



Monitoring and Laboratory Division

Attachment 2

Revised Emission Factors for Phase I Gasoline Bulk Transfer at
California Gasoline Dispensing Facilities

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I. INTRODUCTION

Transfer emissions occur when gasoline vapors are displaced by rising liquid in the gasoline dispensing facility (GDF) underground storage tank (UST) during bulk transfer of gasoline from a cargo tank to an UST. The displaced vapors are collected by a Phase I vapor recovery system that returns them to the cargo tank. Without a Phase I vapor recovery system, vapors displaced from USTs during bulk gasoline transfer are released uncontrolled to the atmosphere. Phase I vapor recovery systems presently control approximately 150 tons per day of gasoline vapor emissions from gasoline bulk transfer at California GDFs.

The current Air Resources Board (ARB) total organic gases (TOG) emission factors for GDFs, in use since May 1999, do not reflect improvements in Phase I vapor recovery system performance achieved through ARB's enhanced vapor recovery (EVR) program. ARB staff has conducted field tests and data analyses to account for these advances, resulting in the proposed revisions to the gasoline bulk transfer emission factors presented in Table I-1 below.

Table I-1 Current and Revised Gasoline Bulk Transfer Emission Factors for Gasoline Dispensing Facilities				
Current (lbs/kgal)		Revised (lbs/kgal)		
Uncontrolled	Phase I Pre-EVR	Uncontrolled	Phase I Pre-EVR	Phase I EVR
8.4	0.42	7.7	0.38	0.15

As shown in Table I-1, ARB's current gasoline bulk transfer emissions inventory is based on two emission factors: 8.4 pounds of TOG per thousand gallons transferred (lbs/kgal) for uncontrolled gasoline bulk transfer at GDFs without Phase I vapor recovery, and 0.42 lbs/kgal for GDFs with Phase I vapor recovery. The revised emission factor of 7.7 lbs/kgal for uncontrolled gasoline bulk transfer is based on UST headspace TOG concentrations measured by ARB staff between February 2012 and September 2013. The revised Phase I EVR transfer emission factor of 0.15 lbs/kgal is a result of both the lower uncontrolled bulk transfer emission factor and improved Phase I vapor recovery system performance achieved through ARB's EVR program. The methodology used to develop revised emission factors for the bulk transfer of gasoline from a cargo tank truck to an UST is presented in this attachment.

II. METHODOLOGY – REVISED GASOLINE BULK TRANSFER EMISSION FACTORS

The method used to develop the revised gasoline bulk transfer emission factors consists of determining an uncontrolled gasoline bulk transfer emission factor (UEF), and then applying control efficiency (CE) factors that are representative of the level of control achieved by Phase I pre-EVR and Phase I EVR systems. For example, the bulk transfer emission factor for a typical GDF equipped with a Phase I pre-EVR system is calculated as:

$$\text{Phase I pre-EVR bulk transfer emissions} = \text{UEF} * (1 - \text{Phase I pre-EVR CE})$$

DETERMINATION OF UEF

Bulk Transfer UEF

The bulk transfer UEF represents emissions from the bulk transfer of gasoline from cargo tank trucks to USTs at GDFs *without* a Phase I vapor recovery system or, alternatively, the emissions available for control by a Phase I vapor recovery system. The 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 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.

UST headspace 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*.¹ The five tests employed a “stratification” sampling technique in which 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 remaining three tests were performed during the winter RVP fuel period.

A bulk transfer UEF was calculated for each of the five stratification tests from the average UST headspace TOG concentration measured during each test using the following equation:

$$\text{Bulk Transfer UEF} = \frac{(C)(M)(1000)}{(385)(7.481)}$$

Where:

- UEF = Uncontrolled emission factor, lbs/1000 gallons transferred.
- C = TOG concentration, as propane, in UST headspace (decimal fraction).
- M = Molecular weight of hydrocarbon gas used to calibrate the gas analyzer, 44 lbs/lb-mole for propane.
- 1000 = Emission factor unit vapor volume basis (gallons).
- 385 = Ideal gas molar volume at 68°F and 29.92 in. Hg (ft³/lb-mole).
- 7.481 = Unit conversion factor (gallons/ft³)

UST headspace TOG concentration data used to derive the revised bulk transfer UEF are presented in Table II-1. The average UST headspace TOG concentration, as propane, and bulk transfer UEF for summer RVP fuel are 49.1 percent and 7.49 lbs/kgal, respectively. The average UST headspace TOG concentration, as propane, and bulk transfer UEF for winter RVP fuel are 51.9 percent and 7.92 lbs/kgal, respectively.

The overall bulk transfer UEF used in bulk transfer emission factor calculations is calculated by weighting the average summer RVP fuel and winter RVP fuel bulk transfer UEFs for statewide gasoline throughput during the respective summer and winter periods. The California State Board of Equalization reported approximately 14.51 billion gallons of gasoline were dispensed statewide² to motor vehicles in 2012. Of the total, approximately 8.59 billion gallons, or 59.2 percent, of gasoline was dispensed during the April through October summer RVP fuel period. The remaining 5.92 billion gallons, or 40.8 percent, was dispensed during the January through March and November through December winter RVP fuel periods. Based on the BOE throughput data, the overall bulk transfer UEF, weighted for seasonal variation in statewide gasoline throughput, is calculated by the following equation:

$$\begin{aligned}
 \text{Overall Bulk Transfer UEF} &= \text{Summer Fuel UEF} * (0.592) + \text{Winter Fuel UEF} * (0.408) \\
 &= 7.49 \text{ lbs/kgal} * (0.592) + 7.92 \text{ lbs/kgal} * (0.408) \\
 &= 7.67 \text{ lbs/kgal}
 \end{aligned}$$

Table II-1				
Gasoline Bulk Transfer UEF Estimated from UST Headspace Vapor Concentration Testing				
Date Tested	Test Description	Fuel Period	Avg. TOG Conc. (%C₃)	UEF (lbs/kgal)
6/21/2012	Stratification testing, Sacramento, Healy w/CAS	Summer	51.2	7.82
9/19/2013	Stratification testing, Sacramento, Healy w/CAS	Summer	46.9	7.16
Average Summer RVP Fuel:			49.1	7.49
2/14/2012	Stratification testing, Sacramento, Healy w/CAS	Winter	52.0	7.95
2/14/2012	Stratification testing, Sacramento, Healy w/CAS	Winter	51.4	7.85
2/15/2012	Stratification testing, Sacramento, Healy w/CAS	Winter	52.2	7.98
Average Winter RVP Fuel:			51.9	7.92

DETERMINATION OF CE

Phase I Pre-EVR CE

The revised gasoline bulk transfer emission factors assume 95 percent in-use CE for Phase I pre-EVR systems, based on both the certification performance standard of 95 percent, and the results from ten Phase I volumetric efficiency tests³ performed at gasoline bulk plant distribution facilities (bulk plant) prior to implementation of Phase I EVR. The tests were performed using the equipment and procedures referenced in ARB Vapor Recovery Test Procedure TP-201.1, *Volumetric Efficiency for Phase I Vapor Recovery Systems*. Only test results for bulk plants configured as GDFs were used to calculate the Phase I pre-EVR in-use CE. Each facility was equipped with USTs, an integrated Phase II vapor recovery system, a +3/-8 inches water column P/V valve, and the additional ability to transfer gasoline from its UST to a cargo tank truck.

Table II-2 summarizes the volumetric efficiency test results from the ten bulk plants tested prior to implementation of Phase I EVR. The test results only include volumetric efficiencies determined for the bulk transfer of gasoline from a cargo tank truck to the bulk plant UST. The average test result of >95 percent volumetric efficiency (the certification performance standard) reported in Table II-1 supports the assumed 95 percent in-use CE assigned to Phase I pre-EVR systems.

Table II-2 Gasoline Bulk Distribution Plant Phase I pre-EVR Volumetric Efficiency Test Results			
Test No.	Date	Location	CE (%)
ST – 01 – 52	19 Dec 2001	Valencia	> 95
ST – 01 – 51	05 Dec 2001	Nevada City	> 95
ST – 01 – 50	04 Dec 2001	Kingsburg	> 95
ST – 01 – 48	23 Oct 2001	Mountain View	> 95
ST – 01 – 46	16 Oct 2001	Ventura	> 95
ST – 01 – 43	31 Aug 2001	Santa Monica	> 95
ST – 00 – 42	13 Jul 2000	Long Beach	> 95
ST – 00 – 41	13 Jul 2000	Irvine	> 95
ST – 00 – 28	18 May 2000	Fullerton	> 95
ST – 99 – 10	25 Mar 1999	Reedley	> 95
Average CE:			> 95

Phase I EVR CE

The revised gasoline bulk transfer emission factors assume 98 percent in-use CE for Phase I EVR systems, based on both the certification performance standard of 98 percent, and the results from ten Phase I volumetric efficiency tests² performed at gasoline bulk plants after implementation of Phase I EVR. The tests were performed using the equipment and procedures referenced in ARB Vapor Recovery Test Procedure TP-201.1, *Volumetric Efficiency for Phase I Vapor Recovery Systems*. Only test results for bulk plants configured as GDFs were used to calculate the Phase I EVR in-use CE. Each facility was equipped with USTs, an integrated Phase II vapor recovery system, a +3/-8 inches water column P/V valve, and the additional ability to transfer gasoline from its UST to a cargo tank truck.

Table II-3 summarizes the volumetric efficiency results from the ten bulk plants tested after implementation of Phase I EVR. The test results only include volumetric efficiencies determined for the bulk transfer of gasoline from a cargo tank to the bulk plant UST. The average test result of >98 percent volumetric efficiency (the certification performance standard) reported in Table II-2 supports the assumed 98 percent in-use CE assigned to Phase I EVR systems.

Table II-3 Gasoline Bulk Distribution Plant Phase I EVR Volumetric Efficiency Test Results			
Test No.	Date	Location	CE (%)
ST – 11 – 09	08 Nov 2011	Diamond Springs	> 98
ST – 11 – 08	03 Nov 2011	Long Beach	> 98
ST – 09 – 13	29 Jul 2009	Anaheim	> 98
ST – 09 – 07	29 Apr 2009	Lemoore	> 98
ST – 07 – 07	27Apr 2007	Oxnard	> 98
ST – 07 – 06	26Apr 2007	Paso Robles	> 98
ST – 06 – 12	20 Oct 2006	Rocklin	> 98
ST – 06 – 08	24 May 2006	Santa Barbara	> 98
ST – 06 – 04	17 Mar 2006	Los Angeles	> 98
ST – 05 – 11	12 Oct 2005	Ventura	> 98
Average CE:			> 98

DETERMINATION OF EMISSION FACTORS

Phase I Pre-EVR Transfer Emission Factor

The revised emission factor for bulk gasoline transfer at GDFs with Phase I pre-EVR systems is calculated from the overall bulk transfer UEF and Phase I pre-EVR CE using the following equation:

$$\begin{aligned} \text{Phase I pre-EVR transfer emissions} &= \text{UEF} (1 - \text{Phase I pre-EVR CE}) \\ &= 7.67 \text{ lbs/kgal} * (1 - 0.95) = 0.38 \text{ lbs/kgal} \end{aligned}$$

Phase I EVR Transfer Emission Factor

The revised emission factor for bulk gasoline transfer at GDFs with Phase I EVR systems is calculated from the overall bulk transfer UEF and Phase I EVR CE using the following equation:

$$\begin{aligned} \text{Phase I EVR transfer emissions} &= \text{UEF} (1 - \text{Phase I EVR CE}) \\ &= 7.67 \text{ lbs/kgal} * (1 - 0.98) = 0.15 \text{ lbs/kgal} \end{aligned}$$

III. REFERENCES

1. 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
2. California State Board of Equalization Fuel Taxes and Statistics Report-2012. <http://www.boe.ca.gov/sptaxprog/spftrpts12.htm>
3. ARB Testing and Certification Section Test Reports ST-99-10, ST-00-28, ST-00-41, ST-00-42, ST-01-43, ST-01-46, ST-01-48, ST-01-50, ST-01-51, and ST-01-52.
4. ARB Testing and Certification Section Test Reports ST-11-09, ST-11-08, ST-09-13, ST-09-07, ST-07-07, ST-07-06, ST-06-12, ST-06-08, ST-06-04 and ST-05-11.