EPA-450/3-76-001
March 1976

RELIABILITY STUDY OF VAPOR RECOVERY SYSTEMS AT SERVICE STATIONS

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air Quality and Waste Management
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

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RELIABILITY STUDY OF VAPOR RECOVERY SYSTEMS AT SERVICE STATIONS

by

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Contract No. 68-02-1405, Task Order No. 2

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Prepared for

ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Air Quality Planning and Standards
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March 1976

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Publication No. EPA-450/3-76-001

US EPA

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ABSTRACT

Pacific Environmental Services, Inc. (PES) conducted a study of the operational reliability of vapor recovery systems at gasoline service stations in San Diego County. This work was performed under EPA Contract No. 68-02-1405, Task Order No. 2. Periodic inspections of vapor recovery systems at twenty-four stations were conducted over the period May through July 1975 to examine the condition of these systems, to determine their operational status, and to check for observable gasoline vapor losses from control equipment. In all, 140 such inspections were made. During these visits, 506 vehicle refuelings were observed and the gasoline vapor capture effectiveness checked at the nozzle-vehicle fillneck interface using a combustible gas analyzer.

The study demonstrated that capture of vapors <u>at the vehicle</u> as determined by the use of a combustible gas analyzer was more effective with vacuum-assisted systems than with vapor-balance systems. Gasoline vapor concentrations exceeding one tenth of the lower explosive limit were detected in fourteen percent of the vehicle refuelings where vacuum-assisted systems were used. The percent of refuelings exceeding the 0.1 LEL criterion among the individual manufacturers ranged from six to eighteen percent. For vapor balance systems, nozzle design strongly influences effectiveness. The number of refuelings where gasoline concentration at balance systems exceeded 0.1 LEL ranged from twenty-nine percent where better fitting nozzles were used to eighty percent where poorer fitting nozzles were used. The effect of greater capture efficiency of vacuum assist systems was offset to some degree by poorer reliability.

The reliability of the vacuum-assisted systems, as determined by the frequency of equipment malfunctions and gasoline vapor leaks at the vapor recovery units and vents, was not good although there were substantial variations in performance depending upon the type of unit and the location. Specifically, there was some evidence of malfunction or vapor loss in eighty-eight percent of the visits to vacuum assist stations. There were, however, four locations which were partially inoperative during the entire period of the study. In these cases, retrofits expected during the planning stages of the project were not accomplished. If these locations are not included in the evaluation, the proportion of visits to vacuum assist stations where hydrocarbon losses or malfunctions were observed becomes eighty-four percent. There were no hydrocarbon losses or equipment malfunctions observed at one location equipped with a direct flame afterburner unit not incorporating intermediate vapor hold-up in a carbon bed or in a vapor holder. Excessive vapors may have been consumed by this unit because of nearly continuous operation possibly resulting from piping leaks. (See Table V).

Vapor capture effectiveness at the nozzle-fill tube interface did not appear to be affected by "self-serve" gasoline delivery. These were very few instances of gasoline spillage during delivery operations. Activated carbon adsorption bed vents appeared to be a minor source of hydrocarbon losses.

No data on quantitative control efficiencies of complete vapor recovery systems were obtained during this study nor can direct inferences be drawn on efficiencies from the information presented.

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I. INTRODUCTION

In the prevention of photochemical oxidant air pollution, control of gasoline vapor displaced during retail marketing operations has been recognized as an important measure. In a pioneering effort, the San Diego Air Pollution Control District promulgated in 1972 regulations requiring the use of vapor recovery systems at gasoline filling stations, to minimize the escape of hydrocarbon vapors to the atmosphere during the delivery of gasoline to individual vehicles. Several manufacturers have devised and marketed systems for this purpose. They are currently in use in the San Diego and San Francisco areas and to a lesser degree in other metropolitan areas of the United States. These are known as Stage II controls although they can be used to assist in controlling vapors during bulk delivery of gasoline to the service station (Stage I control).

As a special task under EPA Contract 68-02-1405, PES has conducted a study of the effectiveness and operational reliability of new and modified vapor-control systems in San Diego County. The objective was to investigate new systems and those which had been modified since the TRW study of 1974*. Most new and modified systems which were in operation were included in the study. A large number of units were in the process of being modified and were shut down. The approach used in this study was to conduct periodic inspections of selected operating systems to determine whether the systems were in proper operating condition and were being properly utilized, and to test for observable hydrocarbon vapor losses from the equipment and from the interface between the dispensing nozzle and the vehicle fillneck during filling operations.

The San Diego County area was chosen for the study because the two principal types of service station vapor recovery equipment, vapor balance and vacuum assist, were in use and available for

*Powell, D.J. and D.E. Hasselmann. "Reliability Observations and Emission Measurements at Gasoline Transfer Vapor Recovery Systems." TRW, Inc., for EPA under Contract 68-02-0235, November 1974.

observation. In vapor balance systems, the vapor laden air from the fuel tank of the vehicle is displaced directly (through tubing) into the vapor space of the underground storage tank. The motive force is supplied by the pressure generated by the dispensed gasoline in the vehicle tank and by the vacuum created in the undeground tank by gasoline removal. In vacuum assist systems, displaced vapors from the vehicle fuel tank are captured at the vehicle fillneck by means of an air pump or blower. In the latter type of system, excess vapors are treated in a supplementary control unit. Two types of vapor balance and five types of vacuum assist systems were in use at filling stations selected for the survey. These systems are described in Section II of this report.

This report deals primarily with Stage II vapor recovery. Although some information was gathered on Stage I, the data was not sufficient to be treated in this report. (Stage I vapor recovery deals with underground tank refilling operations, Stage II vapor recovery deals with vehicle refueling operations). Subsequent sections cover methods of investigation and equipment utilized in the study, inspection procedures, study-findings, discussion, and conclusions.

Hydrocarbon breakthrough detectors, supplied by the Environmental Protection Agency, were installed at the outlet of carbon bed adsorption units at six service stations. There were two types of detectors (described in Section III-F below) and three makes of control equipment represented. Thus, each type of detector was installed on each of the three makes of control equipment. The detectors were installed to determine whether hydrocarbon concentrations above a pre-set level in exit gases were discharged from the carbon beds.

Further study of the characteristics and performance of carbon units is to be carried out as part of the same contract. The purpose of the carbon study is to determine the capacity of the carbon beds and effectiveness of regeneration cycles, and to indicate whether there is a build-up of residual high molecular weight hydrocarbons on the carbon beds. Carbon samples will be taken once each month for about six months and tested to determine:

1. Capacity and retentivity in adsorption of carbon tetrachloride.
2. Hydrocarbon content by thermal analysis.
3. Loading of particular hydrocarbons, by gas chromatography.
4. Bulk density.

As another subtask, costs associated with the various vapor control sytems have been determined. Information was obtained from installation contractors, station operators, oil companies, the San Diego Air Pollution Control District, and the office of the San Diego County Assessor. A final report on this subtask was submitted earlier titled "Cost Data, Vapor Recovery Systems at Service Stations" by R.J. Bryan and R.L. Norton. Information on this report is available from EPA Emissions Measurement Branch, Research Triangle Park, N.C.

II. VAPOR RECOVERY SYSTEMS

A. VAPOR-BALANCE SYSTEMS

The simplest vapor recovery systems are the vapor-balance systems, which operate on the principle of a simple exchange of materials between the vehicle tank and the service station storage tank. As liquid gasoline is withdrawn from the underground storage tank and pumped into the vehicle tank, it displaces an equivalent volume of vapor-laden air, which either enters the underground tank through a return line to replace the liquid removed or leaks to atmosphere. In principle, with tight connections, such systems might operate indefinitely without loss of hydrocarbons. Achieving such operation is difficult, however, because in practice it is difficult to obtain a tight seal between the nozzle and the fill-neck for all vehicles. Therefore, leakage at this point is frequently encountered. Figure 1 illustrates a typical balance system.

Vapor-balance systems installed by Gulf Oil Corporation and by Standard Oil Company of California at four of the twenty-four systems were the only balance systems in operation in the area during the study period.

Two different piping layouts were used for the vapor balance systems. In the first case vapor return lines were manifolded together and the vapor spaces of the underground tanks were interconnected. In the second design, only the vapor return lines serving the same grade of gasoline were manifolded with no interconnection between tanks.

B. VACUUM-ASSIST SYSTEMS

1. General

In vacuum-assist systems, a negative pressure is maintained within the vapor-return tubing, thus enhancing the capture of vapor at the nozzle-fillneck interface. This approach

Figure 1A. SCHEMATIC DIAGRAM OF MANIFOLDED BALANCE SYSTEM

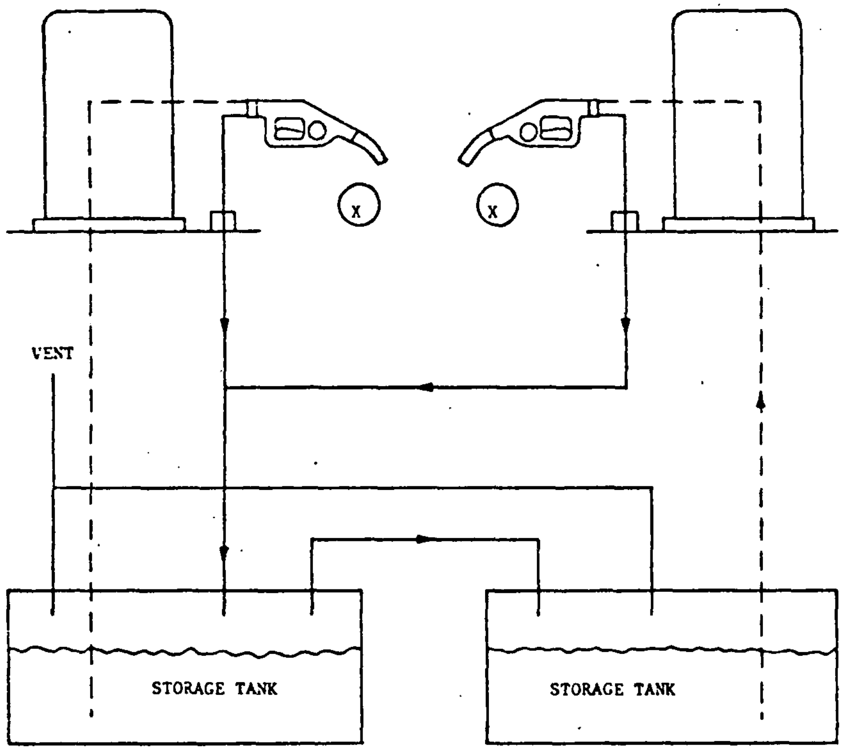
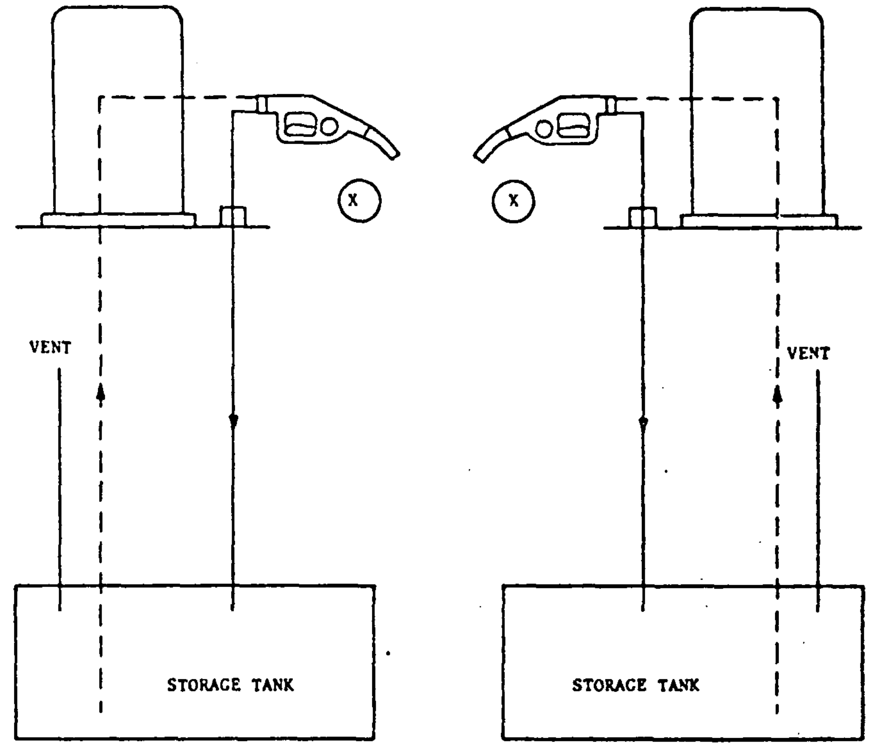


Figure 1B. SCHEMATIC DIAGRAM OF NON-MANIFOLDED BALANCE SYSTEM



(X) EXPLOSIMETER MONITORING LOCATIONS

——— VAPOR LINES

— — — LIQUID LINES

is usually more effective in capturing vapor at the fillneck, provided sufficient flow of air is maintained, as compared to vapor balance systems.

Air movement, in such systems, is induced by blowers or other aspirating devices (in one of the systems suction is provided by a Venturi ejector operated by compressed air). In all vacuum assisted systems the quantity of vapor-air mixture returned exceeds the amount of gasoline delivered, i.e. the V/L ratio exceeds 1, thus requiring the processing of the excess vapor mixture to capture or destroy the hydrocarbons contained therein. In various systems, this processing is achieved by condensation, by burning with or without a catalyst, or by some combination of these methods. Intermittant accumulation of hydrocarbons by use of vapor holders or activated carbon is sometimes utilized.

Reliability and malfunctioning of the mechanical and electrical components are potential problems associated with vacuum assist systems. Specific problems include: leaks at seals, fittings, and vents; mechanical failure of components; improper sequencing; loss of carbon sorbency; poor combustion conditions in afterburners; and failure to follow operating or maintenance procedures.

Vacuum-assist systems marketed by five manufacturers were investigated in this study. For convenience, in this report, the different designs studied will be identified by the names of the manufacturers. It should be noted that the manufacturer of the vacuum assist systems is not usually responsible for full service installations which include piping, electrical hook-up, P-V valves, nozzles, etc.

Illustrations shown are examples of the vapor recovery systems. The vendors will usually carry a line of varying sized units.

2. <u>Intermark Compression Refrigeration Condensation (CRC) System</u>

A system developed by Intermark Industries, Inc., depends upon compression and refrigeration to condense hydrocarbons from the gas stream. A unique feature is a surge tank for containing the air-hydrocarbon vapor until an appropriate amount for processing is accumulated.

Figure 2 is a schematic diagram of the Intermark Mark I system. Vapors are drawn from the nozzle by a blower; a tee provides for the return of vapor to the underground tank. Vapor laden air passing through the blower bubbles through liquid gasoline in the surge tank. This causes further gasoline evaporation if the air is not initially saturated. Within the tank, a flexible bladder moves a switch, activating the compressor of a refrigeration unit when a predetermined position is reached. Air and vapor are withdrawn from the surge tank, compressed and refrigerated, condensing the hydrocarbons to a liquid which is returned to the surge tank and thence to the storage tank.

Figure 2 also indicates the locations of points (x) which were monitored by the study team to detect possible leakage of hydrocarbon vapors, and the location of a pressure tap (p) which was installed to permit checking the bladder tank pressure at which the compressor was activated. New features since the TRW study were the addition of a vapor flow control valve and use of a different model compressor.

3. <u>Process Products Refrigeration/Adsorption System</u>

A system developed by Process Products, Inc. processes the vapor-laden air, first by condensation, then by adsorption. Figure 3 shows a schematic diagram of this system. Vapor-laden air is collected by means of a blower, located at the pump island, and is delivered to the underground storage

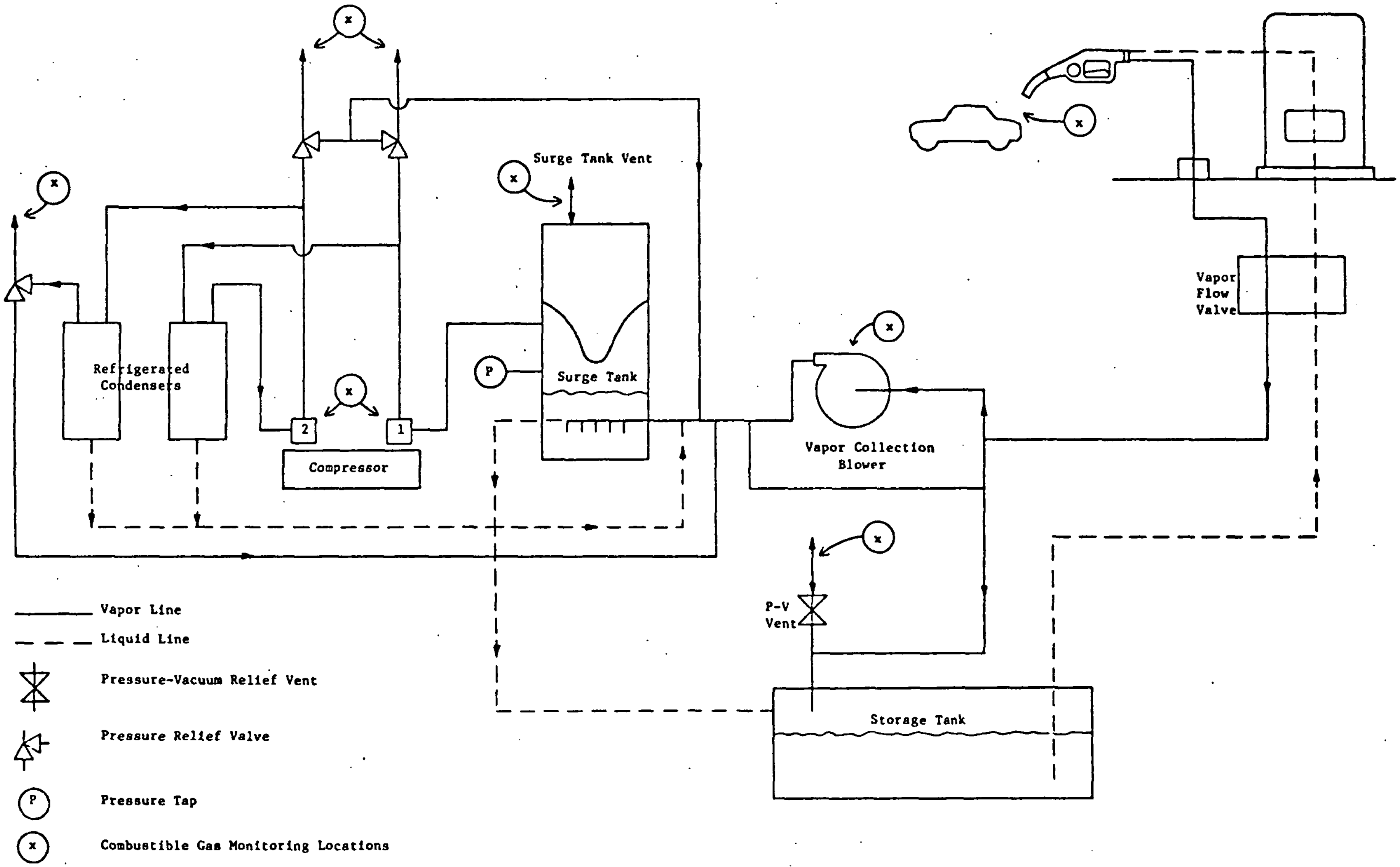


Figure 2. SCHEMATIC DIAGRAM OF INTERMARK SYSTEM (MARK I)

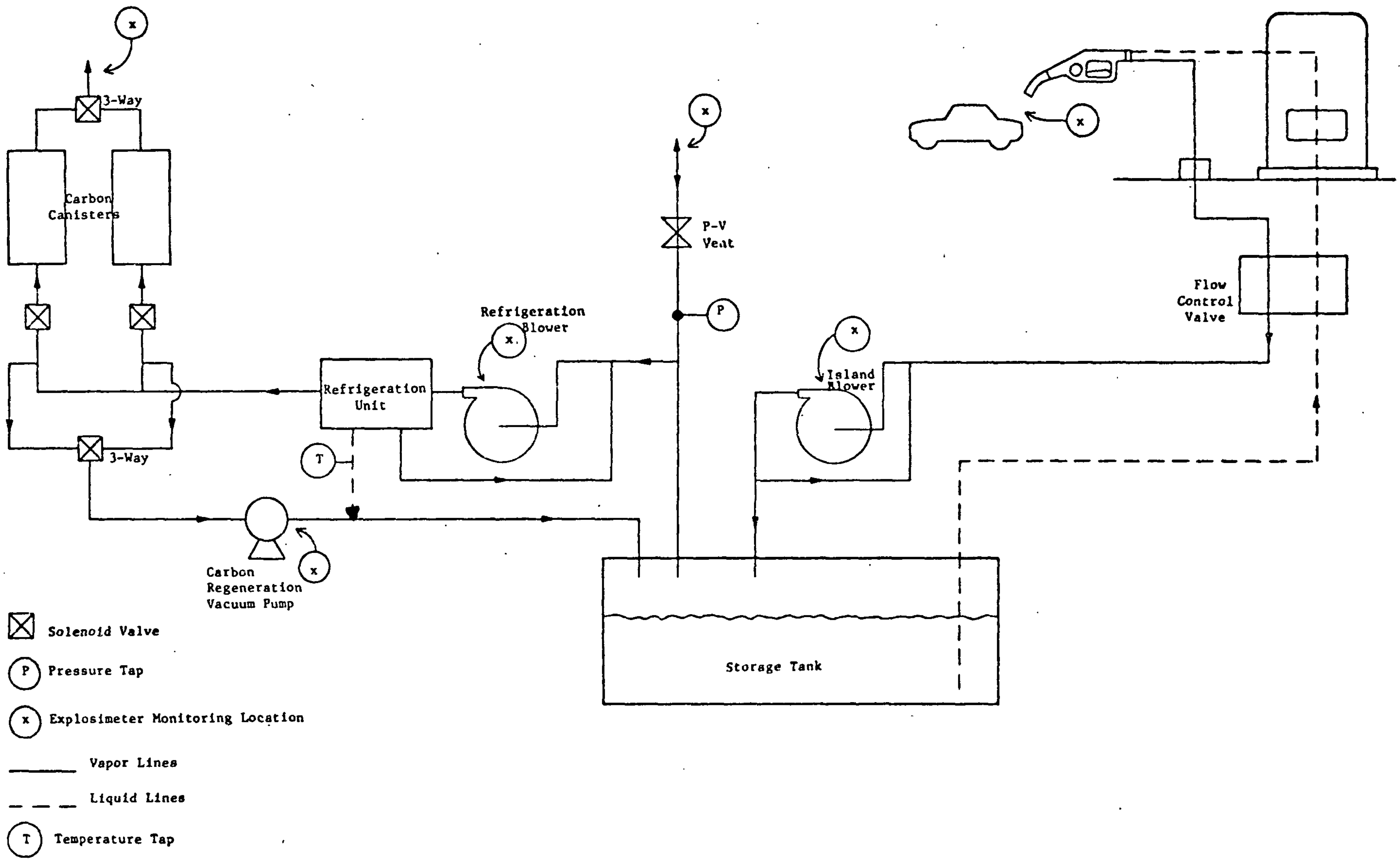


Figure 3. SCHEMATIC DIAGRAM OF PROCESS PRODUCTS SYSTEM

tank. When the pressure in the tank reaches a predetermined value, a second blower is activated, moving air from the tank to a refrigeration unit, from which condensate flows back to the storage tank. As shown in the schematic this model incorporates partial recirculation through the refrigeration unit. The air then passes through carbon beds, which remove much of the remaining hydrocarbons before venting to the atmosphere. When the tank pressure is reduced to another predetermined value, or after thirty minutes, the refrigeration blower is deactivated.

To regenerate the carbon, a pump evacuates the canister (one at a time), delivering the air and desorbed vapors to the air space of the storage tank. This operation is performed automatically, 30 minutes after the refrigeration blower is deactivated.

Figure 3 also indicates the locations of points monitored by the study team to detect possible leakage of hydrocarbon vapors, and the locations of pressure and temperature taps installed to determine tank pressure and condensate temperature. Information provided by the manufacturer indicated that the blower serving the refrigeration unit should be automatically activated when the tank pressure (gauge) reaches one inch of water, and deactivated when tank pressure falls to one half inch.

The condensate temperature is expected to be about 20°F. Modifications to this system since the TRW study consist of the replacement of the belt-driven blower by a direct drive blower and the routing of the refrigerated gas stream directly through the carbon canisters to the atmosphere instead of recycling to the underground tank.

4. <u>Clean Air Engineering Adsorption/Incineration System</u>

A system developed by Clean Air Engineering Inc. employs carbon canisters to adsorb vapors and direct flame burners to dispose of the hydrocarbons released when the sorbent is regenerated. A schematic diagram of the clean air model 5000B is shown in Figure 4. Vapor-laden air is collected by means of a blower and delivered to the processing unit. A tee connector ahead of the blower provides for drainage of any entrained liquid back to the storage tank. A second tee after the blower directs part of the vapor-laden air to the underground tank and the remainder to the processing unit. In the processing unit, activated carbon adsorbs hydrocarbons and the stripped air is vented. After 30 seconds of operation in this mode, a second blower is activated, which draws fresh air through the carbon canisters, delivering the desorbed hydrocarbons to a set of burners, where they are destroyed. Two stages of combustion are employed; the burning continues until the rate of desorption becomes too low to support combustion at either stage, at which time the second blower is deactivated.

Figure 4 also shows the locations of points monitored by the study team to detect possible leakage of hydrocarbon vapors, as well as the location of a pressure tap which was installed to permit checking pressures in the burner manifold. According to the manufacturer, this pressure should normally be maintained at 5 to 5 1/2 inches of water. The modification to this system since the TRW study consists of the replacement of the gasoline engine (which burned the vapors) by a direct-flame, two-stage burner.

5. <u>Environics Adsorption/Catalytic Incineration System</u>

A system developed by Environics, Inc. employs carbon canisters to adsorb vapors and a catalytic reactor to burn the hydrocarbons released when the sorbent is regenerated. A

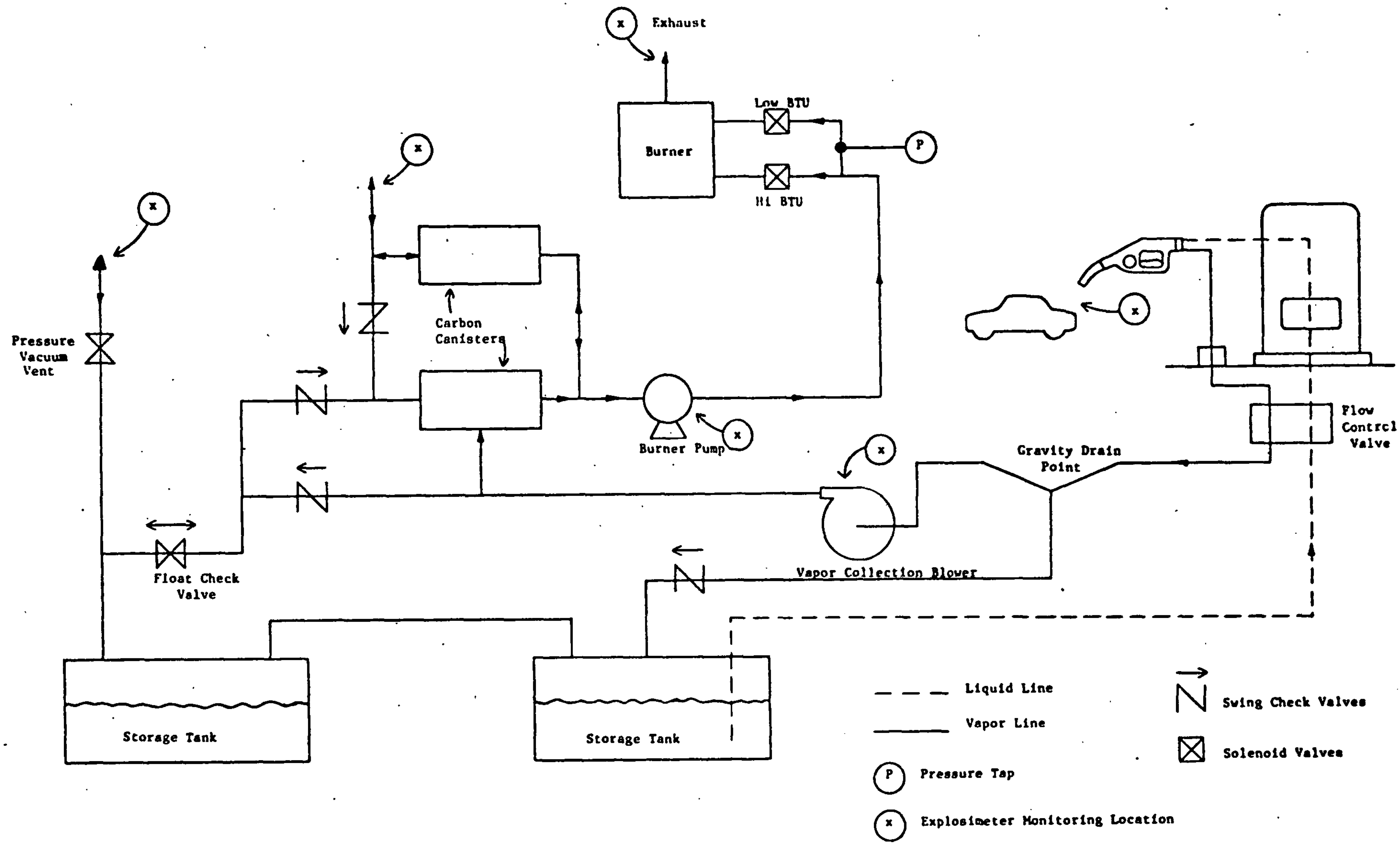


Figure 4. SCHEMATIC DIAGRAM OF CLEAN AIR ENGINEERING SYSTEM (Model 5000B)

schematic diagram of the Environics Model A-3000 is shown in Figure 5. Vapor-laden air is collected by means of a blower and delivered to the underground tank and to the processing unit. (Entrained liquid is trapped and drained to the storage tank).

In the processing unit, activated carbon adsorbs hydrocarbons and the stripped air is vented.

At regular intervals of about thirty minutes, one of two carbon canisters is individually flushed with clean air which carries desorbed vapors to the reactor after dilution with additional air, while the other canister is on stream. Cycling is accomplished by a system of solenoid values.

The reactor is designed to operate at temperatures between 900° and 1200°F. Preheating with an electric element initiates combustion when the unit is activated. When the feed becomes so lean that a temperature of 900°F cannot be maintained, the flushing is terminated. A temperature override switch is also provided, which deactivates the unit in case of overheating; this is set for a limiting temperature of 1300°F.

Figure 5 also shows the locations of points monitored by the study team to detect possible leakage of hydrocarbon vapors, as well as the locations of pressure and temperature taps installed to facilitate observation of the operating parameters of the system. According to information supplied by the manufacturer, a pressure-activated switch allowing the vapor-laden air to enter the carbon canisters should open when the pressure reaches 3 1/2 inches of water. The modifications to this system since the TRW study consist of: 1) the addition of a vapor flow control valve, 2) the rerouting of most of the vapors to the underground tank, and 3) the addition of a thermal overload switch to the reactor.

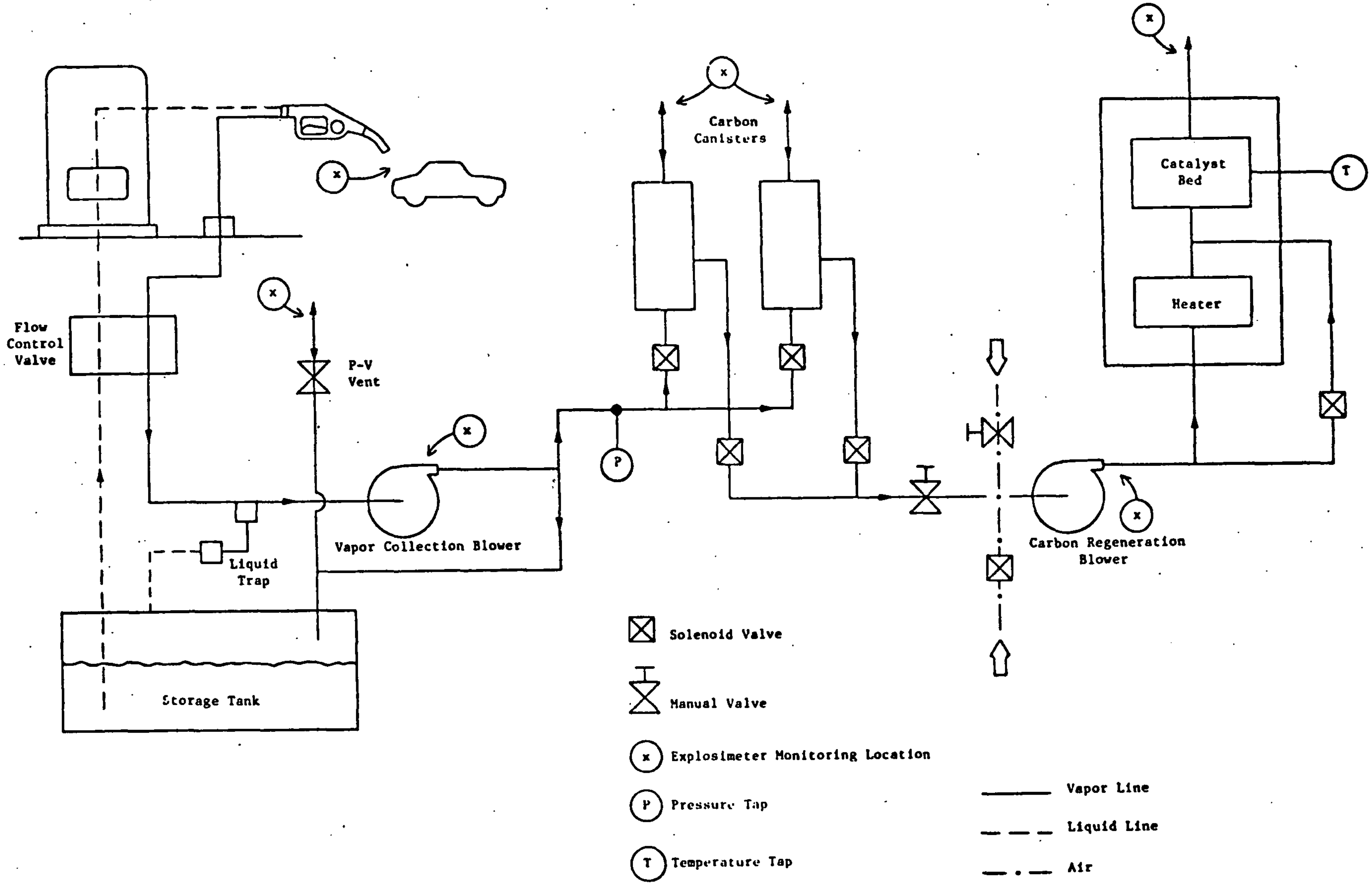


Figure 5. SCHEMATIC DIAGRAM OF ENVIRONICS SYSTEM (MODEL A-3000)

6. The Hirt System

A system developed by Hirt Combustion Engineers employs an air-actuated ejector to maintain negative pressure in the underground storage tank and burners to destroy the hydrocarbons which are carried through the system. A schematic diagram is shown in Figure 6.

Flow of compressed air is initiated whenever the absolute pressure (for clarity of discussion, performance in terms of absolute pressures is used; in practice, differential pressure actuators are used) in the tank rises above a predetermined absolute value. The air flows to a set of burners, entraining vapor-laden air from the tank. Combustion is initiated by a pilot light, fueled by propane; an alarm system notifies the station operator in case the pilot flame should fail. The compressed air flow is automatically halted when the absolute pressure in the underground tank falls below a preset value.

Figure 6 also shows the locations of points monitored by the study team to detect possible leakage of hydrocarbon vapors, as well as the locations of existing pressure taps which were used to check on pressures in the storage tank and in the compressed air system. In the single system observed in this study, the preset levels were -0.58 inches of water to activate compressed air flow, and -0.61 inches to deactivate it. This system was designed and built since the TRW study.

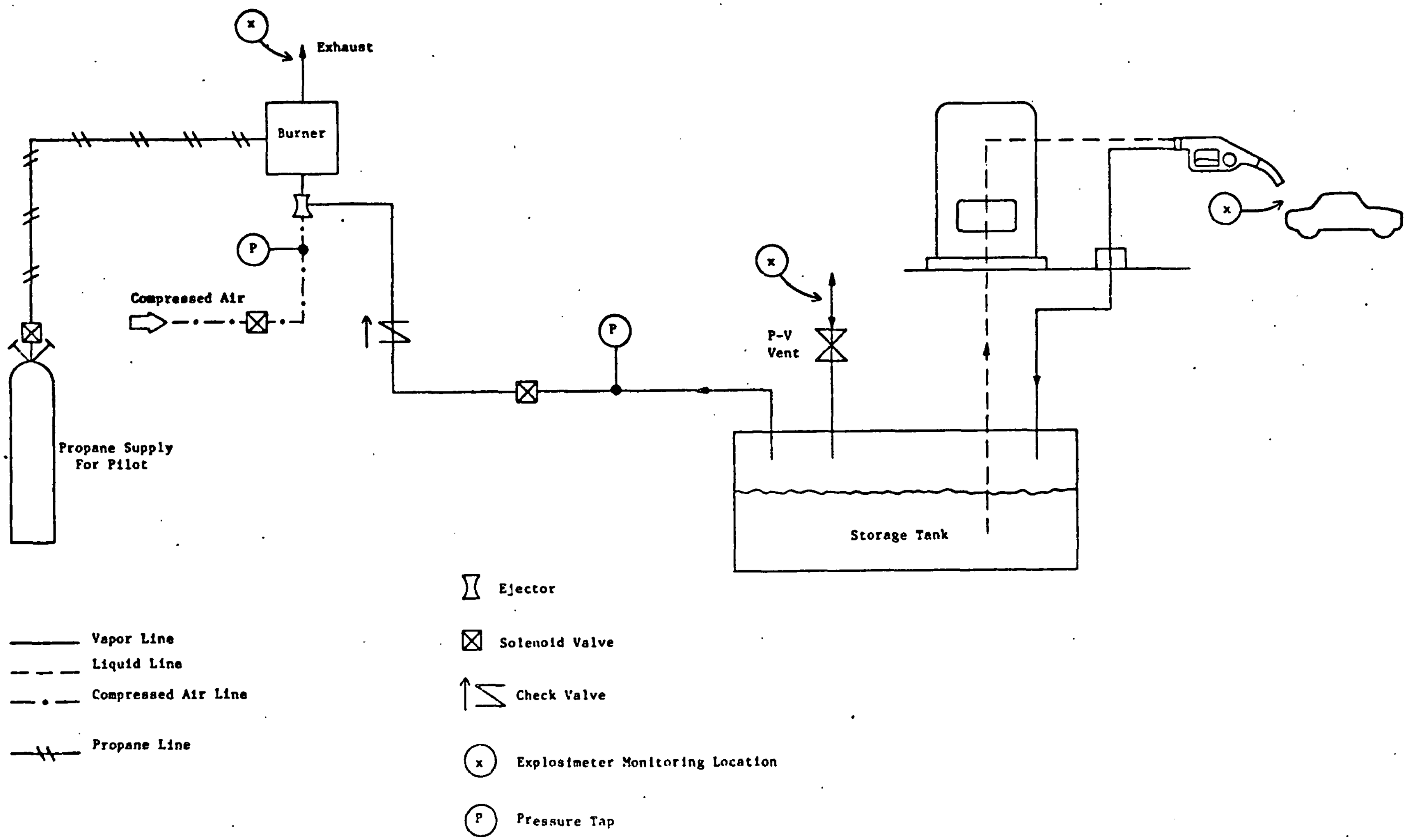


Figure 6. SCHEMATIC DIAGRAM OF HIRT SYSTEM

III. METHODS AND EQUIPMENT

A. THE STUDY PLAN

The basic study plan was to undertake repeated inspection of the operational status of vapor-recovery systems and components at a selected group of gasoline filling stations, to identify reliability problems and to monitor parameters which affect vapor control at these stations. Using a combustible gas indicator the frequency and approximate magnitude of vapor losses were to be checked at delivery nozzles during vehicle service and at potenital leakage points associated with the various recovery systems. As discussed below, there were several criteria used for inclusion of stations in the study, which included selection from a list of stations which had permits to operate as supplied by San Diego County.

Inspection procedures were developed taking into account the configuration of the vapor recovery system and were designed for one visit per station per week. These visits were performed on varying days and at varying times during the day (inspection visits made only during daylight hours).

B. STATION SELECTION

Information necessary for selecting the stations to be studied, as well as for designing inspection forms, checklists and other program elements, was obtained at meetings and interviews with representatives of the vapor recovery system manufacturing companies, the San Diego County Air Pollution Control District, the U.S. Environmental Protection Agency, and others. The original selection plan called for five stations for each of the manufacturers or types of control systems represented in the general study protocol. These stations were to have throughputs of at least 30,000 gallons per month. In order to have sufficient repeat visits, not all operating systems of some manufacturers were included. For other manufacturers where the available number of stations was small, some units which were expected to be in operation soon were included. It was not possible to meet the 30,000 gallons/month minimum criteria in all cases, but most of those which had lower monthly throughputs, did dispense high volumes at certain times of day, associated with shift changes. These stations were non-commercial, self-service stations operated by government agencies or local enterprises with large vehicle fleet operations, such as Stations 16 and 21, of the California Highway Patrol; Station 15, the U.S. Postal Service; and Station 3, for Terminix Pest Control. Station 22 was included because it was the only available example of the Hirt Combustion Engineers vapor control system. Table 1 lists the stations selected, the type of control system used, and other pertinent information.

As shown in Table I, monthly throughput observed during the study ranged from 4,600 to 212,500 gallons but most of the stations ranged between 15,000 and 90,000. The number of vapor-control units representing each type of system was either 4 or 5, except for the single Hirt system installation.

C. INSPECTION FORMS

Using information obtained in the preliminary meetings and interviews, the study team developed an inspection strategy for each type of control system, involving determination of the operational status of the unit, observation of the operational sequence, and tests for hydrocarbon leakage at various appropriate points. For each type of system, an inspection form was designed for recording information to be acquired on each inspection visit. These forms are exhibited in Appendix A; they served as a check list of inspection points, as well as a field record.

Table 1. FILLING STATIONS SELECTED FOR STUDY*

Station No.	Control System	Supplier	No. of Pumps	Throughput, Gallons/mo.	Locality
1	Process Products	Standard	9	44,700	Clairmont, and Clairmont Mesa, San Diego
2	Clean Air Eng.	R.H. Dairy	4	20,500	Mt. Ada Road, San Diego
3	Environics	Terminix	2	4,600	Vickers and Mercury, San Diego
4	Clean Air Eng.	Standard	6	87,100	Tierrasanta Blvd. San Diego
5	Process Products	Union	8	25,100	Waring Rd., San Diego
6	Vapor-balance	Standard	10	44,600	Baltimore and Lake Murray, La Mesa
7	Environics	Texaco	8	36,400	Baltimore and Fletcher Parkway, La Mesa
8	Intermark	Sears	8	72,900	Johnson and Fletcher Parkway, El Cajon
9	Process Products	Standard	12	52,400	Johnson Ave., El Cajon
10	Process Products	Mobil	8	60,900	University and College, San Diego
11	Intermark	Gemco	16	212,500	30th and Highland, National City
12	Vapor-balance	Gulf	6	39,000	University and 40th, San Diego
13	Vapor-balance	Gulf	6	53,000	University and Boundary, San Diego
14	Vapor-balance	Gulf	13	63,800	Texas and El Cajon, San Diego
15	Environics	Post Office	2	19,200	Midway Drive, San Diego
16	Clean Air Eng.	Highway Patrol	2	36,100	Pacific Highway, San Diego
17	Clean Air Eng.	Dep't. of Educ'n		n.a.	Linda Vista Rd., San Diego
18	Process Products	Standard	10	36,000	Friars and Frazee, San Diego
19	Intermark	Standard	12	153,200	Carmel Valley Rd., San Diego
20	Intermark	Union	10	63,500	Santa Fe Dr., Encinitas
21	Clean Air Eng.	Highway Patrol	2	16,300	Oceanside Blvd., Oceanside
22	Hirt	Phillips	6	12,500	Mission and Canyon, Oceanside
23	Environics	Phillips	6	68,300	Elm and Harding, Carlsbad
24	Environics	Union	12	80,000	6th and Robinson, San Diego

*Not all the stations had completed installations when the study started, but completion was expected soon. The systems at Stations 10 and 19 were not completed during the study. Station 17 was dropped when it became apparent that the monthly throughput was substantially less than had been expected.

D. INSPECTION PROCEDURE

On each inspection visit, the study team announced their presence to the station manager and inquired about the operational status and recent experience with the control system. If the unit was operational, an operation sequence check was performed, and relevant pressures and temperatures were measured and recorded. Serial numbers of component machinery (blowers, compressors, pumps, refrigeration units) were recorded and any replacements noted. Combustible vapor readings were taken at all prescribed locations. In most cases, a number of vehicle tank fillings were monitored for hydrocarbon vapor losses, using a combustible gas meter. The probe tip was moved in a circular motion around the nozzle-filler tube interface at a distance of one half inch. Information on the station's throughput of gasoline was recorded, and the operator's comments colicited, before terminating the inspection.

E. EVALUATING OPERATIONAL STATUS

On each visit to each station, the study team was required to determine whether the vapor control system was operating in accord with design specifications. This was done by observing the performance of the various elements of the system to answer the questions listed under "Operational Sequence Check" on the corresponding inspection form (Appendix A).

For each of the vacuum-assist systems, pressures within the system were measured at strategically located pressure taps as indicated in the schematic diagrams, Figures 2 to 6. Magnehelic gauges having a sensitivity of 0.01 inch of water were used, with self-sealing, quick-connecting Imperial Eastman fittings. With two of the systems, temperatures were also determined. For this purpose thermocouples were used, and the potentials generated were measured with a portable potentiometer (Thermo-Electric Co., Model 31101, "Minimite").

F. DETECTION OF HYDROCARBON VAPOR LEAKAGE

An important aspect of the inspections was the detection of leaks. For this purpose the study team used a Combustible Gas Analyzer, Model SSP, manufactured by Bacharach Instrument Co., with scales reading from 0 to 1000 ppm and from 0 to 1.0 relative to the lower explosive limit (L.E.L.). Readings were taken at the points indicated in Figure 1 through 6 on each visit to each station, and at the fillneck of the vehicle tank for each of the several cars served by the station on each visit.

For studying the effectiveness of the carbon adsorption systems (in removing hydrocarbons from the exhaust air), hydrocarbon detectors were installed at two stations for each of the three vapor-control systems (Process Products, Clean Air Engineering, Environics) which incorporate adsorption. These devices were of two designs. The first, or "latching" type triggers a timer whenever the hydrocarbon concentration exceeds the set point, 1.2 percent or 12,000 ppm, V/V. The second, or "non-latching" type similarly triggers a timer at the set-point but, unlike the first, the timer is stopped whenever the hydrocarbon concentration subsequently falls below the set-point. The timers were checked, readings recorded, and instruments re-set if necessary at each inspection of the six selected stations.

There were several purposes for installation of the hydrocarbon detectors: 1) to indicate whether any hydrocarbon leakage above the set point occurred during normal operation, 2) to indicate whether the carbon beds saturate before regeneration, and 3) to indicate whether high molecular weight hydrocarbons build up on the carbon beds and reduce capacity.

G. PERFORMANCE EVALUATION

For purposes of performance evaluation, effectiveness of vapor collection at the vehicle fuel tank was considered separately from performance of the vapor recovery system itself. That is, it would be possible for a system to be nearly completly effective in vapor collection and yet perform poorly in processing these vapors so as to prevent their discharge to atmosphere. For purposes of evaluating reliability of the processing equipment the term malfunction is defined to include both demonstrable malfunction of a component or evidence of a hydrocarbon loss exceeding 100 ppm (the minimum detectable concentration) using a combustible gas analyzer.

IV. RESULTS AND DISCUSSION

A. GENERAL

During the study, 140 inspection visits were made to the stations listed in Table I, and 506 vehicle fillings monitored. The data on vehicle fillings are shown in Appendix B. In the great majority (88 percent) of visits to vacuum assist stations, some malfunction was detected; in only 14 of 115 visits were the vacuum assist systems found to be operating in accord with the manufacturer's specifications and free from hydrocarbon vapor losses. If the stations which did not operate during the entire study period are excluded, malfunctions were detected in 84 percent of the visits (14 of 89 visits).

Since the magnitude of the losses could not be determined, the results of the study are here presented and discussed in terms of frequency of occurrence of combustible vapor readings relative to certain benchmarks, namely, 100 ppm hydrocarbon (lower scale of the indicator); 0.1 LEL (one tenth of the lower explosive limit, as shown on the upper scale of the indicator); and 0.6 LEL. The 0.1 LEL criterion is based upon an EPA finding which stated when there were no leaks at the nozzle/fillneck interface, hydrocarbon concentrations did not exceed 0.1 LEL. The 0.6 LEL criterion is the upper limit allowed by the San Diego County Air Pollution Control District.

Table II shows for each type of control system, the frequency of inspection, the number and percent of the visits on which the control system was found to be operating correctly and without leaks, the number of vehicle fillings observed and the number and percent of vehicle fillings in which hydrocarbon vapors were not detectable. The four vapor-balance systems, having far fewer mechanical components, evidenced no equipment failures, and since no potential leakage points were accessible for testing, no instances of faulty operation were observed. However, the vacuum-assist systems, when operating correctly, were much more effective in controlling vapor losses at the nozzle.

Table II. SUMMARY OF INSPECTIONS

Control System	in Study	No. of Visits	Correct Operations[a] No.	Correct Operations[a] %	Vehicle Refuelings No. of of Obs. Vehicle Fillings	Vehicle Refuelings No. with No HC loss[b]	Vehicle Refuelings %
Vapor-balance	4	25	25	100[c]	105	21	20
Intermark	4 (3)[e]	25 (19)	0	0	85 (70)	46	54(66)
Process Products	5 (2)	35 (15)	4	11 (27)	120 (57)	67 (49)	56(86)
Clean Air Eng.	4	26	3	12	104	77	74
Environics	5	23	1	4	78	24	31
Hirt	1	6	6	100[d]	14	10	71
All Vacuum Systems	19 (15)	115 (89)	14	12 (16)	401 (323)	224(206)	56(64)
All Systems	23 (19)	140 (114)	39	28 (34)	506(468)	245(227)	48(53)

a: For this tabulation "Correct Operations" indicates that the operational sequence followed the manufacturer's specifications and that no combustible vapors (hydrocarbon losses) could be detected at preselected check points.

b. This column indicates the number of fillings observed in which hydrocarbon losses could not be detected; that is, the combustible gas analyzer registered no vapor concentration above its lower detectable limits (100 ppm)

c. At the stations with vapor-balance systems, operated by Gulf Oil Corporation, clear plastic tubing was installed in the vapor return lines at the beginning of the study. These were intended to permit visual inspection of the lines for possible blockage by accumulated liquid gasoline. After about three weeks this tubing was replaced by ordinary opaque tubing, when it was found that the clear plastic deteriorated rapidly and was easily kinked, causing unsatisfactory operations of the system. It should be noted that when the clear plastic tubing was installed, vapors could be seen to easily bubble through any liquid blockage that did occur.

d. Although the Hirt system was always operational, the observed frequency of cycling- about once per minute - suggests that air leaks into the system may have been triggering operation more often than satisfactory vapor loss control would require.

e. Numbers in parentheses denote totals if stations not operating during the study period awaiting retrofit are excluded.

Total system efficiency is not a direct function of nozzle losses as the excess air/vapor ingested and the vapor processing unit efficiency must also be considered.

B. SYSTEM MALFUNCTIONS

During the 115 inspection visits to stations with vacuum assist systems, 174 instances of specific malfunctions were observed, as listed in Table III. The only evidence of malfunction was, in 130 instances, observation of hydrocarbon losses at one of the testing locations specified on the inspection forms. Such malfunctions did not necessarily interfere with the continued operation of the system, but did impair the effectiveness of vapor control. In 36 instances, the systems were inoperable or were, for other reasons, not in operation at the time of the inspection visit. The distribution of these 36 malfunctions is shown in Table IV. In only 9 of these instances (8 percent of the visits) were equipment failures the immediate cause of the shutdown. Another 15 instances were due to failure of station personnel to activate either the vapor collection device or the entire system. In the remaining instances, disconnected vacuum hoses were responsible 8 times, and automatic shutdown due to overheating of a catalyst reactor occurred 4 times. Thus, although the control equipment was out of operation on approximately one third of all the inspection visits, only one third of these instances (13, or 11 percent of the visits) were attributable to system failures. In another 8 instances, the systems were operable but an indication of a malfunction was described by the station operator (4 instances of excessive cycling resulting in extremely high electric bills, 4 instances of poor ITT valve adjustment).

On 14 other inspection visits the systems were inoperable due to the fact that equipment installation had not been completed. Of these visits, 7 occurred at one station where the processing unit had been disconnected because of a fire and not reconnected. The

Table III. FREQUENCY OF OCCURRENCE OF SPECIFIC MALFUNCTIONS AT VACUUM ASSIST STATIONS

Hydrocarbons observed at blowers and pumps	33
Hydrocarbons observed at underground tank vent	25
Hydrocarbons observed during burner ignition	19
Hydrocarbons observed at surge tank vent	13
Hydrocarbons observed at carbon canister vent	9
Unit turned off	8
Vacuum hoses disconnected	8
Hydrocarbons observed at reactor vent	7
Hydrocarbons observed at condenser relief vent	7
Island blower not on	7
Hydrocarbons observed at piping connection	6
Hydrocarbons observed at compressor	6
Hydrocarbons observed at compressor relief vents	5
Poor ITT valve adjustment	4
Unit off due to temperature override	4
Broken blower belt	4
Constant cycling by unit controls	4
Blower motor failure	3
Unit down due to compressor failure	2
Total	174

Table IV. FREQUENCY OF CAUSES OF FAILURE TO OPERATE AT VACUUM ASSIST SYSTEMS

1.	Unit turned off	8
2.	Vacuum hoses disconnected	8
3.	Vapor-collection blower turned off	7
4.	Broken blower belt	4
5.	Automatic temperature cutoff	4
6.	Blower motor failure	3
7.	Compressor failure	2
	Total	36

other 7 instances were noted at another station where installation of a new compressor had not been completed. Table V lists the observed malfunctions by manufacturer.

Hydrocarbon losses, evidenced by testing with the combustible gas analyzer, were predominantly associated with, or caused by equipment failure, as shown in Table VI. Approximately two thirds of the observations appeared to be attributable to such failures. The cause of hydrocarbon observations at the underground tank vent could be attributed to bulk drops in only 10 percent of these occurrances. Other causes were incomplete or faulty installation, as well as improper adjustment or failure to use the equipment properly. About twenty percent of the hydrocarbon loss observations occurred during normal system operation. These included small losses at the Clean Air Engineering burners prior to ignition, and at the reactor vent of the Environics system. Such losses ordinarily do not continue for any protracted period.

C. MEASURED OPERATIONAL PARAMETERS

Pressures and temperatures recorded at the taps described, for the various vacuum-assist vapor control systems, were compared with the values specified as standard by the manufacturers, as given in Section II. Notes reflecting the observations on these parameters are presented in Appendix C.

For the Intermark System, no pressures or temperatures in the CRC unit or bladder tank were specified. Pressures as high as 7.5 inches of water in the surge tank were observed when the bladder was fully distended. When the level indicator registered about one eighth of capacity, observed pressure ranged from about 0.5" to 2.0".

With the Process Products systems, only two of the stations provided useful data; the other units were inoperative most of the time, awaiting delivery of vapor collection blowers. The two operating

Table V. FREQUENCY OF OCCURRENCE OF SPECIFIC MALFUNCTION BY MANUFACTURER

ENVIRONICS - 23 visits

HC at Reactor vent -	7
HC at Carbon Canister Vent -	6
HC at Underground Tank Vent -	6
HC at Blowers and Pumps -	6
Unit Off Due To Temperature Override	4
Poor ITT Valve Adjustment -	4
Blower Motor Failure -	3
HC at Unit Piping -	2
Vacuum Lines Disconnected -	2
Unit Turned Off -	1
	41

PROCESS PRODUCTS - 35 visits

HC at Underground Tank Vent -	15
HC at Blowers and Pumps -	14
Island Blower Not on -	7
Processing Unit Not on -	6
Excessive Cycling -	4
HC at Carbon Canister Vent -	3
HC at Unit Piping -	1
	50

PROCESS PRODUCTS (St #5 and St #18 only) - 15 visits

HC at Underground Tank Vent -	5
HC at Blowers and Pumps -	4
HC at Carbon Cannister Vent -	3
Excessive Cycling -	3
	15

Table V. FREQUENCY OF OCCURRENCE OF SPECIAL MALFUNCTION BY MANUFACTURER (continued)

INTERMARK - 25 visits

HC at Surge Tank Vent -	13
HC at Blowers and Pumps -	8
HC at Condenser Relief Vent -	7
HC at Compressor -	6
Vacuum Lines Disconnected -	6
HC at Compressor Relief Vent -	5
Broken Blower Belt -	4
HC at Unit Piping	3
HC at Underground Tank Vent -	2
Compressor Failure -	2
	56

CLEAN AIR - 26 visits

HC at Burner Exhaust During Ignition	19
HC at Blowers and Pumps -	5
HC at Underground Tank Vent -	2
Unit Off -	1
	27

HIRT - 6 visits

Unit prone to vacuum leaks which cause unit to fire approximately every minute.

Table VI. FREQUENCY OF CAUSES OF HYDROCARBON LOSSES AT VACUUM ASSIST STATIONS

	Number Observed	Per Cent of Total
Malfunctions due to equipment failure	52	37.7
Malfunctions as consequence of equipment failures*	46	33.3
Malfunctions inherent to systems (i.e., hydrocarbons observed at burner ignition are usually very small and last for less than 30 seconds).	26	18.8
Malfunctions due to poor installation	6	4.4
Malfunction due to improper unit adjustment	8	5.8
Total	138	100.0

*Example:

Failure of equipment may cause underground tank pressure to increase if blowers are operating but no processing is taking place. This will force venting and hydrocarbons will be detected at the underground vent.

units had slightly different settings, but pressures showed consistent behavior from week to week. At Station 5, the refrigeration unit was found to start at pressures ranging from 3.5 to 4.5" and to stop at pressures ranging from 0.2 to 1.0" H_2O. At Station 18, the unit started at 1.0 to 1.1" and stopped at 0.3 to 0.5" H_2O. (Manufacturer's information suggested start and stop pressures of 1" and 0.5" H_2O, respectively). The condensate temperature was measured only at Station 18 and was found to vary from 12 to 40^{o}F (expected was about 20^{o}F).

For the Clean Air Engineering systems, design pressure at the burner manifold was 5 to 5 1/2" w.c. Stations 16 and 21 operated consistently within this range. Station 2, for unknown reasons, operated at pressures ranging from 4" to 15", while Station 4 operated in the range of 3.2" to 3.5". The burner system at the latter station had reportedly been readjusted and the manifold pressure reduced in an attempt to control accumulation of soot in the burner.

In the Environics System, the pressure-actuated switch was expected to open at 3.5" H_2O w.c. In actual operation, the switches opened at lower pressures; 2.6" in one case, 1.6" in another. Reactor temperatures also were sometimes found outside the range (900-1200^{o}F), expected for the automatic controls. In one case the reactor pump started when the reactor was at a temperature of 1290^{o}F and continued running until the reactor temperature dropped to 740^{o}F. In another, the reactor was at 848^{o}F when the pump started, and at 760^{o}F when the pump stopped.

In the single Hirt system installation (Station 22), the small burner and the compressed air flow were usually, but not always, activated at -0.58" H_2O; on one visit, the observed activation pressure was -0.61". The burner system was deactivated at -0.61" to -0.65". The controls for these pressures are accessible to station personnel and may occasionally have been adjusted by them.

With respect to the vacuum-assist systems as a group, it appears that the operating parameters are not consistently maintained within design limits; however, the extent to which this lack of control may adversely affect vapor control cannot be assessed from the data obtained in this study.

D. HYDROCARBON LOSSES ON FILLING VEHICLE TANKS

As indicated in Table II, no leaks were detected at the nozzle-fillneck interface in about half of the observed vehicle fillings. The actual fraction was 20 percent with vapor-balance systems, and from 31 to 74 percent with the various vacuum-assist systems, averaging 56 percent for all vacuum-assist units.

A higher proportion of no leak fills is evident if attention is directed only to occasions when the study team found on checking, that the vapor collection blower was operating. Also deleted in this consideration are the stations where the operators complained of poor vapor collection due to poor ITT valve adjustment. About one fourth of the fillings are excluded by this condition. Among those that remain, the proportion of successful control was from 71 to 89 percent with the various vacuum-assist systems, averaging 79 percent.

The proportion of successful control will, naturally be higher, also, if "successful" is defined more leniently. Although the combustible gas analyzer could not be used for a quantitative determination of vapor losses, it seems likely, on the whole, that when higher vapor concentrations are detected, they correspond to greater vapor losses. Also it is possible that vapor losses at times might be negligible, even though detectable with the analyzer.

Accordingly, Table VII lists the results of the refueling checks where hydrocarbon concentrations at the nozzle-fillneck interface were less than three different criterion levels. These were 100 ppm, 0.1 LEL, and 0.6 LEL, respectively. (For gasoline vapors,

Table VII. FREQUENCIES OF OBSERVED CONCENTRATIONS OF HYDROCARBONS AT NOZZLE-FILLNECK INTERFACE AT SELECTED VEHICLE FILLINGS*

MANUFACTURER	Number of Fillings*	Frequency below given level					
		≤100 ppm		≤0.1 LEL[a]		≤0.6 LEL[a]	
		No.	Percent	No.	Percent	No.	Percent
Vapor Balance	105	21	20	40	38.1	43	41.0
Intermark	52	46	88.5	49	94.2	49	94.2
Process Products	57	49	86.0	51	89.5	51	89.5
Clean Air	104	76	73.1	86	82.7	89	85.6
Environics	28	20	71.4	23	82.1	23	82.1
Hirt	14	10	71.4	13	92.9	13	92.9
All Vacuum Systems	255	201	78.8	222	87.1	225	88.2
All Systems	360	222	61 7	262	72.7	268	74.4

* Fillings when vapor collection system of nozzle was operating correctly

a. LEL: Lower explosive limit

the lower explosive limit is approximately 1.2 percent by volume, or 12,000 ppm, V/V.) These figures refer only to those fillings in which the avpor collection system, at the nozzle, was operating as stated above. They show that, of 268 cases with concentrations below 0.6 LEL, 262 or only six less, were also below 0.1 LEL. The number of cases with concentrations below 100 ppm, however, dropped to 222.

Judged at the 0.1 LEL criterion level, as Table VII shows, the vapor-balance systems are far less effective than vacuum-assist systems in capturing vapors during the filling of vehicle tanks. Thirty-eight percent of the fillings with vapor-balance systems were below this level while the corresponding proportion for various vacuum-assist systems, when operating properly, was from 82 to 94 percent.

E. EFFECTIVENESS OF SYSTEMS WHEN OPERATING OPTIMALLY

Since both system malfunctions and operator inattention can prevent vapor-control systems from operating at full efficiency, it is of interest to examine the study data to determine what degree of effectiveness can be observed at those stations where these problems were least apparent. Table VIII shows, for each type of system, the record of successful capture of vapors at the nozzle using three different criterion levels, for the single station having the best record.

With the vapor-balance system, the best record of capture at the 0.6 LEL criterion level was slightly over 50 percent. With vacuum-assist systems, however, four of the five systems demonstrated better than 95 percent success in limiting nozzle losses to the 0.6 LEL criterion level.

Table VIII. DEGREE OF CONTROL ACHIEVED WITH VAPOR-CONTROL STATIONS OPERATING OPTIMALLY

System	Station[a] I.D. No.	No. of Fillings Observed	Tests showing less than					
			100 ppm		0.1 LEL		0.6 LEL	
			No.	%	No.	%	No.	%
Vapor-balance	6	29	10	34	13	45	15	52
Intermark	11	37	34	92	35	95	36	97
Process Products	5	24	23	96	23	96	23	96
Clean Air Eng.	21	19	18	95	19	100	19	100
Environics	3	8	5	63	6	75	6	75
Hirt	22	14	10	70	11	77	14	100

a. Station showing the highest proportion of reliable operation (fewest malfunctions or hydrocarbon leaks) during the study period.

F. EFFECT OF NOZZLE TYPE ON VAPOR LOSSES (WITH VAPOR-BALANCE SYSTEMS)

An insight into the possible importance of seemingly minor details of system construction was fortuitously furnished as the result of a system change which occurred during the study. About three weeks after the beginning of the study, many of the original nozzles of the vapor balance systems were replaced by new nozzles. The new design incorporated a metal disc and Teflon seat, a device intended to provide an improved seal between the nozzle and the fillneck while avoiding undue stress on the rubber boot sheathing the nozzle. Both were manufactured by the same firm.

A comparison of the results obtained before and after the change shows clearly that the performance of the new nozzles was inferior to that of the old. The results are shown in Table IX. With the original nozzles, vapor losses were detected in slightly more than half the fillings (55 percent); with the new nozzles, the proportion rose to over 90 percent. With the original nozzles, fewer than one fourth of the losses (23 percent) reached the 0.6 LEL criterion; with the new nozzles, more than three quarters (78 percent) did so.

G. EFFECT OF ATTENDANT SERVICE VS. SELF-SERVICE ON VAPOR LOSSES

Several stations included in the study permitted customers to use the pumps to fill their own vehicle tanks. Table X shows, for each type of vapor control system, a comparison of the vapor loss experience in such stations with the experience where service was performed by attendants; the data used in compiling the table are taken only from those inspection visits on which the vacuum system was operating satisfactorily. For Intermark and Clean Air Engineering control systems, vapor losses were observed in a smaller proportion of fillings at self-service stations than at other stations. For Environics and vapor-balance systems, the reverse was true.

Table IX. FREQUENCIES OF OBSERVED CONCENTRATIONS OF HYDROCARBONS AT NOZZLE-FILLNECK INTERFACE EXCEEDING VARIOUS CRITERION VALUES, WITH DIFFERENT NOZZLES (VAPOR-BALANCE SYSTEMS)

Nozzles[a]	Number of Fillings	Frequency of Exceeding Level 100 ppm		0.1 LEL[b]		0.6 LEL[b]	
		No.	Percent	No.	Percent	No.	Percent
Original	31	17	55	9	29	7	23
Replacement	74	67	91	59	80	58	78

a. The original nozzles were OPW Model 7VN the replacements were OPW Model 7VP

b. LEL: Lower explosive limit

Table X. VAPOR LOSSES OBSERVED AT SELF-SERVICE AND ATTENDANT-SERVICE STATIONS

Control System	Self-Service			Attendant-Service		
	Number of Fillings	Losses[a] Observed	Per Cent	Number of Fillings	Losses[a] Observed	Per Cent
Intermark	37	3	8	15	3	20
Clean Air Eng.	48	9	19	56	17	30
Environics	9	4	44	19	4	21
Vacuum-Assist Subtotal	94	16	17	90	24	27
Vapor-Balance	45	41	91	60	43	72
All	139	57	41	150	67	44

a. Criterion is detection of hydrocarbons at 100 ppm or above

These differences are not statistically significant and, therefore, furnish no clear evidence that vapor losses at the nozzle are either more or less likely when vehicles are serviced by their drivers than when service-station attendants perform the operation.

H. EFFECT OF VEHICLE FILLNECK CONFIGURATION ON VAPOR LOSSES

In testing the vapor losses on filling vehicle tanks, it was obvious that observed losses were sometimes caused by difficulty of fitting the nozzle to the fillneck, due to unusual and inconvenient configurations of the fillneck or obstructions on the vehicle. Such occurrences were noted on the inspection records.

About forty such observations were recorded, or less than ten percent of the 506 fillings observed. A list of the vehicle models and model-years involved is given in Appendix D, which shows that automobiles of at least eleven manufacturers exhibited poor fits. Only one model (the Chevrolet Corvette) appears more than once in the list. It is therefore apparent that the problem, although a relatively minor one, is likely to be widely encountered.

I. LIQUID LOSSES IN FILLING VEHICLES

A condition known as "spitback" or "spillage", in which liquid gasoline is lost from the tank either after the nozzle is withdrawn from the vehicle fillneck or during filling, was observed by the study team in eight instances, while monitoring more than 500 vehicle fillings. This corresponds to an overall frequency of 1.6 percent. Of these 8 instances, 3 occurred with vapor-balance systems (3 in 105 fillings) and 5 with vacuum-assist systems (5 in 401 fillings).

Some station managers and operators have expressed concern about possible losses of liquid into the vapor line, from which the liquid would drain, unobserved, into the storage tank. The occurrence of spitback may appear to lend substance to these concerns in some cases. However, the study team was unable to detect such liquid losses, and no conclusion can be reached as to whether they occurred during the course of the study.

J. VAPOR LOSSES THROUGH CARBON CANISTERS

Six hydrocarbon detectors were installed at stations with vaccum-assist systems containing carbon canisters. The data are shown in Appendix E. At one station, the detector circuit was tripped shortly after installation, indicating some vapor loss i.e. in excess of 1.2% by volume. After the detector was reset on the next inspection visit, no further losses were detected. However, the vapor control system was not actually in operation during most of the time monitored. At another station, a detector having the accumulating record feature showed a total activation time of 2.6 hours during six weeks of monitoring.

The two observations described occurred at stations equipped with the Environics system. None of the other detectors showed any indications of vapor losses through the carbon canisters.

V. CONCLUSIONS

A. EFFECTIVENESS OF VAPOR RECOVERY SYSTEMS IN CAPTURING HYDROCARBON VAPORS WHEN FILLING VEHICLE TANKS

1. The study demonstrated that several vacuum-assist vapor recovery systems, when operating optimally, can be effective in capturing gasoline vapor losses at the nozzle-fillneck interface. In more than 90 percent of vehicle fillings in large retail gasoline outlets measured hydrocarbon levels near the nozzle were less than 0.6 LEL. In contrast, vapor-balance systems, at best, prevented losses in only about half of the fillings.

2. Under conditions of this study, vacuum-assist vapor recovery systems are found to be non-operational more than vapor-balance systems. When the vacuum-assist stations were not operating, the vapor balance systems were found to be more effective in control of vapors at the nozzle/fillneck interface.

3. Vapor capture is as effective, on the whole, for self-service gasoline marketing as for ordinary attendant-service.

4. The type of delivery nozzle used can have an important effect on vapor capture, especially with vapor-balance systems.

5. A small proportion (less than 10 percent during study) of vehicles served may be expected to have fillneck configurations incompatible with effective use of nozzles in use during this study.

6. In a very small proportion of fillings, liquid losses may be observed as a result of drainage from an overfilled tank ("spitback" or "spillage").

   Concern has been expressed about the possibility of liquid returning to the storage tank, unobserved, via the vapor line; the study did not evaluate this problem.

B. OPERATIONAL RELIABILITY OF VAPOR RECOVERY SYSTEMS

1. Reliability of the system in use, as shown by 140 inspection visits, varied from good to poor. Equipment failures caused shutdown of the units in less than ten percent of the inspections, although tardy delivery of components and delays in installation and maintenance resulted in non-operation of the systems in about one third of the inspection visit. (Three systems from Process Products and one from Intermark remained out of operation from this cause throughout the study.)

2. Only a few of the vacuum assist units operated reliably and without vapor leaks throughout the study. One hundred and thirty-eight instances of hydrocarbon losses from leaks in the vapor recovery systems were detected; the predominant cause of these leaks was system failure of some sort.

3. Incorrect operation or inattention by station operators was a factor in about 20 percent of the observed malfunctions.

4. Operating parameters (pressure and temperature) as observed in the inspections were frequently different from those specified by the manufacturers. It is not clear to what extent these deviations may have resulted from, or possibly caused, system malfunctions.

5. Hydrocarbon vapors were detected in the effluent air from carbon adsorption units in two of six systems tested. The significance of such losses has not been evaluated.

APPENDIX A

Inspection Forms

Time In ____________

Time Out ____________

Date ____________

Inspector ____________

INSPECTION FORM - VAPOR BALANCE SYSTEMS

Station ____________

Address ____________

1. Atmospheric Conditions

Temperature ____________

Sky Conditions ____________

Wind Speed ____________

Humidity ____________

2. Vehicle Fill Nozzle

Type of Nozzle ____________

Make of car being filled ____________

Explosimeter reading ____________

Operator attempt to make a good fit Yes ______ No ______

3. Vapor Return Line

Vacuum at Nozzle Yes ______ No ______

If No, Explain (if reason is known)

Kinks or Liquid Blockage in lines Yes ______ No ______

Does Operator attempt to straighten

Vehicle Fill Nozzle

__________ Type of nozzle __________

__________ Make of car being filled __________

__________ __________

__________ Explosimeter reading __________

Yes ____ No ____ Operator attempt to make a good fit Yes ____ No ____

__________ Location of gas inlet on car __________

__________ Type of nozzle __________

__________ Make of car being filled __________

__________ __________

__________ Expolsimeter reading __________

Yes ____ No ____ Operator attempt to make a good fit Yes ____ No ____

__________ Location of gas inlet on car __________

__________ Type of nozzle __________

__________ Make of car being filled __________

__________ __________

__________ Expolsimeter reading __________

Yes ____ No ____ Operator attempt to make a good fit Yes ____ No ____

__________ Location of gas inlet on car __________

Time In ____________ Date ______________

Time Out ___________ Inspector ___________

INSPECTION FORM - INTERMARK MARK I

Station ____________________________

Address ____

1. Atmospheric Conditions

Temperature ____

Sky Conditions _____________________________________

Wind Speed ____

Humidity ____

2. Vehicle Fill Nozzle

Type of Nozzle _____________________________________

Make of car being filled ___________________________

Explosimeter reading _______________________________

Operator attempt to make a good fit Yes_____ No _____

3. Vapor Return Line

Vacuum at Nozzle Yes _____ No _____

If No, Explain (if reason known)

Kinks or Liquid Blockage in Lines Yes_____ No _____

Does Operator attempt to straighten

lines to minimize liquid blockage Yes _____ No _____

4. Tank Vent

Explosimeter reading ______________________________

5. Tank Drop

Tank Drop made during visit Yes _____ No _____

Volume of Tank Drop (if known) _______________

6. Vapor Collection Blower

Explosimeter Reading______________________________

Condition of drive belts Good _____ Poor _____

7. Surge Tank

Explosimeter Reading ______________________________

Bladder Condition Good _____ Poor _____

8. Compressor

Condition Good _____ Poor _____

Explosimeter Reading

- At Compressor______________________________
- At Compressor Relief Valves ____________________

9 Condenser Pressure Relief Valve

Explosimeter Reading ______________________________

10. Refrigeration Unit

Condition Good _____ Poor _____

11. Overall Piping

Explosimeter Reading ____

12. Operational Sequence Check

Vapor collection blower starts with dispensing Yes _____ No _____

Vapor collection blower stops when dispensing stops Yes _____ No _____

Compressor starts when level switch in surge tank reaches design level (1/8 capacity) Yes _____ No _____

Compressor stops when bladder level drops to design shut off level Yes _____ No _____

Refrigeration unit goes through defrost cycle (20 min.) Yes _____ No _____

13. Comments

Time In ________ Date ______________

Time Out ________ Inspector ______________

INSPECTION FORM - PROCESS PRODUCTS

Vapor Savor Model No. ____________________

Station ________________________________

Address ________________________________

1. Atmospheric Conditions

Temperature ____________________

Sky Conditions ________________

Wind Speed ____________________

Humidity ______________________

2. Vehicle Fill Nozzle

Type of Nozzle ________________

Make of car being filled ________________________

Explosimeter reading ____________________________

Operator attempt to make a good fit . Yes ______ No ______

3. Vapor Return Line

Vacuum at Nozzle Yes ______ No ______

If No, explain (if reason is known)

Kinks or Liquid Blockage in lines Yes _______ No _______

Does Operator attempt to straighten

lines to minimize liquid blockage Yes _______ No _______

4. Tank Vent

Explosimeter reading ______________________

5. Tank Drop

Tank Drop made during visit Yes _______ No _______

Volume of Tank Drop (if known) ______________________

6. Island Blower

Explosimeter reading ______________________

Condition of drive belt Good _______ Poor _______

7. Vapor Refrigeration Blower

Explosimeter reading ______________________

Condition of drive belt Good _______ Poor _______

8. Carbon Regeneration Blower

Explosimeter reading ______________________

Condition of drive belt Good _______ Poor _______

9. Carbon Canister Vent

Explosimeter reading ____________________

10.

11. ~~10.~~ Overall Piping

Explosimeter reading ____________________

12. ~~11.~~ Operational Sequence Check

Island blower starts with dispensing Yes _______ No _______

Island blower stops when dispensing stops Yes _______ No _______

Refrigeration blower starts when tank pressure reaches 1" H_2O Yes _______ No _______

Refrigeration blower stops after four 15 min. cycles or when tank pressure reaches 1/2" H_2O Yes _______ No _______

Carbon regeneration blower starts when refrigeration blower stops Yes _______ No _______

13. ~~12.~~ Comments

Time in ________ Date ______________

Time out _______ Inspector _______________

INSPECTION FORM - CLEAN AIR ENGINEERING 500B & 1000B

Model No. __________

Station ____

Address ____

1. Atmospheric Conditions

Temperature ___________________

Sky Conditions ______________________________

Wind Speed ____________________

Humidity ______________________

2. Vehicle Fill Nozzle

Type of Nozzle ________________

Make of car being filled _______________________

Explosimeter reading ___________________________

Operator attempt to make a good fit-- Yes_____ No_____

3. Vapor Return Line

Vaccuum at Nozzle Yes _______ No _______

If No, Explain (If reason is known)

Kinks or Liquid Blockage in lines Yes _______ No _______

Does Operator attempt to straighten lines

to minimize liquid blockage Yes _______ No _______

4. Tank Vent

Explosimeter reading ______________________________

5. Tank Drop

Tank Drop made during visit Yes _______ No _______

Volume of Tank Drop (if known) ____________________

6. Vapor Collection Blower

Explosimeter reading ______________________________

Condition of Drive Belt Good _____ Poor _______

7. Carbon Canister Vent

Explosimeter reading ______________________________

8. Burner Exhaust

Explosimeter reading ______________________________

9. Overall Piping

Explosimeter reading ____________________

10. Operational Sequence Check

Vapor Blower starts with dispensing - Yes _______ No _______

Vapor Blower stops when stage two burner stops - Yes _______ No _______

Stage two burner starts when stage one burner stops - Yes _______ No _______

Burner ignition energized when dispensing stops - Yes _______ No _______

11. Comments

Time in ________ Date ____________

Time out ________ Inspector ____________

INSPECTION FORM - CLEAN AIR ENGINEERING 2500B & 5000B

Model No. ____________

Station ____________

Address ______________________________

1. Atmospheric Conditions

Temperature ____________

Sky Conditions ____________

Wind Speed ____________

Humidity ____________

2. Vehicle Fill Nozzle

Type of Nozzle ____________

Make of car being filled ____________

Explosimeter reading ____________

Operator attempt to make a good fit Yes ______ No ______

3. Vapor Return Line

Vaccuum at Nozzle Yes ______ No ______

If No, Explain (if reason is known)

Kinks or liquid blockage in lines Yes _______ No _______

Does Operator attempt to straighten

lines to minimize liquid blockage Yes _______ No _______

4. Tank Vent

Explosimeter reading ____________________________

5. Tank Drop

Tank Drop made during visit Yes _______ No _______

Volume of Tank Drop (if known) ________________________

6. Vapor Collection Blower

Explosimeter reading ________________________

Condition of drive belts Good _______ Poor _______

7. Carbon Canister Vent

Explosimeter reading ________________________

8. Burner Pump

Explosimeter reading ________________________

Condition of drive belt ________________________

9. Burner Exhaust

Explosimeter reading ________________________

10. Overall Piping

Explosimeter reading ____________________

11. Operational Sequence Check

- Vapor collection blower starts with dispensing - Yes ______ No ______
- Burner pumps start with dispensing Yes ______ No ______
- Burner ignition energized when burner pump starts - Yes ______ No ______
- If neither burner starts, burner pump stops - Yes ______ No ______
- Once burner pump stops, does not start until dispensing starts - Yes ______ No ______
- Second stage burner starts when first stage burner stops - Yes ______ No ______
- Burner pump stops when second stage burner stops - Yes ______ No ______
- Vapor collection blower stops when dispensing stops - Yes ______ No ______

12. Comments

Time In ________ Date ____________

Time Out ________ Inspector ____________

INSPECTION FORM - ENVIRONICS VAPOX A-3000, A-1500, A-400 & A-400-M

Model No. ____________________

Station ____________________

Address ______________________________

1. Atmospheric Conditions

Temperature ________________

Sky Conditions ________________

Wind Speed ________________

Humidity ________________

2. Vehicle Fill Nozzle

Type of Nozzle ____________________

Make of car being filled ________________

Explosimeter reading ________________

Operator attempt to make a good fit Yes ______ No ______

3. Vapor Return Line

Vacuum at Nozzle Yes ______ No ______

If No, explain (if reason is known)

Kinks or Liquid Blockage in lines Yes _______ No _______

Does Operator attempt to straighten

lines to minimize liquid blockage Yes _______ No _______

4. Tank Vent

Explosimeter reading ____________________________

5. Vapor Collection Blower

Explosimeter reading ____________________________

Condition of drive belt Good _______ Poor _______

6. Carbon Canister Vent

Explosimeter reading ____________________________

7. Reactor Vent

Explosimeter reading ____________________________

Reactor down due to 1300°F override

during visit Yes _______ No _______

8. Carbon Regeneration Blower

Explosimeter reading ____________________________

Condition of drive belt Good _______ Poor _______

9. Overall Piping

Explosimeter reading ______________________

10. Operational Sequence Check

Vapox A-3000

Vapor Collection Pump starts with dispensing	Yes _______	No _______
Pressure switch opens at 3.5" H_2O	Yes _______	No _______
Vapor collection pump stops when dispensing stops-	Yes _______	No _______
Carbon regeneration pump stops when reactor temperature is below 900°F or above 1300°F.	Yes _______	No _______

Vapox A-1500, A-400 & A-400-M

Vapor collection blower starts with dispensing	Yes _______	No _______
Pressure switch opens at 3.5" H_2O	Yes _______	NO _______
Vapor collection blower stops when dispensing is over-	Yes _______	No _______
Carbon regeneration blower starts when dispensing is over-	Yes _______	No _______
Carbon regeneration blower stops when dispensing starts-	Yes _______	No _______
Carbon regeneration stops when reactor temperature is below 900°F or above 1300°F	Yes _______	No _______

11. Tank Drop

Tank Drop made during visit Yes _______ No _______

Volume of Tank Drop (if known) ______________________________

12. Comments

Time In ____________ Date ____________

Time Out ____________ Inspector ____________

INSPECTION FORM - HIRT/HAZELETT

Station ____________________________

Address ____

1. Atmospheric Conditions

Temperature ________________________________

Sky Conditions ______________________________

Wind Speed _________________________________

Humidity ___________________________________

2. Vehicle Fill Nozzle

Type of Nozzle ______________________________

Make of car being filled ____________________

Explosimeter reading ________________________

Operator attempt to make a good fit Yes ______ No ______

3. Vapor Return Line

Vacuum at Nozzle Yes ______ No ______

If No, Explain (if reason is known)

Kinks or Liquid Blockage in lines Yes ______ No ______

Does Operator attempt to straighten
lines to minimize liquid blockage Yes ______ No ______

4. Tank Vent

Explosimeter reading ____________________

5. Tank Drop

Tank Drop made during visit Yes ______ No ______

Volume of Tank Drop (if known) ____________________

6. Burner Exhaust

Explosimeter reading ____________________

Pilot operating during visit Yes ______ No ______

7. Propane Gas Supply

Satisfactory ______ Unsatisfactory ______

8. Compressed Air Supply

Satisfactory ______ Unsatisfactory ______

9. Overall Piping

Explosimeter reading ____________________

10. Operational Sequence Check

Compressed Air starts when tank pressure reaches -0.15" H_2O Yes _______ No _______

Small burner comes on when tank pressure reaches -0.15" H_2O Yes _______ No _______

Large burner comes on when tank pressure reaches +0.1" H_2O Yes _______ No _______

Compressed air stops when tank pressure reaches -0.23" H_2O (for small burner) Yes _______ No _______

Compressed air stops when tank pressure reaches -05"H_2O (for large burner) Yes _______ No _______

11. Comments

APPENDIX B

Automobiles Tested

AUTOMOBILES TESTED

MAKE	MODEL	YEAR	STATION NUMBER WHERE TESTED	FILL NECK LOCATION	HC OBSERVATION	COMMENTS
Oldsmobile	-	1973	1	-	1.0 + LEL	-
Ford	Fairlane	1969	1	Left Rear Panel	1.0 + LEL	Unit down
Ford	Pinto	1972	1	Left Rear Panel	1.0 + LEL	Unit down
Chevy	Nova	1970	1	Under License Plate	1.0 + LEL	Unit down
Mercury	-	1968	1	Left Rear Panel	1.0 + LEL	Unit down
Ford	Maverick	1970	1	Rear Panel	800 PPM	Unit down
Datsun	-	1975	1	Right Rear Panel	1.0 + LEL	Unit down
Chevy	Pickup	1972	1	Left Rear Panel	1.0 + LEL	Unit down
Dodge	Polara	1967	1	Under License Plate	1.0 + LEL	Poor Fit Unit down
Buick	Skylark	1964	1	Under License Plate	0	-
Chevy	LUV	1972	1	Left Rear Panel	0	-
Datsun	Pickup	1975	1	Left Rear Panel	1.0 + LEL	Poor Fit Unit down
Chevy	Bel-Air	1966	1	Left Rear Panel	1.0 + LEL	Unit down
Mazda	-	1971	1	Left Rear Panel	1.0 + LEL	Unit down
Chevy	Pickup	-	1	-	High	Unit down
Chevy	Nova	-	1	-	1.0 + LEL	Unit down
VW	-	1967	1	-	1.0 + LEL	Unit down
VW	-	1970	1	-	1.0 + LEL	-
Plymouth	Fury	1972	1	Under License Plate	1.0 + LEL	Unit down
Chevy	Impala	1967	1	Left Rear Panel	1.0 + LEL	Unit down
Toyota	-	1970	1	Left Rear Panel	1.0 + LEL	Unit down
Ford	Pinto	1970	1	Left Rear Panel	1.0 + LEL	Unit down
Chevy	Malibu	1972	1	Under License Plate	1.0 + LEL	Unit down
Ford	Pinto	1973	1	Left Rear Panel	1.0 + LEL	Unit down
Datsun	1600	1970	2	Left Rear Panel	0	Self-Serve
Chevy	Chevelle	1970	2	Under License Plate	0	Self-Serve
Plymouth	Duster	1974	2	Left Rear Panel	0	Self-Serve
Ford	Mustang	1966	2	Rear Panel	1.0 + LEL	Self-Serve
Ford	Pinto	1972	2	Left Rear Panel	800 PPM	Self-Serve
Ford	Pickup	-	2	-	1.0 + LEL	Poor Fit Self-Serve
Dodge	-	1964	2	Left Rear Panel	0 PPM	Self-Serve
Chevy	Van	1975	2	-	1.0 + LEL	Poor Fit Self-Serve
Oldsmobile	StaWag	1971	2	Left Rear Panel	0	Self-Serve
Ford	StaWag	1972	2	Left Rear Panel	0	Self-Serve
-	Pickup	1970	2	Behind Left Door	0	Self-Serve
Chevy	Bel-Air	1974	2	Under License Plate	0	Self-Serve

AUTOMOBILES TESTED (cont)

MAKE	MODEL	YEAR	STATION NUMBER WHERE TESTED	FILL NECK LOCATION	HC OBSERVATION	COMMENTS
Mercury	-	1967	2	Under License Plate	0-200 PPM	Self-Serve
Ford	LTD	1973	2	Left Rear Panel	0	Self-Serve
Datsun	1600 P/U	1973	2	Right Rear Panel	0	-
Dodge	Pickup	1971	2	Behind Left Door	0	Self-Serve
Dodge	Dart	1964	2	Left Rear Panel	0	Self-Serve
Ford	Mustang	1968	2	Rear Panel	0	Self-Serve
Mercury	Capri	1973	2	Right Rear Panel	0	-
Dodge	CoronetWag.	1973	2	Left Rear Panel	1.0 + LEL	Insufficient Vacuum
Ford	Pickup	1970	2	-	0	-
Buick	Sta.Wag	1967	2	-	High	Poor Fit
Datsun	-	1974	2	Right Rear Panel	0	-
Ford	Mustang II	1974	2	Left Rear Panel	0	Self-Serve
Ford	Pickup	1969	2	Left Rear Panel	0	Spit Back At End of Fill
Chevy	Step-Van	1964	2	Right Rear Panel	0	-
Ford	Maverick	1971	2	Rear Panel	0	-
Chevy	Corvette	1972	2	Above Trunk	0	-
Datsun	1600	1973	2	Right Rear Panel	0	Spit Back at End of Fill
Chevy	Pickup	1972	3	Left Rear Panel	0	-
Ford	Truck	-	3	-	1.0 + LEL	-
Chevy	Pickup	1973	3	Behind Right Door	0	-
Chevy	350 Truck	1973	3	Below Cab Right Side	0-100 PPM	Poor Fit
Chevy	C/50	1968	3	Behind Left Door	0	Poor Fit
Datsun	Pickup	1973	3	Right Rear Panel	0	-
Chevy	Pickup	1974	3	Behind Left Door	1.0 + LEL	-
Chevy	Pickup	1968	3	Behind Left Door	0	-
Chevy	Impala	1969	4	Under License Plate	0-600 PPM	-
VW	Bus	1968	4	Left Rear Panel	0	-
Volvo	Sta.Wag.	1973	4	Right Rear Panel	0-300 PPM	-
Ford	Pinto	1972	4	Left Rear Panel	0	-
BMW	-	1969	4	Right Rear Panel	1.0 + LEL	Poor Fit
Ford	Pinto	1970	4	Left Rear Panel	0	-
Ford	Pinto	1973	4	Left Rear Panel	0	-
Volvo	Sta.Wag.	1971	4	Right Rear Panel	0	-
VW	Sta.Wag.	1970	4	Right Front Panel	0	-
Ford	Fairlane	1969	4	Under License Plate	400 PPM	Supply Hose Leaks Gas at Nozzle

AUTOMOBILES TESTED (cont)

MAKE	MODEL	YEAR	STATION NUMBER WHERE TESTED	FILL NECK LOCATION	HC OBSERVATION	COMMENTS
Ford	Falcon	1962	4	Left Rear Panel	0	-
Chevy	Vega Wagon	1971	4	Right Rear Panel	0	-
Ford	Mustang	1968	4	Rear Panel	0	-
Ford	Pickup	1973	4	Left Rear Panel	0	-
VW	Bus	1971	4	Right Rear Panel	1.0 + LEL	Poor Fit
Opel	Coupe	1970	4	Right Rear Panel	0	-
Volvo	Sta.Wag.	1967	4	Right Rear Panel	0	-
Toyota	Pickup	1973	4	Right Mid Panel	0	-
Chevy	Vega	1971	4	Under License Plate	1.0 + LEL	Nozzle Being Repaired
Datsun	1600	1973	4	Right Rear Panel	0	-
Mercury	Capri	1972	4	Right Front Panel	1.0 + LEL	-
VW	Rabbit	1975	4	-	0	Good Fit
VW	Bug	1968	4	-	0	-
Pontiac	Sta.Wag.	1974	4	-	0	-
VW	Bug	1974	4	-	0	-
Datsun	1200	-	4	Right Rear Panel	1000 PPM	-
Chevy	Chevelle	1973	4	-	1.0 + LEL	Poor Fit
Ford	Pinto Wagon	1973	5	Left Rear Panel	0	-
Chevy	LUV	1972	5	Left Rear Panel	0	-
Volvo	Sta.Wag.	1974	5	Left Rear Panel	0	-
Buick	Le Sabre	1973	5	Under License Plate	0	-
Lincoln	MK IV	1972	5	Under License Plate	0	-
VW	Sta.Wag.	1971	5	Right Front Panel	0	-
Chevy	El Camino	1968	5	Left Rear Panel	0	-
Ford	Fairlane	1967	5	Left Rear Panel	0	-
Buick	Regal	1971	5	-	0	-
Plymouth	-	1969	5	-	0	-
Ford	Pinto Wagon	1974	5	-	0	-
International	-	1971	5	-	0	-
Lincoln	Continental	1974	5	Left Rear Panel	1.0 + LEL	-
Toyota	-	1971	5	Under License Plate	0	-
Dodge	Van	1963	5	Left Rear Panel	0	-
Chevy	Van	1974	5	Left Rear Panel	0	-
Plymouth	Fury	1968	5	Under License Plate	0	-
VW	Bug	1967	5	Right Front Panel	0	-

AUTOMOBILES TESTED (cont)

MAKE	MODEL	YEAR	STATION NUMBER WHERE TESTED	FILL NECK LOCATION	HC OBSERVATION	COMMENTS
Chevy	Impala	1964	5	Left Rear Panel	0	-
Chevy	-	1965	5	Under License Plate	0	-
Ford	Bronco	1970	5	Right Mid Panel	0	-
Dodge	Sta.Wag.	1972	5	Under License Plate	0	-
Chevy	Pickup	1973	5	Right Mid Panel	0	-
Ford	Pinto	1972	5	Left Rear Panel	0	-
Ford	LTD	1975	6	Under License Plate	0-0.2 LEL	-
Chevy	El Camino	1970	6	Left Rear Panel	1.0 + LEL	-
Chevy	Camaro	1972	6	Under License Plate	1.0 + LEL	-
Ford	Torino	1973	6	Under License Plate	1.0 + LEL	-
Chevy	El Camino	-	6	Left Rear Panel	1.0 + LEL	Poor Fit
Chevy	Sta.Wag.	1970	6	Left Rear Panel	0	-
Buick	Riviera	1966	6	Under License Plate	1.0 + LEL	Poor Fit
Lincoln	MK IV	1974	6	Left Rear Panel	0	-
Ford	Pinto	-	6	Left Rear Panel	0	-
Ford	Ranchero	-	6	-	0	-
Dodge	Charger	1970	6	-	1.0 + LEL	-
Ford	Sta.Wag.	1973	6	-	0.2 LEL	-
Chevy	Pickup	1973	6	Right Mid Panel	0	-
Ford	Granada	1975	6	-	0	-
Dodge	Polara	1972	6	-	0-600 PPM	-
Pontiac	-	1973	6	-	0-700 PPM	-
Dodge	Van	1974	6	-	0	-
Plymouth	-	1973	6	-	0-100 PPM	-
Chev	Monte Carlo	1974	6	Under License Plate	-	Readings not taken becaus[e] of gas spillage
GMC	Pickup	1969	6	-	0	-
Chev	Pickup	1975	6	Right Rear Panel	1.0 + LEL	-
Datsun	610	1973	6	Right Rear Panel	1.0 + LEL	-
VW	Bug	1967	6	Right Front Panel	0-500 PPM	-
Ford	LTD	1972	6	Left Rear Panel	1.0 + LEL	-
Ford	Pinto	1970	6	Left Rear Panel	0	-
Chevy	Van	1974	6	Left Rear Panel	1.0 + LEL	-
Ford	Pinto	1973	6	Left Rear Panel	0-1000 PPM	-
Ford	Pickup	1972	6	Left Rear Panel	0	-
Chevy	Pickup	1973	7	Right Side Panel	0	-

AUTOMOBILES TESTED (cont)

MAKE	MODEL	YEAR	STATION NUMBER WHERE TESTED	FILL NECK LOCATION	HC OBSERVATION	COMMENTS
Pontiac	LeMans	1966	7	Under License Plate	0	-
Plymouth	Duster	1972	7	Left Side Panel	0	-
Datsun	Pickup	1972	7	-	1.0 + LEL	Unit down
Cadillac	-	1974	7	Under License Plate	400 PPM	Unit down
Ford	LTD	1972	7	Left Rear Panel	1.0 + LEL	Unit down
Ford	LTD	1970	7	-	0	-
International	-	1968	7	Behind Right Door	0	-
VW	Bug	1964	7	Inside Trunk	0-600 PPM	-
Chevy	Camaro	1968	7	Rear Panel	1.0 + LEL	Vacuum line not hooked up
Ford	Maverick	1970	7	Rear Panel	1.0 + LEL	Poor Fit
Dodge	Colt	1975	7	Left Rear Panel	0	-
Ford	Pickup	1969	7	Left Rear Panel	0	-
VW	Bug	1969	7	Left Front Panel	0	-
Ford	Van	1969	7	Left Rear Panel	1.0 + LEL	Vacuum line not hooked up
Ford	Fairlane	1971	7	Left Rear Panel	-	-
Oldsmobile	Sta.Wag.	1964	7	Left Rear Panel	100 PPM	-
Ford	Mustang	1969	7	Rear Panel	1.0 + LEL	Vacuum Line not hooked up
Chevy	Chevelle	1968	8	-	1.0 + LEL	Unit down
Chevy	-	1957	8	-	1.0 + LEL	Unit down
Ford	Mustang	1966	8	Rear Panel	1.0 + LEL	Unit down
Oldsmobile	98	1968	8	Under License Plate	1.0 + LEL	Unit down
Ford	Fairlane	1971	8	Left Rear Panel	1000 PPM	Unit down
Chevy	Camaro	1968	8	Rear Panel	0	-
Datsun	-	1973	8	Right Rear Panel	0	-
Chevy	-	1969	8	Under License Plate	0	-
Dodge	Satellite	1974	8	Under License Plate	1.0 + LEL	Unit down
Chevy	Chevelle	1970	8	Under License Plate	0	Liquid gas leak at nozzle union
Ford	Pickup	1967	8	Behind Left Door	0	-
Chevy	Malibu Wag.	1968	8	Left Rear Panel	0	-
Datsun	240Z	1969	8	Right Rear Panel	1.0 + LEL	Poor Fit
Oldsmobile	-	1973	8	Under License Plate	0	-
Dodge	-	1973	8	Under License Plate	1.0 + LEL	Unit down
Chevy	Monte Carlo	1974	8	Under License Plate	1.0 + LEL	Unit down

AUTOMOBILES TESTED (cont)

MAKE	MODEL	YEAR	STATION NUMBER WHERE TESTED	FILL NECK LOCATION	HC OBSERVATION	COMMENTS
Opel	1900	1972	8	Right Rear Panel	1.0 + LEL	Unit down
Ford	Van	1969	8	Left Rear Panel	1.0 + LEL	Unit down
Chevy	-	1973	9	Under License Plate	1.0 + LEL	Unit down
Ford	Van	1969	9	Left Rear Panel	1.0 + LEL	Unit down
AMC	Rebel	1967	9	-	0	-
Pontiac	Grand Prix	1969	9	-	0	-
Honda	Civic	1974	9	Left Rear Panel	0	-
Chevy	Pickup	1968	9	Behind Left Door	0	-
Fiat	1200	1963	9	-	0	-
Chevy	Monte Carlo	1970	9	-	0	-
Dodge	Sta.Wag.	1974	9	-	0	-
Honda	Civic	1974	9	Left Rear Panel	1.0 + LEL	Unit down
Datsun	B210	1973	9	Right Rear Panel	1.0 + LEL	Unit down
Chevy	Vega	1970	9	Under License Plate	1.0 + LEL	Unit down
Ford	Maverick	1972	9	Rear Panel	1.0 + LEL	Unit down
Chevy	Monte Carlo	1973	9	Under License Plate	1.0 + LEL	Unit down
Chrysler	-	1974	9	Under License Plate	0	-
Oldsmobile	98	1968	9	Under License Plate	1.0 + LEL	Poor Fit
Ford	Maverick	1972	10	Rear Panel	1.0 + LEL	Unit down
Chevy	Bel-Air	1974	10	Under License Plate	1.0 + LEL	Unit down
Ford	Pinto	1972	10	Left Rear Panel	1.0 + LEL	Unit down
Chevy	Pickup	1973	10	Right Mid Panel	1.0 + LEL	Unit down
Datsun	610	1973	10	Right Rear Panel	1.0 + LEL	Unit down
Dodge	Colt	1971	10	Left Rear Panel	1.0 + LEL	Unit down
Chevy	Pickup	1968	10	Left Rear Panel	1.0 + LEL	Unit down
Chevy	Impala	1959	10	Under License Plate	1.0 + LEL	Unit down
Mercury	Cougar	1970	10	Under License Plate	1.0 + LEL	Unit down
Ford	Maverick	1970	10	Rear Panel	1.0 + LEL	Unit down
Oldsmobile	-	1972	10	Under License Plate	1.0 + LEL	Unit down
Ford	Mustang	1968	10	Rear Panel	1.0 + LEL	Unit down
Porsche	912	1970	10	-	1000+PPM	Unit down
Chevy	Impala	1966	10	-	1000+PPM	Unit down
Mercury	Capri	1971	10	-	1000+PPM	Unit down
Buick	-	1973	10	Under License Plate	1.0 + LEL	Unit down
Pontiac	Sta.Wag.	1972	10	-	High at end of fill	Unit down
Toyota	Pickup	1974	10	Left Mid Panel	1.0 + LEL	Unit down

AUTOMOBILES TESTED (cont)

MAKE	MODEL	YEAR	STATION NUMBER WHERE TESTED	FILL NECK LOCATION	HC OBSERVATION	COMMENTS
Ford	Galaxie	1965	11	Left Rear Panel	0	Self-Serve
Mercury	Comet	1964	11	-	0	Self-Serve
Ford	3/4 Ton P/U	1966	11	-	1000+PPM	Self-Serve
Ford	Ranchero	1975	11	-	0	Self-Serve
Ford	Galaxie	1966	11	-	0	Self-Serve
International	Travelall	1969	11	-	0	Self-Serve
Jeep	-	1973	11	-	0	Self-Serve
Pontiac	GTO	1967	11	-	0	Self-Serve
Buick	Riviera	1966	11	Under License Plate	0	Self-Serve
Mercury	Cougar	1970	11	Under License Plate	0	Self-Serve
Chevy	Nova	1973	11	-	0	Self-Serve
Dodge	Futura	1972	11	-	0	Self-Serve
Buick	Le Sabre	1970	11	-	0	Self-Serve
VW	Bus	1971	11	Right Rear Panel	0	Self-Serve
Ford	3/4 Ton P/U	1970	11	-	0	Self-Serve
Chevy	Sta.Wag.	1972	11	-	0	Self-Serve
Oldsmobile	98	1974	11	-	0	-
Chevy	Nova	1970	11	Under License Plate	0	-
Ford	Falcon	-	11	-	0	-
Chevy	Van	1970	11	-	0	-
Ford	-	1970	11	Left Rear Panel	0	Self-Serve
Chevy	Camaro	1973	11	Under License Plate	0	Self-Serve
Chevy	Pickup	1974	11	Behind Door	0	-
Toyota	Pickup	1969	11	Left Rear Panel	0	-
Chevy	Nova Wagon	1968	11	Left Rear Panel	0	Poor Fit
Mercury	Cougar	1970	11	Under License Plate	0	-
Ford	Maverick	1972	11	Rear Panel	0	-
VW	Bug	1970	11	Right Front Panel	0	-
Pontiac	Ventura	1972	11	Under License Plate	0	Self-Serve
AMC	Javalin	1968	11	Under License Plate	0	Self-Serve
Dodge	Pickup	1974	11	Behind Left Door	0	Self-Serve
Chevy	Nova	1972	11	Under License Plate	0	Self-Serve
Datsun	-	1968	11	Right Rear Panel	0	Self-Serve
Buick	Skylark	1972	11	Under License Plate	0	Self-Serve
VW	Bus	1969	11	Right Rear Panel	0	Self-Serve
Chevy	Impala	1964	11	Left Rear Panel	0	Self-Serve

AUTOMOBILES TESTED (cont)

MAKE	MODEL	YEAR	STATION NUMBER WHERE TESTED	FILL NECK LOCATION	HC OBSERVATION	COMMENTS
Plymouth	-	1966	11	Under License Plate	0-200 PPM	Self-Serve
Datsun	Pickup	1973	12	Right Rear Panel	0-1.0 + LEL	High HC Observation at end of fill
Ford	Ranchero	1967	12	-	0	-
Fiat	128	1973	12	-	0	Poor fit must be hand held
Datsun	240Z	1973	12	Right Rear Panel	0-1000 PPM	Bad Seal
Chevy	Monte Carlo	1972	12	Under License Plate	0-800 PPM	-
Dodge	Charger	1966	12	-	0.6 LEL	-
Ford	Pinto	1971	12	Left Rear Panel	1.0 + LEL	Self-Serve
VW	-	1964	12	Left Rear Panel	1.0 + LEL	Self-Serve
Ford	Falcon	1967	12	Rear Panel	1.0 + LEL	Self-Serve
Chevy	Nova	1965	12	Left Rear Panel	1.0 + LEL	Self-Serve
Triumph	TR6	1968	12	Behind Rear Window	1.0 + LEL	Self-Serve
Ford	Falcon	1970	12	Rear Panel	1.0 + LEL	Self-Serve
Ford	Pickup	1969	12	Left Rear Panel	1.0 + LEL	Self-Serve
Dodge	Satellite	1974	12	Under License Plate	1.0 + LEL	Poor fit
Opel	1900	1972	12	Right Rear Panel	1.0 + LEL	Self-Serve
Buick	Riviera	1971	12	Under License Plate	0	Self-Serve
Mazda	Pickup	1974	12	Left Side Panel	1.0 LEL	Self-Serve
Chevy	Impala	1972	12	Under License Plate	1.0 + LEL	Self-Serve
Ford	Maverick	1973	12	Left Rear Panel	1.0 + LEL	Self-Serve
International	Pickup	1954	12	Behind Left Door	1.0 + LEL	Self-Serve
Cadillac	-	1970	12	Under License Plate	0-400 PPM	-
Ford	Pinto	1971	12	Left Rear Panel	1.0 + LEL	Self-Serve
Ford	LTD	1969	12	Left Rear Panel	1.0 + LEL	Self-Serve
Ford	Mustang	1968	13	Rear Panel	1.0 + LEL	Self-Serve
Datsun	Sta.Wag.	1971	13	Right Rear Panel	1.0 + LEL	Poor fit
Ford	Courier	1971	13	Left Mid Panel	1.0 + LEL	Self-Serve
Fiat	Coupe	1971	13	Left Rear Panel	1.0 + LEL	Self-Serve
Chevy	LUV	1972	13	Left Rear Panel	1.0 + LEL	Self-Serve
Datsun	1600	1973	13	Right Rear Panel	1.0 + LEL	Self-Serve Poor Fit
Ford	LTD	1973	13	Left Rear Panel	1.0 + LEL	-
GMC	Duravan	1973	13	Left Rear Panel	1.0 + LEL	-
Ford	LTD	1973	13	Left Rear Panel	1.0 + LEL	-
Buick	Electra	1964	13	Left Rear Panel	1.0 + LEL	High HC observations appeared to be caused by nozzle

AUTOMOBILES TESTED (cont)

MAKE	MODEL	YEAR	STATION NUMBER WHERE TESTED	FILL NECK LOCATION	HC OBSERVATION	COMMENTS
Chrysler	Imperial	1970	13	Under License Plate	1.0 + LEL	Self-Serve
Mercury	Capri	1972	13	Right Front Panel	1.0 + LEL	Self-Serve
Dodge	Dart	1964	13	Left Rear Panel	1.0 + LEL	Self-Serve
Pontiac	Le Mans	1974	13	Under License Plate	1.0 + LEL	-
Dodge	Dart	1974	13	Left Rear Panel	0-200 PPM	-
Ford	LTD	1972	13	Left Rear Panel	1.0 + LEL	Self-Serve Poor Fit
Chevy	Sta.Wag.	1970	13	Left Rear Panel	1.0 + LEL 0 PPM	Self-Serve Attendant Serve
Ford	Pinto	1974	13	Left Rear Panel	0-200 PPM	Self-Serve
Ford	Mustang	1968	13	Rear Panel	0	Self-Serve
Ford	Falcon	1972	13	-	0	-
Chevy	6/50 Truck	1971	13	-	1.0 + LEL	-
Datsun	1200 P/U	1965	13	-	0-1000 PPM	-
Chevy	El Camino	1963	13	-	1000 + PPM	-
Chevy	Camaro	1967	13	-	0	Good fit
Ford	Pinto	1971	13	Left Rear Panel	0	Good fit
Pontiac	Catalina	1966	13	Under License Plate	1000 PPM	Poor Fit
Ford	Falcon	1964	14	Left Rear Panel	-	Poor Fit must be hand held
Chrysler	Le Baron	1968	14	-	0.2 LEL	Good fit
VW	"Thing"	1973	14	-	0	Hand held
Ford	Thunderbird	1968	14	-	1.0 + LEL	-
Chevy	Van	1975	14	-	1000 + PPM	-
Alfa Romeo	-	1973	14	-	1000 + PPM	-
VW	Dasher	1974	14	-	1000 + PPM	-
Ford	Pinto	1970	14	Left Rear Panel	1.0 + LEL	Self-Serve nozzle fell out of car did not shut off
Dodge	Sta.Wag.	1973	14	Left Rear Panel	1.0 + LEL	Poor fit
Ford	Custom P/U	1974	14	Right Rear Panel	1.0 + LEL	Self-Serve
MGB	-	1968	14	Right Rear Panel	1.0 + LEL	Self-Serve
Datsun	Pickup	1971	14	Left Rear Panel	1.0 + LEL	Self-Serve
Ford	Mustang	1969	14	Rear Panel	1.0 + LEL	Self-Serve
Plymouth	-	1968	14	Left Rear Panel	0	-
Plymouth	Sta.Wag.	1965	14	Left Rear Panel	1.0 + LEL	Self-Serve
Mercedes	-	1971	14	Under License Plate	1.0 + LEL	Poor Fit
Chevy	Sta.Wag.	1970	14	Left Rear Panel	0	Self-Serve
VW	Bus	1969	14	Right Rear Panel	1.0 + LEL	Self-Serve

AUTOMOBILES TESTED (cont)

MAKE	MODEL	YEAR	STATION NUMBER WHERE TESTED	FILL NECK LOCATION	HC OBSERVATION	COMMENTS
Toyota	Corona	1974	14	Left Rear Panel	0-200 PPM	Self-Serve
Mercury	Capri	1974	14	-	1.0 + LEL	-
Toyota	Corrolla	1972	14	Left Side Panel	1.0 + LEL	-
Chev.	Vega	1971	14	Under License Plate	1.0 + LEL	Spit Back
Ford	LTD	1973	14	Left Rear Panel	1.0 + LEL	-
Ford	-	1972	14	Under License Plate	0-300 PPM	-
Oldsmobile	88	1968	14	Under License Plate	1.0 + LEL	Self-Serve
Dodge	Pickup	1974	14	Left Mid Panel	1.0 + LEL	Self-Serve
Toyota	1900	1968	14	Under License Plate	0-200 PPM	-
Chev.	Corvette	1966	14	Above Trunk	1.0 + LEL	Poor Fit
Ford	Van	1970	14	Left Rear Panel	0	-
International	CO 1600	1969	15	-	1.0 + LEL	-
Ford	Fairlane	1972	15	-	1000 + PPM	-
Jeep	-	1975	15	-	0-1000 PPM	-
International	Truck	1969	15	Right Panel	1.0 + LEL	Poor Vacuum
Dodge	4 Ton Truck	1970	15	Right Rear Panel	1.0 + LEL	Poor Vacuum
Chevy	Truck	1968	15	Right Side Panel	1.0 + LEL	Poor Vacuum
AMC	-	1973	15	Right Front Panel	1.0 + LEL	Poor Vacuum
Jeep	-	1968	15	Rear Panel	1.0 + LEL	Poor Vacuum
GM	Truck	1972	15	Rear Panel	0.6 LEL	Unit down
Chevy	1 Ton Truck	1968	15	Right Rear Panel	1.0 + LEL	Unit down
AMC	Truck	1971	15	Rear Panel	1.0 + LEL	Unit down
AMC	Truck	1971	15	Rear Panel	1.0 + LEL	Unit down
International	1/2 Ton Step-Van	1969	15	Right Side Panel	1.0 + LEL	Unit down
International	Truck	1968	15	Left Rear Panel	1.0 + LEL	Unit down
Jeep	Truck	1968	15	Rear Panel	1.0 + LEL	Unit down
Jeep	Truck	1970	15	Right Rear Panel	1.0 + LEL	Unit down
Jeep	Truck	1968	15	Right Rear Panel	1.0 + LEL	Unit down
Jeep	Truck	1975	15	Right Rear Panel	1.0 + LEL	Unit down
Jeep	Truck	1975	15	Right Rear Panel	1.0 + LEL	Unit down
Ford	Torino	1973	15	Under License Plate	1.0 LEL	Poor Fit
Ford	5 Ton Truck	1974	15	-	1.0 LEL	Poor Fit
International	Loadstar	1968	15	-	0	-

AUTOMOBILES TESTED (cont)

MAKE	MODEL	YEAR	STATION NUMBER WHERE TESTED	FILL NECK LOCATION	HC OBSERVATION	COMMENTS
International	1310 Truck	1973	15	-	0-100 PPM	-
Jeep	-	1971	15	-	0-400 PPM	-
Ford	1½ Ton Truck	1971	15	-	0	-
Jeep	-	1975	15	-	0	-
Dodge	-	1974	16	-	1.0 + LEL	-
Dodge	-	1974	16	-	0.1 LEL	-
Dodge	-	1974	16	-	0	-
Dodge	-	1974	16	-	1.0 + LEL	-
Dodge	-	1974	16	-	100 PPM	-
Dodge	Polara	1974	16	Under License Plate	0-200 PPM	-
Dodge	Polara	1974	16	Under License Plate	0	-
Dodge	Polara	1974	16	Under License Plate	0-300 PPM	-
Dodge	Monaco	1974	16	Under License Plate	0	-
Dodge	Monaco	1974	16	Under License Plate	0	-
Dodge	Monaco	1974	16	Rear Panel	0	-
Dodge	Monaco	1974	16	Rear Panel	0	1.0 LEL just before shut-off
Dodge	Monaco	1974	16	Rear Panel	0	1.0 LEL just before shut-off
Dodge	-	1974	16	-	0.1 LEL	-
Dodge	-	1974	16	-	300 PPM	-
Dodge	-	1974	16	-	0	-
Dodge	-	1974	16	-	0.2 LEL	-
Dodge	Monaco	1974	16	Under License Plate	0	-
Dodge	Monaco	1974	16	Under License Plate	0	-
Dodge	Monaco	1974	16	Under License Plate	0	-
Dodge	Monaco	1974	16	Under License Plate	0	-
Dodge	Monaco	1974	16	Under License Plate	0	-
Dodge	Monaco	1974	16	Under License Plate	0	-
Dodge	Monaco	1974	16	Rear Panel	0	-
Dodge	Monaco	1974	16	Rear Panel	0	-
Dodge	Monaco	1974	16	Rear Panel	0	-
Dodge	Monaco	1974	16	Rear Panel	0	-
Dodge	Monaco	1974	16	Rear Panel	0	-
Dodge	Monaco	1974	16	Rear Panel	0	-

AUTOMOBILES TESTED (cont)

MAKE	MODEL	YEAR	STATION NUMBER WHERE TESTED	FILL NECK LOCATION	HC OBSERVATION	COMMENTS
Cadillac	-	1973	18	Under License Plate	0	-
Chevy	Corvette	1969	18	Top of Trunk	1.0 + LEL	Poor Fit
Ford	Pinto	1971	18	Left Rear Panel	0	-
Datsun	1600 Sportscar	1967	18	Right Rear Panel	50-100 PPM	-
Datsun	510	1968	18	Right Rear Panel	0	-
VW	Bus	1974	18	Right Rear Panel	0	-
Chevy	Impala	1974	18	Under License Plate	0	-
Ford	Pinto	1971	18	Left Rear Panel	0	-
Ford	LTD	1973	18	Left Rear Panel	0	-
MG	-	1970	18	Right Rear Panel	0	-
Chevy	LUV	1969	18	Left Side Panel	0	-
Cadillac	-	1973	18	Under License Plate	1.0 + LEL	-
Ford	LTD	1973	18	Left Rear Panel	0	-
Chevy	Chevelle	1975	18	-	0	-
VW	Bug	1974	18	-	0	-
VW	Bug	1969	18		0	-
Oldsmobile	Cutlass	1973	18	-	0	-
AMC	Hornet Wagon	1974	18	-	0	-
Dodge	Van	1971	18	-	0	-
Chevy	Chevelle	1974	18	-	0	-
VW	Bug	1964	18	-	0	-
Ford	350 Pickup	1972	18	-	0	-
Chevy	Chevelle	1974	18	-	0	-
Chevy	Vega	1971	18	Under License Plate	0	-
Pontiac	-	1968	18	-	1.0 + LEL	Poor Fit
Chevy	LUV	1972	18	Left Rear Panel	0	-
Opel	1900	1972	18	Right Rear Panel	0	-
Toyota	-	1969	18	Left Rear Panel	0	-
Ford	Mustang	1969	18	Rear Panel	0	-
Cadillac	Coupe DeVille	1973	18	Under License Plate	0	-
Chevy	Pickup	1970	18	Right Mid Panel	0-200 PPM	-
VW	-	1972	18	Right Front Panel	1.0 + LEL	Poor Fit
Ford	Pinto	1970	18	Left Rear Panel	0	-
Plymouth	Road Runner	1969	19	Under License Plate	1.0 + LEL	No Vacuum
International	5 Ton Truck	1970	19	Below Cab Left Side	1.0 + LEL	No Vacuum

AUTOMOBILES TESTED (cont)

MAKE	MODEL	YEAR	STATION NUMBER WHERE TESTED	FILL NECK LOCATION	HC OBSERVATION	COMMENTS
Chevy	Monte Carlo	1974	19	Under License Plate	1.0 + LEL	No Vacuum
Cadillac	-	1974	19	Under License Plate	1.0 + LEL	Unit down
VW	Bus	1968	19	Right Rear Panel	1.0 + LEL	Unit down
Datsun	1600 P/U	1969	19	Left Mid Panel	1.0 + LEL	Unit down
Ford	Falcon	1964	19	Left Rear Panel	1.0 + LEL	Unit down
Rambler	-	1964	19	Left Rear Panel	1.0 + LEL	Unit down
Dodge	Dart	1974	19	Left Rear Panel	1000 + PPM	Unit down
VW	Bus	1972	19	-	100 PPM	Unit down
Audi	Fox	1974	19	-	1.0 + LEL	Unit down
Mazda	Coupe	1972	19	Left Rear Panel	1.0 + LEL	Unit down
Ford	Maverick	1970	19	Rear Panel	1.0 + LEL	Unit down
Opel	1900	1973	19	Right Rear Panel	1.0 + LEL	Unit down
Datsun	Coupe	1972	19	Right Rear Panel	1.0 + LEL	Unit down
Cadillac	-	1973	20	Rear Panel	1.0 + LEL	Unit down
Ford	Mustang II	1974	20	Left Rear Panel	1.0 + LEL	Unit down
Chevy	Corvette	1969	20	Above Trunk	1.0 + LEL	Poor Fit Unit down
Chevy	Chevelle Wagon	1974	20	Left Rear Panel	1.0 + LEL	Unit down
Ford	Maverick	1972	20	Rear Panel	1.0 + LEL	Vacuum lines disconnected
Chevy	Impala	1973	20	Under License Plate	1.0 + LEL	Vacuum lines disconnected
Chevy	½ Ton P/U	1971	20	-	-	Nozzle does not fit
Chevy	Nova	1973	20	-	0	-
Rambler	StaWag	1966	20	-	1000 + PPM	-
Chevy	Camaro	1966	20	-	0	-
Toyota	Corrolla	1974	20	Left Rear Panel	0	-
Toyota	Pickup	1974	20	Left Mid Panel	0	-
Mercury	Montego	1974	20	-	0	-
Mazda	RX-3	1972	20	Left Rear Panel	0.8 LEL	-
Ford	Galaxie	1965	20	Left Rear Panel	1.0 + LEL	Unit down
Dodge	Monaco	1974	21	Under License Plate	0	-
Dodge	Monaco	1974	21	Under License Plate	0	-
Dodge	Monaco	1974	21	Under License Plate	0	-
Dodge	Monaco	1974	21	Under License Plate	0	-
Dodge	Monaco	1974	21	Under License Plate	0	-
Dodge	Monaco	1974	21	Under License Plate	0	-
Dodge	Monaco	1974	21	Under License Plate	0	-

AUTOMOBILES TESTED (cont)

MAKE	MODEL	YEAR	STATION NUMBER WHERE TESTED	FILL NECK LOCATION	HC OBSERVATION	COMMENTS
Dodge	Monaco	1974	21	Under License Plate	0	-
Dodge	Monaco	1974	21	Under License Plate	100 PPM	-
Dodge	Polara	1974	21	Under License Plate	0	-
Dodge	Monaco	1974	21	Under License Plate	0	-
Dodge	Monaco	1975	21	-	0	-
Dodge	Polara	1973	21	-	0	-
Dodge	Monaco	1974	21	Rear Panel	0	-
Dodge	Monaco	1974	21	Rear Panel	0	-
Dodge	Monaco	1974	21	Rear Panel	0	-
Dodge	Monaco	1974	21	Rear Panel	0	1.0 + LEL at end of fill
Dodge	Monaco	1974	21	Rear Panel	0	-
Dodge	Monaco	1974	21	Rear Panel	0	-
Pontiac	Le Mans	1965	22	Under License	1000 + PPM	Tow Hitch caused poor fit
Dodge	Coronet	1968	22	Under License Plate	0	
Chev.	Malibu	1973	22	-	1000 + PPM	Poor Fit
Plymouth	Belvedere	1964	22	-	100 PPM	-
Dodge	Coronet Wagon	1965	22	-	0	-
Chev.	Monte Carlo	1970	22	Under License Plate	0	-
Datsun	-	1974	22	Right Rear Panel	0	-
Dodge	Coronet	1968	22	Under License Plate	0	-
Dodge	Coronet Wagon	1973	22	Left Rear Panel	0	-
Chev.	Vega	1972	22	Under License Plate	0	-
Ford	Ranchero	1971	22	Left Rear Panel	0	-
Ford	Maverick	1971	22	Rear Panel	0	-
Dodge	Coronet Wagon	1973	22	Left Rear Panel	0-800 PPM	Poor Fit
Ford	Granada	1975	22	-	0	Good Fit
Buick	Electra	1967	23	Under License Plate	1.0 + LEL	Poor Vacuum
Ford	Mustang	1968	23	Rear Panel	1.0 + LEL	Poor Vacuum
Ford	Fairlane	1964	23	Rear Panel	1.0 + LEL	Poor Vacuum
Ford	Falcon	1968	23	Rear Panel	1.0 + LEL	Poor Fit Poor Vacuum
Dodge	-	1973	23	Under License Plate	1.0 + LEL	Poor Vacuum
Plymouth	-	1966	23	Left Rear Panel	0	Spit back at end of fill
Ford	Ranchero	1974	23	Left Rear Panel	0	Spit back at end of fill
Ford	Torino	1972	23	Under License Plate	0	-

AUTOMOBILES TESTED (cont)

MAKE	MODEL	YEAR	STATION NUMBER WHERE TESTED	FILL NECK LOCATION	HC OBSERVATION	COMMENTS
VW	Bug	1966	23	Inside Trunk	1.0 + LEL	Poor Fit
Ford	Pinto Wagon	1973	23	Left Rear Panel	0	-
VW	Bus	1967	23	Right Rear Panel	0	-
Dodge	StaWag	1973	24	Left Rear Panel	1.0 + LEL	Poor Vacuum
Mercedes	-	1969	24	Under License Plate	0-600 PPM	Poor Vacuum
Ford	Pinto	1970	24	Left Rear Panel	1.0 + LEL	Poor Vacuum
VW	Bug	1970	24	Right Front Panel	1.0 + LEL	Poor Vacuum
Mazda	RX2	1972	24	Left Rear Panel	1.0 + LEL	Poor Vacuum
Chevy	Van	1973	24	Left Rear Panel	0	Poor Vacuum
Cadillac	Coupe DeVille	1974	24	Under License Plate	0	Poor Vacuum
Chevy	Camaro	1974	24	Under License Plate	1.0 + LEL	Poor Vacuum
Volvo	142 Sedan	1970	24	Right Rear Panel	1.0 + LEL	Poor Vacuum
Rambler	Nash	1967	24	Rear Panel	1.0 + LEL	Poor Vacuum
Ford	LTD	1973	24	Left Rear Panel	1.0 + LEL	Poor Vacuum
Datsun	StaWag	1967	24	Under License Plate	1.0 + LEL	Poor Fit Poor Vacuum
Ford	Pinto	1970	24	Left Rear Panel	1.0 + LEL	Poor Vacuum
VW	Bug	1965	24	Inside Trunk	200 PPM	Poor Vacuum
Chevy	Vega	1971	24	Under License Plate	0	Poor Vacuum
Jaguar	XKE	1971	24	Left Rear Panel	1.0 + LEL	Poor Vacuum
Cadillac	DeVille	1974	24	Under License Plate	1.0 + LEL	Poor Vacuum

APPENDIX C

Measured Operational Parameters

I. INTERMARK SYSTEMS

Date of Visit	Station Location	Comments
7/1/75	Sears	Bladder level indicator read 1/8 capacity, pressure = 0.64" H_2O.
7/9/75	Sears	Bladder down, pressure = 0.45" H_2O, compressor came on when level indicator read 1/8 capacity, pressure = 2" H_2O.
7/2/75	Gemco	Pressure = 1.5" H_2O when bladder level indicator read 1/8-3/8 capacity, pressure = 0.35" H_2O when level indicator read 1/16 - 1/8 capacity and compressor turned off, pressure = 1.4" H_2O when level indicator read just under 1/8 capacity and compressor started.
7/9/75	Gemco	Bladder in down position, pressure = 0.45" H_2O, pressure = 1.4" H_2O when level indicator read 1/8 capacity.
7/30/75	Gemco	Bladder in full up position, pressure = 7.5" H_2O.
7/3/75	Encinitas	Pressure = 2.4" H_2O, corresponding bladder level not known because level indicator does not work.
7/10/75	Encinitas	Pressure = 0" H_2O, processing unit down.
7/10/75	Carmel Valley	Pressure = 0" H_2O, processing unit down.

II. PROCESS PRODUCTS SYSTEMS & TEMPERATURE DATA

6/18/75	Waring Road	Refrigeration unit starts at 4" H_2O stops at 0.5" H_2O.
6/30/75	Waring Road	Refrigeration unit starts at 3.5 - 3.8" H_2O, stops at 0.5" H_2O
7/8/75	Waring Road	Refrigeration unit starts at 4.5" H_2O, stops at 0.5" H_2O

II. PROCESS PRODUCTS SYSTEMS & TEMPERATURE DATA (cont)

Date of Visit	Station Location	Comments
7/16/75	Waring Road	Refrigeration unit starts at 4.5" H_2O, stops at 0.5" H_2O
7/22/75	Waring Road	Refrigeration starts at 4.2" H_2O, stops at 0.2" H_2O
7/29/75	Waring Road	Refrigeration starts at 4.5" H_2O, stops at 1" H_2O.
6/19/75	Friars & Frazee	Condensate return = 12F, no pressure data
6/23/75	Friars & Frazee	Refrigeration starts at 1.1" H_2O, stops at 0.5" H_2O
6/26/75	Friars & Frazee	Condensate return = 22F, no pressure data
7/3/75	Friars & Frazee	Refrigeration starts at 1" H_2O, stops at 0.5" H_2O.
7/9/75	Friars & Frazee	Condensate return = 30F, refrigeration starts at 1.1" H_2O, stops at 0.3" H_2O
7/17/75	Friars & Frazee	Refrigeration starts at 1" H_2O, stops at 0.5" H_2O
7/22/75	Friars & Frazee	Condensate return = 30F, refrigeration starts at 1.1" H_2O, stops at 0.5" H_2O.
7/30/75	Friars & Frazee	Condensate return = 40F, refrigeration starts at 1" H_2O, stops at 0.5" H_2O
7/15/75	Clairmont & Clairmont Mesa	Tank pressure at 0.6" H_2O, processing unit down
7/22/75	Clairmont & Clairmont Mesa	Tank pressure 0" H_2O, unit down.
7/9/75	Bubble Machine	Tank pressure = 3.5" H_2O, unit down.

III. CLEAN AIR ENGINEERING SYSTEMS

6/25/75	Tierrasanta	Manifold pressure = 3" H_2O.
6/30/75	Tierrasanta	Manifold pressure = 3.5" H_2O.
7/8/75	Tierrasanta	Manifold pressure = 3.5" H_2O (low pressure adjusted to reduce sooting, according to Clean Air).
7/22/75	Tierrasanta	Manifold pressure = 3.2" H_2O while burning.
7/29/75	Tierrasanta	Manifold pressure = 3.3" H_2O

III. CLEAN AIR ENGINEERING SYSTEMS (cont)

Date of Visit	Station Location	Comments
6/26/75	Highway Patrol, S.D.	Manifold pressure = 5.5" H_2O
7/2/75	Highway Patrol, S.D.	15" H_2O when just vapor recovery blower on, 5.3" H_2O when burner pump starts, when burner pump stopped pressure went to -3" H_2O but leveled to zero after 2 min.
7/10/75	Highway Patrol, S.D.	Manifold pressure = 5" H_2O.
7/15/75	Highway Patrol, S.D.	Manifold pressure = 5.5" H_2O while burning.
7/28/75	Highway Patrol, S.D.	Manifold pressure = 5.3" H_2O
6/30/75	Rocky Home Dairy	14.4" H_2O when vapor collection blower on, pressure went to 6.8" H_2O when burner on.
7/8/75	Rocky Home Dairy	Pressure goes to 15" H_2O when vapor collection blower starts, as burner starts pressure decreases to 6.5" H_2O.
7/16/75	Rocky Home Dairy	Manifold Pressure = 6.8" H_2O while burning
7/22/75	Rocky Home Dairy	Manifold Pressure = 6.3" H_2O.
7/28/75	Rocky Home Dairy	Manifold Pressure = 4.2" H_2O.
7/3/75	Highway Patrol, Onsde	5.5" H_2O while burner pump on, 15" H_2O before burner activated.
7/10/75	Highway Patrol, Onsde	15" H_2O before burner pump on, 5-5½" H_2O after burner pump started.
7/18/75	Highway Patrol, Onsde	Manifold pressure = 5.3" H_2O
7/31/75	Highway Patrol, Onsde	Manifold pressure = 4.0" H_2O

IV. HIRT SYSTEM DATA

7/10/75	Oceanside	Compressed air starts when tank pressure = -0.58" H_2O, small burner starts when tank pressure = -0.58" H_2O,

IV. HIRT SYSTEM DATA (cont)

Date of Visit	Station Location	Comments
		compressed air and burners stop when tank pressure = -0.65" H_2O (large burner starts when tank pressure = -0.1" H_2O, this was not observed but information was supplied by Hirt).
7/15/75	Oceanside	Compressed air starts when tank pressure = -0.61" H_2O, small burner starts when pressure = -0.61" H_2O.
7/31/75	Oceanside	Compressed air and small burner start when tank pressure = -0.58" H_2O, both stop when tank pressure = -0.61" H_2O.

V. ENVIRONICS SYSTEMS

Date of Visit	Station Location	Comments
7/1/75	Parkway Texaco	Reactor Temp. = 73F (?), unit down.
7/9/75	Parkway Texaco	Reactor Temp. = 1065F.
7/16/75	Parkway Texaco	Reactor starts at 1290F, carbon regeneration pump deactivates when temp. reaches 740F.
7/29/75	Parkway Texaco	Pressure switch at 1.6" H_2O, 2.6" H_2O when vapor collection blower starts then back to 1.6" H_2O.
7/2/75	Post Office	Reactor Temp. at 848F when burner pump came on, then went down to 760F.
7/10/75	Post Office	Reactor temp at 872F before any gas fillups.
7/17/75	Post Office	Processing unit down, reactor temp ≈ 635F.
7/21/75	6th & Robinson	Pressure switch opened at 1.5" H_2O.

APPENDIX D

Automobiles with Fillnecks Poorly Fit by Nozzles

AUTOMOBILES WITH FILLNECKS POORLY FIT BY NOZZLES

Maker	Model	Year	Location of Fillneck
BMW	-	1969	Right Rear Side
Buick	Riviera	1966	Under License Plate
Buick	Sta. Wag.	1967	
Chevy	Malibu	1973	
Chevy	Corvette	1966	On Top Of Trunk
Chevy	El Camino	-	Left Rear Side
Chevy	Nova Wagon	1968	Left Rear Side
Chevy	Corvette	1969	On Top Of Trunk
Chevy	1/2 Ton Pickup	1971	(Nozzle Did Not Fit)
Chevy	Van	1975	
Chevy	Chevelle	1973	
Chevy	350 Truck	1973	Below Cab On Right Side
Chevy	L/50 Truck	1968	Behind Left Cab Door
Chevy	Corvette	1969	On Top Of Trunk
Datsun	Sta. Wag.	1971	Right Rear Side
Datsun	1600	1973	Right Rear Side
Datsun	240z	1973	Right Rear Side
Datsun	240z	1969	Right Rear Side
Datsun	Sta. Wag.	1967	Under License Plate
Datsun	Pickup	1975	Left Rear Side
Dodge	Coronet Wagon	1973	On Left Rear Side
Dodge	Satellite	1974	Under License Plate
Dodge	Sta. Wag.	1973	Left Rear Side

AUTOMOBILES WITH FILLNECKS POORLY FIT BY NOZZLES (Continued)

Maker	Model	Year	Location of Fillneck
Dodge	Polara	1967	Under License Plate
Fiat	128	1973	
Ford	LTD	1972	Left Rear Side
Ford	Falcon	1964	Left Rear Side
Ford	Pickup	-	
Ford	Maverick	1970	At Rear
Ford	Torino	1973	Under License Plate
Ford	5 Ton Truck	1974	
Ford	Falcon	1968	At Rear
Mercedes	-	1971	Under License Plate
Oldsmobile	98	1968	Under License Plate
Pontiac	Le Mans	1965	Under License Plate. Tow Hitch Hindered Fit.
Pontiac	Catalina	1966	Under License Plate
Pontiac	-	1968	
VW	Bus	1971	Right Rear Side
VW	Bug	1966	Inside Trunk
VW	-	1972	Right Front Side

Poor Fits can be due to obstructions such as towing hitches, pop-up gas caps, anti-syphon devices, door hatches over fill necks, etc.

APPENDIX E

Observations with EPA Hydrocarbon Detectors

OBSERVATIONS WITH EPA HYDROCARBON DETECTORS

I. Clean Air Engineering Systems

Date of Visit	Station Location	HC Detector Reading	Comments
6/10/75	Rocky Home Dairy	10.6 Hr	Start time on detector was 10.6 Hr, detector installed was #245-3 504-3 Probe #5 (Latching Type)
6/18/75	Rocky Home Dairy	10.6 Hr	
6/19/75	Rocky Home Dairy	No Reading	
6/25/75	Rocky Home Dairy	10.6 Hr	
6/30/75	Rocky Home Dairy	10.6 Hr	
7/8/75	Rocky Home Dairy	10.6 Hr	
7/16/75	Rocky Home Dairy	10.6 Hr	Recorded as 0.6 Hr on data sheet, but detector will not run in reverse and not enough hours had passed to complete a total revolution of the timer, so reading was assumed to be 10.6 Hr
7/22/75	Rocky Home Dairy	No Reading	
7/28/75	Rocky Home Dairy	10.6 Hr	Recorded as 0.6 Hr
6/17/75	Highway Patrol, S.D.	0.5 Hr	Start time on detector was 0.5 Hr, detector installed was #245-2, 504-1, Probe #2 (Non-latching Type)
6/26/75	Highway Patrol, S.D.	No Reading	
7/2/75	Highway Patrol, S.D.	0.5 Hr	
7/10/75	Highway Patrol, S.D.	0.5 Hr	
7/15/75	Highway Patrol, S.D.	0.5 Hr	
7/28/75	Highway Patrol, S.D.	0.5 Hr	

OBSERVATIONS WITH EPA HYDROCARBON DETECTORS (Continued)

II. Environics Systems

Date of Visit	Station Location	HC Detector Reading	Comments
6/11/75	Midway Post Office	0.2 Hr	Start time on detector was 0.2 Hr, detector installed was #245-3 504-1, Probe #6 (Latching Type)
6/24/75	Midway Post Office	306.5 Hr	Read at 0830 and reset with start at 306.6 Hr
6/27/75	Midway Post Office	306.6 Hr	Upon visit found main power to processing unit off. Reason unknown.
7/2/75	Midway Post Office	306.6 Hr	Blower failure observed during visit.
7/10/75	Midway Post Office	306.6 Hr	Blower still not repaired
7/17/75	Midway Post Office	306.6 Hr	Blower still not repaired
7/31/75	Midway Post Office	306.6 Hr	Blower repaired
6/10/75	Parkway Texaco	0.35 Hr	Start time on detector was 0.35 Hr, detector installed was #245-2, 504-1, Probe #3 (Non-latching Type)
6/17/75	Parkway Texaco	No Reading	
6/18/75	Parkway Texaco	0.40 Hr	
6/26/75	Parkway Texaco	0.45 Hr	
7/1/75	Parkway Texaco	0.80 Hr	
7/9/75	Parkway Texaco	1.6 Hr	
7/16/75	Parkway Texaco	2.4 Hr	
7/29/75	Parkway Texaco	2.6 Hr	

OBSERVATIONS WITH EPA HYDROCARBON DETECTORS (Continued)

III. PROCESS PRODUCTS SYSTEMS

Date of Visit	Station Location	HC Detector Reading	Comments
6/19/75	Friars & Frazee	0.3 Hr	Start time on detector was 0.3 Hr, detector installed was #245-2, 504-2, Probe #1 (Latching Type)
6/23/75	Friars & Frazee	0.3 Hr	
6/26/75	Friars & Frazee	0.3 Hr	
7/3/75	Friars & Frazee	0.3 Hr	
7/9/75	Friars & Frazee	0.3 Hr	
7/17/75	Friars & Frazee	No Reading	HC Detector disconnected by ARB so they could do their own testing
7/22/75	Friars & Frazee	No Reading	
7/30/75	Friars & Frazee	0.3 Hr	
6/17/75	College Car Wash	No Reading	Processing unit down Detector installed was #245-3, 504-2, Probe #4 (Non-latching Type)
6/18/75	College Car Wash	No Reading	Processing unit down
7/2/75	College Car Wash	No Reading	Processing unit down
7/11/75	College Car Wash	0.2 Hr	Processing unit down Found blown fuse in detector
7/17/75	College Car Wash	No Reading	Processing unit down
7/23/75	College Car Wash	No Reading	Processing unit down
7/30/75	College Car Wash	No Reading	Processing unit down

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1. REPORT NO. EPA-450/3-76-001	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Reliability Study of Vapor Recovery Systems at Service Stations		5. REPORT DATE March 1976
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) R. J. Bryan R. L. Norton L. G. Wayne		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Pacific Environmental Services, Inc. 1930 14th Street Santa Monica, California 90404		10. PROGRAM ELEMENT NO.
		11. CONTRACT/GRANT NO. 68-02-1405 Task Order No. 2
12. SPONSORING AGENCY NAME AND ADDRESS U. S. Environmental Protection Agency Research Triangle Park, North Carolina 27711		13. TYPE OF REPORT AND PERIOD COVERED Control Systems Evaluation
		14. SPONSORING AGENCY CODE
15. SUPPLEMENTARY NOTES		

16. ABSTRACT

A study was conducted of the operational reliability of vapor recovery systems at gasoline service stations in San Diego County, California. Periodic inspections at 24 stations were conducted to examine the condition of these systems, to determine their operational status, and to check for detectable gasoline vapor losses from control equipment.

The study demonstrated that capture of vapors at the vehicle was more effective with vacuum-assisted systems than with vapor balance systems. However, the reliability of the vacuum-assisted systems was not good in general although there was substantial variation depending upon the type of unit.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Pollution Gasoline Marketing Service Station Vapor Recovery	Air Pollution Control Stationary Sources Mobile Sources Hydrocarbons	

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