San Joaquin Valley
AIR POLLUTION CONTROL DISTRICT

# 2007 Area Source Emissions Inventory Methodology
## 420 – FOOD AND AGRICULTURE – WINE AND BRANDY AGING

## I. Purpose

This document describes the Area Source Methodology used to estimate fugitive emissions of ethanol (ethyl alcohol), a volatile organic compound (VOC), from the aging of wine and brandy in wood barrels (cooperage) in the San Joaquin Valley Air Basin. An area source category is a collection of similar emission units within a geographic area (i.e., a County). An area source category collectively represents individual sources that are small and numerous, and that may not have been inventoried as specific point, mobile, or biogenic sources. The California Air Resources Board (CARB) has grouped these individual sources with other like sources into area source categories. These source categories are grouped in such a way that they can be estimated collectively using one methodology.

## II. Applicability

The emission calculations from this Area Source Methodology apply to facilities that are identified by the following Category of Emission Source (CES) code and Reconciliation Emission Inventory Code (REIC):

**Table 1. Emission inventory codes.**

| CES | REIC | Description |
|---|---|---|
| 60467 | 420-410-6090-0000 | Wine Aging (Brandy) |

## III. Point Source Reconciliation

Emissions from the area source inventory and point source inventory are reconciled against each other to prevent double counting. This is done using relationships created by the California Air Resources Board (CARB) between the area source REIC and the point sources' Standard Industry Classification (SIC) code and emissions process Source Category Code (SCC) combinations. The area sources in this methodology are not represented within our point source inventory at this time; therefore, reconciliation is not necessary.

# IV. Methodology Description

## A. Wine Aging

Wine is an alcoholic beverage produced by the fermentation of sugars in fruit juices, primarily grape juice. In general, wines are classified into table or dessert wines based on alcohol content. Table wines are typically 7% to 14% alcohol by volume and dessert wines are typically 14% to 24% alcohol by volume. During the aging process, ethanol and water are lost through the barrel (cooperage) surfaces and emitted into the atmosphere by evaporation. The aging process and rate of ethanol evaporation are functions of temperature, ventilation, and existing ethanol content of the air within the aging warehouse. During the aging process, each barrel is periodically opened and topped off with wine to fill the void created by the ethanol and water loss.

This methodology estimates fugitive ethanol (VOC) emissions due to evaporative loss during the aging of wine in wood cooperage. Fugitive ethanol emissions (VOCs) emitted during the filling of barrels and the bottling process are not included in this methodology. The volume of wine stored in wood tanks subject to District Rule 4694 (Wine Fermentation and Storage Tanks) was not included as the emissions from these tanks are reported through the point source inventory and reconcile to the wine fermentation EIC (420-08-6090-000).

In cooperation with the California Wine Institute, a survey was conducted to determine the amount of wine aged in wooden barrels in the District. Wineries were identified as facilities having "Non-Retail Type 02-Winegrower (Winery)" licenses in the California Department of Alcoholic Beverage Control (ABC) licensing database. In the survey, wineries were asked to report the gallons of low alcohol (<14% ethanol) and high alcohol ($\geq$14% ethanol) wine aged in wooden barrels in 2007. The volumes of wine (<14% ethanol and $\geq$14% ethanol) reported aged in the District were multiplied by emission factors to estimate emissions.

## B. Brandy Aging

Brandy is an alcoholic distillate or mixture of distillates obtained from fermented juice, mash, or wine from grapes or other fruit. Brandy is produced at less than 190° proof and is bottled at not less than 80° proof. In the United States, "proof" denotes the ethyl alcohol (ethanol) content of a liquid at 15.6°C (60°F), stated as twice the percent ethyl alcohol (ethanol) by volume.

After distillation, brandy is transferred into tanks where the proof is adjusted by the addition of water. The volume difference between the starting and ending volume of brandy in the filling tank is corrected for temperature and proof content, using methods specified by the U. S. Department of the Treasury's Alcohol and Tobacco Tax and Trade Bureau (TTB) to determine the number of

original proof-gallons (OPG) transferred into the lot. The lot is then aged in a warehouse for a minimum of two years.

During the aging process, ethanol and water are lost through evaporation and brandy is added periodically to compensate for this loss. After aging is complete, the barrels of brandy are removed by lot and dumped into gaging tanks to determine residual loss and proof. The amount of ethanol lost to evaporation ("proof-gallon loss" or "pg-loss") is measured by comparing the volume and alcohol percentage or proof of the lot originally transferred into the barrels ("original proof-gallons") with the volume and alcohol percentage or proof remaining in the lot ("residual proof-gallons") at the end of the aging period.

This methodology estimates fugitive ethanol (VOC) emissions due to evaporative loss during the aging of brandy in wood cooperage. The aging process and rate of ethanol evaporation are functions of temperature, ventilation, and existing ethanol content of the air within the aging warehouse. Ethanol (VOCs) emitted into the atmosphere during the transfer of brandy into and from the gauging tanks and during the filling of barrels and bottles is not considered in this methodology.

A survey was conducted to determine the amount of brandy aged in wooden barrels in the District. Potential brandy aging facilities were identified as those having "Type 03-Brandy Manufacturer", or "Type 04-Distilled Spirits Manufacturer" licenses in the California Department of Alcoholic Beverage Control (ABC) licensing database. In the survey, facilities were asked to report the total proof gallons (PG) of brandy lost during 2007. However, if the facility reported proof gallon loss per barrel (PG/bbl-year), the annual barrel inventory was multiplied by the PG/bbl-year to determine the total proof gallons (PG) of brandy lost during 2007. Annual VOC emissions were calculated from the reported proof gallons (PG) lost less the amount of VOC destroyed by control devices.

# V. Activity Data

## A. Wine Aging

Facilities located within the District with an active "02-Winegrower (Winery)" license issued by the California Department of Alcoholic Beverage Control (ABC) were surveyed to determine the gallons of wine aged in wood containers with an alcohol content greater than or equal to 14% ($\geq$14% ethanol) and the gallons aged with an alcohol content less than 14% (<14% ethanol). The volume of wine stored in wood tanks subject to District Rule 4694 (Wine Fermentation and Storage Tanks) was not included as emissions from these tanks are reported through the point source inventory and reconciled to another EIC. A copy of the survey is included in Appendix A. Of the 108 facilities surveyed, 54 responded. The Wine Institute estimated that respondents represented more than 95% by volume of the wine produced within the District. The results of the survey are summarized in the following table:

**Table 2. Gallons of wine aged in wood containers[1] in the San Joaquin Valley Air Pollution Control District in 2007.**

| Wine Aged by Alcohol Content | Gallons |
|---|---|
| <14% Ethanol | 3,383,446 |
| ≥14% Ethanol | 1,178,100 |
| Total | 4,561,546 |

[1]Excludes volume of wine stored in wood tanks subject to District Rule 4694.

### B. Brandy Aging

Facilities located within the District with an active "03-Brandy Manufacturer" or "04-Distilled Spirits Manufacturer" license issued by the California Department of Alcoholic Beverage Control (ABC) were surveyed to determine their average barrel inventory, average barrel capacity in gallons, total proof-gallon (PG) loss, and whether emission controls were installed at the facility. If emission controls were installed at the facility, they were asked the type, the control efficiency, and the number of hours the device was operational during 2007. A copy of the survey is included in Appendix B. Of the 15 facilities surveyed, 14 responded. The results of the survey are summarized in the following table:

**Table 3. Amount of brandy aged in wood containers in the San Joaquin Valley Air Pollution Control District in 2007.**

| Brandy Aged | Quantity |
|---|---|
| Number of barrels | 435,164 |
| Total Proof Gallons Lost | 1,004,293 |

## VI. Emission Factors

### A. Wine Aging

The SJVAPCD assumes a 3% wine aging loss by volume per year for area source emissions inventory calculations if more specific data is not supplied by individual facilities. This value was selected based upon a review of publically available information including the following:

- A California Energy Commission reports states that as wine ages, it typically loses from 2 to 5% by volume per year (on average 3%) due to evaporation or ullage (Lawrence Berkeley National Laboratory, 2005). The ullage rate is directly related to temperature and relative humidity.

- Martin and Canas (2006), in a table extracted from Negré-Francot (1980), show the influence of temperature and relative humidity on yearly wine losses by evaporation. Yearly wine loss by evaporation ranged from 0.6% (50°F and 95% relative humidity) to 7.4% (64.4°F and 45% relative humidity).

- Richard Blazer (1991) reported annual wine aging losses of 1.16 percent in a cave and 3.03 percent in a chai (an air-conditioned, unheated, non-humidified aboveground building).

- The U.S Department of the Treasury, Alcohol and Tobacco Tax and Trade Bureau considers bulk wine losses due to spillage, leaking, soakage, evaporation and other losses normally occurring from racking and filtering that do not exceed 3% as normal and does not tax them (27 CFR §24.266).

- The Santa Barbara Air Pollution Control District uses an annual evaporative wine loss of 3% by volume for permitting purposes. (Santa Barbara County APCD, Winery Calculations: Wine Production Emission Factors).

Since the large wine aging operations within the District are temperature and humidity controlled, we consider an annual loss of 3% by volume to be conservative.

Our wine aging emission factors were developed as follows:

$$Wine\ Aging\ Emission\ Factor = \frac{\%\ loss\ (v/v)}{year}\ x\ [alcohol\ \ content\ \ (\%)]\ x\ \frac{lbs\ ethanol}{gallon\ \ ethanol}$$

For this inventory, we assume the following:

- The average wine aging loss is 3% by volume per year.
- For wine with an alcohol content <14%, the average alcohol content is 13%.
- For wine with an alcohol content ≥14%, the average alcohol content is 15%.
- The density of wine at 60ºF is 6.62 pounds per gallon. (U. S. Department of the Treasury, 40 CFR 27 Part 30 Subpart E, Gauging Manual for the Alcohol and Tobacco Tax and Trade Bureau)

Using this information, the District developed two default wine aging emission factors that are presented in the following table:

**Table 4. Default area source wine aging emission factors used by the San Joaquin Valley Air Pollution Control District.**

| Wine Alcohol Content | Default emission factor (lb EtOH/gallon-year) |
|---|---|
| <14% Ethanol | 0.0258 |
| ≥14% Ethanol | 0.0298 |

These emission factors are used for area source inventory calculations if more specific data is not supplied by individual facilities.

### B. Brandy Aging

The District assumes a proof gallon has 3.31 lbs of ethanol (VOC). This is calculated given that a proof gallon contains 50% by volume ethanol at 60ºF, and the density of ethanol at 60º F is 6.62 lbs per gallon (U. S. Department of the Treasury, 40 CFR 27 Part 30 Subpart E, Gauging Manual for the Alcohol and Tobacco Tax and Trade Bureau).

$$Brandy\ Aging\ Emission\ Factor = \frac{0.5\ gallons\ ethanol}{1\ proof\ \ gallon}\ x\ \frac{6.62\ lbs\ ethanol}{1\ gallon} = \frac{3.31\ lbs\ ethanol}{proof\ \ gallon}$$

## VII. Emissions Calculations

### A. Wine Aging

#### 1. Assumptions

a. Emissions from wine aging are uncontrolled.

b. The average alcohol content of wine produced with an alcohol content less than 14% ethanol is 13%.

c. The average alcohol content of wine produced with an alcohol content greater than14% ethanol is 15%.

d. The emission factors for wine aging are dependent on temperature and humidity; however, per wine industry contact (personal communication from Wendy Garcia at Constellation Wines U.S. Inc., June 17, 2009), wine aging in the San Joaquin Valley is temperature and humidity controlled. Therefore, emissions activity is assumed to be uniform throughout the year.

#### 2. Sample Calculations

VOC emissions for wine aging can be calculated using the following equation:

$$VOC\ Emissions = \left(\frac{gallons\ aged}{year}\right) \times \left(\frac{lbs\ VOC\ emitted}{gallon}\right) \times \left(\frac{1\ ton}{2{,}000\ lbs}\right)$$

For VOC emissions from wine aging at Facility X:

Given:

a. The facility aged 100,000 gallons of wine with less than 14% alcohol content by volume in 2007.

b. Since site specific loss data was not provided, the VOC emission factor is 0.0258 pounds VOC per gallon.

Calculate Emissions:

VOC emissions from wine aging can be calculated using the following equation:

$$VOC\ Emissions = \left(\frac{100{,}000\ gallons}{year}\right) \times \left(\frac{0.0258\ lbs\ VOC}{gallon}\right) \times \left(\frac{1\ ton}{2{,}000\ lbs}\right) = \frac{1.29\ tons\ of\ VOC}{year}$$

## B. Brandy Aging

### 1. Assumptions

a. A regenerative thermal oxidizer (RTO) has a 98% VOC destruction efficiency rate.

b. A proof gallon has 3.31 lbs of VOC (ethanol).

### 2. Sample Calculations

Emissions from brandy aging facilities are calculated in three steps as illustrated below:

Given:

a. A brandy aging facility lost 10,000 proof gallons in 2007.

b. The facility used an RTO (control device) with a VOC destruction efficiency of 98%.

c. The RTO operated for 8,059 out of 8,760 hours in 2007.

Calculate Emissions:

Step 1. Calculate the amount of VOC that was lost:

$$VOC_{lost,\,tons} = proof\ \ gallons\ lost\ x\ \frac{3.31\ lbs\ VOC}{proof\ \ gallon}\ x\ \frac{1\ ton}{2{,}000\ lbs}$$

Example.

$$VOC_{lost,\,tons} = 10{,}000\ \ proof\ \ gallons\ lost\ x\ \frac{3.31\ lbs\ VOC}{proof\ \ gallon}\ x\ \frac{1\ ton}{2{,}000\ lbs} = 16.55\ tons$$

Step 2. Calculate the amount of VOC that was controlled:

$$VOC_{contolled,\,tons} = VOC_{lost,\,tons}\ x \frac{hours\ RTO\ operated\ in\ year}{total\ hours\ in\ year}\ x\ RTO\ efficiency$$

Example.

$$VOC_{contolled,\,tons} = 16.55\ tons\ VOC\ x \frac{8{,}059\ hours}{8{,}760\ hours}\ x\ 0.98 = 14.92\ tons$$

Step 3. Calculate the amount of VOC that was emitted:

$$VOC_{emitted,\,tons} = VOC_{lost,\,tons} - VOC_{controlled,\,tons}$$

Example.

$$VOC_{emitted,\,tons} = 16.55\ tons - 14.92\ tons = 1.63\ tons$$

## VIII. Temporal Variation

We assume the rate of ethanol evaporation and emissions activity is uniform throughout the year.

### A. Daily

CARB Code 24. 24 hours per day - uniform activity during the day.

### B. Weekly

CARB Code 7. 7 days per week - uniform activity every day of the week.

### C. Monthly

Uniform monthly activity.

## IX. Spatial Variation

Wine and brandy aging facilities are located in Fresno, Kern, Madera, San Joaquin and Stanislaus counties.

## X. Growth Factor

Growth factors are developed by either the District's Planning Department or CARB for each EIC. These factors are used to estimate emissions in future years. The growth factors associated with this emissions category may be obtained from the District's Planning Department.

## XI. Control Level

Control levels are developed by either the District's Planning Department or CARB for each EIC. Control levels are used to estimate emissions reductions in future years due to implementation of District rules. These control levels take into account the effect of control technology, compliance and exemptions at full implementation of the rules.

Control levels associated with this emissions category may be obtained from the District's Planning Department.

## XII. CARB Chemical Speciation

CARB has developed organic gas profiles in order to calculate reactive organic gasses (ROG), volatile organic compounds (VOC) or total organic gas (TOG) given any one of the three values. For each speciation profile, the fraction of TOG that is ROG and VOC is given. The organic gas profile codes can also be used to lookup associated toxics. CARB's speciation profile for wine and brandy aging is presented in Table 5.

**Table 5. CARB organic gas speciation profile for 420-410-6090-0000.**

| Profile Description | CARB Organic Gas Profile# | Fractions | |
|---|---|---|---|
| | | ROG | VOC |
| Fermentation - Ethanol | 211 | 1 | 1 |

# XIII. Assessment Of Methodology

This methodology replaces an estimate previously made by CARB. Significant differences between this and CARB's methodology are presented in the following table:

**Table 6. Comparison of this methodology and CARB's 1992 methodology.**

| Parameter | CARB's 1992 Methodology | SJVAPCD's 2007 Methodology |
|---|---|---|
| Data source | Wine Institute | Survey of licensed wine and brandy manufacturers in cooperation with the Wine Institute |
| Brandy process data | Barrels of brandy produced | Proof gallons of brandy lost |
| Wine process data | Not collected | Gallons of wine aged |
| Brandy aging VOC emission factor | 4.96 lbs per barrel-year.<br><br>Estimated assuming (1) specific gravity of a proof gallon is 0.79384, (2) a proof-gallon weighs 8.388 pounds, (3) there is a 2.5% ethanol loss per year per barrel, (4) 50 gallons per barrel, and (5) brandy is 120 proof (60% ethanol). | VOC content of a proof gallon is 3.31 pounds.<br><br>Calculated given that a proof gallon contains 50% by volume ethanol at 60ºF, and the density of ethanol at 60ºF is 6.62 lbs/gallon. |
| Wine aging VOC emission factors | Not evaluated | 0.0258 lbs VOC per gallon for wine with an alcohol content <14%<br><br>0.0298 lbs VOC per gallon for wine with an alcohol content ≥14% |
| Spatial Distribution | Brandy aging activity apportioned to the counties using volume of grapes crushed as a surrogate. | Wine and brandy aging activity data collected by county directly. |

The District assumes a 3% wine aging loss by volume per year for area source inventory calculations if more specific data is not supplied by individual facilities. Since wine aging operations within the District are temperature and humidity controlled, we consider this assumption to be conservative.

In the future, brandy aging facilities with control devices will be reported through the District's point source inventory. Brandy aging facilities that installed RTOs in 2007 will have a marked decrease in VOC emissions in 2008 due to the VOC destruction efficiency of the RTOs.

# XIV. Emissions

Following is the 2007 area source emissions inventory for REIC 420-410-6090-0000 estimated by this methodology.

**Table 7. Area source emissions for REIC #420-410-6090-0000 (2007).**

| District | Emissions (tons/year) | | | | | |
|---|---|---|---|---|---|---|
| | NOx | CO | SOx | VOC[1] | $PM_{10}$ | $PM_{2.5}$[2] |
| Fresno | N/A | N/A | N/A | 181.57 | N/A | N/A |
| Kern | N/A | N/A | N/A | 222.89 | N/A | N/A |
| Kings | N/A | N/A | N/A | 0.00 | N/A | N/A |
| Madera | N/A | N/A | N/A | 3.69 | N/A | N/A |
| Merced | N/A | N/A | N/A | 0.00 | N/A | N/A |
| San Joaquin | N/A | N/A | N/A | 30.56 | N/A | N/A |
| Stanislaus | N/A | N/A | N/A | 377.69 | N/A | N/A |
| Tulare | N/A | N/A | N/A | 0.00 | N/A | N/A |
| TOTAL | | | | 816.41 | | |

(1) The District only reports ROG to CARB. As noted in Section XII, ROG is the same as VOC.

Following is the net change in total unreconciled emissions between this update (2007 inventory year) and the previous inventory year (2006) for REIC 420-410-6090-0000.

**Table 8. Net emissions change for REIC 420-410-6090-0000 (2007 – 2006).**

| County | Emissions (tons/year) | | | | | |
|---|---|---|---|---|---|---|
| | NOx | CO | SOx | VOC[1] | $PM_{10}$ | $PM_{2.5}$[2] |
| Fresno | N/A | N/A | N/A | -560.37 | N/A | N/A |
| Kern | N/A | N/A | N/A | -119.48 | N/A | N/A |
| Kings | N/A | N/A | N/A | -16.80 | N/A | N/A |
| Madera | N/A | N/A | N/A | -256.97 | N/A | N/A |
| Merced | N/A | N/A | N/A | -205.00 | N/A | N/A |
| San Joaquin | N/A | N/A | N/A | -390.01 | N/A | N/A |
| Stanislaus | N/A | N/A | N/A | 244.18 | N/A | N/A |
| Tulare | N/A | N/A | N/A | -244.99 | N/A | N/A |
| TOTAL | | | | -1,549.43 | | |

(1) The District only reports ROG to CARB. As noted in Section XII, ROG is the same as VOC.

# XV. Revision History

2008 This is a new District methodology based on a survey of California Department of Alcoholic Beverage Control (ABC) licensed wineries and brandy/distilled spirits manufacturers located within the District.

## XVI. Update Schedule

In an effort to provide inventory information to CARB and other District programs and maximize limited resources, the District has developed an update cycle based on emissions within the source category as shown in Table 9.

**Table 9. Area source update frequency criteria.**

| Total Emissions (tons/day) | Update Cycle (years) |
|---|---|
| <=1 | 4 |
| >1 and <= 2.5 | 3 |
| >2.5 and <=5 | 2 |
| >5 | 1 |

Since ethanol (VOC) emissions are less than 2.5 tons per day, these area source estimates will be updated every three years.

## XVII. References


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## XVII. Appendices

Appendix A. District Wine Storage/Aging Survey

Appendix B. District Brandy Aging Survey

## Appendix A. District Wine Storage/Aging Survey

San Joaquin Valley
AIR POLLUTION CONTROL DISTRICT

### Wine Storage/Aging Survey for the 2007 Calendar Year

The District is required by the State of California to periodically update our inventory of area-wide emissions. This inventory is vital to ensure that future air pollution control plans and rules reflect actual emissions and do not overestimate industrial emissions. We would appreciate your assistance in updating our inventory of emissions from wine aging operations by completing the survey below and returning it to the District's Central Region office before January 28, 2009. If you have any questions, please call Georgia Stewart at (559) 230-5937.

1. Does your facility store/age wine in wood containers (barrels, puncheons, casks, etc)?

   Y N

2. If your facility does store/age wine in wood, how many gallons were stored/aged in 2007?

   a) Alcohol content equal to or greater than 14%: _____

   b) Alcohol content less than 14%: _____

3. Please provide your contact information.

   Facility: _____

   Address: _____

   Contact person: _____

   Telephone: _____ FAX: _____

   Email: _____

4. Please return your completed survey to:

   Georgia Stewart
   San Joaquin Valley Air Pollution Control District
   1990 E. Gettysburg Avenue
   Fresno, CA 93726-0244

   **or**, if a Wine Institute member, please return your survey to:

   Wendell Lee
   The Wine Institute
   425 Market Street, Suite 1000
   San Francisco, CA 94105

Central Region (Main Office) • 1990 E. Gettysburg Avenue • Fresno, CA 93726-0244 • (559) 230-6000 • FAX (559) 230-6061

## Appendix B. District Brandy Aging Survey

San Joaquin Valley
AIR POLLUTION CONTROL DISTRICT

### Brandy Aging Survey for the 2007 Calendar Year

The District is required by the State of California to periodically update our inventory of area-wide emissions. This inventory is vital to ensure that future air pollution control plans and rules reflect actual emissions and do not overestimate industrial emissions. We would appreciate your assistance in updating our inventory of emissions from brandy aging operations by completing the survey below and returning it to the District's Central Region office before February 13, 2008. If you have any questions, please call Georgia Stewart at (559) 230-5937.

1. Does your facility manufacture brandy? Y N
2. Does your facility age brandy? Y N
3. If your facility manufactures but does not age brandy, where is the brandy aged?
   Name of facility _____
   Address _____
4. If your facility ages brandy, what was your 2007 barrel inventory? _____
5. What is the average capacity of your barrels in gallons? _____
6. What was your total 2007 proof-gallon (PG) loss for brandy aging? _____
7. Are there emission controls on your brandy aging warehouse(s)? Y N
   a) What type of control device(s) is installed? _____
   b) What is the control efficiency of this device (%)? _____
   c) How many hours was the device(s) in operation during 2007? _____

Contact Information:

Facility: _____
Address: _____
Contact person: _____
Telephone: _____ FAX _____
Email _____

Central Region (Main Office) • 1990 E. Gettysburg Avenue • Fresno, CA 93726-0244 • (559) 230-6000 • fax (559) 230-6061