Rec'd 1/17/95

AP-42 Section 9.12.2
Reference 10
Report Sect.
Reference

1990 DEMONSTRATION PROGRAM ETHANOL EMISSIONS CONTROL FROM WINE FERMENTATION TANKS UTILIZING CARBON ADSORPTION TECHNOLOGY

Issued: June 24, 1991

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TABLE OF CONTENTS

Figures

Tables

APPENDICES

1990 DEMONSTRATION PROGRAM
ETHANOL EMISSIONS CONTROL
FROM
WINE FERMENTATION TANKS
UTILIZING CARBON ADSORPTION TECHNOLOGY

INTRODUCTION

This is the final report on the Ethanol Emissions Demonstration Program conducted at the E. & J. Gallo Winery's Fresno, California winery during the 1990 fermentation season.

SUMMARY OF CONCLUSIONS

Amounts of alcohol collected were at or near the predicted amounts, based on the CSUF pilot studies, i.e. lower than the original estimates upon which emission control of wine fermentations was recommended.

Higher than expected gas evolution rates observed during fermentation will require capture systems designed for a maximum capture rate of 8.2 CFM per 1000 gallons fermented. This represents an increase of over 20% in required system capacity. System capital costs will range from $ 4.3 Million to $ 34 Million. The quantifiable cost per pound of removed ethanol ranged from $ 14 to $ 93, depending on the variables occurring between the various winery operations. These figures did not include the costs of disposal of condensate, additional manpower costs for additional operational personnel, code compliance, and the cost of design and installation of a cleaning and sanitation system. Consequently, the actual cost per pound of removed ethanol would be higher.

Foam-over remains an unresolved concern as no foam-over could be induced during this program. Overall effect of anti-foam-over measures and their attendant costs cannot, at this time, be accurately predicted.

Alcohol removal efficiencies for the carbon adsorber unit were 97% or greater; however, overall system efficiencies may have been less when the fermentation rate exceeded earlier predictions.

Collection and disposal of condensate from the system must allow for variations in both concentration and volume of recovered condensate, depending on the type of wine being fermented.

Installation requires both regeneration steam and dry instrument air be available in sufficient quantity for the needs of the installed system.

Operation will require the availability of qualified instrument, electrical and mechanical personnel to monitor system operation.

<u>BACKGROUND</u>

The 1990 Ethanol Emissions Demonstration Program culminated a three-year study of ethanol emissions control technology conducted by an Ad Hoc Committee made up of representatives from Wine Institute and Air Resources Board staff.

During the 1987 and 1988 fermentation seasons, pilot plant studies on the feasibility of ethanol emissions controls on winery fermentation tanks were performed at the California State University, Fresno (CSUF) enology facility at the direction of the ARB.

The 1987 pilot study was designed to determine the potential ethanol emissions from wine fermentation tanks fitted with emission control devices, including water adsorption, catalytic incineration and carbon adsorption, as well as from uncontrolled fermentation tanks. The tests were performed on four fermentation tanks each with four wines: two red and two white. One of the tanks was designated as a control. The remaining three tanks were used to test the feasibility and control efficiency of the catalytic incineration, carbon adsorption and water scrubbing methods of ethanol emissions control.

The 1987 study concluded that each of the control methods was capable of providing at least 90% efficiency in the control of ethanol emissions. However, the Ad Hoc Committee also determined that:

1. Water scrubbing was not feasible because most wineries could not dispose of ethanol laden waters without re-releasing the ethanol to the atmosphere.

2. Catalytic incineration involved a prohibitively high initial capital cost.

3. Carbon Adsorption involved certain operational problems.[1]

The study also showed that previous estimates of the amounts of ethanol emitted by winery fermentation tanks were too high, by a significant degree.

The Ad Hoc Committee recommended that further tests be carried out during the 1988 season.[2] These tests were to utilize carbon adsorption exclusively as the control device. Because the 1987 tests had determined water scrubbing was not applicable to this requirement and catalytic incineration was excessively costly, it was felt that only carbon adsorption offered the only useable control technique. The committee felt another year of testing and equipment modification should resolve the operational problems documented in the 1987 evaluation of the carbon adsorption device.

The data obtained in 1988 again confirmed the ethanol emissions to be lower than the earlier estimates, and better operation of the system was achieved. Based on observations and data collected during those two seasons, the Ad Hoc Committee decided that a demonstration study of a control system utilizing carbon adsorption for a commercial fermentation tank of 50,000 gallons capacity or larger was warranted.

The 1990 Demonstration Program was conceived and performed under the sponsorship of the California Wine Commission, Wine Institute and E. & J. Gallo Winery.

The E. & J. Gallo Winery's Fresno facility was made available as the test site. An emission capture and ethanol adsorption system was installed on a commercial 207,000 gallon fermentation tank. The temporary prototype system, consisting of a tank vent hood, ducting system and carbon adsorption unit was operated over five red wine and three white wine cycles in an attempt to further identify:

a) ethanol emissions amounts
b) achievable condensate ethanol concentrations
c) system sizing criteria
d) potential system operating concerns
e) equipment reliability
f) requirements for foam-over protection
g) personnel requirements
h) utility requirements
i) sanitation and waste requirements

On-site testing and sampling were conducted by staff of the California Air Resources Board (CARB).

SYSTEM DESCRIPTION

A schematic flow diagram illustrating the basics of the prototype system is shown in Figure 1. An uninsulated, 207,000 gallon nominal capacity, stainless steel fermentation tank was modified by the addition of a 12-inch vent nozzle, vapor collection hood and ducting system, to capture and transfer vapors emitted during the fermentation process through a 20" dia. x 72" Foam-over Pot to a carbon adsorption system.

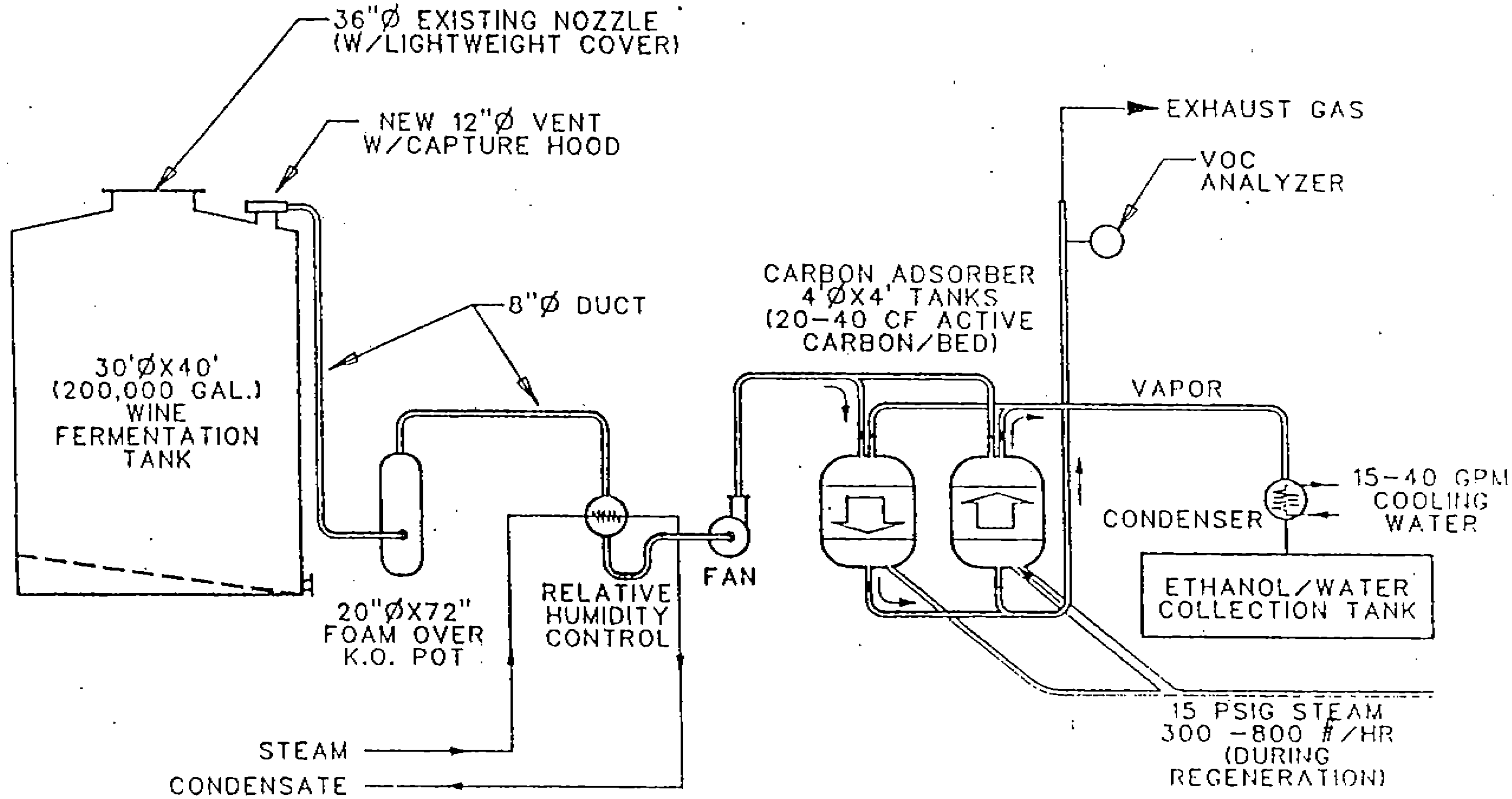
In order to prevent imposing pressure or vacuum on the tank, the hood was designed to allow dilution air to be drawn into the system in order to maintain a constant flow rate to the adsorption system. The design for this was based on previously published preliminary designs by CARB and designs developed during pilot testing at CSUF. The final design of this hood is detailed in Figure 2 and, as installed, is shown in Figures 3 & 4. The hood was made moveable to provide ease of cleaning and sanitizing. A removable deflector cap was provided in the tank nozzle to prevent condensation droplets from entering the tank and to deflect foam formations from the eight-inch vent ducting. Figure 5 shows the pumpover or return-to-tank piping which was used to provide supplemental mixing of the tank contents which is a normal periodic operation during fermentation. The E. & J. Gallo Winery test tank was fitted with a system which eliminated the need for rearranging the hoses for pumpover. Other tanks at this location and at other wineries are not similarly equipped, so additional equipment and its installation would be required for this periodic operation.

Figure 6 is the general plot plan of the tank, carbon absorption system, boiler, condensate accumulation tank and other major items of equipment used in the program.

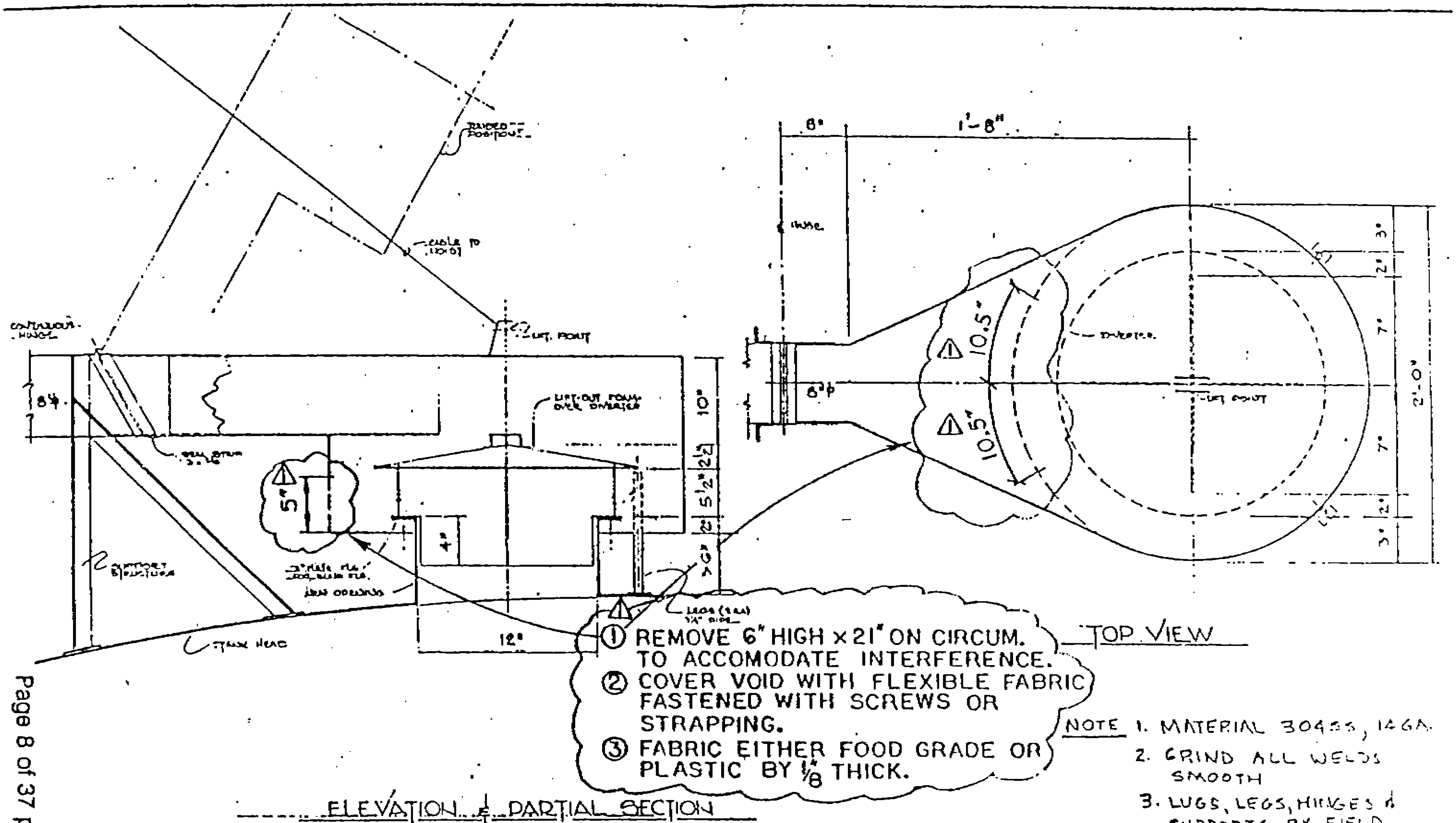
Figure 7 depicts this equipment installed at the winery. As previously noted, the hood, ducting and carbon absorption system are the main pieces of equipment needed to capture and retain the ethanol.

Figure 8 shows the installed foam-over pot included to disengage any liquids and/or foams that might be entrained with the vent gases.

The carbon adsorption unit selected was a commercially available unit with a nominal flow capacity of 1000 CFM. The selected unit was leased from AMCEC Corporation and was operated at a flow rate of 1120 CFM during the test period. Each of the two carbon beds contained 640 pounds of carbon. (See Figure 9 for simplified flow diagram of the unit.) Carbon loading procedures for the beds are attached as Appendix 1.



1. DESIGN FLOW FOR ADSORPTION SYSTEM = 1000 CFM
2. ADSORPTION EFFICIENCY > 95%
3. REGENERATION ACTIVATED BY DETECTION OF ETHANOL IN EXHAUST GAS STREAM
4. FLOW ARROWS SHOWN INDICATE ONE ADSORBER ON STREAM, ONE BED BEING STEAM REGENERATED



NOTE
1. MATERIAL 304SS, 14GA.
2. GRIND ALL WELDS SMOOTH
3. LUGS, LEGS, HINGES & SUPPORTS BY FIELD

FREDERIKSEN
ENGINEERING CO. INC.
OAKLAND CALIFORNIA

HOOD FOR 200,000 GAL. FERMENTATION TANK
ELEV, PARTIAL SECT & TOP VIEW

REV	DATE	REVISIONS
1	8/14/90	TO ELIMINATE INTERFERENCE

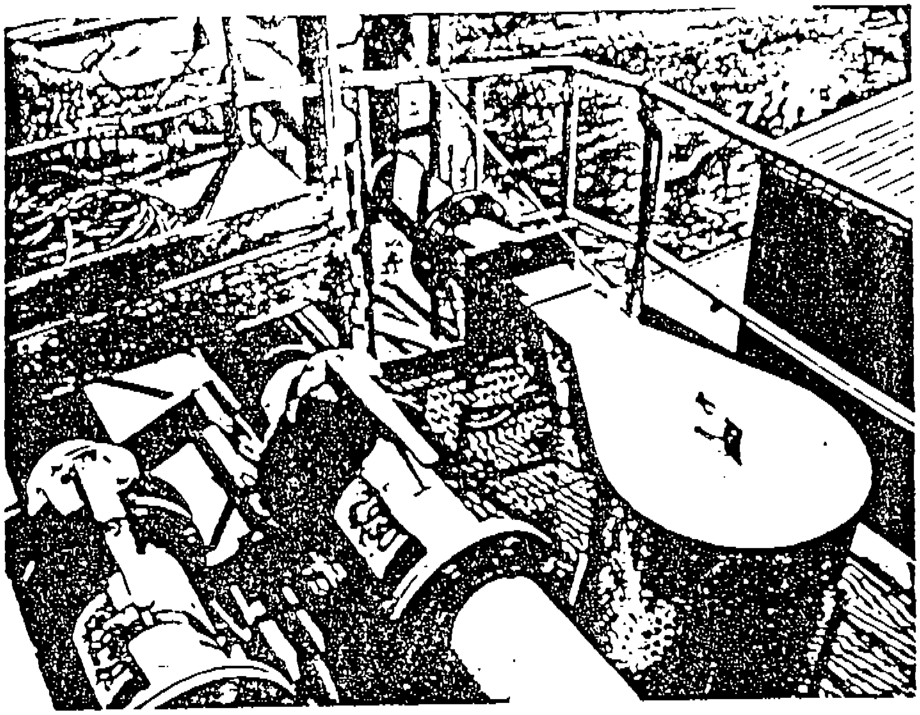


FIGURE 3. FERMENTATION COLLECTION HOOD IN DOWN POSITION; NOTE - LIFTING DEVICE.

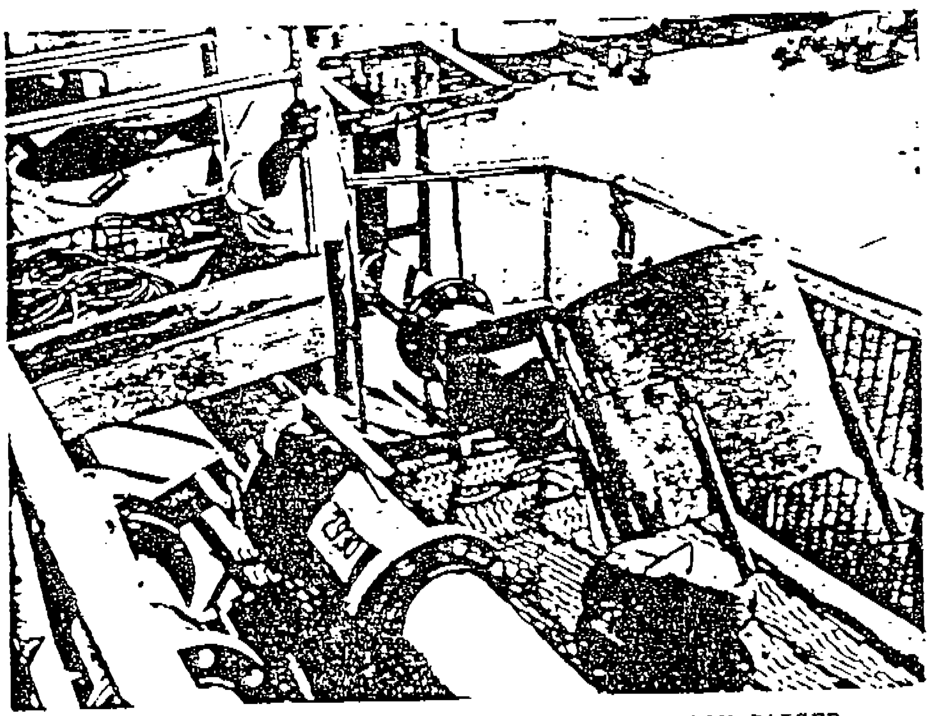


FIGURE 4. FERMENTATION COLLECTION HOOD IN PARTIALLY RAISED POSITION; NOTE - DEFLECTOR CAP IN TANK VENT NOZZLE

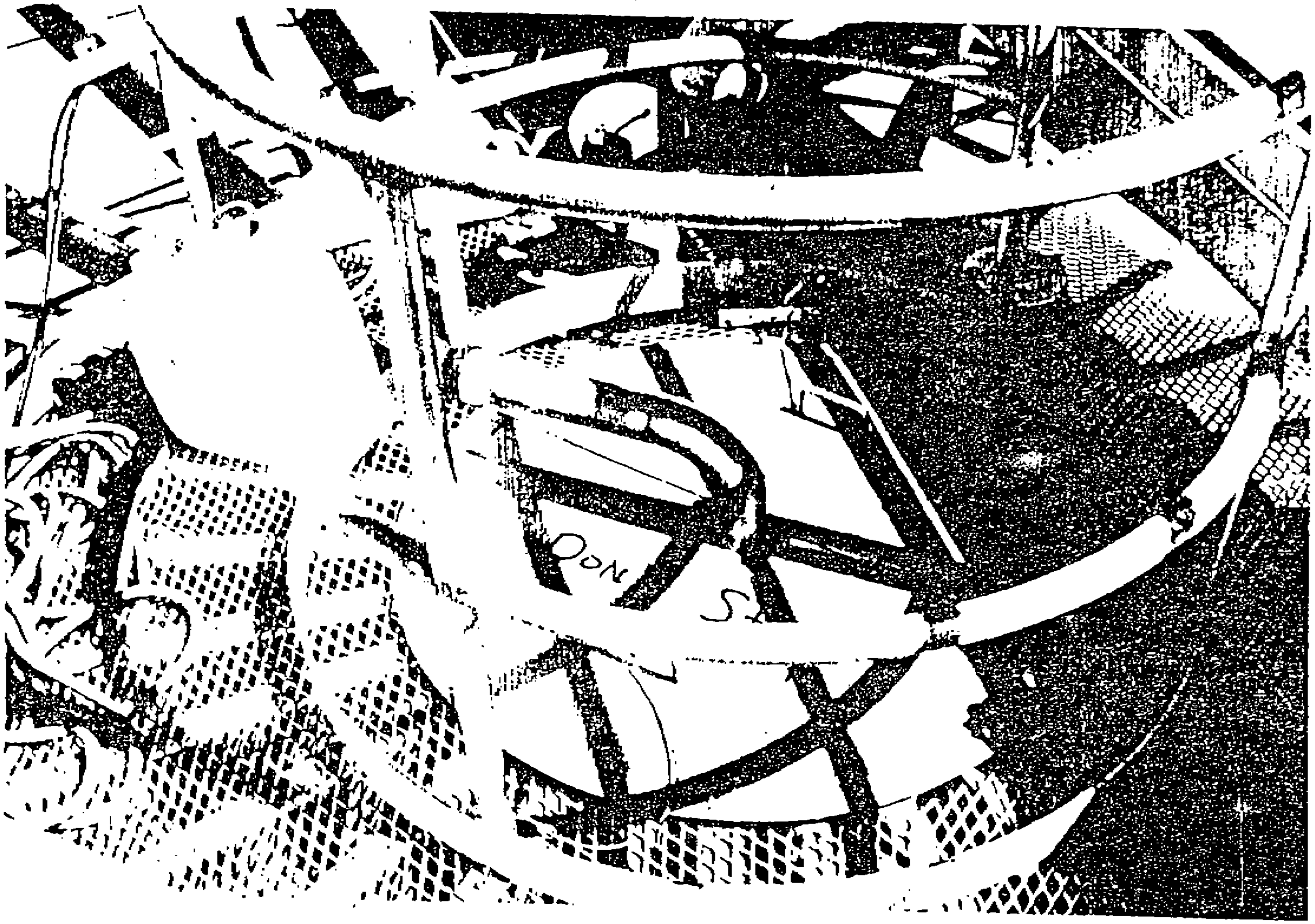


FIGURE 5. LIGHT WEIGHT MANHOLE COVER WITH PUMPOVER PIPING.

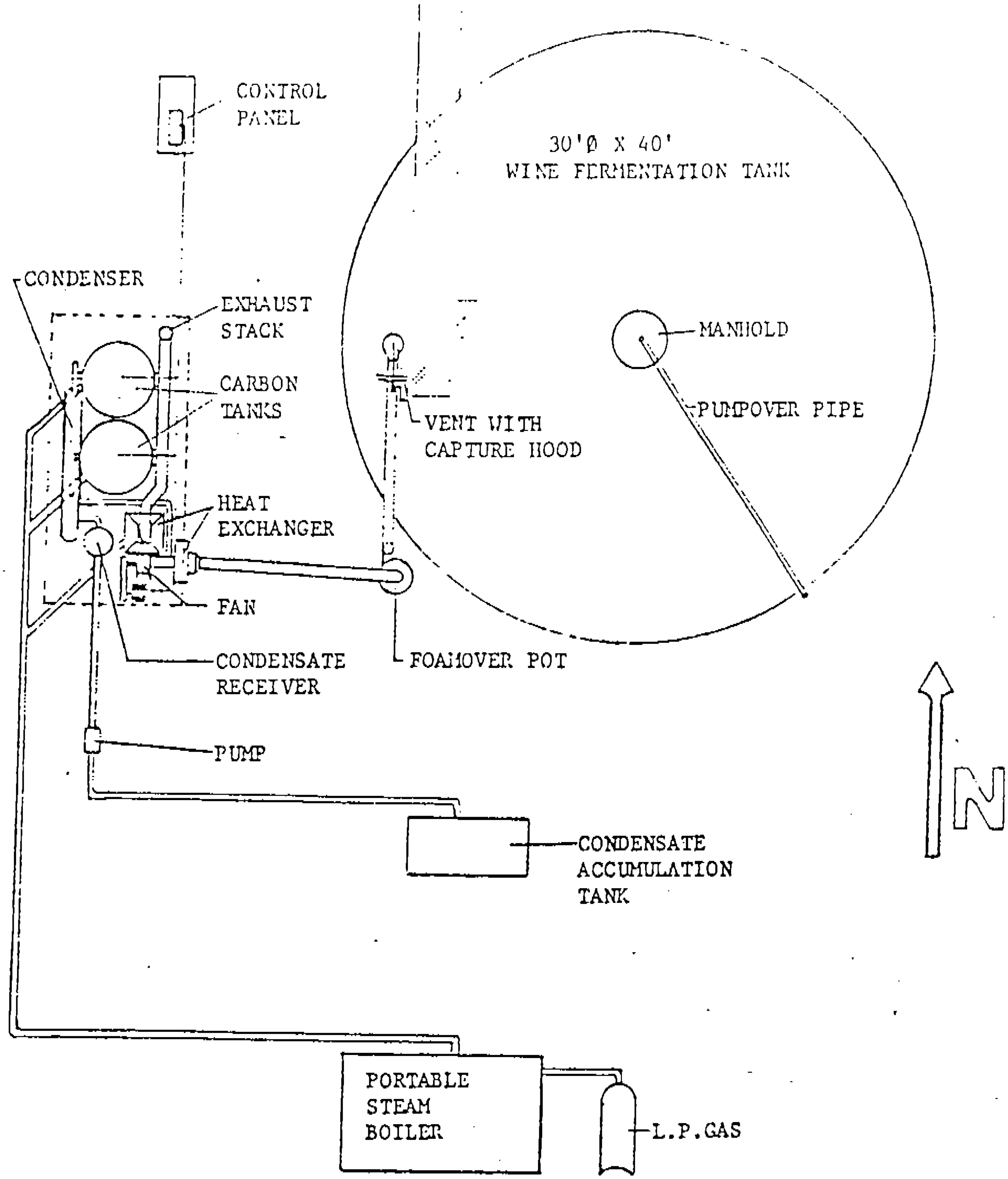


FIGURE 6. GENERAL PLOT PLAN, 1990 DEMONSTRATION PROGRAM

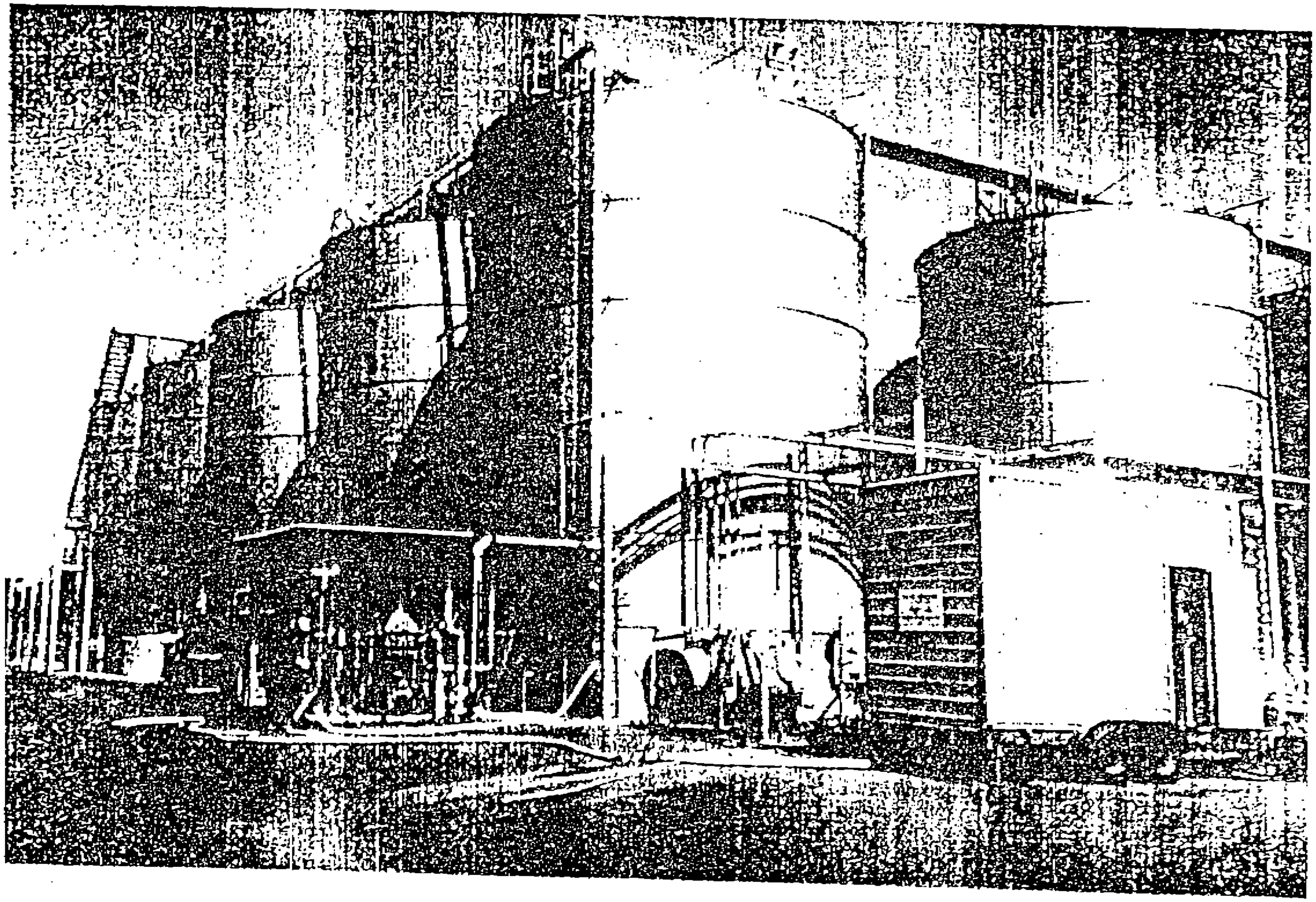


FIGURE 7. 1990 DEMONSTRATION PROGRAM EQUIPMENT, SOUTH SIDE FERMENTATION TANK 2930 AND EQUIPMENT. RENTAL BOILER TO RIGHT, CONDENSATE ACCUMULATION TANK IN CENTER, FERMENTATION TANK BEHIND AND CARBON ADSORPTION UNIT WITH CONTROLS TO LEFT.

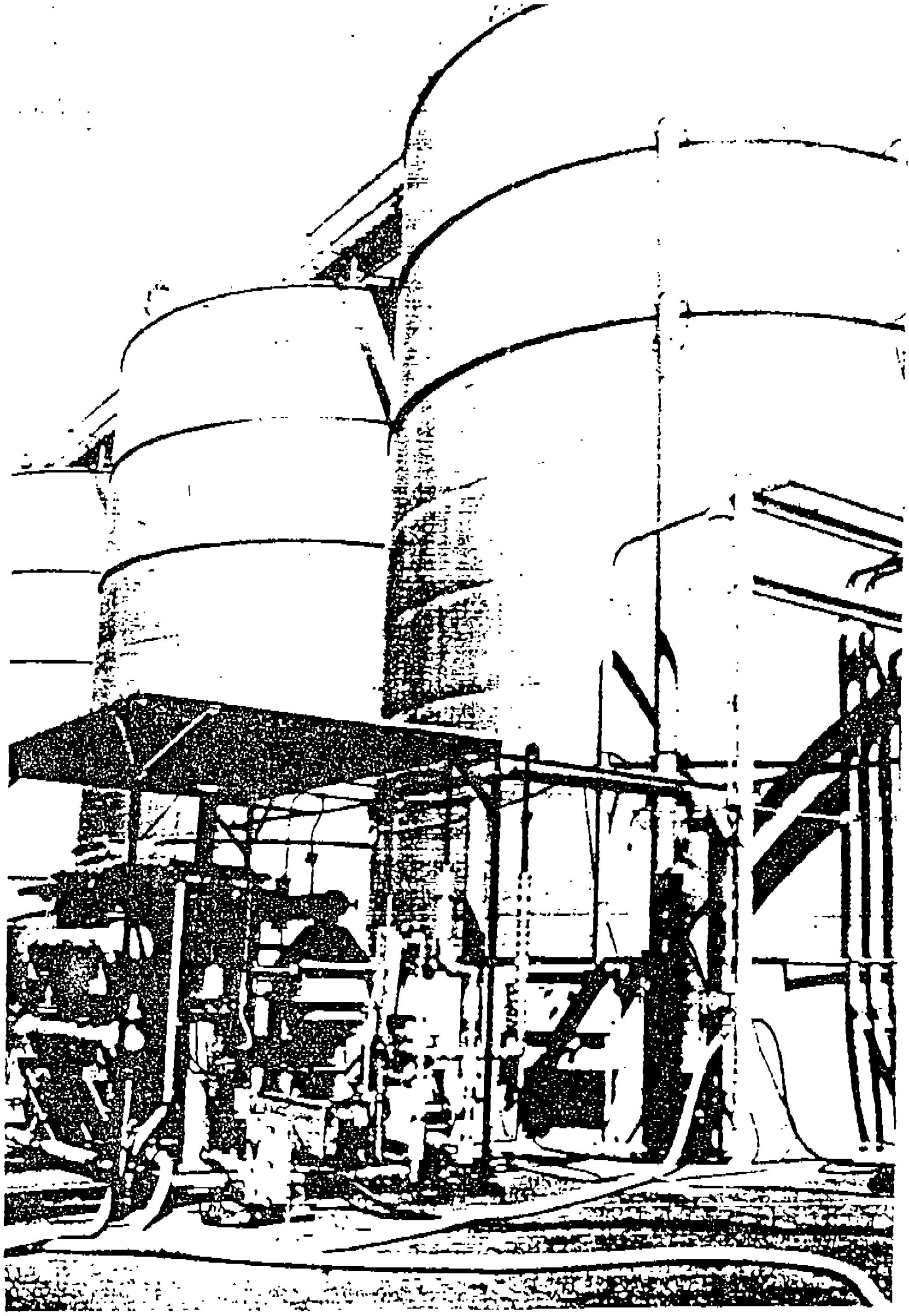
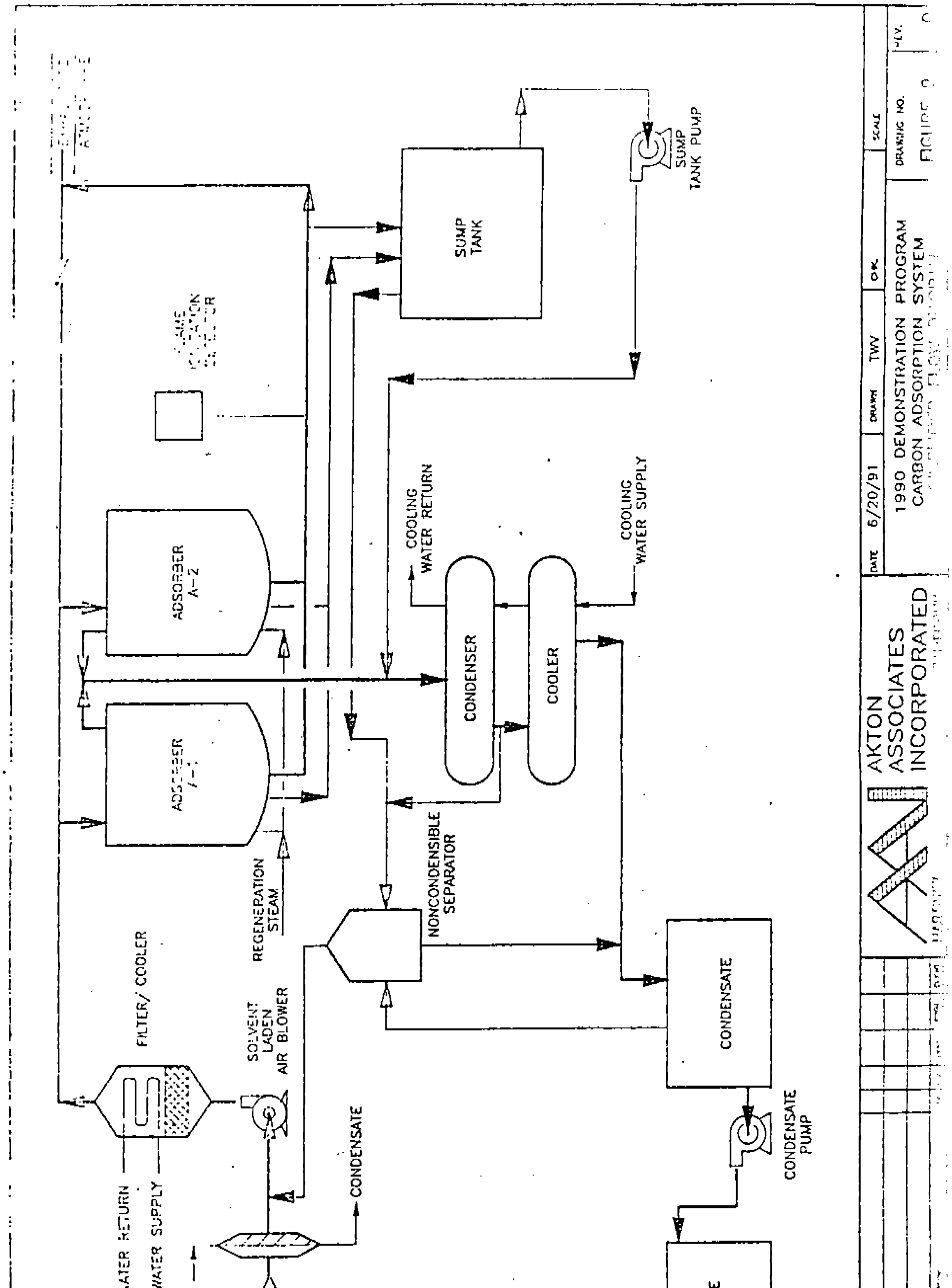


FIGURE 8. SOUTH SIDE VIEW WITH EXHAUST PIPE, FOAMOVER POT AND CARBON ADSORPTION UNIT


SOLVENT LADEN AIR
STEAM
COOLING WATER SUPPLY
COOLING WATER RETURN
CONDENSATE
SOLVENT LADEN AIR BLOWER
FILTER/ COOLER
REGENERATION STEAM
ABSORBER A-1
ABSORBER A-2
NONCONDENSIBLE SEPARATOR
CONDENSER
COOLER
COOLING WATER RETURN
COOLING WATER SUPPLY
SUMP TANK
SUMP TANK PUMP
CONDENSATE
CONDENSATE PUMP
CONDENSATE STORAGE
AKTON ASSOCIATES INCORPORATED
DATE 6/20/91
DRAWN TWY
CK.
SCALE
DRAWING NO.
REV.
1990 DEMONSTRATION PROGRAM
CARBON ADSORPTION SYSTEM

Figures 10 through 13 show the adsorption unit central panel and various items included in the adsorption unit.

In the final step, the adsorbed ethanol was steam stripped from the carbon, the steam and ethanol vapors condensed, and the condensate collected in the accumulation tank shown in Figure 14.

A leased, propane fueled, 50 horsepower boiler was installed to provide 14 psig (nominal) steam for both regeneration of the carbon and for indirect heating of the inlet gas for humidity control. The rental boiler, a trailer-mounted portable unit, was located south of the fermentation tank. It can be seen in Figure 7 where, in its weather-proof enclosure, it resembles a rectangular enclosed trailer.

Water for the condensing of vapors from the steam regeneration of the carbon was provided by once-through cooling water from the winery water system.

SYSTEM OPERATION

As shown on the flow diagram (Figure 1), the concentration of ethanol in the gas vented from the adsorption system was monitored by an analyzer (Beckman 400A recording, flame ionization detector.) This unit was set to automatically initiate a one-hour carbon regeneration cycle when an ethanol concentration of 50 ppm (v/v) was reached.

A default regeneration cycle was initiated at an elapsed time period of 20 hours, whether the maximum outlet concentration was reached or not. Steaming rate was approximately

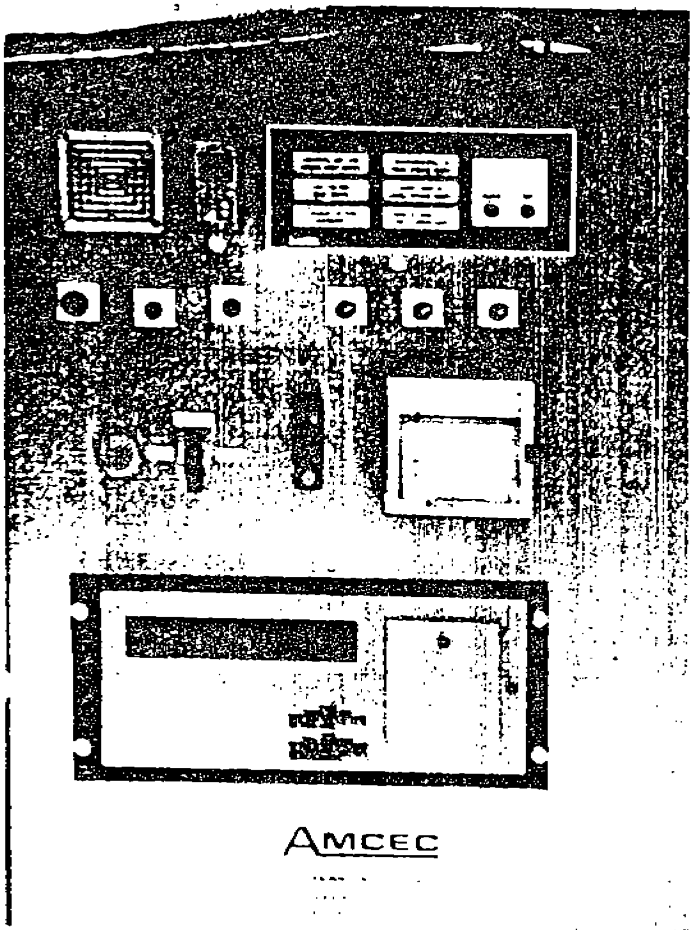


FIGURE 10. CARBON ADSORPTION UNIT CONTROL PANEL SHOWING ALARMS AND VOC OUTLET CONCENTRATION RECORDER.

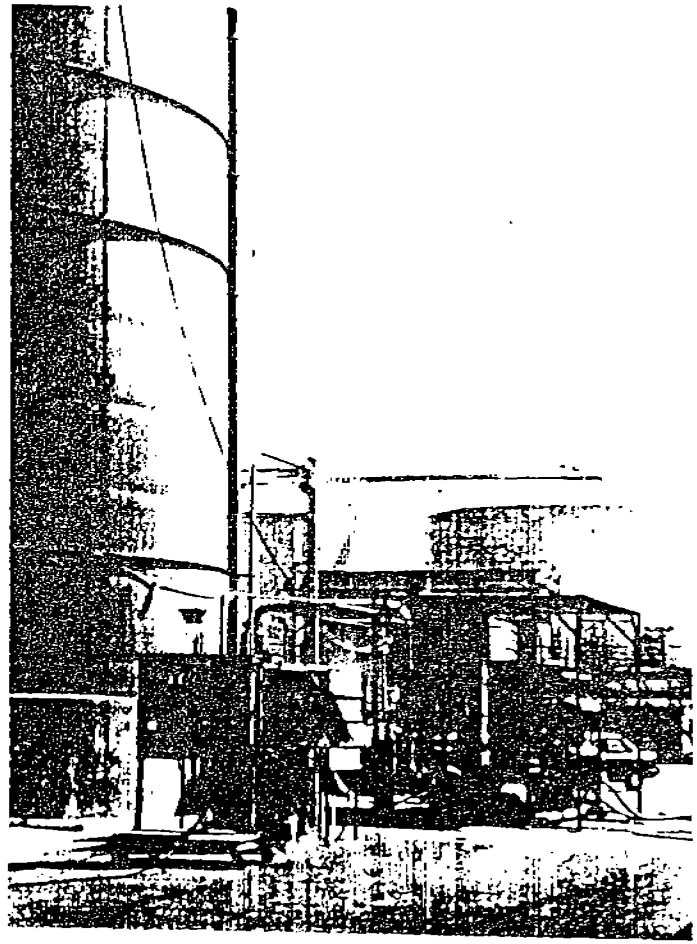


FIGURE 11. NORTH VIEW, ELECTRICAL PANEL WITH CONTROL PANEL BEHIND AND CARBON ADSORPTION UNIT TO RIGHT.

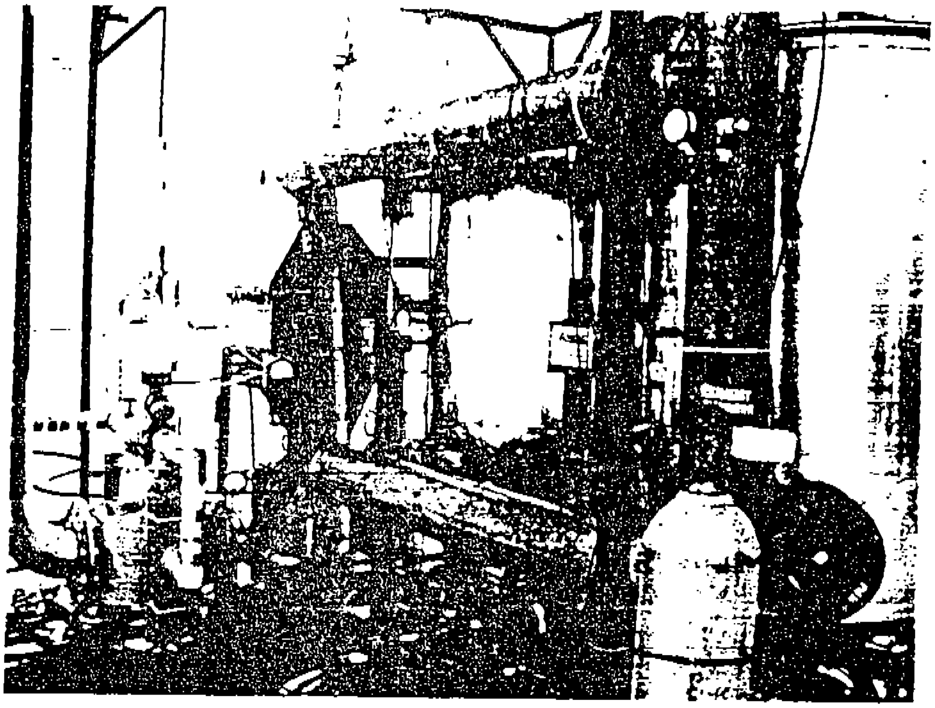


FIGURE 12. EAST SIDE CARBON ADSORPTION UNIT, HEAT EXCHANGER TO LEFT, VAPOR INLET AND OUTLET HEADERS TO RIGHT.

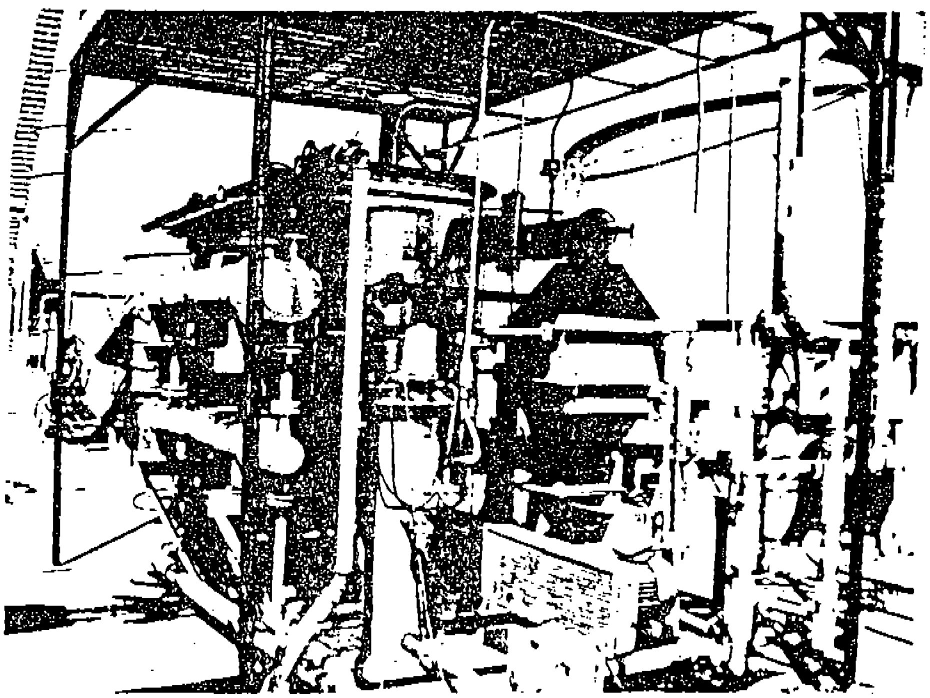


FIGURE 13. WEST AND SOUTH SIDES CARBON ADSORPTION UNIT. FAN AND CONDENSATE IN FOREGROUND, STEAM CONDENSOR BEHIND

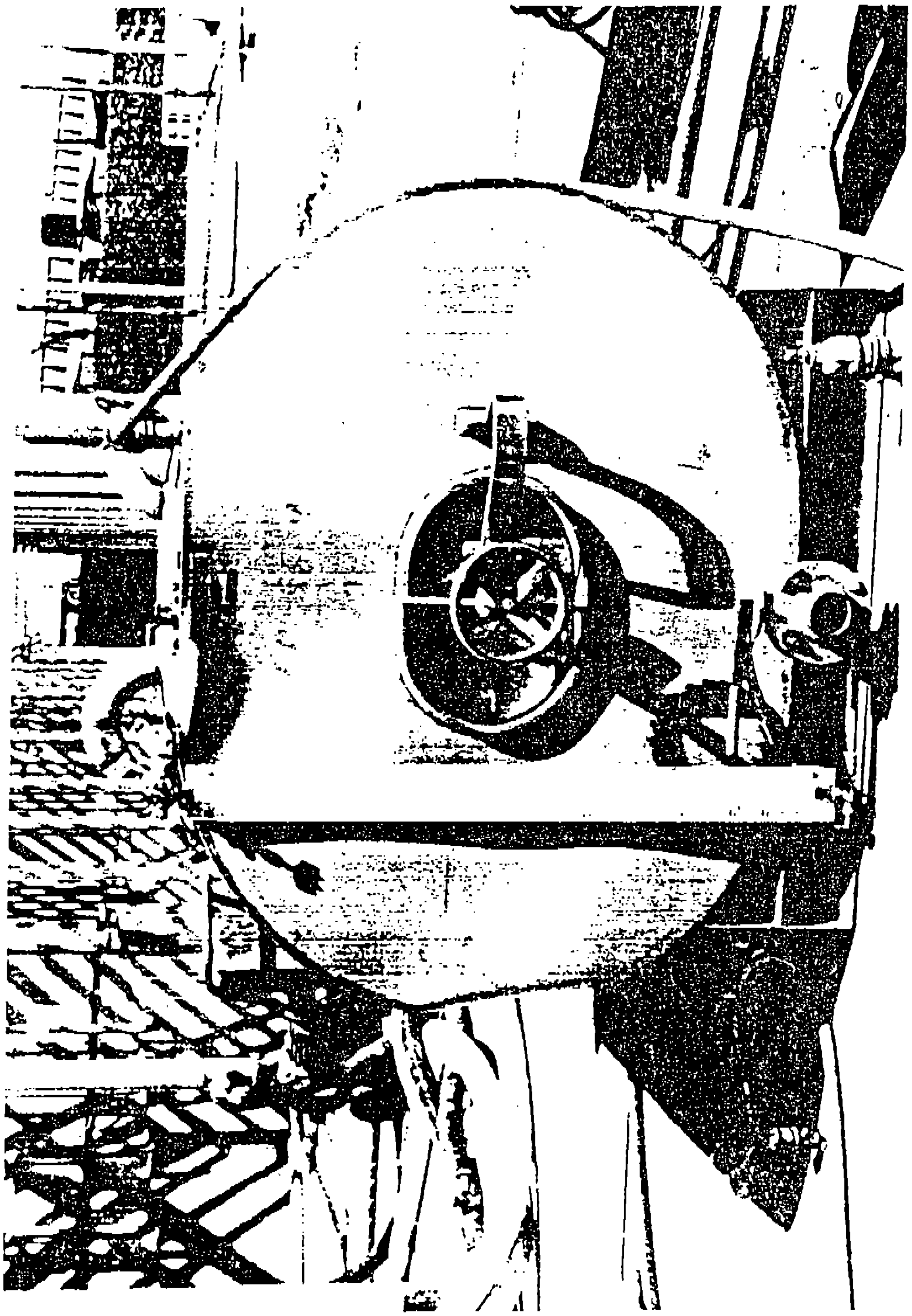


FIGURE 14. CONDENSATE ACCUMULATION TANK

200 pounds per hour at initial steam pressures of 10 to 14 psig measured at the boiler. Outlet bed temperatures of greater than 230°F were obtained during "normal" regeneration cycles.

Condensed regeneration steam (condensate), including recovered ethanol, was collected, measured and analyzed for ethanol content prior to disposal.

Operation of the system was continuously monitored and all pertinent operations were logged at least once per hour. Logged data for all eight fermentation cycles are shown in the "Field Data" section. The duties of the emission test operators are attached as Appendix 2.

Both inlet and outlet ethanol concentrations were monitored by CARB personnel during runs 6, 7 & 8. Chart data for these tests are attached as Appendix 4.

FERMENTATION CYCLES

A total of eight fermentation cycles were conducted between August 29 and September 28, 1990. Fermentation cycles 1, 2 and 8 were conducted with clarified juice at fermentation temperature of approximately 58°F. Initial Ballings (% sugar w/w) were approximately 20° and final alcohol contents were approximately 12 %. Tank fill was a nominal 170,000 gallons.

The remaining fermentation cycles 3 through 7, were red fermentations at nominal fermentation temperatures of 73°F. Initial Ballings were approximately 23°, and final alcohol contents varied from 8.6 to 10.2 % before transfer to other tanks.

All fermentation practices utilized were normal E. & J. Gallo Winery operating procedures. Exhibits 1 through 8 show relationships between time, sugar content, alcohol content and fermentation temperature for each cycle.

All sampling procedures, analysis and record keeping were conducted by E. & J. Gallo Winery personnel in accordance with normal winery operation, and as required by appropriate governmental agencies.

RESULTS OF FERMENTATIONS

Combined average results of fermentation conditions and quantities and composition of carbon regeneration condensate are shown in Tables 1 and 2.

A carbon activity analysis was conducted on a composite sample of carbon removed from the carbon beds after the final regeneration of the carbon at the conclusion of the tests. The reported "slight loss of activity" was judged by the equipment manufacturer to be typical for carbon which has been in service. A report of these tests is included as Appendix 3.

Results of "wipe tests" on inside surfaces of ducting to judge sanitation conditions were negative. Minimal carryover of foam or juice from the tank was noted. Significant discoloring of the hood was noted. No significant foam-over was detected during the program. It was reported that on one occasion, carryover required more extensive cleaning than simply wiping the duct interior. This was not thought to be significant enough to require recording, and the cleaning was completed by operating personnel.

Pressure drop through the carbon beds, (fan discharge to carbon bed outlet), remained constant at approximately 12.0 inches water column at low CO_2 concentrations. Internal fermentation tank pressures of 0.025 inches water column were measured at maximum red fermentation rates and with the adsorption system in normal operation.

The calculated amount of fuel required for the boiler during a normal red wine fermentation cycle requiring an average of 14 regenerations was 6.4 million BTU. Cooling water volume was not measured, but cooling must be supplied at a rate of 25,000 BTU per hour to condense regeneration steam and alcohol.

1990 DEMONSTRATION PROGRAM
FERMENTATION CONDITIONS
TABLE 1

No.	Fermentation Type	Fermentation Date	Volume Fermented (Gallons)	Total Hours	Avg. Temp. (°F)	Initial Balling	Final Balling	Final Alcohol (% v/v)
1	White	8/29-9/3	172,000	164	59	20.0	≤0.2*	12.0
2	White	9/5-9/11	170,000	148	56	20.0	≤0.1*	12.0
3	Red	9/12-9/13	164,000	32	72	23.2	6.5	9.5
4	Red	9/14-9/15	164,000	28	74	23.0	6.2	9.3
5	Red	9/16-9/17	164,000	32	73	23.0	5.0	9.6
6	Red	9/18-9/19	160,000	36	73	22.8	7.0	8.9
7	Red	9/20-9/22	160,000	48	74	22.6	4.6	10.2
8	White	9/23-9/28	170,000	128	57	21.6	≤0.7*	11.7

* Residual Sugar
Note: Fermentation Tank 30'-0" ϕ X 207,000 gallons

1990 DEMONSTRATION PROGRAM
CONDENSATE QUANTITIES AND ANALYSIS
TABLE 2

Fermentation Number	Condensate Collected (Gallons)	Alcohol Content (% v/v)	Alcohol (Pounds)	Pounds Alcohol Per 1000 Gals. Fermented
1	383	9.45	238.3	1.39(a)
2	775	7.75	395.5	2.33
3	275	25.45	460.8	2.80
4	220	24.55	355.6	2.16(b)
5	325	21.85	467.6	2.85(b)
6	352	21.85	506.4	3.17
7	454	21.30	636.7	3.98
8	339	12.50	279.0	1.64

(a) Programming and fan problems resulted in significant unit down-time
(b) Wet carbon beds noted

DISCUSSION OF OPERATIONS

Several major operational problems were encountered during the program. While all were corrected without disturbing the normal fermentation cycle, significant down-time was experienced and, therefore, the overall capture of emitted alcohol was reduced. Since only one fermentation tank was connected to the system, the quantity of ethanol not captured would be variable with the type of wine fermenting and the point in the fermentation cycle. Operational problems included:

1) Excessive fan vibration resulting from failed bearing and distorted shaft. Unit was shut-down and parts replaced.

2) Shut-down of analyzer system on several occasions due to:

   a) loss of fuel

   b) loss of ignition

c) moisture in inlet line

d) sample pump failure

Adsorption unit was bypassed in all cases and analyzer system problems corrected. Time loss was variable from 30 minutes to three hours on each occasion.

3) Initial programming problems of regeneration cycle controller resulted in delayed start-up of unit during initial fermentation cycle.

4) Plugging of condensate withdrawal lines resulting in incomplete regeneration cycles during fermentation cycles 4 and 5. Carbon fines migrated through support screens and plugged drain piping, resulting in an inability to achieve desired regeneration cycles. The unit was shut down and lines cleared. This problem, which was assumed to be a result of new carbon, resulted in both lost unit availability during repair and inefficient operation during period before repair.

Minor operational difficulties were also encountered, but resulted in minimal disruption of unit availability. These include:

Failure of pressure gauges

Adjustment of rental boiler steam pressure controls

Sticking and/or sluggish operation of automatic regeneration valves on an infrequent basis

All operating difficulties were immediately noted by personnel monitoring equipment and corrective action was undertaken to minimize unit down-time and/or reduction in adsorption efficiency.

The feed conditioning system was initially designed to maintain a maximum relative humidity of 50% by indirect heating of the incoming gas stream. While this system worked well, there were times when a moisture removal, or cooling system, may have been desirable to maintain carbon bed temperatures closer to that required for most efficient adsorption.

DISCUSSION OF RESULTS

The following significant points were noted:

Tank Hood Capture Efficiency - Previous data and testing indicated that a system designed on the basis of approximately 6.8 CFM of air per 1000 gallons of fermenting red wine should be adequate for capture of nearly all gas emitted from an actively fermenting tank under most conditions. A system capacity of 1100 CFM should, therefore, have been adequate for the 200,000 gallon capacity (total) tank utilized. Review of collected fermentation data and stoichiometric calculation of sugar conversion versus time at maximum fermentation rates indicate that a system capacity approaching 1340 CFM should have been used to assure maximum capture at all times for the conditions observed during this program. This equates to 8.2 CFM per 1000 gallons fermented. (Both capacities allow a 10% air from ambient.) This higher than expected gas evolution rate could have resulted in a potential loss of 10 to 15% of alcohol vapor emitted during these periods of maximum fermentation of red wine.

This observed maximum fermentation rate, which occurred during normal fermentation, demonstrates the potential for under-design of control systems and consequent cost increases if all potential fermentation conditions are not addressed. While this maximum fermentation rate is only observed during limited periods, the design capture rate should be increased to 8.2 CFM to assure that overall system efficiencies required for capture and control of ethanol are achieved.

The results of the fermentation show that the amounts of alcohol collected per 1000 gallons of white wine (Tests 1, 2 and 8) were close to the amounts predicted by the pilot studies carried out by CSUF during 1987 and 1988 for white wine fermented to dryness.

The red wines were not fermented to dryness in the Demonstration Program as they were during the CSUF tests; therefore, a direct comparison of alcohol collected per 1000 gallons could not be made. However, comparison of data collected during the CSUF testing with data shown in Tables 1 & 2, indicates a reasonably close correlation at the point at which fermentation was interrupted for transfer to other tankage. This transfer was made in accordance with normal E. & J. Gallo Winery practice for red wine fermentation.

Carbon Efficiency - Calculations based on average carbon adsorber outlet gas ethanol concentrations and total amounts of alcohol condensed indicate that alcohol removal efficiencies of greater than 98% were achieved for red wine fermentation cycles 6 and 7 and greater than 97% for white wine fermentation 8. Comparison of inlet versus outlet VOC concentrations as measured by CARB staff confirms that these results were achieved on an overall basis. Analyzer data for three fermentation runs, included herein as Appendix 4, confirms the overall efficiencies noted above. It should be noted that these efficiencies are for the carbon adsorber units only, and do not reflect overall system capture and abatement efficiency. As addressed above, total capture may have been less than 90% during short periods of red wine fermentation.

Overall Efficiency - Overall efficiency is also effected by pumpover and sampling practice. The fermentation tank utilized had facilities which allowed both sampling and pumpover without requiring the removal of tank top opening covers. Capture of gases evolved from the tank during fermentation was, therefore, primarily limited by hood capture efficiency and system flow rate capacity.

Ethanol to Carbon Ratios - The amount of ethanol adsorbed per pound of carbon for each regeneration cycle was within the normally expected range of alcohol concentrations and bed temperatures experienced. Calculated averages were 0.052 pounds ethanol per pound of carbon for red wines and 0.025 pounds per pound of carbon for white wine.

Ethanol Content of Condensate - Condensate ethanol concentrations of 21 to 25% (v/v) for red wine fermentations and 8 to 12% for white wine were observed. These values are within the range of values considered acceptable for feed stocks to ethanol recovery stills. Collection and disposal of condensate from a permanent installation must take into account both the variable concentration and variation in volume.

Utility Availability - A reliable source of steam and dry instrument air for control must be made available. If multiple adsorption units are installed, the simultaneous regeneration of all units must be considered. If steam is to be distributed over any considerable distance, a boiler operating pressure must be provided to allow dry steam at 15 psig at the units.

Operator and Maintenance Personnel - For reliable, continuous operation, the program has demonstrated a need for regular monitoring of the system and the availability of experienced instrument, electrical and mechanical repair personnel at all times.

Sanitation - As previously noted, no significant foam-over in the test tank was experienced and, therefore, "gross" contamination of the ducting with liquid did not occur. An attempt to induce a foam-over during fermentation #8 was unsuccessful and no conclusions could be made regarding the adequacy of the Foam-over Pot to prevent contamination of the carbon.

PERMANENT INSTALLATION

The design of any permanent ethanol emissions control equipment would, of necessity, be determined on a case-by-case basis, as winery installations and operating procedures vary greatly. Tank usage and cycling will impact both installation and operations.

These considerations were not significant for the Demonstration Program, as the tank used was readily available and accessible. With the exception of the new tank nozzle, all of the equipment used for the present program was installed on a "temporary" basis. This vastly simplified the installation process.

Installations of permanent systems would entail far more complex ducting and utilities piping to provide for the connection of all of a winery's fermentation tanks in its tank farm to vapor collection systems. This would necessitate substantial coordination of the construction phase with the normal operations of the winery. For instance, many tanks which are used for fermentation are also used to store wine following fermentation. Therefore, these tanks would be available for modification only for the period of time after the stored wine is removed and before the empty tank is placed in service for the ensuing fermentation season.

E. & J. Gallo Winery has investigated the task of retrofitting its Fresno facility, and has determined that there is a twenty-one week period extending from March through July during which retrofitting might be accomplished. A crew of six workers would be required to complete the retrofitting of four closely spaced tanks within this period. For reasons of employee safety, the size of the retrofit work force would be limited to forty-eight workers, not including the regular plant maintenance and construction forces. Even at this limit, incorporating a force of this size within the framework of the normal plant operations would require significant scheduling and coordination. This would result in eight crews of six to complete the retrofitting, and at best, a force of this size would only be able to retrofit thirty-two tanks. Given these assumptions, the retrofitting of the projected 125 fermentation tanks which are assumed to be required at the E. & J. Gallo Winery facility would require four years to complete. This four-year retrofit period is, of course, in addition to the time required for installation engineering studies and the completion of detailed engineering design.

Installation engineering would require the evaluation of:

- Available space locations within each winery
- Winery vehicle traffic patterns
- Location and availability of utilities
- Constraints resulting from Carbon Adsorption Systems requirements
- Constraints resulting from steam boiler requirements

This work must be substantially completed before the detail design could be performed and the carbon adsorption systems specified. Using the E. & J. Gallo Winery facility as a base case, the engineering evaluation and detail design would have to be sufficiently complete to permit advance specification and procurement of the carbon adsorption systems so that delivery of all equipment (adsorbers, boilers and ancillary equipment) could be scheduled to coordinate with the construction effort permitted within the aforementioned twenty-one week period. An estimated six months would be required for the engineering and equipment specification effort. The procurement process for the carbon adsorbers could not be initiated until at least three months of this design period had elapsed. The order-to-delivery lead time for the adsorbers is presently estimated to be six months. Thus, the engineering-to-equipment delivery schedule would be a minimum of nine months and more probably, one year. Consequently, the engineering evaluation would have to be commenced not later than July 1st of the year preceding installation of the first phase.

For carbon adsorption control technology, both steam and cooling water must be provided. At the E. & J. Gallo Winery facility, good quality steam was not available at the test site. This necessitated the rental of a temporary boiler. For a permanent facility, the cost of providing this steam would be a significant factor in evaluating the economics of the carbon adsorption method. -First the steam must be produced, then it must be distributed to the carbon adsorption system. Each winery would present its own specific situation, so the costs associated with the production and distribution of adequate steam for the process would have to be evaluated on an individual basis.

Design considerations affecting the installed costs should include:

1) Existing boiler capacity vs. provision of new boilers
2) Installation of a central boiler vs. several smaller boilers
3) Use of permanent vs. temporary boilers
4) Use of existing distribution piping vs. new piping

These design considerations will be individually affected by tank farm size and physical layout, number of carbon adsorption systems to be installed, availability of plant water and power, and air emissions permit requirements for the boilers.

If an adequate steam supply were available, the capital cost for the system would be lower than if new permanent boilers are required. This is seldom the case in the wine industry.

COSTS - 1990 DEMONSTRATION PROGRAM

The total costs reported for the 1990 Demonstration Program are $151,861.04 as shown on Table 3. This total includes with few exceptions, all the costs for labor and materials to furnish, install and operate the equipment.

1990 DEMONSTRATION PROGRAM
SUMMARY OF REPORTED PROGRAM COSTS
TABLE 3

Carbon Adsorption Unit Rental	$76,613.62
Tank Collection Hood	1,265.97
Consultant and Engineering	21,277.75
Winery Labor & Materials	43,394.58
Boiler Rental	9,309.12
Total	$ 151,861.04

This reflects. a basic cost of $323 per pound of ethanol trapped during this test. Operational items furnished by the winery and not included in these figures are cooling water and electrical power. The cooling water used to condense the steam and vapor stripped from the carbon during regeneration was obtained from the winery utility system and discharged directly into the winery drain after use. Electrical power for equipment operation was obtained from the winery distribution system.

No costs are included for further handling of the condensate, either for disposal or for alcohol recovery. Additionally, no credit is included for the recovery of the alcohol solution. Parallel Products in Cucamonga, California advised that they would accept ethanol-water solutions for processing into ethanol fuel. Parallel Products would not pay for the solution, and wineries tendering the solution would have to pay the cost of transportation to Parallel Products' plant. This cost would be incurred by wineries lacking access to a municipal industrial waste system for disposal of the ethanol-water solution.

PERMANENT INSTALLATION COSTS

As stated earlier, the 1990 Demonstration Program assumed that the 6.8 CFM per 1000 gallon capture rate used would be adequate for most conditions. However, this capture rate was overpowered by one fermentation mass. Calculations for one four-hour period show that a capture rate of 8.2 CFM per 1000 gallons fermented was necessary to provide a 10% safety factor. The Program demonstrated that the equipment concept was correct and that all equipment previously thought to be required for overall emission control was needed.

Since the 1987 CARB cost effectiveness study was completed on the basis of 6.1 CFM per 1000 gallons capture rate, the new estimated fixed capital costs for the installation of the emission control systems have been derived by ratioing data presented in that study by the scale-up factor of 0.6, in this case $(8.2/6.1)^{0.6}=1.194$. Further, the CARB 1987 cost figures should be adjusted to 1991 dollars. According to the Chemical Engineering Plant Cost Index and the Marshall & Swift Equipment Cost Index as published in Chemical Engineering magazine, the differential experienced through the first quarter of 1991 is 1.12 and 1.14, respectively. For this report an index of 1.13 was used. This provides the following results:

CARB 1987 STUDY - FIXED CAPITAL COSTS
(all figures adjusted to 1991 dollars)

	1987 Tankage	All Tanks
Mont La Salle	3,480,000	3,570,000
Guild-Cribari	5,025,000	6,930,000
Gallo	18,015,000	28,330,000

Above costs adjusted for 8.2 CFM capture rate

	1987 Tankage	All Tanks
Mont La Salle	4,160,000	4,265,000
Guild-Cribari	6,000,000	8,275,000
Gallo	21,510,000	33,835,000

CARB 1987 STUDY COST EFFECTIVENESS
(dollars per pound of ethanol reduced, adjusted to 1991 dollars)

	1987 Tankage	All Tanks
Mont La Salle	11 to 24	11 to 25
Guild-Cribari	29 to 57	40 to 78
Gallo	18 to 37	28 to 63

Above costs adjusted for 8.2 CFM capture rate

	1987 Tankage	All Tanks
Mont La Salle	14 to 28	14 to 63
Guild-Cribari	35 to 60	47 to 93
Gallo	21 to 38	34 to 78

The CARB 1987 Study fixed capital costs were based on three different wine fermentation emission factors derived from the 1986 ARB Winery SCM (Technical Support Document), Dr. Williams Empirical Equation and the 1988 ARB Pilot Study Source Test and give, respectively, emission factors of 2.55, 1.94 and 1.22 pounds of ethanol per 1000 gallons of white wine fermented and 7.76, 5.91 and 4.12 pounds of ethanol emitted per 1000 gallons of red wine fermented. In that study these factors were applied in three cases; the cost effectiveness figures presented in this report represent the resultant ranges of high and low values calculated in the CARB 1987 study and factored for inflation as shown above.

The cost of disposal of collected condensate is estimated to be the cost of hauling this material to a secondary processor. The haulage route would cover some 500 miles round-trip in this case and cost $ 700 to $ 900 for each 6,000 to 7,500 gallon tank load. No salvage value is given for the alcohol contained in the condensate. The crushing season cost to E. & J. Gallo Winery is estimated to be between $25,000 and $30,000 for disposal. Hauling distances for other wineries could be substantially longer.

In addition to the items above, there are several areas to be addressed which are not presently capable of being quantified due to a lack of reliable data. These cost elements, which will impact both capital costs and cost-effectiveness of the abatement system, are briefly discussed below.

As discussed earlier in this report, the analyzer system for the demonstration unit was shut down to correct equipment operation problems for periods from thirty minutes to three hours. The on-site testing and sampling analyzer used by CARB personnel was susceptible to similar problems. Based on the experience gained during the Demonstration Program, the assistance of a qualified instrument technician would be required at all times during the fermentation season. This would necessitate availability of such a technician for twenty-four hours per day seven days per week for the duration of the crush, a period of up to ten weeks. In the case of wineries where there are multiple abatement systems installed, more than one on-duty technician might be required to provide adequate service to ensure minimizing system down time. The cost of this technical assistance alone would add twenty-five to fifty cents per pound of ethanol to the overall cost effectiveness figures for ethanol abatement. Far more critical is the problem of the availability of these technicians for such a short period (circa six weeks). To provide just one on-duty technician at a site would require four individuals.

The Demonstration Program presented no obvious sanitation problems. This experience may, however, be misleading and not representative of full-scale operations. As previously stated, it was not possible to initiate a foam-over during the Demonstration Program fermentation cycle. However, in actual practice, foam-overs will occasionally occur. There was the one instance of reported but unrecorded carryover that did require immediate cleanup to maintain the sanitation level and the additional problem of hood discoloration.

The risk of foam-over and carryover is contamination of the system with "wild" organisms. To minimize this risk, the system must be so designed that each part may be readily accessed for a thorough cleaning in the event that any part of the fermentation liquid is carried beyond the limits of the fermentation tank environment. As these excursions may occur at any time during the fermentation process, the cleaning and sanitizing system must incorporate the "clean-in-place" principle. That is, the entire vapor collection system from the tank hoods through the ducting to the inlet of the adsorbers must be capable of being cleaned and sanitized without being completely dismantled, and without requiring that the fermentation process be interrupted for any extended time. These considerations will require substantial effort during the design process, and will be a major element of the unquantified costs of system installation and operation.

An additional cost element not quantified is the cost of fire safety. Prior to completion of the abatement system design for each individual affected winery, there is no real way to determine these costs. Factors which will impact this cost element are the National Fire Protection Association (NFPA) classifications which will be applicable to the installation. The liquids encountered may be classified as either NFPA Class I or Class II, Flammable Liquid. It is probable that the installation would have to comply with the National Electric Code (NEC) Class I, Hazardous Locations. Depending on equipment location and other factors, either sub-classification Division I or Division II would apply. Electrical installation for such areas could require explosion-proof, purged equipment, intrinsically safe non-sparking equipment or other restrictive measures. Flame producing equipment such as boilers and the flame ionization detector on the carbon adsorption unit would need to be situated out of the areas of influence of the NEC Class I equipment or otherwise protected. The effect of these considerations would be to increase every component of system cost; the design engineering, including permit review, capital expense for the classified equipment, construction and installation to meet code requirements, operation and maintenance of the installed system.

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[1] Muller, C. J., Gump, B. H., Fugelsang, C. K., Clary, C. D. Ethanol Emissions Project Fermentation Data Report, CSUF, VERC, submitted 12/15/87.

[2] Muller, C. J., Gump, B. H., Fugelsang, K. C. Ethanol Emission II Project. Final Report. CSUF, VERC submitted 11/15/88.

CALIFORNIA AIR RESOURCES BOARD

WINERY DEMONSTRATION PROGRAM

PHASE I

- o Pilot Study
- o Tank Usage Study
- o Impact on Wine Quality
- o Cost Estimates

PHASE II

- o Design, Install, and Evaluate Full-Size Control System
- o Re-evaluate Cost-Effectiveness
- o Review Foam-Overs

CALIFORNIA AIR RESOURCES BOARD

RESULTS OF PHASE I

- o Control Efficiencies - >90%
- o No. of Tanks to be Controlled - 50 to 85%
- o Wine Quality Unaffected by Controls
- o Estimated Cost and Cost-Effectiveness

CALIFORNIA AIR RESOURCES BOARD

EMISSION FACTORS

- Pilot Study Emission Factors
  - Red Wine - 4.1 lbs/1000 gal
  - White Wine - 1.2 lbs/1000 gal
- Theoretical Emission Factors
  - Red Wine - 7.4 lbs/1000 gal
  - White Wine - 1.9 lbs/1000 gal
- TSD/EAL Emission Factors
  - Red Wine - 7.8 lbs/1000 gal
  - White Wine - 2.6 lbs/1000 gal

CALIFORNIA AIR RESOURCES BOARD

TOTAL CAPITAL COST

- Carbon Adsorption
  - $3 to $25 million
- Catalytic Incineration
  - $3 to $33 million

CALIFORNIA AIR RESOURCES BOARD

COST-EFFECTIVENESS

- o Carbon Adsorption
  - \$10 to \$70/lb of EtOH controlled
- o Catalytic Incineration
  - \$10 to \$80/lb of EtOH controlled

CALIFORNIA AIR RESOURCES BOARD

PLANS FOR PHASE II AND WINERY SCM

- o Funding for Phase II
- o Evaluate Carbon Adsorption
- o SCM to the Board

California
Air Resources
Board

LOCATION: Lincoln Plaza
Auditorium, First Floor
400 "P" Street
Sacramento, California

PUBLIC MEETING AGENDA

(This facility is accessible to persons with disabilities)

May 11, 1989

10:00 a.m.

		Page No.
89-8-1	Joint Meeting of the Air Resources Board and the Scientific Advisory Committee on Acid Deposition - Consideration of the Atmospheric Acidity Protection Program: Five-Year Research Plan	001
89-8-2	Report to the Board on Follow-Up to the Petition of City of Kingsburg et al. Requesting the Air Resources Board to Exercise Its Oversight Authority with Respect to the San Joaquin Valley Air Pollution Control District's NSR Rules and Permitting of Small Electrical Generation Facilities	---
89-8-3	Status Report on the Demonstration Program to Control Ethanol Emissions from Winery Fermentation Tanks	031
89-8-4	Consideration of Final Adoption of Regulations, Approved at the Board's November 17, 1988 Meeting, Limiting the Sulfur Content and the Aromatic Hydrocarbon Content of Motor Vehicle Diesel Fuel	037

OTHER BUSINESS

a. Closed Session

Personnel (as authorized by State Agency Open Meeting Act, Govt. Code Sec. 11126(a).)

CONTACT BOARD SECRETARY, 1102 'Q' Street, Sacramento, CA 95814, Tele: (916) 322-5594:

- **To submit written comments on an agenda item in advance of the meeting.**
- **To request, in advance of the meeting, to be placed on the list to testify on an agenda item.**
- **To request special accommodations for those persons with disabilities.**

SUMMARY OF BOARD ITEM

ITEM No.: 89-8-3: Status Report on the Demonstration Program to Control Ethanol Emissions from Winery Fermentation Tanks.

RECOMMENDATION: None.

DISCUSSION: Introduction

Overview. This report summarizes the status of the demonstration program on the control of emissions of ethanol from winery fermentation tanks. The program exists in two phases. Phase I ran from the 1987 fermentation season through the 1988 fermentation season. Phase II is planned to begin during the 1989 fermentation season.

Winery fermentation tanks and air quality. During wine fermentation, exhaust gases containing ethanol are vented from fermentation tanks into the atmosphere. Ethanol is a volatile organic compound, and its release to the atmosphere contributes to the formation of atmospheric photochemical oxidants, including ozone. The control of ethanol emissions from winery fermentation tanks is one of the control measures that the Air Resources Board (ARB) and the Technical Review Group (TRG) have considered for the reduction of ozone.

Ethanol losses from winery fermentation operations have been identified as significant sources of oxidant precursors in the San Joaquin Valley Air Basin (SJVAB). Within the SJVAB, the Fresno County Air Pollution Control District has committed in its air quality maintenance plan to control ethanol emissions from winery fermentation tanks. This measure, along with other measures, may be necessary for the attainment and maintenance of the federal ozone standard in Fresno County.

Development of the demonstration program. At the January 22, 1987, Board meeting, the TRG in conjunction with the ARB staff presented a suggested control measure (SCM) for the control of ethanol emissions from winery fermentation tanks. At that meeting, the Wine Institute, the trade organization of the California wine industry, testified before the Board about several issues relating to the technical feasibility and cost of the proposed SCM. As a result, the Board directed the ARB staff to work with the Wine Institute to develop a demonstration program that would resolve these issues.

At the March 27, 1987, Board meeting, the Board approved a demonstration program to assess the feasibility and cost of ethanol emission controls during wine fermentation. The Board deferred taking action on the SCM for control of ethanol emissions from winery fermentation tanks pending the outcome of the demonstration program.

An ad hoc advisory committee comprising of two members of the ARB staff, a member of the TRG, and two representatives appointed by the Wine Institute was formed to implement the demonstration program in two phases.

Phase I

Content of Phase I. Phase I, which began during the 1987 fermentation season and carried over to the 1988 fermentation season, consisted of the following : (1) a pilot program to evaluate three ethanol emission control technologies (scrubbing, carbon adsorption, and catalytic incineration); (2) a study to monitor the number of fermentation tanks used and the patterns in which fermentation tanks are used at three wineries in the Fresno area (Gallo, Christian Brothers, and Guild-Cribari); (3) an evaluation of the possible impact of controls on wine quality; and (4) preparation of cost estimates for these wineries to install venting systems and control equipment.

Results of Phase I. The Wine Institute, with the Committee's approval, contracted with

California State University, Fresno (CSUF) to conduct several red-wine and white-wine fermentations. Source test support for evaluating ethanol concentrations in the fermentation exhaust gases was provided by the ARB. The Committee concluded that: (1) the control technologies evaluated were capable of reducing the ethanol in wine fermentation exhaust gases by 90 percent or greater; (2) 50 to 85 percent of the wineries' fermentation tanks would have to be connected to control systems; (3) wine quality is not affected by the venting system and control equipment; and (4) preliminary cost and cost-effectiveness estimates are possible.

Potential ethanol reductions. The venting system was determined to have a collection efficiency of greater than 97 percent. It was also determined that all the control equipment evaluated can reduce more than 95 percent of the ethanol emissions. Therefore, the control systems (venting system and control equipment) are capable of reducing more than 90 percent of the ethanol in the exhaust gases emitted during wine fermentation. Of the control technologies evaluated, carbon adsorption was selected as the preferred technology. The basis for this decision is that carbon adsorption is the preferred contol technology of the wineries, primarily because it was the lowest cost control method. The Committee also concluded that water scrubbing would not be feasible due to technical problems relating to the disposal of the waste water and that catalytic incineration would not be feasible due to the inordinately high cost of implementation.

Tank usage study. The tank usage study consisted of site visits by the ARB staff to the three operating wineries in the Fresno area during the 1987 fermentation season. The purpose of the visits was to monitor tank usage patterns and review historical fermentation tank usage patterns for the years 1984 through 1986. The tank usage data allowed the Committee to evaluate the number of tanks that would have to be ducted for each of the three wineries. This information is needed to determine the overall costs of emission control.

Affect of venting and control system on wine quality. The University of California at Davis was contracted to study the impact of controlling ethanol emissions on wine quality. It was determined that the venting system and control equipment have no affect on wine quality.

Emission factors. To determine emission factors, the ARB staff conducted source tests during two red-wine and two white-wine fermentations. From the source tests, the average red-wine emission factor was estimated to be 4.12 pounds of ethanol per 1000 gallons of wine produced, and the average white-wine emission factor was 1.22 pounds of ethanol per 1000 gallons of wine produced. These emission factors are about 50 percent less than the emission factors given in the 1986 ARB report A Suggested Control Measure for the Control of Ethanol Emissions From Winery Fermentation Tanks - Technical Support Document or the emission factors estimated by theoretical equations.

Preliminary cost of pollution-control equipment. The ARB staff has estimated the capital cost for the three wineries to install carbon adsorption and catalytic incineration systems to reduce ethanol emissions during wine fermentation. The capital costs for the three wineries range from about $3.1 to $25 million for carbon adsorption systems and about $3.7 to $33 million for catalytic incineration systems.

The capital cost of a control system consists of the cost of the venting system and the cost of the control device. The cost of the venting system represents about 70 percent of the total capital cost of a carbon adsorption system and about 60 percent of the total capital cost of a catalytic incineration system. Therefore, the cost of a control system is most dependent on the venting system design and the number of tanks vented to the control devices.

Preliminary cost-effectiveness analysis. based on information acquired in Phase I, the ARB staff estimated: (1) the costs for Christian Brothers (Mont La Salle Vineyard), Guild-Cribari, and Gallo to install and operate carbon adsorption and catalytic incineration systems; (2) the ethanol emissions emitted during the 1987 fermentation season; and (3) the ethanol emission reductions that would result if control devices were installed.

With this information, the ARB staff estimated the cost-effectiveness of reducing ethanol emissions from winery fermentation tanks (for the three wineries) to range from $10 to $69 per pound of ethanol reduced when carbon adsorption is used and $12 to $80 per pound of ethanol reduced when catalytic incineration is used.

Phase II

Content of Phase II. Phase II is a full-scale demonstration program to evaluate carbon adsorption equipment on one or more fermentation tanks with capacities greater than 50,000 gallons at an operating winery. Phase II includes (1) engineering design of a full size control system; (2) installation and evaluation of a control system during a fermentation season; (3) re-evaluating the cost-effectiveness estimates based on information from Phase II; and (4) reviewing the problem of foam-overs. The Committee is planning to begin and, if possible, carry out Phase II during the 1989 fermentation season.

Because Phase I used more funds than anticipated, the remaining funds may not be sufficient to complete Phase II this year. However, at a minimum, the Committee will do the engineering design of the control system this year.

The ARB staff recently submitted a grant application to the California Department of Commerce requesting funds to supplement Phase II of the demonstration program. If these funds become available and with time permitting, the committee may proceed to complete Phase II this fermentation season.

(It should be noted that the fermentation season is normally August through September.) As of April 20, 1989, the ARB staff has not received confirmation if the grant has been approved by the Department of Commerce.

As appropriate, the ARB staff will recommend changes to the suggested control measure to reduce ethanol emissions from winery fermentation tanks. At this time, we are planning to present the proposed SCM to the Board next April.

The problem of foam-overs. One of the issues that continues to be of concern to the wineries is foam-overs. In red-wine production, the entire mass of juice, skins, pulp, and seeds (collectively called the "must") is fermented together. Red wines are fermented with the skin in the mixture for maximum color and tannin extraction. During red-wine fermentation, the skins, pulp, and seed rise to the surface and form a "cap" from one to several feet thick. The temperature in the cap is higher than the fermenting liquid, and fermentation within the cap is more rapid than in the bulk of the fermenting juice.

If the temperature of the fermenting must is not controlled, the juice may foam-over and exit through the vents on top of the tank. In the event of a foam-over, the wine cap can enter the venting system and contaminate and reduce the capture efficiency of the venting system.

Foam-overs do not normally occur during white-wine fermentation. In white-wine production, only the juice is fermented.

The Committee agreed that foam-overs are potential problems. However, the ARB staff believes that solutions to minimize foam-overs are available and the control system can be designed to accommodate foam-overs.

DRAFT

Basis of ARB Staff's

Cost Effectiveness Analysis of Ethanol Emissions Controls

Design of Control System

Scenario A - Data from the 1987 tank usage study was used to estimate: number of tanks to be vented to control system, length of vent piping, configuration of vent piping, and size of control equipment.

Scenario B - Assume all tanks at a winery, except tanks which were not used as fermentors for the last four years, are vented to a control system. The costs of control equipment are estimated based on the assumption that all tanks are at maximum fermentation rate.

Wine Fermentation Emission factors

(lbs. of EtOH / 1,000 Gallons of Wine Fermented)

Case	White Wine	Red Wine	Reference
1	2.55	7.76	1986 ARB Winery SCM (Technical Support Document)
2	1.94	5.91	Dr. William's Empirical Equation
3	1.22	4.12	1988 ARB Pilot Study Source Test

Assumptions for Total Pre-Tax Annual Cost

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1. Annualized the total fixed-capital costs with a capital recovery factor of 0.19 (annual interest rate at 15 percent and equipment life of 15 years).

2. Annual maintenance, insurance, local taxes and plant overhead at 5.75 percent of the fixed-capital cost of the control system.

3. Utility cost based on the 1987 wine production.

The ARB staff estimated the cost-effectiveness for different combinations of tank group arrangements and emission factors. For example, the cost-effectiveness for Scenario A-1 were calculated with the total annual cost of tank group scenario A and annual emission reduction based on emission factors from case 1. The cost-effectiveness of the control system are obtained by dividing the total pre-tax annual cost by the annual emission reduction.

Total Fixed-Capital Costs*
to Install Control Systems at Wineries
for Control of Ethanol Emissions During Wine Fermentation
(Dollars)

Carbon Adsorption

Winery	A	B
Mont La Salle Vineyard	3,080,000	3,160,000
Guild-Cribari Winery	4,445,000	6,130,000
Gallo Winery	15,940,000	25,070,000

Catalytic Incineration

Winery	A	B
Mont La Salle Vineyard	3,707,000	3,857,000
Guild-Cribari Winery	5,175,000	7,110,000
Gallo Winery	19,950,000	33,110,000

* Includes the total installed costs of exhaust venting system and control equipment.

Total Pre-Tax Annual Costs*

(Dollars)

Carbon Adsorption

Winery	A	B
Mont La Salle Vineyard	813,973	834,493
Guild-Cribari Winery	1,155,997	1,588,199
Gallo Winery	4,188,610	6,530,455

Catalytic Incineration

Winery	A	B
Mont La Salle Vineyard	973,725	1,012,200
Guild-Cribari Winery	1,337,020	1,823,347
Gallo Winery	5,172,894	8,548,434

* See assumptions on page 2.

Annual Ethanol Emissions and Emission Reductions

Annual Ethanol Emissions*

(lbs. of EtOH Emitted)

Winery	1	2	3
Mont La Salle Vineyard	88,950	67,675	42,865
Guild-Cribari Winery	50,350	38,325	25,495
Gallo Winery	294,700	220,755	143,105

Annual Emission Reductions**

(lbs. of EtOH Reduced)

Winery	1	2	3
Mont La Salle Vineyard	80,055	60,910	38,580
Guild-Cribari Winery	45,315	34,490	22,945
Gallo Winery	265,220	198,680	128,795

* Based on the 1987 wine production from the wineries and emission factors on page 1.

** Based on the pilot study, which assumes control equipment to be 90 percent effective in removing ethanol emissions from the exhaust stream.

Reducing Ethanol Emissions from Winery Fermentation Tanks

(Dollars per lb. of ethanol emission reduced)

Mont La Salle Vineyard

Scenario	Carbon Adsorption	Catalytic Incineration
A-1	10	12
A-2	13	16
A-3	21	25
B-1	10	13
B-2	14	17
B-3	22	26

Guild-Cribari Winery

Scenario	Carbon Adsorption	Catalytic Incineration
A-1	26	30
A-2	34	39
A-3	50	58
B-1	35	40
B-2	46	53
B-3	69	80

Gallo Winery

Scenario	Carbon Adsorption	Catalytic Incineration
A-1	16	20
A-2	21	26
A-3	33	40
B-1	25	32
B-2	33	43
B-3	56	66

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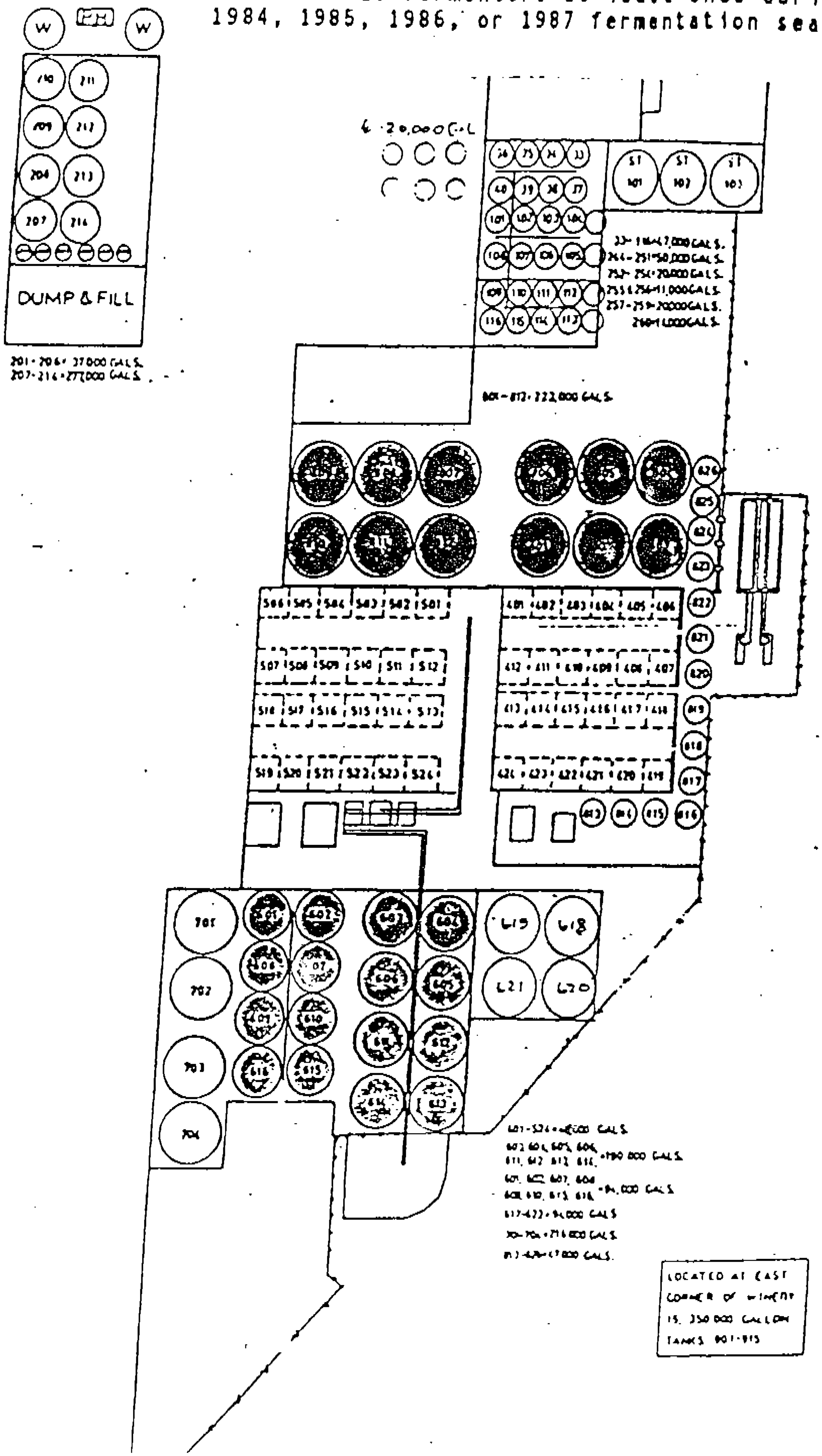
Tank Group Arrangements, Fixed-Capital Costs and Layout of Mont La Salle Vineyard, Gallo Winery and Guild-Cribari Winery

Mont La Salle Vineyards

Shaded tanks are tanks that have been used as fermentors at least once during 1984, 1985, 1986, or 1987 fermentation seasons.



Mont La Salle Winery

Scenario A

Tank Group Arrangement

Tank Group #	Tank #	Wine Type	Size of Tanks in Tank Group, gal	Number of Tanks in Group	Number of Tanks at Max. Fermentation Rate
1	601 - 602 607 - 610 615 - 616	R	94,000	8	7
2	603 - 606 611 - 614	R	190,000	8	7
3	801 - 806	R	185,000	6	5
4	807 - 812	R	185,000	6	5

Fixed Capital Costs ($)

Tank Group #	Tank #	Wine Type	Ducting	Carbon Adsorp.	Cat. Incineration
1	601 - 602 607 - 610 615 - 616	R	510,000	170,000	280,000
2	603 - 606 611 - 614	R	740,000	230,000	450,000
3	801 - 806	R	510,000	205,000	350,000
4	807 - 812	R	510,000	205,000	350,000
Total			2,270,000	810,000	1,430,000

Mont La Salle Winery

Scenario B

Tank Group Arrangement

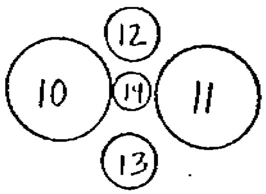
Tank Group #	Tank #	Wine Type	Size of Tanks in Tank Group, gal	Number of Tanks in Group	Number of Tanks at Max. Fermentation Rate
1	601 - 602 607 - 610 615 - 616	R	94,000	8	8
2	603 - 606 611 - 614	R	190,000	8	8
3	801 - 806	R	185,000	6	6
4	807 - 812	R	185,000	6	6

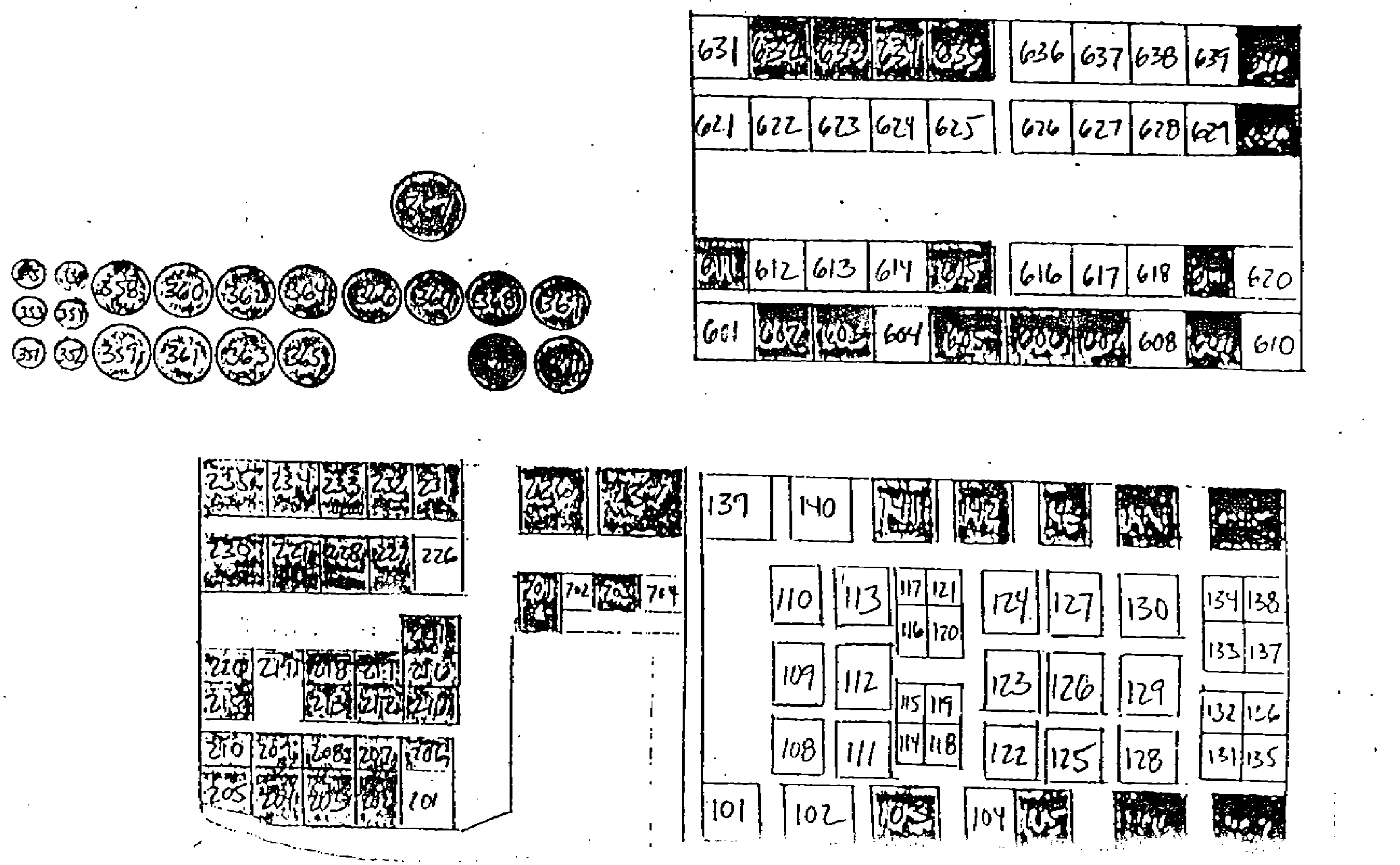
Fixed Capital Costs ($)

Tank Group #	Tank #	Wine Type	Ducting	Carbon Adsorp.	Cat. Incineration
1	601 - 602 607 - 610 615 - 616	R	510,000	190,000	320,000
2	603 - 606 611 - 614	R	740,000	250,000	480,000
3	801 - 806	R	510,000	225,000	390,000
4	807 - 812	R	510,000	225,000	390,000
Total			2,270,000	890,000	1,580,000

Guild-Cribari Winery

Shaded tanks are tanks that have been used as fermentors at least once during 1984, 1985, 1986, or 1987 fermentation seasons.





Guild-Cribari Winery

Scenario A

Tank Group Arrangement

Tank Group #	Tank #	Wine Type	Size of Tanks In Tank Group, gal	Number of Tanks In Group	Number of Tanks at Max. Fermentation Rate
1	141 - 145	W	200,000	5	5
2	201 - 210	W	55,000	10	10
3	211 - 213 215 - 221	W W	113,000 62,000	3 7	2 6
4	226 - 235	W	55,000	10	9
5	351 - 356	W	61,000	6	4
6	358 - 369 370 - 371	R R	127,000 136,000	12 2	11 1
7	601 - 608	W	99,000	8	4
8	103 - 105	R	200,000	3	3
9	236 - 237	R	200,000	2	2
10	357	R	400,000	1	1

Guild-Cribari Winery

Scenario A

Fixed Capital Costs ($)

Tank Group #	Tank #	Wine Type	Ducting	Carbon Adsorp.	Cat. Incineration
1	141 – 145	W	180,000	110,000	130,000
2	201 – 210	W	140,000	95,000	100,000
3	211 – 213 216 – 221	W W	210,000	90,000	110,000
4	226 – 235	W	140,000	90,000	100,000
5	351 – 356	W	90,000	70,000	90,000
6	358 – 369 370 – 371	R R	1,100,000	300,000	500,000
7	601 – 608	W	170,000	80,000	85,000
8	103 – 105	R	350,000	180,000	300,000
9	236 – 237	R	300,000	160,000	250,000
10	357	R	380,000	210,000	450,000
Total			3,000,000	1,385,000	2,115,000

Guild-Cribari Winery

Scenario B

Tank Group Arrangement

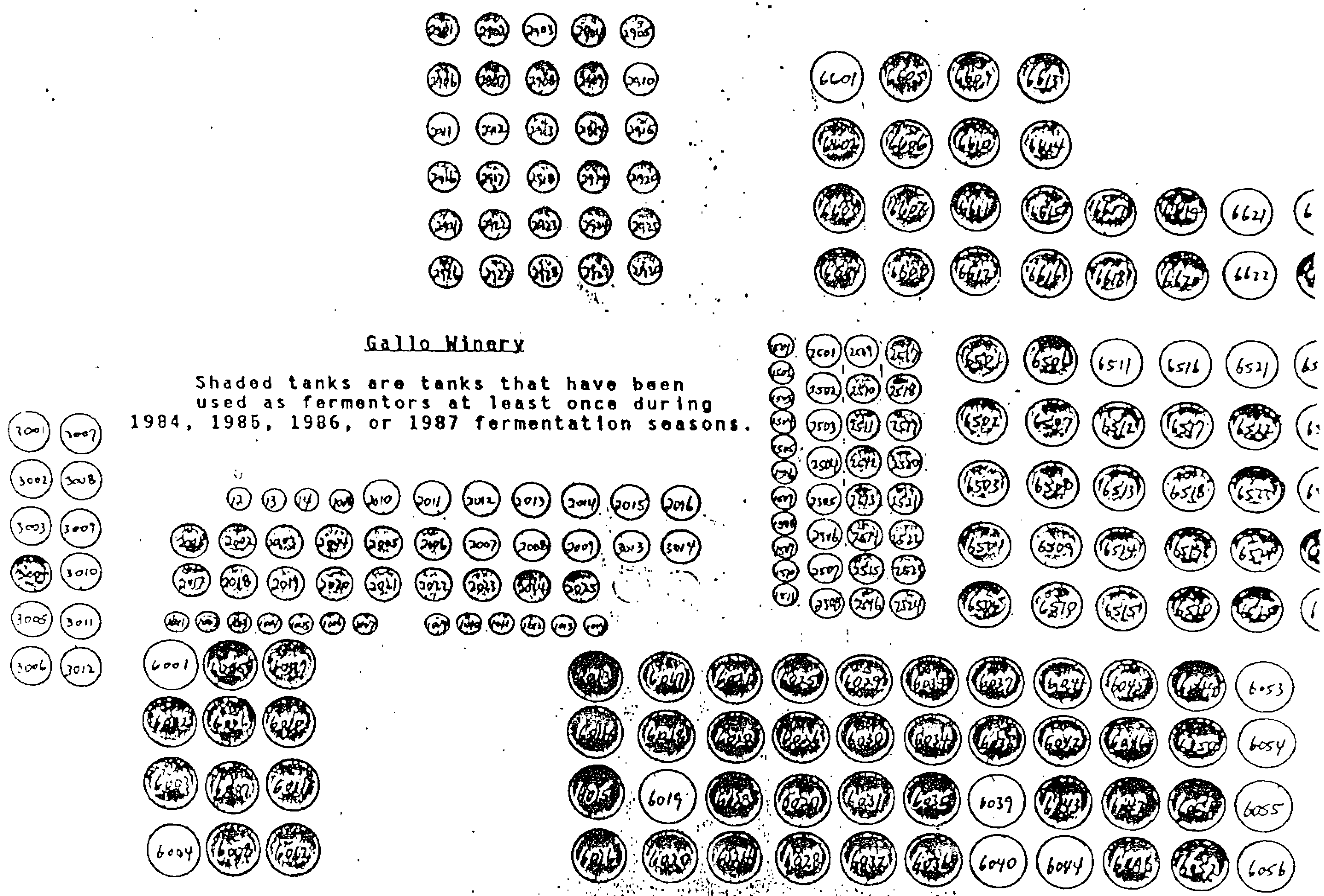
Tank Group #	Tank #	Wine Type	Size of Tanks In Tank Group, gal	Number of Tanks In Group	Number of Tanks at Max. Fermentation Rate
1	141 – 145	W	200,000	5	5
2	201 – 210	W	55,000	10	10
3	211 – 213	W	113,000	3	3
	215 – 221	W	62,000	7	7
4	226 – 235	W	55,000	10	10
5	351 – 356	W	61,000	6	6
6	358 – 369	R	127,000	12	12
	370 – 371	R	136,000	2	2
7	601 – 610	W	99,000	10	10
8	611 – 620	W	99,000	10	10
9	621 – 630	W	99,000	10	10
10	631 – 640	W	99,000	10	10
11	701	R	94,000	1	1
	702 – 704	R	52,000	3	3
12	103 – 105	R	200,000	3	3
13	236 – 237	R	200,000	2	2
14	357	R	400,000	1	1

Guild-Cribari Winery

Scenario B

Fixed Capital Costs ($)

Tank Group #	Tank #	Wine Type	Ducting	Carbon Adsorp.	Cat. Incineration
1	141 - 145	W	180,000	110,000	130,000
2	201 - 210	W	140,000	95,000	100,000
3	211 - 213 215 - 221	W W	210,000	100,000	120,000
4	228 - 235	W	140,000	95,000	105,000
5	351 - 356	W	90,000	80,000	95,000
6	358 - 369 370 - 371	R R	1,100,000	370,000	650,000
7	601 - 610	W	200,000	110,000	135,000
8	611 - 620	W	200,000	110,000	135,000
9	621 - 630	W	200,000	110,000	135,000
10	631 - 640	W	200,000	110,000	135,000
11	701 702 - 704	R R	400,000	225,000	300,000
12	103 - 105	R	330,000	180,000	300,000
13	236 - 237	R	300,000	165,000	250,000
14	357	R	380,000	200,000	450,000
Total			4,070,000	2,060,000	3,040,000



Gallo Winery

Shaded tanks are tanks that have been used as fermentors at least once during 1984, 1985, 1986, or 1987 fermentation seasons.

Gallo Winery

Scenario A

Tank Group Arrangement

Tank Group #	Tank #	Wine Type	Size of Tanks In Tank Group, gal	Number of Tanks In Group	Number of Tanks at Max. Fermentation Rate
1	1002 - 1007	R	100,000	6	4
2	2001 - 2025	R	200,000	15	7
3	2906 - 2920	R	200,000	15	10
4	2921 - 2930	R	200,000	10	10
5	6005 - 6012	R	600,000	8	5
6	6013 - 6024	W	600,000	12	7
7	6025 - 6034	W	600,000	10	7
8	6035 - 6044	W	600,000	10	7
9	2510 - 2524	R	200,000	14	7
10	6501 - 6505	R	600,000	5	5
11	6506 - 6510	R	600,000	5	5
12	6511 - 6515	R	600,000	5	5
13	6516 - 6520	R	600,000	5	5
14	6601 - 6610	W	600,000	10	7
15	6613 - 6622	W	600,000	10	7

Gallo Winery

Scenario A

Fixed Capital Costs ($)

Tank Group #	Tank #	Wine Type	Ducting	Carbon Adsorp.	Cat. Incineration
1	1002 - 1007	R	400,000	140,000	200,000
2	2001 - 2025	R	1,200,000	250,000	500,000
3	2906 - 2920	R	1,200,000	300,000	700,000
4	2921 - 2930	R	800,000	300,000	700,000
5	6005 - 6012	R	1,000,000	350,000	800,000
6	6013 - 6024	W	800,000	150,000	250,000
7	6025 - 6034	W	700,000	150,000	250,000
8	6035 - 6044	W	700,000	150,000	250,000
9	2510 - 2524	R	800,000	250,000	500,000
10	6501 - 6505	R	800,000	350,000	780,000
11	6506 - 6510	R	800,000	350,000	780,000
12	6511 - 6515	R	800,000	350,000	780,000
13	6516 - 6520	R	800,000	350,000	780,000
14	6601 - 6610	W	700,000	150,000	240,000
15	6613 - 6622	W	700,000	150,000	240,000
Total			12,200,000	3,740,000	7,750,000

Gallo Winery

Scenario B

Tank Group Arrangement

Tank Group #	Tank #	Wine Type	Size of Tanks In Tank Group, gal	Number of Tanks In Group	Number of Tanks at Max. Fermentation Rate
1	1001 - 1007	R	100,000	6	6
2	1009 - 1014	R	100,000	6	6
3	2001 - 2015	R	200,000	15	15
4	2016 - 2025	R	200,000	10	10
5	2501 - 2508	R	200,000	8	8
6	2509 - 2516	R	200,000	8	8
7	2517 - 2524	R	200,000	8	8
8	2901 - 2910	R	200,000	10	10
9	2911 - 2920	R	200,000	10	10
10	2921 - 2930	R	200,000	10	10
11	6001 - 6006	R	600,000	6	6
12	6007 - 6012	R	600,000	6	6
13	6013 - 6022	W	600,000	10	10
14	6023 - 6032	W	600,600	10	10
15	6033 - 6044	W	600,000	12	12
16	6045 - 6056	W	600,000	12	12
17	6501 - 6505	R	600,000	5	5
18	6506 - 6510	R	600,000	5	5
19	6511 - 6515	R	600,000	5	5
20	6516 - 6520	R	600,000	5	5
21	6521 - 6525	R	600,000	5	5
22	6526 - 6530	R	600,000	5	5
23	6601 - 6608	W	600,000	8	8
24	6609 - 6616	W	600,000	8	8
25	6616 - 6624	W	600,000	8	8

Gallo Winery

Scenario B

Fixed Capital Costs ($)

Tank Group #	Tank #	Wine Type	Ducting	Carbon Adsorp.	Cat. Incineration
1	1001 - 1007	R	400,000	165,000	260,000
2	1009 - 1014	R	400,000	165,000	260,000
3	2001 - 2015	R	1,200,000	450,000	1,300,000
4	2016 - 2025	R	800,000	300,000	700,000
5	2501 - 2508	R	670,000	265,000	550,000
6	2509 - 2516	R	670,000	265,000	550,000
7	2517 - 2524	R	670,000	265,000	550,000
8	2901 - 2910	R	800,000	300,000	700,000
9	2911 - 2920	R	800,000	300,000	700,000
10	2921 - 2930	R	800,000	300,000	700,000
11	6001 - 6006	R	870,000	370,000	900,000
12	6007 - 6012	R	870,000	370,000	900,000
13	6013 - 6022	W	700,000	160,000	320,000
14	6023 - 6032	W	700,000	160,000	320,000
15	6033 - 6044	W	800,000	180,000	360,000
16	6045 - 6056	W	800,000	180,000	360,000
17	6501 - 6505	R	800,000	350,000	780,000
18	6506 - 6510	R	800,000	350,000	780,000
19	6511 - 6515	R	800,000	350,000	780,000
20	6516 - 6520	R	800,000	350,000	780,000
21	6521 - 6525	R	800,000	350,000	780,000
22	6526 - 6530	R	800,000	350,000	780,000
23	6601 - 6608	W	520,000	155,000	230,000
24	6609 - 6616	W	520,000	155,000	230,000
25	6616 - 6624	W	520,000	155,000	230,000
Total			18,310,000	6,760,000	14,000,000

CC: A. CAPUTI-RES

L ID: RES TANK: ART 5100=60=0358 EXP. RUN #1

ACC 173 REQ 07Sep90 1120 DRAW 04Sep90 0000 C 8

[redacted]	[redacted]	MG/L	
ALC	11.75	VOL %	
ALD	40.	MG/L	
FO	281.	MG/L	
FSO2	5.	MG/L	
ISOA	149.	MG/L	
ISOB	23.	MG/L	
MEOH	47.	MG/L	
NBUT	UND	MG/L	UNDETECTABLE
NPRO	87.	MG/L	
PH	3.56		
RSLC	0.04	GM/100ML	
SECB	UND	MG/L	UNDETECTABLE
TA	0.64	G/100ML	
TSO2	65.	MG/L	
VA	0.023	G/100ML	

10-10-90 07:17 AM RESEARCH SUMMARY

L ID: RES TANK: AC 0000=00=0000

ACC 9798 REQ 09Oct90 1526 DRAW 09Oct90 0000 C 8 RUN #7

ACTA	226.	MG/L	
ALC	21.35	VOL %	
ALD	170.	MG/L	
FO	1558.	MG/L	
ISOA	1010.	MG/L	
ISOB	217.	MG/L	
MEOH	88.	MG/L	
NBUT	2.	MG/L	
NPRO	100.	MG/L	
SECB	2.	MG/L	
VA	0.019	G/100ML	

ACC 9799 REQ 09Oct90 1526 DRAW 09Oct90 0000 C 8 RUN #5

ACTA	114.	MG/L	
ALC	21.95	VOL %	
ALD	260.	MG/L	
FO	1082.	MG/L	
ISOA	631.	MG/L	
ISOB	193.	MG/L	
MEOH	119.	MG/L	
NBUT	2.	MG/L	
NPRO	140.	MG/L	
SECB	UND	MG/L	UNDETECTABLE
VA	0.009	G/100ML	

ACC 9800 REQ 09Oct90 1527 DRAW 09Oct90 0000 C 8 RUN #6

ACTA	169.	MG/L	
ALC	21.80	VOL %	
ALD	180.	MG/L	
FO	1298.	MG/L	
ISOA	793.	MG/L	
ISOB	217.	MG/L	
MEOH	109.	MG/L	
NBUT	2.	MG/L	
NPRO	114.	MG/L	
SECB	3.	MG/L	
VA	0.011	G/100ML	

ACC 9801 REQ 09Oct90 1527 DRAW 09Oct90 0000 C 8 [redacted]

[redacted]	[redacted]	MG/L	
ALC	7.10	VOL %	
ALD	105.	MG/L	
FO	259.	MG/L	
ISOA	143.	MG/L	
ISOB	22.	MG/L	
MEOH	22.	MG/L	
NBUT	UND	MG/L	UNDETECTABLE
NPRO	74.	MG/L	
SECB	UND	MG/L	UNDETECTABLE
VA	0.013	G/100ML	

10-10-90 07:17 AM

RESEARCH SUMMARY

CC: A CAPUTI-RES CC: A. CAPUTI-RES

L ID: RES TANK: AC 0000=00=0000

ACC 9795 REQ 09Oct90 1526 DRAW 09Oct90 0000 C 8 [redacted]

[redacted]	[redacted]	MG/L	
ALC	9.15	VOL %	
ALD	55.	MG/L	
FO	324.	MG/L	
ISOA	189.	MG/L	
ISOB	23.	MG/L	
MEOH	19.	MG/L	
NBUT	UND	MG/L	UNDETECTABLE
NPRO	89.	MG/L	
SECB	UND	MG/L	UNDETECTABLE
VA	0.006	G/100ML	

ACC 9796 REQ 09Oct90 1526 DRAW 09Oct90 0000 C 8 RUN #3

ACTA	84.	MG/L	
ALC	25.05	VOL %	
ALD	745.	MG/L	
FO	1212.	MG/L	
ISOA	632.	MG/L	
ISOB	152.	MG/L	
MEOH	230.	MG/L	
NBUT	5.	MG/L	
NPRO	338.	MG/L	
SECB	UND	MG/L	UNDETECTABLE
VA	0.010	G/100ML	

ACC 9797 REQ 09Oct90 1526 DRAW 09Oct90 0000 C 8 RUN #4

ACTA	87.	MG/L
ALC	24.60	VOL %
ALD	550.	MG/L
FO	1299.	MG/L
ISOA	671.	MG/L
ISOB	165.	MG/L
MEOH	199.	MG/L
NBUT	6.	MG/L
NPRO	369.	MG/L
SECB	2.	MG/L
VA	0.011	G/100ML

10-10-90 07:17 AM RESEARCH SUMMARY

CC: A. CAPUTI-RES CC: A. CAPUTI-RES

L ID: RES TANK: AC 0000=00=0000

ACC 9795 REQ 09Oct90 1526 DRAW 09Oct90 0000 C 8 RUN #2B

ACTA	23.	MG/L	
ALC	9.15	VOL %	
ALD	55.	MG/L	
FO	324.	MG/L	
ISOA	189.	MG/L	
ISOB	23.	MG/L	
MEOH	19.	MG/L	
NBUT	UND	MG/L	UNDETECTABLE
NPRO	89.	MG/L	
SECB	UND	MG/L	UNDETECTABLE
VA	0.006	G/100ML	

ACC 9796 REQ 09Oct90 1526 DRAW 09Oct90 0000 C 8 [redacted]

[redacted]	[redacted]	MG/L	
ALC	25.05	VOL %	
ALD	745.	MG/L	
FO	1212.	MG/L	
ISOA	632.	MG/L	
ISOB	152.	MG/L	
MEOH	230.	MG/L	
NBUT	5.	MG/L	
NPRO	338.	MG/L	
SECB	UND	MG/L	UNDETECTABLE
VA	0.010	G/100ML	

ACC 9797 REQ 09Oct90 1526 DRAW 09Oct90 0000 C 8 RUN #4

ACTA	87.	MG/L
ALC	24.60	VOL %
ALD	550.	MG/L
FO	1299.	MG/L
ISOA	671.	MG/L
ISOB	165.	MG/L
MEOH	199.	MG/L
NBUT	6.	MG/L
NPRO	369.	MG/L
SECB	2.	MG/L
VA	0.011	G/100ML

CC: A. CAPUTI-RES   CC: A. CAPUTI-RES

L ID: RES   TANK: AC   0000=00=0000

ACC 9795 REQ 09Oct90 1526 DRAW 09Oct90 0000 C 8   RUN #2B

ACTA	23.	MG/L	
ALC	9.15	VOL %	
ALD	55.	MG/L	
FO	324.	MG/L	
ISOA	189.	MG/L	
ISOB	23.	MG/L	
MEOH	19.	MG/L	
NBUT	UND	MG/L	UNDETECTABLE
NPRO	89.	MG/L	
SECB	UND	MG/L	UNDETECTABLE
VA	0.006	G/100ML	

ACC 9796 REQ 09Oct90 1526 DRAW 09Oct90 0000 C 8   RUN #3

ACTA	84.	MG/L	
ALC	25.05	VOL %	
ALD	745.	MG/L	
FO	1212.	MG/L	
ISOA	632.	MG/L	
ISOB	152.	MG/L	
MEOH	230.	MG/L	
NBUT	5.	MG/L	
NPRO	338.	MG/L	
SECB	UND	MG/L	UNDETECTABLE
VA	0.010	G/100ML	

ACC 9797 REQ 09Oct90 1526 DRAW 09Oct90 0000 C 8   [redacted]

[redacted]		MG/L
ALC	24.60	VOL %
ALD	550.	MG/L
FO	1299.	MG/L
ISOA	671.	MG/L
ISOB	165.	MG/L
MEOH	199.	MG/L
NBUT	6.	MG/L
NPRO	369.	MG/L
SECB	2.	MG/L
VA	0.011	G/100ML

10-10-90 07:17 AM

RESEARCH SUMMARY

L ID: RES TANK: AC 0000=00=0000

ACC 9798 REQ 09Oct90 1526 DRAW 09Oct90 0000 C B RUN #7

ACTA	226.	MG/L	
ALC	21.35	VOL %	
ALD	170.	MG/L	
FO	1558.	MG/L	
ISOA	1010.	MG/L	
ISOB	217.	MG/L	
MEOH	88.	MG/L	
NBUT	2.	MG/L	
NPRO	100.	MG/L	
SECB	2.	MG/L	
VA	0.019	G/100ML	

ACC 9799 REQ 09Oct90 1526 DRAW 09Oct90 0000 C B [redacted]

[redacted]		MG/L	
ALC	21.95	VOL %	
ALD	260.	MG/L	
FO	1082.	MG/L	
ISOA	631.	MG/L	
ISOB	193.	MG/L	
MEOH	119.	MG/L	
NBUT	2.	MG/L	
NPRO	140.	MG/L	
SECB	UND	MG/L	UNDETECTABLE
VA	0.009	G/100ML	

ACC 9800 REQ 09Oct90 1527 DRAW 09Oct90 0000 C B RUN #6

ACTA	169.	MG/L	
ALC	21.80	VOL %	
ALD	180.	MG/L	
FO	1298.	MG/L	
ISOA	793.	MG/L	
ISOB	217.	MG/L	
MEOH	109.	MG/L	
NBUT	2.	MG/L	
NPRO	114.	MG/L	
SECB	3.	MG/L	
VA	0.011	G/100ML	

ACC 9801 REQ 09Oct90 1527 DRAW 09Oct90 0000 C B RUN #2A

ACTA	20.	MG/L	
ALC	7.10	VOL %	
ALD	105.	MG/L	
FO	259.	MG/L	
ISOA	143.	MG/L	
ISOB	22.	MG/L	
MEOH	22.	MG/L	
NBUT	UND	MG/L	UNDETECTABLE
NPRO	74.	MG/L	
SECB	UND	MG/L	UNDETECTABLE
VA	0.013	G/100ML	

ID: RES TANK: AC 0000=00=0000

ACC 9798 REQ 09Oct90 1526 DRAW 09Oct90 0000 C 8 RUN #7

ACTA	226.	MG/L
ALC	21.35	VOL %
ALD	170.	MG/L
FO	1558.	MG/L
ISOA	1010.	MG/L
ISOB	217.	MG/L
MEOH	88.	MG/L
NBUT	2.	MG/L
NPRO	100.	MG/L
SECB	2.	MG/L
VA	0.019	G/100ML

ACC 9799 REQ 09Oct90 1526 DRAW 09Oct90 0000 C 8 RUN #5

ACTA	114.	MG/L	
ALC	21.95	VOL %	
ALD	260.	MG/L	
FO	1082.	MG/L	
ISOA	631.	MG/L	
ISOB	193.	MG/L	
MEOH	119.	MG/L	
NBUT	2.	MG/L	
NPRO	140.	MG/L	
SECB	UND	MG/L	UNDETECTABLE
VA	0.009	G/100ML	

ACC 9800 REQ 09Oct90 1527 DRAW 09Oct90 0000 C 8 [redacted]

[redacted]		MG/L
ALC	21.80	VOL %
ALD	180.	MG/L
FO	1298.	MG/L
ISOA	793.	MG/L
ISOB	217.	MG/L
MEOH	109.	MG/L
NBUT	2.	MG/L
NPRO	114.	MG/L
SECB	3.	MG/L
VA	0.011	G/100ML

ACC 9801 REQ 09Oct90 1527 DRAW 09Oct90 0000 C 8 RUN #2A

ACTA	20.	MG/L	
ALC	7.10	VOL %	
ALD	105.	MG/L	
FO	259.	MG/L	
ISOA	143.	MG/L	
ISOB	22.	MG/L	
MEOH	22.	MG/L	
NBUT	UND	MG/L	UNDETECTABLE
NPRO	74.	MG/L	
SECB	UND	MG/L	UNDETECTABLE
VA	0.013	G/100ML	

10-10-90 07:17 AM RESEARCH SUMMARY

L ID: RES TANK AC 0000=00=0000

ACC 9798 REQ 09Oct90 1526 DRAW 09Oct90 0000 C 8 [redacted]

[redacted]		MG/L
ALC	21.35	VOL %
ALD	170.	MG/L
FO	1558.	MG/L
ISOA	1010.	MG/L
ISOB	217.	MG/L
MEOH	88.	MG/L
NBUT	2.	MG/L
NPRO	100.	MG/L
SECB	2.	MG/L
VA	0.019	G/100ML

ACC 9799 REQ 09Oct90 1526 DRAW 09Oct90 0000 C 8 RUN #5

ACTA	114.	MG/L	
ALC	21.95	VOL %	
ALD	260.	MG/L	
FO	1082.	MG/L	
ISOA	631.	MG/L	
ISOB	193.	MG/L	
MEOH	119.	MG/L	
NBUT	2.	MG/L	
NPRO	140.	MG/L	
SECB	UND	MG/L	UNDETECTABLE
VA	0.009	G/100ML	

ACC 9800 REQ 09Oct90 1527 DRAW 09Oct90 0000 C 8 RUN #6

ACTA	169.	MG/L
ALC	21.80	VOL %
ALD	180.	MG/L
FO	1298.	MG/L
ISOA	793.	MG/L
ISOB	217.	MG/L
MEOH	109.	MG/L
NBUT	2.	MG/L
NPRO	114.	MG/L
SECB	3.	MG/L
VA	0.011	G/100ML

ACC 9801 REQ 09Oct90 1527 DRAW 09Oct90 0000 C 8 RUN #2A

ACTA	20.	MG/L	
ALC	7.10	VOL %	
ALD	105.	MG/L	
FO	259.	MG/L	
ISOA	143.	MG/L	
ISOB	22.	MG/L	
MEOH	22.	MG/L	
NBUT	UND	MG/L	UNDETECTABLE
NPRO	74.	MG/L	
SECB	UND	MG/L	UNDETECTABLE
VA	0.013	G/100ML	

10-03-90 07:12 AM RESEARCH SUMMARY

CC: A. CAPUTI-RES

L ID: RES TANK: ART 0000=00=0000 EXP. RUN #8

ACC 7645 REQ 02Oct90 0858 DRAW 28Sep90 0000 C 4 TK: 2930 CONDENSATE

ACTA	58.	MG/L	
ALC	12.35	VOL %	
ALD	105.	MG/L	
FO	638.	MG/L	
ISOA	388.	MG/L	
ISOB	47.	MG/L	
MEOH	16.	MG/L	
NBUT	UND.	MG/L	UNDETECTABLE
NPRO	145.	MG/L	
SECB	UND	MG/L	UNDETECTABLE
VA	0.020	G/100ML	

920.71★ Pentosans in Wines

Final Action
Surplus 1970

(Applicable to dry wines only)

See **11.044★**, 10th ed.

967.10 Aldehydes (Free) in Wines

Direct Method

First Action 1967
Final Action 1968

A. Reagents

See **972.08A**.

B. Determination

Pipet 50 mL sample, contg ≤30 mg acetaldehyde, into 500 mL distg flask and proceed as in **972.09A**, beginning ". . . add 50 mL *satd borax soln*, . . ."

Ref.: JAOAC **50**, 305(1967); **55**, 566(1972).

948.07 Caramel in Wines

Mathers Test

Final Action

A. Reagents

(**a**) *Pectin soln.*—Dissolve 1 g pectin in 75 mL H_2O, add 25 mL alcohol to preserve, and shake well before using.

(**b**) *2,4-DNPH soln.*—Dissolve 1 g 2,4-dinitrophenylhydrazine in 7.5 mL H_2SO_4 and dil. to 75 mL with alcohol. (If kept in g-s bottle, soln will remain clear and stable several months.)

B. Preliminary Test

Place 10 mL filtered sample in Babcock cream bottle, **920.111B**(a), or other centrf. tube. Add 1 mL pectin soln and mix; add 3–5 drops HCl and mix; fill bottle with alcohol (ca 50 mL), mix, centrf., and decant. Dissolve ppt in 10 mL H_2O, and add HCl and alcohol as above; shake well, centrf., and decant. Repeat operation until alc. liq. is colorless. Finally, dissolve gelatinous residue in 10 mL hot H_2O. If soln is colorless, caramel is absent; if soln is clear brown, caramel may be present. Confirm as follows: Add 1 mL 2,4-DNPH soln, mix, and heat 30 min in boiling H_2O. Ppt forms if caramel is present.

C. Confirmatory Test★
—Surplus 1965

See **11.047**, 10th ed.

Ref.: JAOAC **31**, 178(1948).

CAS-8028-89-5 (caramel)

960.20 Carbon Dioxide in Wines

Manometric Method

First Action 1960

A. Reagents

(a) *Sodium bicarbonate std solns.*—Dry 150–200 g $NaHCO_3$ over H_2SO_4 24 hr. Weigh designated amts of dried $NaHCO_3$, transfer to 1 L vol. flasks with ca 700 mL recently boiled H_2O, and add 15 mL NaOH soln, (c). Add 200 mL absolute alcohol, mix, cool, and dil. to vol. with boiled H_2O. Use 4.2955 g for 225 mg CO_2/100 mL std; 4.7727 g for 250; and 5.2500 g for 275.

(b) *Hydrogen peroxide soln.*—10%. Dil. 20 mL 30% H_2O_2 with 40 mL recently boiled H_2O.

(c) *Sodium hydroxide soln.*—50%. Transfer 763 g reagent grade NaOH pellets to 1 L Pyrex graduate, add recently boiled H_2O, cool, and dil. to 1 L. Mix until soln is complete and set aside ≥5 days until Na_2CO_3 settles, leaving clear soln.

B. Apparatus

(a) *Carbon dioxide apparatus.*—*See* Fig. **960.20**. Vol. of system is ca 350 mL. (Available from New York Laboratory Supply Co.) Test all glass joints with vac. tester.

(**b**) *Vacuum tester.*—High frequency self-contained generator operated from 115 v ac outlet. Consists of adjustable interrupter, vibrating spark gap, condenser, resonator coil, and gap tip.

(**c**) *Magnetic stirrer with Teflon stirring bar.*— Fisher Flexa-Mix, or equiv., with stirring bars 1–1$^{3}/_{16}$" long.

(**d**) *Vacuum pump.*—Sargent-Welch pump, No. 1399B, or equiv., with motor, single stage, vented exhaust; to be operated with vented exhaust valve open for pumping condensable vapors. Insert 3-way stopcock between pump and app. to allow air to enter system. Ordinary high vac. pump can be used if H_2SO_4 trap with 3-way stopcock is inserted between pump and app. Change acid frequently.

(**e**) *Silicone grease, high vacuum type.*—Stable to heat and contains no carbon-to-carbon linkages. Grease may be removed from glassware with Varsol or hot kerosene.

C. Calibration of Vacuum System

(*Caution:* See safety notes on vacuum.)

Pipet 50 mL std $NaHCO_3$ soln and 3 mL 10% H_2O_2 soln into reaction flask, and carefully grease joints. Start mag. stirrer and evacuate system ca 1 min. Close system to pump at 3-way stopcock, gently tap Hg columns, and read manometer to nearest 0.5 mm to obtain initial reading. Hg levels should remain const; changes indicate leak, probably caused by insufficient grease at joints.

Add 10 mL H_3PO_4 and continue rapid stirring 5 min. Gently tap Hg columns and read total pressure in cm Hg to nearest 0.5 mm to obtain final reading. Record gas temp. in °C.

Open 3-way stopcock on app. to pump. Then slowly open 3-way stopcock between pump and app. to let air flow into system. Disconnect app. and thoroly wash inner portion of acid dispensing unit and reaction flask. Rinse with acetone and dry with suction.

Det. total pressure from each $NaHCO_3$ std soln in triplicate and calc. av. vol. of system as follows:

From final pressure reading in cm Hg, subtract initial reading and vapor pressure increase due to H_3PO_4 effect as given in table:

% Alcohol	Vapor Pressure, cm, Increase Due to H_3PO_4
0	0.67
5	0.68
10	0.69
15	0.75
20	0.77
25	0.77
50	1.00
75	1.53
100	2.80

Then $V = 76RTg/MP$, where V is system vol. in L; R is gas const in L-atm./degree/mole, 0.08205; T is absolute temp., 273 + room temp. in °C; g is g CO_2 in 50 mL sample; M is MW of CO_2 in g; and P is corrected pressure of CO_2 in cm Hg.

sample contains >20 g ester/100 L, dil. with H_2O to ester concn of 5–20 g/100 L.

E. Determination

(Mix all solns by swirling to avoid formation of bubbles.)

Just before use, prep. stock soln of reaction mixt. by combining 5.0 mL $H_2NOH.HCl$ and 5.0 mL 3.5*N* NaOH for each std and sample soln. Discard after 6 hr.

Prep. ref. soln by pipetting 4 mL reaction mixt. and 2 mL 4*N* HCl into 25 × 200 mm test tube. Mix and add 2.0 mL sample. Same ref. soln may be used for series of samples of different ester content, but they must have same proof.

Pipet 2 mL sample and 4 mL reaction mixt. into another 25 × 200 mm test tube. Mix and let react 1–20 min. Pipet in 2 mL 4*N* HCl and mix.

To ref. soln, pipet in 2 mL $FeCl_3$ soln. Rinse ref. cell twice with this soln, fill cell, and place in cell holder. This ref. soln may be used for 1 day if tightly capped; otherwise refill periodically to avoid evapn error.

To sample soln, pipet in 2 mL $FeCl_3$ soln and mix. Complete reading of each sample before proceeding to next. Rinse sample cell twice, fill cell, and place in cell holder. Read *A* at 525 nm immediately, since color of sample fades rapidly. If instrument has single cell or tube, use same cell or tube for both ref. and sample. Calc. or obtain $\Delta A = A_{sample} - A_{ref}$.

F. Preparation of Standard Curve

Analyze std solns, **972.07C(b)**, as in **972.07E**. Plot ΔA against EtOAc concn (g/100 L at 100° proof). (*Note:* Std curve need not be repeated for each analysis. Check periodically and repeat if new instrument or reagents are used.)

G. Preparation of Proof Factor Curve

Analyze std solns, **972.07C(c)**, as in **972.07E**. Plot ΔA/g EtOAc against proof in the 15 solns (0–192° proof). *See Note,* **972.07F**.

To calc. ester content of samples, read *A*/g value from proof factor curve at sample proof. If sample was dild, use dild proof in calcn. Divide observed *A* by *A*/g to obtain g EtOAc/100 L. Correct for sample diln, if necessary. To express as g/100 L at 100° proof, multiply above ester value by ratio: 100/sample proof.

Ref.: JAOAC **55**, 559(1972).

972.08 Aldehydes in Distilled Liquors

Titrimetric Method

First Action 1972

Final Action 1973

Method I

(Applicable to ext-free spirits—brandy and wine spirits)

A. Reagents

(a) *Potassium metabisulfite soln.*—Dissolve 15 g $K_2S_2O_5$ in H_2O, add 70 mL HCl, and dil. to 1 L with H_2O. Bisulfite titer of 10 mL soln should be ≥24 mL 0.1*N* I soln.

(b) *Phosphate-EDTA soln.*—Dissolve 200 g $Na_3PO_4.12H_2O$ (or 188 g $Na_2HPO_4.12H_2O$ + 21 g NaOH; or 72.6 g $NaH_2PO_4.H_2O$ + 42 g NaOH; or 71.7 g KH_2PO_4 + 42 g NaOH) and 4.5 g Na_2H_2EDTA in H_2O and dil. to 1 L.

(c) *Dilute hydrochloric acid.*—Dil. 250 mL HCl to 1 L with H_2O.

(d) *Sodium borate soln.*—Mix 100 g H_3BO_3 with 170 g NaOH and dil. to 1 L with H_2O.

B. Total Aldehydes

Pipet 50 mL sample (contg ≤30 mg acetaldehyde), reduced to ca 100° proof, or 25 mL high proof sample and 25 mL H_2O, into 750 mL or 1 L erlenmeyer contg 300 mL boiled or deaerated H_2O and 10 mL $K_2S_2O_5$ soln. Stopper flask, swirl to mix, and let stand 15 min. Add 10 mL phosphate-EDTA soln. (pH should be 7.0–7.2. If not, adjust pH by adding HCl or NaOH soln to $K_2S_2O_5$ soln and start with new sample.) Stopper flask, swirl, and let stand addnl 15 min. Add 10 mL HCl, (c) (when analyzing series, make complete detn on first sample before adding acid to next), and ca 10 mL fresh *0.2% starch indicator.* Swirl to mix. Add enough ca 0.1*N* I soln to just destroy excess bisulfite and bring soln to light blue end point.

Add 10 mL Na borate soln, and rapidly titr. liberated bisulfite with 0.05*N* I soln from 10 mL buret (or 0.02*N* I soln from 25 mL buret) to same light blue end point as above, swirling gently and continuously, avoiding direct sunlight. (pH should be 8.8–9.5. If necessary, adjust by adding HCl or NaOH soln to Na borate soln and start with fresh sample.)

$$\text{mg } CH_3CHO/100 \text{ mL} = \text{mL I soln} \times \text{normality I soln} \times 22.0 \times 100/\text{mL sample}$$

C. Free Aldehydes

Pipet identical sample as in **972.08B** into 750 mL or 1 L erlenmeyer contg 300 mL boiled or deaerated H_2O and 10 mL each $K_2S_2O_5$ and phosphate-EDTA solns. Stopper flask, swirl, and let stand 15 min. Proceed as in **972.08B**, beginning "Add 10 mL HCl, (c) . . ."

Ref.: JAOAC **50**, 305(1967).

972.09 Aldehydes in Distilled Liquors

Titrimetric Method

First Action 1972

Final Action 1973

Method II

(Applicable to spirits contg ext—aged in wood)

A. Free Aldehydes

Pipet 50 mL sample (contg ≤30 mg acetaldehyde), reduced to 80–100° proof, if necessary, into 500 mL distg flask, add 50 mL *satd borax soln*, and distil ca 50 mL into 750 mL or 1 L erlenmeyer contg 300 mL H_2O and 10 mL each $K_2S_2O_5$ and phosphate-EDTA solns. (pH should be 7.0–7.2. If necessary, adjust by adding HCl or NaOH soln to $K_2S_2O_5$ soln and start with fresh sample.) Proceed as in **972.08B**, beginning "Add 10 mL HCl, (c) . . ."

B. Aldehydes as Acetal

Transfer 200 mL sample measured at std temp. in vol. flask to 500 mL distg flask, and rinse vol. flask 2–3 times with small amts H_2O into distg flask. Add 50 mL *satd borax soln* and distil, slowly at first, nearly 200 mL into same vol. flask contg 2–3 mL H_2O and immersed in ice bath. Bring distillate to vol. at same temp. used for measuring sample.

Det. total aldehydes (including acetal) as in **972.08B**. Det. free aldehydes as in **977.08C**. Total aldehydes − free aldehydes = combined aldehydes equiv. to acetal as mg CH_3CHO/100 mL. Alternatively, combined aldehydes as acetal/100 mL = (combined aldehydes equiv. to acetal as mg CH_3CHO/100 mL) × 2.68.

DEPARTMENT OF THE TREASURY
BUREAU OF ALCOHOL, TOBACCO AND FIREARMS
1401 Research Boulevard
Rockville, Maryland 20850

JUL 17 1989

Masao Ueda
Chemist
E. & J. Gallo Winery
Modesto, California 95353

Dear Mr. Ueda:

Under Alcohol, Tobacco, and Firearms Procedure 86-2, chemists and laboratories analyzing wines for export must be certified as being qualified to perform these examinations. You have met the requirements for this certification and are certified for two years. This certification will expire on July 17, 1991.

Sincerely yours,

C. Michael Hoffman

C. Michael Hoffman
Director, Laboratory Services

Brief description of the gas detector pump:

The gas detector pump is a hand-operated bellows pump (Fig. 2). This pump supplies 100 cm^3 with each stroke. Thus, not only does the gas detector pump suck in the gas sample, but it also simultaneously carries out a volume measurement with each stroke. Its mode of operation is, therefore, that of a dosage pump.

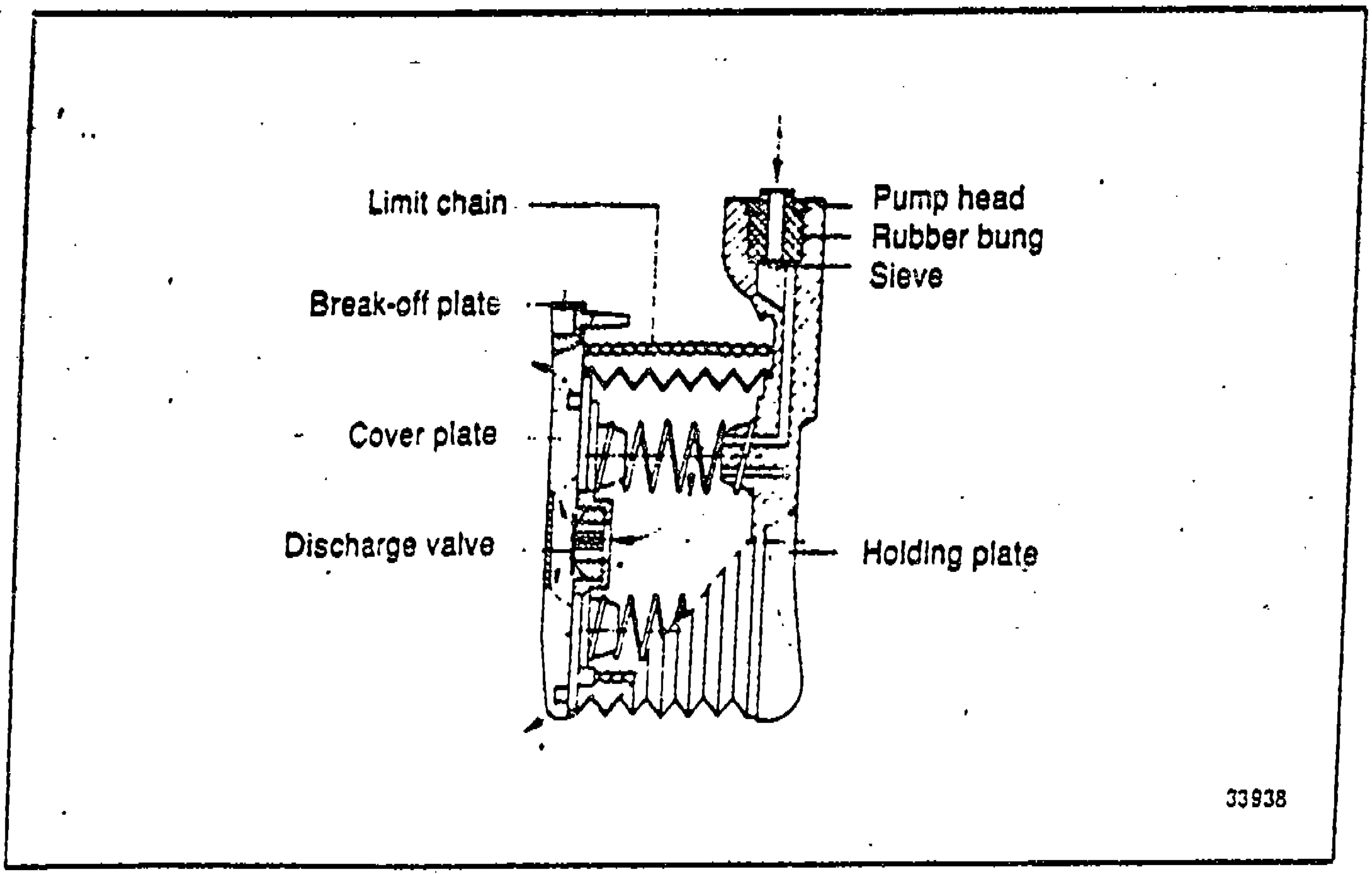


Fig. 2 Cross-section through the gas detector pump

1. Drãger Tube 0.5/a analysis for Hydrogen Sulfide:

a. Standard range of measurement (20° C, 1013 mbar): 0.5 to 15 ppm hydrogen sulphide.

b. Number of strokes of the Drãger gas detector pump: n=10.

c. Relative standard deviation: 10 to 5%.

d. Description: Scale tube - white indicating layer, reagent: mercury complex - color change to pale brown.

e. Reaction principle: H_2S + Hg complex → Pale brown sulphide

f. Cross-sensitivity: As yet, no interference by other gases and vapors has been observed, but investigations are still in progress.

2. Dräger Tube 1/c analysis for Hydrogen Sulfide:

a. Standard range of measurement (20° C, 1013 mbar): 1 to 20 ppm hydrogen sulphide, 10 to 200 ppm hydrogen sulphide.

b. Number of strokes of the Dräger gas detector pump: n=10, n = 1.

c. Relative standard deviation: 10 to 5%.

d. Description: Scale tube - white indicating layer, reagent: lead compound - color change to pale brown.

e. Reaction principle: H_2S + Pb^{2+} (lead compound) → PbS (Pale brown lead sulphide) + 2H.

f. Cross-sensitivity: SO_2 concentrations of up to 20 ppm have no influence on the H_2S indication; in the presence of higher SO_2 concentrations, the H_2S indication is somewhat too high (e.g. a mixture of 5 ppm H_2S and 40 ppm SO_2 gives an indication of about 8 ppm H_2S; a mixture of 10 ppm H_2S and 100 ppm SO_2 gives an indication of about 15 ppm H_2S. SO_2 alone does not discolor the indicating layer.

g. Extension of the range of measurement: The number of strokes can be increased directly to n = 100, whereby the range of measurement is 0.1 to 2 ppm H_2S. Concentrations below 0.1 ppm H_2S can also be determined, if the number of strokes is increased above n = 100. Up to 500 strokes are possible, but it must be ensured that the indicating layer does not dry out during the test, since this would lead to diffuse discolorations which are difficult to evaluate (drying out can be prevented, for example, by connecting a small gas wash bottle containing 5% sulphuric acid in front of the H_2S detector tube during measurement).

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 = 0.42 lb H_2S

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 = 0.33 lb H_2S

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 = 0.51 lb H_2S

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1. Factors Used in the Following Calculations:
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) ÷ 2 = 2.6 ppm
(2.6 ppm ÷ 10^6) x (66,000 x 16) = 2.75 ft^3
2.75 ft^3 ÷ 11.23 ft^3/lb = <u>0.24 lb H_2S</u>

<u>Average pounds H_2S - red wines</u> = 0.25 lb
<u>Average pounds H_2S - white wines</u> = 0.24 lb

<u>Pounds H_2S/ Total Gallons - red</u> = (0.25 lb ÷ average total gallons red wine) x total gallons wine produced = **21.1 lb**

<u>Pounds H_2S/ Total Gallons - white</u> = (0.24 lb ÷ average total gallons white wine) x total gallons wine produced = **36.3 lb**

<u>Total pounds H_2S - 1990 Fermentation</u> = **57.4 lb**

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							

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			

.00	.00	.00	.00	.00	9.20	9.20	9.20	9.20	9.20	9.20	9.20
303.89	309.54	305.78	.00	.00	.00	.00	.00	.00	.00	.00	.00
.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
.00	.00	.00	.00	.00	296.04	295.15	285.29	266.76	240.13	265.34	289.00

1012 00 .999884 6533634201490 4.65

3 × 1.82 × 210 = 1146.60 white