Background Report Reference

AP-42 Section Number: 9.12.2

Background Chapter: 4

Reference Number: 10

Title: "Ethanol Emissions Control from Wine Fermentation Tanks Using Charcoal Adsorption"

J.A. Heredia

California Air Resources Board

October 1992

AP-42 Section 9.12.2
Reference
Report Sect. 4
Reference 10

October 16, 1992

Mr. David Todd, Testing Section
Engineering Evaluation Branch
Air Resources Board
Post Office Box 2815
Sacramento, California 95812

RE: Submittal of Report on Ethanol Emission Control from Wine Fermentation Tanks

Dear David:

Attached are two copies of the final Report on Ethanol Emission Control from Wine Fermentation Tanks Using Charcoal Adsorption 1990 Demonstration Study. Please sign the bound copy and return to me. This is the copy that I will be giving to Dr. Cota. I did not bind your copy as I thought you may want to make additional copies. It has been a pleasure working with you on this project. I hope that we will stay in contact in the future.

Sincerely,

Joan A. Heredia

encl.

ETHANOL EMISSIONS CONTROL
FROM WINE FERMENTATION TANKS
USING CHARCOAL ADSORPTION
1990 DEMONSTRATION STUDY

Submitted to:

Harold Cota, PhD., P.E.

Civil and Environmental Engineering Department

Submitted by:

Joan A. Heredia
California Polytechnic State University
San Luis Obispo

October 14, 1992

State of California
AIR RESOURCES BOARD

ETHANOL EMISSIONS CONTROL FROM WINE FERMENTATION TANKS USING CHARCOAL ADSORPTION 1990 DEMONSTRATION STUDY

Test Report

Engineering Evaluation Branch
Monitoring and Laboratory Division

Project Number: C90-086

Report Date: October 14, 1992

by
Joan A. Heredia
California Polytechnic State University
San Luis Obispo

APPROVED

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Testing Section

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ABSTRACT

Carbon adsorption control efficiency of ethanol emissions during wine fermentation was measured at the Gallo Winery, Fresno, California. Ethanol and carbon dioxide vapors from a 207,000 gallon commercial fermentation tank were collected using a 1120 cfm vapor collection system. The vapors were routed to one of two carbon beds arranged in parallel, each containing 640 pounds of carbon. The carbon was regenerated onsite using steam desorption. Hydrocarbon concentrations were continuously measured at the inlet and the outlet to the carbon canisters using a flame ionization detector. Data was collected for two red wines and one white wine. The control efficiency was greater than 90 percent for all three fermentations.

ACKNOWLEDGEMENTS

The project engineer was David Todd of the ARB. Assistance was provided by students from California State University Fresno, Department of Enology. Figures and operational information were provided by Akton Associates and Gallo Winery. Additional assistance was provided by Dr. Cota, California Polytechnic State University, San Luis Obispo and Peter Ouchida, ARB.

SECTION 1 INTRODUCTION

The mission of the California Air Resources Board (ARB) is to define the health threat of air pollution and, in conjunction with county and regional air pollution control agencies, regulate its causes where necessary to achieve or maintain air which does not cause harmful effects. In California, the ARB:

- Sets air quality standards;
- Monitors air quality;
- Provides technical expertise to help county and regional air pollution control officials set emission limits for industrial sources of air pollution; and
- Operates one of largest air pollution research programs in the world.

Ambient air quality standards for ozone are frequently violated throughout the State. Ethanol is a reactive organic compound which combines with nitrogen oxides in the presence of sunlight to form ozone. Emissions from wine fermentation tanks contribute to ozone formation by the release of ethanol vapor through vents in the tank roof.[1]

A Suggested Control Measure (SCM) for control of ethanol emissions from winery fermentation tanks has been considered by the ARB. The Board deferred action on the SCM pending outcome of a demonstration program to further evaluate the methods to reduce emissions from winery fermentation tanks.

The first phase of the demonstration program was conducted during the 1987 fermentation season. An Ad Hoc Committee was formed composed of ARB technical staff and wine industry representatives. The Wine Institute and Winegrowers of California jointly funded a pilot project utilizing the Viticulture and Enology Research Center at California State University, Fresno (CSUF). The pilot study objective was to determine the potential ethanol from wine fermentation tanks equipped with emission control devices. Four separate wine fermentations were performed at CSUF, two white and two red. The equipment configuration for each fermentation consisted of using four nearly identical 1400 gallon general wine fermentation tanks. One tank had no emissions control and the other three tanks were equipped with control devices to reduce the ethanol content of fermentation exhaust gases. Water scrubbing, carbon adsorption and catalytic oxidation were evaluated to determine the ethanol removal efficiency.

The study concluded that each of the control methods was capable of providing at least 90% efficiency in the control of ethanol emissions.[2]

However, the Ad Hoc Committee also determined that:

1. Water scrubbing was not feasible because most wineries could not dispose of the ethanol laden waters.

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

3. Carbon Adsorption involved some operational problems.

It was recommended that further tests be carried out during the 1988 season.[3] These tests utilized carbon adsorption exclusively as the control device, as it appeared to be the most feasible method of control. The committee felt that another year of testing and equipment modification could resolve the operational problems documented in the 1987 evaluation of the carbon adsorption study.

The data obtained in 1988 indicated that better operation of the system was achieved. Based on observations and data collected during 1987 and 1988, it was 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 project was conceived and the results of the hydrocarbon monitoring from this study are documented in this report. A portion of 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 207,000 gallon commercial tank. The demonstration project consisted of five red and three white fermentations. Information on all of the eight fermentations involved in the 1990 demonstration project is contained in "1990 Demonstration Program Ethanol Emissions Control from Wine Fermentation Utilizing Carbon Adsorption Technology", by Akton Associates.[4]

The last three fermentations, two reds and a white, were evaluated to determine the control efficiency of ethanol emissions using carbon adsorption. The ARB measured control device inlet and outlet ethanol concentrations to determine the efficiency. The results of the ARB ethanol measurements are documented and discussed in this report. This report contains information on the control device and other equipment that was used, description of the sampling methods used and the test results.

SECTION 2 THEORY

WINE FERMENTATION

Fermentation is the process that makes wine from the juices of fruits such as grapes. Fermentation is the anaerobic (without free oxygen) breakdown of organic compounds by the action of microorganisms or their extracts, to products simpler than the starting substrate. With wine, this breakdown is caused by yeast. The yeast provides complicated enzymes that create alcohol, carbon dioxide gas, glycerin and other products from the sugar in the juice.

The concentration of alcohol in wine is based upon sugar content, extent of fermentation, and losses or additions of alcohol. Wine grapes generally contain 15-25 percent sugar. One percent sugar yields about 0.55 percent alcohol. In general, the theoretical chemical reaction for converting sugar to alcohol is:

$$C_6H_{12}O_6 = 2\ C_2H_5OH + 2\ CO_2$$

According to the above equation, sugar ($C_6H_{12}O_6$) should yield 51.1 percent alcohol by weight. Based on experimental data, sugar only yields about 47 percent retained alcohol by weight of the sugar fermented (glucose).[5] The reduced yield is attributed to the formation of other products such as glycerin, hydrogen sulfide, methyl and ethyl mercaptans and lost alcohol.

The fermentation is initiated by adding yeast inoculation to the grape juice. The juice is recirculated or "pumped over" every six hours to promote uniform fermentation. The fermentation chemical reaction releases heat and the temperature is controlled by circulating chilled water through the tank jacket. If the temperature is not kept under control, the rate of fermentation can escalate to the point where a foamover can occur.

During the fermentation, alcohol is lost with escaping carbon dioxide (CO_2). The losses can range from less than 0.1 percent to over 10 percent. This alcohol loss is affected by alcohol concentration within the wine, agitation of the fermenting liquid, the presence of a pomace cap, fermentation temperature and the rate at which carbon dioxide is produced.

CARBON ADSORPTION

Carbon adsorption is a physical separation process in which organic or inorganic materials are removed from an air stream by sorption or attraction and accumulation of materials onto the surface of the carbon. Activated carbon is considered to be a non-polar sorbent and tends to sorb the least polar and least soluble organic compounds; it will sorb most organic compounds.[6] Prior to entering the carbon bed, the gas stream is typically cooled and heated to make it as dry as practical.

Much of the surface area available to sorption by carbon is found in the pore space within the carbon particles created during the activated process. As activated carbon adsorbs organics from the process stream, the carbon pores eventually becomes saturated and break through occurs. The exhausted saturated carbon must be regenerated for use or replaced with fresh carbon. The adsorption capacity of the carbon can be restored by chemical or thermal regeneration.

Thermal regeneration is most commonly used and involves heating the carbon at 820 to 980 degrees Celsius in the presence of steam. The organics are liberated by the steam and removed. The steam and organics are then condensed and may be further treated or disposed of. During the regeneration process, some elemental carbon is lost to the process but this is usually limited to 10 % by weight. Eventually regenerated carbon will breakdown and need to be replaced by fresh carbon.

Multi-stage carbon beds allow continuous treatment of organics in exhaust gases during regeneration. Two carbon beds may be placed in parallel, with the flow passing through one carbon bed at a time. Eventually the carbon bed cannot adsorb any more ethanol and breakthrough occurs. At that time, the gases are routed to a standby bed. The used bed is purged with steam to desorb the ethanol and carry it out of the bed. Outside the bed, the steam and ethanol are allowed to cool and condense. The water and ethanol are then either treated or disposed, and the carbon bed is put on standby until the other carbon bed begins to show signs of breakthrough.

SECTION 3 EQUIPMENT AND MATERIALS

FERMENTATION AND VAPOR COLLECTION EQUIPMENT

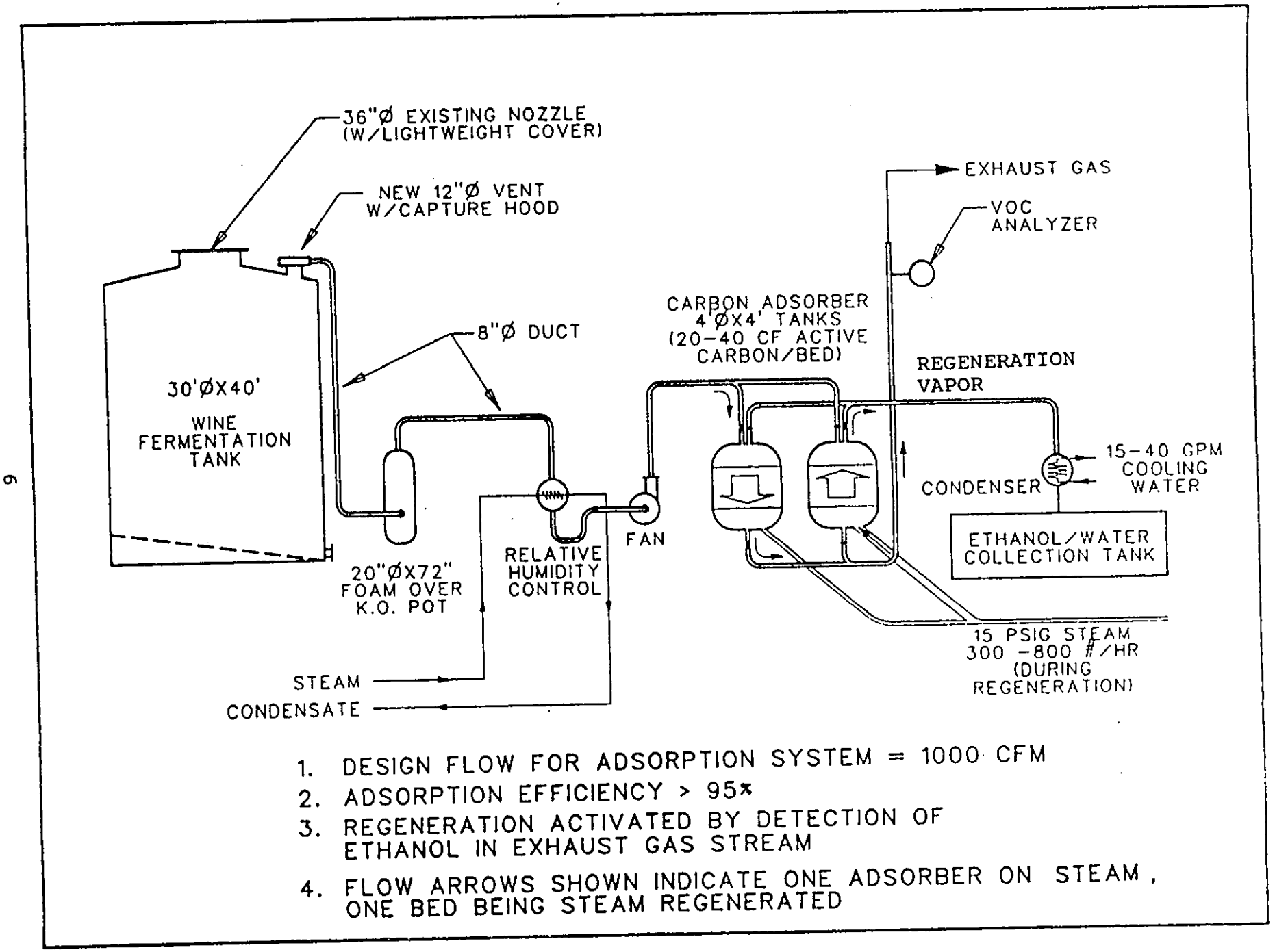
A schematic flow diagram illustrating the basics of the demonstration system is shown in Figure 1. An uninsulated 207,000 gallon nominal capacity, stainless steel fermentation tank was modified by the addition of a 12-inch vent nozzle, vapor collection hood and ducting system. The vapor collection system captured and transferred vapors emitted during the fermentation process. Vapors were routed through a 20 inch diameter by 72 inch Foam-over pot to disengage any liquids or foams that might be entrained in the vapor. Ethanol was removed from the vapors using a carbon adsorption system.

The hood was designed to allow dilution air to be drawn into the system to maintain a constant flow rate to the adsorption system and to prevent imposing pressure or vacuum on the tank. The design for this was based on previously published preliminary designs by ARB and designs developed during pilot testing at CSUF.[7] The final design of the hood is detailed in Figures 2. Figures 3 and 4 shown the hood, as installed. 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 pump-over or recycle piping which is 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 to rearrange the recycle hoses.

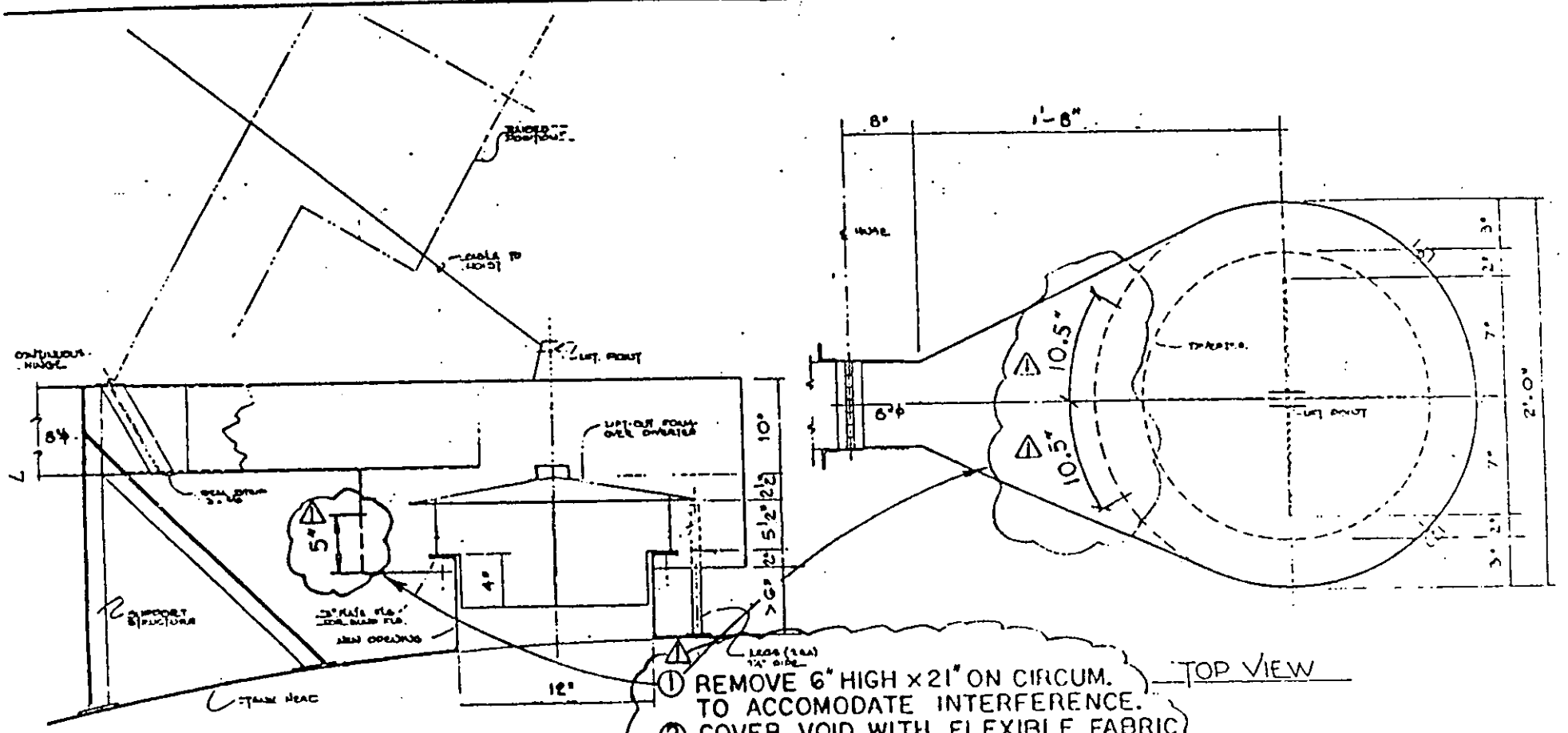
Figure 6 is the general plot plan of the tank, carbon adsorption system, boiler, condensate accumulation tank and other major items of equipment used in the program.

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



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 STEAM, ONE BED BEING STEAM REGENERATED

FIGURE 1 - SCHEMATIC FLOW DIAGRAM



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

FREDERIKSEN
ENGINEERING CO. INC.
OAKLAND CALIFORNIA

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

J-1748

FIGURE 2 - VAPOR COLLECTION HOOD DESIGN DIAGRAM

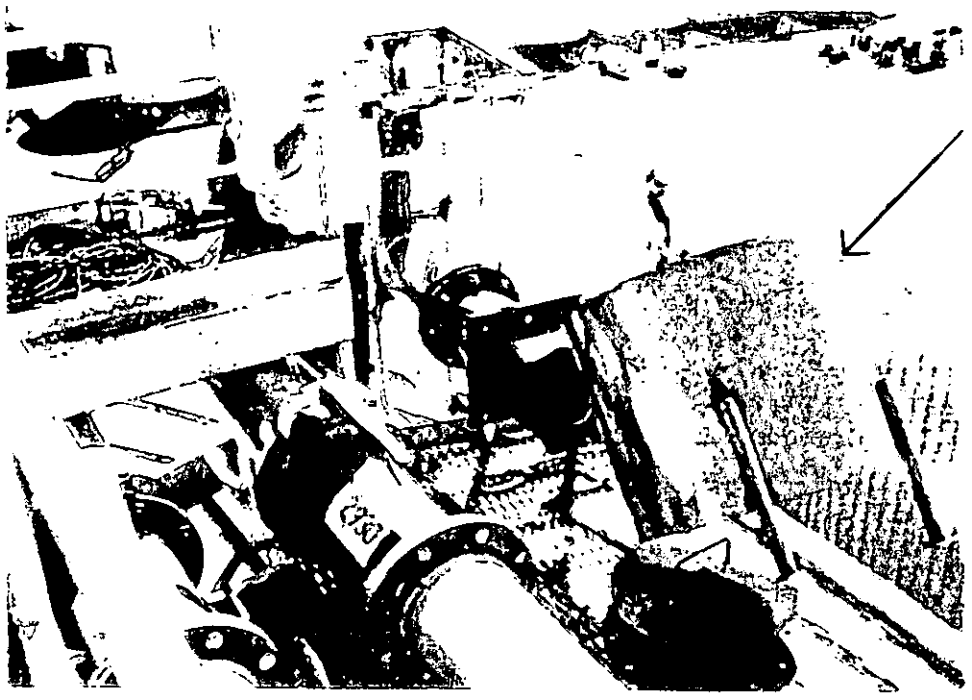


FIGURE 3 FERMENTATION COLLECTION HOOD IN UP POSITION;
NOTE - LIFTING DEVICE

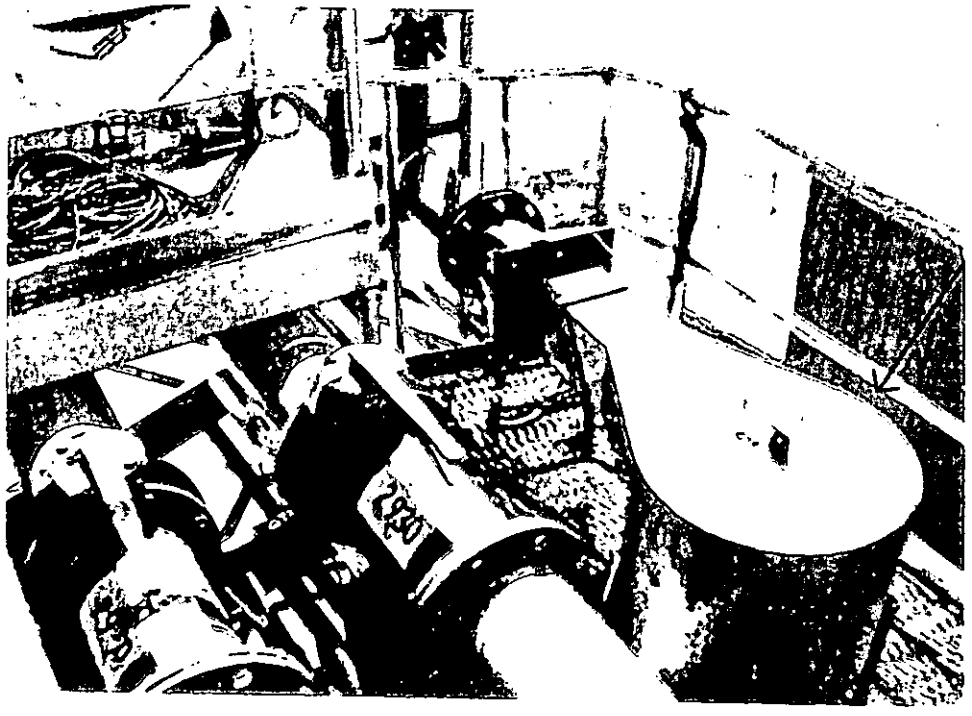


FIGURE 4 FERMENTATION COLLECTION HOOD IN DOWN POSITION;
NOTE - DEFLECTOR CAP IN TANK VENT NOZZLE

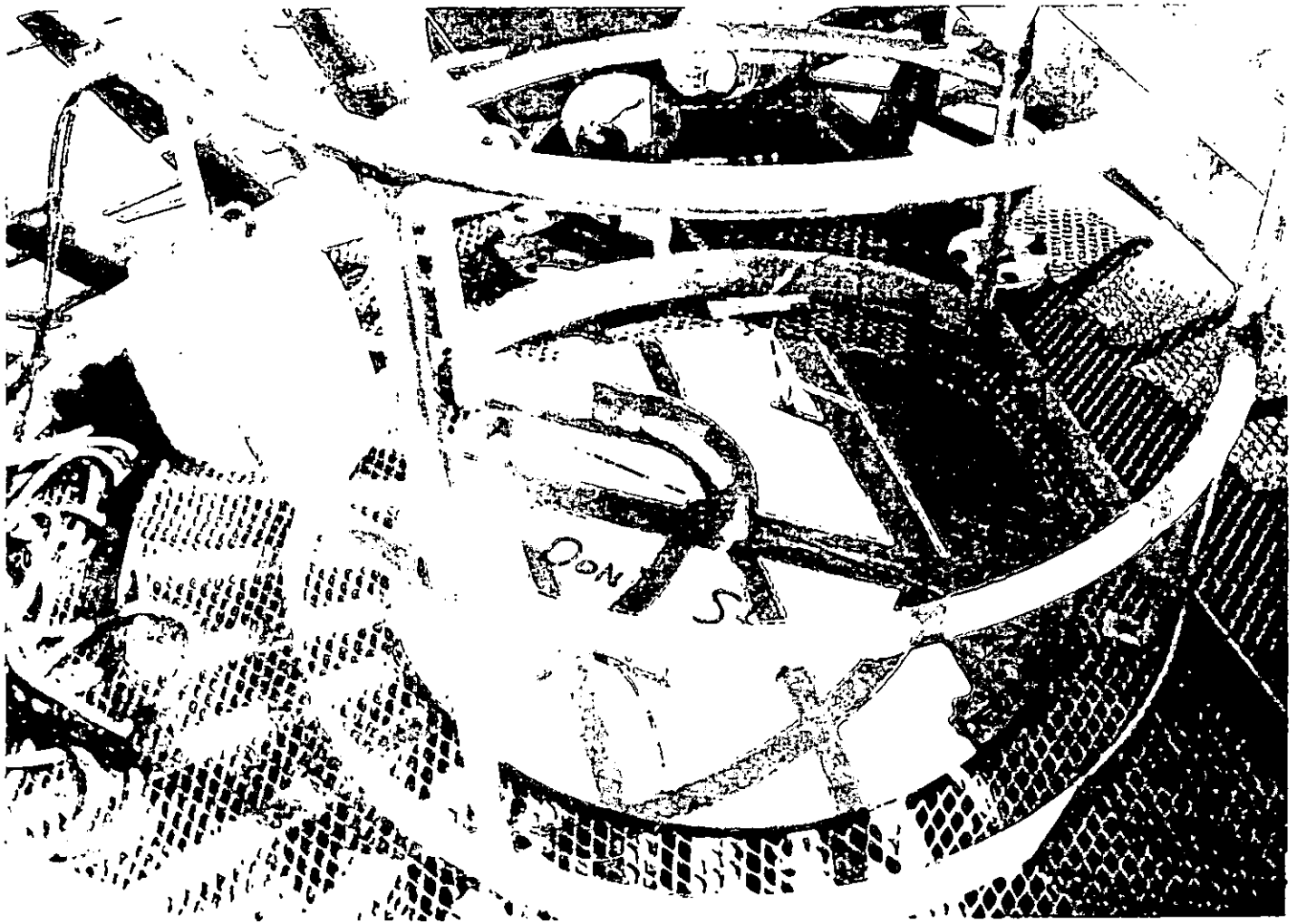


FIGURE 5. LIGHT WEIGHT MANHOLE COVER WITH PUMPOVER PIPING.

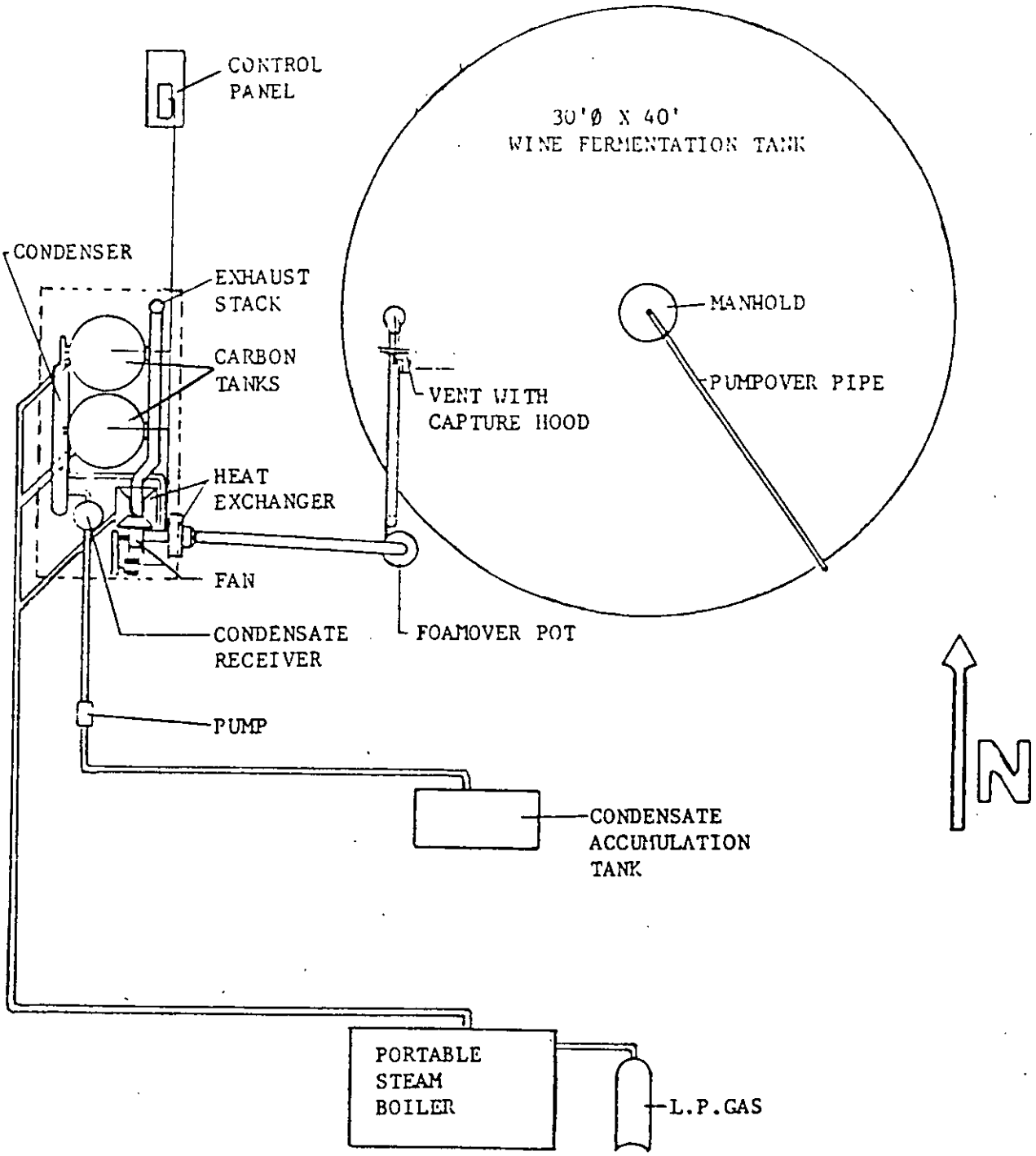


FIGURE 6. GENERAL PLOT PLAN, 1990 DEMONSTRATION PROGRAM

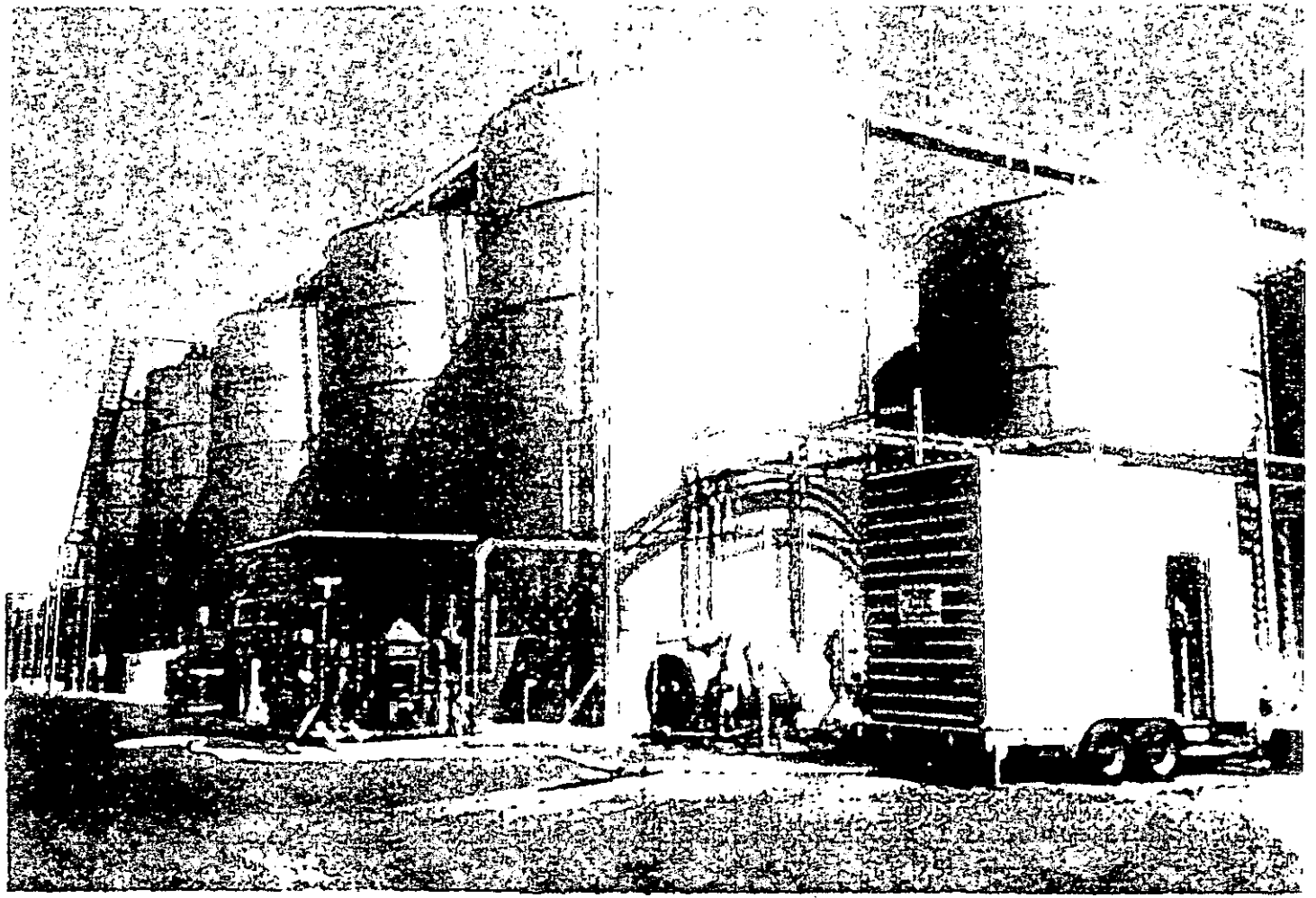


FIGURE 7. 1990 DEMONSTRATION PROGRAM EQUIPMENT, SOUTH SIDE FERMENTATION TANK 2930 AND EQUIPMENT. RENTAL BOILER TO RIGHT, CONDENSATE ACCUMULATION TANK IN CENTER, FERMENTATION TANK BEHIND AND CARBON ADSORPTION UNIT WITH CONTROLS TO LEFT.

EMISSIONS CONTROL EQUIPMENT

The carbon adsorption unit selected was a commercially available unit with a nominal flow capacity of 1000 CFM. The capacity of the unit was selected based on the fermentation reaction stoichiometry and experience with past carbon adsorption systems used for ethanol emissions control. 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. Figure 1 shows a simplified flow diagram of the control equipment.

The volatile organic analyzer (VOC) Analyzer in Figure 1 was used to monitor the total hydrocarbon concentration in the exhaust flow to indicate when the carbon beds needed to be changed. This analyzer was located with the control panel shown in Figure 6. A pitot tube was used to measure the flow rate to the carbon adsorption system.

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, in its weather proof enclosure, it resembles a rectangular enclosed trailer.

EMISSIONS MONITORING EQUIPMENT

As shown on the flow diagram (Figure 8), the concentration of ethanol in the gas before and after the adsorption system was monitored by two Beckman 400A, flame ionization detectors (FID), with a chart recorder. Total hydrocarbon concentration (mostly ethanol) was measured by the analyzer. The gas samples were drawn through separate Teflon sampling lines by two sampling pumps and exhausted to the analyzers. These two analyzers were maintained by the ARB to determine the ethanol collection efficiency of the carbon unit.

Dry ambient temperature impingers were placed prior to the sample pump as an emergency knockout vessel. These were not necessary because the liquid knock out and dilution air did an adequate job of drying the tank emission stream under normal operating conditions. However, had there been a catastrophic event (such as a foam over) the knockout vessel would have protected the sample pump. The emergency knockout vessel consisted of one quart jars with screw lids. These vessels only collected a few drops at a time, which quickly evaporated and passed on to the appropriate FID. A rotameter was used to monitor the flow rate into the hydrocarbon sampling instruments.

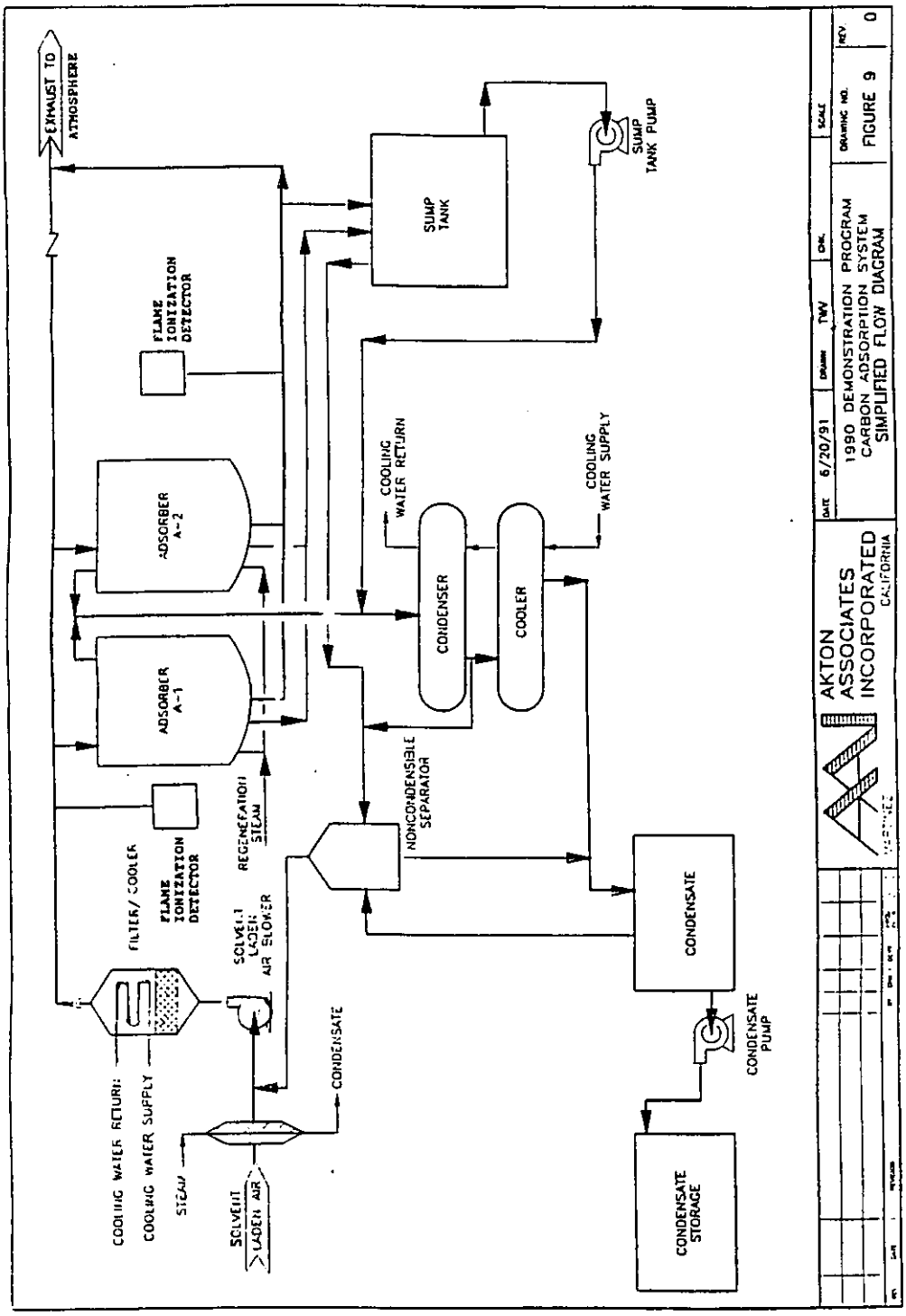


FIGURE 8 SIMPLIFIED PROCESS FLOW DIAGRAM

SECTION 4 PROCEDURES

A total of eight fermentation cycles were conducted between August 29 and September 28, 1990. All fermentation practices (ex. temperature, ballings, pumpover, etc..) utilized normal E&J Gallo Winery operating procedures. Sugar content, alcohol content and fermentation temperature was recorded for fermentations 1 through 8. The ARB monitored total hydrocarbons using a flame ionization detector at the inlet and outlet to the carbon adsorption system to determine the control efficiency for fermentations 6,7, and 8.

Fermentation 1,2 and 8 were conducted with clarified juice at fermentation temperature of approximately 58 degrees Fahrenheit. Initial ballings (% sugar w/w) was approximately 20 % and final alcohol content approximately 12 %. Tank fill was nominally 170,000 gallons.

The remaining fermentation cycles 3 through 7, were red fermentations at nominal fermentation temperatures of 73 degrees Fahrenheit. Initial ballings were approximately 23 degree, and final alcohol content varied from 8.6 to 10.2 percent before transfer to other tanks.

Ethanol content of the fermenting wine was determined as specified in "Gas Chromatographic Determination of Ethanol in Wine: Collaborative Study".[8] For each fermentation cycle the ethanol content was measured every four hours.

Ballings was determined following procedures contained in "Reducing Sugars by Liquid Chromatography".[9] For each fermentation cycle the sugar content was measured every four hours.

Temperature of the fermentation tank was measured using a Weston Dial Thermometer which was placed at a height of approximately six feet from ground level. The tank height was 40 feet. Tank temperatures were recorded every hour.

The vapor collection system flow rate was measured prior to entering the carbon bed using a pitot tube. A duct traverse was performed at the beginning and ending of each fermentation. During the fermentation the pitot tube was placed in the center of the ducting to ensure that the system flow rate was a constant 1120 cfm.

Hydrocarbon sampling was initiated for fermentation 6, 7 and 8, immediately after inoculation with yeast. Emissions sampling was performed at the inlet to the carbon unit and at the exhaust gas outlet. Sampling procedures were in accordance with California Air Resources Board stationary source sampling method, "Method

100 - Procedures for Continuous Emission Stack Sampling." This method is used to determine gaseous emissions from stationary sources. Flame ionization detectors were calibrated using propane at the ARB Sacramento facilities before the emission test, and in the field before, during (at least every 12 hours) and after each fermentation.

Two gaseous hydrocarbon sampling instruments were used by CARB to sample the inlet to the carbon unit and the exhaust gas outlet, simultaneously. Total hydrocarbon concentration (mostly ethanol) were measured as propane by the analyzers which were equipped with a flame ionization detector (FID). Data from the two instruments were recorded on strip charts. The FID was calibrated using propane gas. Measured concentrations were converted to actual ethanol concentrations (ppmC) by multiplying the recorded concentration by a factor of 1.72.

Rotameters were used to monitor the flow rate into the CARB hydrocarbon sampling instruments. The rotameters were calibrated at the ARB Sacramento facilities prior to the emissions test. The analyzer air flow rate was maintained at approximately one liter per minute.

A third hydrocarbon sampling instrument was used to initiate a one-hour carbon regeneration cycle when the carbon outlet measured concentration reached 50 ppmv (measured as propane). A rotameter was used to monitor the flow rate into this hydrocarbon sampling instrument. The analyzer air flow rate was maintained at approximately 5 scfh.

Initial carbon loading procedures for the bed are attached as Appendix A. The ethanol adsorbed onto the carbon was steam stripped, the steam and ethanol vapors condensed, and the condensate collected in the accumulation tank as shown in Figure 8 and 9. Water for the condensing of vapors from the steam regeneration of the carbon was provided by a once through cooling water from the winery water system.

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 200 pounds per hour at initial steam pressure of 10 to 14 psig measured at the boiler. Carbon bed outlet temperatures of greater than 230 degrees 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.

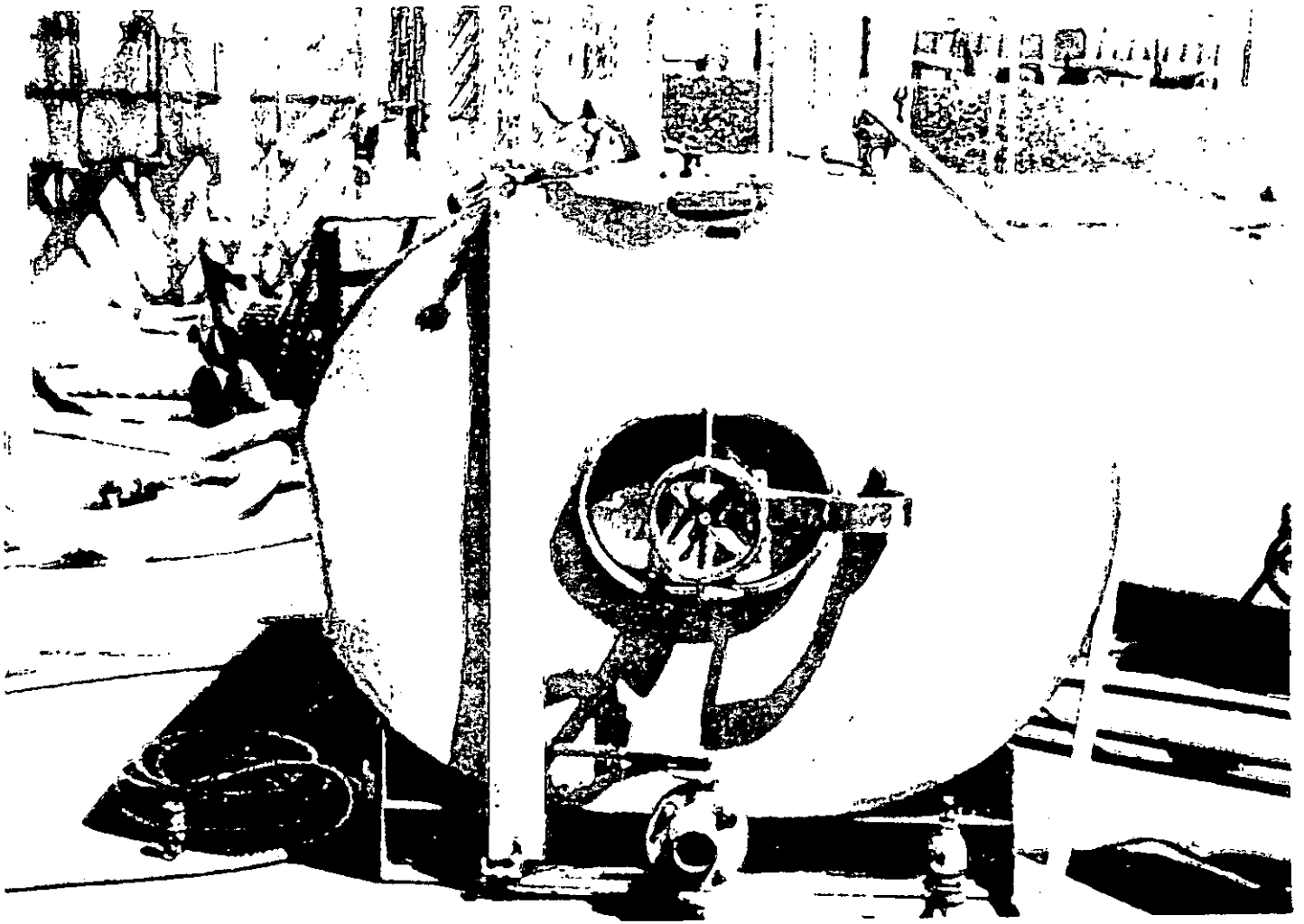


FIGURE 9 CONDENSATE ACCUMULATION TANK

Operation of the system was continuously monitored and all pertinent data was recorded once an hour. The duties of the emission test operators are attached as Appendix B.

Inlet and outlet ethanol concentrations were monitored by the ARB for the last three fermentation cycles and are shown in Appendix C. The concentration data in Appendix C was read off the strip charts from the monitor recorder. Based on the number of hours of fermentation, concentration data was recorded in half hour averages for fermentations 6 and 7, and hour averages for fermentation 8.

SECTION 5 DISCUSSION OF RESULTS

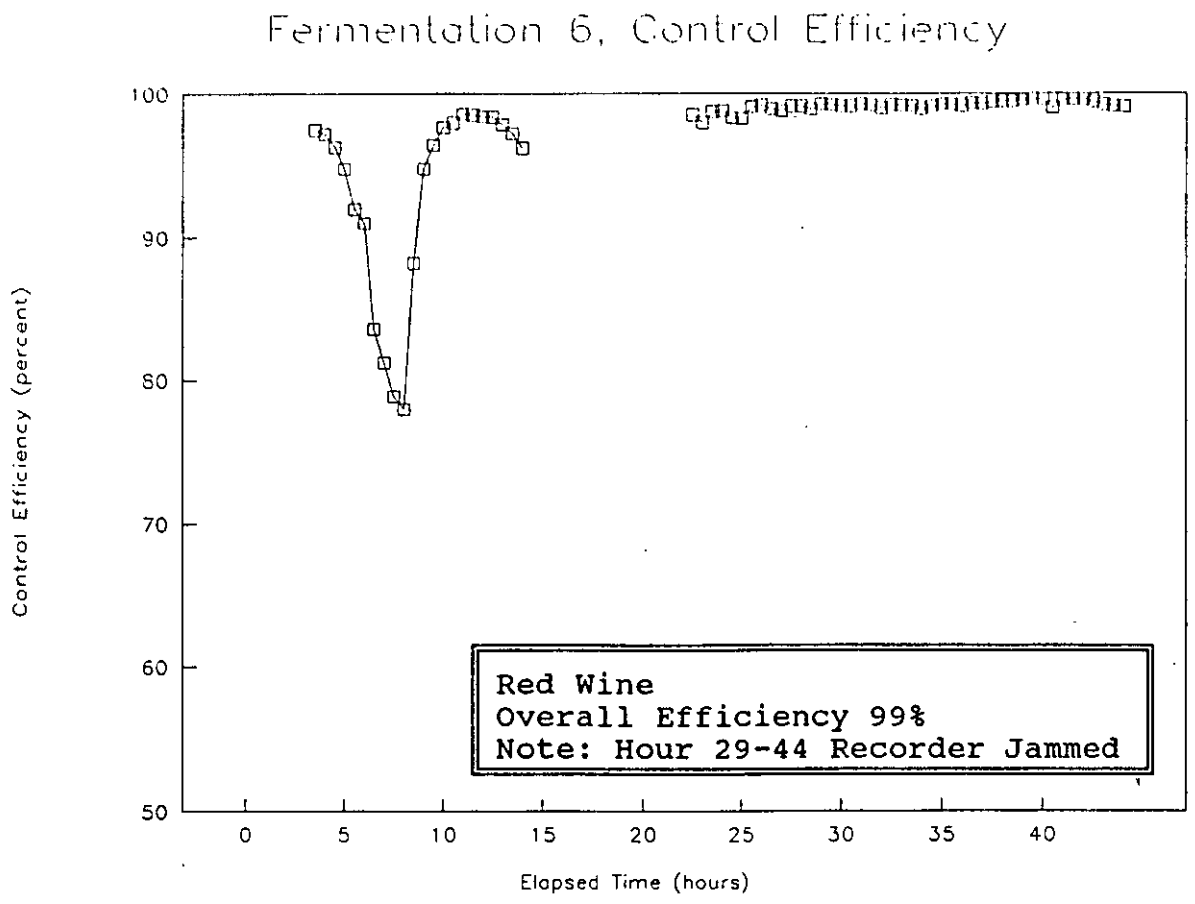
The carbon adsorption unit achieved control efficiencies of 99, 98.6 and 92.5 for fermentations 6, 7 and 8, respectively. Process conditions were representative of typical Gallo operating procedures based on the decrease in ballings and the concomitant increase in alcohol content during fermentation. The quantity and composition of carbon regeneration condensate was consistent with the past pilot scale study at CSUF. Several vapor monitoring operational problems were encountered during the fermentations; all were corrected without disturbing the normal fermentation cycle.

Figures 10, 11 and 12, show the control efficiency and adsorber outlet concentration of ethanol as a function of time for each fermentation. The graphs for control efficiency as a function of time show that the carbon adsorption system achieved a control efficiency better than 98.5 percent for fermentations 6 and 7. Fermentation 8 had an efficiency of 92.5. The reduced efficiency in the final fermentation may have been caused by the loss of elemental carbon from the carbon adsorber during regeneration.

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 conclusions of the tests. The manufacturer performed tests which indicated carbon tetrachloride adsorption indices between 59 and 63%, compared to 70 % for virgin carbon. This is considered a slight loss in activity and is typical of carbon that has been in service.[10] A decrease in activity can cause a reduction in control efficiency.

The control efficiency graphs indicate a reduced efficiency during the initial stages of fermentation. This is caused by the inherent difficulties in measuring and comparing low ppm ethanol concentrations. In addition, at low concentrations carbon beds may indicate a reduced control efficiency due to the small quantity of inlet contaminant in contrast to the outlet concentration. The calculated control efficiency near the start of the fermentations may not be representative of actual conditions.

The graphs of adsorber outlet concentration versus time show that ethanol concentrations at the start of fermentation are low and increase with time. Note that the graphs show the concentrations measured by the flame ionization detector, ethanol emissions are determined by multiplying the recorded concentrations by an ethanol response factor of 1.72. The carbon regeneration cycle was initiated at measured outlet concentrations below 30 ppm for



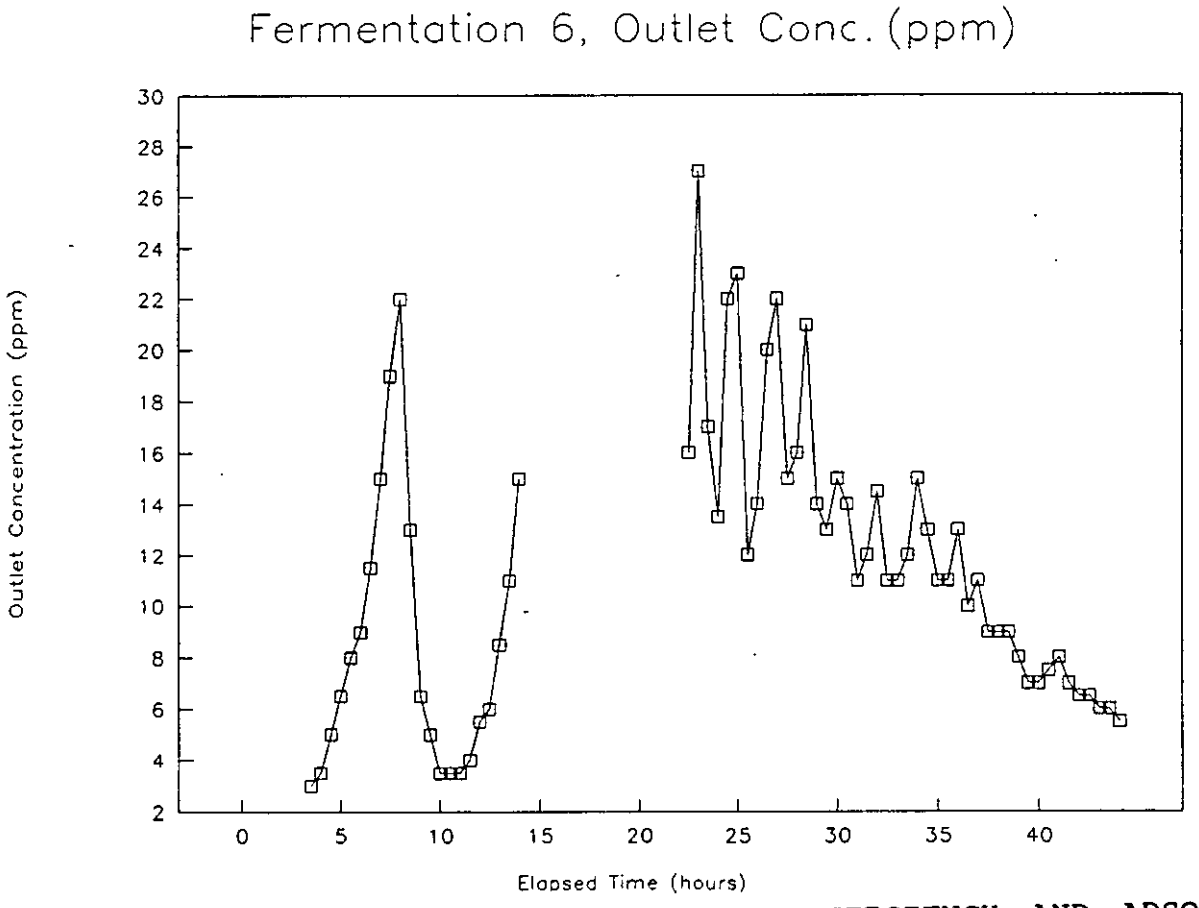
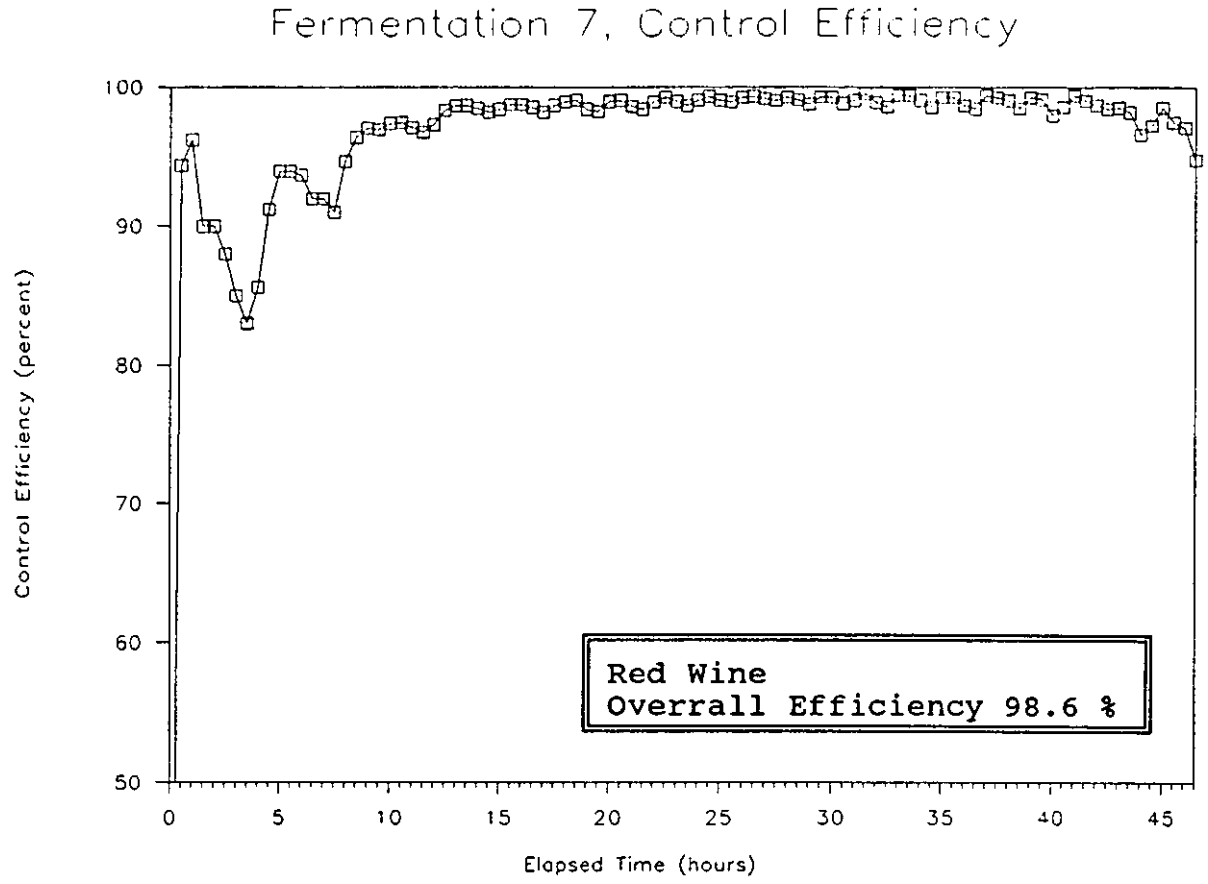


FIGURE 10 - FERMENTATION 6, CONTROL EFFICIENCY AND ADSORBER OUTLET CONCENTRATION



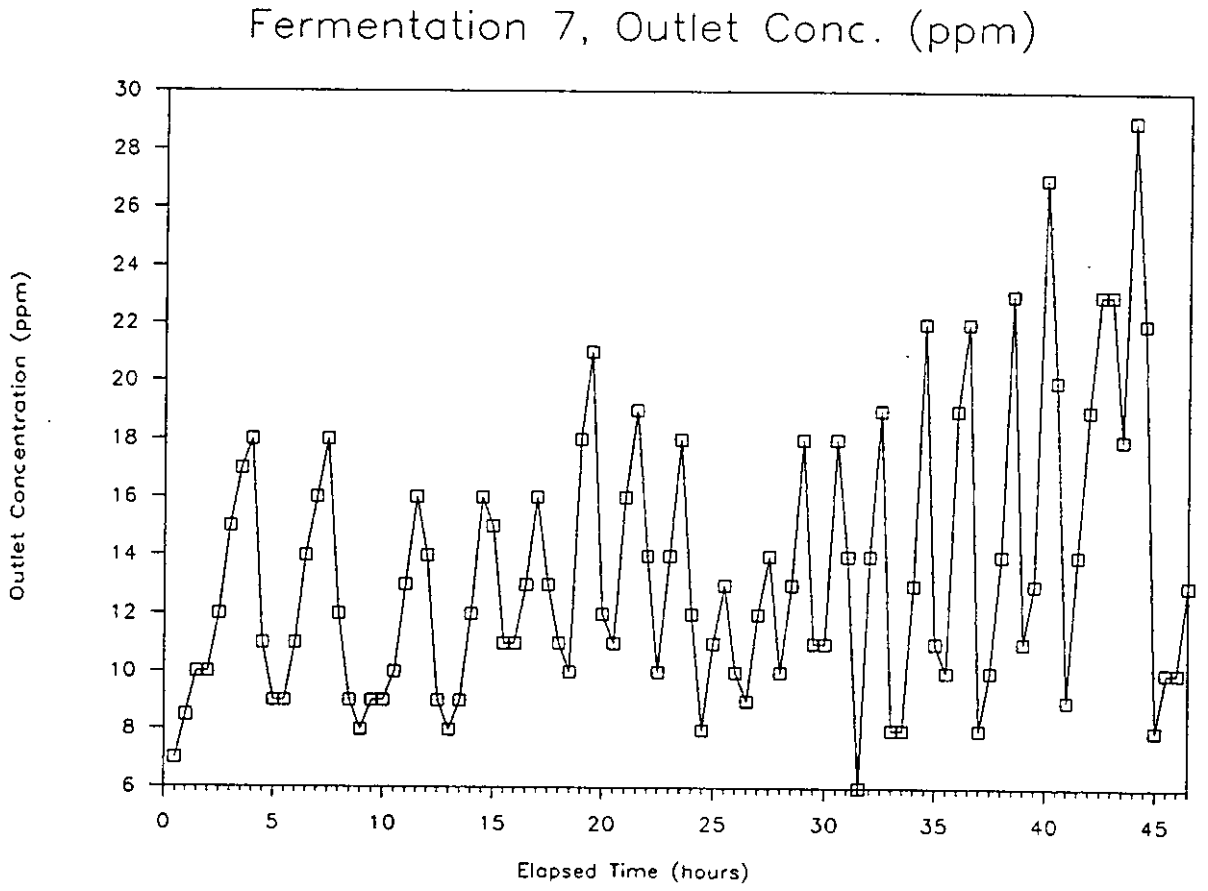
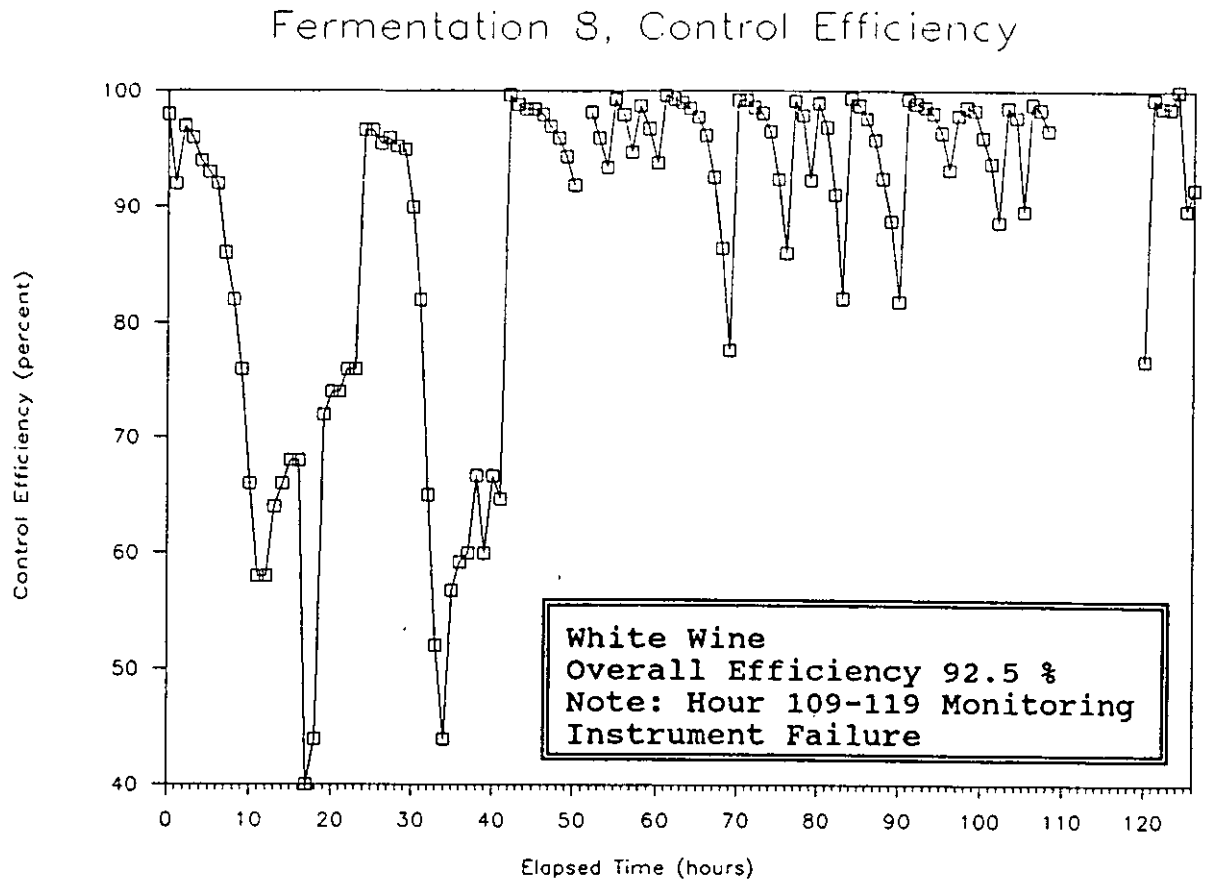


FIGURE 11 - FERMENTATION 7, CONTROL EFFICIENCY AND ADSORBER OUTLET CONCENTRATION



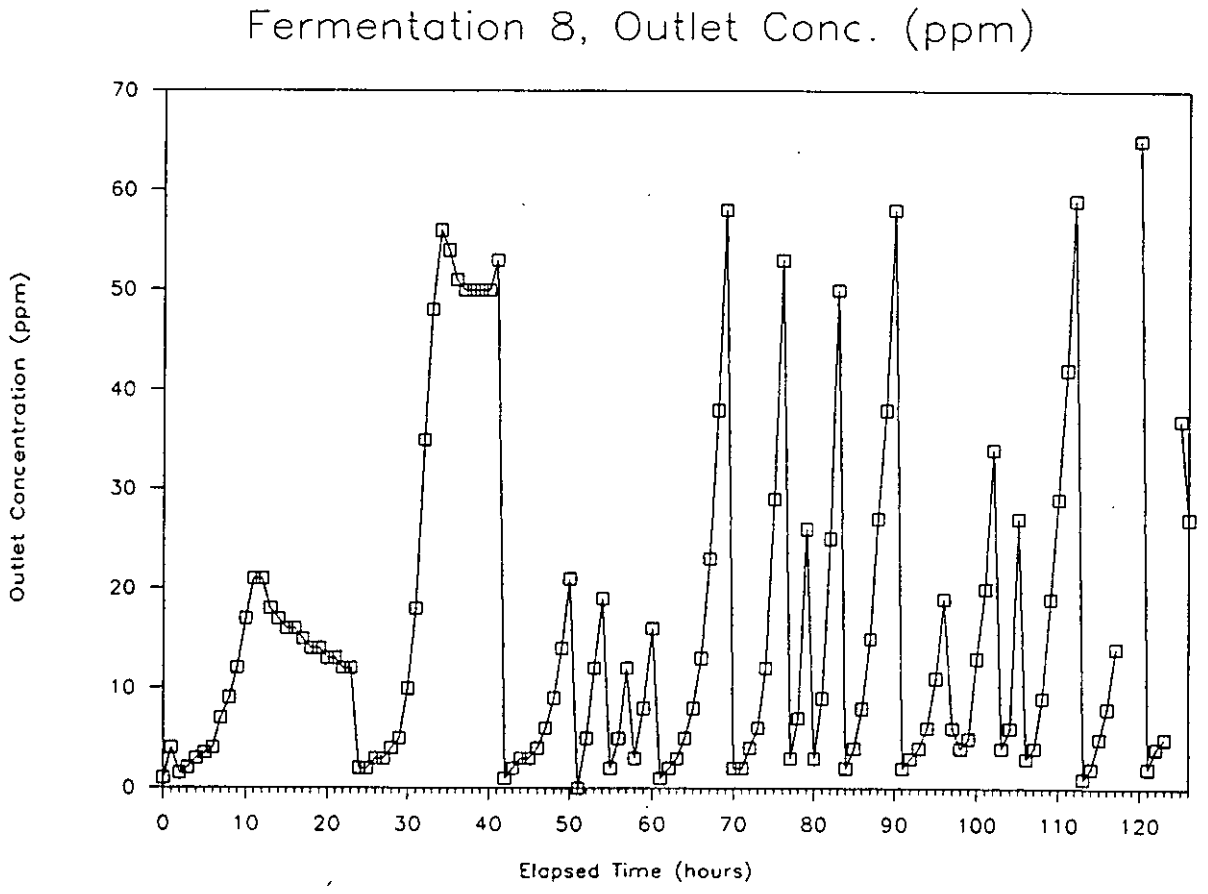


FIGURE 12 - FERMENTATION 8, CONTROL EFFICIENCY AND ADSORBER OUTLET CONCENTRATION

fermentations 6 and 7. During fermentation 8 outlet concentrations reached up to 65 ppm. It appears during this fermentation breakthrough occurred more quickly, before regeneration could be initiated and the second carbon bed brought on-line.

Table 1 shows fermentation conditions during the source test. These conditions are representative of normal winery fermentation operating parameters.

TABLE 1. Fermentation Conditions

No.	Type	Volume Fermented (Gallons)	Total Hours	Average Temp. (F)	Initial Balling (%)	Final Balling (%)	Final Alcohol (%v/v)
6	Red	160,000	35	73	22.8	7.0	8.9
7	Red	160,000	48	74	22.6	4.6	10.2
8	White	170,000	128	57	21.6	0.7	11.7

Based on the analysis of the regeneration steam condensate, the amount of ethanol collected on the carbon bed during white wine fermentation was 1.64 pounds ethanol collected per 1000 gallons fermented. This result shown in Table 2, is comparable to the amounts obtained during the pilot studies carried out at CSUF in 1987 and 1988 for white wine fermented to dryness. The CSUF tests determined that the pounds of ethanol collected on a carbon bed per 1000 gallons of white wine fermented ranged from 3.22 to 1.67.

The red wines were not fermented to dryness in the Demonstration Program as they were during the CSUF tests; therefore, a direct comparison of ethanol collected per 1000 gallons fermented could not be made. However, comparison of data collected during the CSUF study with data shown in Table 2, indicates a reasonably close correlation at the point when fermentation was interrupted for transfer to another tank.

TABLE 2. Regeneration Condensate Data

No.	Condensate Collected (Gallons)	Alcohol Content (%v/v)	Alcohol (Pounds)	Pounds Alcohol Per 1000 Gals. Fermented
6	352	21.85	506.4	3.17
7	454	21.30	636.7	3.98
8	339	12.50	279.0	1.64

no - this represents only lbs collected not lbs emitted - does not take into account the EtOH that was not adsorbed.

To validate the amount of ethanol captured on the carbon during the fermentation, calculations were performed using the measured hydrocarbon concentrations and the vapor system flow rate. The difference between the inlet and outlet average hourly concentrations was multiplied by the vapor collection system flow rate. A constant vapor collection system flowrate of 1120 cfm was used based on pitot tube measurements. These calculated values resulted in an estimate of total captured emissions of 507.4, 634 and 330 pounds for fermentations 6, 7 and 8, respectively. The calculated values were lower for fermentations 6 and 7, but were higher for fermentation 8. Fermentation 6 and 7 values correlate within 0.3 % and fermentation 8 varied by 15 % of the amount of alcohol collected in the condensate. Deviation may occur due to using average hourly concentration values, lapses in concentration data due to recorded failures and potential interference of CO_2.

Due to vapor monitoring problems, data lapses occurred during fermentations 6 and 8. No problems were observed during fermentation 7. Fermentation operations were not disturbed. Specific problems are detailed below.

During fermentation 6, the recorder pen jammed during hours 14.5 through 22. Water was observed in the sample line rotameter during hour 24, subsequently a knock out vessel was added to the sample line. No other sampling or operational deviations were observed.

Fermentation 8 was near foam over conditions from hour 5 through hour 12. The outlet monitor was taken off line during hour 51 for repair of the sampling line. The sample lines were purged to remove moisture during hours 79 and 102. The monitoring instrument failed hours 109 through 119.

SECTION 6 REFERENCES

1 Todd, D.F., Castronovo, C.L., "Ethanol Emissions Control from Wine Fermentation Tanks Using Charcoal Adsorption A Pilot Study" California Air Resources Board, Monitoring and Laboratory Division, Sacramento, California, March, 1990.

2 Todd, D. F., Castronovo, C. L., "Ethanol Emissions Control for Wine Fermentation" Report # ARB/ML-88-027, California Air Resources Board, Monitoring and Laboratory Division, Sacramento, California, April, 1988.

3 Muller, C.J., Gump, B.H., Fugelsang, K.C., "Ethanol Emissions II Project Final Report", California State University Fresno, VERC submitted, November, 1988.

4 Akton Associates, "1990 Demonstration Program Ethanol Emissions Control from Wine Fermentation Using Carbon Adsorption Technology" Martinez, California September, 1991.

5 Todd, D. F., Castronovo, C. L., "Ethanol Emissions Control for Wine Fermentation" Report # ARB/ML-88-027.

6 Environmental Protection Agency. "Carbon Adsorption", Report # 600/2, 82-001a, September, 1981.

7 Akton Associates, "1990 Demonstration Program Ethanol Emissions Control from Wine Fermentation Using Carbon Adsorption Technology".

8 Caputi, Mooney, "Gas Chromatographic Determination of Ethanol in Wine: Collaborative Study" J. Assoc. of Anal. Chem., Vol. 66, No. 5, 1983.

9 Gallo Winery, "Reducing Sugars by Liquid Chromatography", Fresno, California, February 1989.

10 Worrall, Michael, AMCEC, Vice-President. Personal letter to Art Caputi. 2 Jan. 1991.

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03 August 1990

Amcec Carbon Handling and
Installation Instructions

For

Wine Institute
Fresno, California 93727
Amcec Reference CA750/4

Introduction

The efficient operation of a solvent recovery system is dependent on each adsorber having a correctly installed carbon bed. Each adsorber on a multi-adsorber system must be uniform in volume and depth.

Activated carbon for use in this solvent adsorption system is supplied in the form of small pellets, 5 mm diameter with random lengths and furnished in various forms of packaging including, in this case, 55 gallon drums at 160 pounds each.

The following instructions incorporate the same standards for the care and handling during installation that are followed by Amcec's own engineers. Failure to observe these instructions will result in damage and subsequent loss of carbon due to lack of care during handling and storage, and loss of plant efficiency in the base of badly installed carbon beds.

We cannot over-emphasize the importance of installing the carbon pellets correctly within the adsorbers so that they form the optimum configuration in the carbon bed. Not only will the guaranteed system performance be jeopardized from the time of system startup, but with the cyclic operation of passing steam and solvent laden air through the beds, errors in the uniformity of a carbon bed will be self-perpetuating and increasing bed disturbance will occur rapidly. This can lead to such extensive pellet movement that the carbon may be carried through vessel exhaust stacks or into other parts of the system. Blockages can occur in pipe lines and equipment which will require major maintenance operations with subsequent system shutdown.

Amcec Carbon Handling and
Installation Instructions
Wine Institute CA750/4
Fresno, California

Delivery and Storage

To minimize physical damage and improve handling conditions, drums should remain palletized during storage. WARNING! Caution is strongly advised if having to deal with carbon which which has broken loose from its packaging. It is important for carbon effectiveness that it be clean. Carbon spilled directly onto earth, dirt, gravel, sand, etc. is usually considered beyond reclamation.

What is of the utmost importance and must be under constant supervision by responsible personnel is that no combustible material (paper, wood, etc.) be allowed to enter a vessel with the carbon. This could be the most significant cause for starting a carbon bed fire within a vessel.

Manual Loading

Vessels will be loaded with carbon pellets according to volume. There must be no variance between chambers. Total amount of carbon supplied: 1,280 pounds. Total amount of carbon per MICROBLOC vessel: 640 lbs

Each carbon bed must be of uniform thickness over the entire bed frame area.

Because of the dusty nature of new carbon, the carbon loading can be uncomfortable for the handlers. In summer temperatures it will be necessary to provide some forced ventilation by means of a blower or fan. In any event, personnel working inside a vessel should be equipped with breathing masks and goggles, and all handlers should be provided with overalls and gloves. An extractor fan would also be a useful addition to draw the carbon dust out of the vessel.

The minimum recommended crew would comprise two (2) laborers - one person inside the vessel and one moving the carbon bags from the storage area and pouring carbon into the vessel. A fork lift truck or small rubber tired crane may be used to lift sacks to the vessel openings.

Manual Loading continued ...

Before introducing carbon into the vessel, remove all covers, gaskets and bolts from vessel upper and lower manhole openings.

Inspect entire surface area of the titanium bed support screens. The supporting structure of the bed screen is sufficient that the screens will support a person. However, care must be exercised when placing feet in an unsupported area, and steel tipped shoes or boots should NOT be worn. Splits or tears in the perforations of the support screen cannot be accepted and, if found, Amcec must be informed to evaluate repair or sheet replacement.

Screen repairs require a special technique and should not be attempted without Amcec's advice.

The inside of a vessel will be very dark, more so as carbon dust fills the air space, and handlers inside the vessel can very easily lose their sense of perspective. The following procedure provides a definite assistance to the rough dispersement of the carbon prior to the more critical final leveling. Using the bed depth dimension provided by Amcec and increasing it by 3", paint a white line completely around the inside perimeter wall of the vessel using the bed screen as a datum. This will allow a white line to be seen at all times irrespective of the amount of carbon inside the vessels. If the carbon build-up is contained approximately within 3" of the visible line it will minimize the amount of carbon movement necessary during the final leveling.

In addition to the aforementioned, the following items will be found to be useful:

: 12" x 24" x 1/2" spreader boards to permit walking on carbon within the vessel.

: 2" x 8" approximately 8'0" long for final levelling.

: 2'0" long builder's level.

: Industrial bristle brooms.

: Snow shovels or similar.

Manual Loading continued ...

Carbon loading should be through the top cover, building up depth to the prescribed level.

After a depth of 12" to 14" is established, the possibility of crushing pellets on the screen is minimized. However, spreader boards should be used on top of the carbon to avoid excessive disturbance.

The rough leveling can be done with shovel and broom using the white line as a guide.

When the correct volume of carbon is inside the vessel, final leveling can proceed. NOTE: Verify correct weight as given by Amcec.

The required end result is a uniform bed depth over the entire bed area, with not more than a 1" deviation between the highest and lowest points. This degree of smoothness is achieved by using a 2" x 8" board as a scraper and, combined with the 2'0" level, working in a manner similar to that used to smooth the surface of wet concrete.

Unlike wet concrete, the carbon pellets have no tendency to gravitate to a level of their own and must be mechanically spread with the use of brooms. The brooms must also be used to level out the disturbance caused by the handlers making their final exit from the vessel. The final check for bed depth uniformity should be made by using a graduated dip stick. If the bed depth noted is different by more than 2" from Amcec's theoretical depth, Amcec should be advised immediately.

After a uniform, flat top surface has been achieved the top screens should be installed. Covers may now be replaced. However, as a condition of performance guarantee, each carbon bed must be inspected and approved by an Amcec representative before final sealing of the vessels.

There will be an amount of dust collected in the lower chamber of the vessel beneath the bed screen. This dust must be removed through the bottom manhole and can be swept, washed or vacuumed out according to preference.

Amcec Carbon Handling and
Installation Instructions
Wine Institute CA750/4
Fresno, California

Manual Loading continued ...

The total amount of carbon for this CA750 project is 1,280 lbs, which is 640 pounds per vessel giving a depth of about 27". Carbon is provided in 160 lb drums, use 4 drums per vessel.

MT:BB
03 August 1990

APPENDIX B - DUTIES OF ONSITE OPERATORS

ETHANOL EMISSIONS TEST

OPERATOR DUTIES

1. Fill out hourly check list of temperatures and pressures. Also check the gauges on the compressed gases next to control panel shelter at least once during each shift. The regulated pressures should be:

Ultra zero air:	12 psig
Hydrogen/nitrogen	32 psig
110 ppm methane	16 psig

Notify Cesare Dianna if the unregulated pressure drops below 500 psig on any of the tanks.

Inlet flow (Magnehelic 1) should be about 0.8" H_2O. It will be higher if both absorbers are open during the cool mode. If this gauge reading drops to 0, it means that all valves are closed. This condition should not exist for more than 60 seconds. If it does, shut the unit down and call a supervisor.

2. Check steam generator operation. Refill boiler additive tank with water and add boiler compound as necessary. Wear protective equipment per MSDS.

Check steam temperature which should be about 225° F. Steam flow during regeneration should be 200-240 lbs. per hour which can be calculated from condensate flow.

3. Perform boiler chemical concentration test and water softness check every other day.

4. When condensate discharge storage tank reaches approximately 1/2 full mark, record volume, sample, label bottle with date and time of sample and take to laboratory for analysis. Then sample at least one gallon (or more if so directed), then empty tank and close drain valve for the next series of cycles.

5. Follow appropriate directions to respond to alarm conditions (see separate sheet).

6. In the event of mechanical problems contact Harvey Sons or Cesare Dianna.

7. In the event of problems with the control panel or analyzer, contact Fred Daniel.

8. If anything appears abnormal, call any of the above people, or a supervisor. An officer at the entrance

security post can always contact one of these people.

9. In the event of a foam-over of the fermenting tank, SHUT DOWN THE UNIT and open the drain valve on the foam-over surge tank.

10. Normal shut down: Wait until one column is absorbing and the second is in the idle mode before stopping. Avoid stopping the system during a steam regeneration and before the cooling step is completed.

11. Start up: Close steam valves to the unit and blow condensate out of the lines. Note the number of turns required to close steam valve to absorber. When condensate has been removed, reopen the steam valve the same number of turns used to close it.

ANALYZER INSTRUCTIONS

1. Zero and adjust span of analyzer at beginning of each shift. Mark time and date on chart recorder. Set span at 61 (on x25 range setting) with the 110 ppm methane calibration gas.

2. Check analyzer line filters for moisture at least once a shift.

3. Analyzer air flow should be approximately 5 scfh.

4. Range setting of x25 is used for 0-100 ppm full scale display. This is the normal setting for analyzing the exhaust gas and controlling the unit.

To check inlet gas concentration;

1. Turn range switch to x250 position.

2. Close manual sample valve at exhaust sample fitting.

3. Open manual valve at absorber inlet.

4. After inlet reading levels off, record reading and return sample valves to original positions. Do not exceed 60 seconds for this reading.

5. Reset range switch to x25 position.

Note: Alarm will gp off if reading is greater than 80.

In x250 range, actual concentration is 10 x display reading. This range is good only to 1000 ppm. If reading exceeds this level, switch range setting to x1000 position and multiply reading by 40.

Operator: _____ Date: _____

ITEM	TIME								
1 Magnehelic 1									
2 Magnehelic 2									
3 Temperature A1									
4 Temperature A2									
5 Filter temp - top									
6 Filter temp - bottom									
7 Ambient temperature									
8 Water temperature (out)									
9 Nitrogen pressure									
10 Fermentation temperature									
11 Monitor exhaust (ppm)									
12 Alarm status									
13 Relative humidity									
14 Monitor intake (ppm)*									
Unit in operation									

* Do not sample in this position over 60 seconds.

Changeover time: _____

Slop tank volume: _____

Slop sample date & time: _____

Check: Time

1. Level in condensate receiver _____
2. Boiler
   - A. Water level _____
   - B. Chemical concentration _____
   - C. Feed water hardness _____

Comments: _____

APPENDIX C - CONCENTRATION DATA

WINE III, FERMENTATION 6

Date	Time	THC, ppm C3 In	Out	Recovery, percent
9/18/90	1000	No Data.		
	1030			
	1100			
	1130			
	1200			
	1230			
	1300			
	1330	120	3	97.5
	1400	125	3.5	97.2
	1430	135	5	96.3
	1500	125	6.5	94.8
	1530	100	8	92.0
	1600	100	9	91.0
	1630	70	11.5	83.6
	1700	80	15	81.3
	1730	90	19	78.9
	1800	100	22	78.0
	1830	110	13	88.2
	1900	125	6.5	94.8
	1930	140	5	96.4
	2000	150	3.5	97.7
	2030	175	3.5	98.0
	2100	250	3.5	98.6
	2130	275	4	98.5
	2200	350	5.5	98.4
	2230	375	6	98.4
	2300	400	8.5	97.9
	2330	400	11	97.3
9/19/90	2400	400	15	96.3
	0030			
	0100	Chart paper jammed.		
	0130	No Data.		
	0200			
	0230			
	0300			
	0330			
	0400			
	0430			
	0500			
	0530			
	0600			
	0630			
	0700			
	0730			
	0800			
	0830	1100	16	98.5
	0900	1350	27	98.0
	0930	1350	17	98.7
	1000	1150	13.5	98.8

WINE III, FERMENTATION 6

Date	Time	THC, ppm C3 In	Out	Recovery, percent
	1030	1300	22	98.3
	1100	1350	23	98.3
	1130	1300	12	99.1
	1200	1800	14	99.2
	1230	1950	20	99.0
	1300	1850	22	98.8
	1330	1800	15	99.2
	1400	1900	16	99.2
	1430	2050	21	99.0
	1500	2100	14	99.3
	1530	1750	13	99.3
	1600	1800	15	99.2
	1630	1650	14	99.2
	1700	1550	11	99.3
	1730	1500	12	99.2
	1800	1500	14.5	99.0
	1830	1450	11	99.2
	1900	1400	11	99.2
	1930	1450	12	99.2
	2000	1450	15	99.0
	2030	1500	13	99.1
	2100	1500	11	99.3
	2130	1500	11	99.3
	2200	1550	13	99.2
	2230	1550	10	99.4
	2300	1600	11	99.3
	2330	1650	9	99.5
9/20/90	2400	1700	9	99.5
	0030	1800	9	99.5
	0100	1800	8	99.6
	0130	1800	7	99.6
	0200	1800	7	99.6
	0230	750	7.5	99.0
	0300	1800	8	99.6
	0330	1800	7	99.6
END	0400	1650	6.5	99.6
AVERAGES (Ferm. only)		1093	12	97.0
		Overall Eff. =>		98.9
Emptying Tank	0430	1150	6.5	99.4
	0500	800	6	99.3
	0530	700	6	99.1
	0600	600	5.5	99.1

WINE III, FERMENTATION 7

Date	Time	THC, ppm C3 In	Out	Recovery, percent
9/20/90	1300	Start		
	1330	125	7	94.4
	1400	225	8.5	96.2
	1430	100	10	90.0
	1500	100	10	90.0
	1530	100	12	88.0
	1600	100	15	85.0
	1630	100	17	83.0
	1700	125	18	85.6
	1730	125	11	91.2
	1800	150	9	94.0
	1830	150	9	94.0
	1900	175	11	93.7
	1930	175	14	92.0
	2000	200	16	92.0
	2030	200	18	91.0
	2100	225	12	94.7
	2130	250	9	96.4
	2200	275	8	97.1
	2230	300	9	97.0
	2300	350	9	97.4
	2330	400	10	97.5
9/21/90	2400	450	13	97.1
	0030	500	16	96.8
	0100	525	14	97.3
	0130	550	9	98.4
	0200	600	8	98.7
	0230	700	9	98.7
	0300	800	12	98.5
	0330	900	16	98.2
	0400	950	15	98.4
	0430	900	11	98.8
	0500	900	11	98.8
	0530	900	13	98.6
	0600	900	16	98.2
	0630	1000	13	98.7
	0700	1050	11	99.0
	0730	1100	10	99.1
	0800	1150	18	98.4
	0830	1200	21	98.3
	0900	1200	12	99.0
	0930	1200	11	99.1
	1000	1175	16	98.6
	1030	1200	19	98.4
	1100	1350	14	99.0
	1130	1350	10	99.3

WINE III, FERMENTATION 7

Date	Time	THC, ppm C3 In	Out	Recovery, percent
	1200	1400	14	99.0
	1230	1350	18	98.7
	1300	1300	12	99.1
	1330	1250	8	99.4
	1400	1200	11	99.1
	1430	1250	13	99.0
	1500	1350	10	99.3
	1530	1400	9	99.4
	1600	1450	12	99.2
	1630	1450	14	99.0
	1700	1450	10	99.3
	1730	1425	13	99.1
	1800	1500	18	98.8
	1830	1500	11	99.3
	1900	1500	11	99.3
	1930	1550	18	98.8
	2000	1500	14	99.1
	2030	1350	6	99.6
	2100	1300	14	98.9
	2130	1350	19	98.6
	2200	1350	8	99.4
	2230	1325	8	99.4
	2300	1400	13	99.1
	2330	1500	22	98.5
9/22/90	2400	1550	11	99.3
	0030	1450	10	99.3
	0100	1450	19	98.7
	0130	1450	22	98.5
	0200	1450	8	99.4
	0230	1450	10	99.3
	0300	1525	14	99.1
	0330	1550	23	98.5
	0400	1550	11	99.3
	0430	1475	13	99.1
	0500	1350	27	98.0
	0530	1425	20	98.6
	0600	1500	9	99.4
	0630	1450	14	99.0
	0700	1500	19	98.7
	0730	1500	23	98.5
	0800	1575	23	98.5
	0830	1000	18	98.2
	0900	850	29	96.6
	0930	800	22	97.3
	1000	550	8	98.5
	1030	400	10	97.5
	1100	350	10	97.1
End	1130	250	13	94.8
AVERAGES		960	13	97.2
		Overall Eff. =>		98.6

WINE III, FERMENTATION 8

Date	Time	THC, ppm C3 In	Out	Recovery, percent
9/23/90	0800	50	1	98.0
	0900	50	4	92.0
	1000	50	1.5	97.0
	1100	50	2	96.0
	1200	50	3	94.0
	1300	50	3.5	93.0
	1400	50	4	92.0
	1500	50	7	86.0
	1600	50	9	82.0
	1700	50	12	76.0
	1800	50	17	66.0
	1900	50	21	58.0
	2000	50	21	58.0
	2100	50	18	64.0
	2200	50	17	66.0
	2300	50	16	68.0
9/24/90	2400	50	16	68.0
	0100	25	15	40.0
	0200	25	14	44.0
	0300	50	14	72.0
	0400	50	13	74.0
	0500	50	13	74.0
	0600	50	12	76.0
	0700	50	12	76.0
	0800	60	2	96.7
	0900	60	2	96.7
	1000	67	3	95.5
	1100	75	3	96.0
	1200	85	4	95.3
	1300	100	5	95.0
	1400	100	10	90.0
	1500	100	18	82.0
	1600	100	35	65.0
	1700	100	48	52.0
	1800	100	56	44.0
	1900	125	54	56.8
	2000	125	51	59.2
	2100	125	50	60.0
	2200	150	50	66.7
	2300	125	50	60.0
9/25/90	2400	150	50	66.7
	0100	150	53	64.7
	0200	300	1	99.7
	0300	175	2	98.9
	0400	200	3	98.5

WINE III, FERMENTATION 8

Date	Time	THC, ppm C3 In	Out	Recovery, percent
	0500	200	3	98.5
	0600	200	4	98.0
	0700	200	6	97.0
	0800	225	9	96.0
	0900	250	14	94.4
	1000	260	21	91.9
	1100	300	-	
	1200	280	5	98.2
	1300	300	12	96.0
	1400	290	19	93.4
	1500	280	2	99.3
	1600	250	5	98.0
	1700	230	12	94.8
	1800	240	3	98.8
	1900	250	8	96.8
	2000	260	16	93.8
	2100	270	1	99.6
	2200	290	2	99.3
	2300	310	3	99.0
9/26/90	2400	340	5	98.5
	0100	360	8	97.8
	0200	340	13	96.2
	0300	310	23	92.6
	0400	280	38	86.4
	0500	260	58	77.7
	0600	260	2	99.2
	0700	270	2	99.3
	0800	290	4	98.6
	0900	320	6	98.1
	1000	350	12	96.6
	1100	380	29	92.4
	1200	380	53	86.1
	1300	360	3	99.2
	1400	340	7	97.9
	1500	340	26	92.4
	1600	300	3	99.0
	1700	290	9	96.9
	1800	280	25	91.1
	1900	280	50	82.1
	2000	310	2	99.4
	2100	330	4	98.8
	2200	340	8	97.6
	2300	360	15	95.8
9/27/90	2400	360	27	92.5
	0100	340	38	88.8
	0200	320	58	81.9
	0300	280	2	99.3
	0400	290	3	99.0
	0500	300	4	98.7
	0600	320	6	98.1

WINE III, FERMENTATION 8

Date	Time	THC, ppm C3 In	Out	Recovery, percent
	0700	310	11	96.5
	0800	280	19	93.2
	0900	290	6	97.9
	1000	290	4	98.6
	1100	300	5	98.3
	1200	330	13	96.1
	1300	320	20	93.8
	1400	300	34	88.7
	1500	280	4	98.6
	1600	270	6	97.8
	1700	260	27	89.6
	1800	270	3	98.9
	1900	260	4	98.5
	2000	270	9	96.7
	2100		19	
	2200		29	
	2300		42	
9/28/90	2400		59	
	0100		1	
	0200		2	
	0300		5	
	0400		8	
	0500		14	
	0600			
	0700			
	0800	280	65	76.8
	0900	290	2	99.3
	1000	290	4	98.6
	1100	340	5	98.5
	1200	350		100.0
	1300	360	37	89.7
	1400	320	27	91.6
AVERAGES		213	16	88.0
		Overall Eff. =>		92.5

APPENDIX A - CARBON LOADING PROCEDURES