California Environmental Protection Agency

AIR RESOURCES BOARD

Monitoring and Laboratory Division

Attachment 5

Proposed Emission Factors for Gasoline Dispensing Hose Permeation at California Gasoline Dispensing Facilities

December 23, 2013

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I. INTRODUCTION

The Air Resources Board (ARB) is updating the emission inventory for total organic gases (TOG) emissions attributable to gasoline marketing operations at California gasoline dispensing facilities (GDF). ARB is proposing the addition of emission factors for gasoline dispensing hose permeation losses to this category. Hose permeation losses occur when liquid gasoline or gasoline vapors diffuse through the dispensing hose outer surface to the atmosphere. Currently, ARB's emissions inventory does not include hose permeation losses.

ARB adopted performance standards for gasoline dispensing hose permeation on July 26, 2012. Prior to this date, there were no hose permeation standards for California GDFs. Facilities subject to this standard have four years from its effective date to attain compliance. The effective date is defined as the date when the first dispensing hose meeting the performance standard is certified by ARB. As of this date, no dispensing hose is certified to the adopted performance standard; therefore, the earliest compliance date is in calendar year 2017.

Retail GDFs in California are equipped with Phase II vapor recovery systems that use coaxial hoses (consisting of concentric inner and outer hoses) to create separate paths for gasoline delivery and vapor return. The orientation of the gasoline dispensing and vapor recovery hoses as the inside or outside hose is dependent on whether the Phase II vapor recovery system operates on the balance or vacuum assist principle. GDFs with balance vapor recovery systems dispense gasoline through the inner hose and return vapor through the outer hose. GDFs with vacuum assist vapor recovery systems dispense gasoline through the outer hose and return vapor through the inner hose. Vacuum assist hoses account for approximately 70 percent[1] of the almost 100,000 Phase II vapor recovery hoses installed at California GDFs. Conventional hoses (those used in GDFs without Phase II vapor recovery) are similar to vacuum assist hoses in regards to the liquid gasoline being carried against the inside of the outer hose wall.

Of the variables influencing hose permeation rates, the most significant is the concentration gradient across the outer hose wall. In vacuum assist and conventional hoses, the outer hose is continually exposed to liquid fuel; therefore, the permeation rate is not affected by the frequency of fueling events. However, in balance hoses, the permeation rate is affected by the frequency and type of vehicles fueled. Vehicles equipped with onboard refueling vapor recovery systems (ORVR), by design, return very little, if any, vapor through the vapor return hose during a fueling event, thus impacting the concentration gradient across the outer hose wall. Because gasoline throughput to ORVR vehicles is expected to increase each year, hose permeation emissions from balance hoses are expected to decline in future years.

Table I-1 below presents the proposed 2013, and 2017, emission factors derived from test data collected by ARB staff during development of the dispensing hose permeation performance standards.

Table I-1 Emission Factors Gasoline Dispensing Hose Permeation Losses (lbs/kgal)			
Source	**Without Phase II**	**Phase II Pre-EVR**	**Phase II EVR**
2013 Proposed	0.062	0.062	0.062
2017 Proposed	0.009	0.009	0.009

ARB staff proposes an emission factor of 0.062 pounds per thousand gallons (lbs/kgal) for calendar year 2013. In 2017, assuming full implementation of the hose permeation standard and a higher ORVR gasoline throughput, ARB proposes an emission factor of 0.009 lbs/kgal.

II. METHODOLOGY - PROPOSED GASOLINE DISPENSING HOSE PERMEATION EMISSION FACTORS

<u>Uncontrolled Permeation Emission Factor – Vacuum Assist, Conventional and Balance Hoses</u>

Permeation rates for vacuum assist and conventional hoses are relatively unaffected by activity level. Since vacuum assist and conventional hoses share the design characteristic that the inside of the outer hose wall is always exposed to liquid gasoline, their daily permeation rates are assumed to be the same as long as there is some level of activity. In ARB laboratory tests,[2] the uncontrolled permeation rate was determined as 77.4 grams per meters squared per day ($g/m^2/day$) at 71.9°F. The permeation rate is highly dependent on fuel temperature; therefore, adjusting for the annual average fuel temperature in California[3] of 71°F results in an uncontrolled value of 74.8 $g/m^2/day$.

The permeation rate of balance hoses is dependent on the frequency of fueling events and the fraction of fuel distributed to ORVR vehicles. During April and May of 2008, ARB conducted tests to determine vapor permeation rates of GDF balance style hoses used in California.[4] The average steady state permeation rate for balance hoses was calculated as 104.5 $g/m^2/day$ at an average temperature of 71.0^o F for saturated vapor. Because ORVR vehicles return unsaturated vapor to the GDF storage tank, the permeation rate has to be adjusted to account for the increasing percentage of fuel distributed to ORVR vehicles. The average permeation rate of a balance hose in year 2013 is calculated as 27.0 $g/m^2/day$. The uncontrolled emission factor for balance hose permeation is projected to decrease as the fraction of fuel distributed to ORVR vehicles increases each year.[5]

The adjusted permeation rates for vacuum assist, conventional and balance hoses are used in the following equations to calculate the average annual uncontrolled emissions from GDF hoses:

$$E_{vac} = PR_{vac} \times SA_{vac} \times HOSES_{vac} \times CF$$
$$E_{bal} = PR_{bal} \times SA_{bal} \times HOSES_{bal} \times CF$$

where:

$\mathrm{E_{vac}}$ = Average annual uncontrolled emissions from vacuum assist and conventional hoses (lbs/day)

$\mathrm{E_{bal}}$ = Average annual emissions from balance hoses (lbs/day)

$\mathrm{PR_{vac}}$ = Permeation rate of vacuum assist and conventional hoses (74.8 g/m^2/day)

$\mathrm{PR_{bal}}$ = Permeation rate of balance hose for a given year (g/m^2/day)

$\mathrm{SA_{vac}}$ = Surface area of a typical vacuum assist and conventional hose (0.1823 m^2)

$\mathrm{SA_{bal}}$ = Surface area of a typical balance hose (0.3344 m^2)

$\mathrm{HOSES_{vac}}$= Total statewide vacuum assist and conventional hoses[3] (66,430)

$\mathrm{HOSES_{bal}}$ = Total statewide balance hoses (29,700)

CF = Conversion factor from grams to pounds (0.0022 lbs/g)

The uncontrolled permeation emission factor for vacuum assist, conventional, and balance hoses is calculated by applying the volume of gasoline dispensed daily in California for a particular year:

$$EF_{vac} = E_{vac} \div GAS$$
$$EF_{bal} = E_{bal} \div GAS$$

where:

EF_{vac} = Uncontrolled hose permeation emission factor for vacuum assist and conventional hoses (lbs/kgal)

EF_{bal} = Uncontrolled hose permeation emission factor for balance hoses (lbs/kgal)

E_{vac} = Average annual emissions from vacuum assist and conventional hoses (lbs/day)

E_{bal} = Average annual emissions from balance hoses (lbs/day)

GAS = Thousands of gallons gasoline dispensed daily for a particular year (kgal/day)

Uncontrolled hose permeation emission factors for vacuum assist, conventional and balance hoses for the years 2013, through 2017, are presented in Table II-1. Also included in Table II-1 are all input variables used to calculate the uncontrolled hose permeation emission factors. The year 2013 baseline uncontrolled hose permeation emission factor for vacuum assist and conventional hoses is 0.048 lbs/kgal. The year 2013 baseline uncontrolled hose permeation emission factor for balance hoses is 0.014 lbs/kgal.

Note that because the balance hose uncontrolled permeation emission factor is based upon a correlation between GDF hose population and activity level, this emission factor should be reevaluated if significant changes occur in statewide throughput, station count, characteristic number of hoses per station, statewide temperature profile, gasoline formulation, GDF hose design, or change in projected ORVR fuel throughput.

Controlled Permeation Emission Factor – Vacuum Assist and Conventional Hoses

ARB has established a hose permeation standard of 10.0 g/m^2/day at 100^o F for vacuum assist and conventional hoses. Because fuel temperature is the driving variable in determining hose permeation rates, adjusting for the average California fuel temperature[3] of 71^o F yields a controlled permeation rate of 3.23 g/m^2/day.

The adjusted permeation rate is used in the following equation to calculate the average annual controlled emissions for vacuum assist and conventional hoses meeting ARB's permeation standard. There is no controlled permeation emission factor calculation for balance type hoses since the ARB permeation standards do not apply to this hose type.

$$E_{vac} = PR_{vac} \times SA_{vac} \times HOSES_{vac} \times CF$$

where:

E_{vac} = Average annual emissions from vacuum assist and conventional hoses (lbs/day)

PR_{vac} = Controlled permeation rate of vacuum assist and conventional hoses (3.23 g/m^2/day)

SA_{vac} = Surface area of a typical vacuum assist and conventional hose (0.1823 m^2)

$HOSES_{vac}$ = Total statewide vacuum assist and conventional hoses[3] (66,430)

CF = Conversion factor from grams to pounds (0.0022 lbs/g)

The controlled permeation emission factor for vacuum assist and conventional hoses meeting ARB's permeation standard is calculated by applying the volume of gasoline dispensed daily in California for a particular year:

$$EF_{vac} = E_{vac} \div GAS$$

where:

EF_{vac} = Hose permeation emission factor for vacuum assist and conventional hoses (lbs/kgal)

E_{vac} = Emissions from vacuum assist and conventional hoses (lbs/day)

GAS = Thousands of gallons gasoline dispensed daily for a particular year (kgal/day)

Controlled hose permeation emission factors for the years 2017 through 2020 are presented in Table II-2. Table II-2 also includes all input variables used to calculate the controlled hose permeation emission factors. The year 2017 controlled emission factor for vacuum assist and conventional hoses is 0.002 lbs/kgal. This is the earliest year in which a controlled emission factor may apply, since no low permeation hoses are yet certified by ARB for use in California.

Table II-1
Uncontrolled Gasoline Dispensing Hose Permeation Emission Factors

Year	Hose Type	Permeation Rate PR (g/m2/day)	Surface Area per Hose SA (m2)	Hose Population HOSES	Conversion Factor CF (lbs/g)	Emissions E (lbs/day)	Gasoline Throughput Daily GAS (kgal/day)	Emission Factor EF (lbs/kgal)	Combined EF (lbs/kgal)
2013	Vac	74.8	0.1824	66430	0.0022	1994	41700	0.0478	0.062
	Bal	27.0	0.3344	29700	0.0022	590	41700	0.0141	
2014	Vac	74.8	0.1824	66430	0.0022	1994	42056	0.0474	0.060
	Bal	23.4	0.3344	29700	0.0022	511	42056	0.0122	
2015	Vac	74.8	0.1824	66430	0.0022	1994	42528	0.0469	0.058
	Bal	20.8	0.3344	29700	0.0022	455	42528	0.0107	
2016	Vac	74.8	0.1824	66430	0.0022	1994	42996	0.0464	0.056
	Bal	18.3	0.3344	29700	0.0022	400	42996	0.0093	
2017	Vac	74.8	0.1824	66430	0.0022	1994	43468	0.0459	0.053
	Bal	13.9	0.3344	29700	0.0022	304	43468	0.0070	

Table II-2 Controlled Gasoline Dispensing Hose Permeation Emission Factors*									
Year	Hose Type	Permeation Rate PR (g/m2/day)	Surface Area per Hose SA (m2)	Hose Population HOSES	Conversion Factor CF (lbs/g)	Emissions E (lbs/day)	Gasoline Throughput Daily GAS (kgal/day)	Emission Factor EF (lbs/kgal)	Combined EF (lbs/kgal)
2017	Vac	3.23	0.1824	66430	0.0022	86	43468	0.0020	0.0090
	Bal	13.90	0.3344	29700	0.0022	304	43468	0.0070	
2018	Vac	3.23	0.1824	66430	0.0022	86	43954	0.0020	0.0087
	Bal	13.60	0.3344	29700	0.0022	297	43954	0.0068	
2019	Vac	3.23	0.1824	66430	0.0022	86	44414	0.0019	0.0075
	Bal	11.40	0.3344	29700	0.0022	249	44414	0.0056	
2020	Vac	3.23	0.1824	66430	0.0022	86	44914	0.0019	0.0070
	Bal	10.40	0.3344	29700	0.0022	227	44914	0.0051	

Note:
* - Controlled emission factors apply only to vacuum assist hoses, no permeation standard for balance hoses.

Overall Permeation Emission Factors – Vacuum Assist, Conventional and Balance Hoses

Overall, or combined, hose permeation emissions are determined by combining the emission factors for the three different hose types: vacuum assist, conventional and balance. Since vacuum assist and conventional hose permeation rates are assumed to be the same, the overall emission factor is calculated as:

$$EF = EF_{vac} + EF_{bal}$$

where:

EF = Hose permeation emission factor (lbs/kgal)

EF_{vac} = Hose permeation emission factor for vacuum assist and conventional hoses (lbs/kgal)

EF_{bal} = Uncontrolled hose permeation emission factor for balance hoses (lbs/kgal)

Combined uncontrolled hose permeation factors calculated for the years 2013, through 2017, are shown in previously presented Table II-1. The combined uncontrolled hose permeation factor for 2013 is 0.062 lbs/kgal, and decreases to 0.053 lbs/kgal in 2017 (the earliest year in which affected facilities may be required to comply with ARB adopted permeation standards).

Combined controlled hose permeation factors calculated for the years 2017, through 2020, are shown in previously presented Table II-2. The combined controlled hose permeation factor for 2017 is 0.0090 lbs/kgal, and decreases to 0.0070 lbs/kgal in 2020.

III. REFERENCES

1. ARB, Gasoline Dispensing Facility (GDF) Fueling Point Population Report, July 20, 2011, Jason McPhee, P.E.

2. ARB, Gasoline Dispensing Facility (GDF) Vacuum-Assist and Conventional Hose Permeation Study, July 19, 2010, Jason McPhee, P.E.

3. ARB, Initial Statement of Reasons, August 3, 2011, Appendix 4, Gasoline Dispensing Facility Hose Emissions Inventory for Vacuum Assist and Conventional Hoses.

4. ARB, Gasoline Dispensing Facility (GDF) Balance Hose Permeation Study, June 19, 2008, revised October 6, 2010, Jason McPhee.

5. ARB, Low Permeation GDF Hose Emissions Spreadsheet, July 19, 2011, Jason McPhee, P.E.