California Environmental Protection Agency

Air Resources Board

Gasoline Dispensing Facility (GDF) Balance Hose
Vapor Quality and Permeation Analysis

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Introduction

The California Air Resources Board (ARB) staff conducted an analysis of gasoline vapor quality for balance GDF hoses (Figure 1) in 2011. The purpose of the analysis was to characterize the vapor quality from balance GDF hoses to estimate emissions due to permeation. The emissions estimates are used to support a proposed regulation to reduce permeation from GDF hoses. If adopted, the regulation would be fully implemented by 2017. The analysis showed that the 2017 annual average permeation rate for balance GDF hoses would be approximately 13.9 grams per square meter per day (g/m^2/day), given an average ambient temperature of 71.0°F (21.7°C) when using California summer time pump fuel. Throughout this analysis, test results are expressed with different baseline temperatures. This is due to the testing parameters of the individual tests involved. However, the data have been normalized and the performance standard has been adjusted to the appropriate temperature.

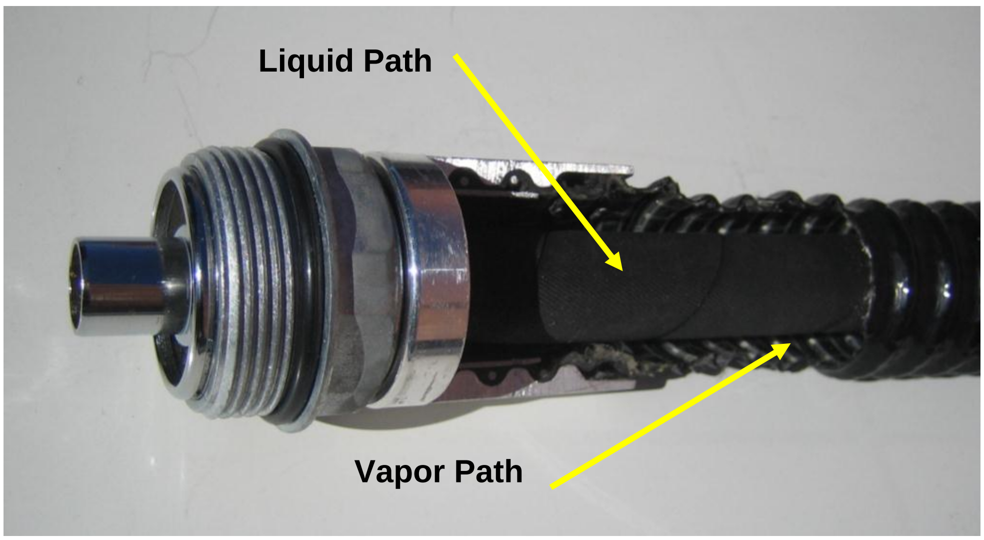


Figure 1. Cutaway of a balance GDF hose showing the vapor and liquid paths.

Permeation

Permeation is defined as the diffusion of a liquid or vapor (the permeate) through a solid substance. Permeation rate, or flux, may be affected by temperature, permeate type, concentration gradient of the permeate across the solid, and the solid material type and thickness. Depending upon these factors, some common fuel hose materials can permeate at rates of over 500 g/m^2/day. For GDF hose permeation, the permeate is gasoline and the solid through which the permeate is diffused is the outer hose wall.

The Society of Automotive Engineers (SAE) has several test methods that have been used to determine permeation rates for fuel hoses.[1, 2] The methods generally measure permeation either directly or indirectly by weight loss of the specimen. In addition, research published by SAE suggests that a saturated vapor permeates at approximately the same rate as it would in liquid form under the same conditions.[3, 4, 5, 6] A saturated vapor is a vapor that when the substance is present in both liquid and vapor states, the substance is in equilibrium between the two states. The vapor in the fuel tank of a car is considered a saturated vapor as a state of equilibrium between the vapor and liquid states frequently exists.

The vapor that is being transferred in a balance GDF hose comes from a vehicle fuel tank and therefore is considered a saturated vapor. This is also the case immediately following the fueling event. However, due to the time between refueling events in which the vapor is stagnant and permeating through the outer hose wall, the vapor within a balance GDF hose cannot be characterized as a saturated vapor at all times. Therefore, a model is necessary to characterize permeation emissions from GDF hoses.

Balance GDF Hose Permeation Testing

Staff conducted two separate tests to determine balance GDF hose gasoline permeation rates. The first test was conducted in 2004 and the second test was conducted in 2008.

In 2004, a GDF hose permeation test was conducted to estimate the amount of emissions due to permeation from GDF hoses.[7] For balance GDF hoses, the test included filling the inner (liquid) path to 75 percent full and capping the hose assembly to separate the liquid and vapor paths. Testing exposed the hoses to ambient temperature conditions for a period of approximately one month while recording weight loss at regular intervals. Weight loss was attributed to fuel loss due to permeation. No attempt was made to control vapor quality in the hose vapor paths and the test did not address test fuel degradation. Because of these limitations the vapor quality in the vapor path never achieved a saturated vapor. Despite these short comings, balance GDF hose permeation rates of 22.6 $g/m^2/day$ were observed for an average ambient temperature of 69 °F (20.5 °C) when using California summer time pump fuel.

In 2008, staff conducted another balance GDF hose permeation test to measure the permeation of a saturated vapor from a balance GDF hose.[8] The Test included removing the inner (liquid) hose path, filling the hose assembly with liquid fuel to 90 percent capacity, and capping the hose assembly. The test exposed the hoses to room temperature for approximately one month while recording weight loss over regular intervals. Weight loss was attributed to fuel loss due to permeation. Staff controlled fuel degradation to less than 2 percent by refreshing the fuel daily. To approximate the saturated vapor permeation rate for balance GDF hoses, staff assumed a saturated vapor permeates at the same rate as liquids given the same conditions. The test determined a balance GDF hose saturated vapor permeation rate of 104.5 $g/m^2/day$ for an average ambient temperature of 71.0°F (21.7°C) when using California summer time pump fuel.

Balance GDF Hose Vapor Quality

To determine when a saturated vapor is present in a balance GDF hose, staff conducted an efficiency and emissions factor test in 2007.[9] Data was collected from fueling events of more than 200 cars over the course of five days (Attachment 1). As part of the test, return vapor quality was measured in the vapor return path at a point immediately proceeding where the hose terminates into the dispenser. A non-dispersive infrared (NDIR) absorbance sensor (Figure 2) was used to measure concentrations. The data were collected for the purpose of determining the efficiency of the vapor recovery system. However, staff found this information useful in characterizing the saturated vapor quality and typical operational vapor quality within the hose. Time between fueling events measured during this test ranged from 5 to 15 minutes.

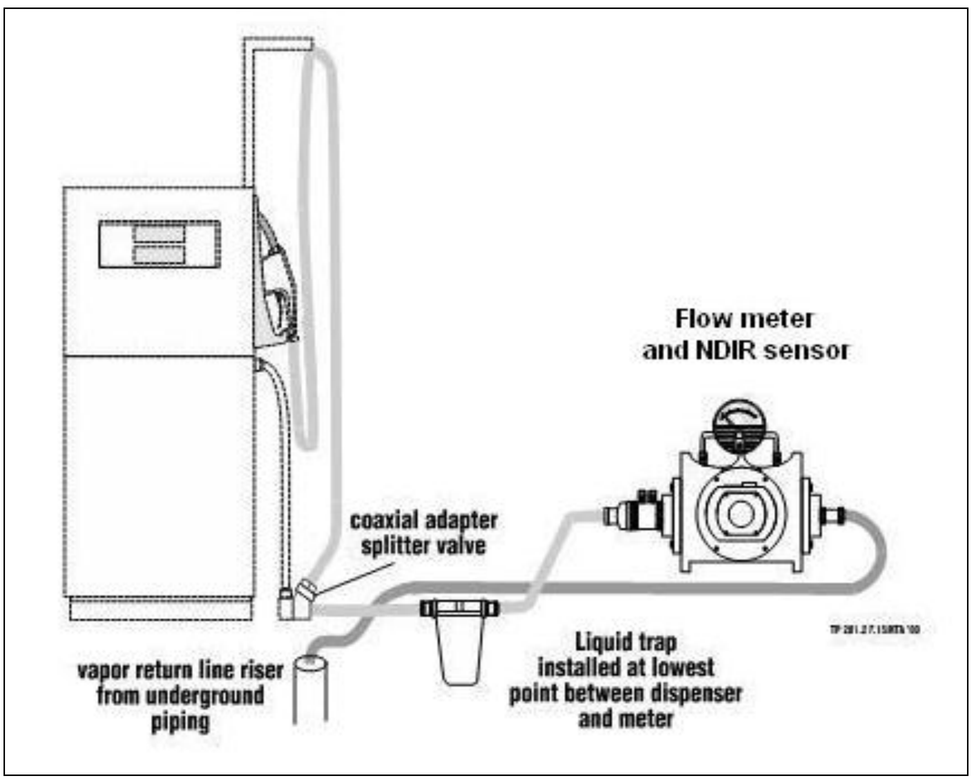


Figure 2 Test set up for measuring return vapor volume and quality at a GDF.

Staff looked at three specific fuel event characteristics associated with the test. These characteristics include: Vehicle class as On-Road Vapor Recovery (ORVR) or not, vapor to liquid ratio (V/L) of the returning vapors, and vapor quality as measured in percent propane (percent C_3H_8). These characteristics impact vapor quality as follows:

- ORVR vehicles, by design, should return very little, if any, vapor through the balance GDF hose during a fueling event. This is because the displaced vapors from the tank of an ORVR vehicle are routed to a carbon canister for storage until they can be purged during optimum vehicle running conditions. Theoretically, only air that leaks into the system at an improperly seated nozzle should be returned through the hose vapor return path during the fueling of ORVR vehicles. By contrast, fueling a non-ORVR vehicle would force displaced vapor in the vehicle fuel tank through the vapor return path of the balance GDF hose as they are drawn into the GDF tank.
- V/L ratios describe the ratio of the volume of the returning vapors to the volume of the dispensed liquid. For non-ORVR vehicles, a fueling event with a properly operating balance vapor recover system should result in a V/L of 1. This represents an equal volume transfer between the vehicle tank and the GDF tank. Also, an ORVR vehicle fueling event should result in a V/L approaching zero. For all fueling events conducted in the test, the average V/L for ORVR vehicles was 0.5 and the average V/L for non-ORVR vehicles was 1.4. This implies that during most fueling events, excess air was introduced into the system. This implies that the vapor quality would generally be less than saturated.
- Percent propane represents the equivalent HC concentration measured by the NDIR. Theoretically, the percent propane observed for a fueling event with a V/L of 1 for a non-ORVR vehicle, should represent the equivalent HC concentration of a saturated gasoline vapor for the conditions measured.

Determining Balance GDF Hose Saturated Vapor Quality

As previously discussed, staff assumes that the gasoline vapor immediately transferred into the vapor path of a balance GDF hose, during an ideal non-ORVR fueling event is a saturated vapor. For the purposes of this paper, an ideal fueling event is one in which there are no leaks in the vapor return path. An ideal fueling event for a non-ORVR vehicle is characterized as having a V/L of 1. Therefore, an HC concentration corresponding to a V/L of 1 should represent a saturated vapor. Staff calculated the average HC concentration for non-ORVR vehicle fueling events with a V/L ranging from 0.9 to 1.1. The results indicate average HC concentrations for a saturated vapor was 45 percent C_3H_8.

Determining Hose Vapor Quality for Normal Operating Conditions

Vapor quality within the hose degrades over time (due to permeation, air being drawn into the system, time between non-ORVR fueling events, etc.). Also, some ORVR vehicles seem to be returning large quantities of air through the hoses. This is illustrated by the average V/L of 0.5 during ORVR fueling events. However, because ORVR vehicles should not be returning vapor during fueling events, and are likely ingesting some amount of air, observations taken from successive ORVR fueling events present an opportunity to observe the most extreme case of vapor quality degradation within balance GDF hoses.

Staff developed a trends model to evaluate the data. First, the average vapor quality for all non-ORVR fueling events performed during the test was calculated. The average HC concentrations were 36 percent C_3H_8, approximately 81 percent of a saturated vapor. This average HC concentration was used as the initial data point for determining the trend. For the next data point, staff looked at the average vapor quality for ORVR fueling events which directly followed a non-ORVR fueling event and found this average HC concentration to be 19 percent C_3H_8, approximately 43 percent of a saturated vapor. Staff continued this process for the 2nd, 3rd and 4th consecutive ORVR vehicles following a non-ORVR vehicle fueling event. The results of this analysis are an exponential trend shown in Figure 3.

The data shows that vapor quality degrades in a clear and predictable exponential manner. This is demonstrated by the square of the correlation coefficient (R^2) being close to 1 when fitted to an exponential curve (Figure 3). The predictive equation that was generated from these data to model exponential degradation of HC concentration with consecutive ORVR vehicle fueling events is as follows:

$$\textbf{\textit{HC concentration}} = \mathbf{34.45e^{-0.533x}\ \%\ C_3H_8}$$

Where the number of consecutive cars is denoted by x.

Staff did not factor into the analysis data for the 5th consecutive ORVR vehicle due to a small sample size. The exponential equation predicts that HC concentrations should approach zero, with the HC concentration being approximately 0.5 percent C_3H_8 for the 8th consecutive ORVR vehicle. Staff has determined it unrealistic to assume that the model would predict accurate HC concentrations below this point. This is due to uncertainty from potential spills and leaks near the nozzle interface, time between fueling episodes and permeation from the inner hose path into the outer hose path. For emissions modeling purposes, staff assumes the model for HC concentration in the vapor path of the balance GDF hose is valid for eight consecutive ORVR vehicle fueling events. Also, successive ORVR events should be assumed to have an HC concentration of 0.5 percent C_3H_8 (~ 1.1 percent of a saturated vapor).

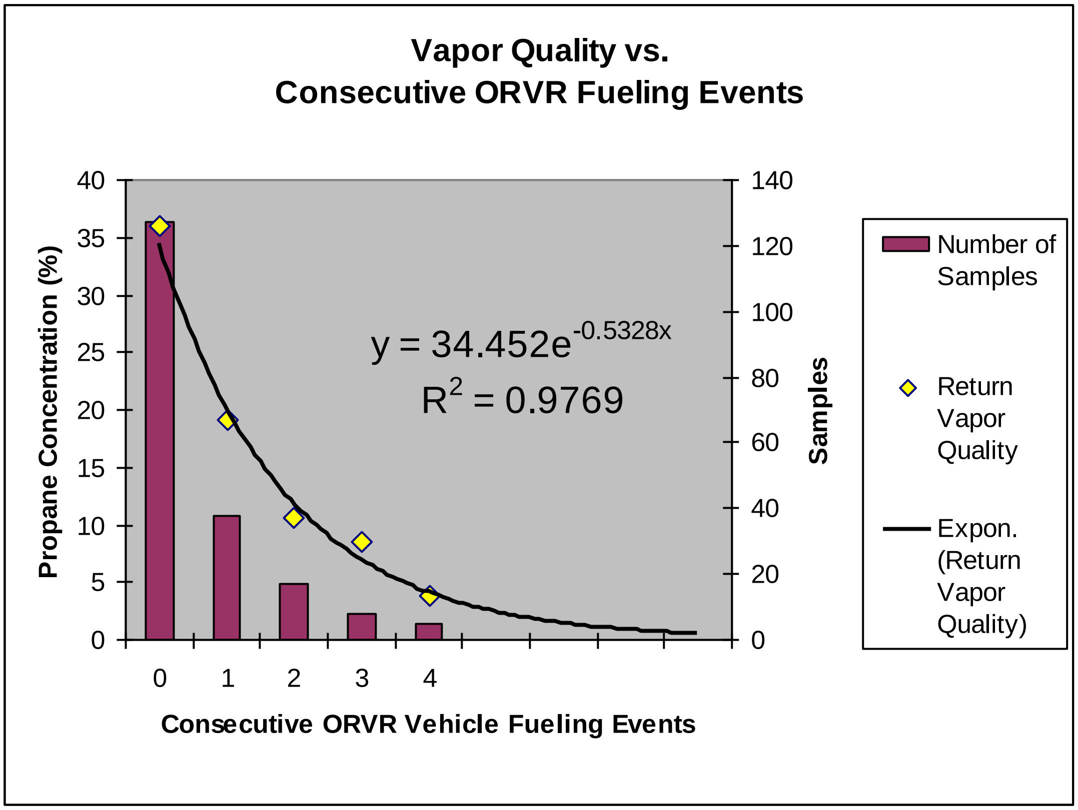


Figure 3 Chart displaying vapor quality degradation with successive ORVR fueling events.

The model to predict HC concentrations for balance GDF hoses requires the population of ORVR vehicles and an estimate of the number of fueling episodes per GDF fueling point per day.

ORVR vehicle populations are increasing yearly to meet federal mandates. Staff's proposal for regulating GDF hose permeation emissions are expected to take effect in 2017. This is the year the ORVR population data will be applied. Staff has completed an analysis of this trend, and predicts that ORVR vehicles will be approximately 90 percent of the 2017 California vehicle population by vehicle miles traveled.[10] Also, based on more than a years worth of data collected from multiple GDF internal system diagnostic logs of fueling events, staff estimates that there are roughly 65 fueling events per fueling point per day at the average GDF.

Given these factors, the equation for modeling HC concentrations may be applied to predict for HC concentrations in balance GDF hoses. The only remaining variable is to determine the proper distribution for ORVR and non-ORVR vehicles over the 65 fueling events per day. Staff approached this by determining the scenarios which would deliver both the highest and lowest HC concentrations, and then taking the average of the two scenarios.

Staff modeled the scenario for the highest average HC concentration (7.6 percent C_3H_8) by distributing the non-ORVR vehicle fueling events evenly through the 65 fueling events of a day. Because non-ORVR vehicles essentially reset the HC concentration curve to its highest value (34.5 percent C_3H_8), this leads to many more ORVR fueling events being near the middle of the HC concentration curve rather than at the bottom. This results to a higher average HC concentration for the day. Staff also modeled the scenario for the lowest average HC concentration (4.5 percent C_3H_8) by stacking the non-ORVR vehicle consecutively within the day. Because this leads to many more ORVR fueling events being at the bottom of the HC concentration curve rather than in the middle, this leads to a lower average HC concentration for the day. From these two scenarios, staff calculated the average balance GDF hose HC concentrations to be approximately 6.1 percent C_3H_8, roughly 13 percent of a saturated vapor. This is demonstrated graphically in Figure 4.

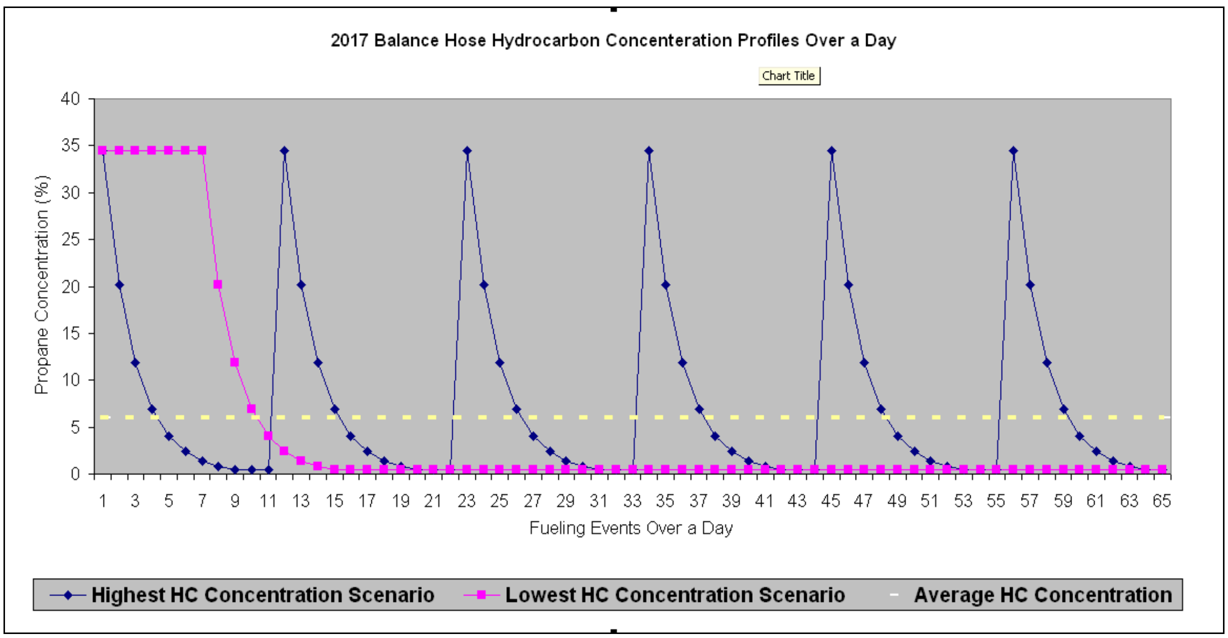


Figure 4 Highest, Lowest, and Average balance hose HC concentration profiles for a day.

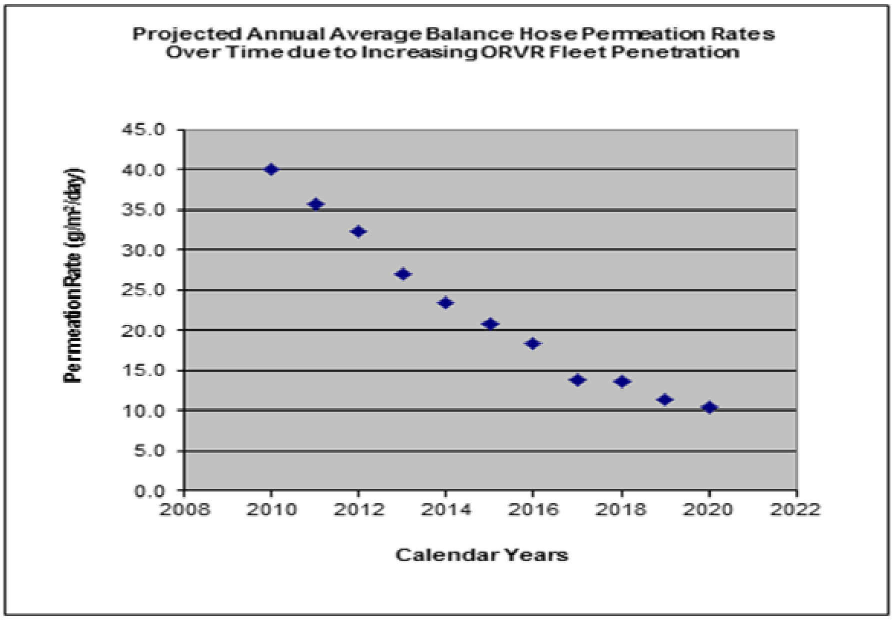
The specific predictions given by the equation to model for HC concentration (percent C_3H_8) are valid for the specific testing conditions at which the 2007 EVR efficiency test was performed. The most important condition is temperature. However, staff assumes that the model will predict the correct distribution with respect to average vapor quality as it relates to percent of a saturated vapor at the given conditions. This is because temperature shifts which affect HC concentrations should proportionately shift the entire distribution. This would likely result in little effect when considering vapor quality as a percent of saturated vapor for a given set of conditions.

Estimating Permeation Rate Given Vapor Quality

As previously discussed, staff has determined through testing that a balance GDF hose containing a saturated vapor has a permeation rate of approximately 104.5 g/m^2/day for an average ambient temperature of 71.0°F (21.7°C) when using California summer time pump fuel. Further, a hose with no vapor in it (having a vapor quality of zero) would permeate at a rate of zero. Given these two data points, and the previously mentioned ARB 2004 test results showing that an intermediate HC concentration that was less than saturated and greater than zero did not produce a permeation rate close to either of the extremes of 104.5 g/m^2/day or zero, it is reasonable to assume that linear interpolation for HC concentrations between the two extremes can be used to approximate the permeation rates within balance GDF hoses. Interpolating the estimate for the 2017 average balance hose vapor concentration of 6.1 percent C_3H_8 (roughly 13 percent of a saturated vapor), predicts a permeation rate for balance GDF hoses of 13.9 g/m^2/day, given an average ambient temperature of 71.0°F (21.7°C) when using California summer time pump fuel.

It is important to note, that 71.0°F is the annual average temperature of gasoline dispensed as demonstrated in a study published by the California Energy Commission.[11] Therefore, 13.9 g/m^2/day is the annual average balance hose permeation rate for 2017.

Similarly, staff performed the previously discussed analysis for the years 2010 through 2020 with the previously discussed assumptions. The corresponding permeation rates are given below in Figure 5. From the trend it is clear that future peramtion rates for balance hoses approach a rate that is somewhere between 0 and 10 g/m^2/day.



Year	*Permeation Rate g/m^2/day*
2010	40.0
2011	35.7
2012	32.3
2013	27.0
2014	23.4
2015	20.8
2016	18.3
2017	13.9
2018	13.6
2019	11.4
2020	10.4

Figure 5 Estimated balance hose annual average permeation rates for 2010 through 2020.

Conclusion

Staff has determined that the 2017 annual average permeation rate for balance GDF hoses will be approximately 13.9 $g/m^2/day$, given an average ambient temperature of 71.0°F (21.7°C) when using California summer time pump fuel. With increasing ORVR populations, the average permeation rate of balance GDF hoses will decrease in years subsequent to 2017 due to decreasing vapor quality within these hoses.

Works Cited

[1] Society of Automotive Engineering. "SAE J1737:Test Procedure to Determine the Hydrocarbon Losses from Fuel Tubes, Hoses, Fittings, and Fuel Line Assemblies by Recirculation," Society of Automotive Engineering Surface Vehicle Recommended Practice, REV. NOV 2004.

[2] Society of Automotive Engineering. "SAE J1527:Marine Fuel Hoses," Society of Automotive Engineering Surface Vehicle Standard, REV. MARCH 2004, pp. 8.

[3] Tuckner, P., Baker, J., "Fuel Permeation Testing using Gravimetric Methods," Society of Automotive Engineering Technical Paper 2000-01-1096, pp. 5.

[4] Nulman, M., Olejnik, A., Samus, M., Fead, E., Rossi, G., "Fuel Permeation Performance of Polymeric Materials," Society of Automotive Engineering Technical Paper 2001-01-1999, sec. IV.

[5] Samulski, Michael J., Characterization and Control of Evaporative Emissions from Fuel Tanks in Non-road Equipment. Society of Automotive Engineering Technical Paper 06SETC-92, pp. 14.

[6] Nulman, M., Olejnik, A., Samus, M., Fead, E., Rossi, G., Fuel Permeation Performance of Polymeric Materials Analyzed by Gas Chromatography and Sorption Techniques. Society of Automotive Engineering Technical Paper 981360, pp. 3.

[7] California Air Resources Board (CARB), GDF Hose Permeation Study Review. 29, Oct. 2007. <http://www.arb.ca.gov/vapor/gdfhe/gdfpermreport07.pdf>.

[8] California Air Resources Board (CARB), Gasoline Dispensing Facility (GDF) Balance Hose Permeation Study. Revised 6, Oct. 2010. <http://www.arb.ca.gov/vapor/gdfhe/balance-rep-final.pdf>

[9] California Air Resources Board (CARB), Source Test Report: Test Number 07-01. 13, March 2007.

[10] California Air Resources Board (CARB), MEMO: Percent of Gasoline Dispensed to Vehicles with ORVR . 14, Dec. 2009. <http://www.arb.ca.gov/vapor/orvr-pen09.pdf>

[11] CEC. (2010). Fuel Delivery Temperature Study. Publication # CEC-600-2009-002-CMF. March 2010. California Energy Commission. <http://www.energy.ca.gov/2010publications/CEC-600-2010-002/CEC-600-2010-002-SF.PDF>

Attachment 1

The table given below is a presentation of the data collected in Source Test Report Number 07-01. It has been truncated to included only data that is relevant to the analysis of balance hose vapor quality. All samples marked Invalid in the matrix number column were excluded from consideration in this study with the exception of sample number 53, which was one of a series of consecutive ORVR vehicle fueling events. Because it was only excluded from the EVR efficiency test on the grounds that it was an extra vehicle, staff felt that its value as part of a consecutive series of ORVR fueling events warranted its inclusion in the data set. Samples marked conv under the vehicle fuel system type column refer to non-ORVR vehicles.

Source Test Report: Test Number 07-01 (Truncated)

Matrix No.	Vehicle Year	Vehicle Fuel System Type	Dispensed Fuel (Gallons)	Vapor Return Line Avg Conc ($\%C_3H_8$)	Vapor Return Line Volume (ft^3)	V / L Ratio	Qual.
February 21, 2007							
1	2006	orvr	11.092	3.337	0.10	0.07	
2	1999	conv	7.406	25.995	1.45	1.46	
3	2004	orvr	6.759	11.576	1.39	1.54	
4	2001	conv	19.200	46.715	2.44	0.95	
5	1971	conv	8.802	38.190	1.68	1.43	
6	1999	orvr	6.759	13.338	1.02	1.13	
7	1999	conv	17.425	35.338	3.13	1.34	
8	2000	orvr	7.249	31.831	0.06	0.06	
9	1989	conv	10.127	39.306	1.70	1.26	
Invalid	1997	conv	3.356	41.943	0.49	1.09	<6 gal
11	2000	orvr	13.571	3.873	2.91	1.60	
12	2003	orvr	7.249	2.132	0.04	0.04	
Invalid	1995	conv	3.625	15.914	1.59	3.28	<6 gal
14	1997	conv	18.700	48.582	2.62	1.05	
15	2000	orvr	7.247	16.695	1.76	1.82	
16	2002	orvr	14.444	2.882	0.67	0.35	
17	1998	conv	6.405	21.158	1.62	1.89	
Invalid	1998	conv	1.812	26.024	0.30	1.24	<6 gal
19	1995	conv	15.728	56.440	2.04	0.97	
20	2005	orvr	13.545	44.789	0.40	0.22	
21	2001	orvr	7.249	10.194	0.34	0.35	
22	2004	orvr	12.239	6.690	0.10	0.06	
23	2007	orvr	14.682	6.880	0.05	0.03	
Invalid	1993	conv	7.249	38.364	2.06	2.13	Leak
25	2005	orvr	20.513	14.633	0.30	0.11	
26	1998	conv	7.930	22.89	2.08	1.96	
27	2002	orvr	7.249	17.810	0.08	0.08	
Invalid	1991	conv	4.349	34.662	0.56	0.96	<6 gal
29	2001	orvr	10.644	24.728	0.04	0.03	

Attachment 1

30	2001	orvr	13.164	17.378	0.15	0.09	
31	1999	conv	14.203	39.971	2.35	1.24	
32	2006	orvr	9.493	30.468	2.24	1.77	
33	2006	orvr	13.474	32.262	0.26	0.14	
34	1997	conv	14.803	39.639	2.56	1.29	
35	2006	orvr	19.056	13.227	2.07	0.81	
36	2003	conv	9.189	8.063	0.42	0.34	
37	2003	orvr	15.631	4.120	5.46	2.61	
38	2005	orvr	6.658	3.163	0.08	0.09	
39	2004	conv	25.582	43.211	4.03	1.18	
40	1996	conv	7.145	51.722	0.98	1.03	
41	1997	conv	11.768	53.849	1.62	1.03	
42	2003	orvr	10.874	26.805	0.06	0.04	
43	2003	orvr	10.087	6.512	3.16	2.34	
44	2005	orvr	17.331	3.209	1.10	0.47	
45	2002	orvr	7.349	2.879	0.77	0.78	
46	2001	orvr	8.945	1.919	0.29	0.24	
47	1990	conv	14.707	42.407	1.44	0.73	
48	2004	orvr	9.518	40.174	0.10	0.08	
49	2004	orvr	11.149	9.254	2.34	1.57	
February 22, 2007							
50	1999	conv	20.618	21.712	7.07	2.57	
51	2005	orvr	18.653	4.112	4.18	1.68	
52	2005	orvr	18.034	3.635	2.84	1.18	
Invalid	2006	orvr	13.427	1.089	0.08	0.04	Extra
54	2006	orvr	14.699	0.982	0.03	0.02	
55	2004	orvr	25.377	35.542	4.60	1.36	
56	2000	conv	11.170	47.868	1.47	0.98	
57	2002	orvr	14.798	12.226	3.02	1.53	
58	2004	orvr	14.188	3.997	0.15	0.08	
59	2005	orvr	15.33	3.557	0.10	0.05	
60	2004	orvr	12.147	2.215	0.07	0.04	
61	2004	orvr	13.382	1.816	0.17	0.10	
Invalid	2005	orvr	7.296	1.591	2.29	2.35	Extra
Invalid	2003	conv	19.573	41.497	2.80	1.07	Extra
64	2000	conv	7.095	37.440	1.20	1.27	
65	1993	conv	20.590	46.936	2.21	0.80	
66	2002	orvr	18.704	21.777	1.37	0.55	
67	1998	conv	15.448	40.065	2.07	1.00	
68	2004	orvr	23.887	33.408	0.14	0.04	
69	1999	conv	11.522	37.460	2.06	1.34	
70	1977	conv	6.852	33.727	1.00	1.09	
71	2003	orvr	15.668	12.611	1.10	0.53	
72	2004	orvr	7.095	5.550	0.22	0.23	
73	2004	orvr	17.476	15.718	0.56	0.24	
74	2003	orvr	14.793	5.767	0.40	0.20	
75	2005	orvr	14.188	4.107	1.42	0.75	
76	1997	conv	7.095	31.714	1.21	1.28	
77	2001	orvr	10.09	25.521	0.52	0.39	
78	2000	conv	8.072	32.368	1.28	1.19	
79	2002	conv	7.518	31.649	0.19	0.19	

Attachment 1

80	1988	conv	13.520	28.677	3.29	1.82	
81	2002	orvr	16.409	29.273	0.09	0.04	
82	1994	conv	16.103	42.830	2.41	1.12	
Invalid	2005	orvr	13.946	42.301	0.01	0.01	Extra
Invalid	2001	conv	10.909	47.942	1.48	1.01	Extra
85	1998	conv	11.791	53.362	1.57	1.00	
86	1988	conv	10.253	54.102	1.37	1.00	
87	1996	conv	7.095	32.015	1.16	1.22	
88	2000	orvr	7.095	25.121	0.12	0.13	
89	2004	orvr	17.108	18.840	0.25	0.11	
90	1998	orvr	13.469	14.759	0.02	0.01	
91	1998	conv	18.065	44.237	2.72	1.13	
92	1999	conv	12.781	56.196	1.24	0.73	
93	1996	conv	7.095	52.352	1.18	1.24	
94	1991	conv	7.095	49.566	0.26	0.27	
95	1992	conv	9.261	49.870	1.41	1.14	
96	2007	orvr	25.463	16.491	2.10	0.62	
97	2000	conv	16.341	43.606	2.04	0.93	
98	1990	conv	15.914	20.334	6.92	3.25	
Invalid	1994	conv	15.61	43.642	1.95	0.93	Leak
100	1999	conv	10.735	47.133	0.06	0.04	
February 23, 2007							
Invalid	2001	orvr	7.424	0.8	0.06	0.06	Shutoffs
102	2003	orvr	9.688	0.78	0.03	0.02	
103	2000	conv	9.461	22.64	2.20	1.74	
104	1992	conv	6.625	35.8	1.21	1.37	
105	1999	conv	17.422	36.9	3.25	1.40	
Invalid	2004	orvr	20.654	16.5	0.88	0.32	Extra
107	2001	conv	19.962	45.1	2.47	0.93	
108	1999	conv	9.372	33.8	2.39	1.91	
109	1998	orvr	14.590	3.6	0.81	0.42	
110	2000	orvr	8.884	2.8	0.26	0.22	
111	2003	orvr	17.203	11.2	0.26	0.11	
112	2000	conv	15.857	40.4	2.31	1.09	
113	1995	conv	10.641	31.9	1.85	1.30	
Invalid	1990	conv	3.548	32.0	0.58	1.22	<6 gal
115	1999	orvr	14.517	28.6	0.51	0.26	
116	1986	conv	7.095	36.1	1.13	1.19	
117	1988	conv	7.095	48.7	0.96	1.01	
118	1998	conv	7.095	44.0	1.04	1.10	
119	1996	conv	7.095	35.3	1.27	1.34	
120	1992	conv	12.367	49.7	1.66	1.00	
121	1991	conv	15.250	45.1	2.45	1.20	
122	1987	conv	7.095	43.3	1.03	1.09	
Invalid	1997	conv	13.199	38.6	2.55	1.45	Extra
124	1995	conv	6.008	39.0	1.05	1.31	
Invalid	2003	orvr	13.788	22.7	0.08	0.04	Extra
126	1990	conv	7.095	35.0	1.36	1.43	
127	2001	orvr	7.095	30.2	0.17	0.18	
Invalid	1996	conv	7.095	28.5	2.43	2.56	Leak
129	1997	conv	16.962	29.5	4.28	1.89	

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Invalid	2002	orvr	15.075	NA	NA	NA	Lost Data
131	1999	conv	7.095	40.568	1.08	1.14	
132	1987	conv	7.095	45.067	1.17	1.23	
133	2006	orvr	6.834	25.045	0.46	0.50	
134	1975	conv	7.095	16.824	2.92	3.08	
135	1988	conv	12.751	40.309	1.92	1.13	
Invalid	2001	orvr	5.321	26.384	0.12	0.17	<6 gal
Invalid	1973	conv	4.257	42.221	0.78	1.37	< 6 gal
138	1992	conv	13.911	38.012	2.57	1.38	
139	2005	orvr	12.245	37.471	0.40	0.24	
140	2002	orvr	8.432	27.120	0.33	0.29	
141	1998	conv	14.747	39.858	2.33	1.18	
142	1992	conv	7.668	45.335	1.15	1.12	
143	1994	conv	8.868	32.619	2.69	2.27	
144	1987	conv	7.095	41.647	1.13	1.19	
145	2005	orvr	24.345	36.764	0.53	0.16	
146	2006	orvr	20.546	24.864	0.27	0.10	
147	2002	orvr	7.095	12.374	0.11	0.12	
148	1989	conv	13.746	29.697	3.19	1.74	
Invalid	1998	conv	20.636	46.059	3.15	1.14	Extra
150	1988	conv	7.095	41.058	1.34	1.41	
151	1991	conv	7.095	35.375	1.50	1.58	
152	1988	conv	7.095	43.286	0.80	0.84	
153	1986	conv	7.095	44.272	1.56	1.64	
154	1994	conv	16.152	30.534	4.22	1.95	
155	2000	conv	15.954	45.704	2.04	0.96	
Invalid	1995	conv	11.408	NA	NA	NA	Lost Data
157	1987	conv	7.095	46.559	1.05	1.11	
158	1995	conv	7.095	39.499	1.05	1.11	
159	1995	conv	9.664	41.562	1.54	1.19	
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160	1993	conv	7.054	18.408	2.33	2.47	
161	1996	conv	11.503	20.735	4.21	2.74	
162	1999	orvr	6.581	3.309	1.93	2.19	
163	2001	orvr	14.244	2.368	0.01	0.01	
164	1965	conv	7.045	22.145	1.81	1.92	
165	1965	conv	7.045	36.259	1.18	1.25	
166	1993	conv	7.045	43.976	1.19	1.26	
167	1998	conv	6.284	36.456	0.83	0.99	
168	1999	conv	16.163	25.940	4.02	1.86	
169	1984	conv	7.045	33.262	1.35	1.43	
170	1992	conv	7.045	14.595	4.99	5.30	
171	1989	conv	7.045	29.836	1.27	1.35	
172	1999	conv	9.059	23.257	3.38	2.79	
173	1970	conv	6.581	31.462	1.20	1.36	
174	1984	conv	7.045	39.933	1.10	1.17	
175	2006	orvr	7.045	20.046	0.87	0.92	
Invalid	1988	conv	5.243	22.742	1.26	1.80	<6 gal
177	2002	orvr	11.363	12.819	0.08	0.05	
178	1989	conv	7.045	34.497	0.97	1.03	
179	1999	conv	7.045	33.613	0.27	0.29	

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180	1990	conv	7.045	43.111	0.87	0.92	
181	1994	conv	20.559	51.838	2.68	0.98	
182	1986	conv	13.162	41.673	3.40	1.93	
183	1994	conv	14.269	33.909	1.74	0.91	
184	1999	conv	21.134	49.217	2.88	1.02	
185	1995	conv	10.567	50.557	1.17	0.83	
186	1977	conv	6.581	29.476	2.14	2.43	
187	1990	conv	7.045	34.164	1.22	1.30	
188	1998	conv	16.573	47.016	2.23	1.01	
189	1989	conv	7.045	32.984	1.59	1.69	
Invalid	1998	conv	11.769	40.435	2.13	1.35	Extra
191	1995	conv	7.045	41.723	1.16	1.23	
192	2002	orvr	7.045	20.969	0.06	0.06	
193	2000	orvr	7.045	NA	NA	NA	
194	2001	conv	7.045	39.690	1.06	1.13	
Invalid	1991	conv	6.662	21.563	2.17	2.44	Extra
196	1991	conv	7.045	38.334	1.18	1.25	
Invalid	1978	conv	6.581	39.623	1.66	1.89	Spitback
198	1987	conv	7.045	42.335	1.10	1.17	
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199	1994	conv	7.045	19.849	1.99	2.11	
200	1994	conv	7.045	27.527	1.29	1.37	
201	1994	conv	7.045	31.946	1.08	1.15	
202	2001	conv	8.806	23.936	2.37	2.01	
203	1990	conv	10.592	34.007	1.62	1.14	
Invalid	1994	conv	4.271	36.733	0.52	0.91	<6 gal
205	2000	orvr	13.354	9.829	1.79	1.00	
206	1994	conv	7.045	30.412	1.30	1.38	
207	1986	conv	6.578	15.568	2.09	2.38	
208	1989	conv	7.045	34.386	0.97	1.03	
209	1988	conv	6.581	45.127	0.82	0.93	
210	2002	conv	7.045	44.236	1.07	1.14	
211	1994	conv	6.805	32.684	1.99	2.19	
212	1989	conv	7.045	20.608	2.65	2.81	
213	1989	conv	7.045	19.540	2.60	2.76	
214	2000	orvr	10.95	7.514	0.03	0.02	
215	1989	conv	7.045	20.194	2.84	3.02	
216	1989	conv	7.045	22.242	2.30	2.44	
217	2002	conv	7.045	31.664	1.72	1.83	
Invalid	2001	conv	6.805	30.257	1.50	1.65	Extra
219	1989	conv	6.085	6.244	0.04	0.05	
220	2000	orvr	7.045	7.676	0.06	0.06	
221	1986	conv	16.466	18.323	6.54	2.97	
222	1989	conv	7.045	20.742	3.11	3.30	
223	1987	conv	6.021	23.242	0.81	1.01	
224	1987	conv	7.045	45.274	0.89	0.95	
225	1987	conv	7.045	39.596	1.45	1.54	
226	1999	orvr	6.581	6.930	0.03	0.03	
227	1999	orvr	7.045	8.466	0.02	0.02	
228	1989	conv	13.527	4.628	2.45	1.35	