California Environmental Protection Agency

AIR RESOURCES BOARD

Monitoring and Laboratory Division
Engineering and Certification Branch

MEASUREMENT OF GASOLINE VAPOR EMISSIONS FROM VEHICLES EQUIPPED WITH ON-BOARD VAPOR RECOVERY

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1. EXECUTIVE SUMMARY

Staff of the Air Resources Board (ARB) measured gasoline vapor emissions from dispensing gasoline to vehicles equipped with on-board vapor recovery systems at a gasoline dispensing facility with no Phase II vapor recovery system. The vehicle on-board refueling vapor recovery (ORVR) system captures the gasoline vapors that are displaced when gasoline is dispensed to the vehicle tank and stores those vapors in a canister filled with activated carbon. When the vehicle engine is started, gasoline vapors stored on the carbon are purged and burned in the engine. The Phase II vapor recovery system collects vapors during vehicle fueling and returns them to the facility's underground storage tank.

The emissions study was conducted at a dispensing facility for a rental vehicle company with a fleet of ORVR vehicles. Emissions were monitored at the vehicle fillpipe during fuel dispensing and at the pressure/vacuum (P/V) vent valve from the underground storage tank (UST) for both ORVR and non-ORVR vehicles. Emissions were measured for both summer and winter commercial gasolines (California Reformulated Gasoline, Phase 3). Fillpipe emissions for non-ORVR vehicles were: 5.8 lb/1000 gallons gasoline dispensed for summer fuel and 9.2 lb/1000 gallons for winter fuel. Emissions from ORVR vehicles were 0.043 lb per 1000 gallons dispensed for summer fuel and 0.094 lb per 1000 gallons for winter fuel, or about 1% of the emissions from a non-ORVR vehicle.

During a two day test period in the summer and a second two day period in the winter, a vacuum was maintained in the underground storage tank (UST) and there were no emissions from the P/V vent valve, despite the nightly shut down of fuel dispensing. The UST pressure was monitored thirty days with summer fuel and thirty days with winter fuel. During these monitoring periods there were periodic spikes in the UST pressure, resulting in fugitive emissions of 0.20 lb per day in the summer and 0.28 lbs per day in the winter.

Fillpipe and fugitive emissions from the test facility without a Phase II vapor recovery system met ARB's emission limits for a Phase II enhanced vapor recovery (EVR) system.

Gasoline throughput at this facility was about 12,000 gallons per month, which is a low throughput when compared to the typical throughput of 100,000 gallons per month for a retail dispensing facility. It is possible that a UST with a higher throughput would generate more significant fugitive emissions than those measured at this facility.

2. INTRODUCTION

Since the 1970's, Phase II vapor recovery systems have been installed on gasoline dispensing facilities in California to capture and control the gasoline vapors emitted during the refueling of gasoline-powered vehicles. In 2005, a new generation of Phase II systems, enhanced vapor recovery (EVR), was introduced in California.

The on-board refueling vapor recovery (ORVR) system for vehicles was also designed to prevent gasoline vapors from being emitted to the atmosphere during refueling. The ORVR system was first installed on some passenger vehicle models in 1998. Since the 2006 model year, most passenger cars and trucks have been equipped with ORVR. As a result, the number of ORVR vehicles on the road is increasing each year, such that by 2020, 94% of the miles driven on California highways will be driven by vehicles with ORVR[1]. Currently some commercial and government fleets are predominantly ORVR vehicles. The U.S. Environmental Protection Agency (EPA) has determined that if 95% of the vehicle fleet serviced at a non-retail gasoline dispensing facility has on-board vapor recovery, a state can apply for a revision of the State Implementation Plan (SIP) to remove the Clean Air Act requirement for a Phase II vapor recovery systems at that facility. In California, the federal ozone SIP, the state air toxics program and the state ozone control program for meeting the California Clean Air Act include Phase II emission controls at gasoline dispensing facilities. Accordingly, information is needed on any emissions associated with removing Phase II vapor recovery systems for ORVR fleet facilities.

The two Phase II EVR systems currently certified in California are designed to be compatible with ORVR vehicles by limiting the amount of air and gasoline vapor that is returned to an underground storage tank during the refueling of an ORVR vehicle. As a result of this design feature, during periods of gasoline dispensing, the refueling of ORVR vehicles provides a vacuum in the underground storage tank (UST). A UST without a Phase II vapor recovery system also operates at a vacuum while gasoline is dispensed, since no vapor is returned to displace the gasoline dispensed. However, at gasoline dispensing facilities that shut down at night, air that is ingested from ORVR vehicle refueling and UST leaks causes pressure growth in the UST and results in fugitive emissions. Air Resources Board (ARB) staff documented the overnight pressure increase at a high throughput gasoline dispensing facility[2]. This study was conducted to provide information on the fugitive emissions from a low-throughput UST during an overnight shut down.

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[1] See the projection for future years of the percentage of ORVR vehicles in use on California roads at http://www.arb.ca.gov/vapor/ORVR Percent VMT 2008.pdf . Memorandum from Frances Cameron to George Lew, California Air Resources Board, "Miles Traveled by ORVR Vehicles in California", July 1, 2008.

[2] ARB Project No. V-05-035, Phase II Vapor Recovery Balance System Challenge Mode Study, October 25, 2006.

3. TEST SITE AND PROTOCOL

A rental vehicle facility which services ORVR vehicles and has no Phase II vapor recovery system was selected for testing. The (San Francisco) Bay Area Air Quality Management District's Regulation 8, Rule 7 exempts gasoline dispensing facilities with a fleet of over 90% ORVR vehicles from District requirements for Phase II vapor recovery.

3.1 Test Site and Phase I Vapor Recovery Performance Checks

The test facility configuration, operation schedule and gasoline throughput are provided in Table 1, below.

Table 1: Test Site Characteristics

Location	San Jose, California
Type of operation	Rental car facility with 100% ORVR fleet
Monthly gasoline throughput	12,000 gallons, 3 to 4 deliveries per month (Note that this throughput is substantially lower than that of a typical retail facility, with a throughput of about 100,000 gallons per month.)
Gasoline Product	Commercial gasoline, 87 octane, California Reformulated Gasoline, Phase 3, Summer Fuel RVP = 6.9 psi, and Winter Fuel RVP = 11.9 psi
Facility configuration	One 10,000 gallon UST, 2 dispensers, 4 fueling points
Phase I vapor recovery system	OPW E.O. VR-102, Husky Model No. 4885 P/V vent valve
Phase II status	The vapor return line is capped off in the dispensers
Hanging hardware	OPW 11-B nozzle (conventional) Goodyear hose, 559N Flexsteel, ¾" (fuel only)
Operating Schedule	Open daily, 365 days per year, 6:00 a.m. – 10:00 p.m.

Before commencing the monitoring study, ARB staff and a service station contractor confirmed that the Phase I vapor recovery system was operating in conformity with the requirements of ARB Executive Order VR-102-H for the OPW Phase I vapor recovery system. Also, before testing, a new Husky 4885 Pressure/Vacuum (P/V) vent valve was bench tested and installed. Table 2 outlines the pretest procedures that were conducted before the August 3 and December 4 tests. The UST passed all of these performance tests for both the study periods.

Table 2: Phase I Vapor Recovery Performance Checks

1. TP-201.1E: Determination of Leak Rate and Cracking Pressure of Pressure/Vacuum Vent Valves (Off-site bench test before August 3 only and on-site, for both testing periods.)
2. TP-201.1B: Static Torque of Rotatable Phase I Adaptors.
3. TP-201.1C: Leak Rate of Drop Tube/Drain Valve Assembly
4. TP-201.3: Determination of 2 in WC static pressure performance of vapor recovery systems of dispensing facilities. (Includes pre and post test checks.)

3.2 Test Protocol

ARB staff conducted two investigations to quantify gasoline vapor emissions from ORVR vehicles:

(1) Vehicle refueling emissions were determined using ARB Test Procedure (TP) 201.2[3], Efficiency and Emission Factor for Phase II Systems (Amended May 25, 2006). Emissions from the vehicle fillpipe and the pressure/vacuum vent valve for the UST were measured for ORVR and non-ORVR vehicles. Fill pipe emissions during vehicle refueling were collected by a sleeve that fit over the dispensing nozzle. Emissions were measured for 33 ORVR vehicles and 6 non-ORVR vehicles with summer fuel on July 31 – August 1, 2007. Emissions were also measured for 25 ORVR vehicles and 10 non-ORVR vehicles with winter fuel on December 4-5, 2007.

The following changes were made to the test procedure in order to measure emissions from a facility with no Phase II vapor recovery system:

- Available fleet ORVR vehicles were tested, rather than the matrix of vehicles defined by TP-201.2A, used in certifying a Phase II vapor recovery system. Employee vehicles which were determined to be non-ORVR were also tested to provide emissions data for Phase 3 California Reformulated Gasoline (CaRFG3).
- There was no vapor return line or vapor processor outlet to monitor at this facility.
- The vehicle fillpipe emissions were captured by the nozzle sleeve apparatus of TP 201.2 at two different flow rates. The nozzle sleeve captured fillpipe emissions at a flow rate of 5 cubic feet per minute (CFM) for the ORVR vehicles and at a flow rate of 9 CFM for the non-ORVR vehicles. Since there is no on-board system that captures gasoline vapor during refueling of non-ORVR vehicles, all gasoline vapor displaced from the vehicle tank exits the fillpipe. For this reason, the sleeve capture flowrate was higher for non-ORVR vehicles than for ORVR vehicles.

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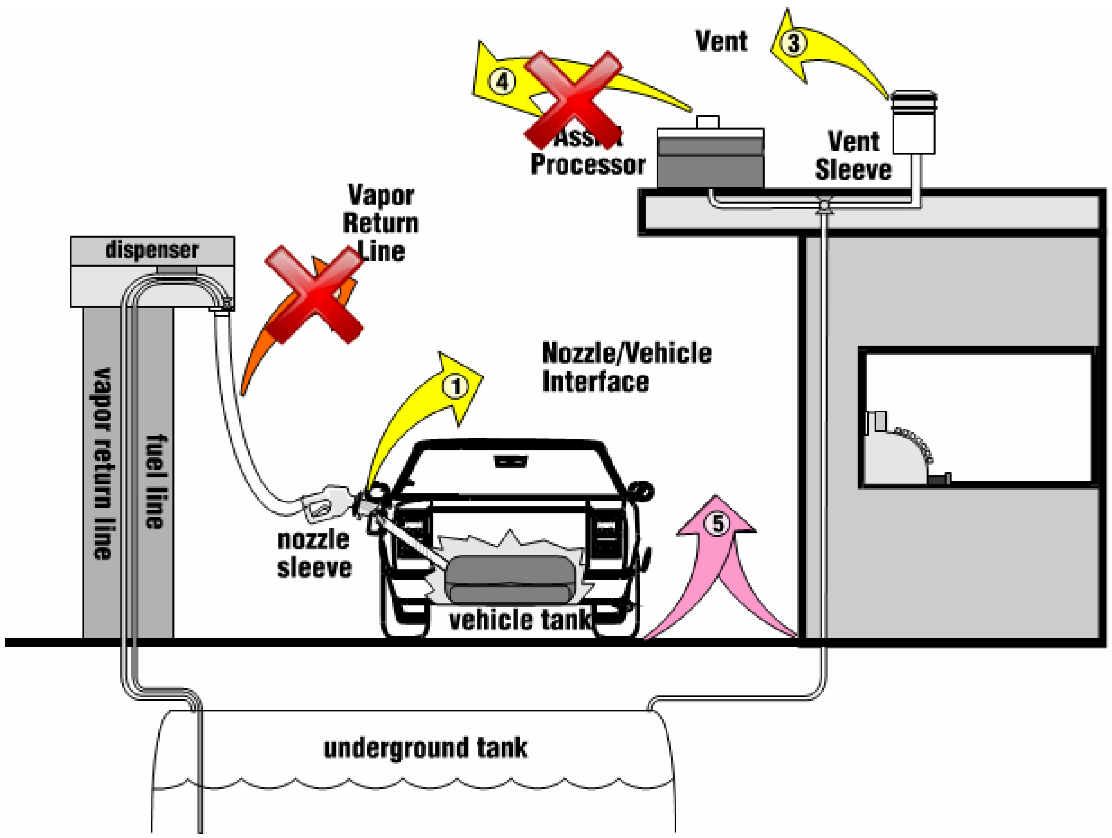
[3] ARB vapor recovery test procedures are located at: http://www.arb.ca.gov/testmeth/vol2/new2006vol2.htm

Figure 1 shows the modifications of the TP 201.2 test configuration for this study. The source test reports for the two monitoring periods are provided as Appendix 1 and Appendix 2 of this report.

Figure 1: Modifications of ARB Test Procedure 201.2 for this study



(2) The underground storage tank pressure was monitored in accordance with TP 201.7, Continuous Pressure Monitoring for two 30 day periods. The monitoring periods were August 3 to September 1, 2007, for summer fuel, and December 5, 2007, to January 3, 2008, for winter fuel. The underground tank pressure, ambient temperature and barometric pressure were continuously collected on a Campbell Scientific data logger installed by ARB on August 1, and left in place until the end of the winter fuel study period in January, 2008. The pressure transducer was checked against a National Institute of Standards and Technology traceable secondary device before and after the study. Sixty second averages of tank pressure, ambient temperature, and barometric pressure were recorded and transmitted to ARB staff via a cell phone connection. TP-201.3, the leak decay test, was conducted before each 30 day monitoring period, at the midpoint and at the end of each monitoring period. The system passed TP-201.3

each time it was performed. The leak decay test results are listed in Table 3, below:

Table 3: Static pressure performance from TP 201.3 runs
Initial pressure of 2.00 inches water

Date	Conditions	Final Press after 5 min, in water	Ullage, gal	Allowable final pressure after 5 minutes from TP 201.3 (1), in water
8/1/2007	beginning of 30 day period	2.02	6605	≥ 1.78
8/14/2007	mid point of 30 day period	1.88	6610	≥ 1.78
9/5/2007	end of 30 day period	1.92	3212	≥ 1.58
12/5/2007	beginning of 30 day period (2)	2.10	3095	≥ 1.56
12/19/2007	mid point of 30 day period	1.7	4423	≥ 1.68
1/14/2008	end of 30 day period	1.92	3916	≥ 1.65

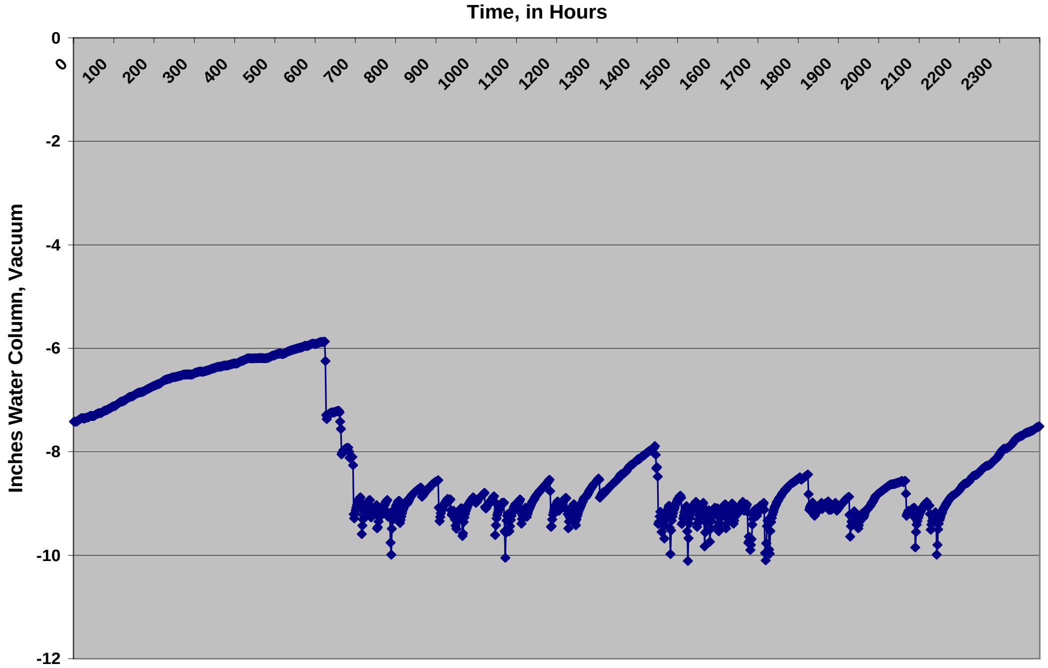
(1) Note that TP201.3 applies to an underground storage tank with a Phase II vapor recovery system and the allowable limit provided in this table is for a balance system with 1 to 6 nozzles.

(2) Initial pressure was 2.15 in water.

4.0 UST PRESSURE MONITORING AND FUGITIVE EMISSIONS

The ullage pressure of the underground storage tank (UST) was monitored for 30 days with summer fuel in August, 2007, and then for 30 more days with winter fuel in December, 2007. Figure 2 shows the pressure profile for a typical summer day: During facility operation hours from 6:00 a.m. to 10:00 p.m., the UST pressure was consistently about 9 inches water column vacuum. During the day, the gasoline dispensing with no vapor return drew down the vacuum until the P/V valve “cracked” at about 8.5 inches water. This “draw down” was balanced by the intake of fresh air at the P/V valve vent. During the overnight shutdown, no dispensing occurred to keep the UST ullage at the negative cracking pressure. Overnight, the air ingested at the P/V valve and from other leaks in the UST piping also caused vapor growth from the liquid phase, resulting in a steady pressure increase to about 6 inches water column vacuum by 6:00 a.m. the following morning. When dispensing began, the UST pressure promptly fell to the negative cracking pressure.

Figure 2: UST Pressure Trace on August 29, 2007



When the ullage pressure was monitored in December for winter fuel, a similar daily pressure profile occurred: during operating hours the tank vacuum was at the negative cracking pressure. Due to the higher Reid vapor pressure of winter fuel at 11.9 psi, compared with 6.9 psi for summer fuel, the overnight tank pressure increased slightly to about 5 inches water column vacuum. Figure 3 is the pressure profile for a winter day.

Figure 4 is a trace of UST pressure over 15 days in August. Pressure spikes occurred as a result of cargo tanker fuel deliveries on August 8 and August 17, and the performance of ARB TP 201.3 on August 14. A number of the other pressure spikes were possibly due to a continuous stream of "mini" fuel deliveries from vehicle degassing, although these degassing events were not logged for this study. When a vehicle was removed from the facility fleet, the vehicle fuel tank was drained, or degassed. The gasoline removed from the vehicle was transferred to a portable tank and then drained from that tank into the UST. Degassing occurred up to twice daily during the month of August. The portable degassing set-up at this facility included a vapor return line. If the vapor line had been properly connected, the vapor displaced from the UST by the gasoline drained into the UST would have been pushed into the portable tank without a sizeable increase in the UST pressure. It is possible that a number of the additional pressure spikes in Figure 4 were the result of the degassing operation without connection of the vapor line. If a fuel delivery or degassing event occurred during a period of no gasoline dispensing, such as during evening hours, the UST pressure occasionally migrated above atmospheric pressure.

Figure 3: UST Pressure Trace on December 6, 2007

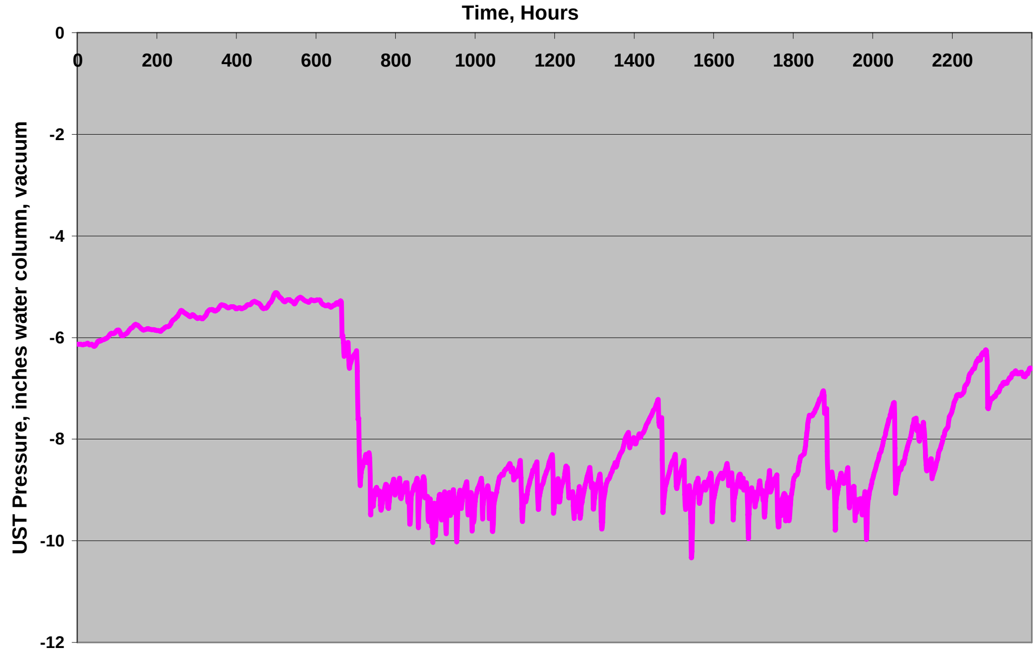


Figure 4: UST Pressure over 15 days for Summer Fuel, No Phase II

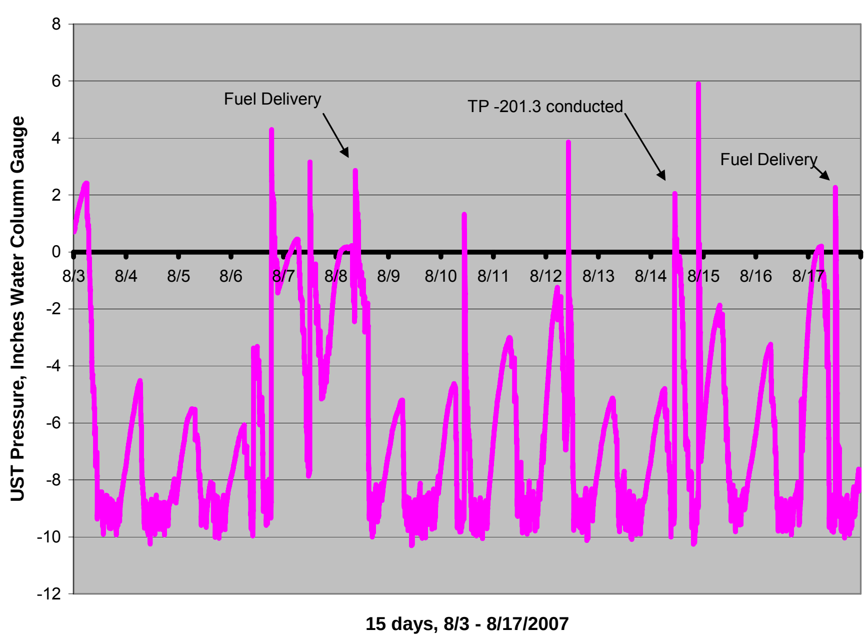


Figure 5 is a pressure trace over fifteen days for the underground fuel tank with winter fuel. There were fewer pressure spikes during this period, but on

December 31, there were two pressure spikes possibly resulting from instrumentation irregularities. The first spike was a change of 17 inches of water in 2 minutes, the second spike an hour later was 8 inches within a minute. Without any accompanying UST activity to explain these spikes, it is likely that the pressure transducer experienced some anomaly.

There was also an extended period of positive pressure beginning January 1 and continuing until 0600 on January 2. Although the rental vehicle facility operates every day of the year, it appears likely from the pressure trace of Figure 5 that no vehicle refueling occurred on January 1. If a tank which is leak-tight remains idle, as the barometric pressure drops, the tank gauge pressure increases by the same amount. Figure 6 shows this effect: as the barometric pressure dropped, the UST gauge pressure increased by the same amount, until gasoline dispensing commenced at 0600 on January 2.

Figure 5: UST Pressure over 15 days for Winter Fuel, No Phase II

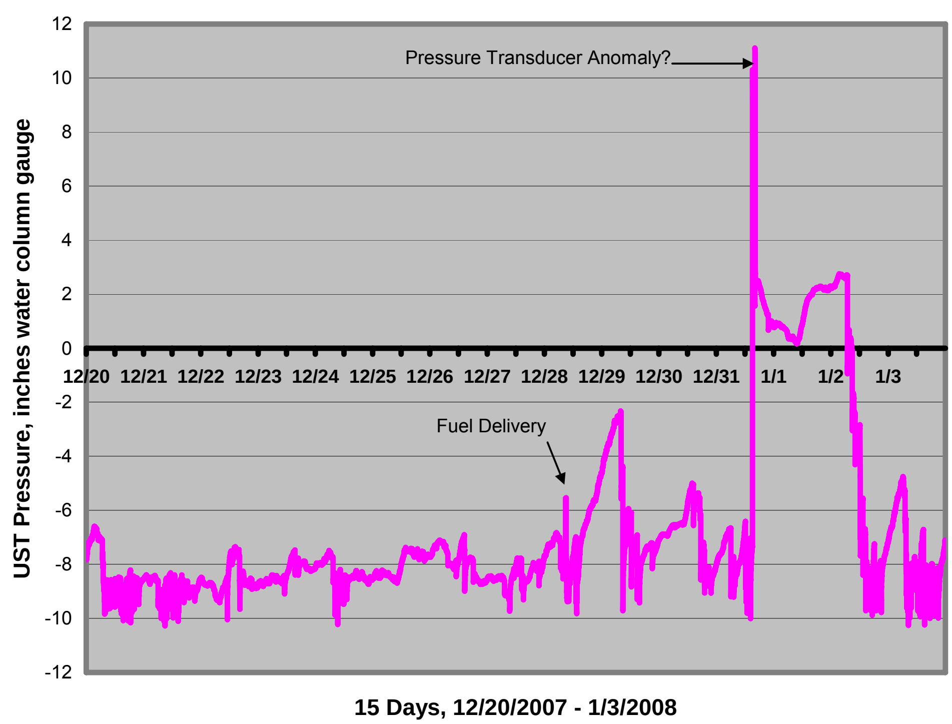
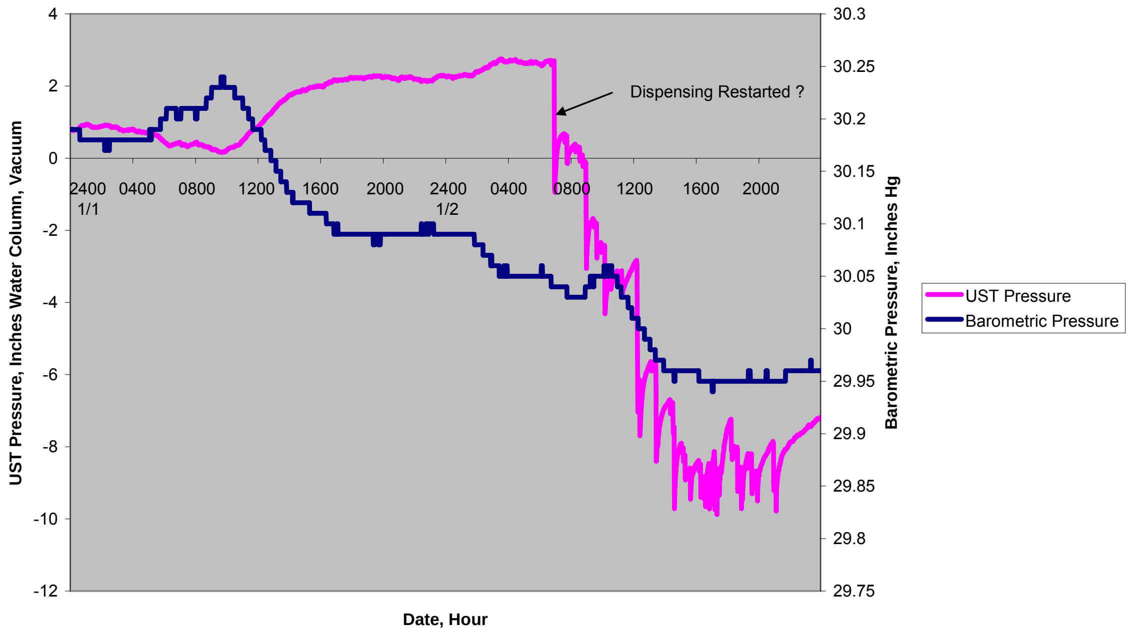


Figure 6: UST and Barometric Pressure over New Year's Day, 1/1/ - 1/2/2008



Fugitive emissions were estimated for each 30 day period from the pressure data for the UST and the average leak rate determined from the leak decay tests, as shown in Table 4. With the exception of the leak decay performed on December 19, the final pressure after three minutes of each leak decay test did not differ more than 5% from the initial pressure of 2 inches water ((2.00 – 1.92)/2.00 * 100% = 4%). Since this is a small pressure change, the average leak rate for this UST at 2.00 inches was calculated as shown in Table 4.

Table 4: Leak rate from TP 201.3 runs
Initial pressure (Pi) of 2 inches water, gauge

Date	Conditions	Final Press after 3 min, in water (Pf)	Average Pressure during the first 3 minutes, in water	Ullage volume, gal	Initial UST press - Final UST Press, (Pi - Pf), in water	Average leak rate Q, CFM (2)	Average leak rate Q, CFH
8/1/2007	beginning of 30 day period	2.01	2.01	6605	-0.01	-0.01	0.00
8/14/2007	mid point of 30 day period	1.92	1.96	6610	0.08	0.06	3.47
9/5/2007	end of 30 day period	1.94	1.97	3212	0.06	0.02	1.27
12/5/2007	beginning of 30 day period (1)	2.1	2.13	3095	0.05	0.02	1.02
12/19/2007	mid point of 30 day period	1.79	1.90	4423	0.21	0.10	6.10
1/14/2008	end of 30 day period	1.95	1.98	3916	0.05	0.02	1.29
						Average leak rate, CFH =	2.19

(1) Initial pressure was 2.15 in water.
(2) Q = (Pi - Pf) / (Pbar, 406.9 in water) * Ullage volume (gal) / 7.48 gal/ft3 / 3 minutes

Correction factors were determined for adjusting the average leak flow rate at two inches of water, gauge, from Table 4 to the flow rate for pressure increments between 0 and 3.00 inches water, the positive cracking pressure of the P/V vent valve. The correction factors for the leak rate from the UST at these pressure increments were calculated from flow rate and pressure data obtained in the development of ARB's TP-201.2F, Pressure Related Fugitive Emissions. Both the TP-201.2F pressure and flow data and the hourly pressure data for the test site are included in Appendix 3. For each 30 day period of pressure monitoring data, UST hourly average pressure data were ranked from maximum to minimum. First a pressure-corrected flowrate was assigned to each hour of positive UST pressure, and then each hourly flowrate was summed for a total leak flow, Q_{test}, over the 30 days. Fugitive emissions were calculated for the period August 3 to September 1, 2007, as shown below from Equation 9.3.1 of TP-201.2F for the 30 days of monitoring data in Appendix 3:

$$M = \left[\frac{(Q_{test})(C)(MW)}{(MV)(100)} \right] / \text{ 30 days}$$

where:

M	=	Mass rate of fugitive emissions, lb/day
Q_{test}	=	Total volumetric flow over the test period, cubic feet (ft^3), 145.1 ft^3 from Appendix 3 for summer fuel
C	=	Hydrocarbon vapor concentration, percent, 36 for C_3
MW	=	Molecular weight, lb/lb-mole, 44.096 for C_3
MV	=	Molar volume, 386.7 ft^3/lb-mole at 70°F
100	=	Conversion factor for percent to mole fraction

$$M = \left[\frac{(145.1)(36)(44.096)}{(386.7)(100)} \right] / \text{ 30 days}$$

M = 0.20 lbs/day for summer fuel

Fugitive emissions were calculated by the same method to be 0.28 lbs per day for winter fuel.

Fugitive emissions from the UST in this study were low due to the leak-tight condition of the tank, the absence of a Phase II vapor return line, and the relatively low gasoline throughput at this facility. During the emissions measurement periods, July 31 – August 1 and December 4 and 5, the UST pressure was maintained at 8.5 inches vacuum for periods of gasoline dispensing. The pressure profiles in Figure 2 and Figure 3 show that this vacuum was a buffer to keep the UST at a vacuum throughput the overnight shutdown.

The gasoline throughput at this facility, about 12,000 gallons/month, is low compared with the throughput at a typical retail gasoline dispensing facility of 100,000 gal per month. With a higher gasoline throughput, more air is ingested into the UST during periods of dispensing, resulting in more rapid vapor growth during an overnight shut down. Thus, it is likely that a UST with a higher throughput would generate more significant fugitive emissions.

Over the two thirty day periods of monitoring the UST pressures, fugitive emissions did occur at this facility. Figures 4 and 5 show a number of periods during which the UST pressure briefly exceeded atmospheric pressure. During periods of no gasoline dispensing, if a gasoline delivery or degassing event occurred, or if the barometric pressure dropped, periods of positive pressure did occur, resulting in fugitive emissions.

5. DISCUSSION OF ORVR VEHICLE EMISSIONS

Vehicle fillpipe emissions from gasoline dispensing and fugitive emissions from the underground storage tank are summarized in Table 5. Fillpipe emissions for non-ORVR vehicles were: 5.8 lb/1000 gallons gasoline dispensed for summer fuel and 9.2 lb/1000 gallons for winter fuel. Emissions from ORVR vehicles were 0.043 lb per 1000 gallons dispensed for summer fuel and 0.094 lb per 1000 gallons for winter fuel, or about 1% of the emissions from a non-ORVR vehicle.

The variation in emissions for individual fueling events was much greater for ORVR vehicles than for non-ORVR vehicles. The standard deviation of the non-ORVR measurements was between 6% (Summer fuel: 0.34/5.75 x 100%= 6%) and 7% (Winter fuel: 0.63/9.2 x 100% = 7%) of the mean, compared with a standard deviation of about two times the mean for the ORVR vehicles (Summer fuel: 0.08/0.043 x 100%= 2%, Winter fuel: 0.18/0.094 x 100% = 2%). Emissions from individual fueling events for ORVR vehicles ranged from 0.002 to 0.05 lbs per 1000 gallons for summer fuel, and from 0.004 to 0.75 lbs per 1000 gallons for winter fuel. The variation in the ORVR emission factor may be due to variations in the design and operation of each vehicle's vapor control system. Each on-board system includes a check valve in the vehicle fillpipe, a vapor path from the vehicle fuel tank through the carbon canister, and a shutoff valve which is activated when the tank fill level has been reached.

Table 5
Gasoline vapor emissions from ORVR and non-ORVR vehicles at a dispensing facility with no Phase II vapor recovery

Emission Measurements	**Emissions, lbs per 1000 gallons dispensed**	
	Summer Fuel, RVP = 5.8 psi	Winter Fuel, RVP = 11.9 psi
Vehicle fillpipe emissions		
ORVR vehicles, average of 33 summer and 25 winter fueling events ± standard deviation[4]	**0.043 ± 0.080**	**0.094 ± 0.18**
ORVR vehicles, range of emissions factors for fueling events	**0.002 – 0.05**	**0.004 – 0.75**
non-ORVR vehicles, average of 6 summer and 10 winter fueling events ± standard deviation	**5.75 ± 0.34**	**9.20 ± 0.63**
Fugitive Emissions (30 days of UST pressure data)	**0.20 lbs/day**	**0.28 lbs/day**

[4] The summer and winter ORVR emission factors in this table are the average of the individual vehicle emission factor for each vehicle refueling event. The summer and winter ORVR emission factors reported in Appendices 1 and 2 are 0.042 lb/1000 gallons and 0.10 lb/1000 gallons, respectively, and are the emission factors averaged by throughput, or the total amount of emissions from all vehicle refueling divided by the total amount of gasoline dispensed.

In California, the Phase II enhanced vapor recovery (EVR) systems are certified to meet limits for both total emissions and fugitive emissions. As shown in Table 6, the emission factors calculated for the facility in this study, without a Phase II system, meet both of the EVR Phase II emission limits. The ARB[5] requires that the factor for total emissions is less than or equal to 0.38 lbs/1000 gallons of gasoline dispensed, and the factor for fugitive emissions is less than or equal to 0.19 lbs/1000 gallons dispensed. The emission limits apply to both summer and winter fuels, and are calculated for a throughput of 150,000 gallons of gasoline dispensed per month.

Table 6: Comparison of test facility emissions with ARB Certification Procedure emission limits for Phase II EVR systems

Test Results and ARB Limits	Fugitive Emissions, lbs/day	Fugitive emissions, lb/1000 gal for 150,000 gal/month throughput	Fillpipe emissions, lb/1000 gal	Total emissions, lb/1000 gal
Summer Fuel	0.20	0.04	0.04	0.08
Winter Fuel	0.28	0.06	0.09	0.15
ARB CP-201 Limit		**0.19**		**0.38**

Table 7 summarizes the available data from ARB and EPA studies on emissions during the dispensing of gasoline to ORVR vehicles. ORVR emissions from this study were compared with ORVR emissions with Phase II vapor recovery. The two previous ARB studies provided data on the capture of ORVR fillpipe emissions by the two Phase II EVR systems currently available in California. As shown in Table 7, it is estimated that a Phase II EVR system captures and controls about 0.09 lb gasoline vapor per 1000 gallons of fuel dispensed to ORVR vehicles.

Data from EPA's test program for in-use ORVR vehicles is also provided in Table 7. Vehicle manufacturers are required by EPA to conduct the federal test procedure for measuring emissions during vehicle refueling for a sample of in-use vehicles. The vehicle is placed in a sealed evaporative housing (SHED) so that both the fugitive emissions at the vehicle fillpipe and any "breakthrough" emissions from the on-board carbon canister are captured and measured.

Because the ARB and EPA test methods and testing conditions are different, emissions data from the two types of studies cannot be directly compared. Several observations can be made, however. In both the EPA SHED tests and this ARB study, the standard deviation for ORVR vehicle emissions was significant. Table 5 shows ORVR emissions from the SHED test were 0.25 ± 1.15, with a standard deviation about five times the mean (1.15/0.25 x 100%). Of the 318 vehicles in the EPA study, 17 vehicles, or 5.3% of the total failed the

[5] ARB Certification Procedure for Vapor Recovery Systems at Gasoline Dispensing Facilities (CP-201), Section 4.1, May 25, 2006.

ORVR fueling standard of 0.2 grams/gal (0.44 lb/1000 gal). As shown in Table 5, the vehicles in the EPA study were somewhat older than those in this study, with a mean odometer reading of 19,100 miles, compared with mean odometer readings of 13,400 and 14,100 for the two groups of vehicles in this study.

Table 7
Emissions data for ORVR Vehicles from ARB tests at gasoline dispensing facilities and from EPA/Manufacturer SHED tests

Emission Measurements	Emissions, lbs per 1000 gallons dispensed		
	CaRFG3 Summer Fuel 6.9 RVP	Federal Test Procedure Fuel, 9 RVP	CaRFG3 Winter Fuel,11.9 RVP
ARB Test Procedure 201.2 at gasoline dispensing facilities			
Fillpipe, no Phase II, mean ± standard deviation (This study)	0.043 ± 0.08		0.094 ± 0.18
Average odometer reading, miles, for vehicles in this study, 2006 – 2007 model years.	13,400		14,100
Fillpipe, with Phase II EVR (Average of two ARB studies.)[6]			0.01
Estimated reduction of fillpipe emissions for ORVR vehicle with Phase II control (winter fuel, RVP not specified)[7]			0.09
EPA/Manufacturers ORVR vehicle emissions measurement according to the Federal Test Procedure			
Fillpipe and on-board canister emissions ± std deviation (Average for 337 dispensing events)[8]		0.25 ± 1.15	
Average odometer reading, miles		19,100	
Number of vehicles failing the 0.2 gram/gallon ORVR standard = 17, or 5.3% of vehicles tested			

[6] ARB Source Test Report 04-01 (Healy), December 15, 2004 and ARB Source Test Report 07-01 (VST), March 13, 2007. ORVR vehicles from model years 1998 – 2007 were included in these tests.
[7] 0.09 lb/1000 gal reduction = The throughput-averaged winter emission factor, 0.10, – 0.01 = 0.09. See footnote 4.
[8] Results of SHED data for 337 2004 -2005 model vehicles (including retests), provided in an email on June 30, 2008 by David Good, U.S. EPA Office of Air and Radiation, Office of Transportation and Air Quality, Compliance Information Systems.

6.0 CONCLUSIONS: ORVR VEHICLES AND NO PHASE II VAPOR RECOVERY

The following conclusions result from this study:

1. Gasoline vapor emissions from dispensing gasoline to ORVR vehicles were about 0.043 lb/1000 gallons for summer fuel and 0.094 lb/1000 gallons for winter fuel, or about 1% of the gasoline vapor emissions from a non-ORVR vehicle.

2. Fugitive emissions from the underground storage tank at this facility were about 0.20 lb/day for summer fuel and 0.28 lb/day for winter fuel. The test facility was a low-throughput facility, with a leak-tight Phase I vapor recovery system and no Phase II system. During periods of gasoline dispensing, the UST pressure was maintained at the P/V vent valve cracking vacuum, - 8.5 inches water, gauge. During the overnight shut downs at this facility, the UST remained at a vacuum, unless gasoline deliveries or degassing occurred, or the barometric pressure dropped.

3. Fillpipe and fugitive emissions from the test facility without a Phase II system met the ARB's emission limits for a Phase II enhanced vapor recovery (EVR) system.

4. Finally, this investigation did not include a consideration of the spillage emissions during vehicle refueling. Phase II EVR nozzles have been certified to result in a spillage rate of less than 0.24 lbs/1000 gallons gasoline dispensed. This is a reduction of about .18 lbs/1000 gallons dispensed over the emission factor of 0.42 lb/1000 gallons for nozzles without Phase II EVR technology.