



Monitoring and Laboratory Division

Attachment 4

Revised Emission Factors for Gasoline Spillage at
California Gasoline Dispensing Facilities

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I. INTRODUCTION

Spillage emissions occur as the result of liquid gasoline spills during the various stages of vehicle fueling,¹ including pre-fueling, fueling, shut-off, and post-fueling.

Current gasoline marketing emission factors for the category of vehicle fueling spillage are 0.64 pounds per thousand gallons dispensed (lbs/kgal) for gasoline dispensing facilities (GDF) without a Phase II vapor recovery system and 0.42 lbs/kgal for GDFs with a Phase II pre-enhanced vapor recovery (EVR) system. The current emission factors have been in effect since May 1999, prior to adoption of EVR requirements for California GDFs. Therefore, there is currently no accepted emission factor for spillage losses applicable to EVR nozzles.

The current emission factors were determined from a 1992 ARB study of emissions from conventional nozzle dispensing events at California GDFs (Morgester, et al.)², which was published in the March 1992 Journal of Air and Waste Management Association.

Air Resources Board (ARB) staff have developed new spillage emission factors based on data collected from the 1992 ARB study and current certification procedure performance specifications. The revised emission factors proposed by ARB are 0.61 lbs/kgal for GDFs with no Phase II vapor recovery system, 0.42 lbs/kgal for GDFs with a Phase II pre-EVR system, and 0.24 lbs/kgal for GDFs with a Phase II EVR system. A comparison of the current and revised emission factors is presented in Table I-1.

	Without Phase II	Phase II Pre-EVR	Phase II EVR
Current	0.64	0.42	Not Applicable
Revised	0.61	0.42	0.24

II. METHODOLOGY - REVISED GASOLINE SPILLAGE EMISSION FACTORS

The methodology for revised gasoline spillage emission factors is based on the original data from ARB's 1992 spillage study, including Table II-1 - *Spillage Data Summary*. Table II-1 shows spill volumes recorded during segments of the vehicle fueling event. There were three types of spills recorded:

M = measurable spills on concrete (spills > 1 ml)

V = 1 to 3 ml spills on vehicle (quantified as 2 ml each)

D = Drops (less than 1 ml) which result in stains the size of dimes, quarters or half-dollars

The fueling event was defined as follows:

Pre-fuel: Includes removing nozzle from dispenser and inserting it into vehicle fill-pipe.

Fueling: Includes the dispensing process from start to nozzle shut-off phase.

Shut-off: Includes spills at nozzle shut-off either by automatic or customer controlled shut-off

Post-fuel: Includes spillage occurring from removal of nozzle from the vehicle to hanging the nozzle up on the dispenser.

Also note in Table II-1 that M and V spills are given in milliliters (ml), but the drops are the number of drops observed. The percentage columns indicate the proportion that a type of spill occurred during a certain portion of the fueling event.

Table II-1 Gasoline Spillage Data Summary					
Portion of Fueling Event	Type of Spill	Conventional Nozzle	% of Total	Vapor Recovery Nozzle	% of Total
Pre-fuel	V (ml)	12	3%	12	6%
	M (ml)	65	1%	432	13%
	D (# drops)	173	5%	124	5%
Fueling	V (ml)	38	9%	38	18%
	M (ml)	1662	30%	1121	33%
	D (# drops)	35	1%	3	0%
Shut-off	V (ml)	210	51%	42	20%
	M (ml)	3563	63%	839	25%
	D (# drops)	92	3%	14	1%
Post-Fueling	V (ml)	150	37%	120	56%
	M (ml)	328	6%	981	29%
	D (# drops)	3052	91%	2357	94%
TOTAL	V (ml)	410	100%	212	100%
	M (ml)	5618	100%	3373	100%
	D (# drops)	3352	100%	2498	100%
Gasoline Dispensed (gallons)		16,200		14,043	

Only the total vehicle (V) and measurable (M) spills were used in calculating the vapor recovery nozzle spillage emission factor, since drops (D) are defined as less than 1 ml. Drop spillage was not quantified as to the volume of gasoline it represents and not included in any calculations presented in the 1992 ARB study.

Gasoline Spillage Emission Factor – No Phase II Vapor Recovery System

An ARB staff review of the original data from the 1992 gasoline spillage study indicates that the emission factor for GDFs without Phase II vapor recovery should have been 0.61 lbs/kgal instead of the 0.64 lbs/kgal value currently in use. This emission factor is calculated from the sum of V and M spills (ml) from conventional nozzles in Table II-1, the gasoline dispensed (G = gal) by the same nozzles, the density of gasoline (d = 6.2 lbs/gal), and a unit conversion factor (ucf = gal/3785.3 ml) as follows:

$$\begin{aligned} &\text{Gasoline Spillage without Phase II (lbs/kgal)} \\ &= (V+M) * \text{ucf} * (1000/G) * d \\ &= 6028 \text{ ml} * (\text{gal}/3785.3 \text{ ml}) * (1000 \text{ gal}/16,200 \text{ gal}) * 6.2 \text{ lbs/gal} \\ &= 0.61 \text{ lbs/kgal} \end{aligned}$$

In the absence of documentation supporting 0.64 lbs/kgal value, ARB staff recommends correcting the uncontrolled emission factor to 0.61 lbs/kgal for GDFs without Phase II vapor recovery systems.

Gasoline Spillage Emission Factor – Phase II Pre-EVR System

Based on the data presented in the same 1992 ARB spillage study, ARB staff proposes maintaining the gasoline spillage emission factor for GDFs with Phase II pre-EVR systems at its current value of 0.42 lbs/kgal. This emission factor is calculated from the data for vapor recovery nozzles in Table II-1 as follows:

$$\begin{aligned} &\text{Gasoline Spillage with Phase II Pre-EVR (lbs/kgal)} \\ &= (V+M) * \text{ucf} * (1000/G) * d \\ &= 3585 \text{ ml} * (\text{gal}/3785.3 \text{ ml}) * (1000 \text{ gal}/14,043 \text{ gal}) * 6.2 \text{ lbs/gal} \\ &= 0.42 \text{ lbs/kgal} \end{aligned}$$

Gasoline Spillage Emission Factor – Phase II EVR System

ARB recommends the addition of an emission factor for Phase II EVR systems of 0.24 lbs/kgal, which is equivalent to the EVR nozzle certification performance standard established by ARB's Enhanced Vapor Recovery regulation.³ In the staff report for this regulation, the results of the 1992 ARB spillage study were used to demonstrate that this performance standard could be achieved with a redesigned vapor recovery nozzle that eliminates pre- and post-fueling spills. Additionally, ARB Certification Procedure CP-201, *Certification Procedure for Vapor Recovery Systems at Gasoline Dispensing Facilities*,⁴ Section 4.7 (Nozzle Criteria) requires each vapor recovery nozzle shall be "dripleless", meaning that no more than three drops shall occur following each refueling operation.

The gasoline spillage emission factor for Phase II EVR systems is calculated by adjusting the 1992 study results for pre-EVR nozzles in Table II-1 to account for the design of EVR nozzles to eliminate all type (D) drops, and all (V) and (M) pre-fueling and post-fueling spills as follows:

$$\begin{aligned} &\text{The total volume, in ml, of EVR nozzle spillage (V) + (M)} \\ &= (38 \text{ ml} + 42 \text{ ml}) + (1121 \text{ ml} + 839 \text{ ml}) \\ &= 2,040 \text{ ml} \end{aligned}$$

$$\begin{aligned} &\text{Phase II EVR Gasoline Spillage Factor (lbs/kgal)} \\ &= (V+M) * \text{ucf} * (1000/G) * d \\ &= 2,040\text{ml} * (\text{gal}/3785.3 \text{ ml}) * (1000 \text{ gal}/14,043 \text{ gal}) * 6.2 \text{ lbs/gal} \\ &= 0.24 \text{ lbs/kgal} \end{aligned}$$

ARB staff has measured gasoline spillage from over 3,000 fueling events⁵ during certification testing of vacuum assist and balance EVR nozzles, and the results show spillage rates far below the 0.24 lbs/kgal performance standard. However, in order to account for the spillage limits established by the regulation, ARB staff recommends the more conservative emission factor set at the 0.24 lbs/kgal performance standard.

III. REFERENCES

1. Air Resources Board, Gasoline Dispensing Facilities, Underground Tanks (ARB Proposal, June 2010).
2. James J. Morgester, Robert L. Fricker, G. Henry Jordan (1992) Comparison of Spill Frequencies and Amounts at Vapor Recovery and Conventional Service Stations in California, Journal of Air & Waste Management Association, Vol 42, No. 3, pp284-289, March 1992.
3. Air Resources Board, Enhanced Vapor Recovery, Initial Statement of Reasons for Proposed Amendments to the Vapor Recovery Certification and Test Procedures for Gasoline Loading and Motor Vehicle Gasoline Refueling at Service Stations, February 4, 2000.
4. Air Resources Board, Certification Procedure for Vapor Recovery Systems at Gasoline dispensing Facilities, CP-201, Adopted: December 9, 1975, Amended: May 25, 2006.
5. TP-201.2C test results during certification testing of the Healy EVR nozzle (2004), VST EVR nozzle (2007) and Emco Wheaton EVR nozzle (2009).