madam:

Mont La Salle Vineyards is opposed to the ARB proposed control measures for reducing ethanol emissions from winery fermentation tanks. Design integrity, disregard for wine processing procedures, and feasibility are factors which support this opinion.

To an industry already burdened with economical problems, the initiation of such proposed controls could be the demise of a number of California wineries. Mont La Salle Vineyards does not object to the mandate of the Clean Air Act of 1978, it does question the board's recommendations of designed systems for an industry which they do not fully understand.

The most successful evidence of ethanol emissions reduction has been demonstrated through temperature control. Mont La Salle Vineyards recognizes this to be the most effective means to achieve an overall reduction. This approach does afford the winemakers some latitude for his art-form as well as providing year-around processing advantages, enhancing the cost effectiveness of the control measure.

Aside from this type of control, the proposed ducting system for fermentation tanks is not practical. The system is labor extensive and does not address important sanitary control procedures. The cumbersome deployment of carbon dioxide gas and disturbed vapor pressure within the fermentation tank are questions which can only be resolved through designed "demonstration projects". Quality assurance evaluation must also be considered.

The various disposal methods proposed by the ARB lacks sufficient information to determine the design integrity. For example, water from any type of scrubbing system would require a totally independent ponding system. Currently, waste discharge water from Mont La Salle Vineyards enters the ponding system at approximately 200°F. Mixing ethanol with this hot discharge material does not represent sound judgement.

Further, evaporation records maintained at University of California Kearney Agriculture Center shows totals of 14.86 and 14.66 inches of evaporation during the fermentation periods of 1984 and 1985. From this data, it appears impractical to discharge an ethanol mixture onto the land in the San Joaquin Valley during August and September. Acquisition of additional land for this purpose would not be considered.

Included in this response are cost analysis for a ducting system and disposal recommendations determined from the ARB cost projections. Computations are based on 57°F. fermentation temperatures and 2.55 pounds of ethanol emitted per 1000 gallons, for the design limits of Mont La Salle Vineyards. Also included are emission rates at the present rates.

Currently, processing procedures do not require colder fermentation temperatures. This in principal is due to the production of a white wine base material for distillation. The current average fermentation temperature for this distilling material is 85° F.

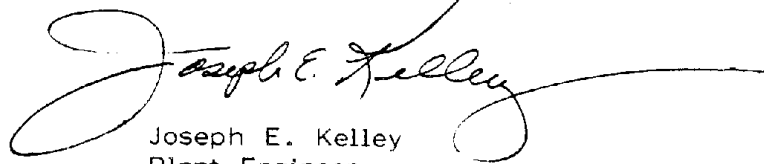
Mont La Salle Vineyards will be required to sustain an expenditure of \$1.5 million to meet industry standards if the ARB order is in any way temperature related. This expense coupled with ducting and disposal requirements would create a serious financial hardship.

Before adoption of any rule, Mont La Salle Vineyards suggests that the TRG give further consideration to:

- (1) Photochemical reactive of ethanol.
- (2) Feasibility and cost effectiveness analysis.
- (3) Degradation of product quality.

Sincerely,

MONT LA SALLE VINEYARDS

  
Joseph E. Kelley  
Plant Engineer

JEK:sk  
Encls.



MONT LA SALLE VINEYARDS COST ANALYSIS - WHITE WINE FERMENTATION AT 57 DEGREES F.

| Fermentation Tanks: |    |      | Quantity  | Size       | Gallons   | Modules | Gallons | Ducts +53% | Utility Costs  | Carbon Absorption | Scrubbing | Cat. Incineration |           |             |
|---------------------|----|------|-----------|------------|-----------|---------|---------|------------|----------------|-------------------|-----------|-------------------|-----------|-------------|
|                     | 14 | 50K  | 700,000   | 1-10(100K) | 1,000,000 |         |         | \$143,561  | (Card. Absor.) | \$114,000         | \$6,400   | \$105,000         |           |             |
|                     | 6  | 200K | 1,300,000 | 1-5(300K)  | 1,500,000 |         |         | \$135,559  |                | \$131,000         | \$7,200   | \$122,000         |           |             |
|                     | 12 | 100K | 2,304,000 | 2-10(100K) | 2,000,000 |         |         | \$286,722  |                | \$228,000         | \$12,800  | \$210,000         |           |             |
|                     | 8  | 80K  | 736,000   | 1-5(100K)  | 500,000   |         |         | \$78,336   |                | \$105,000         | \$5,300   | \$83,980          |           |             |
|                     | 48 | 40K  | 1,920,000 | 2-10(100K) | 2,000,000 |         |         | \$286,722  |                | \$228,000         | \$12,800  | \$210,000         |           |             |
|                     | 88 |      | 7,040,000 |            | 7,000,000 |         |         | \$930,699  | \$14,195       | \$806,000         | \$44,500  | \$730,980         |           |             |
| TOTALS:             |    |      |           |            |           |         |         |            |                |                   |           | \$1,736,699       | \$975,199 | \$1,661,679 |

FERMENTATION SEASON; AUGUST-OCTOBER: 50 DAYS

CAPACITY OF GRAPES CRUSHED: 85,000 TONS

PORTION OF WHITE GRAPES:  
BRANDY 82 PERCENT  
DRY WINE 3 PERCENT

AVERAGE WHITE JUICE 13,005,000 GALLONS/YEAR

WHITE FERMENTATION TEMP.

AT 85 DEGREES AT 57 DEGREES

Ethanol emitted from white juice 7.76#/1000 Gal 2.55#/1000 Gal

Refrigeration alone would reduce emissions by 33%

90,826 lbs. 29,845 lbs.

Capital Costs X3  
Annual Operating Costs

\$5,210,097  
\$42,585 \*\*\*\*\*  
\$14,195

After Tax Annual Cost:

\$541,850

Ethanol Control @ 90%

29,845 lbs

Cost Effectiveness Dollar/Lb.

\$5.96/lb \$6.05/lb

# Monterey Peninsula Winery

467 Shasta Avenue  
Sand City, California 93955  
(408) 394-2999

July 30, 1986

Mr. Alan Goodley, Chief  
Strategy Assessment Branch  
Stationary Source Division  
Air Resources Board  
PO Box 2815  
Sacramento, California 95812

Dear Mr. Goodley:

I am usually inclined to applaud efforts to improve the quality of our environment, including cleaning up air pollution. However, I am alarmed at the prospect of having to cope with ethanol emissions from wine fermenters.

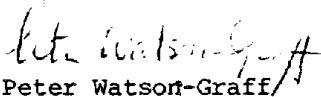
We are a small winery producing some 5000-10000 gallons of wine from 100-200 tons of grapes. Our white fermentations are carried out in 60 gallon barrels which spew yeast and grape solids out the bung hole during the maximum fermentation rate. Controlling anything being emitted from these containers would be messy and complicated. There are wineries which are fermenting wine in hundreds of barrels. I fail to see a cost-effective means which would trap emissions.

Our red wine fermentations are carried out in straight-sided tanks of 3000 gallon capacity with open tops. These are "pumped over" at least twice a day requiring the tanks to be open for spraying the juice over the floating "cap" of skins. It is also necessary for proper fermentation that the top of the tank be left open to the air in order that the CO<sub>2</sub> be released and the O<sub>2</sub> be absorbed.

Our wines have won some 140 medals including 24 this year alone. These methods which are traditional and time-honored are part of the reason for our success. We cannot change these methods without changing the character of our wines and losing our competitive edge.

In other words, I can see no method for trapping emissions from our fermenters without great expense or completely changing our procedures. The former is impossible and the latter unthinkable.

Sincerely,

  
Peter Watson-Graff  
Winemaker

*Sherrill Cellars*

1185 Skyline Blvd.  
P.O. Box 620050  
Woodside, CA 94062  
(415) 851-1932

Alan Goodley, Chief  
Strategy Assessment Branch  
Stationary Source Division  
Air Resources Board  
P.O. Box 2815  
Sacramento, CA 95812

Dear Mr. Goodley,

I have just received your letter requesting comments on ethanol emissions from winery fermentation tanks.

The only comment I wish to make is to ask that your commission please be reasonable when you consider the size of winery involved and exempt those who are very small from any recommendations you make.

We have eight 4X4 fermenters and live 15 miles from the nearest suburban area. I can't believe that those eight fermenters can make any difference to our air quality. If you or your commission can prove that it is so then perhaps we should be included. That does seem unlikely. I will follow your decisions with interest.

Thank you for your attention.

Sincerely,

*Jan W. Sherrill*

Jan W. Sherrill  
Sherrill Cellars

8/1/86

THE CHRISTIAN BROTHERS.  
VINTNERS SINCE 1882

MONT LA SALLE VINEYARDS  
P.O. BOX 420 NAPA, CALIFORNIA 94559 707-226-5566

August 22, 1986

RECEIVED

AUG 26 1986

William J. Roddy  
Chairman  
Technical Review Group  
Air Resources Board  
1102 Q Street  
P.O. Box 2815  
Sacramento, CA 95812

RE: Suggested Control Measures (SCM)  
for Winery Fermentation Tanks

Dear Mr. Roddy:

Control of ethanol emissions (or alcohol vapors) from fermentation tanks could cost the wine industry immense sums of money and still not solve any air pollution problems.

Some air pollution authorities make the claim that ethanol emissions are hydrocarbons which contribute to the development of photo-chemical smog. There is no proof that this claim is supported by facts.

Practical observation indicates that ethanol emissions are not a problem. If they were, each large winery would have a plume of smog downwind from the winery. And there are no such downwind plumes. In fact, our employees, who are closest to the source, and our downwind neighbors, do not suffer from or complain about ethanol emissions.

Another practical observation is that the general smog condition in the San Joaquin Valley is lower in the fall - the wine fermentation season - than at some other periods of the year. Whereas, if ethanol emissions were a smog contributor, one would think that the wine fermentation season should be the smoggiest time of the year.

THE CHRISTIAN BROTHERS.

VINTNERS SINCE 1882

---

Page 2

William J. Roddy

Brother Timothy

SCM for Winery Fermentation Tanks

August 22, 1986

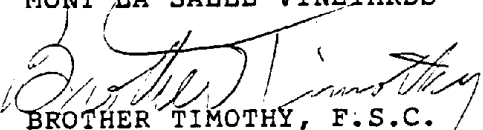
As this subject is of concern to vineyardists and winery people, I call your attention to the fact that the sprinkling of many thousands of acres of vineyards washes or "scrubs" the atmosphere, improving air quality by removing particulate matter and other contaminants from the air. This is a major benefit that is a direct mitigation of any air pollution problems which may have arisen in wine grape vineyards or wineries. In fact, it is possible that vineyard sprinkling may remove from the air more pollutants than are traceable to vineyards and wineries.

We are active members of Wine Institute and support the arguments Wine Institute may present to your committee. As a member of the Wine Institute Executive Committee, I know that Smog Chamber research, financed by the wine industry, is under way to determine the facts about the reactivity of ethanol emissions and their role, if any, in the production of photochemical smog. I believe it reasonable and equitable that your committee wait for the results of this Smog Chamber research so that any decision is based on facts rather than unsupported opinion. I respectfully urge you to adopt such a responsible course of action.

I remain,

Respectfully yours,

MONT LA SALLE VINEYARDS

  
BROTHER TIMOTHY, F.S.C.  
Vice President/Cellarmaster

BT:ab

cc: Technical Review Group Members

Heublein Wines  
12667 Road 24 P O Box 99 Madera California 93639



AUGUST 25, 1986.

W.J. Roddy, Chairman, TRG.  
FRESNO COUNTY AIR POLLUTION  
CONTROL DISTRICT  
P.O. Box 11867  
Fresno, Ca 93721

SUBJECT: SCM FOR WINERY FERMENTATION TANKS.

Dear Mr. Roddy:

The ARB Technical Support Document for subject matter was received at the end of July, 1986.

The time is too short to allow a detailed response to all the areas of question in the report prior to Aug.29, 1986.

The report itself and the comments and responses section indicate to us that the ARB staff has not listened to us in previous meetings and/or did not hear what we said.

We suggest that the TRG visits our winery during crush to first hand experience the special problems associated with managing fermentation tanks.

We would also recommend that the visit covers a full fermentation cycle or at least 5-7 days to experience all aspects of handling large fermenting tanks and to better envision the insurmountable problems with any ducting system.

We have still basically the same comments, issues and concerns as expressed in our previous letter dated May 5, 1986 addressed to Mr.Goodley.

No ethanol emission control rule should be proposed and/or implemented prior to:

- 1.The results from the second phase of the Wine Institute sponsored Smog Chamber test to determine the reactivity of ethanol.
- 2.The successful completion of the Demonstration Project.

Mr. W.J. Roddy, Chairman, TRG.  
SCM for Winery Fermentation Tanks  
August 25, 1986  
Page two

Regarding the proposed demonstration project, we don't believe it is practical or justified to require each winery producing 10 million gallons of wine per year (approx. 50,000 tons of grape crush) to invest monies in a demonstration project.

It seems to us that the first thing to demonstrate is that a reliable Ducting System can be designed, built, operated and maintained in an economical, efficient, safe and sanitary manner.

It should suffice to build one ducting system with one of the proposed control devices to demonstrate the feasibility of the most important part of the system i.e. the ducting.

The system could be designed by independent experts, who could also monitor the actual operation at the selected winery. The funding of the project could be prorated by all wineries, which would be affected by the proposed rule.

If the first demonstration project were to be successful, the next step would be to try out the remaining three control methods.

We are once more stating our previously expressed concerns and opinion:

All four proposed methods of emission control require that tanks used for fermentation be equipped with a ducting system to collect the CO<sub>2</sub> gas with the ethanol.

None of the four proposed methods has been demonstrated and proven as safe, practical and reliable to use in a food processing operation with its special public health requirements and regulations.

It is our strong opinion that any control method employing a ducting system should be ruled out for the following reasons:

The ARB cost numbers are considerably understated. This is understandable since they are based on a very simplistic layout and design without detailed knowledge of operating conditions and winery requirements for equipment design.

The existing tank construction does not allow any higher internal pressure than one half ounce per square inch. This pressure limitation results in large dia. ducts with high installation costs and impractical operation.

Mr. W.J. Roddy, Chairman, TRG.  
SCM for Winery Fermentation Tanks  
August 25, 1986  
Page three

It is very doubtful that a design could be devised to make a ducting system functional relative to sanitation, safety, reliability and practical operation.

Major portions of the emission collecting system will have to be bypassed on a regularly scheduled basis for sanitation. This non-productive time is in addition to downtimes for repairs and maintenance.

There is a risk that additional ethanol is released from the surface of the liquid in the fermenter due to disturbing the normal equilibrium. This could also remove flavor and aroma components from the end product i.e. the wine.

We also seriously question the rationale for ARB's proposed plans for the recovered ethanol.

It just doesn't make good sense to spend a lot of money to collect an alleged pollutant and then let it out in the environment in the same or slightly altered form.

It is likely that the emissions reduced by lowering fermentation temperatures will equal the total net ethanol recovery from any of the gas collection methods after adjustments for all downtimes due to equipment breakdowns and scheduled sanitation shutdowns.

It should be noted that the fermentation process cannot be arrested upon demand and that ethanol will continue to be emitted until the fermentation is completed.

In view of the above it is our recommendation, if any ethanol emission control must be implemented, that ARB follows the lower fermentation temperature control method recommended earlier by the Fresno County Air Pollution Control District.

This control method is practical, reliable and will also improve the end product.



Mr. W.J. Roddy, Chairman, TRG.  
Chairman, TRG  
SCM for Winery Fermentation Tanks  
August 25, 1986  
Page four

NO RULE SHOULD BE ADOPTED PRIOR TO THE OUTCOME OF A DEMONSTRATION PROJECT AND/OR THE PHASE TWO SMOG CHAMBER TEST STUDY.

In summary the areas of concern:

Ethanol's reactivity classification.

Cost effectiveness of proposed control methods.

Net ethanol recovery from proposed ethanol recovery systems.

Reliability of ethanol recovery systems.

Capital cost of ethanol recovery systems.

Annual operating cost of ethanol recovery systems.

Disposition of recovered ethanol. Secondary pollution.

Area required to dispose of recovered ethanol.

Size and cost of ducting system.

Sanitation of ducting system.

Safety of operation of ducting system.

Additional ethanol loss from using ducting system.

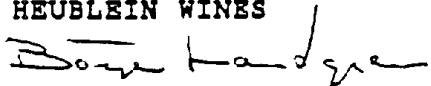
Flavor and aroma deterioration from using ducting system.

Product integrity.

Weakened economic position relative to competition from imported wines.

Sincerely,

HEUBLEIN WINES

  
BORJE LANDGREN.

DIRECTOR OF ENGINEERING AND MAINTENANCE

Copy:  
TRG Members.

RECEIVED

AUG 29 1986

THE CHRISTIAN BROTHERS,

Library Source

ENTREPRENEUR

THE SOURCE

Library Source

MONT LA SALLE VINEYARDS

P.O. BOX 589 REEDLEY CALIFORNIA 93654 209-638-3544

August 28, 1986

Mr. Alan Goodley  
Air Resources Board  
P. O. Box 2815  
Sacramento, Ca. 95812

Dear Mr. Goodley:

The Christian Brothers Mont La Salle Vineyards is opposed to the Suggested Control Measure for reducing ethanol emissions from winery fermentation tanks, published June, 1986. The document is technically weak, lacking in practical cost effective control measures. Ambiguous contradictions appear within the report when attempting to justify cost projections. These areas of concern coupled with the recently completed study conducted by Systems Application Incorporated of San Rafael, Ca., confirming that ethanol is not the strong photooxidant it once was theorized to be, warrants additional research and engineering feasibility studies. Nowhere in the report has proprietary production practices been considered. The presentation has eluded that wine production is a common day to day practice and has failed to consider the highly regulatory nature of this food processing industry.

The modeling and smog chamber studies have established the chemical reaction of ethanol. Conclusive evidence indicates additional meteorological and engineering studies are warranted before the adoption of regulatory measures. The study further confirms that considerations could be given to lowering wineries on the priority list of industrial pollutants compiled by the ARB. It is now recognized that ethanol is not classified as an air pollutant. The compiling of this data can effectively be applied to the ARB proposed San Joaquin Basin study slated for 1988.

The five control methods recommended by the ARB are of questionable integrity within themselves. ARB admits to an demonstration project as a final determination of feasibility. In our opinion, the purchase and installation costs are greatly underestimated. Tank alterations and support requirements for additional equipment to the already in place equipment are costly items not considered by the ARB. The single most important item, the proposed ducting system needs realistic engineering analysis before it is mandated. With the recent tax restructuring, cost effective measures can no longer be considered tax advantages for offsetting payback.

THE CHRISTIAN BROTHERS,

---

Page 2

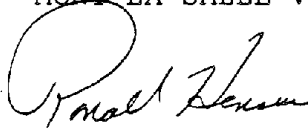
The need for a demonstration project is recognized by the ARB as well as the industry. There are, however, major areas to overcome before any attempt is made. Namely, site selection, funding, and creditability. Perhaps a more realistic approach would be pilot scale investigation of feasibility by independent experts or coupling University environmental and enology experts for evaluation. Funding of such a project could be resolved among the wineries.

Any rule formulation should definitely be deferred until demonstrations can be evaluated.

As a member of the Technical Review Group, we ask that you give earnest consideration to our views.

Sincerely,

MONT LA SALLE VINEYARDS



Ronald Hanson  
Plant Manager

RH:sk

RECEIVED

AUG 29 1986

THE CHRISTIAN BROTHERS,  
CONTINERS SINCE 1912

Primary Source  
THE SOURCE  
The Source, Inc.

MONT LA SALLE VINEYARDS

P.O. BOX 589 REEDLEY CALIFORNIA 93654 209-638-3544

August 28, 1986

Mr. Alan Goodley  
Air Resources Board  
P. O. Box 2815  
Sacramento, Ca. 95812

Dear Mr. Goodley:

The Christian Brothers Mont La Salle Vineyards is opposed to the Suggested Control Measure for reducing ethanol emissions from winery fermentation tanks, published June, 1986. The document is technically weak, lacking in practical cost effective control measures. Ambiguous contradictions appear within the report when attempting to justify cost projections. These areas of concern coupled with the recently completed study conducted by Systems Application Incorporated of San Rafael, Ca., confirming that ethanol is not the strong photooxidant it once was theorized to be, warrants additional research and engineering feasibility studies. Nowhere in the report has proprietary production practices been considered. The presentation has eluded that wine production is a common day to day practice and has failed to consider the highly regulatory nature of this food processing industry.

The modeling and smog chamber studies have established the chemical reaction of ethanol. Conclusive evidence indicates additional meteorological and engineering studies are warranted before the adoption of regulatory measures. The study further confirms that considerations could be given to lowering wineries on the priority list of industrial pollutants compiled by the ARB. It is now recognized that ethanol is not classified as an air pollutant. The compiling of this data can effectively be applied to the ARB proposed San Joaquin Basin study slated for 1988.

The five control methods recommended by the ARB are of questionable integrity within themselves. ARB admits to an demonstration project as a final determination of feasibility. In our opinion, the purchase and installation costs are greatly underestimated. Tank alterations and support requirements for additional equipment to the already in place equipment are costly items not considered by the ARB. The single most important item, the proposed ducting system needs realistic engineering analysis before it is mandated. With the recent tax restructuring, cost effective measures can no longer be considered tax advantages for offsetting, payback.

THE CHRISTIAN BROTHERS,

CONFIDENTIAL

Page 2

The need for a demonstration project is recognized by the ARB as well as the industry. There are, however, major areas to overcome before any attempt is made. Namely, site selection, funding, and creditability. Perhaps a more realistic approach would be pilot scale investigation of feasibility by independent experts or coupling University environmental and enology experts for evaluation. Funding of such a project could be resolved among the wineries.

Any rule formulation should definitely be deferred until demonstrations can be evaluated.

As a member of the Technical Review Group, we ask that you give earnest consideration to our views.

Sincerely,

MONT LA SALLE VINEYARDS



Ronald Hanson  
Plant Manager

RH:sk



RECEIVED

SEP 3 - 1986

NOT RECORDED  
AIR RESOURCES DIVISION

August 29, 1986

Mr. Bill Roddy, TRG Chairman  
Fresno County Air Pollution Control District  
P.O. Box 11867  
Fresno, CA 93721

Dear Mr. Roddy:

There are a substantial number of issues which Sebastiani Vineyards feels need to be addressed before a Control Measure, like the one first proposed at the workshop on April 8, can be seriously considered.

A primary concern is the cost/benefit ratio. Subjectively, the potential benefit to be derived from controlling ethanol emissions from winery fermentations seems inconsequential when compared to the costs that would be incurred. Capital expenditures of this magnitude are a serious obstacle to California wineries in view of current market conditions.

The seriousness of winery ethanol emissions is itself a very important issue in this regard. If the reactivity of ethanol as a pollutant is as clearly established as the COMMENTS AND RESPONSES section accompanying the most recent SCM states, it would be helpful to know the specific references and sources of the data cited in sections VII. A. 1. and 2. It is the understanding of much of the wine industry that this relationship has not been clearly established to date. The industry-sponsored cloud chamber study was designed to determine whether ethanol emissions from wine fermenters are a serious pollution hazard. Pending results from that study or other concrete evidence, it is Sebastiani Vineyard's position that ethanol emissions from wineries do not constitute a serious pollution hazard.

In addition, there is substantial question as to which, if any, of the methods presented during the workshop are applicable to winery operations. To my knowledge, no winery in the world has used any of the proposed technologies to control ethanol emissions under the very special conditions that exist in a winery environment. Projections of capital and operating costs and resultant cost effectiveness calculations could be subject to substantial error without an objective history of actual operations. Any errors in those calculations could have a profound effect on the decision-making process from both a regulatory and a business standpoint.

Until very recently it was my understanding that the proposed reduction in ethanol emissions would affect only wineries in the Fresno Air Pollution Control

P.O. BOX AA - 389 FOURTH STREET EAST - SONOMA, CALIFORNIA 95476 - 707-938-5532

CARB-SBAPCD HB 000424

Page two

District. Regulated and monitored control of fermentation temperatures to attempt to reduce ethanol emissions in that district seemed likely at some unspecified time in the future. As recently as December, 1985 the Fresno County APCD presented an SCM to the TRG recommending temperature control as the method of choice for reducing ethanol emissions in the Fresno APCD. I suspect that most wineries in other districts, like Sebastiani Vineyards, were interested but not concerned, since they were not directly affected by the measure.

The TRG rejected the Fresno APCD recommendation. The ramifications of that rejection first surfaced at the April 8, 1986 workshop. At that time it became clear that the ARB felt that all wineries using tanks larger than 50,000 gallons for fermentations would be equally subject to the proposed regulation; it also became apparent for the first time that temperature control was no longer the recommended control method.

Suddenly wineries which were only peripherally interested became directly affected; not only could they be affected by the regulation itself, but the whole scope of the regulation had changed. Additional refrigeration is a known, proven, familiar and highly useful technology. Putting fume hoods and charcoal filters or after-burners on fermenting wine tanks is an expensive, risky, unproven, probably unnecessary and certainly extremely novel approach to what seems intuitively to be a fairly minor problem.

Such a proposal requires serious consideration and discussion with all affected parties. The wineries that will bear the highest cost/pound for ethanol removal as well as the highest cost/gallon produced are those with tanks at the low end of the control measure. Cost-effectiveness decreases dramatically at tank sizes below 100,000 gallons.

Sebastiani Vineyards has 32 tanks with capacities above 50,000 gallons; 16 of them have a capacity of 50,803 gallons, all but two are under 100,000 gallons. All of them could be conceivably required to be used as fermenters at some point. Based on curves presented in the first draft of your SCM I would estimate annual costs to equip and operate the suggested ducting/catalytic conversion systems at about \$110,000 per tank, a total of \$3,500,000 per year!

The perceived benefit to be gained by placing this burden on the wine industry is open to question. If in fact the calculations and studies presented in the SCM are correct, the benefit would be that 500-600 tons of ethanol exhaled by healthy yeasts in the process of making wine will be converted to CO<sub>2</sub> and water.

The cost, in addition to the monetary outlay, will be the pollution resulting from mining, milling, manufacturing, transporting, erecting and operating tons of 302 stainless steel ducting and machinery that will have to be replaced in 10-15 years. If one were to draw a "pollution balance" around the coal mines, steel mills, power plants and diesel trucks necessary to execute this endeavor, will the result be a net reduction in pollution? Although I have not done the research to date to support it, I very seriously doubt it.

These observations are a first response to the information I have received to date. It is possible that with time and sound investigation, it will become

Page three

apparent that the measure you are proposing is a necessary step to protect our environment. That point has not been reached to date.

The pilot scale operation is a reasoned move in that direction. If it proves conclusively that substantial amounts of serious pollutants can be removed in a genuinely cost-effective manner, that will be a step in the right direction. Even then it will be necessary to evaluate the results of that study before formulating a Control Measure that will make sense.

For the Air Resources Board to approve a Control Measure for winery emissions in the absence of sound scientific and engineering data regarding necessity and efficacy of the proposal seems very premature and unnecessary.

Sebastiani Vineyards will be happy to work with your organization to clarify these issues at future meetings and workshops; please contact us with regard to any future meetings or discussions.

Sincerely,

SEBASTIANI VINEYARDS



Glenn O'Dell  
Director of Technical Services

GD/tjg

cc Mr. Dennis Beauregard, Vice Chairman  
Mr. Ronald A. Friesen, Secretary  
Mr. Alan Goodley  
Mr. Peter Hess  
Mr. Harry Dillon  
Mr. Eric Skelton  
Mr. Walter Mook  
Mr. Dick Smith  
Mr. Larry Bowen  
Mr. Jim Breitlow



9/10 - California Air Resources Board  
By letter, 9/10/86

# WINE INSTITUTE

165 Post Street  
San Francisco, CA 94108  
415/986-0878  
Telex 5101004310 Cable "WINE" Telecopy 415/391-4269

Morris H. Katz  
Director Governmental Affairs

August 29, 1986

Mr. William J. Roddy  
Chairman, Technical Review Group  
County of Fresno Department of Health  
1221 Fulton Mall  
P.O. Box 11867  
Fresno, CA 93775

RECEIVED

SEP 2 - 1986

Ordinary Source  
Div. 10  
Air Resources Board

Re: ETHANOL EMISSIONS  
ARB Proposed SCM

Dear Mr. Roddy:

Wine Institute, the trade association of the California wine industry, submits the attached Supplemental Comments and accompanying exhibits in response to the revised proposed Suggested Control Measure For Emissions of Ethanol From Winery Fermentation Tanks and the Technical Support Document prepared by the staff of the California Air Resources Board. Wine Institute received the revised SCM and Technical Support Document at the end of July. Due to the short deadline for comments and the fact that this is the crush season for industry members, Wine Institute was not able to complete its research for the Supplemental Comments. If further information becomes available, it will be presented at the September 16, 1986 workshop in Sacramento.

The Technical Review Group has also asked for the final report on the Wine Institute sponsored smog chamber study of ethanol reactivity. A copy of that report and an executive summary, prepared by Systems Applications, Inc., are also being submitted with this letter.

The Supplemental Comments should be read in connection with Wine Institute's comments submitted to the ARB on May 9, 1986. Those comments were addressed to the SCM first proposed by ARB staff and the staff's draft supporting document. The original staff SCM, like the revised SCM, required 90% control of ethanol emissions.

In the May Comments, Wine Institute pointed out that the SCM set an impossible standard for compliance because the ARB staff had failed to consider a great many technical problems in evaluating control methods to achieve the required 90% reduction of ethanol emissions. Those deficiencies in the staff's analysis meant that the proposed control methods could not be considered feasible. Wine Institute also described several omissions and mistaken assumptions that rendered the staff's estimates of the costs of emissions controls both unreliable and far too low. Among other things, the staff had failed to account for the fact that virtually all tanks at a winery would have to be equipped with ducting to any control device.

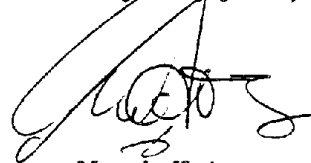
Mr. William J. Roddy  
August 29, 1986  
Page 2

The staff's revised SCM and Technical Support Document discuss some of the concerns raised by Wine Institute in May. However, as noted in the Supplemental Comments, serious omissions remain in the staff's discussion of both the technical aspects of and the cost estimates for the control methods that the staff believes would allow wineries to comply with the SCM. Perhaps recognizing these weaknesses, the staff proposes to include a pilot study requirement in the SCM. Unfortunately, too little time is allowed for such pilot studies. The staff also fails to provide for reevaluation of the feasibility and cost effectiveness of the SCM after the pilot studies are completed.

Wine Institute believes that the proposed SCM should not be adopted until ethanol emissions are proven to have an adverse effect on air quality. The ARB staff has proceeded on the assumption that ethanol is reactive and, on a pound for pound basis, produces as much ozone as a typical urban VOC mix. However, the SAI smog chamber study and two previous studies of ethanol reactivity indicate that, at worst, ethanol is far less effective at producing ozone than a typical urban VOC mix, and this effectiveness declines to zero as atmospheric conditions vary. Furthermore, Wine Institute notes that the San Joaquin Valley Air Basin Control Council intends to conduct a comprehensive study of the sources and possible solutions to air pollution in the valley air basin. This study is prompted in part by concerns over the effectiveness of existing emission control regulations. Accordingly, Wine Institute submits that control of ethanol emissions should not be a regulatory priority, and the TRG should consider deferring any proposed SCM until there is some evidence that control is justified.

Wine Institute appreciates the opportunity to present its views to the TRG at the September 16, 1986 workshop. A representative from SAI will also be present to explain the results of the smog chamber study and answer any questions.

Very truly yours,



Morris Katz  
Director of Governmental Affairs

cc: TRG Members

Enclosures

SUPPLEMENTAL COMMENTS OF  
WINE INSTITUTE ON TECHNICAL  
SUPPORT DOCUMENT AND PROPOSED  
SCM FOR ETHANOL EMISSIONS CONTROL

August 29, 1986  
Wine Institute  
165 Post Street  
San Francisco, CA 94108

1. Pages 3-5: Background:

The ARB staff's description of the events leading to development of the proposed SCM does not explain why the Fresno APCD abandoned its original SCM proposal. This proposed SCM, like the one now proposed by ARB staff, would have required installation of control equipment that could reduce ethanol emissions by 90%.

After the Fresno APCD proposed the SCM requiring 90% control, Wine Institute pointed out (in comments submitted in January, 1983) that the proposed SCM was not feasible, because no available control equipment could operate with the required efficiency and the costs per pound of ethanol removed from the atmosphere would be far greater than any potential benefit to air quality. Wine Institute made the same points in a presentation to the TRG on April 14, 1983. As a result of this meeting, the TRG asked the Fresno APCD to develop a fermentation temperature control rule. In 1983, the TRG apparently was concerned about the feasibility and cost-effectiveness of an SCM requiring installation of emissions control equipment. Wine Institute believes that those concerns should still exist.

The staff also claims that, on April 22, 1986, it "presented detailed schematics of the ducting system which the industry had requested." These drawings were neither "detailed schematics" nor did they respond to the industry's requests. This issue was discussed at pages 13-18 of the May 9, 1986 Wine Institute Comments Regarding California Air Resources Board Proposed Suggested Control Measure For Ethanol Emissions From Winery Fermentation Tanks And Supporting Review Materials ("May Comments").

The staff has also failed to understand that virtually every tank at a winery must be ducted and linked to a control device, substantially increasing the costs of ducting and control equipment. The staff states that it learned in April meetings with Wine Institute members that an additional 35% excess working capacity is necessary within each group of tanks ducted to a control device. This prompted a revision of the cost estimates for the control measures. Unfortunately, while additional tank capacity is necessary for fermentation, this does not remove the need for virtually every tank at a winery to be used as a fermenter at one time or another.

2. Page 6. Ethanol emissions from fermentation tanks can be reduced by 90% using commercially available emission control equipment. (Conclusion 2):

This conclusion apparently is drawn from the staff's experience with other industries, like the petroleum industry, where conditions are completely different from the wine

industry. Some of these differences were discussed at page 9 of the May Comments. However, as Wine Institute pointed out in May, the control technologies recommended by the staff have never been tested, much less used in the unique conditions of the wine industry. The staff now concedes that a pilot study will be necessary to evaluate these control methods. Since the ARB's cost-effectiveness estimates depend on the unproven assumption of 90% control, the proposed SCM cannot be properly evaluated at this time.

3. Page 6. The overall cost effectiveness of the proposed SCM cannot be determined because of lack of detailed information on each of the wineries. This is the reason costs were estimated for specific groupings of tanks (Conclusion 3):

Wine Institute has previously pointed out that the tank groupings assumed by the ARB represent the ideal situation and therefore are the most economical possible. (See May Comments, page 13). If the staff had asked, Wine Institute would have provided actual tank layouts for the purpose of making cost estimates.

Wine Institute has performed cost estimates for the ducting (without any control devices) installed at the facility of an industry member in Livingston, California. Despite serious reservations regarding the staff's assumptions about the costs and feasibility for the ducting system as designed, Wine Institute accepted those assumptions for the purpose of making the cost estimates. Wine Institute also made the most economical

grouping of the tanks possible, even though this economy may not be achieved in practice. Even with those assumptions, Wine Institute found that the pre-tax cost per pound of ethanol removed for the ducting alone would be more than \$19.00 per pound. (May Comments, page 19).

4. Pages 6-7, capital costs and overall cost-effectiveness for catalytic incineration, scrubbing, condensation, and carbon adsorption (Conclusions 4-6):

All of these conclusions depend on the accuracy of the staff assumptions regarding the costs and efficiency of the control methods. These assumptions are unproven and ignore many important facts.

5. Page 7. Application of control equipment to reduce ethanol emissions would have a negligible environmental impact (Conclusion 7):

Wine Institute assumes this statement is based only on the additional pollution caused by generation of power necessary for the proposed control measures. The staff has not adequately addressed the costs or environmental impact resulting from disposal of wastes produced by the proposed control measures. These issues are discussed in more detail later in these comments.

6. Page 7. To eliminate any unforeseen difficulties, the SCM should provide for a demonstration program (Conclusion 8):

A pilot study is necessary, but the proposed SCM contemplates a program that will be too brief to yield meaningful results. In addition, Wine Institute believes that the SCM cannot be properly evaluated until the results of a pilot study are available. Wine Institute will amplify these points in its comments on the proposed SCM.

7. Pages 9 and B-7, time for each fermentation cycle:

On page 9 of the Technical Support Document, the staff states that white wines "are fermented in seven to 10 days," and red wines "take from three to six days to ferment." These estimates are approximately correct. However, on page B-7, in a note to Table 2, the staff states that the fermentation time in one cycle is "[s]even days for white wine, and one day for red wine." this statement appears to be inconsistent with the statement on page 9.

8. Pages 12-13, appropriate fermentation temperatures for red and white wine:

Fermentation temperature is a variable used by each winemaker to determine the style of wine that will be produced. As a result, the staff errs in stating that ranges of "recommended"

fermentation temperatures exist or that temperatures above a certain level "yield lesser quality wines". While average fermentation temperatures have been dropping over recent years, some winemakers may still prefer to ferment some wines at higher temperatures to achieve a certain style of wine.

9. Page 13. Fermenting must may "foam-over" if fermentation temperatures are not carefully controlled:

Catastrophic "foam-over" incidents can occur even when strenuous efforts are made to control fermentation temperatures. Therefore, any emissions control method involving ducting of tanks must incorporate as one of its operating assumptions the possibility that large quantities of foam may erupt into the ducting system.

10. Pages 23-24. Exhaust ducting is designed to occupy the vacant aisles:

In the May Comments (page 18), Wine Institute pointed out that exhaust ducting cannot be placed in open aisles because those aisles must be kept clear to allow access to the tanks by heavy equipment. Consequently, the ducting systems would have to be installed in the aisles where ducting is already in place, considerably increasing the costs and difficulty of installation. The Staff Report has failed to take this into account in its cost calculations.



11. Pages 25, 27-28, Figures V-1, V-2, and V-3:

These drawings present essentially the same ducting system design and layout as those drawings made available on April 22, 1986. Wine Institute has already pointed out that these drawings are a gross oversimplification of the system that would be required (May Comments, pages 13 et seq). For example, the drawings assume that the fermentation tanks will be in the most economical layout possible. The drawings also fail to demonstrate how the supports would be designed for any part of the ducting system. This omission is critical, because the design of the supports must be specified before determining whether and how winery fermentation tanks would need to be modified.

So much has been left out of the staff's design of the proposed ducting system that little credence can be given to the staff's cost estimates. For example, the staff estimates the cost of painting and installing the ducting supports as 5% of "fixed capital costs" for the ducting system. However, the staff does not discuss the costs and difficulties of modifying the fermentation tanks to hold the supports.

Fermentation tanks are designed to accommodate a certain structural load, including existing catwalks and ladders. Existing tanks have not been designed to support an additional large ducting system, including an additional emission vent, and the ladders and catwalks associated with that system. Each tank will have to be analyzed to determine if it will support the additional load. If a given tank will not support the load, it will have to be bolstered, at additional expense.

The work necessary to install a new emission vent has been described at pages 15-16 of the May Comments. That description did not include the installation of new catwalks and ladders to the vent and the installation of ducting supports on each tank. If the tank is insulated, the insulation must be stripped before the work can proceed. The catwalks, ladders, and supports must be welded to the tank and tested. Then the tank must be tested for leaks. Finally, new insulation must be applied. The cost of this work alone will be substantial.

12. Pages 24,26. The ducting system can be kept free of foam and cleaned by installing a foam separator and an "automated clean in place system":

Wine Institute is not aware of any foam separator that could reliably protect the blower and control device from foam and other materials sucked into the ducting system. As previously noted (May Comments, p. 17, n.6), the centrifugal foam separator mentioned by an industry member in an informal discussion with an ARB staff member was based on different specifications and was intended only as a starting point for discussion. No representation was made that the foam separator would work under the conditions required by the ARB's proposed ducting system.

While some wineries use automatic clean in place systems for their large must lines, Wine Institute believes that these systems cannot automatically be extrapolated for use on the ducting systems proposed by the staff. Winery must lines are typically 8" or less in diameter, are designed to carry large

quantities of liquid, and are hooked to both pumps and tanks. Thus, the quantities of cleaning solution needed are manageable, and facilities exist to pump the solution through the lines and accommodate it in a tank for ethanol disposal. The proposed ducting systems will have none of these attributes. Special valves, pumps, and cleaning solution disposal facilities would have to be installed as part of each ducting system. Due to the large size of some of the ducts (up to 30" in diameter, according to Table IV-2 on page A-22 of the Technical Support Document), those pumps and facilities must handle a huge quantity of cleaning solution. The staff has not considered the costs of such special cleaning facilities.

13. Page 26 and Appendix C, proposed exhaust vent and "china cap" design:

The staff now appears to agree that a separate vent must be installed to exhaust ethanol emissions into the proposed ducting system. Recognizing the serious sanitation concerns created by an open vent covered by a ducting system (May Comments, p. 18 and Exhibit H), the staff proposes placing a "china cap" over the vent. This design creates more problems than it solves.

First, the proposed vent opening appears to be undersized. On page C-2, the staff states that the maximum pressure drop through the tank opening must be  $4.5 \text{ lb/ft}_2$  to maintain the tank at a safe pressure level. The staff goes on to assume that the  $4.5 \text{ lb/ft}_2$  consists of two pressures: a pressure drop across the orifice and a pressure drop across a "90 degree ell".

The staff's equations in Appendix C are in a form which suggest an isothermal approach. Wine Institute believes that an adiabatic approach would be more appropriate. (This and other issues are discussed in the 4th Edition of Perry's Chemical Engineer's Handbook, at pages 5-24 to 5-45.) Furthermore, entrance and exit loss need to be considered, and the assumption that the area between the china cap and the tank opening can be set equal to the area of the orifice to prevent pressure buildup is not substantiated by any calculations in Appendix C.

The equations used in Appendix C are for gas flow only, and will probably not apply to two-phase flow when foam is present. Experimental information will have to be developed to estimate the pressure drop when foam is present. In fact, some of the equations in Perry's Chemical Engineer's Handbook are arrived at experimentally.

The staff also neglects that a duct is to be located near the tank opening. The pressure drop from the tank opening through the duct to the "turboblower" must be considered as part of the 4.5 lb/ft<sup>2</sup>.

Second, the proposed china cap will be a source of contamination to the tank, due to solid or liquid build-up on the underside of the cap. The cap also substantially increases the chance of damage to the tank due to a catastrophic "foam-over" incident. If the foam contains solid matter (particularly likely if red wine is being fermented), the cap could cause the vent opening to become plugged with solids. The resulting pressure in the tank would damage the tank. Since foam-over incidents are

not uncommon at wineries during fermentation season, particularly when power outages occur, the danger of damage to the tanks caused by the china cap cannot be disregarded.

14. Pages 29-31, design of carbon adsorption system and Figure V-4:

The staff describes how carbon adsorption works in theory, but fails to describe the equipment used in a carbon adsorption system. Figure V-4 is only a diagram of how the pieces of equipment in such a system might relate to each other. The figure provides no information on the design of the equipment. Given this deficiency, which the staff has known about for some time (May Comments, p. 21), Wine Institute can neither determine whether the equipment will achieve the required 90% control efficiency nor evaluate the accuracy of the specific cost estimates made by the staff.

Wine Institute believes that carbon adsorption is generally used for removal of aromatic and nonpolar gases like solvents from emissions streams (see Exhibit 1, an excerpt from a supplier's technical information sheet). Ethanol is both aliphatic and polar, so that information gained from typical applications of carbon adsorption is not transferable to ethanol emissions.

The staff states that a particulate filter will be necessary to remove particulates and droplets that would reduce the adsorptivity of the carbon bed. No specifications are given for this filter. Wine Institute assumes that this unspecified filter would be placed after the similarly unspecified centrifugal

separator that the staff has proposed as part of the ducting system. If not, the filter would become clogged the first time a significant amount of foam or other solid or liquid matter entered the ducting system. However, even with this arrangement, a breakdown of the foam separator or its failure to work effectively would lead to a clogging of the filter. Consequently, the feasibility of this filter/centrifugal separator arrangement cannot be ascertained without a pilot study.

The staff states that carbon adsorption proceeds until the carbon bed is saturated and needs regeneration. Wine Institute would be interested in learning how the need for regeneration is determined and what additional equipment would be needed.

The staff indicates that design of the carbon adsorption system must be optimized between steam costs and increased bed size to compensate for the reduced working capacity due to the ethanol "heel." However, the staff does not appear to account for this design criterion in estimating costs for the system.

15. Pages 31-33, design of the condensation system:

The staff has not changed its description of the condensation system in any way that is responsive to the following comments made previously by Wine Institute (see May Comments, p. 26):

In its look at condensation, the Staff Report accepts the conditions for a successful condensation system described by Professor Lynn Williams. [See p. A-60] The estimated cost for the system was adopted from a 1982 quote from L & A Engineering & Equipment. That quote does not include costs for the piping and equipment necessary for storage and

disposal of the condensate. Moreover, the quote does not reflect an operational system.

The quote was obtained from L & A by Wine Institute to illustrate that actual costs of a condenser would be far greater than had been estimated by the Fresno APCD. The bidder was not asked to account for the unique conditions applicable to wineries. For example, the emissions gases are loaded with moisture. At a condenser temperature of  $-12^{\circ}\text{F}$ , the coils would ice up almost immediately, and the efficiency of condensation would drop to unacceptable levels. Any condenser system would have to have several coils, each with a defrost cycle. Even with this feature, the efficiency of the system could not be guaranteed in advance.

Wine Institute attached a more recent quote for condensation equipment (which had the same technical limitations as the 1982 quote) as Exhibit M to its May 1986 Comments. The staff did not use this more recent quote in calculating condensation costs.

The staff claims that icing on condenser coils will not be a problem because the vendor did not think it would occur. However, the vendor refused to guarantee this claim. In fact, icing on the condenser coils is inevitable.

The staff calculates that, to achieve condensation of 90% of the ethanol in the exhaust stream, the condenser must achieve temperatures of  $-12^{\circ}\text{F}$  for red wine and  $-36^{\circ}\text{F}$  for white wine. (Technical Support Document, p. A-60). As both red and white wine fermenters may be attached to the same control device,  $-36^{\circ}\text{F}$  will be the standard operating temperature for condensation. The Staff assumes that condensation will produce a liquid that is 40-44% ethanol by volume. (Technical Support Document, p. 86). However, Professor Williams suggests that intermediate condensates would contain a lesser percentage of ethanol. (Technical Support Document, p. A-82).

A solution of 44% ethanol by volume has a freezing point no lower than -20°F. (See the graph attached as Exhibit 2, taken from Mellan, Industrial Solvents Handbook, 2nd Ed., Noyes Data Corp (1977)). Therefore, even the most concentrated ethanol in water solution will rapidly ice up the condenser coils.

The staff believes that a hot gas defrost system could be installed to handle icing on the coils. Even if this system were feasible, it would require additional condenser coils to be operating while other coils are being defrosted. The staff's cost estimates do not cover the cost of this defrost system or the cost of the additional condenser coils. (See pp. A-60 through A-66 of the Technical Support Document).

16. Pages 33-35, design of catalytic incineration system and Figure V-5:

Wine Institute believes that the staff's assumptions regarding operating parameters and costs for the catalytic incinerator may be very optimistic. The ethanol being incinerated is associated with a much larger volume of non-combustible carbon dioxide, and the relative proportions of each can be expected to vary depending on the fermentation stage of the must in each tank attached to the incinerator. Even at the maximum ethanol concentration (which the staff accepted as the design criterion), the gas mixture is expected to consist of only between 0.64% and 1.6% ethanol. Furthermore, the staff is assuming an operating temperature of 500°F. Wine Institute believes that this is the lowest end of normal operating



temperatures for catalytic incinerators. To the extent operating temperatures must be higher and the catalytic incinerator must be specially designed due to the composition of the fermentation exhaust stream, the actual costs may be higher than estimated by the staff. These are issues that can only be addressed by a pilot study.

Wine Institute also notes that the staff is predicting little  $\text{NO}_x$  production by catalytic incineration at 500°F. However, if the incineration must proceed at higher temperatures,  $\text{NO}_x$  emissions may present a pollution problem.

Wine Institute has previously pointed out (May Comments, p. 21) that the staff is also underestimating the normal costs of operating a catalytic incineration system by predicated those costs on the use of pipeline natural gas. Many wineries do not have access to natural gas in this form. These wineries would be forced to use LNG, propane, or butane delivered to them by tank truck or railcar. Not only are these fuels much more expensive than pipeline natural gas, but they are also much more dangerous to handle.

Even wineries with access to natural gas cannot rely on it. Wineries are included as industrial users of gas, and are subject to curtailment. For example, PG&E's G-58 service schedule provides that natural gas service is subject to curtailment at any time, and PG&E's contracts require customers to maintain back-up equipment. Thus, each catalytic incinerator equipped for natural gas would need back-up equipment to allow use of another fuel in the event the natural gas supply is interrupted.

17. Pages 34, 36-37, design of scrubbing system and Figure V-6:

While the staff has provided an example of a scrubbing unit in Figure V-6, it is not clear whether the cost quotes set forth on page A-47 are for the scrubber shown or for some other system. In any event, the sizing and efficiency of any scrubbing unit are issues that would have to be resolved in a pilot study.

The staff still has not addressed the problem of disposing of scrubbing wastes. Wine Institute believes that the ethanol in these wastes is likely to return to the atmosphere and that this problem alone renders scrubbing infeasible. This is discussed at greater length later in these comments.

18. Page 40, Table V-1:

This table is meaningful only if the emissions control measures work with the efficiencies assumed by the staff. Wine Institute has repeatedly pointed out that this is a doubtful assumption, because those emissions controls have never been demonstrated to work in the unique conditions of the wine industry.

19. Page 42. The overall emissions reductions achievable with exhaust control are much greater than with temperature control, indicating that emissions control should be the basis for any proposed SCM:

Wine Institute believes that this conclusion ignores certain important advantages that fermentation temperature control has over emissions control. First, fermentation temperature control definitely works with the predicted efficiency. No one can say whether the proposed emissions controls will work at all, much less work with the required 90% efficiency. Second, while fermentation temperature control may restrict winemakers' ability to make styles of wine that require high temperature fermentation, it does not directly threaten product quality. In contrast, emissions controls may actually threaten product quality, due to sanitation concerns (See Exhibit H to the May Comments). Finally, a fermentation temperature control rule would help maintain the reductions in ethanol emissions that have occurred since 1977 due to the general reduction in fermentation temperature. Despite the staff's fears, no one predicts a significant shift in the market back towards red wine consumption in the foreseeable future.

20. Page 42. The costs of emissions control systems are subject to economies of scale:

Wine Institute believes that this statement is speculative until the actual costs and workings of emissions control are explored through a pilot study.

21. Page 43. In making cost estimates, it is appropriate to add 50% more tank space to the tank farms attached to each control device to account for the 35% excess fermentation capacity required by wineries:

This statement reflects a fundamental error in the staff's understanding of the practical aspects of winery operation. Wineries need to maintain excess fermentation tank capacity, consisting of empty tanks into which fermenting must can be put or transferred at need. However, this fact has no impact on the cost of ducting, because virtually all tanks at a winery must be equipped with ducting. Wineries need to be able to use virtually all of their tanks as fermenters at one time or another, even though not all tanks at a winery may actually be used as fermenters during a given season.

The staff has assumed that only the tanks actually used for fermentation during the season need to be ducted. This is tantamount to the assumption that wineries have designated fermentation tanks and only those tanks are used for fermentation each season. That assumption is wrong. It causes the staff's cost estimates for ducting to be gross underestimates. If the staff had not made this error, the staff might have come up with pre-tax cost estimates for its ducting system similar to the \$19.37 per pound of ethanol removed derived by Wine Institute. (see pp. 18-19 in the May Comments).

Wine Institute also believes that ducting all of the tanks means that additional control equipment would have to be installed, even though all of the equipment might not be used in

each season. The staff has not included these costs in its estimates.

Wineries use virtually all of their tanks for fermentation from time to time because this is the most efficient way to operate a winery. If certain tanks are to be designated as fermenters, as the staff assumes, then every winery would have to construct a substantial number of additional tanks at its facility (many wineries do not have the room to do this). The staff has not addressed the cost and difficulty of constructing such additional tanks.

22. Pages 44-53, methodology for cost effectiveness curves:

The staff's cost effectiveness calculations and curves are illusory unless the staff has made accurate assumptions regarding the efficiency of the proposed emissions control systems and the costs of installing and operating them. Wine Institute has repeatedly warned the staff that the proposed emissions control systems may not be feasible. Even if those systems are feasible, the control efficiency may be far lower and the costs far higher than the staff assumes.

The staff claims that the cost effectiveness of the proposed control methods can be maximized by increasing the number of tanks ducted to each control device. Assuming such economies of scale exist, many wineries will not be able to take advantage of them because their tanks are dispersed and some are inside buildings.

The staff believes that cost-effectiveness can be assessed on an after-tax basis, no doubt because this halves the cost per pound of ethanol removed. However, as Wine Institute has previously noted (see page 11 of the May Comments), impending changes in federal tax laws and the financial condition of many wineries make after-tax calculations based on current law highly unrealistic. Since the staff is proposing a SCM that becomes fully effective in 1990, when the tax laws may look very different than they do now, cost effectiveness should be assessed solely on the basis of pre-tax costs.

The staff argues that cost effectiveness of the proposed control equipment will be substantially more favorable after the equipment is fully depreciated. However, the staff is assuming that the equipment will last beyond the applicable depreciation period. Wine Institute believes that the life of emissions control equipment cannot be determined until the equipment is tested under actual winery conditions. Wine Institute also notes that operating and maintenance expenses can be expected to rise as the equipment ages. The staff's cost estimates have apparently not taken such cost increases into account.

23. Pages 54-65, Proposed SCM, Summary, and Discussion:

Preliminarily, Wine Institute observes that the SCM is predicated on the staff's assumption that 90% reduction of ethanol emissions is reasonable because "there are several commercially available, cost-effective control technologies capable of achieving reductions of 90 to 99 percent." In fact,

the control technologies cannot be called "commercially available" in the wine industry and the 90% control requirement cannot be called reasonable until proven through pilot studies. While the control measures proposed by the staff may have worked in other contexts, they have never been demonstrated in the unique conditions of the wine industry.

Even the staff recognizes the vital importance of pilot studies. However, the staff severely underestimates the time necessary to conduct these studies properly. The staff also underestimates the time necessary to install control equipment, if a pilot study shows that any such equipment is feasible and cost effective.

First, the proposed SCM puts an administrative burden on the local APCDs, requiring that they be given some time to set up the pilot studies. Among other things, the APCDs must consult with the wineries within their jurisdiction regarding which wineries will test which control method. The APCDs must also have time to evaluate the pilot study proposals submitted by wineries after the projects have been allocated.

Second, Wine Institute believes that the difficulties involved in modifying fermentation tanks (May Comments, pp. 15-16) and installing ducting and control equipment mean that at least one year will be required for set up after an APCD approves a winery pilot study proposal. Since the equipment is experimental, once it is installed it will have to be adjusted under operating conditions. Due to the short length of the fermentation season, the equipment may not be properly adjusted

in time to provide meaningful results during the first season of testing. The proposed SCM requires a test including at least 4 fermentation cycles on red wine and 10 cycles on white wine. Since a tank is typically used for at most 3-4 fermentation cycles in a season, the SCM's requirements will be virtually impossible to meet during the first year.

If the control equipment does not work with the projected efficiency, the APCDs may ask wineries to alter the equipment in an effort to gain greater efficiency. The disposal problem for some of the projected control methods may also require considerable experimentation. Consequently, pilot studies could require several fermentation seasons to yield meaningful results.

Assuming that pilot studies show that emissions controls are feasible and cost-effective, all of the tanks at every winery subject to the SCM will have to be ducted and attached to control equipment. This cannot be done at once. Wineries will only be able to modify the tanks that can be emptied and will not be needed for blending or transfer of wine during the construction period. As a practical matter, this means that no tanks can be modified during the fermentation season or immediately thereafter, when most wineries have little excess storage capacity. Consequently, the timetables for implementation set forth in the proposed SCM are unrealistically optimistic.

Wine Institute also believes that the proposed SCM does not contain sufficient flexibility in the event pilot studies indicate: (1) one or more of the proposed control methods will not work; (2) the proposed control methods will not work with the



anticipated 90% efficiency; or (3) the costs of installing the control methods are significantly above the staff's estimates. If any of these applies, the SCM should be completely reevaluated, not just made the subject of a hearing in which the requirement(s) of the SCM "may be modified." Otherwise, the APCDs will feel constrained to simply modify the amount of control required by the rule (even if only a small measure of control is possible and at an astronomical expense).

Wine Institute submits that sufficient time must be allowed for pilot studies to be properly planned, conducted, and evaluated. Once the results of the pilot studies are available, the entire SCM should be re-evaluated for feasibility and cost effectiveness.

24. Pages 66-67. Ethanol is considered reactive because it is more reactive than ethane, which is considered reactive, and because it can be oxidized to compounds of much higher reactivity (General Response 1):

The staff states that the above response is based on "smog chamber studies," but fails to specify which ones. The two most recent prior studies of which Wine Institute is aware indicated that ethanol has low or zero reactivity.

In any event, Systems Applications, Inc. has completed the smog chamber study of ethanol reactivity sponsored by Wine Institute. SAI's report on this study is being submitted to the TRG with these supplemental comments.

The study confirms the results of prior studies indicating that ethanol has low or zero reactivity. Under atmospheric conditions where control of VOC, rather than  $\text{NO}_x$ , is most likely to contribute to improving air quality, ethanol is only one-quarter as reactive as a typical urban VOC mixture. To put it another way, 4 tons of ethanol must be removed from the atmosphere to have the same air quality benefit as one ton of typical VOC. The smog chamber tests also suggest that, under certain conditions, ethanol actually suppresses ozone production.

Given these results, Wine Institute submits that ethanol can hardly be considered an ozone precursor, let alone one whose control should be a regulatory priority. Wine Institute also submits that the cost-effectiveness of any proposed control measures must be evaluated in light of the fact that, at worst, ethanol can contribute only 1/4 as much to ozone formation as typical urban VOC. Therefore, ethanol emissions controls cannot be justified unless they are far more cost effective than controls aimed at other VOC. Since the SCM now under consideration would impose huge costs for doubtful benefits, Wine Institute submits that the SCM should not be adopted. At a minimum, the SCM should be deferred until after the effect of ethanol emissions on air quality and the costs and benefits of control have been more thoroughly evaluated.

25. Pages 67-68. From 1982 to 1985, the number of exceedences of the federal ozone standards indicate that oxidant levels are not decreasing significantly during the winery fermentation season (General Response 3):

Wine Institute does not have the data on exceedences of the ozone standards for 1982-84. However, the table attached as Exhibit 3 shows the exceedences of both the California Ambient Air Quality Standard ( $\geq 0.10$  ppm) and the National Ambient Air Quality Standard ( $> 0.12$  ppm) for ozone in Fresno County, Kern County, and the San Joaquin Valley Air Basin for selected months in 1985. That table shows that both the daily and hourly numbers of exceedences declined sharply in September 1985 from their August 1985 levels. Furthermore, the number of hourly and daily exceedences in September were clearly far less than the 40% of the annual total referred to by the staff.

The crush began relatively early in 1985, so that September was the peak fermentation month in the southern San Joaquin Valley counties. If Winery ethanol emissions have any effect on air quality, it should have been indicated in the 1985 air quality data for September. No effect is evident.

The staff argues that wineries contribute only a small percentage of "total ozone precursor emissions" and therefore winery ethanol emissions cannot be expected to have a significant effect on ozone levels. This argument begs the questions of whether ethanol is a reactive ozone precursor. The SAI study and other studies of ethanol reactivity have found that ethanol has low to zero reactivity, so ethanol would not be expected to have

an adverse effect on air quality. The 1985 aerometric data appear to confirm this conclusion.

Finally, Wine Institute notes that the San Joaquin Valley Air Basin Control Council intends to conduct a comprehensive study of the sources and possible solutions to air pollution in the valley air basin. The study is prompted in part by concerns that existing emissions control regulations may not be working. Wine Institute submits that sufficient doubt should exist about the efficacy and cost effectiveness of an SCM aimed at controlling ethanol emissions to warrant deferring it until the effect of ethanol on air quality (if any) is better understood.

26. Page 69. A fermentation temperature control rule would not significantly decrease ethanol emissions and might be rendered less effective by a shift in the market toward red wine (General Response 5):

One advantage of a fermentation temperature control rule is its effect of "locking in" the emissions reductions resulting from the trend to lower fermentation temperatures during the last decade. The staff asserts that the market could shift back towards increased production of red wine, increasing average fermentation temperatures and thus ethanol emissions. However, industry members believe that the trend to increased consumption of white wine relative to red wine will continue. A fermentation temperature control rule would ensure that this white wine was fermented at very low temperatures, so that ethanol emissions from wineries will be held at minimum levels achievable through such production controls.

27. Pages 69-70. The cost estimates take into account the facts that winery tanks are not filled to capacity and excess fermentation tank capacity must be available during fermentation season (Ducting Response 1):

Although the staff recognizes that excess fermentation capacity must be available during the fermentation season, it does not understand that virtually every tank at a winery needs to be used as a fermentation tank at one time or another and therefore would require ducting under the proposed SCM. (See pp. 18-19, supra.)

28. Pages 70-71. The staff does not believe that additional ladders and catwalks will be necessary for the separate emission control vent and believes that welding ductwork supports to the sides of the tanks will be a simple operation (Ducting Response 2):

The staff's response does not address the concerns previously expressed by Wine Institute (May Comments, pp. 15-16). The staff still does not include in its estimates the cost of installing the additional vent that it now seems to concede will be necessary (see page 26 of the Technical Support Document). Installing this vent will be a major project for each tank.

Wine Institute also does not agree that existing catwalks and ladders will be sufficient for the new vent and ducting system attached to each tank. If any ducting system is to be successful, it must be cleanable and serviceable.

When the emissions vent is cut into the top of the tank and all the paraphernalia suggested by the staff placed on the tank, 360° access to the tank opening will be required to maintain and clean it. Most large fermenters today have a top center manhole with a catwalk crossing over the tank through its centerline. The catwalk widens at the center to provide 360° access at the manhole. Since the hole required for the ducting system will probably need to be similar in size to the manhole, a wider section of catwalk would be needed.

There is no place on the top of the tank where a manhole size opening could be placed and at the same time provide 360° access without adding a platform or catwalk. Even if the vent were placed immediately adjacent to an existing catwalk, it could not be serviced and cleaned without adding a catwalk. Any winery that tried to get by without an additional catwalk would be in violation of Cal-OSHA safety requirements (see 8 Cal Admin. Code §3210). Therefore, the staff should have included the relevant costs in its estimates.

Even assuming that the ducting and new catwalk supports can be safely welded to the sides and top of the tanks, the insulation on large portions of the tanks must be stripped and then reapplied after the work is done. The staff also ignored the costs for this work, which would be a substantial project for each tank.

29. Page 71. The staff has calculated the diameter of the emissions vent opening necessary to maintain acceptable pressures (Ducting Response 3):

The staff has made a textbook calculation and the resulting vent opening is probably undersized. This issue is discussed on pages 9-10, supra. Wine Institute also notes that a pilot study could determine the effect of lowering vapor pressure on total ethanol emissions.

30. Pages 71-72. The staff's cost estimates have left ample room in the "contingency" numbers to cover the cost of customized pieces used in the ducting (Ducting Response 5).

The staff has provided no basis for its opinion that the cost of customized pieces is adequately covered in its "contingency" cost estimates. Wine Institute submits that these costs need to be evaluated in a pilot study.

31. Page 72. Due to the differences between wineries, the staff has had to use a simplified tank farm layout, but the cost estimates are nevertheless representative of actual winery costs (Ducting Response 6):

As the staff seems to concede, the tank farm layout it has used in estimating ducting costs represents an ideal. While wineries would use the most economical groupings possible for their tanks, few or none would be able to achieve the economy of grouping tanks assumed by the staff. Therefore, the staff's cost estimates cannot be called "representative." They are actually minimum-cost figures.

32. Page 72. Ducting would be installed in the aisles already occupied by piping without any major difficulties (Ducting Response 7):

Wine Institute has never claimed that ducting could not be installed in the aisles clogged with piping, but doing so will substantially increase the costs and difficulties of installing the ducting. The staff has not taken these costs and difficulties into account in its cost estimates. Despite the staff's response here, the staff still assumes in its cost estimates that the piping will be placed in the open aisles (see pp. 23-24 and A-7 of the Technical Support Document).

33. Pages 72-73. The proposed SCM may have to be modified if the demonstration program shows that the exhaust manifold will not pick up all of the ethanol emissions from the tank (Ducting Response 8):

The staff apparently agrees with Wine Institute that the efficiency of the proposed exhaust manifold in picking up ethanol emissions is uncertain. Since the performance of the manifold affects the feasibility of the proposed SCM, the SCM cannot be properly evaluated without a pilot study.



34. Page 73. The exhaust manifold is not likely to pick up entrained sugar or large quantities of dust, insects, or foam. If it does, the filters will take care of them. These concerns, plus any effect on product quality will be resolved during the demonstration program (Ducting Response 9):

The presence of entrained sugar in emissions from fermentation tanks is a well known phenomenon. Wine Institute also notes that insects and dust will inevitably be sucked into the ducting system given the airspeeds at the ducting manifold that the staff contemplates. The staff again agrees that a pilot study would be vital in resolving concerns about the feasibility of the proposed SCM.

35. Pages 73-74. The fans necessary to create the required intake airspeed at the exhaust manifolds on each tank will typically operate at approximately 3,500 rpm, not 40-50,000 (Ducting Response 10):

Perry's Chemical Engineer's Handbook indicates (at page 6-21) that "most turboblowers operate at speeds of 3500 rpm or higher," indicating that the staff's estimate of the typical rpm for the fans is at the low end. In any event, the staff concedes that the size and speed of the blower will depend on the number of tanks attached to it, the expected rate of gas flow, and other design specifications.

36. Pages 74-75. One way to prevent contamination of a tank from the exhaust manifold is to place a "china cap" over the emissions vent. This cap plus standard winery sanitation practices should prevent contamination of the fermenting must (Ducting Response 11):

The china cap may prevent contamination from the ducting system, but it will be a source of contamination for the tank. The cap also creates a danger of pressure damage to the tank. See the discussion at pp. 10-11, supra.

37. Page 75. Exhaust controls are not likely to be down long for cleaning or repairs and, if they are, local APCD rules will provide waivers from the SCM requirements (Ducting Response 12):

This response does not address the industry concern that prompted the comment. The staff is projecting a control efficiency of 90%, in order to justify the proposed SCM as cost effective. However, the staff has not evaluated the effect on overall efficiency of shutdowns due to cleaning or equipment breakdown. To the extent that the actual level of control may be less than 90% due to such events, the staff's cost effectiveness assumptions are not accurate.

38. Page 76. A properly constructed ducting system will not result in unacceptable noise levels, especially as these levels are already high due to operation of heavy equipment (Ducting Response 15):

Wine Institute notes that the ducting system will be another source of noise in an already noisy environment. This and other safety issues need to be evaluated in a pilot study.

39. Pages 76-77. An SCM based on 90% control of ethanol emissions is not unreasonable because each of the control methods recommended by the staff has achieved 90% control on other emissions sources. In any event, this issue will be resolved by the demonstration program (Control Equipment Response 1):

The staff seems to feel that control methods which have worked in other contexts can automatically be applied to the wine industry. However, the wine industry is considerably different from other industries with which the ARB may be familiar (May Comments, pp. 8-9). In addition, the many problems with the proposed control methods that have been pointed out by wine industry members in meetings with the staff provide substantial reason to believe that the control methods will not work with the projected efficiencies. The staff concedes that such concerns should be examined through pilot studies.

40. Pages 77-78. Catalytic incineration does not produce significant amounts of NO<sub>x</sub> or any other pollutants. (Control Equipment Response 3):

The staff apparently expects little NO<sub>x</sub> or other pollutants to be produced by catalytic incineration because it is projecting catalytic incineration to operate at 500°F. As previously discussed, this appears to be a minimum operating temperature for catalytic incineration. Due to the actual operating conditions at wineries, operating temperatures may need to be higher. See pp. 14-15, supra. The staff has not considered whether such possibly higher temperatures may produce NO<sub>x</sub> or other pollutants.

41. Page 78. Wineries that do not have access to pipeline natural gas can use some control method other than catalytic incineration, and those with access are unlikely to be curtailed (Control Equipment Response 4):

All wineries will be required to use catalytic incineration, if no other control method proves feasible. In this event, the staff's cost estimates, which assume use of pipeline natural gas, will be much too low for wineries that would have to use propane. Also, even though no shortages in natural gas supply are projected in the short run, wineries using natural gas must plan for curtailments, and would have to be able to operate the incinerator with a backup fuel. (Under PG&E's most favorable industrial rates, users are required to have facilities to use a backup fuel.) The cost of equipment necessary to use a backup fuel has not been considered by the staff.

42. Pages 78-79. The ethanol/steam mixture left after condensation will not be returned to the atmosphere, it will be recirculated through the carbon adsorption beds. These beds selectively absorb ethanol versus water (Control Equipment Response 5):

Once the carbon bed reaches capacity, only 1/3 of the adsorbed ethanol can be steamed off during regeneration (see p. A-49, Technical Support Document). If the ethanol/moisture mixture left over after condensation is recirculated through the bed, even less capacity will be available for new gas. Since ethanol is not the type of gas that the carbon beds are most efficient at adsorbing (see p. 11, supra) this may have a significant effect on the control efficiency of the bed, requiring a larger bed and more frequent regeneration than the staff contemplates in its cost estimates. Such issues would need to be examined as part of a pilot study.

43. Page 79. Wineries without access to municipal water supplies for scrubbing can use another method of control (Control Requirement Response 6):

If none of the other control systems are feasible, wineries would have no choice but to incur the additional cost of installing wells and pumps to provide water for the scrubber. These costs should be taken into account in evaluating the cost effectiveness of the proposed SCM.

Wine Institute believes that scrubbing is not likely to be proven feasible, due to the unsolvable nature of the disposal problem.

44. Pages 79-80. The cost estimates for the condensation system are based on a quote obtained by Wine Institute and nothing in that quote indicates that the system would not be operational. The vendor of the system thinks that icing would not occur. However, such problems could be resolved during the demonstration program (Control Equipment Response 7):

Wine Institute's response to the points made by the staff is at pp. 12-14, supra. The staff concedes that the "uncertainty" of the condensation system makes a pilot study necessary. Wine Institute agrees that condensation must be demonstrated to be feasible before it can be considered for control of ethanol emissions.

45. Pages 80-81. If handled properly, disposal of the wastes resulting from the control methods should not cause any adverse environmental impact. Each winery will select the control method best suited to its own resources for waste disposal (Control Equipment Response 8):

The staff's response is in two parts. First the staff argues that each winery will select the control method most appropriate for it. Thus, if the wastes generated by one control method present a disposal problem for a winery, that winery will simply use another control method. However, this syllogism depends on the assumption that all control methods will be proven feasible. If only one of the control methods works at anything near the 90% control efficiency required by the SCM, wineries

will be forced to implement that control method. That control method may present unsolvable or exorbitantly expensive waste disposal problems.

The staff defers its discussion of why waste disposal will not cause any adverse environmental impact until Chapter VIII of the Technical Support Document. Wine Institute will respond to this point in its comments on that chapter.

46. Page 83. After-tax cost effectiveness calculations are appropriate for wineries making a profit and for most other wineries, because the relevant tax deductions can be deferred. The staff used the current tax law because it is the most recent information available. (Cost Effectiveness Response) :

The current tax laws do not represent the most current information available. The staff should recognize that the tax laws are about to change. Under the new tax bill agreed upon by the House-Senate Joint Conference Committee, maximum corporate tax rates will be reduced, depreciation allowances will be less generous, and the investment tax credit will be repealed. (See Wall Street Journal, August 19, 1986, at 6-7.) All of these changes affect the staff's after-tax cost effectiveness calculations.

The staff shows a lack of knowledge about business realities when it cannot imagine how a winery could remain in business for several years without showing a profit. Some wineries stay in business because they are co-ops and, even though they are losing

money, their members depend on them to furnish a home for their grapes. Wineries may also stay in business by just breaking even. For these wineries, the adverse effects of the costs from an ethanol emissions control rule are the most pronounced. Since these wineries cannot take advantage of any tax benefits, and the staff's after-tax calculations are probably not meaningful anyway, before-tax costs are the appropriate measure for calculating cost effectiveness.

47. Page 84, projected ethanol emissions reductions resulting from implementation of the proposed SCM:

The staff estimates that enacting the proposed SCM in the San Joaquin Valley air basin would result in an 80% reduction of overall ethanol emissions there. This estimate will be valid only if the wineries required to comply with the SCM can install control methods having the assumed 90% control efficiency. In addition, the staff has not projected the impact of this rule on overall air quality in the nonattainment areas in the San Joaquin basin. The SAI study sponsored by Wine Institute and other studies of ethanol reactivity, taken with the 1985 aerometric data, suggest that ethanol emissions have little or no effect on air quality. Moreover, winery emissions of ethanol are seasonal and probably not substantial compared to ethanol emissions from agricultural products left to rot in the fields each year.



48. Pages 85-87, disposal of wastes from proposed emissions control methods:

Waste disposal is a major obstacle to feasibility of the staff's proposed carbon adsorption, condensation, and scrubbing methods of ethanol emissions control. All of these control methods generate an ethanol/water solution as waste. The difficulty and costs of disposing of this waste without the ethanol returning to the atmosphere (which would render the SCM an exercise in futility) raise serious questions. The staff's discussion of these issues fails to answer the concerns raised by Wine Institute in the May Comments.

The staff believes that carbon adsorption and condensation wastes could be distilled. However, most wineries lack stillage facilities, and those wineries with stillage facilities have little excess capacity during fermentation season. Furthermore, the alcohol distilled from this waste may not be suitable for beverage purposes.

The staff also feels that if distillation is impossible these wastes could simply be sold to "recovery plants." It is not clear what recovery plants the staff is talking about, and no one can predict the terms on which such plants (if any exist) could be induced to take the wastes. The transportation costs alone for the many thousands of gallons of waste that the staff anticipates will be produced by major wineries would be considerable.

In sum, distillation or off-site disposal of the wastes from carbon adsorption and condensation potentially represents a

substantial additional operational cost of the proposed SCM. The staff has not considered this cost in estimating the costs for carbon adsorption or condensation.

The staff concedes that the ethanol/water waste generated by scrubbing would be far too dilute for effective distillation and far too great in volume for transport to off-site recovery plants. However, the staff believes that this waste could be adequately disposed of either into a municipal sewage system or on land.

Wine Institute has previously pointed out that discharging this waste into municipal sewer systems presents major problems. (May Comments, pp. 23-24) Most wineries do not have access to municipal waste systems. Where municipal waste systems exist, those systems are often overloaded, and the operating agency might refuse permission for the winery to put huge additional scrubbing waste loads into the system. Also, the wastes from municipal waste systems are usually aerated as part of the treatment process. Since ethanol is volatile, this aeration provides an ideal avenue for the ethanol to return to the atmosphere. (May Comments, p. 24 and note 8.) While the staff argues that microbial action will degrade the ethanol before more than a minimal amount evaporates, it has no support for this argument. It is more likely that a substantial part of the ethanol will be lost to the atmosphere.

Where a municipal waste system is not available, land disposal is the only alternative. Acquiring the real estate and putting in the facilities necessary for the land disposal (May

Comments, p. 24) would represent a huge expense. Performing the disposal properly would add to operating and maintenance expenses. Moreover, many wineries are located in areas which have become built up around them, so that they simply do not have the land available for land disposal. The staff has ignored these costs and practical concerns.

In the May Comments, Wine Institute presented calculations by Roger Boulton of R.B. Boulton, Inc. which demonstrated the significant possibility that ethanol disposed of on land would return to the atmosphere. (May Comments, pp. 24-25 and Exhibit K). A Wine Institute member has conducted experiments to show the rate of ethanol loss from dilute ethanol/water solutions. The results are shown in 3 tables and 3 graphs, which are collectively attached as Exhibit 4.

Table I shows that the percentage of ethanol lost is essentially independent of the ethanol concentration of the solution at these relatively low levels. The temperature of the solution and the depth measurements were taken to allow the volume of the solution to be corrected to a standard temperature, thus permitting the computation of the absolute volume of ethanol lost.

Table II gives evaporation rate data for three different depths of solution, approximately 0.5", 1", and 2". Because each of these experiments contains at least one sample of 0.1% ethanol and 1" depth in filtered sunlight, it also shows the effect that the variations in ambient temperature or sunlight exposure had on each test. This table shows, as would be expected, that the

evaporation rate varies inversely with the depth of the liquid.

Table III gives the data for evaporation rates in dark trays versus light ones, and for full sunlight versus partial sun. The other tests had all been run in partial sun or filtered shade. The full sun exposure exacerbates the ethanol loss.

The graphs depict the loss rates for the different depth samples in partial sun, and for the 1" depth sample in full sun. The latter figures were corrected to the temperature environment of the other three.

In none of the experiments did the temperatures begin to approach the tremendous extremes that are encountered in Fresno and Kern Counties during a large portion of the crush period. At times, highs well over 100°F are experienced and the lows never go below 80°F. These conditions would almost guarantee that the bulk of the ethanol in the waste would be vaporized almost instantaneously as it hit the hot fields.

Wine Institute also notes that ethanol can evaporate from the soil once the ethanol/water solution has soaked in. There is no guarantee that microbes in the soil will be able to metabolize a substantial part of this ethanol before it evaporates.

The disposal of scrubbing wastes presents such unsolvable problems and tremendous costs that scrubbing cannot be considered a feasible means for control of winery ethanol emissions.

Wine Institute cannot comment on the pollution problems created by catalytic incineration until the actual operating temperatures are known. So long as there is a possibility of NO<sub>x</sub> and other pollutants, Wine Institute submits that catalytic incineration must be viewed with caution.

49. Pages 87- 88, economic impact of proposed SCM:

The staff concedes that it has no idea of the economic impact of the proposed SCM on the wine industry. The staff cannot contend that the California wine industry is healthy. In fact, the wine industry has been going through difficult economic times.

In 1975, foreign table wines constituted only 17% of the U.S. market. In 1985, foreign table wines commanded 30% of the market. Shipments of California table wine, the backbone of the industry, fell from 273.3 million gallons in 1982 to 257.4 million in 1985. In recent years, San Joaquin Valley wineries have been among those hardest hit, and their economic situation is reflected in vineyard value and grape prices. The value of San Joaquin vineyards has fallen as much as 50% to 80% between 1982-1985. In the same period, grower returns have fallen 17% across the state, from \$194.07 to \$160.95 average per ton. In 1986, the California Agricultural Statistics Service estimates that 79,000 acres of California vineyards will either be abandoned or not harvested. These are major consequences in a state where grapes are among the top four agricultural products in terms of farm value and where 8% of all harvested agricultural land is planted in grapes.

Wine Institute believes that the cost of emissions control equipment might drive some wineries out of business, resulting in a significant adverse impact on the economic health of the state.

50. Page A-8, excess tank capacity:

Even with this excess tank capacity assumption, the staff's cost estimates are much too low. As discussed before (see pp. 18-19, supra), wineries must be able to use virtually all of their tanks as fermenters, and those tanks would have to be ducted and connected to control equipment. This would substantially increase the costs of installing the ducting and control equipment. Furthermore, operating and maintenance costs would increase, because some regular inspection and maintenance would be required even if the equipment for a given tank or group of tanks were not used during a fermentation season.

51. Page A-43, catalyst costs and attrition.

The staff assumes that a catalytic incinerator will operate only one month per year, and therefore 1% a year attrition for the catalyst is appropriate. However, the staff concedes that the fermentation season can extend from mid August until November. Therefore, the catalyst attrition may be greater.

52. Page A-67, cost assumptions for annual operating and maintenance costs:

The staff's assumptions for the annual costs of operating and maintaining the emissions control equipment are rough estimates only. The staff has not considered how these costs would rise as the equipment ages.

Wine Institute is unable to comment on these estimates without more information about the assumptions behind them. For example, the staff does not indicate whether its cost assumptions include the cost of personnel necessary to monitor the ducting system and emissions control equipment.

-----○-----



ACTIVATED CARBON DIVISION  
CALGON CORPORATION  
SUBSIDIARY OF MERCK & CO., INC.  
CALGON CENTER, BOX 1346, PITTSBURGH, PA 15230

### GAS PHASE CALCULATION SHEET

- I. The succeeding pages will enable you to solve most gas phase problems more quickly and easily just by following the step by step directions.
- II. The following general rules may be helpful:
  - A. Humidity above 60% will reduce capacity for most gases. It may also present a corrosion problem.
  - B. The higher the molecular weight and/or critical temperature, the greater the weight capacity and preference.
  - C. Aromatic and/or non-polar gases are preferentially adsorbed.
  - D. Air, being 78% nitrogen and 21% oxygen, is not adsorbed to any significant amount at normal temperatures. When it is present, it can be treated as the diluent or solvent much like water in a liquid phase system.
  - E. In solvent recovery, the normal procedure is to determine the pounds of solvent which are evaporated; and then calculate how much air must be used to maintain the solvent concentration at 25-50% of the Lower Explosive Limit (LEL).
  - F. Accuracy in gas phase calculations does not justify the use of figures beyond the first decimal place.
- III. The Procedure:
  - A. Fill in information on Page 3, Parts I and II, Columns 1 and 2.
  - B. Although it is very uncommon, the gas analysis may be given as percent by weight. If so, the following steps can be taken:
    1. Multiply total pounds per hour by the percent of each gas to obtain individual pounds per hours (Column 5).
    2. Divide Column 5 by the respective molecular weight to obtain Mols per hour (Column 3).



# **FREEZING POINTS OF ETHYL ALCOHOL-WATER MIXTURES**

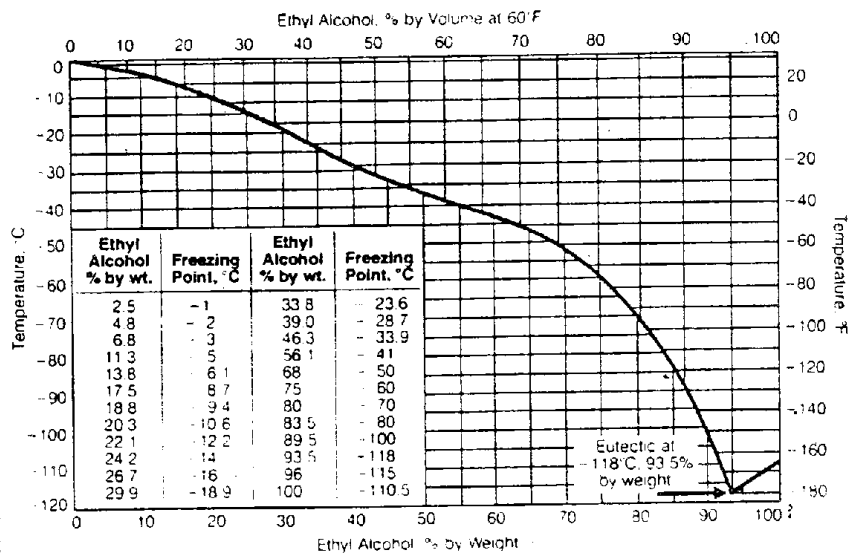


EXHIBIT 2

EXHIBIT 3  
NUMBER OF EXCEEDENCES OF AMBIENT AIR QUALITY  
STANDARDS FOR OZONE IN 1985 (SELECTED MONTHS)

CALIFORNIA ( $\geq 0.10$  ppm)

|        |   | May | June | July | Aug. | Sept. | Oct. | Nov. |
|--------|---|-----|------|------|------|-------|------|------|
| Fresno | H | 3   | 21   | 22   | 19   | 11    | 11   | 1    |
| County | D | 10  | 98   | 98   | 94   | 47    | 44   | 3    |
| Kern   | H | 5   | 18   | 23   | 26   | 11    | 14   | 3    |
| County | D | 12  | 108  | 106  | 139  | 41    | 57   | 4    |
| SJV    | H | 8   | 25   | 29   | 26   | 15    | 16   | 3    |
| Basin  | D | 24  | 203  | 209  | 199  | 66    | 78   | 9    |

NATIONAL ( $> 0.12$  ppm)

|        |   | May | June | July | Aug. | Sept. | Oct. | Nov. |
|--------|---|-----|------|------|------|-------|------|------|
| Fresno | H | 0   | 6    | 7    | 8    | 4     | 5    | 0    |
| County | D | 0   | 20   | 13   | 19   | 10    | 12   | 0    |
| Kern   | H | 1   | 6    | 5    | 10   | 4     | 1    | 0    |
| County | D | 1   | 10   | 5    | 23   | 9     | 1    | 0    |
| SJV    | H | 1   | 11   | 12   | 14   | 6     | 5    | 0    |
| Basin  | D | 1   | 35   | 27   | 37   | 16    | 19   | 0    |

Source: California Air Resources Board, Aerometric Data System  
1985 Report.

TABLE I  
CONSTANT VOLUME (2 LITERS)

| Time  | Air Temp °F | 0.04% ETOH |          |          | 0.1% ETOH |          |          | 0.4% ETOH |          |          | 1.0% ETOH |          |          |
|-------|-------------|------------|----------|----------|-----------|----------|----------|-----------|----------|----------|-----------|----------|----------|
|       |             | Temp °F    | Depth cm | ETOH ppm | Temp °F   | Depth cm | ETOH ppm | Temp °F   | Depth cm | ETOH ppm | Temp °F   | Depth cm | ETOH ppm |
| 8:30  | 61.5        | 63         | 2.8      | 463      | 63        | 2.8      | 1113     | 63        | 2.8      | 3915     | 63        | 3.0      | 9628     |
| 9:35  | 72          | 67         | 2.8      | 459      | 66        | 2.85     | 1069     | 65        | 2.8      | 3682     | 65        | 3.05     | 9280     |
| 10:30 | 70.5        | 70.5       | 2.8      | 445      | 70.5      | 2.8      | 1030     | 70.5      | 2.8      | 3620     | 71        | 3.0      | 8873     |
| 11:30 | 74.5        | 70.5       | 2.8      | 455      | 70        | 2.8      | 954      | 67        | 2.8      | 3439     | 69        | 3.0      | 8336     |
| 12:30 | 77          | 86         | 2.75     | 393      | 85        | 2.75     | 883      | 82        | 2.75     | 3246     | 81        | 2.95     | 7768     |
| 1:30  | 78.5        | 92.5       | 2.7      | 341      | 90.5      | 2.75     | 794      | 90        | 2.7      | 2911     | 90.5      | 2.9      | 7040     |
| 2:30  | 81          | 81.5       | 2.65     | 347      | 83        | 2.65     | 731      | 85.5      | 2.6      | 2583     | 86.5      | 2.85     | 6189     |
| 3:30  | 83.5        | 76         | 2.6      | 302      | 76        | 2.6      | 682      | 77        | 2.6      | 2392     | 78        | 2.85     | 5700     |

TABLE II  
CONSTANT ETHANOL CONTENT (0.1%)

| Time  | Air Temp °F | 1 LITER |          |          | 2 LITERS |          |          | 4 LITERS |          |          |
|-------|-------------|---------|----------|----------|----------|----------|----------|----------|----------|----------|
|       |             | Temp °F | Depth cm | ETOH ppm | Temp °F  | Depth cm | ETOH ppm | Temp °F  | Depth cm | ETOH ppm |
| 8:30  | 73          | 69.5    | 1.5      | 1046     | 69.5     | 2.85     | 1025     | 69       | 5.4      | 1057     |
| 9:30  | 78          | 72      | 1.5      | 934      | 72       | 2.85     | 1070     | 71.5     | 5.4      | 1037     |
| 10:30 | 84          | 77.5    | 1.5      | 843      | 77       | 2.85     | 940      | 76       | 5.35     | 972      |
| 11:30 | 91          | 76.5    | 1.4      | 743      | 77       | 2.8      | 897      | 76.5     | 5.35     | 958      |
| 12:30 | 91          | 89      | 1.5      | 689      | 87       | 2.9      | 825      | 85       | 5.35     | 917      |
| 1:30  | 93.5        | 94      | 1.4      | 508      | 95       | 2.75     | 733      | 93       | 5.3      | 859      |
| 2:30  | 91          | 90      | 1.35     | 417      | 88       | 2.7      | 634      | 89       | 5.2      | 778      |
| 3:30  | 94          | 78.5    | 1.3      | 330      | 81       | 2.7      | 590      | 84       | 5.2      | 765      |

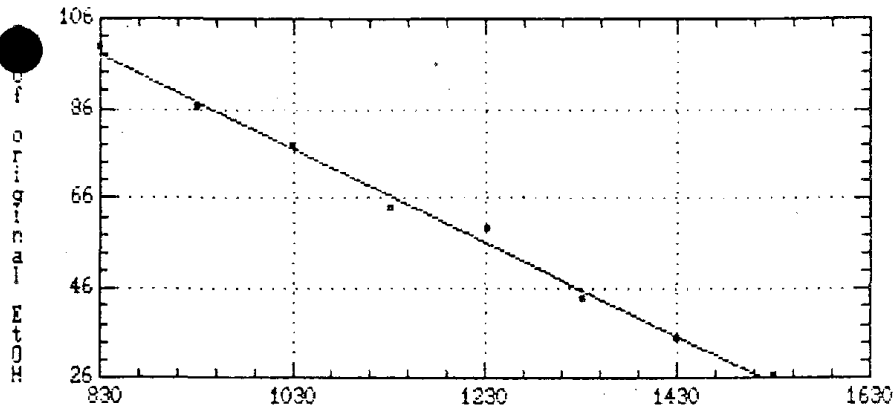
7/24/86

TABLE III  
CONSTANT VOLUME AND CONTENT

| Time  | Air Temp °F | PARTIAL SUN |          |          |            |          |          | FULL SUN   |          |          |            |          |          |
|-------|-------------|-------------|----------|----------|------------|----------|----------|------------|----------|----------|------------|----------|----------|
|       |             | Black Tray  |          |          | White Tray |          |          | Black Tray |          |          | White Tray |          |          |
|       |             | Temp °F     | Depth cm | ETOH ppm | Temp °F    | Depth cm | ETOH ppm | Temp °F    | Depth cm | ETOH ppm | Temp °F    | Depth cm | ETOH ppm |
| 8:30  | 69.5        | 66          | 3.15     | 994      | 66         | 2.9      | 1029     | 70.5       | 3.1      | 1038     | 68.5       | 2.8      | 997      |
| 9:30  | 66          | 67          | 3.15     | 948      | 66         | 2.85     | 970      | 72         | 3.1      | 961      | 69         | 2.85     | 952      |
| 10:30 | 71.5        | 71          | 3.15     | 938      | 69.5       | 2.8      | 930      | 79.5       | 3.1      | 897      | 75         | 2.8      | 885      |
| 11:30 | 76          | 73          | 3.15     | 900      | 71.5       | 2.8      | 892      | 91.5       | 3.05     | 830      | 84         | 2.8      | 784      |
| 12:30 | 78          | 79          | 3.2      | 824      | 75         | 2.8      | 841      | 92         | 3.0      | 726      | 83         | 2.7      | 714      |
| 1:30  | 83          | 95          | 3.15     | 783      | 86         | 2.8      | 778      | 102        | 2.95     | 647      | 90.5       | 2.7      | 656      |
| 2:30  | 83          | 89.5        | 3.05     | 752      | 84         | 2.75     | 731      | 100        | 2.9      | 541      | 89         | 2.65     | 586      |
| 3:30  | 85          | 83          | 3.05     | 666      | 80.5       | 2.75     | 684      | 100        | 2.85     | 485      | 88.5       | 2.6      | 509      |

7/24/86

# EtOH Loss Rate (1/2 Inch Depth) Partial sun



time

|    |    |    |    |    |    |    |    |                 |
|----|----|----|----|----|----|----|----|-----------------|
| 70 | 72 | 78 | 77 | 89 | 94 | 90 | 79 | Liquid temp. °F |
| 73 | 78 | 84 | 91 | 91 | 94 | 91 | 94 | Air temp. °F    |

Simple Regression of evapil on time

| Parameter | Estimate  | Standard Error | T Value  | Prob. Level |
|-----------|-----------|----------------|----------|-------------|
| Intercept | 185.188   | 4.11277        | 45.0275  | 8.03654E-9  |
| Slope     | -0.104714 | 3.4215E-3      | -30.6048 | 8.07763E-8  |

## Analysis of Variance

| Source | Sum of Squares | Df | Mean Square | F-Ratio  |
|--------|----------------|----|-------------|----------|
| Model  | 4605.3343      | 1  | 4605.3343   | 936.6555 |
| Error  | 29.500714      | 6  | 4.916786    |          |

Total (Corr.) 4634.8350 7

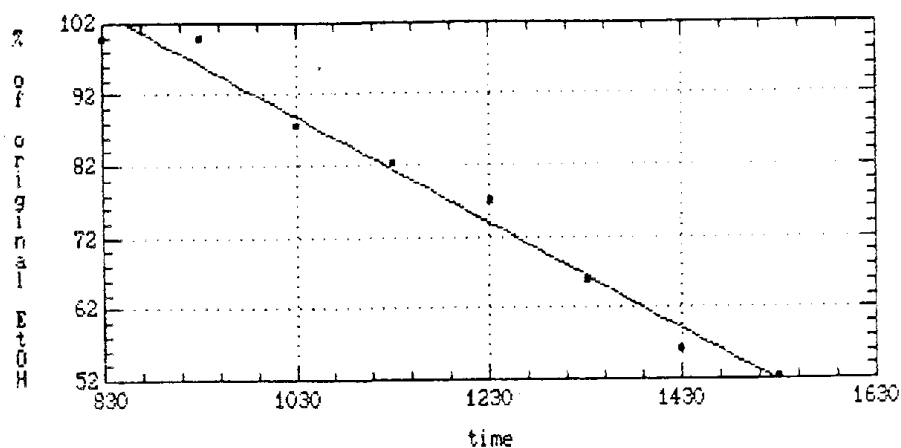
Correlation Coefficient = -0.996812

Std. Error of Est. = 2.21738

Do you want to plot the fitted line? (Y/N):

1HELP 2LABEL 3SAVSC 4RECORD 5 6 7 8 9REVIEW 10QUIT  
 PRINT WED JUL 23 1986 10:53:00 AM VERSION 1.2 REC:OFF

# EtOH Loss Rate (1 Inch Depth) Partial sun



|    |    |    |    |    |    |    |    |                 |
|----|----|----|----|----|----|----|----|-----------------|
| 70 | 72 | 77 | 77 | 87 | 95 | 88 | 81 | Liquid temp. °F |
| 73 | 78 | 84 | 91 | 91 | 94 | 91 | 94 | Air temp. °F    |

Simple Regression of evap21 on time

| Parameter | Estimate   | Standard Error | T Value  | Prob. Level |
|-----------|------------|----------------|----------|-------------|
| Intercept | 165.413    | 5.28931        | 31.2732  | 7.10069E-8  |
| Slope     | -0.0743333 | 4.40028E-3     | -16.8929 | 2.75014E-6  |

## Analysis of Variance

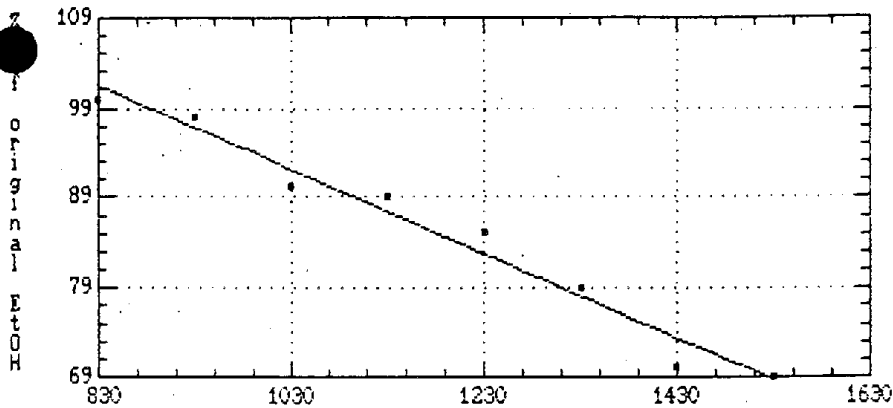
| Source        | Sum of Squares | Df | Mean Square | F-Ratio  |
|---------------|----------------|----|-------------|----------|
| Model         | 2320.6867      | 1  | 2320.6867   | 285.3693 |
| Error         | 48.793333      | 6  | 8.132222    |          |
| Total (Corr.) | 2369.4800      | 7  |             |          |

Correlation Coefficient = -0.98965  
 Stnd. Error of Est. = 2.85171

Do you want to plot the fitted line? (Y/N):

1HELP 2LABEL 3SAVSC 4RECORD 5 6 7 8 9REVIEW 10QUIT  
 NT THR JUL 24 1986 12:46:00 PM VERSION 1.2 REC:OFF

# ItOH Loss Rate (2 Inch Depth) Partial sun



|    |    |    |    |      |    |    |    |                 |
|----|----|----|----|------|----|----|----|-----------------|
| 69 | 72 | 76 | 77 | time | 93 | 89 | 84 | Liquid temp. °F |
| 73 | 78 | 84 | 91 | 85   | 94 | 91 | 94 | Air temp. °F    |

Simple Regression of evap41 on time

| Parameter | Estimate   | Standard Error | T Value  | Prob. Level |
|-----------|------------|----------------|----------|-------------|
| Intercept | 140.39     | 3.92064        | 35.8079  | 3.16304E-8  |
| Slope     | -0.0468452 | 3.26165E-3     | -14.3624 | 7.13244E-6  |

## Analysis of Variance

| Source | Sum of Squares | Df | Mean Square | F-Ratio   |
|--------|----------------|----|-------------|-----------|
| Model  | 921.68006      | 1  | 921.68006   | 206.27939 |
| Error  | 26.808690      | 6  | 4.468115    |           |

|               |           |   |
|---------------|-----------|---|
| Total (Corr.) | 948.48875 | 7 |
|---------------|-----------|---|

Correlation Coefficient = -0.985766

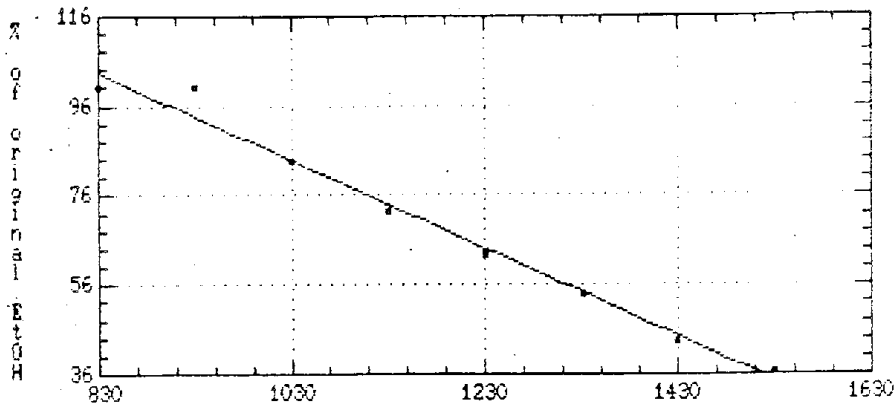
Std. Error of Est. = 2.11379

Do you want to plot the fitted line? (Y/N):

|       |            |                  |             |   |   |   |   |         |        |
|-------|------------|------------------|-------------|---|---|---|---|---------|--------|
| 1HELP | 2LABEL     | 3SAVSC           | 4RECORD     | 5 | 6 | 7 | 8 | 9REVIEW | 10QUIT |
| INT   | THR JUL 24 | 1986 12:56:00 PM | VERSION 1.2 |   |   |   |   | REC:OFF |        |



EtOH Loss Rate in Sun (1 Inch Depth)



|    |    |    |    |    |    |    |    |                 |
|----|----|----|----|----|----|----|----|-----------------|
| 69 | 69 | 75 | 84 | 83 | 90 | 89 | 89 | Liquid temp. °F |
| 70 | 66 | 72 | 76 | 78 | 83 | 83 | 85 | Air temp. °F    |

Simple Regression of evap21a on time

| Parameter | Estimate   | Standard Error | T Value  | Prob. Level |
|-----------|------------|----------------|----------|-------------|
| Intercept | 184.996    | 5.98492        | 30.9103  | 7.6128E-8   |
| Slope     | -0.0982381 | 4.97897E-3     | -19.7306 | 1.09906E-6  |

Analysis of Variance

| Source        | Sum of Squares | Df | Mean Square | F-Ratio  |
|---------------|----------------|----|-------------|----------|
| Model         | 4053.3038      | 1  | 4053.3038   | 389.2966 |
| Error         | 62.471190      | 6  | 10.411865   |          |
| Total (Corr.) | 4115.7750      | 7  |             |          |

Correlation Coefficient = -0.992382

Std. Error of Est. = 3.22674

Do you want to plot the fitted line? (Y/N):

|       |            |                  |             |   |   |   |   |         |        |
|-------|------------|------------------|-------------|---|---|---|---|---------|--------|
| 1HELP | 2LABEL     | 3SAVSC           | 4RECORD     | 5 | 6 | 7 | 8 | 9REVIEW | 10QUIT |
| 11    | THR JUL 24 | 1986 02:59:00 PM | VERSION 1.2 |   |   |   |   | REC:OFF |        |

September 15, 1986

Mr. William Roddy  
Chairman, Technical Review Group  
County of Fresno, Dept. of Health  
1221 Fulton Mall  
P.O. Box 11867  
Fresno, CA 93721

Re: Ethanol Emissions  
ARB Proposed SCM

Dear Mr. Roddy:

Attached please find comments Guild Wineries wishes to present to you and the TRG expressing our very serious concern about the ARB Proposed SCM, and hope that we can present these views at the TRG September 16, 1986 workshop.

This is a most serious matter to our industry and we believe this proposal lacks sufficient convincing scientific data to justify such a SCM at this time.

The Smog Chamber Study results indicate no or very low reactivity for ethanol, and this study should be given serious consideration by the TRG, particularly since doubts are raised about its reactivity, if any at all, as noted in the SAI Reports Executive Summary.

We recognize the pressure exerted by governmental agencies to have a SCM for wine industry, but we believe it would be wrong to impose without real sound basis such a SCM, and great harm will be imposed on one of California's main agriculture industries.

We request the TRG recommend deferring any tentative rule until all testing is completed.

Sincerely,

  
E. C. Skofas

Vice President, Production

ECS:lb  
Attachment

Comments  
Guild Wineries and Distilleries  
Regarding California Air Resources Board  
Proposed Suggested Control Measure for  
Ethanol Emissions from Winery Fermentation  
Tanks and Supporting Materials

September 15, 1986

Guild Wineries & Distilleries  
P.O. Box 1068  
Fresno, California 93714

-----

Guild Wineries and Distilleries is a cooperative winery composed of some 450 grower members. It has producing wineries and a bottling cellar. Its corporate headquarters are located at 1 - Winemasters' Way, Lodi, CA 95241-1907.

First, we want to state that we concurred in the Fresno Air Pollution Control District proposal that temperature control was the only method which would be both effective and practical in ethanol emission reduction.

We have also supported Wine Institute efforts in the smog chamber study to determine real reactivity of ethanol emissions in atmosphere and whether it is a precursor to smog formation. To date there has been no convincing scientific data that ethanol emissions are actually harming the atmosphere. Our wine industry, through this Wine Institute research smog chamber study performed by SAI of San Rafael, wants to have reliable scientific facts rather than arbitrary decisions that ethanol is a pollutant of the atmosphere.

We want to also point out that before any rules, tentative or otherwise, are made that the ARB give our wine industry and us sufficient time to test out any suggested method for control. Methods proposed by ARB staff are not realistic and very expensive. There are no tax saving incentives, as pointed out in the ARB staff report. In our industry today over 80% of the wineries are operating at a loss due to many reasons which have been cited in Wine Institute's comments, and particularly by the cheap imported wines, whose producers will be benefited more by any requirements imposed on the California wine industry. The 1985 U.S. International Trade Commission reported that by

1984 over 80% of the wineries producing approximately 83% of American non-premium table wines were sustaining operating losses. In our case we are one of those sustaining large operating losses, and to impose on us requirements to control ethanol emissions will cause our cooperative winery with its 450 grower members to go bankrupt.

Our engineering staff has calculated (see Attachment 1) the capital cost to install a carbon adsorption system at our Cribari Winery based on ARB developed costs to be approximately \$2,791,000. This winery does primarily white wine, and the annual cost based on a peak crush of 80,000 tons is estimated to be around \$15.09 per lb. ethanol removed, using Lee graph (Fig. 2). Since we are on municipal discharge system, we don't believe we'll be able to discharge the scrubbing effluents with ethanol into this system, and must go with carbon adsorption.

We also have a medium size winery at Lodi, California which does around 28,000 tons per year. We have not calculated that cost, but believe it will exceed the \$15.09 per pound for our Cribari Winery in Fresno.

We want to further state and recommend to the ARB that a more comprehensive and realistic study and testing be done to 1) insure that ethanol is a real pollutant, 2) whether the cost to control the quantities emitted are necessary, and 3) that the controls imposed will not bankrupt the grape and wine industry in California and cause great economic damage to the State of California.

We have seen letters sent to you by other wineries and concur 100% in their comments. The TRG should take seriously our request that any SCM rulemaking recommendation be deferred until more convincing evidence is developed to support such SCM.

Submitted by E. C. Skofis *E. C. Skofis*  
Vice President, Production  
GUILD WINERIES & DISTILLERIES  
September 15, 1986

GUILD WINERIES  
CRIBARI WINERY - FRESNO  
ETHANOL RECOVERY  
BASED ON ARB DEVELOPED COSTS

| Location      | Red or<br>White | Ducting   | Carbon<br>Adsorp. | Carbon Adsorp.<br>Annual Cost per<br>Fig. 2 - Graph |
|---------------|-----------------|-----------|-------------------|-----------------------------------------------------|
| OUTSIDE TANKS |                 |           |                   |                                                     |
| 6-60,000 G.   | W               | 73,000    | 101,000           | 40,000                                              |
| 14-130,000 G. | W or R          | 444,000   | 500,000           | 60,000                                              |
| 1-400,000 G   | W               | 30,000    |                   | 12,000                                              |
| 200 CELLAR    |                 |           |                   |                                                     |
| 20-50,000 G.  | W               | 215,000   | 180,000           | 140,000                                             |
| 2-200,000 G.  | W               | 40,000    | 40,000            | 16,000                                              |
| 5-60,000 g.   | W               | 58,000    | 63,000            | 35,000                                              |
| 3-122,000 G.  | W               | 53,000    | 63,000            | 30,000                                              |
| 100 CELLAR    |                 |           |                   |                                                     |
| 10-200,000 G. | W               | 175,000   | 112,000           | 65,000                                              |
| 10-100,000 G. | W               | 134,000   | 114,000           | 50,000                                              |
| 600 CELLAR    |                 |           |                   |                                                     |
| 20-100,000 G. | W               | 168,000   | 228,000           | 50,000                                              |
| TOTALS        |                 | 1,390,000 | 1,401,000         | \$498,000                                           |

CARBON  
TOTAL = \$2,791,000

CRUSH DATA: 80,000 TONS 13,200,000 WG White Wine or 33,000 lbs. Ethanol

ANNUAL COST: \$498,000  
 -----  
 33,000# = \$15.09/lb Ethanol Removed

ATTACHMENT 1

# WINE INSTITUTE

100 East Street  
San Francisco, CA 94105  
(415) 398-0078

Telex: 250000 WINE INSTITUTE SAN FRANCISCO

Mr. Roddy  
Technical Review Group

October 6, 1986

William J. Roddy  
Chairman, Technical Review Group  
County of Fresno Department of Health  
1221 Fulton Mall  
P. O. Box 11867  
Fresno, CA

Re: Draft Suggested Control Measures for Emissions  
of Ethanol from Winery Fermentation Tanks

Dear Mr. Roddy:

These comments on the Draft Suggested Control Measure for Emissions of Ethanol from Winery Fermentation Tanks (the "SCM") Technical Support Document are submitted by the Wine Institute to supplement comments previously submitted on May 8 and August 29, 1986. The comments contained in this letter address certain issues raised at the September 16, 1986 TRG meeting on the draft Technical Support Document. They also address the attachment to the Technical Support Document first distributed by the ARB staff at the September 16, 1986 meeting.

As stated in these comments and the Wine Institute's previous comments, the Wine Institute does not believe the proposed SCM can be finalized without further review by the ARB staff and substantial revision in accordance with the Wine Institute's comments. The Wine Institute appreciates the TRG's efforts thus far and remains willing to meet with the TRG to discuss any necessary changes to the proposed SCM. In addition, the Wine Institute has proposed to participate in a pilot study of emissions controls in the wine industry, prior to the adoption of the SCM, to resolve all of the issues relating to the SCM raised by the Wine Institute and others.

I. Issues Raised at the September 16, 1986 TRG Meeting

A. Effect of the New Tax Law on the ARB Staff's Cost Calculations.

The cost-effectiveness calculations contained in the proposed SCM should be based on the pre-tax cost of pollution control equipment to the wine industry. The new federal tax law has been passed by Congress and should be signed into law in the near future. This new tax law removes many of the tax advantages taken into account by the ARB staff in its original calculations. Accordingly, the ARB staff must recalculate the cost-effectiveness analysis used to evaluate the proposed SCM based on pre-tax costs.

B. Economic Impact of the Proposed SCM.

The Technical Support Document conspicuously lacks any estimate of the economic impact of the proposed SCM. In fact, the staff's estimate of the cents per gallon costs of ethanol emissions control minimizes the effect of imposing any substantial additional costs on wineries that are losing money. Any significant additional costs threaten the financial viability of these wineries. The draft SCM should be revised to reflect this potential economic impact.

C. Costs of the Suggested Control Measures.

The Technical Support Document does not reflect all of the costs associated with implementing the suggested control measures. Attached to this letter is a quote from Valley Foundry for the installation of a china cap on winery fermentation tanks. Installation of a china cap will increase substantially the costs of emissions control over the ARB staff estimates. Valley Foundry has advised the Wine Institute that its estimate of the cost of installing a china cap will be much higher for fermentation tanks that are not accessible with a crane, thus further increasing the costs of retrofitting existing winery fermentation tanks.

The costs of installing ducting for all of the tanks used for fermentation also has been substantially underestimated by the ARB staff. Specifically, the ARB staff has underestimated both the per tank costs and the number of tanks that must be connected to the ducting system. The draft SCM should be revised to reflect these substantially higher costs of retrofitting existing winery fermentation tanks.

D. Technical Feasibility of the Suggested Control Measures.

The technical problems associated with the suggested control measures also are not fully discussed in the Technical Support Document. At the September 16, 1986 meeting, Professor Roger Bolton made a presentation on technical aspects of the emissions control methods proposed by the ARB staff. Professor Bolton is very familiar with the wine industry and the operating conditions in the industry that affect equipment design. He has a Ph.d in chemical engineering and has been a member of the chemical engineering and enology faculty of the University of California at Davis for 10 years. Professor Bolton has supervised the construction of two distillation columns and a pilot winery at the University and has frequently assisted commercial wineries in the selection of winery equipment.

As pointed out by Professor Bolton at the September 16 meeting, the operating experience in other industries relied on by the ARB staff to develop the SCM cannot be readily transferred to the wine industry. Failure to take into account actual conditions in the wine industry is a major flaw in the ARB staff's cost and feasibility analyses. This error has affected many of the staff's assumptions and has resulted in incomplete and oversimplified specifications for the equipment suppliers that submitted quotes for control equipment.

For example, the ARB staff has not adequately considered the impact of moisture in fermentation tank emissions. Moisture in the emissions stream is likely to cause any condenser coils used in the pollution control equipment to ice up immediately, thus drastically reducing the efficiency of the equipment. Further, inadequate consideration also has been given to the intrusion of foam into the control system during frequent foam-over events.

No consideration has been given to the costs or feasibility of the devices needed to monitor the composition of the emissions stream entering the pollution control equipment. Unlike other industries, in the wine industry, the emissions stream may vary considerably depending on the stages of fermentation and the types of wine being produced and will affect substantially the effectiveness of the pollution control equipment.



Finally, the emissions streams from winery fermentation tanks may not be effectively controlled by catalytic incineration. The problems caused by the potential poisoning of the catalyst by sulphur compounds in the emissions stream from the tank and potential generation of NOx by the incinerator have not been adequately considered in the SCM.

Significantly, when the equipment suppliers were notified of these and other specific operating problems experienced in the wine industry, they could not guarantee the effectiveness of their pollution control equipment. The ARB staff should consider these industry specific operating problems more fully and must revise the SCM accordingly.

E. Waste Disposal Problems Associated with Emissions Control.

As Professor Bolton also noted, the difficulty of disposing of ethanol/water wastes forecloses carbon adsorption, scrubbing, and condensation as viable control options. Most wineries do not have access to stills or municipal sewers for waste disposal. The only alternative for disposal of ethanol/water wastes is shipment off-site and land disposal. Experimental data shows that land disposal is not feasible, as the ethanol would rapidly volatilize back into the atmosphere. Even after an ethanol/water mixture has been absorbed into the ground, ethanol would continue to volatilize into the atmosphere because of the suppression of bacterial activity by the large amount of CO<sub>2</sub> dissolved in the ethanol/water mixture. Thus, land disposal of ethanol wastes would not reduce significantly the level of ethanol emissions.

II. Comments on the September 16 Attachment to the Technical Support Document

The ARB staff has made several revisions to the Technical Support Document since the Wine Institute originally commented on the SCM. Copies of these revisions were provided to the Wine Institute for the first time at the September 16 TRG meeting. Among the revisions made by the ARB staff is an analysis of the costs of controlling ethanol emissions in terms of cents per gallon of wine fermented at each winery. In its analysis, the staff used the assumed after-tax costs for white wine fermentation to calculate the cents per gallon estimates. As noted above, passage of the new tax law renders the staff's calculations inaccurate. And, as Wine Institute has repeatedly pointed out in its previous written comments and at the

September 16 meeting, the ARB staff has substantially underestimated the actual costs of any emissions control for existing winery fermentation tanks. For example, as noted above, the cost of the necessary ducting and the installation of a china cap would be several times greater than the staff's overall estimates of total control costs.

### III. Conclusion.

The Wine Institute requests that the TRG reevaluate the proposed SCM based on the Wine Institute's May 8 and August 29 comments, as well as the comments contained in this letter. The Wine Institute has demonstrated that the ARB staff's cost estimates for emissions controls are unrealistically low and that the controls proposed in the SCM have not been demonstrated to be feasible.

Furthermore, recent studies of ethanol reactivity, including the SAI study sponsored by Wine Institute, demonstrate that ethanol has extremely low reactivity. Consequently, there currently is no evidence that ethanol emissions contribute to high ozone levels in non-attainment areas such as Fresno County.

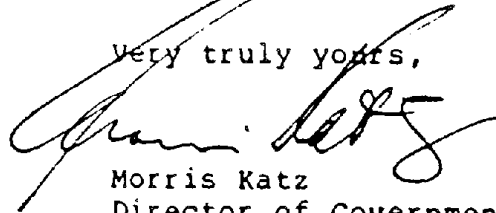
Accordingly, the Wine Institute has commissioned a modeling study by SAI of ethanol emissions in the Fresno County area to determine whether ethanol emissions affect ozone levels in that area and to what extent. We believe that the results of the modeling analysis will help determine the actual benefits from ethanol emissions reductions at the wineries.

The Wine Institute remains willing to cooperate with the ARB staff to determine the effects of ethanol emissions on ozone formation and, if necessary, to participate in a pilot study on ethanol emissions controls in the wine industry prior to the adoption of an SCM for winery fermentation tanks. The Wine Institute requests that the TRG direct the ARB staff to reconsider and revise the proposed SCM in light of the Wine Institute's comments and pilot study proposal, and requests that the TRG postpone any final action on the SCM until the SAI modeling study has been completed and the feasibility and cost of emission controls in the wine industry have been demonstrated in a pilot program. Only at that time can a

William J. Roddy  
Page 6

technically and economically sound SCM for winery fermentation tanks be developed.

Very truly yours,

A handwritten signature in dark ink, appearing to read "Morris Katz", with a large, sweeping flourish extending from the end of the signature.

Morris Katz  
Director of Governmental  
Affairs

# AMETEK

VALLEY FOUNDRY & MACHINE DIVISION • PO BOX 1626 (93717), 2510 SOUTH EAST AVE., FRESNO, CA 93706 • Tel (209) 233-6135

October 1, 1986

Bob - Per our discussion - this price is dependent upon crane access to each tank. Pricing will be significantly higher if this is not so. Each tank would have to be viewed separately. Rick Speechley 11/18/86

Bronco Wine Company  
P. O. Box 789  
Ceres, California 95307

Attention: Mr. Bob Darby

Dear Bob:

We offer the following budget prices for your consideration:

12 - Ducting connections for 350,000 gallon stainless steel wine tanks.

Duct work consists of approximately 36" Ø x 4' high cylinder with 36" x 8" concentric reducer, quick release fittings 8" and internal 24" diameter deflection cone.

Customer shall supply duct work from ground to top of tank above this fitting.

All stainless steel parts including top angle supports.

Price, installed, including sales tax----- \$ 3,900.00 per tank

Additional price to install on side of tank----- \$ 320.00 per tank

The attached general conditions apply to this quotation.

We thank you for the opportunity to submit our budget prices and hope to be favored with your most valued order.

Very truly yours,

AMETEK/Valley Foundry & Machine Division

*Rick Speechley*

Rick Speechley

RS:dt

Attachment

ART CAPUTI, JR

OCT 02 1986



CARB-SBAPCD HB 000494

# AMETEK

VALLEY FOUNDRY & MACHINE DIVISION • PO BOX 1626 (93717), 2510 SOUTH EAST AVE. FRESNO, CA 93706 • Tel (209) 233-6135

Purchaser Bronco Wine Company

Date of Quotation,  
Sale or Contract: October 1, 1986

## GENERAL CONDITIONS APPLICABLE TO ALL QUOTATIONS, SALES AND/OR CONTRACTS

1. No electrical equipment is included.
2. Customers shall be responsible for making installations in compliance with all applicable laws including safety codes and standards.
3. No piping is included or furnished.
4. No concrete work or anchors are included.
5. Foundations and all necessary permits, fees or licenses are to be furnished by purchaser.
6. Purchaser is to guarantee free and easy access to jobsite.
7. When installation or erection is included, purchaser is to provide 230 or 460 volt, 3 phase, 60 cycle and 115 volt single phase electricity for the operation of welders and other Valley equipment.
8. Purchaser is to furnish water and personnel for leak testing of tanks and other equipment.
9. Sales tax for only those quotations in which sales tax has been included has been computed by using the current state-wide and special district tax rates. In the event that an increase in sales tax occurs prior to the time of shipment, said increases will be added to the original amounts quoted.
10. When installation or erection is included, purchaser agrees to furnish and establish a special entrance reserved for the exclusive use of Valley Foundry & Machine Works, its employees, suppliers, materials and deliveries. Such entrance should be sufficiently far removed from that general entrance used by other contractors and/or purchaser's personnel.
11. The above prices are valid for a period of sixty (60) days from the date on the written quotation. If the date the order is placed lapses beyond the sixty (60) day period, the quoted price may be escalated to reflect any increase in cost which might occur based upon our actual increase of our cost of labor and materials.

VALLEY FOUNDRY & MACHINE WORKS

  
Pete P. Peters  
President

(Rev. 5/4/84)



CARB-SBAPCD HB 000495

# WINE INSTITUTE

165 Post Street  
San Francisco, CA 94108  
415 986-0878  
Cable "WINE" Telecop: 415 391-4260

December 3, 1985

Ms. Linda Lee  
California Air Resources Board  
P. O. Box 2815  
Sacramento, CA 95812

Dear Ms. Lee:

Attached is a complete copy of the comments we gave to the Fresno Air Pollution Control District in response to their initial proposal on winery ethanol emission control. The sections of this report that will probably be of the most interest to you and which we discussed over the telephone yesterday are J, K, and L. These sections include Bob Calvin's cost analysis of the carbon absorption system, Dr. Lynn Williams' calculations on the refrigeration requirements for the condensation method, and a cost estimate from L & A Engineering to provide refrigeration equipment for the condensation process.

You may be interested in looking at the rest of the documents; however, I should give you a little more background on this problem and the Wine Institute's position. This report, of course, is almost three years old now and was presented prior to adoption of the controlled fermentation temperature approach to minimize ethanol emissions. The control methods originally proposed by the Fresno APCD required extensive ducting and manifolding, causing serious industry concern about sanitation problems, backpressure on fermentation tanks, and the potential for cross contamination of wines.

As you are aware, and as the attached document points out, the evidence demonstrating the reactivity of ethanol as a photochemical precursor is not unequivocal. The wine industry has retained Systems Applications, Inc. of San Rafael to undertake once and for all a comprehensive evaluation of ethanol reactivity to determine if ethanol emissions have any significance in terms of air quality. SAI has, in turn, subcontracted with Batelle Institute to perform the actual smog chamber studies. The experimental protocol for these tests is being completed at this time and within the next week or so will be sent out to both CARB and the EPA for evaluation and suggestions prior to commencing the work.

If you have any questions of a technical nature concerning the smog chamber study, please call either Dave Souten or Dr. Gary Whitten at SAI (415-472-4011). I hope this information will be of value to you.

Sincerely yours,

*Arthur Caputi, Jr.*

Arthur Caputi, Jr.  
Chairman, Subcommittee on  
Ethanol Emissions

AC:sm  
Enclosures (5)

CARB-SBAPCD HB 000496

# WINE INSTITUTE

165 Post Street  
San Francisco, CA 94108  
415 986 0878  
Telex: WINE 706 415 1112

Noted: 2/13/86

Wendell C. Lee  
Attorney at Law

February 13, 1986

Ms. Linda Lee  
California Air Resources Board  
P.O. Box 2815  
Sacramento, CA 95812

RE: WINERY FERMENTATION CONTROL

Dear Ms. Lee:

We understand that you prepared a report concerning suggested control measures for winery fermentation emissions which was submitted to the Technical Review Group earlier this month. We respectfully request that a copy of this report, preliminary drafts of this report, notes, inter-agency and/or intra-agency memoranda retained by your office in the ordinary course of business relating to winery fermentation emissions, and any source material used in the preparation of your report, be sent to this office.

Should you have any questions concerning our request, please do not hesitate to call.

Very truly yours,



Wendell C.M. Lee  
Attorney At Law

WCML/bk

cc: Elie Skofis/Cribari & Sons  
Art Caputi/Gallo

# WINE INSTITUTE

1015 Post Street  
San Francisco, CA 94108  
(415) 398-0878  
Telex: WINE 1-425 791 420

San Francisco Counsel

Wendell C. Allee  
Victorine Horton

February 14, 1986

Ms. Linda Lee  
Stationary Source Division  
California Air Resources Board  
1102 - Q Street  
Sacramento, CA 95812

RE: WINERY MAILING LIST

Dear Ms. Lee:

Pursuant to the telephone request this date by Ms. Sue Kaiser at your office for a mailing list of Wine Institute members, I am enclosing printed mailing labels of our membership's key officials. It should be noted that Heublein Wines is not a member of the Wine Institute; however, representatives from that company have been actively engaged with the emission issue. We request that you send a copy of the meeting notice to the following:

Mr. Burt Landgren and  
Mr. R. W. Calvin  
HEUBLEIN WINES  
P.O. Box 99  
Madera, CA 93639

You may also wish to send a meeting notice to:

Dr. Cornelius Ough  
University of California at Davis  
Department of Viticulture and Enology  
1027 Wickson Hall  
Davis, CA 95616

In the same telephone conversation, I requested from Ms. Kaiser a copy of your most recent report to the Technical Review Group concerning winery ethanol emissions, any source material and research that is public information which was used in the preparation of your report, and any other information which supports your conclusions. She indicated that she would comply with this request.



Page Two  
Linda Lee  
February 14, 1986

Should you have any questions concerning this letter, please do not hesitate to call. I look forward to meeting with you at the workshop. Thank you in advance for your prompt response to our request.

Very truly yours,



Wendell C.M. Lee  
Attorney At Law

WCML/bk

Enclosure

cc: Elie Skofis/Cribari and Sons  
Art Caputi/E. & J. Gallo  
Mathew Weston-Dawkes/Gallo  
Burt Landgren/Heublein  
Dr. Cornelius Ough/UC Davis

# CARNEROS CREEK WINERY



1285 Dealy Ln.  
Napa, California 94559  
(707) 253-WINE

RECEIVED

MAR 17 1986

State of California  
Air Resources Board

March 14, 1986

Dear Mr. Friesen,

In reference to your letter of March 10, 1986 regarding the ethanol emissions from winery fermentation tanks, I would like to refer you to an article by the late Dr. Lynn Williams and Dr. Roger Boulton from the Department of Viticulture and Enology at the University of California, Davis. It was published in the American Journal of Enology and Viticulture. I have enclosed a copy from Vol. 34 No. 4 pp.234 - 242,1983. I would appreciate it if you would forward it to the appropriate personal on the Air Resources Board, or the Technical Review Group so that they might read it prior to the consultation meeting April 8th. If they are not yet aware of this research, perhaps this information will be instructive.

If you, or they have any questions, they would be best directed to Dr. Roger Boulton of the Department of Viticulture and Enology at U. C. Davis.

Thank you for your time and consideration.

Sincerely,

A handwritten signature in cursive script that reads "Melissa Moravec". The signature is fluid and elegant, with a large initial 'M'.

Melissa Moravec

# WINEY INSTITUTE

165 Post Street  
San Francisco, CA 94108  
415/386-0878  
Cable: WINEY Telecopy: 415/386-0269

San Francisco Counsel

Wendell C.M. Lee  
Victoria G. Horton

April 18, 1986

Mr. Ronald Friesen, Asst. Chief  
Stationary Source Division  
AIR RESOURCES BOARD  
1102 Q Street  
Sacramento, CA 95812

RE: WINERY ETHANOL EMISSIONS

Dear Mr. Friesen:

At the conclusion of the consultation meeting of April 8, 1986, you requested that written comments to the Preliminary Findings on Ethanol Emissions from Winery Fermentation Tanks be submitted by April 25, 1986. Because members of the industry will be meeting with members of your staff on April 21 and April 22 in Madera, and because our members will be receiving sketches of the proposed emissions control designs on April 22, we would find it difficult to respond by the April 25 deadline. We respectfully request that the written comment period be extended to May 9.

We anxiously await your decision on this matter. If there are any questions which this letter raises, please do not hesitate to call.

Very truly yours,



Wendell C.M. Lee  
Attorney At Law

/lw

cc: Elie Skofis  
Art Caputi  
Alan Goodley  
Vickie Horton

bc: Robert Effa

# WINE INSTITUTE

165 POST STREET • SAN FRANCISCO, CALIFORNIA 94108

TELEPHONE 415/986-0878

JOHN A. DE LUCA  
PRESIDENT

August 1, 1986

Mr. William J. Roddy  
Supervising Air Quality Engineer  
FRESNO AIR POLLUTION CONTROL DISTRICT  
1221 Fulton Mall  
Fresno, CA 93721

RE: TRG Meeting of August 5, 1986

Dear Mr. Roddy:

I understand that the TRG will be discussing the SCM for Winery fermentation emissions at its August 5 meeting. On behalf of the Wine Institute, the trade association of the California wine industry, I respectfully request that the TRG withhold consideration of the SCM until its October meeting so that Wine Institute has the opportunity to submit written comments. I further request that Wine Institute be permitted to make a presentation to the TRG at that meeting.

On May 8, 1986, Wine Institute submitted comments on an earlier version of the SCM and a draft Technical Support Document. At that time, Wine Institute requested an opportunity to comment on the final SCM and Technical Staff Document, because we had been informed that they might be substantially revised. Wine Institute also asked for the opportunity to present the results of its smog chamber study of ethanol reactivity.

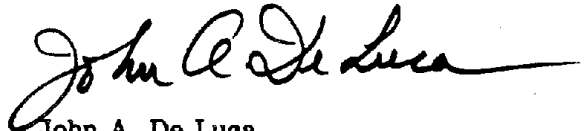
On July 24, 1986, Wine Institute received a copy of the revised Technical Support Document and proposed Suggested Control Measure from the ARB. Members of Wine Institute's Energy and Environmental Studies Committee did not receive those documents until this week. The documents are quite long (188 pages), and contain substantial new information, including new assumptions regarding costs for ethanol emissions control, together with responses to some of Wine Institute's May 8 comments. Due to the brief time Wine Institute has had to review the revised Technical Support Document and proposed SCM and the fact that the crush season has begun at many wineries, Wine Institute will not have an adequate opportunity to respond before the August 5 TRG meeting. In view of the substantial revisions to the proposed SCM and Technical Support Documents, Wine Institute is asking for the right to submit comments and be heard before TRG considers the SCM.

Mr. William J. Roddy  
August 1, 1986  
Page 2

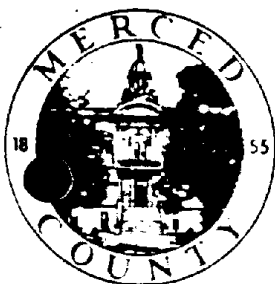
In addition, the report on the smog chamber study sponsored by Wine Institute on the reactivity of ethanol in the atmosphere is near completion, but will not be ready by August 5. Our contractor, Systems Applications, Inc. (SAI), believes that the report would be valuable to the TRG in arriving at an informed decision on the merits and feasibility of the SCM. The report will be provided to the TRG in the near future. Moving consideration of the proposed SCM to the October meeting will give TRG time to review the report and solicit comments from third parties.

We would appreciate your response to this request as soon as possible.

Respectfully submitted,

A handwritten signature in black ink, reading "John A. De Luca". The signature is fluid and cursive, with the first name "John" being the most prominent.

John A. De Luca  
President



# DEPARTMENT OF HEALTH

POST OFFICE BOX 471 - 240 E. 15TH STREET  
MERCED, CALIFORNIA 95341-0471

Richard W. Wells, M.D., M.P.H.  
Director  
Department of Health  
185742  
Administrative  
185745  
Laboratory  
185748  
Public Health Services  
185749  
Environmental Health  
185750  
201 E. 15th Street

September 4, 1986

William J. Roddy  
1221 Fulton  
Fresno, CA 93721

RE: ETHANOL EMISSIONS FROM WINERY FERMENTATION TANKS

Dear Mr. Roddy:

Merced concurs with the Rule Development Process outlined by the California Air Resources Board. This process first determines that the substance to be controlled is indeed an air contaminant and is hazardous to health. Following such a determination, a rule is then developed and proposed in order to minimize the emissions of the subject substance in as economical manner as possible consistent with health considerations. In the case of ethanol emissions from wineries, it appears that there are differing viewpoints on these matters.

The Technical Review Group (TRG), with Fresno APCD as lead agency, determined that ethanol emissions could be reduced by requiring wineries to reduce fermentation temperatures; the TRG proposed a rule which required fermentation temperatures to be reduced incrementally over a 5 year period for red wine and a 10 year period for white wine. The California Air Resources Board (CARB) countered that such measures would not be adequate and presented several other methods for control.

The control measures suggested by the CARB had been considered by the TRG. These measures have been disputed by the Wine Institute as being costly, impractical and of questional benefit.

Merced suggests that:

- 1). The rule proposed by the TRG/Fresno APCD be adopted since temperature reductions can be accomplished by the wineries in a relatively short time.
- 2). Add to the TRG/Fresno APCD Rule: Pilot Plant testing by the Wine Institute shall be undertaken in order to demonstrate the possibility of more effective control of ethanol at reasonable cost. Reports of this investigation shall be made on a semi-annual basis to the CARB and TRG to assure reasonable progress.
- 3). Concurrently studies should be made to determine the reactions of ethanol in the atmosphere in order to establish its contribution as a precursor to ozone. Reports of progress on these studies should also be presented to the CARB and TRG.

By pursuing the course of action outlined, a gradual reduction of ethanol emissions would be realized with the prospect of more positive

controls in the future. Furthermore, scientific determinations would define position of Ethanol as an ozone precursor and health hazard.

Very truly yours,

Jeff Palsgaard, M.S., Director *JP*  
Division of Environmental Health

*Richard L. Wachs*  
Richard L. Wachs, P.E.  
Air Pollution Control Engineer

JP/RLW/jrd

## AIR RESOURCES BOARD

1102 Q STREET  
P.O. BOX 2815  
SACRAMENTO, CA 95812



September 11, 1986

Mr. Wendell C. M. Lee  
Wine Institute  
165 Post Street  
San Francisco, CA 94108

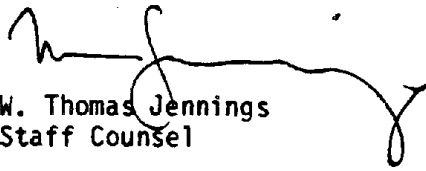
Re: Workshop on Suggested Control Measure for Winery Fermentation  
Tanks

Dear Mr. Lee:

This will confirm our telephone conversation today in which you asked whether you could tape record the proceedings of the above-referenced September 16, 1986 workshop to which the interested public is invited. I advised you that there were no restrictions to your tape recording of this public workshop.

If you have any questions about this matter, please contact me at (916) 322-2884.

Very truly yours,

  
W. Thomas Jennings  
Staff Counsel

bcc: Ron Friesen  
Bill Lovelace



Edward D. Landels  
Philip E. Diamond  
Bruce W. Hyman  
Frederick M. Pownall  
James F. Feiler  
Yanush Sashynsky  
James A. Bruce  
Stephen C. Lewis  
Richard C. Cuffie  
Susan M. Reid  
Bruce W. Landels  
Geoffrey M. Dugan  
Thomas D. Trapp  
Deborah J. Schmal  
John F. Burg  
Ted C. Radmesch  
Paul M. Zeff  
Rebecca De Kait  
Gretchen A. Beck  
Susan T. Taylor  
Julie Finley  
Scott D. Rogers  
James B. LeRoy, Jr.  
Elyse R. Arell  
Matthew J. Geyer  
Patrick R. S. Bupara

Lari M. Ripley  
John H. Baker  
Greg A. Gandy  
John M. Anderson  
James A. Murre  
Harvey L. Lederman  
Jon Enner  
Anthony O. Garms  
John E. Mitchell  
Richard D. Warren  
Ronald C. Haslam  
Patrick J. Callery, Jr.  
Ann Julius  
Curtis E. A. Karnow  
Deborah K. Miller  
Jamin Hawks  
Renée M. Rusk  
Jayne A. Poteris  
Brian S. Haughwout  
Rebecca R. Wetzels  
Robert K. Klotz  
Candace Hale  
Eric R. Newman  
Karen Boyko-Gale  
Michael W. Perville  
Kimberly S. Muschell

# Landels, Ripley & Diamond Attorneys

450 Pacific Avenue  
San Francisco, California 94133  
(415) 788-5000

925 L Street, Suite 920  
Sacramento, California 95814  
(916) 448-8300

October 6, 1986

Tels 2781 61  
Cable LARDI UN

VIA ZAP MAIL

Mr. William J. Roddy  
Chairman, Technical Review Group  
County of Fresno Department of Health  
1221 Fulton Mall  
Post Office Box 11867  
Fresno, California 93775

Re: October 7, 1986 Technical Review  
Group Meeting

Dear Mr. Roddy:

This letter confirms that I requested the opportunity to attend the October 7, 1986 meeting of the Technical Review Group in San Diego. I made that request on behalf of the Wine Institute which has retained this law firm to represent the Institute concerning various proposals to regulate potential ethanol emissions generated from winery fermentation tanks. Specifically, I requested the opportunity to attend, observe and, as appropriate, present comments to the TRG. In addition, I requested the opportunity to record the meeting. Unfortunately, you denied these requests.

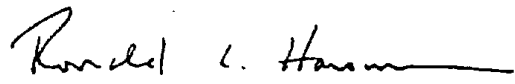
Subsequent to our discussion, I discussed the Wine Institute's right to attend and observe the meeting under the provisions of the Brown Act, Government Code §§54950, et seq. with David Nawi, General Counsel to the Air Resources Board. Mr. Nawi confirmed that counsel to the ARB had been consulted by the TRG concerning the applicability of the Brown Act to TRG activities and has informed the TRG that, in the opinion of ARB's legal staff, TRG meetings are not governed by the Brown Act and that the TRG may conduct its actions in closed, non-public sessions.

Mr. William J. Roddy  
October 6, 1986  
Page 2

We disagree with that legal conclusion. More importantly, we believe that regardless of any legal mandate, all interested persons are better served when the government acts openly, with full opportunity for public comment. Open meetings, at which affected and interested parties can attend and participate prevents factual and other misunderstandings and ensures public confidence in the governmental decision-making process.

Again, we regret your decision and will evaluate the legal options available to the Wine Institute.

Sincerely,

  
Ronald C. Hausmann

RCH:ss

cc: David Nawi, Esq.  
Morris Katz, Esq.

State of California  
AIR RESOURCES BOARD

NOTICE OF PUBLIC MEETING TO CONSIDER APPROVAL OF A SUGGESTED CONTROL MEASURE  
FOR CONTROL OF ETHANOL EMISSIONS FROM WINERY FERMENTATION TANKS

The Air Resources Board (the "Board"), pursuant to the authority vested by Sections 39000, 39001, 39003, 39600, 39602, 39605, and 41500 of the Health and Safety Code, will conduct a public meeting to consider approval of a suggested control measure to limit the emissions of ethanol from winery fermentation tanks.

DATE: January 22, 1987

TIME: 10:00 a.m.

PLACE: Lincoln Plaza Auditorium, First Floor  
400 "P" Street  
Sacramento

This item will be considered at a two-day meeting of the Board which will commence 10:00 a.m. January 22, 1987 and will continue 8:30 a.m. January 23, 1987. This item may not be considered until January 23, 1987. Please consult the agenda for the meeting, which will be available at least 10 days before January 22, 1987, to determine the day on which this item will be considered.

Pursuant to the federal Clean Air Act and the California Health and Safety Code, federal and state ambient air quality standards have been established for ozone and oxidant, respectively. These standards are exceeded in several California air basins. Atmospheric emissions of ethanol from winery fermentation tanks react with oxides of nitrogen in the presence of sunlight to form oxidants including ozone, the principal component of photochemical smog. The Fresno County Nonattainment Area Plan (NAP) contains a commitment to adopt a winery fermentation tank emission control measure. The Kern County NAP identifies the control of winery fermentation tank emissions as a further study measure.

The Technical Review Group has drafted a suggested control measure for the control of emissions of ethanol from winery fermentation tanks. The Technical Review Group consists of representatives of the Environmental Protection Agency, the Air Resources Board, and local air pollution control districts. The major requirements of the measure are:

1. The ethanol content of the exhaust gases from any fermentation tank of 50,000 gallons capacity or more shall be reduced by 90 percent.
2. The owner or operator of any winery with fermentation tanks of 50,000 gallons capacity or more shall submit to the Air Pollution Control Officer a control plan including a list of all fermentation tanks subject to

control and their respective capacities, identification of the type of control to be applied to each tank, and a construction schedule.

3. All equipment identified in the control plan shall be installed by the beginning of the 1990 fermentation season. To determine initial compliance, source testing of the emissions from each fermentation tank subject to control shall be conducted within 30 days after the beginning of the 1990 fermentation season.

4. Thereafter, compliance with this rule shall be demonstrated by periodic source testing of the emissions from one or more fermentation tanks subject to control.

5. Approved demonstration and pilot programs shall be conducted to identify any unforeseen problems that may be associated with the installation, operation, and maintenance of ethanol exhaust control equipment for fermentation tanks. The demonstration and pilot programs shall be conducted during the 1988 fermentation season.

6. If the results of the demonstration and pilot programs do not support the requirement of a 90 percent reduction in the ethanol content of the fermentation tank exhaust gases, a hearing will be held by the district to amend the requirements of this rule.

If approved by the Board, the suggested control measure will be forwarded to the appropriate air pollution control districts for consideration and adoption in regulatory form to the extent necessary to provide attainment and maintenance of the ambient air quality standards. Until formally adopted as a rule of a district, the suggested control measure remains nonbinding, and compliance by operators of wineries is not required.

The Board staff has prepared a staff report on the proposed suggested control measure, which discusses the background, necessity for, and environmental impact of the proposal. The Staff Report, the full text of the proposed suggested control measure, and any other information on which the proposal is based will be available for inspection at the Air Resources Board Public Information Office, 1102 "Q" Street, Sacramento, CA 95814, (916) 322-2990, at least 30 days prior to the scheduled meeting. Copies of the Staff Report and the text of the suggested control measure may be obtained at the above Public Information Office.

Further inquiries regarding this matter should be directed to Alan Goodley, Chief of the Strategy Assessment Branch, Stationary Source Division, P.O. Box 2815, Sacramento, CA 95812, (916) 322-6020.

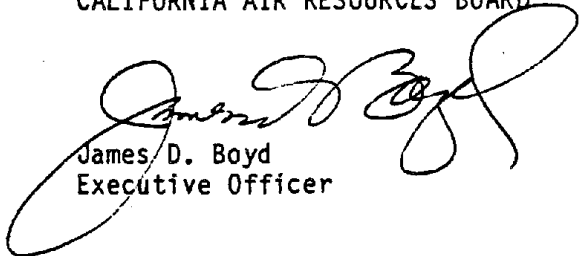
The public may present comments relating to this matter orally or in writing. To be considered by the Board, written comments must be addressed to and received by the Board Secretary, Air Resources Board, P.O. Box 2815, Sacramento, CA 95812, no later than 12:00 noon on January 21, 1987, or



received by the Board Secretary at the meeting. The Board requests but does not require that 20 copies of any written statement be submitted and that all written statements be filed at least 10 days prior to the meeting.

Following the public meeting, without further notice, the Board may approve the suggested control measure as proposed, approve it with such modifications as the Board deems appropriate, or take other action consistent with the terms of this notice.

CALIFORNIA AIR RESOURCES BOARD



James D. Boyd  
Executive Officer

Date: December 19, 1986