Appendix E:

Statewide Emission Reductions Anticipated from the Proposed Amendments to the Fill Pipe Specifications

The purpose of this document is to explain the methodology, assumptions, and calculations used to estimate statewide emission reductions anticipated from the proposed amendments to the Fill Pipe Specifications. The proposal is intended to minimize air leakage from vented fill pipes by adopting a performance leak standard and decrease the vapor/liquid (V/L) ratio at California gasoline stations. A decrease in the V/L ratio means a reduction in pressure-driven emissions caused by the evaporation of gasoline within the GDF storage tank headspace and overpressure. To estimate emissions and emission benefits, this document provides the assumptions used in the analysis.

I.   INTRODUCTION

As stated in the staff report, California gasoline stations with assist type nozzles lead to a misidentification of On-board Refueling Vapor Recovery (ORVR) vehicles when they do not form a good seal with the vapor recovery nozzle. If the vehicle is not identified as an ORVR vehicle, the vapor recovery nozzle ingests outside air rather than gasoline vapor, leading to overpressure in the underground storage tank (UST). In order to decrease overpressure and the number of overpressure alarms, the V/L ratios at gas stations need to be lowered to acceptable levels.

The V/L ratio is defined as the volume of vapor (when refueling non-ORVR-equipped vehicles) or the volume of air (when refueling ORVR-equipped vehicles) returned to the GDF storage tank divided by the volume of gasoline dispensed from the nozzle. Upon refueling of non-ORVR-equipped vehicles, a V/L ratio of about one (1.0) is desired. For every gallon of gasoline dispensed, a gallon of vapor is displaced from the vehicle tank and is returned to the GDF storage tank. Upon refueling of ORVR-equipped vehicles, a V/L ratio of approximately 0.5 or less is desired because the ORVR systems capture at least 95 percent of the displaced gasoline vapors into a carbon canister within the vehicle. With ORVR-equipped vehicles, there is very little vapor available for collection at the nozzle and fill pipe interface. Because of this, the volume of air returned to the storage tank relative to the volume of gasoline dispensed must be reduced to suppress vapor growth and pressure-driven emissions caused by excess air ingestion.

As mentioned in the staff report, staff identified three types of fill pipes that lead to high V/L at gasoline stations. The first is the vented fill pipe, which the Fill Pipe Specification proposal addresses via the performance leak standard.   The second is locking lip depth causing a loose latch, which both this proposal and the nozzle proposal address. The third is the bayonet style fill pipe, which does not form a good seal. Overall, the goal of the proposal is to reduce overpressure, which in turn leads to a reduction in V/L ratio at gasoline stations and reduced pressure-driven emissions.

II.   OVERPRESSURE AND ITS RELATION TO THE V/L RATIO

Because UST emissions can vary on a daily basis, staff used the assumptions outlined below to determine the target V/L ratio. The ratio is based on vapor concentrations evident in the winter, when the problem occurs.

- First, all air that enters the system will cause the evaporation of liquid gasoline until a vapor-liquid equilibrium is present in the system. Pressure-driven emissions will occur if the volume of air entering the system during ORVR fueling events produces a volume of hydrocarbon-saturated air that is greater than the liquid volume dispensed. In reality, some fraction of the air that enters the system can be subsequently removed before it is fully saturated with gasoline vapor. This could occur during Phase I fuel deliveries and through vent valves and fugitive leaks that occur when the tank is at positive pressure. Therefore, the assumption may produce an unquantifiable positive bias in the emission estimates.
- Second, the only source of air entering the system is through the Phase II nozzles. In reality, air can enter the system through vent valves and fugitive leaks sources. Therefore, the second assumption may produce an unquantifiable negative bias in the emission estimates.

Since pressure-driven emissions only occur when the system is not at equilibrium, or when the volume of air entering the system produces a volume of hydrocarbon saturated air that is greater than the liquid volume dispensed during refueling, the aim is to reach equilibrium. To ensure neutral pressure, the following assumptions were made to determine the target V/L using fuel RVP and temperature data from two ARB overpressure study sites. The data is for winter season gasoline present at the study sites between November 2009 and March 2011.[1]

Table 1: Assumptions used to determine V/L in the winter

V/L for Maximum Vapor Concentration	V/L for Average Vapor Concentration
45.9% by volume	41.5% by volume
1.848 gallons of saturated gasoline vapor per gallon air ingested when a gallon of gasoline is dispensed[a]	1.709 gallons saturated gasoline vapor per gallon air ingested when a gallon of gasoline is dispensed[b]

[a.] *At a concentration of 45.9% by volume, one volume of gasoline vapor contains 0.459 volumes of hydrocarbon and 1-0.459 =0.541 volumes of air. So the air concentration in the saturated mixture would have be 54.1 %.*
This is expressed by: (1 gallon $_{vapor}$/ 0.541 gal $_{air}$) = 1.848 gallon $_{vapor}$ / gal $_{air}$
[b.] *1.709 yielded using a similar calculation as used to calculate 1.848 in note* [a], *except using 41.5% as* concentration.

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[1] CARB. 2017. Gasoline Sampling and Analysis to Investigate the Effect of Reid Vapor Pressure on Vapor Recovery System Overpressure, Report Number VR-OP-G1. Overpressure Study Technical Support Document prepared by staff of the Vapor Recovery and Fuel Transfer Branch, Monitoring and Laboratory Division, California Air Resources Board (CARB). December 1, 2017. (Reid Vapor Pressure Study) Available at: https://www.arb.ca.gov/vapor/op/studies/gdf/vropg1.pdf

For the purpose of this analysis, a system is defined to be at equilibrium when one gallon of gasoline dispensed is replaced by one gallon of saturated vapor. Using the assumptions for maximum and average vapor concentration in Table 1, staff used the equation below to solve for a target V/L.

For illustrative purposes, the equation for V/L threshold at maximum vapor concentration in the underground storage tank is illustrated by the following:

$$\left(\frac{x_{air\ ingested}}{gal_{fuel\ dispensed}}\right) \times \frac{1.848\ gal_{vapor}}{gal_{air\ ingested}} = 1.0\ \frac{gal_{vapor}}{gal_{gas\ dispensed}}$$
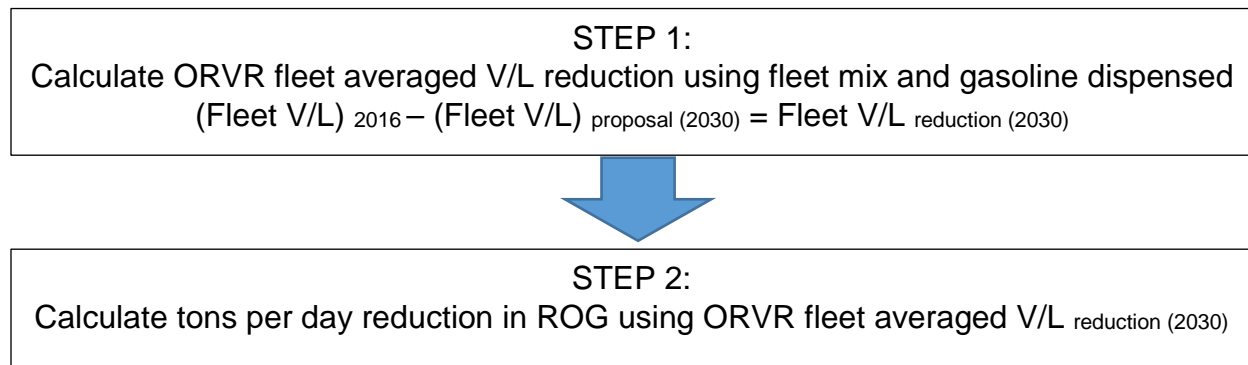
$$x_{air\ ingested} = 0.54$$

At equilibrium, the V/L threshold at maximum vapor concentration is 0.54. At average vapor concentration, using the assumptions in Table 1, the threshold at average vapor concentration is 0.59.

These two values represent the target V/L ratios that provide the maximum emission benefit for a vehicle fleet and represents the equilibrium value. Lowering the V/L ratio beyond these values may not result in any emission benefits.

III.   EMISSION REDUCTIONS FOR THE VEHICLE FILL PIPE PROPOSAL

The assumptions used to calculate emissions are described in two steps in this chapter. Staff calculated the emission estimates with and without vented fill pipes in California based on the California fleet in 2016 and 2030.

To estimate the emission reduction associated with mitigating air leakage at vented fill pipes, CARB staff followed the following steps:

STEP 1:
Calculate ORVR fleet averaged V/L reduction using fleet mix and gasoline dispensed
(Fleet V/L) 2016 – (Fleet V/L) proposal (2030) = Fleet V/L reduction (2030)

STEP 2:
Calculate tons per day reduction in ROG using ORVR fleet averaged V/L reduction (2030)

These steps and their associated assumptions and equations are described in detail in the sections below.

III.A: STEP 1: Calculate ORVR Fleet Averaged V/L ratio reduction using fleet sales mix and gasoline dispensed to the California Fleet

To calculate the ORVR fleet averaged V/L ratio for vented fill pipes in 2016 and 2030, staff used the proportion of gasoline dispensed to vehicles with vented fill pipes and ORVR vehicles with good identification rates. Staff used gasoline dispensed to calculate a weighted ORVR fleet averaged V/L value for the baseline and proposal.

Fleet Sales mix:
To account for attrition and the introduction of new vehicles, staff used EMFAC 2017 to determine the number of vehicles in the California fleet equipped with vented capless fillpipes. This information was also used to estimate ORVR fleet averaged V/L ratios for 2016 and 2030. The assumptions used for sales mix are as follows:

- *Number of Vehicles in the California fleet in 2016 and 2030 with vented fill pipes* - Vented capless fill pipes were first introduced in model year (MY) 2008 vehicles. Based on sales information from certification, and the observed percentage of vehicles with capless fill pipes in CARB's ORVR Recognition Study,[2] staff estimates the number of vented capless fill pipes to be 3% of the total vehicle fleet in calendar year (CY) 2016. From 2008 to 2016, the percentage of new vehicles equipped with vented capless fill pipes grew linearly from 2% (2008) to 10% (2016). This resulted in a 3% overall fleet number in calendar year 2016. Staff assumed this percentage of vented fill pipes would remain at 3% of the total vehicle fleet for CY 2017 without the proposal. Based on discussions with manufacturers, this is a conservative assumption since this type of fill pipe is expected to increase in numbers.

- *Number of vehicles in California fleet in 2016 and 2030 that meet the performance leak standard* - Staff assumed manufacturers would not introduce any additional new vehicles with vented capless fill pipes starting with the 2017 MY. This is earlier than the full phase in of the regulation, but staff believe this is accurate because manufacturers and suppliers worked recently with CARB to change their fill pipes.

ORVR Fleet Averaged V/L ratio:
ORVR Fleet Averaged V/L ratios for vehicles with good ORVR recognition (0.44) and vehicles with vented ORVR (1.2) are from CARB's ORVR Recognition Study.[3] Also

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[2] CARB. 2017. Healy Model 900 Assist Vapor Recovery Nozzle ORVR Vehicle Recognition Study, Report Number VR-OP-A3. Overpressure Study Technical Support Document prepared by staff of the Vapor Recovery and Fuel Transfer Branch, Monitoring and Laboratory Division, California Air Resources Board (CARB). November 29, 2017. (ORVR Recognition Study) Available at:
https://www.arb.ca.gov/vapor/op/studies/assist/vropa3.pdf
[3] CARB 2017 Healy Model 900: Same reference in Footnote 2 above

included in the overall ORVR fleet averaged V/L ratios are V/L values assigned to vehicles with other fill pipe types known to influence V/L. Table S1 at the end of this appendix contains these V/L values used for each vehicle fill pipe type and the calculation.

The ORVR fleet averaged V/L reduction attributed to the clarification of the Fill Pipe Specifications and the proposal at years 2030 is summarized in Table 2. An example calculation of the fleet averaged V/L for 2030 Baseline Condition is shown in Table S2 at the end of this appendix.

Table 2: ORVR fleet averaged V/L ratio in 2030

	ORVR Fleet Averaged V/L in 2030
Baseline	0.62
Proposal	0.58
Reduction	0.04

The proposal to minimize air leakage in vented fill pipes reduces the V/L ratio by 0.04 in 2030. It also brings the V/L ratio to 0.58, which is below the target V/L ratio of 0.59 for average vapor concentration.

III.B: STEP 2: Mass emissions reductions based on reduction in ORVR Fleet Averaged V/L ratio

To calculate the emissions benefit in tons per day from the reduction in V/L, staff used the daily volume of gasoline dispensed through pressure while dispensing assist sites and calculated the amount of hydrocarbon (HC) in the vapor using maximum and average vapor concentration values. The assumptions made in this analysis are based on data from CARB MLD studies.

Daily volume of gasoline dispensed through PWD Assist Sites

Minimizing air leakage in vented fill pipes may help all gasoline stations with overpressure problems. However, only gasoline stations with assist nozzles are included when estimating emissions, since this proposal only impacts those sites. The emission reductions are also only estimated for assist vapor recovery systems that show positive pressure while dispensing fuel.

Daily Volume of gasoline dispensed through PWD Assist Sites:

$$\frac{(Gasoline_{Consumption\ in\ CA}) \times (Gasoline_{Dispensed\ to\ ORVR\ vehicles}) \times (\%\ Assist\ GDFs) \times (\%\ PWD)}{(\#\ of\ Days)}$$

Where:

Gasoline Consumption (x 1,000 gallons) = 15.491 billion gallons.[4]
Gasoline Dispensed to ORVR Vehicles = 0.81 or 81% in 2016[5]
% Assist GDFs = 0.52 or 51%.[6]
% PWD = 0.34 or 34%.[7]
# of Days = 365. Total number of days in a year

$$\frac{15.491\ billion \times 81\% \times 52\% \times 34\%}{365} = 6.0779\ million\ gallons\ per\ day$$

Calculate mass emissions per gallon of excess air ingested

To estimate mass emission reductions staff used the same assumptions about ingested air defined in Table 1.

Using this information, the mass emissions per gallon of excess air is estimated using the following equation:

$$\frac{(\frac{Gallon_{HC}}{Gallon_{vapor}}) \times (\frac{Gallon_{vapor}}{Gallon_{air\ ingested}})}{gallons\ per\ ft^3} \times (\frac{lbs/lbmol}{ft^3/lbmol})$$

Where: Maximum/average concentration is 0.459/0.415[8]
Maximum/average gallons of vapor emitted per gallon air ingested is 0.85/0.709[9]

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[4] Gasoline throughput according to the following California Retail Fuel Outlet Annual Reports:

CEC. 2017. 2016 California Annual Retail Fuel Outlet Report Results (CEC-A15). Microsoft Excel file dated October 10, 2017, downloaded from California Energy Commission (CEC) website accessed on April 24, 2018: http://www.energy.ca.gov/almanac/transportation_data/gasoline/piira_retail_survey.html

CEC. 2018. California Retail Fuel Outlet Annual Reporting (CEC-A15) Results for 2016. California Energy Commission (CEC) website accessed on April 24, 2018: http://www.energy.ca.gov/almanac/transportation_data/gasoline/piira_retail_survey.html

[5] Figure 1 in ISOR
[6] Percentage of GDFs equipped with the Healy Assist Phase II VRS in California. Table 2 of the ISOR
[7] Percentage of GDFs equipped with the Healy Assist Phase VRS in California that exhibited PWD during the ORVR Recognition Study [CARB, 2017a].

[8] Table 1 of this document
[9] These values are obtained by subtracting 1 from the values in Table 1, above, for gallons of saturated gasoline vapor per gallon of air. These values are indicative of how much vapor is in excess in one gallon of air ingested.

7.481 gallons per cubic foot[10]
67.4 lbs per lbmol for the average gasoline vapor molecule
385 cubic feet per lbmol of ideal gasoline at standard temperature and pressure

<u>Maximum</u> mass emissions per gallon of excess air ingested:

$$\frac{(0.459) \times (0.85)}{7.481} \times \frac{67.4}{385} = 0.00913 \; lb/gal \; excess \; air$$

<u>Average</u> mass emissions per gallon of excess air ingested:

$$\frac{(0.415) \times (0.709)}{7.481} \times \frac{67.4}{385} = 0.00689 \; lb/gal \; excess \; air$$

<u>Daily emission Reduction in tons/day for 2030:</u>

The final step is to take the ORVR Fleet Averaged V/L reduction from Step 1, the total amount of gasoline dispensed at PWD Assist gasoline stations, and the mass emissions for maximum and average saturated vapor pressures to calculate emissions in tons per day.

The following formula is used:

$$tons \; per \; day = \frac{(gasoline \; dispensed) \times (fleet \; (V/L) \; reduction) \times (saturated \; vapor \; concentration)}{2000 \; lb/ton}$$

Where:

Gasoline dispensed	=	6.0779 million
ORVR Fleet Averaged V/L reduction	=	0.03[11]
Saturated vapor concentration	=	0.00689 (average)
Saturated vapor concentration	=	0.00913 (maximum)

The estimated daily emission reductions for calendar year 2030 that result from reducing the V/L ratio by 0.04 are summarized in the following table.

Saturated vapor concentration	Emissions Reduction in CY 2030 (tons/day)
Average	0.63
Maximum	1.03

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[10] Conversion factor
[11] *Although the V/L is dropped by 0.04, only 0.03 of that drop is above the threshold of 0.59 and results in emission reductions. Consequently, there is no difference in the emission reduction for the proposed performance leak test, and the combined performance leak test and nozzle proposals.*

On a day with an average saturated vapor concentration, the proposal to minimize air leakage in vented fill pipes by adopting a performance leak standard would result in an emissions reduction up to 0.63 tons per day of reactive organic gases (ROG), which also contain benzene. At the maximum saturated vapor concentration, the proposal would result in an emissions reduction of 1.03 tons per day of ROG.

IV. EMISSION REDUCTIONS ESTIMATED FOR IMPLEMENTATION OF IMPROVED ASSIST NOZZLE

In a parallel rulemaking, CARB's Monitoring and Laboratory Division (MLD) staff is proposing amendments for nozzle spout assembly dimensions to improve the compatibility and seal performance at the vehicle fill pipe and nozzle interface.[12] CARB staff predicts that emission reductions will result from the statewide implementation of the vacuum assist nozzle with the "Enhanced ORVR-Vehicle Recognition" spout assembly (EOR nozzle) because the newly improved EOR nozzle enables a better seal between the nozzle's vapor collection bellows and ORVR vehicle fill pipe, thereby reducing excess air ingestion at assist system equipped GDFs. As noted in Table S2, ARB staff estimated the ORVR fleet averaged V/L at 0.62 gallons of air returned from ORVR vehicles per gallon of fuel dispensed for the year 2030. This estimate does not include potential emission reductions associated with implementation of the EOR nozzle at GDFs with Phase II enhanced vapor recovery systems (assist system).

As a first step for generating an estimate of potential emission reductions associated with the MLD EOR nozzle proposal, ARB staff compared ORVR vehicle fueling event V/L data available for a single retail gas station collected before (2015) and after (2016) EOR nozzle installation.[13] The comparison indicates installation of the EOR nozzle resulted in a statistically significant ($p < 0.05$) reduction of 24 percent in average V/L for the "loose latch bad"[14] ORVR vehicle fill pipe category as described in Table S1. The comparison indicates no statistically significant reduction in average V/L for the other vehicle fill pipe categories. ARB staff applied the 24 percent reduction to the "Categ V/L" in Table S1 for the "loose latch bad" category, which reduces the "loose latch bad" category V/L from 1.13 to 0.86, which in turns reduces the ORVR fleet averaged V/L from 0.62 to 0.57 (an 8 percent reduction).

Dropping the ORVR fleet average V/L from 0.62 to 0.57 will eliminate 0.05 gallons of excess air for each gallon of fuel dispensed. At the winter average vapor concentration

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[12] CARB. 2018a. Initial Statement of Reasons for Rulemaking: Proposed Certification Procedure Amendments for Gas Station Nozzle Spout Dimensions to Help Address Storage Tank Overpressure.
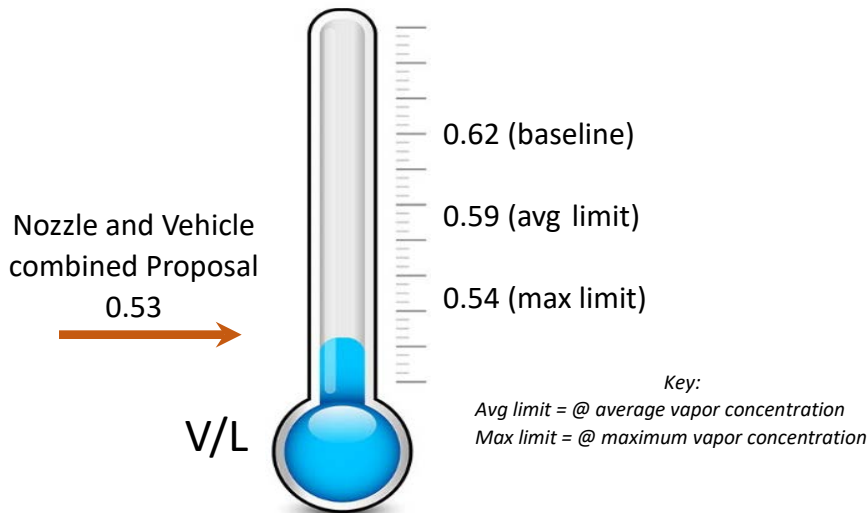
[13] CARB. 2018b. Comparison of Vehicle Fueling Event V/L Ratios at a Gas Station Before and After EOR Nozzle Installation. Data and calculation spreadsheets prepared by staff of the Vapor Recovery and Fuel Transfer Branch, Monitoring and Laboratory Division, California Air Resources Board (CARB). July 2018.

[14] "Loose latch bad" are all vehicles with a locking lip depth of 10 mm or more and/or a fill pipe outer diameter over 57.5 mm from four major auto manufacturers from model year 2016 or 2017, which staff believes are representative of the entire vehicle fleet.

of 41.5%, the above estimates predict that this 0.05 drop in V/L ratio will be enough to drop below the previously explained 0.59 V/L threshold and ensure neutral pressure within the GDF storage tank. On days when the vapor concentration is greater than the average concentration, excess air from the dispensing nozzles may still cause over pressure emissions.

However, as described earlier, ARB staff estimated the proposed fill pipe amendments would eliminate excess air that currently results from vented capless fill pipe and would drop the ORVR fleet averaged V/L by 0.04 gallons of excess air for each gallon of fuel dispensed. The combined performance leak test and EOR nozzle implementation are expected to eliminate 0.09 gallons of excess air for each gallon of fuel dispensed and drop the ORVR fleet averaged V/L from 0.62 to 0.53. Such a reduction would be enough to drop the V/L ratio below the V/L thresholds needed to ensure neutral pressure on days with winter average and winter highest observed vapor concentrations, 0.59 and 0.54, respectively, as shown in Figure 2. Consequently, these estimates indicate that the combined performance leak test and EOR nozzle implementation will greatly reduce over pressure emissions that result from incompatibilities at the interface between the nozzle and fill pipe.

Figure 2: V/L reductions from proposed nozzle and vehicle changes combine to reach V/L threshold for maximum improvement

Nozzle and Vehicle combined Proposal 0.53

0.62 (baseline)

0.59 (avg limit)

0.54 (max limit)

V/L

Key:
Avg limit = @ average vapor concentration
Max limit = @ maximum vapor concentration

At the average winter time saturated vapor concentration (0.00689), the daily emission reduction (tons/day) for year 2030 that results from dropping the V/L by 0.09 for the combined performance leak test and EOR nozzle implementation, is estimated as:

$$tons\ per\ day = \frac{(gasoline\ dispensed) \times (fleet\ (V/L)\ reduction) \times (saturated\ vapor\ concentration)}{2000\ \text{lb/ton}}$$

Where: Gasoline dispensed = 6.0779 million
ORVR Fleet Averaged V/L reduction = 0.03[15] and 0.08[16]
Saturated vapor concentration = 0.00689 (average)
Saturated vapor concentration = 0.00913 (maximum)

The estimated daily emission reductions for calendar year 2030 that result from reducing the V/L ratio by 0.09 are summarized in the following table.

Saturated vapor concentration	Emissions Reduction in CY 2030 (tons/day)
Average	0.63
Maximum	2.2

Note, the method this ISOR appendix uses to estimate emission reductions associated with EOR nozzle implementation is based on a comparison of ORVR vehicle fueling event V/L data collected from a single retail gas station before (2015) and after (2016) EOR nozzle installation; it assumes EOR nozzle performance will be repeatable for different sites and over time. In addition, this method is different from that described in the parallel rulemaking ISOR for proposed nozzle dimensions.[17] The calculation method described in this appendix focuses only on the excess air potentially generated due to incompatibilities at the nozzle and vehicle fill pipe interface. In contrast, the nozzle spout assembly dimensions ISOR method is based on field studies that encompass additional potential sources of excess air, including, but not limited to, leaks in storage tank vent lines, dispenser vapor return piping, whip hoses, vapor processor, and excess air at the nozzle/fill pipe interface that results from variations in customer behavior. Consequently, the nozzle spout assembly dimensions ISOR method results in emission baseline and reduction estimates that are greater than those produced by the method described in this appendix and are not directly comparable.

Other scenarios previously considered included changing existing fill pipe dimensions. But since the proposed change of the performance test combined with the improved

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[15] *Although the V/L is dropped by 0.09, only 0.03 of that drop is above the threshold of 0.59 and results in emission reductions. Consequently, there is no difference in the emission reduction for the proposed performance leak test, and the combined performance leak test and nozzle proposals.*
[16] *Although the V/L is dropped by 0.09, only 0.08 of that drop is above the threshold of 0.54 and results in emission reductions. The proposed performance leak test alone results in a 0.04 reduction that is entirely above the threshold. Consequently, there is a greater emission reduction for the combined performance leak test and nozzle proposals compared to the emission reduction estimated for the proposed performance leak test alone (1.11 tons per day winter), for days with high vapor concentrations.*
[17] CARB. 2018a. Initial Statement of Reasons for Rulemaking: Proposed Certification Procedure Amendments for Gas Station Nozzle Spout Dimensions to Help Address Storage Tank Overpressure.

assist style nozzle are projected to combine to bring the average V/L just below the threshold of emission reductions, further improvements now are not expected to yield additional reduction in emissions. Instead, the proposed fill pipe dimensional changes shall apply when a manufacturer undergoes its own design change in model year 2024 and beyond in order to ensure future compatibility and preserve these emission reductions. Therefore, staff believes the proposal contains the most effective and feasible combination to achieve the desired result of reducing overpressure emissions at California's gas stations.

V.   CONCLUSION

The combined performance leak test and EOR nozzle implementation would eliminate 0.09 gallons of excess air for each gallon of fuel dispensed and drop the ORVR fleet averaged V/L from 0.62 to 0.53. Such a reduction would be enough to drop the V/L ratio below the V/L thresholds needed to ensure neutral pressure on days with winter average and winter highest observed vapor concentrations, 0.59 and 0.54, respectively. Consequently, these estimates indicate that the combined performance leak test and EOR nozzle implementation may eliminate over pressure emissions that result from incompatibilities at the interface between the nozzle and fill pipe, without any additional fill pipe changes.

On any winter day, the emission reductions projected for year 2030 may vary depending on saturated vapor concentration from 0 to 2.22 tons per day with an average value of 0.63 tons per day under the staff proposal.

Supporting Tables (referenced earlier in this appendix):

Table S1: V/L by Vehicle Category and Supporting Information

Type of Fill Pipe (on ORVR vehicle):	Category V/L	Method of selection:
Vented	1.20	Average V/L of all capless vehicles in study[1] with a V/L > 0.5
Outer Ring - Bad[2]	1.18	Average V/L of BMW/Mercedes in study[1] which had V/L > 0.5
Loose latch (1) - Bad[2]	1.13	Average V/L of Hard to Latch[3] vehicles in study[1] which Had V/L > 0.5
Total Good	0.44	Average V/L from all vehicles in study[1] which had V/L < 0.5

[1] CARB's ORVR Recognition Study [CARB, 2017d].
[2] Both Outer Ring and Loose Latch vehicles which had V/L < 0.5 were included in the "Total Good" category V/L calculation.
[3] Hard to Latch vehicles were defined as having a locking lip depth at least 10 mm deep and/or an outer diameter > 57.5 mm. Both of these attributes lead to more force needed to latch the nozzle. The vehicles selected for determining this number were selected from the entire MY 2016 fleet from four auto manufacturers (Toyota, Hyundai, Honda, and Chrysler), which staff believed to represent the entire vehicle fleet.

Table S2: Example of Fleet Average V/L Calculation for 2030 Baseline Condition

2030			
	Gasoline gal/d [1]	ORVR Fleet %	Category V/L ratio
Vented ORVR	1,269,949	4.1	1.20
Non-ORVR Vehicles	1,012,524		0.99
Outer Ring ORVR - Bad	1,409,062	4.5	1.18
Outer Ring ORVR – Good [2]	462,977		
Loose latch ORVR – Bad	5,044,719	16.3	1.13
Loose latch ORVR – Good [2]	8,828,258		
Good ORVR Vehicles	23,297,941	75.1	0.44
ORVR Fleet %	97%		
Weighted average V/L [3]:			**0.62**

[1] Gasoline gal/d estimated using EMFAC 2017 model, factoring in new vehicles sold and vehicle attrition leading up to 2030.

[2] Both Outer Ring and Loose Latch vehicles, which had V/L < 0.5, were included in the "Total Good" category V/L calculation, and are shown here for reference only.

[3] Weighted average V/L calculated as:

$$\frac{4.1\% * 1.20\ V/L + 4.5\% * 1.18\ V/L + 16.3\% * 1.13\ V/L + 75.1\% * 0.44\ V/L}{100\%} \mathbf{= 0.62}$$

VI.   REFERENCES

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    https://www.arb.ca.gov/vapor/op/studies/gdf/vropg1.pdf

2. CARB. 2017. Healy Model 900 Assist Vapor Recovery Nozzle ORVR Vehicle Recognition Study, Report Number VR-OP-A3. Overpressure Study Technical Support Document prepared by staff of the Vapor Recovery and Fuel Transfer Branch, Monitoring and Laboratory Division, California Air Resources Board (CARB). November 29, 2017. (ORVR Recognition Study) Available at:
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3. CARB. 2017 Healy Model 900. (same as referenced above in 2.)

4. CEC. 2017. 2016 California Annual Retail Fuel Outlet Report Results (CEC-A15). Microsoft Excel file dated October 10, 2017, downloaded from California Energy Commission (CEC) website accessed on April 24, 2018:
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12. CARB. 2018b. Comparison of Vehicle Fueling Event V/L Ratios at a Gas Station Before and After EOR Nozzle Installation. Data and calculation spreadsheets prepared by staff of the Vapor Recovery and Fuel Transfer Branch, Monitoring and Laboratory Division, California Air Resources Board (CARB). July 2018.

16. CARB. 2018. Initial Statement of Reasons (same as referenced above in 11.)