AP42 Section:	9.12.2
Title:	Comments and letters

Note: This material is related to a section in *AP42, Compilation of Air Pollutant Emission Factors, Volume I Stationary Point and Area Sources.* AP42 is located on the EPA web site at www.epa.gov/ttn/chief/ap42/

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CALIFORNIA AIR RESOURCES BOARD

Rec'd 12/8/94 TL

Stationary Source Division, Criteria Pollutants Branch
2020 "L" Street, P.O. Box 2815
Sacramento, CA 95812

Date Requested: ____________

Date Sent: 11/29/92

State of California
California Environmental Protection Agency
Air Resources Board
Fuels Section
Criteria Pollutants Branch
Stationary Source Division

Nelson Chan
Air Resources Engineering Associate
(916) 327-1510
ATSS 8-467-1510

2020 L Street
P.O. Box 2815
Sacramento, CA 95814

To: Tom Lapp
Midwest Research Institute
401 Harrison Oaks Blvd, Suite 35
Cary, NC 27513

The enclosed material is forwarded:

____ At your request

✓ For your information

The Criteria Pollutants Branch, Stationary Source Division is pleased to make the following material available to you:

1.) "Technical Assessment Document on Ethanol Emissions and Control from California Wineries", Joan Heredia, June 1993

2.) Technical Support Document, A Suggested Control Measure for Control of Winery Emissions, ARB, October 1986.

3.) Letter from Dean C. Simeroth, ARB, to Mark Boese, San Joaquin Valley APCD.

WINES AND BRANDY

ELIE SKOFIS

FAX NO. : (209) 449-1243

Phone No. : (209) 431-0550

Address : P.O. Box 1068
FRESNO, CA 93725

① Call M.A. → with any comments

~~② Call Larry Lowry X1539~~

③ Karen Randolph (703) 308-8651

Ron Ryan
541-4330

give Ron
last 3 numbers

up to 70 character description

Fire

9/27/95

Wines and Brandy

lb per 1,000 gal ~~wine~~ fermented juice 11 - Screening
lb per ton of pomace pressed 12 - Pomace
lb per 1,000 gal wine ~~13~~ 21 - Bottling

3-02-011-11
3-02-011-12
3-02-011-~~13~~ 21

Bottling 3-02-011-~~13~~ 21 Fugitive ~~ethanol~~ emissions from wine bottling ~~process~~.

Screening 3-02-011-11 Fugitive ~~ethanol~~ emissions from screening of pomace from red fermented juice ~~wine~~.

Pomace Press 3-02-011-12 Fugitive ~~ethanol~~ emissions from pomace pressing. ~~of the pomace~~

REVIEWERS FOR SECTION 9.12.2, WINES AND BRANDY

1. Mr. Nelson Chan
   Air Resources Board
   2020 L Street
   Sacramento, CA 95812

2. Mr. Elie Skofis
   P.O. Box 1068
   Fresno, CA 93725

3. Ms. Maria Lima **(unbound copy)**
   San Joaquin Valley Unified Air Pollution Control District
   1999 Tuolumne Street
   Suite 200
   Fresno, CA 93721

4. Mr. Arthur Caputi, Jr.
   E&J Gallo Wineries
   P.O. Box 1130
   Modesto, CA 95353

5. Mr. John Franzia
   Bronco Wine Company
   P.O. Box 789
   Ceres, CA 95307

WINE INSTITUTE

September 6, 1995

425 Market Street
Suite 1000
San Francisco
California 94105
(415) 512-0151

Dallas W. Safriet
Environmental Engineer
U.S. Environmental Protection Agency
Emission Factor and Inventory Group (MD-14)
Research Triangle Park, North Carolina 27711

Dear Mr. Safriet:

In response to your request for reviews of the draft version of **Section 9.12.2, Wines and Brandy** to be published in **AP-42**, we, the undersigned, felt it appropriate to submit a joint appraisal. Since we all serve on the Ethanol Emissions Subcommittee of Wine Institute, we are quite familiar with most aspects of this issue, and were pleased to have had the opportunity to examine this document.

At the outset, we would like to say that we are in agreement with the factors proposed for ethanol emissions produced during fermentation. We would like to address some corrections in the background information relating to wine and brandy production so that it will be as accurate and factual as possible. We would also like to address the proposed quality rating of the data, and to also propose including factors for hydrogen sulfide emissions during fermentation. We have also taken the liberty of enclosing the most current proposed version of a Technical Assessment Document "Strategies and Costs for Winery Ethanol Emission Control" with the permission of Dean Simeroth, Chief of the Criteria Pollutants Branch of the California Air Resources Board. Our Wine Institute Subcommittee is satisfied with the document in its present form and it only awaits final review and approval by CARB before becoming official. Finally, we are enclosing a copy of a smog chamber study commissioned by Wine Institute entitled "Potential Impact of Ethanol Emissions on Urban Smog: A Preliminary Modeling and Smog Chamber Study." The protocol for this work was presented to both EPA and CARB prior to its inception, and the results show that ethanol is only one fourth to one third as reactive as a typical hydrocarbon as an ozone precursor. Although these data have no impact on the emission factors developed for **AP-42**, we feel EPA should be aware of this study.

We have scanned into a word processor the portions of the **AP-42** draft that we believe need to be modified, and generated a "red-lined" version. Most of the comments tend to deal with the technology of wine and brandy production and correct some misunder-standings and inaccuracies in the supporting information. There are a few, however, that deal directly with ethanol emissions or potential control systems. For example, the paragraph beginning on the bottom of page 2-19 and concluding at the top of page 2-20

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states "Carbon adsorption is not considered a viable option because of the large amount of duct piping and other auxiliary equipment required to incorporate all of the fermentation tanks into the control system." This problem exists for *all* the control systems, not just carbon adsorption. The major cost in implementing any kind of emission controls on fermentation tanks is the number of tanks that would have to be modified, fitted with special hoods, and ducted to appropriate control devices.

The second paragraph on page 2-20 suggests that stillage (the dealcoholized solution produced from the still) is a potential source of emissions during its disposal. In fact, the process of distillation has removed virtually all VOC's, and wineries have measuring devices on their distilling columns to ensure that less than 0.02% - 0.03% ethanol remains in the discharge stream.

The next issue we would like to address is the "Data Quality Rating." We feel the data on ethanol emissions clearly deserves a rating higher than the "E" classification proposed. First of all, all the tests were devised in conjunction with the staff of the California Air Resources Board, and their representatives monitored most of them. The tests were conducted at a number of different facilities, including California State University, Fresno. The size of the tanks ranged from under 2,000 gallons to several hundred thousand gallons. The results were reasonably consistent across the entire range of tests, and were quite consistent in the most carefully planned and controlled experiments. It is important to understand that we are dealing with a dynamic system in which ethanol vapor is carried into the atmosphere with large varying volumes of carbon dioxide. This is much different from evaporation of volatile organic liquids stored in a static system from which simple vapor pressure calculations can accurately predict potential emissions. The data available on ethanol emissions are undoubtedly as good as can ever be obtained, and represent actual operating conditions, not some kind of theoretical or laboratory simulation.

A similar case can be made for the quality of data for the development of acetaldehyde and hydrogen sulfide emission factors for wine fermentation. Both of these compounds are formed in varying concentrations depending upon a number of factors. For acetaldehyde, not only temperature of fermentation, but yeast strain, and various yeast nutrients, as well as levels of sulfur dioxide in the fermenting must, can influence the levels produced. All of these factors also are involved in determining the levels of hydrogen sulfide produced, and one important additional one. That is the level of elemental sulfur applied to grapes to prevent mildew from forming. This obviously varies from region to region, variety to variety, year to year, and region to region. In appendix F, page F-2 quotes a letter from Arthur Caputi, Jr. to Maria Lima of the San Joaquin Valley Unified Air Pollution Control District. In an underlined portion of the letter, Caputi states "As the results showed, <u>H_2S quantities varied tremendously</u>: some fermentations had none, and those which tested positive did not show a consistent pattern of emission."

These results are not the results of poor test protocol or inadequate analyses; they are the result of the nature of the fermentation process and the presence, or absence, of critical compounds involved in the biochemical pathways involved in the formation of hydrogen sulfide. We have included the results on hydrogen sulfide production that were appended to the letter to Ms. Lima for your consideration to be included in the list of fermentation emission factors. While it is true that the raw data show a large amount of variation, the total quantities of wine fermented in these tests far exceed anything that is likely to be used in any future tests, and the results are probably as good as will ever be obtained in any such experiment.

We hope this information will be of some value to you. If you have additional questions, please feel free to call any of us.

Sincerely yours,

Arthur Caputi, Jr.

Arthur Caputi, Jr., Chairman
Wine Institute Subcommittee on Ethanol Emissions

John Franzia, Jr.
J F J Bronco Winery

Bill Nakata

Bill Nakata
Delicato Vineyards

Elie C. Skofis

Elie Skofis, Consultant
Fresno, California

Hydrogen Sulfide Emission Factors

Red Fermentations:

	Fermentation No.	Lbs. H_2S Produced	Gallons Fermented	lbs/1,000 gal
72°F 23°B	3	0	157,120	0
74°F 23°B	4	0	152,740	0
73°F 23°B	5	0.42	145,280	0.0029
73°F 22.8	6	0.33	146,145	0.0023
74°F 22.6	7	0.51	144,475	0.0035
	Totals	1.26	745,760	

Factor = 0.0017 lbs. H_2S/1,000 gallons (1.26/745,760)

White Fermentation:

	Fermentation No.	Lbs. H_2S Produced	Gallons Fermented	
57°F 21.6°B	8	0.24	169,028	0.0014

Factor = 0.0014 lbs. H_2S/1,000 gallons (0.24/169,028)

Hydrogen Sulfide Calculations

1990 Fermentation - Fresno[1]

Fermentation #3
(Red)

0 Hydrogen Sulfide

Fermentation #4
(Red)

0 Hydrogen Sulfide

Fermentation #5
(Red)

Portion of ferm. with measurable H_2S = 16 hours
Average H_2S = 4 + 5 +2 = 4.5 ppm
(4.5 ppm + 10^6) x (66,000 x 16 hrs) = 4.75 ft^3
4.75 ft^3 + 11.23 ft^3/lb = <u>0.42 lb H_2S</u>

Fermentation #6
(Red)

Portion of ferm. with measurable H_2S = 8 hours
Average H_2S = 7 ppm
(7 ppm ÷ 10^6) x (66,000 x 8 hrs) = 3.7 ft^3
3.7 ft^3 + 11.23 ft^3/lb = <u>0.33 lb H_2S</u>

Fermentation #7
(Red)

Portion of ferm. with measurable H_2S = 17 hours
Average H_2S = (6 + 4 + 6 + 5 + 4.5) + 5 = 5.1 ppm
(5.1 ppm + 10^6) x (66,000 x 17) = 5.72 ft^3
5.72 ft^3 + 11.23 ft^3/lb = <u>0.51 lb H_2S</u>

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1. <u>Factors Used in the Following Calculations:</u>
1,100 cfm x 60 = 66,000 cfh
To calculate the number of volumes of gas: ppm H_2S is divided by 1,000,000
H_2S = 11.23 ft^3/lb

Fermentation #8
(White)

Portion of ferm. with measurable H_2S = 16 hours
Average H_2S = $(4 + 1.25) \div 2 = 2.6$ ppm
$(2.6 \text{ ppm} \div 10^6) \times (66{,}000 \times 16) = 2.75 \text{ ft}^3$
$2.75 \text{ ft}^3 \div 11.23 \text{ ft}^3/\text{lb}$ = <u>0.24 lb H_2S</u>

Hydrogen Sulphide Concentration - 1990 Fermentations

Hydrogen Sulphide Concentration - Fermentation #3 (Red)

time/ date	0710	1020	1100	1425	1500	1600	2300
9/12	0		0		0		0
9/13		0		0		0	

Hydrogen Sulphide Concentration - Fermentation #4 (Red)

time/ date	0710	1210	1315	1600	1700
9/14			0	0	
9/15	0	0			0

Hydrogen Sulphide Concentration - Fermentation #5 (Red)

time/date	1130	1855	2300
9/16			0
9/17	4	5	0

Hydrogen Sulphide Concentration - Fermentation #6 (Red)

time/date	0640	1200	1530	2330	2355
9/18			0		0
9/19	0	7		0	

Hydrogen Sulphide Concentration - Fermentation #7 (Red)

time/date	0640	0720	1220	1505	2345
9/20				0	0
9/21	6	4	6	5	4.5

Hydrogen Sulphide Concentration - Fermentation #8 (White)

time/ date	0630	0640	0645	0705	1205	1210	1230	1320	1530	2330	2345
9/23									0	4	
9/24				0	0						0
9/25			0			0					0
9/26	0						0				
9/27		0						Trace		0	
9/28				1.25							

Hydrogen Sulphide Concentration (ppm) - Fermentations #3 - #8 - 1990 (Fresno)

date/tim	9/12	9/13	9/14	9/15	9/16	9/17	9/18	9/19	9/20	9/21	9/23	9/24	9/25	9/26	9/27	9/28
0630														0		
0640								0		6			0		0	
0650																
0700												0				
0710	0			0						4						1.25
1020		0														
1100	0															
1130						4										
1200								7				0				
1210				0									0			
1220										6						
1230														0		
1315			0													
1320															Tr.	
1425		0														
1515	0								0	5						
1530							0				0					
1600		0	0													
1700				0												
1740																
1855						5										
1920																
2300	0				0	0										
2330															0	
2345							0	0	0	4.5	4	0	0			

DRAFT
3869/460203
7/25/95

2. INDUSTRY DESCRIPTION

This section includes a brief description of the wine making industry, an overview of the process involved in making wines and brandy, and a discussion of the air emissions to be considered.

2.1 INDUSTRY CHARACTERIZATION[1-4]

~~U.S. consumption of alcoholic beverages, in general, is declining and consumption patterns are shifting from premium brands to less expensive brands and to light or reduced calorie (reduced alcohol) beverages. Household weekly expenditures on alcoholic beverages in the United States declined from $5.52 per household in 1985 to $5.09 in 1989 (a decrease of 8 percent). United States wine consumption peaked in 1984 at approximately 216 million cases (9 liters [L] per case) and declined to 180 million cases in 1990.~~

Table 2-1 shows the distribution of wineries across the United States. Although wineries are by far most prevalent in California (with 293 of a total 510 establishments), New York has 32 wineries and Washington has 27 wineries. ~~Production of fine California wines is concentrated in the Napa Valley Region, and table and dessert wines are produced primarily in the Central Valley.~~

Several states actively promote the development of the wine industry through their departments of agriculture or economic development. In particular, the number of small wineries has been increasing. Between 1982 and 1987, the number of wineries with 50 or less employees grew by 48 percent, from 315 wineries to 453. The growth of small wineries has increased the dispersion of wine making emissions across the country.

The Standard Industrial Classification (SIC) code for wines and brandy is 2084. This code encompasses the production of wines, wine coolers, brandy, and brandy spirits; it also includes bonded wine cellars engaged in blending wines.

2.2 PROCESS DESCRIPTION[5-7,9]

Wine is an alcoholic beverage produced by the fermentation of sugars in fruit juices, primarily grape juice. In general, wines are classified into two types based on alcohol content: table

wines (~~7~~9 percent to 14 percent alcohol, by volume) and fortified wines (17 percent to 22 percent alcohol, by volume). Table wines are subdivided into still and sparkling categories, depending upon the carbon dioxide (CO_2) content retained in the bottled wine. Wines found in the category of still table wines are divided based on the color of the wine into three groups: red, white, and rose (or blush). In terms of overall production, still table wines represent the vast majority of all of the wines produced in the United States. Sparkling wines are often classified by the method used to achieve the CO_2 content in the wine; the three primary production techniques are: methode champagnoise (fermented in this bottle)~~traditional (as in champagne)~~, transfer, and bulk. In all three methods, yeasts are used to generate the CO_2 to produce the effervescence.~~, but some wines also derive their sparkle from CO2 incorporated under pressure.~~

Dessert~~Fortified~~ wines may achieve their higher alcohol content by the addition of distilled spirits (fortified wine) or by fermentation of high sugar content juices. These wines are produced in a wide range of styles, either dry or sweet, and are typically consumed in small amounts either before or after meals. Examples of dry fortified wines are dry vermouth or dubonnet; examples of sweet types are sweet vermouth, sherry, port, and Madeira.

The production of still table wines is discussed in detail in the following sections, followed by more concise discussions of the production of sweet table wines, sparkling wines, dessert~~fortified~~ wines, and brandy.

2.2.1 Still Table Wines

The basic steps in vinification (wine production) include harvesting, crushing, pressing, fermentation, clarification, finishing, and bottling. A simplified process diagram outlining the basic steps in the production of still table wines is shown in Figure 2-1.

2.2. 1.1 Harvesting. Harvesting of grapes is usually conducted during the cooler periods of the day to prevent or retard heat buildup in the grape; if the temperature is high, the grapes must be cooled immediately after harvest to prevent flavor deterioration. During harvest, some grapes are unavoidably bruised or the skin broken resulting in release of the juice. When this occurs, oxidative degradation of the juice can begin and the juice can become contaminated with yeast or bacteria present on the grape skin. To minimize this degradation, the grapes may be field-treated with sulfite

compounds after harvest. Some wineries crush the grapes in the vineyard and transport the crushed fruit to the winery.

2.2.1.2 Stemming and Crushing. Stemming and crushing are commonly conducted as soon as possible after harvest and are currently done in separate steps. Removal of the stems, leaves, and stalks prior to crushing helps control the production of undesirable compounds during subsequent production steps. For convenience and efficiency, stemming and crushing are often performed in a crusher-stemmer. The stemmer portion of the machine contains an outer perforated cylinder that allows the grapes to pass through but prevents the passage of stems, leaves, and stalks. After stemming, the grapes pass immediately to the crusher. Crushing the grapes after stemming permits fermentation to commence almost immediately and limits microbial contamination. From 75 to 150 milligrams per liter (mg/l) of liquefied sulfur dioxide (SO_2) is added to the crushed grape mass to control oxidation, wild yeasts and spoilage bacteria.

Crushing is accomplished by any one of many procedures; the processes generally favored are: (1) pressing grapes against a perforated wall; (2) passing grapes through a set of rollers; or (3) using centrifugal force. In the perforated wall process, the juice, pulp, seeds, and skin pass through the openings, are collected, and pumped to a retaining tank or vat. The roller process crushes the grapes between a pair of spiral ribbed or grooved rollers turning in opposite directions. Centrifugal crushers turn the grapes into a pulpy slurry; this process is generally undesirable because juice clarification is difficult and the seeds are commonly broken. In crushing, it is important to avoid crushing the seeds to preclude contaminating juice slurry with seed oils, which can produce rancid odors and bitter tannins. In most direct to press operations, stemming and crushing are not performed.

2.2.1.3 Maceration. Maceration is the breakdown of grape solids following crushing. ~~, and results in the rupture and release of enzymes from grape cells. The enzymes facilitate the release of flavor ingredients from the skins, seeds, and pulp and promotes the synthesis of additional flavor compounds~~. In red and rose wine production, the slurry of juice, skins, seeds, and pulp is termed the , "must". In white wine production, the skins, seeds, and pulp are separated from the juice before inoculation with yeast and only the juice is fermented. A fermenting batch of juice is also called "must." Thus, the term "must" can refer to either the mixture of juice, seeds, skins, and pulp for red or rose wines or only the juice for white wines. Maceration is always involved in the initial phase of red wine fermentation. Maceration temperature and duration of the process are the major factors

influencing the degree of compound extraction and types of compounds released. During maceration, the temperature of the mass is adjusted and controlled to influence the types and amounts of compounds released. ~~For red-skinned grapes, maceration times of less than 24 to 36 hours commonly produce a rose wine; early consumption red wines are macerated for 3 to 5 days; and long aging reds may be macerated for 5 days to 3 weeks.~~

2.2.1.4 Pressing.. ~~If the volume of must is small,~~ The juice from the grapes may be~~is~~ extracted from the must directly in the press. Additionally ~~However, for large volumes of must,~~ ~~de~~juicers may be~~are often~~ used to initially separate the majority of the juice from the crushed grapes by gravity flow, and the presses are used to extract the juice remaining in the pomace. There are many designs of dejuicers but, in general, they consist of a tank fitted with a perforated basket at the exit end. The must is introduced into the tank and juice flows through the basket into a receiving tank (sump). The must may be allowed to rest in the press and the juices forced out under the weight of the skins and seeds (pomace). When drainage is complete, the basket is raised to facilitate pomace discharge for transport to the press. After gravity dejuicing has occurred, the pomace is placed in the press and the remaining juice extracted. There have been several major advances in press design including the use of hydraulic force instead of muscle power, removable bottoms for easier pomace discharge, increased drainage surface area, and the design of the horizontal press and the continuous screw press. The horizontal press is used for either crushed or uncrushed grapes. The must is loaded at the upper raised end of the press and one or both end plates moved forward to compress the must. Juice escapes between slats in the press cylinder; the remaining pomace cake is then removed from the lower end of the cylinder. A pneumatic press can also be used for either crushed or uncrushed grapes as well as for fermented must. The press is filled through an elongated opening in the top and, after filling and closure, the press is inverted to allow any free-running juice to escape. Pressing occurs by one of two mechanisms: (1) the grape mass is filled into a central sack, and gas is forced between the sack and the cylinder walls to compress the mass against perforated plates in the center of the cylinder; or (2) the mass is filled between the sack and perforated cylinder walls, and gas forced into the sack presses the mass against the perforated cylinder walls. The remaining pomace cake is crumbled and removed from the cylinder.

In the~~The~~ continuous screw press ~~is the only one that operates uninterrupted and works bes:- with fermented must but can be adjusted for crushed, nonpulpy grapes.~~ the ~~M~~must is pumped into the press via a hopper at one end and a fixed helical screw forces the mass into a pressing chamber where

perforated walls allow the juice to escape. Pressed pomace accumulates at the opposite end of the press and is periodically discharged through a port opening. After pressing, white must is typically clarified prior to fermentation to retain the fruity character. The white juice is commonly allowed to settle for up to 12 hours but may be centrifuged to speed the clarification.

2.2.1.5 Fermentation. Fermentation is the process whereby the sugars (*glucose* and fructose) present in the must undergo reaction by yeast activity to form ethyl alcohol (ethanol) and CO_2 according to the equation:

$$C_6H_{12} - 2\ C_{12}H_5OH + 2\ CO_2$$

Based on this equation, about one percent of sugar fermented yields 0.55 volume percent of ethanol. Thus, a juice sugar content of about 16.4 percent is the minimum necessary to produce a wine with 9 Volume percent ethanol. In the U.S., the sugar content of the juice is commonly measured with a hydrometer in units of degree Brix (°B), which is grams (g) of sugar per 100 grams of liquid. Because sugars constitute the major component of grape soluble solids when over 18° Brix (i.e., 18 g of sugar per 100 g of juice), this reading is a fairly accurate indicator of the capacity of the juice to produce ethanol.

Fermentation may be~~is~~ initiated by the addition of yeast inoculation to the must. The fermentation process takes place in tanks, barrels and vats of a wide variety of shapes, sizes, and technical designs. Tanks are differentiated from vats by being enclosed whereas vats have open tops. In most of the larger wineries, tanks have almost completely replaced vats. Most fermenting tanks (termed fermentors) are straight-sided or have the form of slightly inverted cones. Since the 1950's, the move has been away from wooden tanks to primarily stainless steel tanks; however, in certain areas, lined concrete tanks are also used. In addition, fiberglass tanks are becoming more popular due to their light weight and lower cost. However, stainless steel has the distinct advantage of rapid heat transfer, which is very important for cooling the fermenting juice. The fermentation process is an exothermic reaction and requires temperature control of the fermenting must. Double-jacketed stainless steel tanks, circulating coolant between the inner and outer walls, can provide the required temperature control. Red wines are typically fermented at 25° to 28°C (70° to 82° F) and white wines at 8° to 15° C (46° to 59° F).

2-7

Almost all of the fermentation is conducted by the batch process; continuous fermentors are rarely used in the U.S. The size of the fermentors is based primarily on the volume of juice or must to be fermented. For many premium wines, fermentor volumes commonly range from 50 to 100 hectoliters (hl); 1 hectoliter equals 26.42 U.S. gallons. With standard quality wines, fewer but larger fermentors are used and common sizes range from 200 to over 2,000 hl (5,300 to 53,000 gallons). For large scale wineries, fermentation tanks with capacities in excess of 7,570 hl (200,000 gallons) are common.

During fermentation of red wines, the CO_2 released by the yeast metabolism becomes entrapped in the pomace layer of skins and seeds) and causes it to rise to the top of the tank where it forms a cap. ~~Cap formation helps to prevent contact of the fermenting must with air, which can lead to undesirable side reactions.~~ The entrapped CO_2 can ~~also~~ prevents contact between the pomace and the juice, which retards the extraction of those compounds from the skins, seeds, and pulp necessary to provide the red wine with its flavor and character. When open-top vats were used for the fermentation of red wines, the pomace cap was manually submerged (punched down) to improve contact with the juice. ~~The shift from open vats to closed tanks has resulted in an array of methods to periodically punch down the pomace cap.~~ In addition to improving color removal, punching down aerates the fermenting must, limits growth of spoilage organisms in the cap, and helps equalize the temperature in the fermenting must.

Many U.S. wineries are replacing manual punching down by pumping the fermenting wine over the cap ("pumping over").

For white wines, fermentors are of simple design with the main technical requirement being efficient temperature control. If not initially cool, the juice must be cooled before the yeast inoculation occurs and the fermenting juice maintained between 8° and 15° C (46° to 59° F).

Temperature is one of the most influential factors affecting the fermentation process. At the upper and lower limits, temperatures can cause yeast cell death; however, inhibiting effects are experienced well within the temperature extremes. During fermentation with no temperature control, a juice with an initial reading of 23° Brix could increase in temperature by about 30°C (54°F). If this were to occur, the yeast cells would die before completing fermentation; however, this temperature rise is not realized in practice. Because the heat is liberated over several days to weeks, some of the heat is lost with the escaping CO_2 and water vapor as well as through the walls of the tank. During fermentation, the CO_2, water vapor, and ethanol are released through a vent in the top of the tank. Heat buildup is controlled by the initial juice temperature at the beginning of fermentation, the size

and shape of the fermentor, and the presence or absence of a pomace cap. The formation of CO_2 during white and rose wine fermentation often creates sufficient agitation of the juice to maintain a uniform temperature. However, for red wines, the pomace caps can disrupt effective circulation and mixing of the must by the CO_2. A pomace cap-to-liquid temperature difference of 10°C (18° F) is often observed.

2.2.1.6 Malolactic Fermentation. The principal effect of malolactic fermentation is a reduction in the acidity of the fermented juice or must. ~~During fermentation, lactic acid bacteria ferment sugars to lactic acid or a combination of lactic acid, ethanol, and CO2.~~ The major benefit of this fermentation step is the metabolism of a dicarboxylic acid (malic acid)~~, formed during fermentation,~~ to a monocarboxylic acid (lactic acid) which leads to a reduction in ~~juice~~ acidity and increased pH. ~~While increased pH provides conditions more favorable to microbial stability, it~~Malolactic fermentation may also affect the sensory characteristics of the wine. There are very diverse opinions about this step because the fermentation, to varying degrees, can improve or reduce wine quality.

2.2.1.7 Maturation and Clarification.

2.2.1.7.1 Maturation. All wines undergo a period of adjustment (maturation) prior to bottling. The process of maturation involves the precipitation of particulate and colloidal material from the wine as well as a complex range of physical, chemical, and biological changes that tend to maintain and/or improve the sensory characteristics of the wine. The major adjustments are acidity modification, sweetening, dealcoholization, color adjustment, and blending.

Acidity adjustments can be either a deacidification or an acidification. Wines may be deacidified by either physicochemical or biological means; the biological process usually involves malolactic Fermentation whereas the physicochemical process includes precipitation (primarily for tartaric acid neutralization) or column ion-exchange. ~~The addition of tartaric acid is the method most commonly used to increase the acidity in wines,~~ The methods used to sweeten wines depend on the type of wine. Sparkling wines may be sweetened with sugar whereas still wines are sweetened by the addition of partially fermented or unfermented grape juice, termed sweet reserve. ~~The most widely used dealcoholization technique currently involves reverse osmosis or double reverse osmosis. Color adjustments focus mainly on decolorization and typically employ a membrane technique, called ultrafiltration, which can selectively retain constituents based on molecular size.~~

Blending of wine from different varieties is a long established practice in many wine regions. The blending of individual varietal wines is especially important in the production of fortified and in. sparkling wines and also in the production of standard quality table wines where consistency of character is most important. in the production of many premium table wines, blending is performed but the wines are usually from the same geographical area or vineyard. The basic result of blending is an improvement in the fragrance and flavor of the finished wine.

2.2.1.7.2 Clarification . Following the fermentation process, a preliminary clarification step is used to remove the sediment from the wine. This step is commonly accomplished by decanting the wine from one vessel to another, called racking, in order to separate the sediment (lees) from the wine. Sediment consists principally of yeast and bacteria] cells, grape cells, and precipitated tannins, proteins, and tartrate crystals. If left in contact with the wine, the lees may cause the production of off-colors or microbial spoilage. Current racking practices range from manually decanting wine from barrel to barrel to highly sophisticated, automated, tank-to-tank transfers. In all cases, separation occurs with minimal agitation to avoid resuspending the particulate matter. The residue from racking may be filtered to recover wine otherwise lost with the lees or used "as is" for brandy production. Racking is generally more effective in clarifying wine matured in small barrels or kegs (cooperage) than in large tanks. In addition to racking, other means of clarification include centrifugation and filtration. Centrifugation often replaces racking when early bottling is desired or if the wine is heavily laden with particulate matter.

2.2.1.8 Stabilization and Finishing. Stabilization and finishing steps involve procedures designed to produce a permanently clear wine with no flavor faults. These steps entail various stabilization procedures, additional clarification (fining), and a final filtration prior to bottling. Aging the wine for a period of months or years is a common stabilization technique used for many red wines and some white wines. During the aging process in red wines, the excess tannins are gradually oxidized or combine with aldehydes and precipitate. In addition, the color of the wine shifts from red towards brown and the wine becomes less bitter and astringent. In the ~~A~~aging of white wines ~~*results in a loss of acidity as*~~ ester formation increases and the wine darkens in color to a yellow or gold. Ester formation during aging of white wine generates much of the fragrance in the wine.

White oak has traditionally been the material of choice for the barrels used to age wine, but currently its usage is reserved primarily for the production of premium white and red wines and some

fortified wines. Vessels used to store and age wine, termed cooperage, are produced in a wide range of sizes, depending on their intended use. Wine, placed in well-made barrels, bunged tight, and rotated so the wine covers the bung, is exposed to air only during procedures such as racking or topping off barrels. Limited exposure to air is designed to restrict oxidation of the wine~~, oxidation of hydrogen sulfide,~~ and microbial spoilage. Water and ethanol are lost through the barrel surfaces and a partial vacuum develops in the space created by the loss of the ethanol and water. Each barrel is periodically opened and topped off with wine to fill the void created by the ethanol and water loss.

Cooperage constructed from materials other than wood has many advantages and is less expensive to maintain. Stainless steel is often preferred, but fiberglass and concrete are also used. Concrete tanks require a coating of paraffin wax, glass, or epoxy resin to prevent excessive seepage of calcium from the concrete/cement into the wine and to prevent corrosion of the tank walls by the wine. Fiberglass tanks possess less strength than steel, and are more difficult to cool and clean.

In addition to aging, other stabilization procedures are used, such as tartrate stabilization, which prevents formation of crystalline deposits in bottled wine, protein stabilization, polysaccharide removal and stabilization, oxidative casse (haziness) stabilization, metal casse stabilization, and microbial stabilization. Sulfur dioxide may be added at various stages in wine production to prevent microbial growth and oxidation.~~but it is always added after fermentation.~~

Finishing (fining) agents which bind or absorb particulate matter are commonly used to accelerate the ~~spontaneous~~ precipitation of suspended material in wine. Primary fining agents include activated charcoal, albumin, bentonite, casein, gelatin, kieselsol (an aqueous solution of silicon dioxide), isinglass, polyvinylpolypyrrolidone (PVPP), and tannin. The aggregates formed by the fining agents are generally sufficiently large enough that they quickly precipitate; if not, filtration or centrifugation is used.

Prior to bottling, a final clarification step is used to remove any remaining suspended material and microbes in the wine. This step involves only physical means of clarification and generally consists of a filtration procedure. With the development of new filters and support systems, filtration is currently classified into four categories. Conventional filtration employs depth-type fibrous filters that remove particles down to about one micrometer in diameter. Other filtration techniques are based on

membranes and, depending upon the size range of the membrane perforations, are classified as microfiltration, ultrafiltration, or reverse osmosis/dialysis.

2.2.1.9 Bottling. Wooden vessels were the primary means for wine storage and transport for centuries, but glass bottles replaced barrels. Due to some disadvantages, bottles are sometimes being replaced by new containers, such as bag-in-box, for many standard quality, high volume wines. Glass bottles are still the container of choice for the premium quality wines and for sparkling wines. To protect the wine against microbial spoilage, and to limit oxidation, the wine is adjusted to a final level of 50 mg/L of sulfur dioxide before filling. Glass bottles are filled either by a siphoning (or gravity) feed or by use of pressure (or vacuum). Siphoning and gravity feeding are the simplest but slowest methods, so the pressure or vacuum fillers are more appropriate for rapid, automated filling lines. Regardless of the method, precaution is taken to minimize contact with air during filling and thereby reduce oxidation. This is accomplished by flushing the bottle with inert gas~~CO2~~ before filling or flushing the headspace with inert gas~~CO2~~ after filling.

For the bag-in-box container, the bag collapses as the wine is removed, but because the empty volume is not filled with air, wine can be periodically removed over several weeks or months without noticeable loss in quality. In its current form, the packaging protects wine from oxidation by air for nine months or longer. To minimize contact with air during filling, the bags are placed under vacuum before filling and the headspace charged with an inert gas after filling.

2.2.2 Sweet Table Wines

The most famous of the sweet wines are those made from noble-rotted, *Botrytis*-infected grapes. 'These wines are produced to a limited extent in the United States. The mature grapes are left on the vine to develop the *Botrytis* mold and to hopefully develop the desired noble rot instead of the destructive bunch rot. The mold acts to loosen the grape's skin so moisture loss occurs rapidly and the sugar concentration in the grape increases. The grapes are then selectively picked, followed by pressing, and fermentation. Fermentation is a slow process, however, because of the high sugar content and the use Of SO_2 to retard the growth of undesirable molds and microorganisms.

Botrytis can also be induced by spraying harvested fruit with a solution of spores and holding the fruit at warm, humid conditions for 24 to 36 hours to permit the spores to germinate and penetrate

the fruit. Next, cool dry air is passed over the fruit to induce partial dehydration and restrict invasion. After 10 to 14 days, the fruit is then pressed and fermented.

Nonbotrytized sweet wines are also produced. Drying is probably the oldest procedure used to produce sweet wines. It involves allowing the grapes to dehydrate on mats or trays in the shade for weeks or months and then crushing the grapes and fermenting the concentrated juice. Heating or boiling is also used to concentrate juice or semisweet wines. When the method of freezing is used, the juice becomes concentrated as water is extracted to form ice crystals. By harvesting and pressing the grapes while they are frozen, most of the water remains in the press as ice and the concentrated juice is largely undiluted. The simplest and most easily controlled method used is the addition of unfermented grape juice (sweet reserve) to dry wine or stopping the fermentation prior to conversion of all the grape sugar to alcohol..

2.2.3 Sparkling Wines

Most sparkling wines obtain CO_2 supersaturation by a second alcoholic fermentation, typically induced by adding yeast and sugar to dry white wine. Sparkling wine owes much of its development to a series of events that occurred in the 1700s, including major improvements in the manufacture of glass, reintroduction of cork bottle closures to France, and an unusually long period of cold weather in Europe. Rather than producing inferior red wines during this cold spell, Don Perignon introduced techniques that culminated in the production of champagne. There are three principal methods of sparkling wine production: the traditional method, the transfer method, and the bulk method.

2.2.3.1 Traditional Method. Although both red and white grapes may be used, most sparkling wines are white. The grapes are harvested earlier than those used for table wines, and pressed whole without prior stemming or crushing to extract the juice with a minimum of pigment and tannin extraction; this is important for producing white sparkling wines from red-skinned grapes. Primary fermentation is carried out at approximately 15°C (59°F) and bentonite and/or casein may be added to aid the process. Inoculation with selected yeast strains helps avoid production of undesirable volatiles by indigenous yeasts.

The blending of wines produced from different sites, varieties, and vintages distinguishes the traditional method. Before preparing the blend *(cuvée)*, the individual base wines are clarified and

stabilized. Aging typically takes place in stainless steel but occasionally takes place in oak cooperage. Blending is based on sensory evaluation of the wines concerned.

The secondary fermentation requires inoculation of the *cuvée* wine with a special yeast strain. A concentrated sucrose solution is added to the *cuvée* just prior to the yeast inoculation, which, upon fermentation, produces a pressure appropriate for sparkling wine (about 6 atmospheres [atm]). About 4.2 g of sugar is required to produce 2 g of CO_2 (most sparkling wines contain about 15 g of CO_2). The wine is then bottled, capped, and stacked horizontally at a stable temperature, preferably between 10° and 15°C (50° and 59°F), for the second fermentation. After fermentation, the bottles are transferred to a new site for maturation and stored at about 10°C (50° F).

Riddling is the technique used to allow removal of the yeast sediment lees). The process involves loosening and suspending the cells by manual or mechanical shaking and turning, and positioning the bottle to move the lees toward the neck. Automated riddling takes 1 week to 10 days, while manual riddling can take from 3 to 8 weeks. After riddling, the bottles may be left neck down for several weeks in preparation for sediment removal.

Disgorging takes place about a year after bottling. The bottles are cooled to about 7°C (45°F) and the necks immersed in an ice/$CaCl_2$ ice/glycol solution (about -20°C [-4°F]) to freeze the sediment. Cooling also increases the solubility of the CO_2 and reduces the likelihood of gushing upon opening the bottle. The disgorging machine rapidly removes the cap on the bottle, allowing for ejection of the frozen yeast plug. The mouth of the bottle is quickly covered and the fluid level is adjusted. Some sparkling wines receive a sucrose solution dissolved in high quality white wine and/or brandy to achieve the sweetness desired; this solution is referred to as the *dosage*. Small quantities of sulfur dioxide or ascorbic acid may be added to prevent subsequent in-bottle fermentation and limit oxidation.

Once the volume adjustment and other additions are complete, the bottles are sealed with special corks, the wire hood is added, and the bottles agitated to disperse the additions. The bottles are then decorated with their capsule and labels and stored for about 3 months to allow the corks to set in the necks.

~~The incorporation of yeasts and other microbes into a gel matrix is increasingly being~~

~~used in industry. By injecting the mixture through fine needles into a fixing agent, small beads of encapsulated yeasts are generated. Because of the mass of these beads, they settle rapidly to the neck when the bottle is inverted, eliminating the need for riddling. This elimination provides substantial cost and labor savings. Cartridges composed of water- and gas-permeable membranes which contain the yeasts, sugars, and nutrients are also in limited use.~~

2.2.3.2 Transfer Method. With advancements in automated riddling and yeast encapsulation, the advantages of the transfer method have been virtually negated. The preparation of the sparkling wine is identical to the traditional method up to the riddling stage.

During aging, the bottles are stored neck down. When the aging process is complete, the bottles are chilled below 0°C (32°F) before discharge into a transfer machine and passage to pressurized receiving tanks. The wine is usually then sweetened and sulfated, clarified by filtration, and is sterile filtered just before bottling.

2.2.3.3 Bulk Method. In this method, fermentation of the juice for the base wine may proceed until all the sugar is consumed or be prematurely terminated to retain sugars for the second fermentation. The yeast is removed by centrifugation and/or filtration. Once the *cuvée* is formulated, the wines are combined with yeast additives and, if necessary, sugar. The second fermentation takes place in stainless steel tanks similar to those used in the transfer process.

Removal of the lees takes place at the end of the second fermentation by centrifugation and/or filtration, carried out at isobarometric pressure to maintain the level of CO_2. Sugar and sulfur dioxide content are adjusted just before sterile filtration and bottling.

2.2.3.4 Other Method . Other methods of production of sparkling wine include the "rural' method and carbonation. The rural method involves prematurely terminating the primary fermentation by repeatedly removing the yeasts by filtration. Then, a second in-bottle fermentation converts the residual sugars to CO_2, and the remaining yeast is removed by riddling and disgorging. The injection of CO_2 under pressure at low temperatures is the least expensive and the least prestigious method of producing sparkling wines.

Fortified wines are classified together because Of their elevated alcohol content. They usually have wine spirits added at some stage in their production. Among the most common fortified wines are sherries and ports.

2.2.4.1 Sherry. Baking is the most popular technique for producing sherries in the United States. Both white and red grapes are used because baking destroys the original color of the wine. Grapes are crushed and stemmed and sulfur dioxide is added as soon as possible to control bacteria and oxidation. The maximum amount of juice is separated from the skins and the juice is transferred to fermentors. The juice is inoculated with starter and fermented at temperatures of 25° to 300°C (77° to 86°F). Usually the must is fermented until all of the sugar is consumed or to a low sugar content and then allowed to settle before fortification.

The new wine is then pumped from the fermentor or settling tank to the fortification tank. High proof spirits are added to the sherry material, or shermat, to raise the alcohol content to 17 to 18 percent by volume and then the wine is thoroughly mixed. The wine is then clarified and filtered before baking.

Slow baking occurs when the wine is stored in barrels exposed to the sun. More rapid baking is achieved through the use of artificially heated storage rooms or heating coils in barrels or tanks. Heating induces the formation of a wide variety of compounds, including furfurals, caramelization compounds, and browning by-products, and promotes the oxidation of ethanol to acetaldehyde, Air or oxygen may be bubbled through the heated wine to accelerate oxidation.

After baking, the sherry is cooled, clarified, and filtered. Maturation is then required, and is usually carried out in oak barrels; aging can last from 6 months to 3 years. Various lots of sherry may then be blended. Baked wines are usually sweet, a result of the addition of fortified grape juice to a base wine or residual sugar resulting from the early termination of fermentation by fortification.

2.2.4.2 Ports and Portlike Wines . Port wines are produced by the premature termination of fermentation by addition of brandy. When red grapes are used to produce ports, the major problem in production is the extraction of sufficient color. The extraction can be aided by mixing the juice

and pomace, heating, adding SO_2, and using highly pigmented varieties of grapes. Port can be produced by baking, but with a shorter baking time than baked sherries.

When the fermenting must is run off (separated from the pomace by gravity), it is fortified with wine spirits containing about 77 percent alcohol. The first press fraction for red port is fortified to the same level as the free-run and may be kept separate for independent aging or blended with the free-run. Most white ports are fortified when half the original sugar content has been fermented. However, semidry and dry white ports are fortified later in the process.

The type and duration of aging depend on the style of wine desired. Slight fortification after each racking compensates for alcohol evaporation from the cooperage, and blending is used to achieve the desired properties of the wine. The final blend is left to mature in oak cooperage for several months prior to fining, filtration, stabilization, and bottling.

2.2.5 Brandy Production

Brandy is an alcoholic distillate or mixture of distillates obtained from the fermented juice, mash, or wine of grapes or other fruit (e.g., apples, apricots, peaches, blackberries, or boysenberries). Brandy is produced at less than 190° Proof and bottled at a minimum 80° proof. In the United States, "proof" means the ethyl alcohol content of a liquid at 60°F, stated as twice the percent ethyl alcohol by volume.) Two types of spirits are produced from wine or wine residue: beverage brandy and "wine spirits." Beverage brandy is distilled at 170° proof or lower from the fermented juice or mash of whole fruit, reduced to 102° to 130° proof for aging, and further reduced to 80° to 100° proof for bottling. Wine spirits include all spirits eligible for addition to wines: neutral spirits (190° or more proof), neutral brandy (171° to 189° proof), and brandy (140° to 170° proof).

In brandy production, the grapes are pressed immediately after crushing. There are two major differences in the fermentation process between wine and brandy production. Pure yeast cultures are not used in the fermentation process for brandy. ~~For brandy, the fermentation process is not temperature controlled as it is in wine production.~~ Brandy can be made solely from the fermentation of fruit or can be distilled from the lees leftover from the racking process in still wine production or the pomace cap that is leftover from red still wine fermentations.

Distillation starts immediately after the fermentation and continues until all newly fermented wine is distilled. Nearly all U.S. producers use continuous column distillation, usually with an aldehyde section, instead of pot stills. For a detailed discussion of the distillation and aging of distilled liquors, which include brandy and brandy spirits, refer to AP-42 Section 9.12.3, Distilled and Blended Liquors.

After distillation, the brandy is aged in oak casks. Aging time can vary from 2~~3~~ to 15 years or more. During aging, some of the brandy seeps through the oak and evaporates, so brandy and caramel coloring are added periodically to compensate for this loss. The addition of the caramel coloring gives the brandy a characteristic dark brown color. After aging, the brandy may be flavored, and then chilled, filtered, and bottled.

2.3 EMISSIONS

Ethanol is the primary volatile organic compound (VOC) emitted during the production of wines and brandy. Acetaldehyde, methane, n-propyl alcohol, n-butyl alcohol, sec-butyl alcohol, isobutyl alcohol, and isoamyl alcohol are also generated and emitted but in much smaller quantities compared to ethanol. In addition, a large number of other compounds are formed during the fermentation and aging process. It is the presence of these compounds that gives wines and brandy the complex aroma and flavor.

Prior to the fermentation, liquified sulfur dioxide (SO_2) is often added to the grapes after harvest and to the juice or must; SO_2 emissions can occur during these steps. Except for these potential emissions, there is little potential for emissions prior to the fermentation step in wine production.

During fermentation, large volumes of CO_2 are produced from the yeast metabolism of the sugars present in the juice or must; a general CO_2 production rate of approximately 260 milliliters per gram (mL~~g~~/g) of glucose or fructose has been cited. This represents a volume greater than 50 times the volume of juice fermented. The escape of CO_2 is estimated to remove about 20 percent of the heat generated during fermentation. Ethanol loss was previously believed to occur through entrainment of the liquid droplet in the escaping CO_2 but recent studies indicate that evaporation is the major mechanism for ethanol loss. Ethanol droplets are formed and leave the must surface but

either fall back into the must or impinge on the sides or top of the tank. The upward velocity of the CO_2 is not sufficient to carry the droplets out of the tank. In addition, other VOC's are also evolved through evaporation or entrainment in the CO_2 produced during fermentation; the extent of loss of those compounds depends on the temperature of the juice or must, rate of CO_2 evolution, initial sugar concentration, and the size and shape of the fermentation tank.

Ethanol loss during fermentation has been estimated to be in the range of 0.1 to 1.5 percent of the ethanol produced but this level varies considerably with the temperature of the must and the degree of sugar utilization. Losses of higher alcohols and monoterpenes occur at about the same rate. For some compounds, such as ethyl acetate and other esters, the losses can range up to 25 percent of the quantity produced during the fermentation. Selected examples of specific compounds formed during the fermentation of a Riesling wine include isoamyl acetate, isobutyl acetate, hexyl acetate, 1-hexane, ethyl n-hexanoate, ethyl n-octanoate, ethyl n-butanoate, and ethyl n-decanoate. Selected examples of other types of compounds formed and potentially emitted during fermentation include a variety of acetates, monoterpenes, higher alcohols and acids, and aldehydes and ketones. Emissions generally become negligible after fermentation stops because the production of CO_2 ceases and the liquid temperature decreases. Small quantities of dissolved CO_2 and ethanol may escape from the wine during subsequent processing steps. If the wine is aged in oak barrels, some small levels of ethanol loss may occur through the sides of the barrel. Other potential sources of emissions are the screening of the pomace from the juice (drag screen), the pomace pressing where the residual red wine is extracted from the pomace following fermentation, and the wine bottling process. There are very limited data available on emissions from these fugitive sources.

Except for the harvesting of the grapes and possibly the unloading of the grapes at the winery, there is essentially no potential for particulate (PM) emissions from this industry. Any PM emissions are expected to be negligible.

2.4 CONTROL TECHNOLOGY

Emission control methods are not currently used in the production of wines and brandy. Several potential systems have been studied to control emissions from the fermentation tanks. These studies were conducted at wineries or universities in California, primarily by the California Air Resources Board (CARB). The five systems under study were: (1) carbon adsorption; (2) water

scrubbing; (3) condensation; (4) catalytic incineration; and (5) temperature control. Of the five systems, temperature control is probably the least effective and has operational disadvantages.

Control efficiency for the condensation system is lower than the remaining three system considering the lower efficiency, and is not as cost effective. Of the remaining three systems, water scrubbers present a problem due to the generation of significant quantity of containminated wastewater that must be directed to a treatment facility. Catalytic incineration is the least cost effective of all five systems. All of the capture systems (carbon absorption, water scrubbing, condensation, and catalytic incineration)~~Carbon adsorption is~~are not considered ~~a~~ viable options because of the large amount of duct piping and other auxiliary equipment required to incorporate all of the fermentation into the control system. None of these systems are currently used at wineries in California. Continuing discussions are being conducted between the wine industry and CARB concerning the potential applicability of some type of emission control system.

Disposal of the dealcoholized solution (less than 0.05% alcohol by volume) produced from the still constitutes one of the major problems of the brandy industry. This problem results from the high percentage of material in solution or suspension and the difficulty of decomposition of the material. One solution is centrifugation and sale of the solids for uses such as fertilizer or feedstock. Another method of disposal is the use of shallow ponds in sandy fields. The ponds, not more than 6 inches deep, are filled in succession, and each is allowed to dry for six days. This method of disposal is a potentially small source of emissions from the evaporation of the residual ethanol and other VOC's due to pre-evaporated nature of the still wastewater. ~~evaporation.~~ Deep ponding is not allowed as a method of disposal.

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4.2.9 Reference 9

This study culminated a three year investigation of ethanol emissions control technology that included the studies discussed in References 7 and 8. Testing was conducted in September of 1990 at E&J Gallo's Fresno, California, winery using a 7874 hl (207,000 gal) fermentation tank and a carbon adsorption unit. The study was conducted to further examine ethanol emissions in order to develop ethanol emission factors and to determine the feasibility and requirements of the carbon adsorption system. A detailed cost analysis of implementing carbon adsorption systems was presented as part of the report.

The design of the adsorption system was based on the pilot test design in Reference 8 and contained a tank vent hood, ducting system, and carbon adsorption unit. Three white and five red wine fermentation cycles were tested. Total organic compounds were monitored using a flame ionization detector at the inlet and outlet of the adsorption system only during runs 6, 7, and 8. For runs 1 through 5, only the concentration of ethanol in the carbon adsorption condensate was measured. Gas evolution rates during fermentation were higher than expected, but alcohol removal efficiencies for the adsorber were over 97 percent. After ethanol emissions reached 50 ppm or after 20 hours, the unit initiated a regeneration cycle. The emissions were then condensed and a comprehensive chemical analysis was performed using gas chromatography. Constituents other than ethanol, such as acetaldehyde, were also measured in the analysis but no evaluation of the data was presented. This is the only reference cited that presented data for emissions of VOC's other than ethanol from the fermentation process.

Problems experienced during the test included failure of fan parts and shut-down of the analyzer system due to loss of fuel, loss of ignition, moisture in the sample line, or sample pump failure, Plugging of condensate withdrawal lines also resulted in incomplete regeneration cycles during fermentations 4 and 5. The results show that the amounts of alcohol collected per 1,000 gallons of wine fermented were close to the amounts predicted by the pilot studies carried out in 1987 and 1988.

For runs 1 through 5, the ethanol concentrations were measured only in the aqueous condensate from the carbon adsorption unit. ~~No measurements were made of e~~Ethanol levels at the outlet ~~gas~~ of the adsorber were under 50 ppm. ~~Thus, t~~The data represent only the ethanol captured by the adsorber and

not the total quality released during fermentation. Use of these data would underestimate the total quantity of ethanol released. If the adsorber collection efficiency had been measured, the total quantity released during fermentation could be calculated but these data were collected only during runs 6, 7, and S. Since the inlet and outlet concentrations at the adsorber were measured only during runs 6, 7, and 8, these three runs were used in emission factor calculations. The ethanol emissions data in this report are rated C. Pertinent test data, process data, and emission factor calculations are provided in Appendix E.

4.2.10 Reference 10

This report is a more detailed presentation of the data from the fermentation runs 6, 7, and 8 in the study discussed in Reference 9. No new data are presented, therefore this reference was not used in the development of emission factors.

4.2.11 Reference II

This reference is a memorandum from Gallo to the San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD) concerning the protocol and results of the study in Reference 9. The SJVUAPCD provided only copies of the analytical data sheets which contain data for acetaldehyde and other selected VOC's emitted during the test, the volume of condensate for each fermentation, and the calculations of the average content of acetaldehyde emitted during the fermentations. No protocol or sampling and analysis information is provided in this reference; only the final emissions data are provided. The VOC emissions data presented in this reference are rated D. The emission data and emission factor calculations are provided in Appendix F.

4.2.12 Reference 12

This reference is a Master of Science dissertation on ethanol emissions and control from California wineries presented to the faculty of the Civil/Environmental Engineering Department of California Polytechnic State University at San Luis Obispo in June 1993. This document compiles the results of studies conducted in California on ethanol emissions from wineries and options for control of ethanol emissions during wine fermentation. An estimate of total uncontrolled ethanol emissions from wineries in California and emission factors for red and white wines are presented, as is an assessment of control technologies and their costs.

DRAFT

This is preliminary material, in draft form, for purposes of review. This material must not be quoted, cited, or in any other way considered or used as final work.

9.12.2 WINES AND BRANDY

9.12.2.1 General

Wine is an alcoholic beverage produced by the fermentation of sugars in fruit juices, primarily grape juice. In general, wines are classified into two types based an alcohol content: table wines (7~~9~~ percent to 14 percent, by volume) and dessert~~fortified~~ wines (14~~17~~ percent to 24~~22~~ percent, by volume). Table wines are further subdivided into still and sparkling categories, depending upon the carbon dioxide (CO_2) content retained in the bottled wine. Still table wines are divided into three groups: red, rose (or blush), and white based on the color of the wine.

9. 12.2.2 Process Description[1-4]

The production of still table wines is discussed in the following paragraphs, followed by more concise discussions of the production of sweet table wines, sparkling wines, dessert~~fortified~~ wines, and brandy.

Still Table Wines - The basic steps in vinification (wine production) include harvesting, crushing, pressing, fermentation, clarification, finishing, and bottling. A simplified process diagram outlining the basic steps in the production of still table wines is shown in Figure 9.12.2-1.

Harvesting of grapes is usually conducted during the cooler periods of the day to prevent or retard heat buildup and flavor deterioration in the grape. Most wineries transport the whole grapes but some crush the grapes in the vineyard and transport the crushed fruit to the winery. Stemming and crushing are commonly conducted as soon as possible after harvest. These two steps are currently done separately using a crusher-stemmer, which contains an outer perforated cylinder to allow the grapes to pass through but prevents the passage of stems, leaves, and stalks. Crushing the grapes after stemming is accomplished by any one of many procedures; the three processes generally favored are: (1) pressing grapes against a perforated wall; (2) passing grapes through a set of rollers; or (3) using centrifugal force. From 75 to 150 milligrams per liter (mg/L) of liquefied sulfur dioxide (SO_2) is added to the crushed grape mass to control wild yeast contamination and spoilage bacteria.

Maceration is the breakdown of grape solids following crushing of the grapes. In red and road wine production, the slurry of juice, skins, seeds, and pulp is termed the "must". In white wine production, the skins, seeds, and pulp are separated from the juice before inoculation with yeast and only the juice is fermented. A fermenting batch of juice is also called "must". Thus, the term "must" can refer to either the mixture of juice, seeds, skins, and pulp for red or road wines or only the juice for white wines. Maceration is always involved in the initial phase of red wine fermentation. If the volume of must is small, the juice is extracted from the must in a press. However, for large volumes of must, gravity flow dejuicers are often used to initially separate the majority of the juice from the crushed grapes and the press used to extract the juice remaining in the mass of pulp, skins, and seeds (pomace). There are many designs of dejuicers but, generally, they consist of a tank fitted with a perforated basket at the exit end. After gravity dejuicing has occurred, the pomace is placed in a press and the remaining juice extracted. There are three major types of presses. The horizontal press is used for either crushed or uncrushed grapes. A pneumatic press can be used for either crushed or uncrushed grapes as well as for fermented must. The continuous screw press is the only one that operates uninterrupted and works best with fermented must but can be adjusted for crushed, nonpulpy grapes. After pressing, white must is typically clarified prior to fermentation to retain the fruity character. The white juice is commonly allowed to settle for up to 12 hours but may be centrifuged to speed the clarification.

Fermentation is the process whereby the sugars (glucose and fructose) present in the must undergo reaction by yeast activity to form ethyl alcohol (ethanol) and CO_2 according to the equation:

$$C_6H_{12} - 2\ C_2H_5OH + 2\ CO_2$$

In the U. S., the sugar content of the juice is commonly measured with a hydrometer in units of degree Brix (°B), which is grams (g) of sugar per 100 grams of liquid. Fermentation is initiated by the addition of yeast inoculation to the must. The fermentation process takes place in tanks and vats of a wide variety of shapes, sizes, and technical designs. Tanks are different from vats in that tanks are enclosed, whereas vats have open tops. In most of the larger wineries, tanks have almost completely replaced vats. Since the 1950s, the move has been away from the use of wooden tanks to primarily stainless steel tanks; lined concrete tanks are also used and fiberglass tanks are becoming more popular due to their light weight and lower cost.

The fermentation process is an exothermic reaction and requires temperature control of the fermenting must. Red wines are typically fermented at 25° to 28° C (70° to 82° F) and white wines at

with wine to fill the void created by the ethanol and water loss. Cooperage constructed from materials other than wood has many advantages and is less expensive to maintain. Stainless steel is often preferred, but fiberglass and concrete are also used. In addition to aging, other stabilization procedures are used to prevent formation of potassium bitartrate or calcium tartrate crystals, haziness (casse) resulting from protein coalescence, casse resulting from oxidation of tannins present in the wine, and haziness due to metal ions, such as iron and copper. Enzyme mixtures are used to remove polysaccharides which can cause filtration problems and haze formation. Most wines contain viable but dormant microorganisms. Racking is used as an initial step in microbial stabilization but longterm stability frequently requires use of sulfur dioxide as the antimicrobial agent. Other methods include pasteurization and filter sterilization. Sulfur dioxide may be added at various stages in wine production to prevent microbial growth but it is always added after fermentation. Finishing (fining) agents are commonly added to accelerate the spontaneous precipitation of suspended material in wine. Prior to bottling, a final clarification step is used to remove any remaining suspended material in the wine. This step involves only physical methods of clarification and generally consists of a filtration procedures.

Glass bottles are the container of choice for premium quality wines and for sparkling wines. Due to some disadvantages, glass bottles are sometimes being replaced by new containers, such as bag-in-box, for many standard quality, high volume wines. To protect the wine against microbial spoilage, and to limit oxidation, the wine is adjusted to a final level of 50 mg/L of SO_2 before filling. Precaution is taken to minimize contact with air during filling and thereby reduce oxidation. Ibis is done by flushing the bottle with CO_2 before filling or flushing the headspace with CO_2 after filling.

Sweet Table Wines - The most famous of the sweet wines are those made from noble-rotted, *Botrytis-infected* grapes. These wines are produced to a limited extent in the United States. The *Botrytis* mold acts to loosen the grape's skin so moisture loss occurs rapidly and the sugar concentration increases in the grape. The grapes are then selectively picked, followed by pressing, and fermentation. Fermentation is a slow process, however, because of the high sugar content and the use of SO_2 to retard the growth of undesirable molds and microorganisms. Non-botrytized sweet wines are also produced by drying the grapes. Drying involves allowing the grapes to dehydrate on mats or trays in the shade for weeks or months and then crushing the grapes and fermenting the concentrated juice. Heating, boiling, or freezing is also used to concentrate juice for semisweet wines.

Sparkling Wines - Most sparkling wines obtain CO_2 supersaturation using a second alcoholic fermentation, typically induced by adding yeast and sugar to dry white wine. There are three principal methods of sparkling wine production: the traditional method, the transfer method, and the bulk method. In the traditional method, both red and white grapes may be used but most sparkling wines are white. The grapes are harvested earlier than those used for still table wines and pressed whole without prior stemming or crushing to extract the juice with a minimum of pigment and tannin extraction; this is important for producing white sparkling wines from red-skinned grapes. Primary fermentation is carried out at approximately 15°C (59°F) and bentonite and/or casein may be added to aid the process. The blending of wines produced from different sites, varieties, and vintages distinguishes the traditional method. Before preparing the blend *(cuvée),* the individual base wines are clarified and stabilized. Aging typically takes place in stainless steel tanks but occasionally takes place in oak cooperage. The secondary fermentation requires inoculation of the *cuvée* wine with a special yeast strain. A concentrated sucrose solution is added to the *cuvée* just prior to the yeast inoculation. The wine is then bottled, capped, and stacked horizontally at a stable temperature, preferably between 10° to 15° C (50° to 59° F), for the second fermentation. After fermentation, the bottles are transferred to a new site for maturation and stored at about 10°C (50°F).

Riddling is the technique used to remove the yeast sediment (lees). The process involves loosening and suspending the cells by manual or mechanical shaking and turning, and positioning the bottle to move the lees toward the neck. Disgorging takes place about a year after bottling. The bottles are cooled and the necks immersed in an ice/$CaCl_2$ Or ice/glycol solution to freeze the sediment. The disgorging machine rapidly removes the cap on the bottle, allowing for ejection of the frozen yeast plug. The mouth of the bottle is quickly covered and the fluid level is adjusted. Small quantities of SO_2 or ascorbic acid may be added to prevent subsequent in-bottle fermentation and limit oxidation. Once the volume adjustment and other additions are complete, the bottles are sealed with special corks, the wire hood added, and the bottles agitated to disperse the additions. The bottles are then decorated with their capsule and labels and stored for about 3 months to allow the corks to set in the necks. The transfer method is identical to the traditional method up to the riddling stage. During aging, the bottles are stored neck down. When the aging process is complete, the bottles are chilled below 0°C (32°F) before discharge into a transfer machine and passage to pressurized receiving tanks. The wine is usually sweetened, sulfated, clarified by filtration, and sterile filtered just before bottling.

In the bulk method, fermentation of the juice for the base wine may proceed until all the sugar is consumed or it may be prematurely terminated to retain sugars for the second fermentation.

The yeast is removed by centrifugation and/or filtration. Once the *cuvée* is formulated, the wines are combined with yeast - additives and, if necessary, sugar. The second fermentation takes place in stainless steel tanks similar to those used in the transfer process. Removal of the lees takes place at the end of the second fermentation by centrifugation and/or filtration. The sugar and SO_2 contents are adjusted just before sterile filtration and bottling.

Other methods of production of sparkling wine include the 'rural' method and carbonation. The rural method involves prematurely terminating the primary fermentation prior to a second in-bottle fermentation. The injection of CO_2 (carbonation) under pressure at low temperatures is the least expensive and the least prestigious method of producing sparkling wines.

Fortified Wines - Fortified wines are classified together because of their elevated alcohol content. The most common fortified wines are sherries and ports.

Baking is the most popular technique for producing sherries in the United States. Grapes are crushed and stemmed and SO_2 added as soon as possible to control bacteria and oxidation. The maximum amount of juice is separated from the skins and the juice is transferred to fermentors. The juice is inoculated with starter and fermented at temperatures of 25° to 30°C (77° to 86°F). The new wine is then pumped from the fermentor or settling tank to the fortification tank. High proof spirits are added to the sherry material, or shermat, to raise the alcohol content to 17 to 18 percent by volume and then the wine is thoroughly mixed, clarified, and filtered before baking. Slow baking occurs when the wine is stored in barrels exposed to the sun. More rapid baking is achieved through the use of artificially heated storage rooms or heating coils in barrels or tanks. After baking, the sherry is cooled, clarified, and filtered. Maturation is then required and is usually carried out in oak barrels; aging can last from 6 months to 3 years.

Port wines are produced by the premature termination of fermentation by addition of brandy. When the fermenting must is separated from the pomace by gravity, it is fortified with wine spirits containing about 77 percent alcohol. Most white ports are fortified when half the original sugar content has been fermented, except for semidry and dry white ports which are fortified later. The type and duration of aging depend on the desired style of wine. Blending is used to achieve the desired properties of the wine. The final blend is left to mature in oak cooperage for several months prior to fining, filtration, stabilization, and bottling.

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Brandy Production - Brandy is an alcoholic distillate or mixture of distillates obtained from the fermented juice, mash, or wine from grapes or other fruit (e. g., apples, apricots, peaches, blackberries, or boysenberries). Brandy is produced at less than 190° proof and bottled at a minimum of 80° proof an the United States, "proof" denotes the ethyl alcohol content of a liquid at 15.6°C (60°F), stated as twice the percent ethyl alcohol by volume.) Two types of spirits are produced from wine or wine residue: beverage brandy and "wine spirits".

In brandy production, the grapes are pressed immediately after crushing. There are two major differences in the fermentation process between wine and brandy production. Pure yeast cultures are not used in the fermentation process for brandy. For brandy production, the fermentation process is not temperature controlled as it is in wine production. Brandy can be made solely from the fermentation of fruit or can be distilled from the lees leftover from the racking process in still wine production or from the pomace cap that is leftover from still red wine fermentations.

Distillation is commenced immediately after the fermentation step using continuous column distillation, usually with an aldehyde section, instead of pot stills. For a detailed discussion of the distillation and aging of distilled liquors, which include brandy and brandy spirits, refer to AP-42

Section 9.12.3, "Distilled and Blended Liquors'. After distillation, the brandy is aged in oak casks for 2~~3~~ to 15 years or more. During aging, some of the ethanol and water seeps through the oak and evaporates, so brandy and caramel coloring are added periodically to compensate for this loss. The addition of the caramel coloring gives the brandy a characteristic dark brown color. After aging, the brandy may be flavored, and then chilled, filtered, and bottled.

9.12.2.3 Emissions And Controls[5-11]

Ethanol is the primary pollutant emitted during the fermentation step in the production of wines and brandy. Acetaldehyde, methyl alcohol (methanol), n-propyl alcohol, n-butyl alcohol, secbutyl alcohol, isobutyl alcohol, and isoamyl alcohol also are emitted but in much smaller quantities compared to ethanol emissions. In addition, a large number of other compounds are formed during the fermentation and aging process. Selected examples of other types of compounds formed and potentially emitted during the fermentation process include a variety of acetates, monoterpenes, higher alcohols, higher acids, aldehydes and ketones, organosulfides, and hydrogen sulfide. During the fermentation step, large quantities of CO_2 are also formed and emitted.

Fugitive ethanol emissions also occur during the screening of the red wine, pressing of the pomace cap, aging in- oak cooperage, and the bottling process. In addition, liquified SO_2 is often added to the grapes after harvest, to the must prior to fermentation, or to the wine after the fermentation is completed; SO_2 emissions can occur during these steps. There is little potential for VOC emissions before the fermentation step in wine production.

Except for harvesting the grapes and possibly unloading the grapes at the winery, there are essentially no potential for particulate (PM) emissions from this industry.

Emission controls are not currently used during the production of wines or brandy. Five potential control systems have been considered and three have been the subject of pilot-scale emission test studies at wineries or universities in California. The five systems were: (1) carbon adsorption, (2) water scrubbers, (3) catalytic incineration, (4) condensation, and (5) temperature control. All of the systems have disadvantages either in terms of low control efficiency, cost effectiveness, or overall applicability to the wide variety of wineries.

Emission factors for VOC emissions from the fermentation step in wine production are shown in Tables 9.12.2-1 (Metric units) and -2 (English units). The emission factors for controlled ethanol emissions and the uncontrolled emissions of other VOC from the fermentation step should be used with extreme caution because the factors are based on a very small number of tests and fermentation conditions vary considerably from one winery to another.

There are no available data that can be used to estimate emission factors for the production of sweet table wines, fortified wines, sparkling wines, or brandy.

References for Section 9.12.2

1. R. S. Jackson, *Wine Science: Principles And Application,* Academic Press, San Diego, CA, 1994.
2. M. A. Amerine, Mne, *in Kirk-Othmer Encyclopedia Of Chemical Technology,* Third Edition, Volume 24, John Wiley and Sons, New York, 1984.
3. J. A. Heredia, 'Technical Assessment Document on Ethanol Emissions and Control from California Wineries", Master of Science Dissertation, California Polytechnic State University, San Luis Obispo, CA, June 1993.
4. M. A. Amerine, *el al., Technology Of Wine Making,* Fourth Edition, AVI Publishing Company, Westport, CT, 1980.
5. G. C. Miller, J. M. Amon, and R. F. Simpson, "Loss of Aroma Compounds in Carbon Dioxide Effluent During White Wine Fermentation", Food Technol. Aust., 39(5):246-249, 1987.
6. Written communication from Dean C. Simeroth, California Air Resources Board, Sacramento, CA, to Mark Boese, San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD), Fresno, CA, November 1, 1994.
7. EAL Corporation, "Characterization of Ethanol Emissions From Wineries", Final Report, Submitted to the California Air Resources Board, Sacramento, CA, July, 1982.

8. *Ethanol Emissions And Control For Wine Fermentation And Tanks,* Report # ARB/ML-88-027, California Air Resources Board, April 1989.
9. C. Castronovo and D. Todd, "Ethanol Emissions Control from Wine Fermentation Tanks Using Charcoal Adsorption: A Pilot Study", California Air Resources Board, published by California Agricultural Technology Institute, March 1990.
10. *Ethanol Endssions Control From Wine Fermentation Tanks Utilizing Carbon Adsorption Technology,* Akron Associates, Martinez, CA, June 1991.
11. Memorandum to Maria Lima, SJVUAPCD, Fresno, CA, from Arthur Caputi, Jr., E&J Gallo Winery, Modesto, CA, December 14, 1992.

Rec'd 9/18/95
TL

San Joaquin Valley
Unified Air Pollution Control District

August 24, 1995

Mr. Dallas W. Safriet
Environmental Engineer
U.S. EPA
Emission Factor and Inventory Group (MD-14)
Research Triangle Park, NC 27711

Dear Mr. Safriet:

Thank you for the opportunity to review and comment on the draft version of Section 9.12.2, Wines and Brandy (Emission Factors). We are pleased with the consideration of new data for the development of emission factors. The new addition of emission factors to AP-42 for methanol, n-Proyl, n-Butyl, Sec-Butyl, Isobutyl, Isoamyl alcohols, and acetaldehyde will be very useful. The District agrees with your statement that the information published in AP-42 be as sound as possible.

Staff has some concerns about substituting the current "B" rated emission factor for ethanol emissions with the proposed "E" rated emission factor for ethanol. It appears unjustified to replace a higher rated emission factor with a lower rated emission factor even though the two vary only slightly. We recommend that the "E" rated emission factors for the additional compounds be incorporated but maintain the current AP-42 "B" rated emission factor for ethanol. Staff has additional comments which are general in nature and can be found as an attachment to this letter. These comments are made for the purpose of clarity and reference to the page number and paragraphs have been noted for identification.

Once again, we would like to thank you for the opportunity to comment. We look forward to receiving the final draft and if you have any questions, please do not hesitate to contact us at (209) 497-1075.

Sincerely,

Maria Lima

Maria G. Lima
Environmental Planner

c: Rick McVaigh, Technical Services
enclosure

David L. Crow
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General Comments

- (Page 2-5, Section 2.2.1.2, Last Sentence Line)
  This sentence indicates that 75 to 150 mg/L of SO_2 is added to a mass quantity of grapes but does not indicate a specific quantity of grapes. For clarification, a quantity of the mass of grapes would be useful.

- (Page 2-5, Section 2.2.1.3, First Sentence)
  This sentence refers to maceration as the breakdown of grape solids, no indication is given as to how that breakdown is accomplished, such as mechanically, chemically, or enzymatically. A further explanation of the breakdown may be useful for those who have no knowledge of the process.

- (Page 2-5, Section 2.2.1.3, This paragraph & throughout the document)
  The word "must" is defined as a slurry of juice, skins, seeds, and pulp. When referencing the slurry the word "must" is found in quotes on page 2-5 but on the following pages, the word "must" is no longer in quotes. When quickly skimming the document, the lack of quotes may appear as a syntax problem rather than a reference to a slurry. For consistency and clarity, you may want to place quotes around the word "must" when referring to the slurry.

- (Page 2-7, Section 2.2.1.5, The equation for the fermentation of glucose)
  The current equation in the report does not balance and reads as follows:
  $$C_6H_{12} \rightarrow 2\ C_2H_5OH + 2\ CO_2$$
  We believe the equation should read as follows:
  $$C_6H_{12}O_6 \rightarrow 2\ C_2H_5OH + 2\ CO_2$$

- (Page 2-8, Second Paragraph)
  The second sentence states that cap formation helps to prevent contact of the fermenting "must" with air, which can lead to undesirable side reactions. The last sentence, indicates that a punching down of the cap aerates the fermenting "must", limiting the growth of spoilage organisms in the cap, and helps equalize the temperature in the fermenting "must". These two sentences appear to contradict each other. After reading this paragraph, it was unclear as to whether it is beneficial to introduce air into the fermenting process or not.

- (Page 2-19 & 2-20 Section 2.4)
  Keeping a neutral tone when establishing emission factors based on technical data is important and has been successfully accomplished through-out this draft but when reviewing Section 2.4, it leaves the reader with the impression that wineries will never opt for emission control equipment. Our concern is that this section reinforces and validates the draw backs of emission control options which may be referenced by wineries as a defense for not controlling their emissions. We realize that these options may not be cost effective at this time but may become cost effective in the future.

- (Page 3-3, Middle of the page)
  The words, "Source operation", following 1. need to be underlined.

- (Attached Supporting Source Test Data)
  Page B-11 begins in the middle of a sentence and the previous pages do not start the sentence. The end of this page is also cut off. *Page E-2* begins with an incomplete sentence and the following page is the title page and does not complete that sentence. The supporting data needs to be complete for review.

Rec'd 9/25
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DISTILLED
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COUNCIL
OF THE
UNITED
STATES

September 22, 1995

Thomas W. Lapp, Ph.D.
Principal Environmental Scientist
Midwest Research Institute
401 Harrison Oaks Boulevard
Suite 350
Cary, North Carolina 27513-2412

Dear Dr. ~~Lapp~~: Tom

Thank you for the opportunity to provide comments concerning the draft AP-42 Chapter for brandy. To that end, please find enclosed a copy of our comments.

On behalf of DISCUS, I again want to express our appreciation for meeting with us last month. The meeting was both productive and informative, and we look forward to working with you as the Agency finalizes the AP-42 Chapter pertaining to the distilled spirits industry.

Sincerely,

Lynne J. Omlie
General Counsel

LJO:bca

Enclosure

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