California Environmental Protection Agency

AIR RESOURCES BOARD

Monitoring and Laboratory Division

Attachment 3

Revised Emission Factors for Pressure Driven Emissions at California Gasoline Dispensing Facilities

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I. INTRODUCTION

The vapor retained in a gasoline dispensing facility (GDF) storage tank is influenced by a number of variables including: temperature, vapor pressure and evaporation rate, onboard refueling vapor recovery (ORVR) equipped vehicles, overnight facility shutdown or extended facility inactivity, gasoline bulk delivery schedule, vapor recovery system operating principle, and vapor recovery system pressure integrity. These variables can act singularly or in combination to produce pressure driven emissions from the storage tank vent and/or Phase II vapor recovery system components.

ARB began monitoring static pressure in the underground storage tanks (UST) at six GDFs in November 2009 to examine the pronounced increase in the number of vapor recovery system pressure alarms triggered by the in-station diagnostic (ISD) system (and the resultant pressure driven emissions) during the November through March period in which there is no restriction to gasoline Reid vapor pressure (RVP) (ISD over-pressure study). This attachment summarizes how ISD over-pressure study data was used to calculate the revised GDF pressure driven emission factors.

The current Air Resources Board (ARB) total organic gases (TOG) pressure driven (or breathing loss) emission factors for GDFs, in use since May 1999, do not account for advances in vapor recovery system performance from implementation of ARB's enhanced vapor recovery (EVR) program, or the dynamics caused from interaction between EVR systems and ORVR equipped vehicles. ARB staff has revisited the methodology and engineering assumptions used to derive GDF pressure driven emission factors, including performing field tests, literature research and data analyses to account for these advances. A comparison of the current and revised pressure driven emission factors for California GDFs is presented in Table I-1 below. ARB staff believes the revised emission factors are rooted in a database more representative of the current California GDF population than previous estimates.

Table I-1
Current and Revised GDF Pressure Driven Emission Factors (lbs/kgal)

	Without Phase II	Phase II Pre-EVR	Phase II EVR
Current	0.84	0.10	NA*
Revised	0.76	0.092	0.024

* *Current emission factors were in effect before introduction of Phase II EVR systems or widespread population of ORVR vehicles.*

As shown in Table I-1, ARB's current estimates for GDF pressure driven emissions are based on two emission factors: 0.84 pounds TOG per thousand gallons dispensed (lbs/kgal) for GDFs without Phase II vapor recovery and 0.10 lbs/kgal for GDFs with Phase II pre-EVR systems. There is no current emission factor for GDFs with Phase II EVR systems. The revised emission factor of 0.024 lbs/kgal for GDFs with Phase II EVR systems, which dispense approximately 95 percent of the gasoline sold in California, is a result of the pressure management performance standards included in

ARB's Phase II EVR regulation, and represents a 76 percent decrease from the current emission factor of 0.10 lbs/kgal.

II. METHODOLOGY – REVISED GDF PRESSURE DRIVEN EMISSION FACTORS

Test Facilities

The revised pressure driven emission factors presented in this attachment were derived from data collected at six GDFs and one fleet dispensing facility in Northern California. The six GDF sites were selected as part of ARB's ISD over-pressure study to examine the substantial increases in the number of ISD over-pressure alarms during the transition from summer fuel with RVP restricted to less than or equal to 7 pounds per square inch, to winter fuel with no RVP restriction. The ISD over-pressure study sites represent a cross section of the California GDFs equipped with Phase II EVR and are summarized in Table II-1 below.

Table II-1

ISD Over-Pressure Study Site Summary

Brand	Location	Vapor Recovery/ ISD system	Approx. Throughput	Fueling Points	UST Volume (gallons)	Overnight Shutdown
Costco	Sacramento, CA	Healy/ Veeder Root	750 kgal/mo.	12	20k, 20k, 20k	Yes
Sam's Club	Yuba City, CA	VST/Veeder Root	550 kgal/mo.	12	20k, 20k, 20k	Yes
ARCO	Marysville, CA	Healy/Incon	330 kgal/mo.	16	10k, 10k, 10k	No
ARCO	Sacramento, CA	Healy/ Veeder Root	170 kgal/mo.	8	10k, 10k, 10k	No
Chevron	Sheldon, CA	Healy/Incon	145 kgal/mo.	12	12k, 20k	No
Valero	Davis, CA	VST/Veeder Root	130 kgal/mo.	12	4k, 8k, 12k	No

The six ISD over-pressure study sites are equipped with ISD systems which provide UST pressure and ullage data. ARB also installed Franklin Fueling Systems pressure vacuum (p/v) zero valves and data acquisition (DAQ) equipment at all six test sites to continuously record barometric pressure and UST static pressure. The p/v zero type pressure vacuum valves have a fixed cracking pressure (4 inches water column), allowing the volume of vent emissions to be calculated from UST ullage volume and changes in UST static pressure. All six sites were tested for vapor recovery system pressure integrity, dispenser tightness and dispensing nozzle air to liquid (A/L) ratio, where applicable, after installing the p/v zero valves and DAQ equipment. Sites with non-compliant results were repaired and retested until results met the applicable performance standards. The six sites were also subject to scheduled compliance testing as required by their Air District issued permit to operate.

Gasoline RVP samples were collected from all six test sites on a weekly basis during winter months (November – March) and on a monthly basis during summer months (April – October). Summer RVP samples were not collected from the Marysville and Yuba City locations due to their distance from Sacramento.

The fleet dispensing facility tested in this study is not equipped with Phase II vapor recovery as the fleet serviced by this facility is composed solely of ORVR equipped vehicles.[1] Data acquisition equipment was installed at the facility to record UST static pressure. UST static pressure data collected during two continuous 30-day periods were used to derive the UST pressure driven emission factor for GDFs without Phase II vapor recovery systems.

<u>Pressure Driven Emission Factor for GDFs with Phase II EVR Systems</u>

The revised pressure driven emission factor for GDFs equipped with Phase II EVR represents the sum of p/v vent and fugitive emissions from the six test sites during the twelve-month period between November 2009 and October 2010. This emission factor was calculated using the *Pressure Analysis and Calculation of Emissions* (PACE) Microsoft Excel macro program developed by ARB staff. PACE user-defined values for calculating p/v vent and fugitive emissions are: 46 percent TOG concentration, p/v valve cracking pressure of 4 inches water column ("WC), and fugitive emissions at the rate calculated by ARB Vapor Recovery Test Procedure TP-201.2F, *Pressure Related Fugitive Emissions*,[2] for the corresponding UST static pressure. Gasoline throughput was determined by PACE from UST ullage data.

The 46 percent TOG concentration value is derived from UST headspace TOG concentration data obtained from ten tests performed by ARB staff at three GDFs between February 2012 and September 2013. TOG concentrations were determined using non-dispersive infrared gas analyzers and sampling and quality assurance procedures referenced in ARB Vapor Recovery Test Procedure TP-201.2, *Efficiency and Emission Factor for Phase II Systems*.[3] Five of the ten tests employed a "stratification" sampling technique in which the TOG concentration was measured at six-inch vertical increments from the top of the UST headspace to within 12-inches of the liquid surface. Two of the five stratification tests were performed during the summer RVP fuel period; the other three tests were performed during the winter RVP fuel period. The five remaining tests consisted of continuously monitoring TOG concentration at the base of the p/v vent riser during overnight GDF shutdown. Two of the overnight tests were performed during the summer RVP fuel period; the other three tests were performed during the winter RVP fuel period.

Results of the ten tests used to estimate pressure driven emission TOG concentration are summarized in Table II-2. The test results determined an average summer RVP fuel TOG concentration of 44.2 percent and an average winter RVP fuel TOG concentration of 49.4 percent. The 46 percent average TOG concentration used by PACE analyses was calculated by weighting the average summer RVP fuel and winter RVP fuel TOG concentrations for statewide gasoline throughput during summer and winter fuel periods. The California State Board of Equalization reported approximately 14.51 billion gallons of gasoline were dispensed statewide[4] to motor vehicles in 2012. Of the total, approximately 8.59 billion gallons, or 59.2 percent, of gasoline was dispensed during the summer RVP fuel period. The remaining 5.92 billion gallons, or 40.8 percent, of gasoline was dispensed during the winter RVP fuel period.

Table II-2

UST Headspace TOG Concentration Test Results

Date Tested	Test Description	Fuel Period	Avg. TOG Conc. ($\%C_3$)
6/21/2012	Stratification testing, Sacramento, Healy w/CAS	Summer	51.2
7/13/2012	Overnight monitoring, Sacramento, Healy w/CAS	Summer	41.8
7/18/2012	Overnight monitoring, Yuba City, VST w/Canister	Summer	36.8
9/19/2013	Stratification testing, Sacramento, Healy w/CAS	Summer	46.9
		Average Summer RVP Fuel:	**44.2**
2/14/2012	Stratification testing, Sacramento, Healy w/CAS	Winter	52.0
2/14/2012	Stratification testing, Sacramento, Healy w/CAS	Winter	51.4
2/15/2012	Stratification testing, Sacramento, Healy w/CAS	Winter	52.2
2/23/2012	Overnight monitoring, Sacramento, Healy w/CAS	Winter	50.3
3/7/2012	Overnight monitoring, Yuba City, VST w/Canister	Winter	42.3
1/23/2013	Overnight monitoring, Sacramento, Healy w/CAS	Winter	47.9
		Average Winter RVP Fuel:	**49.4**
Average Weighted for Summer and Winter Fuel Throughput: (0.592 * 44.2% + 0.408 * 49.4% = 46%)			**46**

UST static pressure, ullage and barometric pressure data from six test facilities for the twelve-month period between November 2009 and October 2010 were imported into PACE. PACE calculates the volume of p/v vent and fugitive emissions then combines these two volumes with the user-defined TOG concentration (46 percent) and GDF throughput yielding the combined p/v vent and fugitive mass emissions for each test site.

$$EF_{EVR} = \sum_{1}^{6} EF_i TP_i \quad = \; 0.024 \text{ lbs/kgal}$$

$$EF_i = EF_{venti} + EF_{fi} \quad = \left[\frac{(M_i)(1000)}{(G_i)} \right]$$

where:

EF_{EVR} = Pressure driven emission factor for Phase II EVR systems, weighted for GDF throughput category, lbs/kgal.
EF_i = Pressure driven emission factor determined for each test facility, lbs/kgal.
EF_{venti} = Vent emissions from each test facility, lbs/kgal.
EF_{fi} = Fugitive emissions from each test facility, lbs/kgal.
M_i = Pressure driven emissions for each test facility, lbs/day.
G_i = Average gasoline throughput at each test facility, gal/day.
TP_i = Fraction of gasoline sold statewide by GDFs in same throughput category as test facility, dimensionless (see Table II-4).
1000 = Unit conversion factor, gal/kgal

Data used to calculate the revised pressure driven emission factor for GDFs equipped with Phase II EVR systems are summarized in Table II-3. The revised emission factor is weighted for the percent of gasoline dispensed statewide in the throughput category represented by each test facility. The percentage of statewide throughput that is dispensed through GDFs in various throughput categories was developed from data obtained from the California Energy Commission (CEC) *2008 California Retail Fuel Outlet Annual Report*.[5] The throughput categories reported by CEC were combined to create four throughput categories, identified in Table II-4, which contained one or more of the six ISD over-pressure study sites.

In cases where more than one study site fell in the same throughput category, the percentage was divided equally between the sites. GDFs dispensing below 50 kgal/month were not included in CEC's report; therefore, the fraction of statewide gasoline throughputs in Table II-4 were normalized to account for the 4.8 percent of gasoline dispensed from GDFs excluded from CEC's report.

Table II-3 Summary of Pressure Driven Emission Data from Six Phase II EVR Equipped GDFs					
Site	**Location**	**Emission Factor, EF_i (lbs/kgal)**	**Throughput Category (gal/mo.)**	**Statewide Gasoline Throughput (TP_i,%)**	**Weighted Emission Factor (lbs/kgal)**
Chevron	Sheldon, CA	0.0344	50K – 150K	16.3%	5.6 E-03
Valero	Davis, CA	0.0552	50K – 150K	16.3%	9.0 E-03
Arco	Sacramento, CA	0.0057	150K – 200K	18.9%	1.1 E-03
Arco	Marysville, CA	0.0021	200K – 400K	35.8%	7.4 E-04
Costco	Sacramento, CA	0.0287	>400K	6.3%	1.8 E-03
Sam's Club	Yuba City, CA	0.0937	>400K	6.3%	5.9 E-03
		Pressure Driven Emission Factor (EF_{EVR}):			**2.4 E-02**

Table II-4 GDF Throughput Categories for Pressure Driven Emission Factors	
Throughput (kgal/month)	**Fraction of Statewide Throughput**
50 – 150	0.325
150 – 200	0.189
200 – 400	0.358
> 400	0.126

<u>Pressure Driven Emission Factors for GDFs with Phase II Pre-EVR Systems</u>

The revised pressure driven emission factor for GDFs with Phase II pre-EVR systems is defined as the sum of the 0.024 lbs/kgal emission factor estimated for GDFs with Phase II EVR systems and an emission factor representing the TOG vapor mass captured by a GDF clean air separator (CAS) or carbon canister during UST pressure excursions. It is represented by the following equation:

$$EF_{pre\text{-}EVR} = EF_{EVR} + EF_{cas}$$

where:

$EF_{pre\text{-}EVR}$ = Pressure driven emission factor, Phase II pre-EVR, lbs/kgal.

EF_{EVR} = Pressure driven emission factor, Phase II EVR = 0.024 lbs/kgal.

EF_{cas} = Emissions captured by CAS or carbon canister, lbs/kgal.

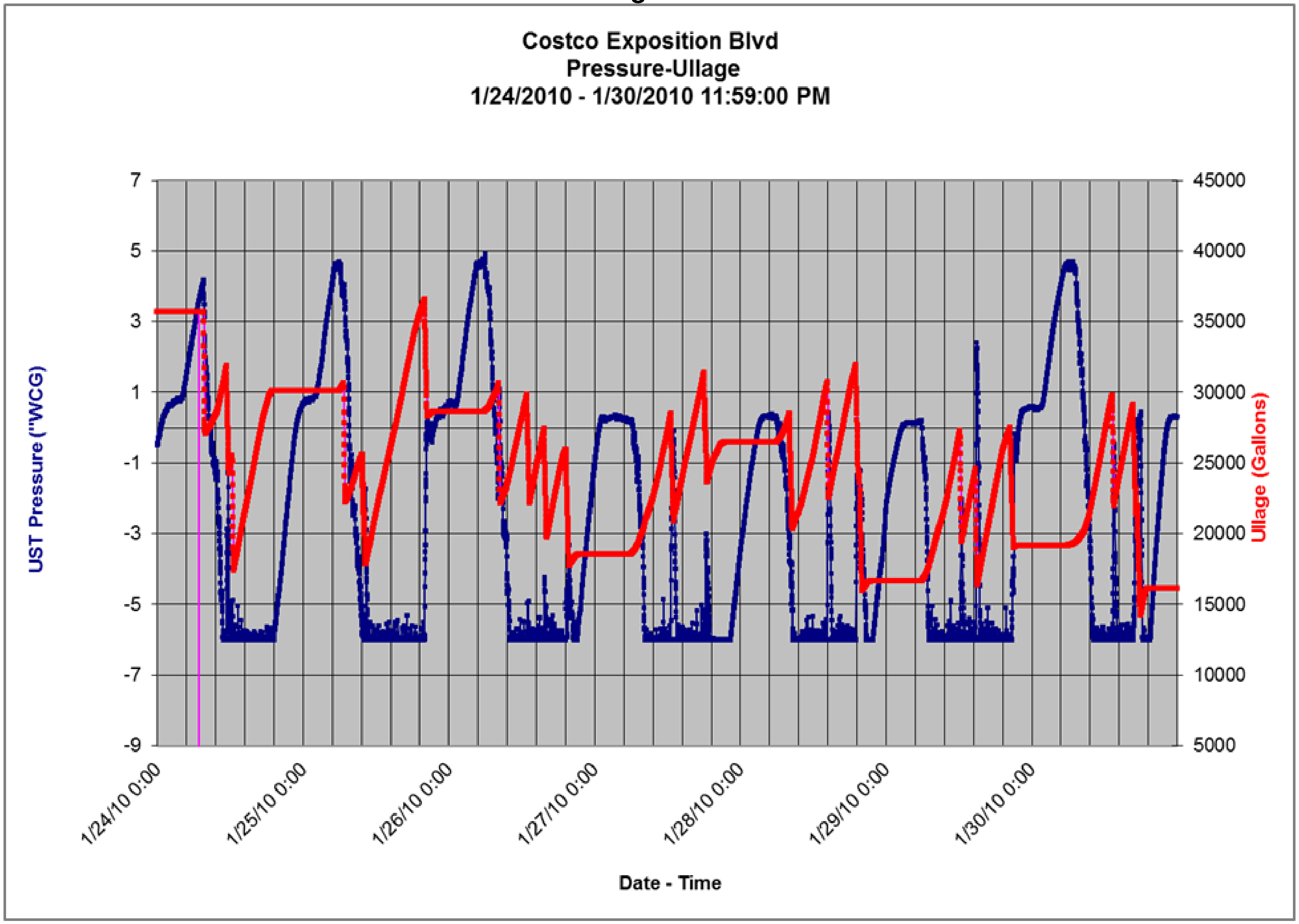
EF_{cas} is best calculated during extended periods of GDF inactivity, such as overnight closure, due to the nature of UST static pressure profiles exhibited by CAS equipped facilities during idle dispensing periods. Four of the six facilities in the ISD over-pressure study are equipped with a CAS, but the Costco GDF in Sacramento is the only facility that discontinues dispensing overnight. Therefore, the vapor volumes quantified at this facility from partial and total filling of its CAS during the summer and winter fuel periods were applied to the results obtained at each of the three other CAS equipped test sites.

EF_{cas} for carbon canister equipped GDFs is derived from data collected at the Sam's Club GDF in Yuba City, one of two carbon canister equipped GDFs in the over-pressure study. The methodology to calculate EF_{cas} for carbon canister equipped GDFs is the same as used for CAS equipped GDFs. The Sam's Club GDF receives the majority of its Phase I gasoline deliveries during overnight shut down periods, which interrupts UST static pressure trend line used to calculate pressure driven emissions during idle dispensing periods, resulting in less available data for carbon canister control volume calculations.

Calculating EF_{cas} for the six test facilities requires two assumptions: gasoline liquid to vapor phase evaporation rates at the six test facilities are approximately equal at any given point in time (i.e., no variation between facilities) and; the Veeder-Root carbon canister vapor processor installed at two of the six test sites performs in the same manner as a CAS (each has an approximate 400 gallon working capacity). A CAS is designed to control pressure driven emissions by accumulating vapor in its internal bladder when UST static pressure reaches approximately 0.5 "WC. Therefore, UST static pressure versus time graphs for EVR systems with a CAS have characteristic inflection points that identify the period during which a CAS is accumulating vapor. Please refer to the static pressure versus time graph presented as Figure II-1. In this graph, the blue trace represents UST static pressure and the red trace represents UST ullage volume. Idle dispensing periods during GDF operation or GDF overnight closure are identified by the red ullage trace having zero slope.

When examining Figure II-1, it is evident that UST static pressure rises at a constant rate during periods for which the slope of the ullage trace equals zero. The increase in UST static pressure is from evaporation of gasoline into the vapor phase as the liquid and vapor mixture in an UST seeks equilibrium. When UST static pressure reaches approximately 0.5 "WC, an inflection point occurs in the pressure trace, indicating a CAS bladder has begun accumulating vapor. At this point, the slope of the pressure trace approaches zero. The slope of the pressure trace remains near zero until the second inflection point is reached and UST static pressure again increases; indicating a CAS has reached its capacity (a partial fill of a CAS is represented by the slope of an UST static pressure curve becoming negative before the second inflection point). UST static pressure then continues to increase until emissions are vented from the p/v valve, which is indicated by the "saw tooth" pattern of an UST pressure trace, or until dispensing resumes and UST pressure decreases as liquid is removed from an UST.

Figure II-1



Costco Exposition Blvd
Pressure-Ullage
1/24/2010 - 1/30/2010 11:59:00 PM
UST Pressure ("WCG)
Ullage (Gallons)
7
5
3
1
-1
-3
-5
-7
-9
45000
40000
35000
30000
25000
20000
15000
10000
5000
1/24/10 0:00
1/25/10 0:00
1/26/10 0:00
1/27/10 0:00
1/28/10 0:00
1/29/10 0:00
1/30/10 0:00
Date - Time

With Figure II-1 as background, the methodology employed in deriving the emission factor EF_{cas} is best illustrated with the aid of an UST static pressure versus time graph presented as Figure II-2. This figure is again representative of an UST static pressure profile during extended idle periods for Phase II EVR systems utilizing a CAS. Examination of Figure II-2 shows the slope of the pressure trace from -0.25 “WC to +0.25 “WC has been extrapolated, in red, from the first inflection point to the pressure at which the p/v valve opened to relieve system pressure. The “saw tooth” pattern indicative of vent emissions is extrapolated, also in red, forward from this point to the point where UST static pressure returns below the cracking pressure of the p/v valve. Once venting has ceased, the red trace mirrors the slope of the blue trace as UST static pressure decreases to zero. The difference in the fugitive and vent emission volumes calculated for the extrapolated, red, and actual, blue, UST static pressure traces represents the volume of vapor controlled by an EVR pressure management system. This volume of vapor would not be contained by a Phase II pre-EVR system.

The extrapolation and emission calculation process illustrated in Figure II-2 was repeated for 1 to 3 shut down periods per week between November 2009 and October 2010, yielding the approximate volume of emissions controlled by an EVR system when its CAS fills to capacity, and during events when its CAS only partially fills. The vapor volume controlled by an EVR system during full and partial CAS utilization is multiplied by the annual number of pressure excursions at a given GDF, during which its CAS is filled partially or completely, yielding the annual volume of vent and fugitive emissions controlled by an EVR system. Assuming no variation in the gasoline evaporation rate between the six test facilities and that the carbon canister vapor processor performs in an equivalent manner to a CAS, the annual pressure driven emission factor for Phase II pre-EVR systems can be estimated using data from all six test GDFs and the following equations:

$$M_{casi} = (V_{fs} * N_{fsi} + V_{fw} * N_{fwi} + V_{ps} * N_{psi} + V_{pw} * N_{pwi}) \left[\frac{(C)(MW)}{(MV)(7.481)} \right] = (lbs)_{casi}$$

$$EF_{casi} = \left[\frac{(M_{casi})(1000)}{(G_i)} \right] = (lbs/kgal)_{casi}$$

$$EF_{pre\text{-}EVR} = EF_{EVR} + \sum_{1}^{6} EF_{casi} TP_i = 0.024 + 0.068 = 0.092 \text{ lbs/kgal}$$

where:

$EF_{pre\text{-}EVR}$ = Pressure driven emission factor for GDFs without Phase II EVR systems, lbs/kgal.

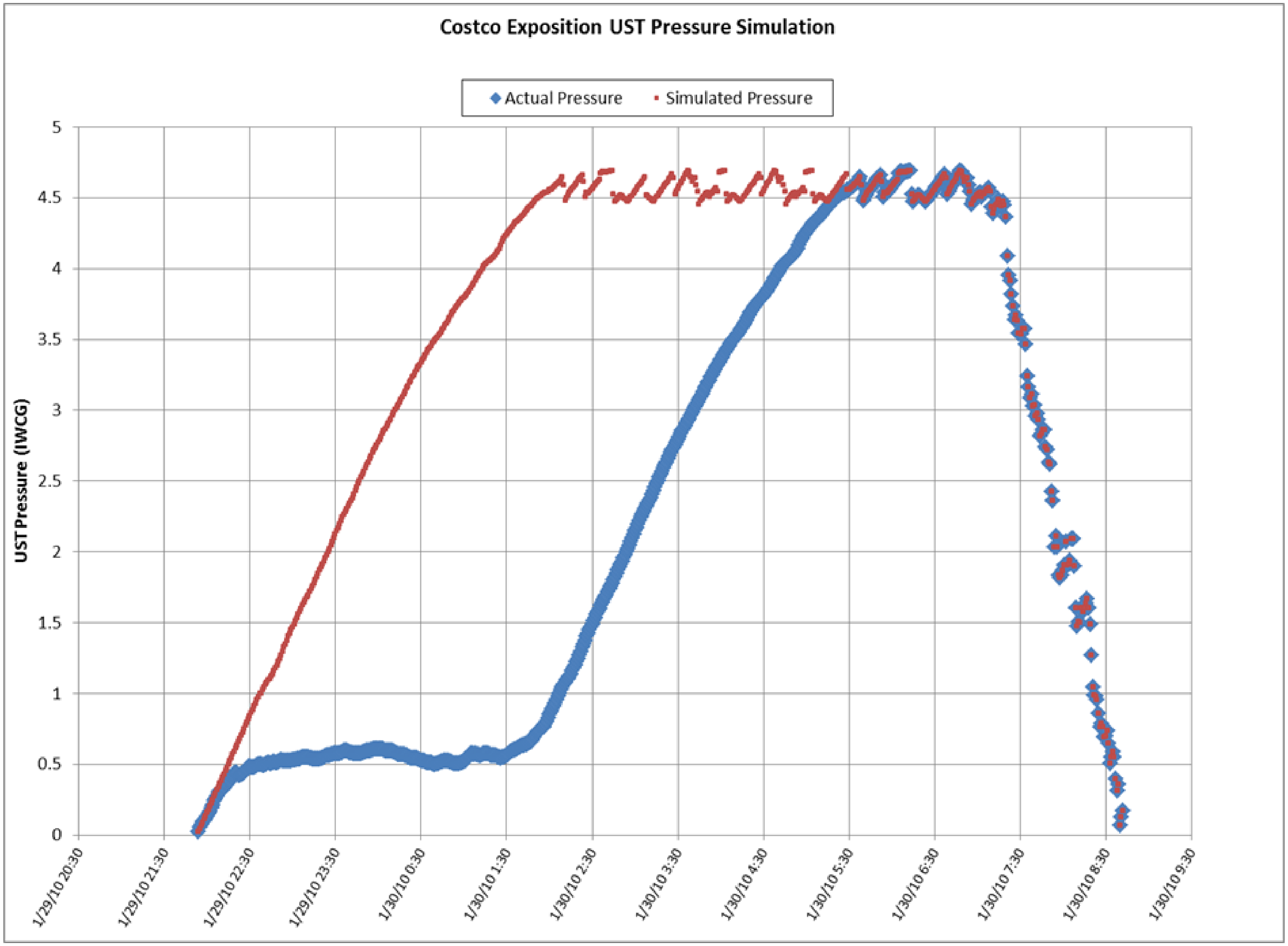
EF_{casi} = Pressure driven emission factor for each of six test GDFs, lbs/kgal.

M_{casi} = Mass of TOG controlled by CAS or carbon canister, lbs.

TP_i = Fraction of gasoline sold statewide by GDFs in same throughput category as test GDF, dimensionless.
N_{fsi} = Number of times CAS fills to capacity at “$i^{\underline{th}}$“ test facility during Apr. – Oct., dimensionless.
N_{psi} = Number of CAS partial fills at “$i^{\underline{th}}$“ test facility during Apr.–Oct, dimensionless.
N_{fwi} = Number of times CAS fills to capacity at “$i^{\underline{th}}$“ test facility during Nov. – Mar., dimensionless.
N_{pwi} = Number of CAS partial fills at “$i^{\underline{th}}$“ test facility during Nov.– Mar., dimensionless.
V_{fs} = Average volume controlled when CAS fills, Apr.-Oct., gallons.
V_{ps} = Average volume controlled when CAS partial fills, Apr.-Oct., gallons.
V_{fw} = Average volume controlled when CAS fills, Nov.-Mar., gallons.
V_{pw} = Average volume controlled when CAS partial fills, Nov.-Mar., gallons.
C = Pressure driven emissions concentration = 0.46 as C_3.
MW = Molecular weight of propane = 44.096 lbs/lb-mole.
MV = Molar volume of ideal gas = 385 ft^3 at 68 ^oF.
G_i = Gasoline dispensed annually at “$i^{\underline{th}}$“ GDF, gal.
7.481 = Unit conversion factor, gal/ft^3.
1000 = Unit conversion factor, gal/kgal.

Data used to calculate the revised pressure driven emission factor for GDFs equipped with Phase II pre-EVR systems are summarized in Table II-5. The revised pressure driven emission factor for GDFs with pre-EVR Phase II systems is also weighted for the percent of gasoline dispensed state-wide in the throughput category represented by each test facility, using CEC data and the method previously described for weighting the pressure driven emission factor for GDFs equipped with Phase II EVR.

Figure II-2



Costco Exposition UST Pressure Simulation
Actual Pressure
Simulated Pressure
UST Pressure (IWCG)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1/29/10 20:30
1/29/10 21:30
1/29/10 22:30
1/29/10 23:30
1/30/10 0:30
1/30/10 1:30
1/30/10 2:30
1/30/10 3:30
1/30/10 4:30
1/30/10 5:30
1/30/10 6:30
1/30/10 7:30
1/30/10 8:30
1/30/10 9:30

Table II-5 Summary of Pressure Driven Emission Data for Six Phase II Pre-EVR Equipped GDFs					
Site	**Location**	**Processor Emission Factor, EF_{CASi} (lbs/kgal)**	**Throughput Category (gal/mo.)**	**Statewide Gasoline Throughput (TP_i, %)**	**Weighted Processor Emission Factor (lbs/kgal)**
Chevron	Sheldon, CA	0.0201	50K - 150K	16.3%	3.3 E-03
Valero	Davis, CA	0.0322	50K - 150K	16.3%	5.2 E-03
Arco	Sacramento, CA	0.0039	150K - 200K	18.9%	7.4 E-04
Arco	Marysville, CA	0.0057	200K - 400K	35.8%	2.1 E-03
Costco	Sacramento, CA	0.0502	>400K	6.3%	3.2 E-03
Sam's Club	Yuba City, CA	0.1075	>400K	6.3%	6.8 E-03
Average Emissions Controlled by Processors:					**2.1 E-02**
Statewide Avg. Pressure Driven Emissions for Phase II pre-EVR: **0.021 lbs/kgal + 0.024 lbs/kgal (from Table II-1) = 0.045 lbs/kgal** **Tons/day Saved by Processors:** **(0.021 lbs/kgal)*(15E+6 kgal/yr)*(yr/365 days)*(ton/2000 lbs) = 0.43 tons/day**					

Pressure Driven Emission Factor for GDFs Without Phase II Vapor Recovery

The revised pressure driven emission factor for GDFs without Phase II vapor recovery was calculated from UST static pressure data collected at a fleet Rental Car GDF located in San Jose, California. This facility operates without a Phase II vapor recovery system under an exemption from the Bay Area Air Quality Management District for fleet facilities dispensing to a vehicle fleet consisting of 90% or greater ORVR equipped vehicles.

UST static pressure data was collected at the fleet facility during two 30-day periods. The first period ranged from August 3, 2007 to September 1, 2007. The second ranged from December 5, 2007 to January 3, 2008. UST static pressure data during these two periods were combined with fugitive flow rate equations in ARB Vapor Recovery Test Procedure TP-201.2F, *Pressure Related Fugitive Emissions*, assumed TOG concentrations of 44.2 percent for summer RVP fuel and 49.4 percent for winter RVP fuel, the facility gasoline throughput of 12,000 gallons per month, and the following equations to yield the revised pressure driven emission factor for GDFs without Phase II vapor recovery:

$$M_s = \left[\frac{(V_s)(C_s)(MW)}{(MV)(100)}\right] = 7.35 \text{ lbs/month}$$

$$M_w = \left[\frac{(V_w)(C_w)(MW)}{(MV)(100)}\right] = 11.7 \text{ lbs/month}$$

and:

$$EF_{unc} = \left[\frac{(M_s)(1000)(0.592)}{(G)}\right] + \left[\frac{(M_w)(1000)(0.408)}{(G)}\right] = 0.76 \text{ lbs/kgal}$$

where:

M_s = Summer fuel 30-day fugitive emissions = 7.35 lbs/mo.
M_w = Winter fuel 30-day fugitive emissions = 11.7 lbs/mo.
EF_{unc} = Pressure driven emission factor, GDF without Phase II vapor recovery (uncontrolled), lb/kgal.
V_s = Calculated fugitive emission volume during 30-day summer fuel test period = 145.1 ft^3/month.
V_w = Calculated fugitive emission volume during 30-day winter fuel test period = 207.2 ft^3/month.
C_s = TOG concentration, summer RVP fuel = 44.2% as C_3.
C_w = TOG concentration, winter RVP fuel = 49.4% as C_3.
MW = Molecular weight, lb/lb-mole, 44.096 for C_3.
MV = Molar volume, 385 ft^3/lb-mole at 68°F *.
100 = Conversion factor for percent to mole fraction.
G = Gallons dispensed during test period (12,000 gallons/mo).
1000 = Conversion factor (gal/kgal).
0.592 = Fraction of summer fuel dispensed statewide, from BOE data.
0.408 = Fraction of winter fuel dispensed statewide, from BOE data.

* *TP-201.2F references molar volume of 386.7 ft^3/lb-mole at 70°F; however, to maintain consistency with volumes used to calculate the other emission factors reported in this document the result is corrected to standard temperature of 68°F*

III. REFERENCES

1. Bay Area Air Quality Management District Regulation 8, Rule 7, paragraph 112.9. http://www.baaqmd.gov/~/media/Files/Planning%20and%20Research/Rules%20and%20Regs/reg%2008/rg0807.ashx?la=en

2. ARB Vapor Recovery Test Procedure TP-201.2F, *Pressure Related Fugitive Emissions*. http://www.arb.ca.gov/testmeth/vol2/tp201.2f_Oct2003.pdf

3. ARB Vapor Recovery Test Procedure TP-201.2, *Efficiency and Emission Factor for Phase II Systems*. http://www.arb.ca.gov/testmeth/vol2/tp201.2_april2013.pdf

4. California State Board of Equalization Fuel Taxes and Statistics Report-2012. http://www.boe.ca.gov/sptaxprog/spftrpts12.htm

5. California Energy Commission (CEC) *2008 California Retail Fuel Outlet Annual Report*.