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AIR RESOURCES BOARD

Monitoring and Laboratory Division

Revised Emission Factors for Gasoline Marketing Operations at California Gasoline Dispensing Facilities

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I. EXECUTIVE SUMMARY

Gasoline marketing operations in California presently distribute approximately 15 billion gallons of gasoline per year[1] to motor vehicles, fuel containers, and gasoline-powered equipment. Hydrocarbon emissions, which are ozone precursors, can occur at several points during transfer, storage, or vehicle refueling as gasoline vapors are displaced from underground storage tanks (UST) or from vehicle fuel tanks.

Vapor recovery systems are used to control emissions from California gasoline dispensing facilities (GDF). Phase I vapor recovery systems collect vapors displaced from an UST when a cargo tank truck delivers gasoline to a GDF. Phase II vapor recovery systems collect vapors displaced during storage or dispensing of gasoline. The Phase I and Phase II systems at a GDF work in combination with vapor recovery systems in vehicles and at gasoline loading terminals to control approximately 370 tons per day of hydrocarbon emissions[2] from California gasoline marketing operations.

The Air Resources Board (ARB) is in the process of updating the emissions inventory for GDFs. This category is currently composed of four subcategories associated with gasoline storage and transfer operations from cargo tank trucks to GDFs and from GDFs to vehicles, fuel containers, and gasoline-powered equipment.

Total organic gas (TOG) emission factors for the four current GDF marketing subcategories were adopted in May 1999 and do not account for advances in vapor recovery system performance achieved through implementation of ARB's enhanced vapor recovery (EVR) program; nor do they reflect the interaction between vapor recovery systems installed at California GDFs and vehicles equipped with onboard refueling vapor recovery (ORVR). Approximately 74 percent of gasoline dispensed statewide in 2013 will be to ORVR vehicles. Therefore, the purpose of this document is to present revised emission factors for four current gasoline marketing subcategories and two new subcategories developed since 1999.

Current subcategories:

i. Phase II Fueling - Non-ORVR Vehicles
ii. Phase I Transfer Losses
iii. Pressure Driven Losses
iv. Phase II Fueling - Spillage

New subcategories:

v. Phase II Fueling - ORVR Vehicles
vi. Gasoline Dispensing Hose Permeation

This document describes the methodologies used to develop new or revised emission factors for the six GDF subcategories. The revised TOG emission factors are presented in Table I-I, along with the emission factors currently in use. The emission factors are segregated into three tiers, each representing varying degrees of vapor recovery equipment control: no vapor recovery system, or uncontrolled emission factor (UEF);

Phase I and Phase II vapor recovery systems predating enhanced vapor recovery (Pre-EVR); and enhanced Phase I and Phase II vapor recovery systems (EVR).

Table I-I

Current and Revised TOG Emission Factors for Gasoline Dispensing Facilities

Sub Category	**Current[a] (lbs/kgal)[b]**		**Revised (lbs/kgal)[b]**		
	UEF	**Pre-EVR**	**UEF**	**Pre-EVR**	**EVR**
Phase II Fueling					
Non-ORVR Vehicles	8.4	0.74	8.4	2.4	0.42
ORVR Vehicles	NA	NA	0.42	0.12	0.021
Phase I Bulk Transfer Losses	8.4	0.42	7.7	0.38	0.15
Pressure Driven Losses	0.84	0.1	0.76	0.092	0.024
Phase II Fueling - Spillage	0.64	0.42	0.61	0.42	0.24
Gasoline Dispensing Hose Permeation					
Year 2013	NA	NA	0.062	0.062	0.062
Year 2017	NA	NA	0.009	0.009	0.009

Notes:

a Current emission factors adopted May 1999, and predate EVR.

b Pounds TOG emitted per thousand gallons dispensed or transferred.

UEF - Uncontrolled emission factor. No Phase I vapor recovery system for bulk transfer emissions, no Phase II vapor recovery system for all other subcategories.

Pre-EVR - Phase I pre-EVR system for bulk transfer emissions, Phase II pre-EVR system for all other subcategories.

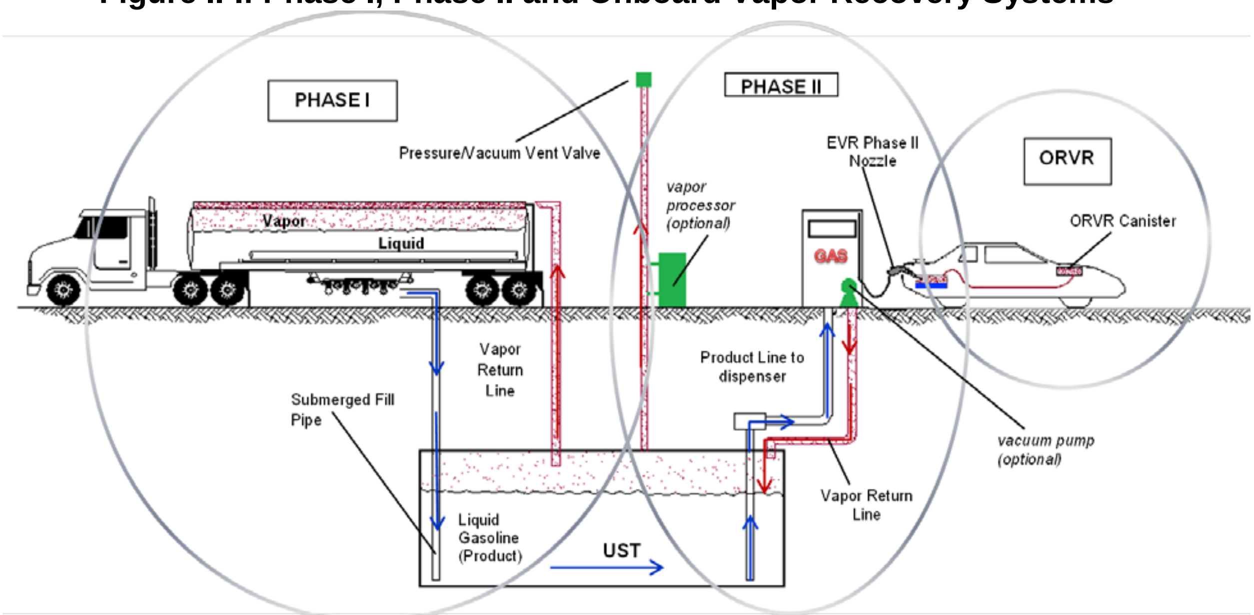
EVR - Phase I EVR system for bulk transfer emissions, Phase II EVR system for all other subcategories.

NA - No current applicable emission factor.

II. INTRODUCTION:

Vapor recovery systems are installed at GDFs to collect gasoline vapors that would otherwise escape into the atmosphere. Gasoline vapor emissions at GDFs are controlled in two phases. Phase I vapor recovery collects vapors displaced from an UST when a cargo tank truck delivers gasoline to a GDF. Phase II vapor recovery collects vapors displaced during the transfer of gasoline from a GDF to a vehicle, fuel container, or gasoline-powered equipment; and the storage of gasoline at a GDF. ARB regulations establish standards for the level of emissions control vapor recovery systems must achieve during the transfer and storage of gasoline. All vapor recovery systems must undergo certification tests to demonstrate compliance with performance standards before they can be sold, offered for sale, or installed in California. Figure II-1 illustrates the interaction between Phase I, Phase II and onboard vapor recovery systems.

Figure II-I: Phase I, Phase II and Onboard Vapor Recovery Systems



Vapor recovery system performance standards for GDFs have become more stringent over the years. Since 2001, ARB has adopted a number of significant advancements as part of the EVR program. Phase I EVR requires more durable and leak-tight components, along with an increased collection efficiency of 98 percent. Phase II EVR includes three major advancements: (1) dispensing nozzles with less spillage and required compatibility with ORVR vehicles, (2) a processor to control the static pressure of the ullage, or vapor space, in the underground storage tank, and (3) an in-station diagnostic (ISD) system that provides warning alarms to alert a GDF operator of potential vapor recovery system malfunctions. Phase I EVR was fully implemented in 2005. Phase II EVR was fully implemented between 2009 and 2011. Only existing GDFs in areas that are designated attainment for the State ozone standard are exempt from Phase I and Phase II EVR requirements. Additionally, ARB's air toxic control measure for benzene requires retail GDFs to install Phase I and Phase II systems at all GDFs except those which: (1) dispense from or transfer gasoline to a storage tank with a capacity less than 260 gallons, (2) dispense gasoline to implements of animal husbandry; or (3) only dispense to vehicles with fuel tanks less than 5 gallons capacity.

The current emission inventory category for gasoline marketing and retailing consists of four subcategories that include processes associated with storage and fuel transfer operations from cargo tank trucks to GDFs and from GDFs to vehicles, fuel containers, and gasoline-powered equipment. The current emission factors have been in effect since May 1999 and do not account for advances in vapor recovery system performance achieved through implementation of ARB's EVR program; nor do they address the interaction between GDF vapor recovery systems and ORVR vehicles.

This document presents updated emission factors for the four current subcategories, and two new subcategories addressing ORVR vehicle refueling and gasoline dispensing hose permeation emissions. The processes that generate emissions in the six subcategories are described below:

Current subcategories:

i. Phase II Fueling - Non-ORVR Vehicles: When dispensing gasoline to vehicles not equipped with ORVR, the rising liquid level in the vehicle fuel tank displaces gasoline vapors back through the fill-pipe where they are captured by a Phase II vapor recovery system. Vapors not captured by the Phase II vapor recovery system are emitted to the atmosphere.

ii. Phase I Bulk Transfer Losses: During transfer of gasoline from cargo tank trucks to a GDF UST, emissions are generated when gasoline vapors in an UST are displaced to the atmosphere by the rising level of the gasoline being loaded into an UST. Emissions are controlled with a Phase I vapor recovery system.

iii. Pressure Driven (Breathing) Losses: Emissions are generated when gasoline vapors are displaced to the atmosphere during the day to day operation of a given GDF. During periods when there is either no dispensing or when there is a significant slowdown in the dispensing of fuel to vehicles, such as overnight periods, gasoline in an UST evaporates into the headspace above the liquid fuel. The vapor growth caused by this evaporation increases UST static pressure and results in pressure driven emissions. Pressure driven emissions are currently controlled by a processing unit that includes either a bladder tank, membrane separator, carbon canister or thermal oxidizer.

iv. Phase II Fueling - Spillage: Emissions are generated from dispensing nozzle spillage of liquid gasoline during the act of vehicle fueling, including pre-fueling, fueling and post-fueling spillage.

New subcategories:

v. Phase II Fueling - ORVR Vehicles: These emissions occur at the vehicle fill-pipe during dispensing of gasoline to ORVR vehicles. ORVR systems were phased in beginning with 1998 model year passenger vehicles, and are now installed on all passenger, light-duty, and medium-duty vehicles manufactured since the 2006 model year. When an ORVR vehicle is fueled, almost all the gasoline vapor displaced from the fuel tank is routed to a carbon canister in the vehicle fuel system. At the start of dispensing, a small portion of the vapor in the vehicle fuel tank may escape through the fill-pipe before the onboard system is fully engaged. Uncontrolled fill-pipe emissions from ORVR vehicles are approximately two orders of magnitude lower than the same emissions from vehicles without ORVR, and are easily captured by Phase II vapor recovery systems.

vi. Gasoline Dispensing Hose Permeation: These emissions are caused by the migration of liquid gasoline through the outer GDF hose material and to the atmosphere through permeation. This condition primarily occurs at GDFs equipped with vacuum assist Phase II vapor recovery systems or no Phase II vapor recovery system.

The following sections present new or revised emission factors for the four current and two new subcategories identified above. The GDF emission factors are segregated into three tiers, each representing varying degrees of vapor recovery control equipment: uncontrolled (UEF), pre-EVR, and EVR.

This document also includes attachments detailing the methodologies and identifying references used to derive the revised emission factors for each GDF subcategory. All revised emission factors are based on test data collected by ARB staff, using established ARB test procedures when applicable.

III. PHASE II FUELING - NON-ORVR AND ORVR VEHICLES

Vehicle fueling emissions occur when gasoline vapors are displaced by rising liquid in the vehicle fuel tank during gasoline dispensing. These vapors are adsorbed in a carbon canister installed on ORVR vehicles. When fueling non-ORVR vehicles, these vapors can be collected by a Phase II vapor recovery system and returned to a GDF storage tank. Without a Phase II vapor recovery system, the vapors displaced from fueling non-ORVR vehicles are uncontrolled and released to the atmosphere.

The current TOG emission factors for vehicle fueling predate the conversion to EVR systems, and do not account for the introduction of ORVR vehicles to California's motor vehicle fleet. Therefore, the current vehicle refueling emission factors are representative of non-ORVR vehicles only. Current and proposed vehicle fueling emission factors are presented in Table III-1 below.

Table III-I Current and Revised TOG Emission Factors for Vehicle Fueling Emissions at Gasoline Dispensing Facilities					
	Current (lbs/kgal)		**Revised (lbs/kgal)**		
Vehicle Category	**UEF**	**Pre-EVR**	**UEF**	**Pre-EVR**	**EVR**
Non-ORVR Vehicles	8.4	0.74	8.4	2.4	0.42
ORVR Vehicles	N/A	N/A	0.42	0.12	0.021

The method used to develop the revised vehicle fueling emission factors consists of determining an UEF and then applying control efficiency (CE) factors that are representative of in-use ORVR and Phase II vapor recovery systems, resulting in controlled emission factors for each possible combination of fuel dispensing systems, ORVR vehicles, and non-ORVR vehicles.

The revised UEF for non-ORVR vehicle fueling was determined from vapor recovery certification tests performed by ARB staff and independent contractors, using ARB Vapor Recovery Test Procedure TP-201.2, *Efficiency and Emission Factor for Phase II Systems*.[3] In addition to vapor recovery certification testing, ARB staff has also performed tests of uncontrolled vehicle fueling at a GDF without a Phase II vapor recovery system, and at a GDF with a disabled Phase II vapor recovery system. The ARB test results determined the non-ORVR vehicle fueling UEF as 8.4 lbs/kgal, which agrees with and validates the current emission factor.

The revised UEF for ORVR vehicles was calculated as 0.42 lbs/kgal based on the non-ORVR vehicle fueling UEF of 8.4 lbs/kgal and 95 percent control efficiency required for certification of ORVR systems. Test data from a U.S. Environmental Protection Agency study[4, 5] suggest in-use efficiency greater than 95 percent. However, since the tests were performed on vehicles that were less than three model years old, ARB staff determined that the certification standard would represent the most conservative approach because an evaluation of the long term performance of the ORVR systems was not possible.

Phase II pre-EVR in-use control efficiency is estimated at 71 percent, based on results presented in two studies by local air districts in California. The first, performed by San Diego County Air Pollution Control District (SDCAPCD) in 2000,[6] concluded that pre-EVR balance systems experienced equipment defects at levels resulting in an estimated 70 percent collection efficiency (with complete failure about 11percent of the time). The second, performed by South Coast Air Quality Management District, shows that in 2006, prior to the Phase II EVR upgrade, about 92 percent of Phase II pre-EVR systems were balance type and 8 percent were vacuum assist type.[7] Assuming pre-EVR vacuum assist systems experience the same 11 percent complete failure rate determined for balance systems by the SDCAPCD study, and the remaining 89 percent operate at 95 percent collection efficiency, the calculated in-use control efficiency for Phase II pre-EVR systems is:

Phase II pre-EVR CE = 0.92 * (Balance CE) + 0.08 * (0.89 * Assist CE)
= 0.92 * (0.70) + 0.08 * (0.89 * 0.95) = 0.71

The revised emission factors for Phase II pre-EVR systems were calculated using the non-ORVR vehicle fueling UEF of 8.4 lbs/kgal, 95 percent ORVR in-use control efficiency and 71 percent Phase II pre-EVR system in-use control efficiency as follows:

ORVR, Phase II pre-EVR = (non-ORVR UEF)*(1 - ORVR CE)*(1- Ph II pre-EVR CE)
= (8.4 lbs/kgal) * (1 - 0.95) * (1 - 0.71) = 0.12 lbs/kgal

Non-ORVR, Phase II pre-EVR = (non-ORVR UEF)*(1 - Ph II pre-EVR CE)
= (8.4 lbs/kgal) * (1 - 0.71) = 2.4 lbs/kgal

Phase II EVR in-use control efficiency for non-ORVR vehicles is estimated at 95 percent based on results from 13 separate vapor recovery system efficiency tests performed by ARB staff between January 2009 and September 2010. The 13 tests represent 221 non-ORVR vehicle fueling events, and the overall vapor recovery system in-use control efficiency determined from these tests was 95 percent.

The emission factors for Phase II EVR systems were calculated using the non-ORVR vehicle fueling UEF of 8.4 lbs/kgal, 95 percent ORVR in-use control efficiency and 95 percent Phase II EVR system in-use control efficiency as follows:

ORVR, Phase II EVR = (non-ORVR UEF)*(1 - ORVR CE)*(1 - Ph II EVR CE)
= (8.4 lbs/kgal)*(1 - 0.95)*(1 - 0.95) = 0.021 lbs/kgal

Non-ORVR, Phase II EVR = (non-ORVR UEF)*(1 - Ph II EVR CE)
= (8.4 lbs/kgal) * (1 - 0.95) = 0.42 lbs/kgal

A more detailed description of the methodologies used to determine the revised vehicle fueling emission factors, including all applicable references is presented in Attachment 1 to this document, *Revised Emission Factors for Phase II Vehicle Fueling at California Gasoline Dispensing Facilities*.

IV. PHASE I BULK TRANSFER LOSSES

Phase I bulk transfer losses are TOG emissions produced during the delivery of gasoline to an UST from a cargo tank, and are also referred to as working losses or transfer emissions. Transfer emissions are controlled by a Phase I vapor recovery system, which operates on the balance principle. As gasoline is transferred by gravity from a cargo tank to an UST, the rising UST liquid level displaces hydrocarbon vapors which are captured by the Phase I vapor recovery system and returned to the headspace area in the cargo tank. This process is again repeated when the cargo tank is refilled at a gasoline bulk terminal, and the vapors displaced from the cargo tank are either recovered as liquid gasoline by and adsorption/absorption process or oxidized by a flare.

The current TOG bulk transfer emission factors predate implementation of ARB's EVR program. The current and revised TOG bulk transfer emission factors are presented in Table IV-I below.

Table IV-I

Current and Revised TOG Emission Factors for Phase I Transfer Emissions at Gasoline Dispensing Facilities

Current (lbs/kgal)		Revised (lbs/kgal)		
UEF	**Pre-EVR**	**UEF**	**Pre-EVR**	**EVR**
8.4	0.42	7.7	0.38	0.15

The method used to develop the revised gasoline bulk transfer emission factors consists of determining a gasoline bulk transfer UEF, and then applying CE factors that are representative of the level of control achieved by Phase I pre-EVR and Phase I EVR systems.

The revised bulk transfer UEF was derived from UST headspace TOG concentration data obtained from five tests performed by ARB staff at a Sacramento, California GDF between February 2012 and September 2013. In determining the revised UEF, ARB staff assumes the average UST headspace TOG concentration measured in these tests is representative of the average TOG concentration of the vapor mass displaced from an UST during bulk gasoline transfer if the emissions were uncontrolled. Based on these test results, ARB staff determined the revised bulk transfer UEF as 7.7 lbs/kgal, which represents an 8 percent decrease from the current value of 8.4 lbs/kgal.

Phase I pre-EVR in-use control efficiency is estimated at 95 percent, based on the performance standard for Phase I pre-EVR equipment certification and results from ten Phase I volumetric efficiency tests performed by ARB staff at gasoline bulk plant distribution facilities (bulk plant) prior to implementation of Phase I EVR. Results for each of the ten tests determined >95 percent volumetric efficiency during bulk transfer of gasoline from a cargo tank to the bulk plant UST.

The revised emission factor for Phase I pre-EVR systems was calculated using the bulk transfer UEF of 7.7 lbs/kgal and 95 percent Phase I pre-EVR in-use control efficiency as follows:

$$\begin{aligned} \text{Phase I pre-EVR} &= \text{(bulk transfer UEF)} * \text{(1 - Phase I pre-EVR CE)} \\ &= \text{(7.7 lbs/kgal)} * \text{(1 - 0.95)} = \text{0.38 lbs/kgal} \end{aligned}$$

Phase I EVR in-use control efficiency is estimated at 98 percent, based on the performance standard for Phase I EVR equipment certification and results from ten Phase I volumetric efficiency tests performed by ARB staff at bulk plants after implementation of Phase I EVR. Results for each of the ten tests determined >98 percent volumetric efficiency during bulk transfer of gasoline from a cargo tank to the bulk plant UST.

The emission factor for Phase I EVR systems was calculated using the bulk transfer UEF of 7.7 lbs/kgal and 98 percent Phase I-EVR in-use control efficiency as follows:

Phase I EVR = (bulk transfer UEF) * (1 - Phase I EVR CE)
= (7.7 lbs/kgal) * (1 - 0.98) = 0.15 lbs/kgal

A more detailed description of the methodologies used to determine the revised Phase I transfer emission factors, including all applicable references, is presented in Attachment 2 to this document, *Revised Emission Factors for Phase I Gasoline Bulk Transfer at California Gasoline Dispensing Facilities*

V. PRESSURE DRIVEN LOSSES

Pressure driven, or breathing, losses are fugitive emissions from UST vent riser and/or Phase II vapor recovery components resulting from the day to day operations at a given GDF. These emissions are influenced by several variables, most notably: gasoline Reid vapor pressure (RVP) and evaporation rate, ORVR vehicle throughput, overnight facility shutdown or extended facility inactivity, gasoline delivery schedule, vapor recovery system operating principle and vapor recovery system pressure integrity. These variables can act singularly or in combination to elevate static pressure in UST headspace, resulting in pressure driven emissions.

Current and revised pressure driven emission factors are presented in Table V-I below. Current pressure driven emission factors for GDFs without Phase II vapor recovery (UEF) and with Phase II pre-EVR vapor recovery systems are 0.84 lbs/kgal and 0.10 lbs/kgal, respectively. There is no current emission factor applicable to GDFs equipped with Phase II EVR systems.

Table V-I

Current and Revised TOG Pressure Driven Emission Factors for Gasoline Dispensing Facilities

Current (lbs/kgal)		Revised (lbs/kgal)		
UEF	**Pre-EVR**	**UEF**	**Pre-EVR**	**EVR**
0.84	0.10	0.76	0.092	0.024

The revised UEF of 0.76 lbs/kgal was calculated from UST static pressure data collected at a fleet rental car GDF located in San Jose, California. This facility is exempt from Phase II vapor recovery requirements by Bay Area Air Quality Management District.[8] UST static pressure data collected at this facility during two 30-day periods were combined with fugitive flow rate equations in ARB Vapor Recovery Test ProcedureTP-201.2F, *Pressure Related Fugitive Emissions*,[9] a TOG concentration of 46 percent as propane, and the facility gasoline throughput of 12,000 gallons per month to yield the revised UEF for pressure driven emissions from GDFs without Phase II systems.

The 46 percent TOG concentration value used in UEF calculation is based on the average UST headspace TOG concentration measured during 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*.

The revised pressure driven emission factors for GDFs with Phase II pre-EVR and Phase II EVR systems were estimated as 0.092 lbs/kgal and 0.024 lbs/kgal, respectively. The revised emission factors were derived from data collected between November 2009 and October 2010 at six GDFs located in Northern California. These sites were randomly selected as part of an ARB program to examine the dynamics causing substantial increases in the number of ISD over-pressure alarms corresponding to the transition from summer formulated fuel with Reid vapor pressure (RVP) restricted to less than or equal to 7 pounds per square inch, to winter formulated fuel with no RVP restriction. The six sites represent a cross section of the characteristics associated with California GDFs, such as throughput category, vapor recovery system operating principle and 24-hour operation versus overnight closure.

The reductions in revised pressure driven emission factors are primarily attributable to advancements in Phase II vapor recovery system technologies exclusive to EVR systems, such as: the Franklin-Healy vapor recovery nozzle which detects ORVR vehicles and reduces its V/L ratio, pressure management processors designed to maintain UST static pressure below defined levels, and ISD systems that monitor vapor recovery system operating parameters and alert GDF operators of vapor recovery equipment failures.

A more detailed description of the methodologies used to determine revised pressure driven emission factors, including all applicable references, is presented in Attachment 3, *Revised Emission Factors for Pressure Driven Emissions at California Gasoline Dispensing Facilities*.

VI. PHASE II FUELING - SPILLAGE

Gasoline spillage emissions are generated from liquid gasoline spills associated with vehicle fueling, including pre-fueling, fueling, and post-fueling spillage. The current and revised emission factors for gasoline spillage during vehicle fueling are presented in Table VI-I below.

Table VI-I Current and Revised TOG Emission Factors for Gasoline Spillage at Gasoline Dispensing Facilities				
Current (lbs/kgal)		**Revised (lbs/kgal)**		
UEF	**Pre-EVR**	**UEF**	**Pre-EVR**	**EVR**
0.64	0.42	0.61	0.42	0.24

Current emission factors for gasoline spillage at GDFs without Phase II vapor recovery (UEF) and with Phase II pre-EVR systems are 0.64 lbs/kgal and 0.42 lbs/kgal, respectively, based on data from tests performed by ARB, (Morgester et al., 1992).[10] There is no current emission factor applicable to GDFs equipped with Phase II EVR systems.

ARB staff has reviewed the test data used to calculate the current gasoline spillage UEF and pre-EVR emission factor. Based on this review, ARB staff determined the revised gasoline spillage UEF is 0.61 lbs/kgal, and the revised gasoline spillage pre-EVR emission factor should remain at 0.42 lbs/kgal. The revised emission factors are essentially unchanged from the current values because there have been no technical advancements for the respective nozzles since the current factors were established.

The gasoline spillage emission factor for GDFs with Phase II EVR is 0.24 lbs/kgal, which is the current performance standard referenced in ARB Certification Procedure CP-201,*Certification Procedure for Vapor Recovery Systems at Gasoline Dispensing Facilities*.[11]

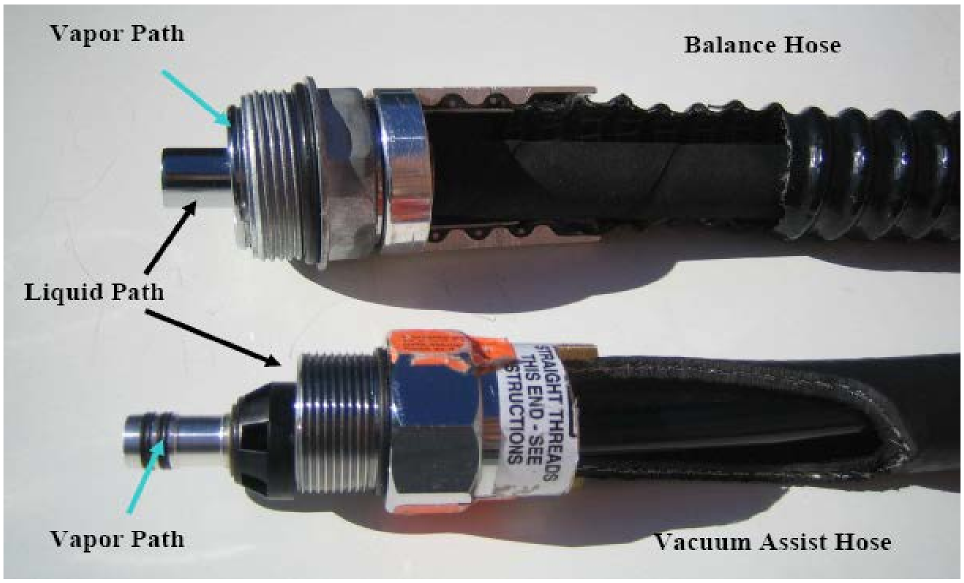
A more detailed description of the methodologies used to determine the revised gasoline spillage emission factors, including all applicable references, is presented in Attachment 4, *Revised Emission Factors for Gasoline Spillage at California Gasoline Dispensing Facilities.*

VII. GASOLINE DISPENSING HOSE PERMEATION

ARB adopted performance standards for gasoline dispensing hose permeation on July 26, 2012. Prior to adoption of these standards there were no hose permeation performance standards for California GDFs. Facilities subject to the standards will have four years from their effective date to comply. The effective date is defined as the date on which the first dispensing hose is certified by ARB to meet the new hose permeation performance standards.

Hose permeation performance standards only apply to hoses in which liquid fuel comes into contact with the outer hose wall, specifically: Phase II vacuum assist and conventional (non-vapor recovery) hoses. Vacuum assist hoses account for approximately 70 percent of the almost 100,000 Phase II vapor recovery hoses installed at California GDFs.[12] There are approximately 1,000 additional hoses installed at facilities without Phase II vapor recovery. The performance standards do not apply to hoses of balance Phase II vapor recovery systems, which dispense gasoline through the center region of a coaxial hose and transport vapor in the outer region. Figure VII-I illustrates the differences in fuel delivery and vapor return pathways for vacuum assist and balance vapor recovery hoses.

Figure VII-I, Cutaways of Vapor Recovery GDF Hose Assemblies Showing Vapor and Liquid Paths



Permeation rates are influenced by several factors, the most significant of which are: fuel temperature, gasoline formulation, and concentration gradient across the barrier material. As is the case with vehicle refueling emissions, gasoline throughput to ORVR vehicles plays a role in the permeation rates of balance type hoses, because refueling of ORVR vehicles affects the concentration gradient across the outer wall of these hoses. Therefore, balance hose permeation emissions are expected to decline in future years as gasoline throughput to ORVR vehicles increases.

When considering an isolated GDF hose, the permeation rate of liquid gasoline through vacuum assist and conventional hoses is relatively unaffected by activity level (i.e., the volume of gasoline dispensed or throughput). These hoses should permeate at the same daily rate as long as there is some level of activity. Therefore, the hose permeation emissions in tons per day can be estimated directly, independent of activity level. However, because other GDF emissions calculations are activity based, hose permeation emission factors were estimated as a function of activity level in order to maintain dimensional consistency with the emission factors proposed for the five other GDF subcategories.

Hose permeation emission factors based on GDF activity and ORVR penetration for years 2013 and 2017 are presented in Table VII-I below.

Table VII-I

Year 2013 and 2017 Hose Permeation TOG Emission Factors for Gasoline Dispensing Facilities

Year 2013 (lbs/kgal)			Year 2017 (lbs/kgal)		
UEF	**Pre-EVR**	**EVR**	**UEF**	**Pre-EVR**	**EVR**
0.062	0.062	0.062	0.009	0.009	0.009

The 2013 emission factors represent the uncontrolled permeation rates determined from ARB laboratory tests on vacuum assist, conventional and balance hoses.[13, 14]

The 2017 controlled emission factors (CEF) assume full implementation of the 3.23 grams per meter squared per day (referenced to 71 ^{o}F) vacuum assist/conventional hose permeation standard at California GDFs. This factor reflects the predicted population of vacuum assist, conventional and balance hoses and their associated permeation rates using the following equation:

$$\begin{aligned} \text{GDF Hose CEF}_{2017} &= \text{CEF}_{\text{vac/con, 2017}} + \text{UEF}_{\text{bal, 2017}} \\ &= 0.002 \text{ lbs/kgal} + 0.007 \text{ lbs/kgal} \\ &= 0.009 \text{ lbs/kgal} \end{aligned}$$

The 2017 hose permeation CEF of 0.009 lbs/kgal represents an 88% reduction in hose permeation emissions compared to the 2013 emissions baseline of 0.062 lbs/kgal. ARB's cost analysis suggests cost savings[15] associated with low permeation hose conversion in both vapor recovery and non-vapor recovery applications.

A more detailed description of the methodologies used to determine the proposed GDF hose permeation emission factors, including all applicable references and intermediate variables such as: permeation rates, hose surface areas, hose populations and gasoline throughput is presented in Attachment 5, *Proposed Emission Factors for Gasoline Dispensing Hose Permeation at California Gasoline Dispensing Facilities.*

VIII. CONCLUSIONS

The revised GDF emission factors show no change to the current UEF for Phase II non-ORVR vehicle refueling of 8.4 lbs/kgal; and a 17 percent percent reduction to the current UEF for Phase I transfer losses from 8.4 lbs/kgal to 7.0 lbs/kgal. The revised emission factor for refueling non-ORVR vehicles with Phase II pre-EVR systems of 2.4 lbs/kgal is approximately 3 times its current value of 0.74 lbs/kgal, due to the lower in-use efficiency assigned to Phase II pre-EVR systems. However, Phase II pre-EVR systems only account for approximately 3 percent of gasoline dispensed at California GDFs.

The revised emission factors also include categories for GDFs with EVR equipment, which currently dispense approximately 95 percent of gasoline sold in California. There are no current emission factors for EVR categories, as the current emission factors predate EVR systems. The revised emission factors proposed for EVR categories are all significantly lower than the current pre-EVR values; and are reflective of both advancements in vapor recovery system performance achieved through ARB's EVR program and the increasing statewide gasoline throughput to ORVR vehicles.

IX. REFERENCES

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Attachments

Attachment 1:	Revised Emission Factors for Phase II Vehicle Fueling at California Gasoline Dispensing Facilities
Attachment 2:	Revised Emission Factors for Phase I Gasoline Bulk Transfer at California Gasoline Dispensing Facilities
Attachment 3:	Revised Emission Factors for Pressure Driven Emissions at California Gasoline Dispensing Facilities
Attachment 4:	Revised Emission Factors for Gasoline Spillage at California Gasoline Dispensing Facilities
Attachment 5:	Proposed Emission Factors for Gasoline Dispensing Hose Permeation at California Gasoline Dispensing Facilities