



# CALIFORNIA

## AIR RESOURCES BOARD

Monitoring and Laboratory Division  
Vapor Recovery and Fuel Transfer Branch  
Vapor Recovery Regulatory Development Section

Project Number: VR-11-11

Report No. VR-OP-A1

### **OVERPRESSURE STUDY:**

Technical Support Document  
Results of Vapor Recovery System Performance Testing  
Conducted at Gasoline Dispensing Facilities Equipped with the  
Assist Phase II Enhanced Vapor Recovery System which Experience Pressure  
Increase While Dispensing

December 6, 2017

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## **EXECUTIVE SUMMARY**

Throughout the winter of 2014, California Air Resources Board (ARB) staff conducted a series of vapor recovery system compliance tests at nine (9) retail gasoline dispensing facilities (GDFs) located in four densely populated regions of California: Los Angeles, San Diego, San Francisco Bay Area, and Fresno. Each of the nine GDFs were equipped with the Assist Phase II Enhanced Vapor Recovery System including In-Station Diagnostics (ISD) per ARB Executive Order VR-202 and had recently exhibited a severe form of underground storage tank overpressure known as “pressure increase while dispensing” or PWD. The objective of this evaluation was to determine if overpressure and PWD conditions can occur at GDFs that are in compliance with existing regulatory performance standards.

Upon review and analysis of the test results and the ISD data collected from seven of nine GDFs, ARB staff concluded that overpressure and PWD is not caused by a readily identifiable vapor recovery equipment failure and that existing compliance test procedures and troubleshooting techniques are unable to identify a common characteristic or “smoking gun” which can explain the occurrence of PWD at some GDF and the absence at others. Two GDFs had excessive leak and were excluded from the analysis.

The results of this evaluation suggest that additional field studies and investigations should be conducted to identify key contributors of PWD other than those which exist in current ARB test procedures troubleshooting guides.

## I. Background

In the fall of 2012, ARB staff held a series of public workshops to discuss proposed amendments to existing vapor recovery certification procedures (CP-201) as part of an effort to address the ISD overpressure alarm issue. Shortly after these workshops, ARB staff was provided with information from a dozen GDFs located in Southern California which exhibited UST pressure increasing while dispensing (PWD) during the 2012 - 2013 winter fuel season. At these particular GDFs, overpressure conditions were present for prolonged periods of time and exceeded the positive relief setting of the pressure/vacuum (PV) vent valve. During the previous two winters these GDFs exhibited approximately a third of the number of alarms that occurred during winter 2012 - 2013. ARB staff assumed that overpressure conditions were only associated with winter blend gasoline and GDFs that experience prolonged idle periods, (periods of no dispensing or GDFs that close down for several hours at night). ARB staff quickly realized that the proposed regulatory solution would not work for facilities with PWD.

As a result, ARB staff conducted an extensive statewide field study during the winter months of 2013/2014 to determine the extent of PWD. ISD data was collected from approximately 400 GDFs located in nine different geographic regions across California. Based on statewide population data obtained from districts, these nine regions contain approximately 95% of the GDFs in California. The sample number in each region is weighted based on the percentage of the state's GDFs that are located in the district. Table II-1 describes the number of GDFs targeted in each region of the state.

**Table I-1: Distribution of 400 GDFs for ISD Data Collection**

District(s)	Bay Area AQMD	Sacramento Yolo Feather	San Diego APCD	San Joaquin APCD	SLO Northern Sonoma Mojave El Dorado Placer	South Coast AQMD	Regions not Samples	
<b>% of Statewide GDF w /ISD</b>	17.1%	6.9%	8.3%	11.3%	11.1%	40.3%	4.9%	
<b>ISD Downloads</b>	<b>Target Number of GDF</b>	58	23	28	38	37	136	0
	Target number of Assist	36	N/A	N/A	25	26	93	0
	Target number of Balance	22	N/A	N/A	13	12	43	0
	<b>Total Per Region</b>	58	46	85	38	37	136	0

The data indicates that the percentage of total GDFs that exhibit PWD is approximately 24%. The percentage of GDFs equipped with the Assist Phase II EVR System that

exhibit PWD is approximately 34%. Balance Phase II system did not exhibit PWD, but did have overpressure issues. (See report titled Emissions from Balance System.)

## **II. OBJECTIVE**

The objective of this evaluation was to determine if readily identifiable vapor recovery component failures or related GDF equipment failures can be attributed to the occurrence of a severe form of overpressure known as PWD at GDFs equipped with the Assist Phase II EVR System. A series of vapor recovery system performance tests (also referred to as compliance tests) were conducted on nine GDFs located throughout the state in a geographically representative manner. Since overpressure conditions are most prevalent from November to March, the testing was conducted during the months when winter blend gasoline is sold. ARB staff is aware that volatility of winter fuel is the primary cause of the overpressure; however, RVP alone does not explain why PWD occurs at only a fraction of California's assist equipped GDF population. Specific questions this evaluation seeks to answer are listed as follows:

**1. Is PWD a function of low gasoline dispensing rate?**

Low-fuel dispensing rates (less than 6 gallons per minute per Exhibit 2 of Executive Order VR-202), are known to cause the assist nozzle to generate excessively high V/L ratio values which leads to excess ingestion of air when refueling Onboard Refueling Vapor Recovery (ORVR) equipped vehicles.

**2. Is PWD found on GDFs that have high V/L ratios?**

The proper V/L ratio range of the assist nozzle is 0.95 to 1.15. If the nozzle is adjusted beyond this range, excess air ingestion will occur during refueling events, leading to overpressure.

**3. Is PWD found within malfunctioning, or out of compliance, ISD components which leads to false alarms?**

If out of calibration or malfunctioning, the values captured by the ISD vapor pressure sensors and ISD vapor flow meters could lead to false alarms.

**4. Is PWD found at GDFs plagued with leaks within the vapor return piping of the dispenser?**

Leaks within vapor return piping are suspected to contribute to overpressure because they can lead to excess air ingestion during vehicle refueling events.

**5. Is PWD attributed to identifiable vapor recovery equipment failures?**

Is there a common, yet easily identifiable equipment malfunction which would explain why PWD is present at some GDF but not others?

**6. Do GDFs which routinely exhibit PWD also exhibit an irregular distribution of V/L ratios for individual fueling transactions?**

Under normal operating conditions, when the distribution of V/L ratios are plotted on a graph using a histogram, there should be a high percentage of fueling events with V/L less than 0.5 and a high percentage of events with V/L at 1.0.

An abnormal distribution would show a high percentage between 0.5 and 0.8 and above 1.15 which is beyond allowable operating range.

### III. METHODOLOGY

#### A. Identification of Vapor Recovery System Performance Testing

Prior to deploying resources and conducting testing, ARB staff identified vapor recovery system operating parameters that are believed to affect UST system pressure. Specifically, ARB staff suspected that excess air ingestion during vehicle fueling events, caused by improperly adjusted nozzles (high V/L ratios or low fuel dispensing flow rates) or inward leaks driven by the vacuum pump in the dispenser plumbing, as key contributors to overpressure conditions, including PWD. ARB staff then identified applicable compliance test procedures which are listed within the Assist System Executive Order VR-202 or Certification Procedure CP-201. ARB staff also identified performance testing to verify the ISD monitoring equipment is operating correctly.

Because PWD only occurs on GDFs equipped with Assist Phase II EVR systems, only those GDFs were evaluated. Table IV-1 provides a complete listing of vapor recovery system performance tests that were conducted at each GDF.

**Table III-1: Description of Vapor Recovery System Performance Testing for GDFs Equipped with Assist Phase II EVR System**

Test Procedure	Description	Reference
VR-202, Exhibit 9 or VR-202, Exhibit 10	Veeder-Root ISD Operability Test Procedure or INCON VRM Operability Test Procedure	<a href="http://www.arb.ca.gov/vapor/eos/eo-vr202/">http://www.arb.ca.gov/vapor/eos/eo-vr202/</a>
VR-202, Exhibit 5	Vapor to Liquid Ratio	
VR-202, Exhibit 5	Fuel Dispensing Rate	
VR-202, IOM Section 8	Dispenser Integrity	
VR-202, Exhibit 4	Determination of Static Pressure Performance of the Clean Air Separator	

In addition to vapor recovery system performance testing, ARB staff downloaded recent ISD reports (daily and monthly), the most recent 30 hours of pressure and ullage data, and V/L ratio data for individual fueling transactions. The V/L data is stored on the TLS console for the most recent 1,000 fueling transactions for each dispenser at each GDF. The specific ISD reports downloaded are identified in the Table IV-2.

**Table III-2: Description of ISD Reports to Download from Each GDF**

ISD Report	Description	
Individual Fueling Transaction	<b>Veeder Root ISD System</b>	<b>INCON ISD System</b>
	Fueling Transaction (last 1000 records for each Dispenser)	Fueling Transaction (last 1000 records for each Fueling Point)
UST Pressure and Ullage Data	Most recent 30 hours of UST pressure and ullage data	Most recent 2 weeks of UST pressure and ullage data
Monthly Report	Monthly ISD Report (available for last 12 months)	
Daily Reports	Daily ISD Report (available for last 365 days)	

**B. Geographic Distribution of GDF Selected for Testing**

Upon analysis of ISD data collected from approximately 400 GDF in October and December, 2013, ARB staff identified a total of 93 GDFs which exhibited PWD. This list was further subdivided by region.

Based on time constraints and available ARB resources, a total of nine GDFs located in four different regions were selected for vapor recovery system performance testing. As shown in Table IV-3, three GDF were located in South Coast Air Quality Management District (SCAQMD), two GDF located in San Diego County Air Pollution Control District (SDCAPCD), two GDF in San Joaquin Valley Air Pollution Control District (SJVAPCD), and two GDFs in the Bay Area Air Quality Management District (BAAQMD). GDFs in the Sacramento region were not chosen due to lower occurrence of PWD. Due to the transition from winter blend gasoline to summer blend gasoline, testing in Southern California and in Northern California were conducted in February and March, respectively. This testing sequence was chosen because the change from winter blend to summer blend gasoline occurs one month early.

**Table III-3: Distribution of GDFs for VRS Performance Testing**

Region	Bay Area	Sacramento	San Joaquin	San Diego	South Coast	Other	Total
% of Statewide Population GDF with ISD	17.1%	7.0%	11.3%	8.3%	40.3%	15.9%	100%
Number of GDF Targeted Per Region	2	0	2	2	3	0	9

### C. Selection Criteria within Each Region

In terms of GDF selection process within each region, ARB staff used the following criteria to identify GDF from the larger population of 400 GDFs visited in 2013:

- Equipped with Assist Phase II EVR with Veeder-Root ISD or INCON ISD;
- Exhibited UST PWD in December 2013 and February of 2014 with high RVP fuel (severe form of overpressure condition);
- Exhibited UST pressure in deep vacuum in October with low RVP fuel (normal baseline condition); and
- ISD alarm history free of leak and collection alarms for the last six to twelve months.

Upon review of the ISD data collected from various GDF for the five regions listed in Table IV-4 along with review of the ISD alarm history for the past six to twelve months, the following nine GDFs were identified as optimal for vapor recovery compliance testing in February and March (four GDFs in northern California and five GDFs in southern California).

**Table III-4: GDFs Targeted for VRS Performance Testing**

	GDF Description	Region (Air District)	ISD Type
<b>NORTHERN California</b>	SITE A Campbell	BAAQMD	Veeder Root
	SITE B Redwood City	BAAQMD	Veeder Root
	SITE C <sup>1</sup> Madera	SJVAPCD	Veeder Root
	SITE D <sup>2</sup> Fresno	SJVAPCD	Veeder Root
<b>SOUTHERN California</b>	SITE E La Cañada-Flintridge	SCAQMD	Veeder Root
	SITE F Hacienda Heights	SCAQMD	Veeder Root
	SITE G Garden Grove	SCAQMD	Veeder Root
	SITE H San Diego	SDCAPCD	INCON
	SITE I San Diego	SDCAPCD	Veeder Root

<sup>1</sup> This site was removed from the individual tables in the result section except for Section F. Compliance testing of this site was not completed due to multiple dispenser leaks and irregular location of ISD components. Additionally, this site did not exhibit PWD as shown in Table V-1

<sup>2</sup> See Note 1

## IV. RESULTS

### A. UST Pressure and Ullage Volume Profile Immediately Prior to Testing

Immediately prior to conducting vapor recovery system performance testing, ARB staff downloaded the most recent 30 hours of UST pressure and ullage data from the ISD system installed at each GDF. This data was necessary to determine whether each GDF was continuing to exhibit PWD. Prior GDF visits conducted in December of 2013 and February of 2014 had indicated PWD conditions were present based on downloaded ISD data. The downloaded ISD data was populated into an Excel spreadsheet, which calculated the average UST pressure, and indicated if the GDF was exhibiting PWD, as shown in Table V-1. Note, each of the nine sites had exhibited PWD during prior sites visits in February of 2014.

**Table IV-1: GDF Average UST Pressure and PWD<sup>3</sup> Status**

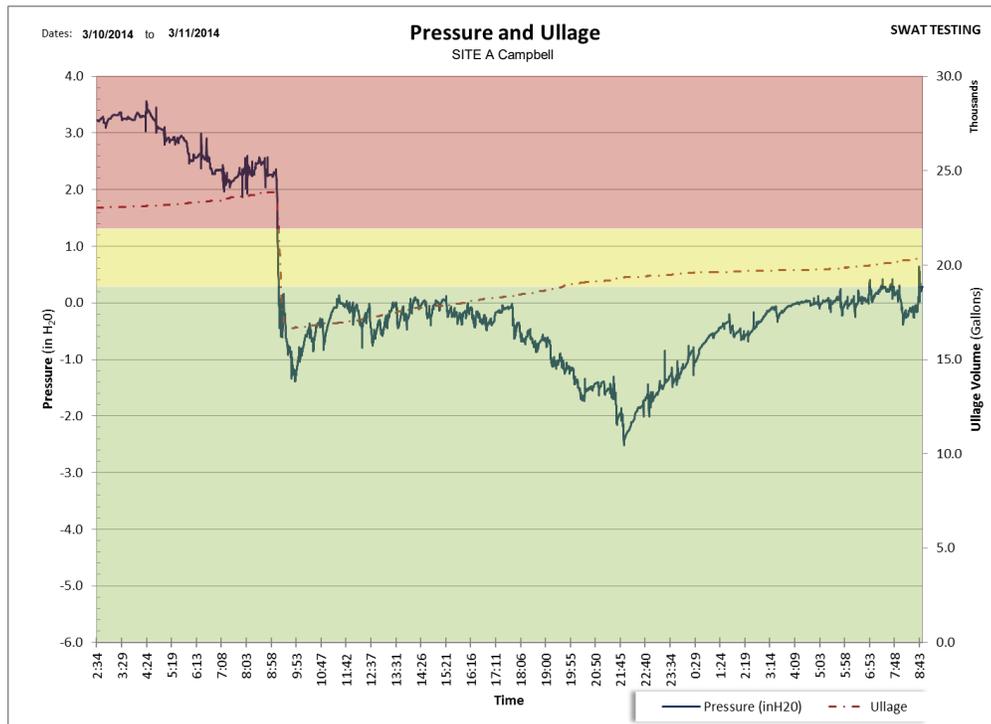
<b>GDF Info</b>	<b>Average UST Pressure * (Inches WC)</b>	<b>PWD Status (Yes / No)</b>	<b>Date of VRS Testing</b>
SITE A Campbell	<b>0.193</b>	<b>Yes</b>	<b>3/11/2014</b>
SITE B Redwood City	<b>3.412</b>	<b>Yes</b>	<b>3/12/2014</b>
SITE C Madera	<b>-2.919</b>	<b>No</b>	<b>3/18/2014</b>
SITE D Fresno	<b>-2.842</b>	<b>No</b>	<b>3/19/2014</b>
SITE E La Cañada-Flintridge	<b>-5.173</b>	<b>No</b>	<b>2/11/2014</b>
SITE F Hacienda Heights	<b>1.932</b>	<b>Yes</b>	<b>2/12/2014</b>
SITE G Garden Grove	<b>1.989</b>	<b>Yes</b>	<b>2/13/2014</b>
SITE H San Diego	<b>-6.689</b>	<b>No</b>	<b>2/19/2014</b>
SITE I San Diego	<b>-5.953</b>	<b>No</b>	<b>2/20/2014</b>

\*(Recent 30 Hours of Data from ISD)

<sup>3</sup>To identify PWD, ARB staff created an Excel macro to identify sites that demonstrated specific data traits (flags). To be deemed PWD, at least 20% of the daily ullage data must exceed 1.3"WC at least 75% of the daily ullage pressure data are less than 0.2"WC, deemed invalid data (flat lines, indicative of a leak); and at least three consecutive hours of positive pressure slope and positive ullage volume based on daily ullage pressure data.

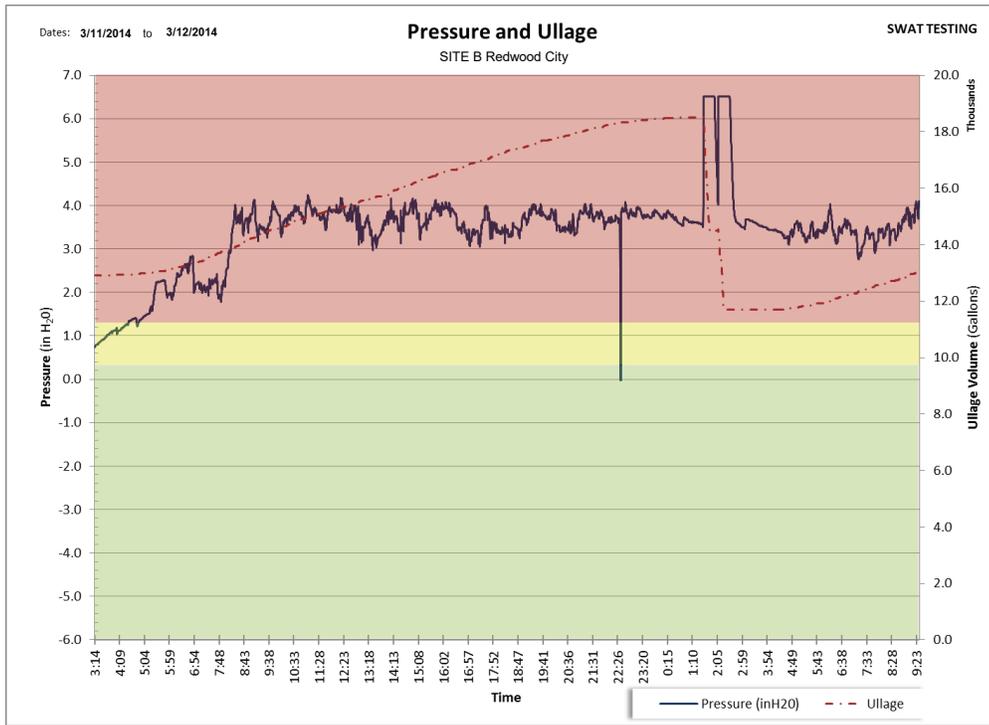
As indicated in the Table V-1, four of the nine GDFs selected for this experiment were still actively exhibiting PWD. Although the remaining five did not exhibit PWD at the time of testing, the decision was made to continue with testing as staff resources had already been committed, arrangements had been made with each district, and the winter fuel season was beginning to be phased-out in southern California. In another study, ARB staff found that RVP begins to decline rapidly in mid-February for Southern California. Figures V-1 to V-9 displays the 30 hour pressure profile of all nine GDFs downloaded immediately prior to conducting vapor recovery system (VRS) performance testing.

**Figure IV-1: Pressure Ullage Chart – SITE A Campbell<sup>4</sup>**

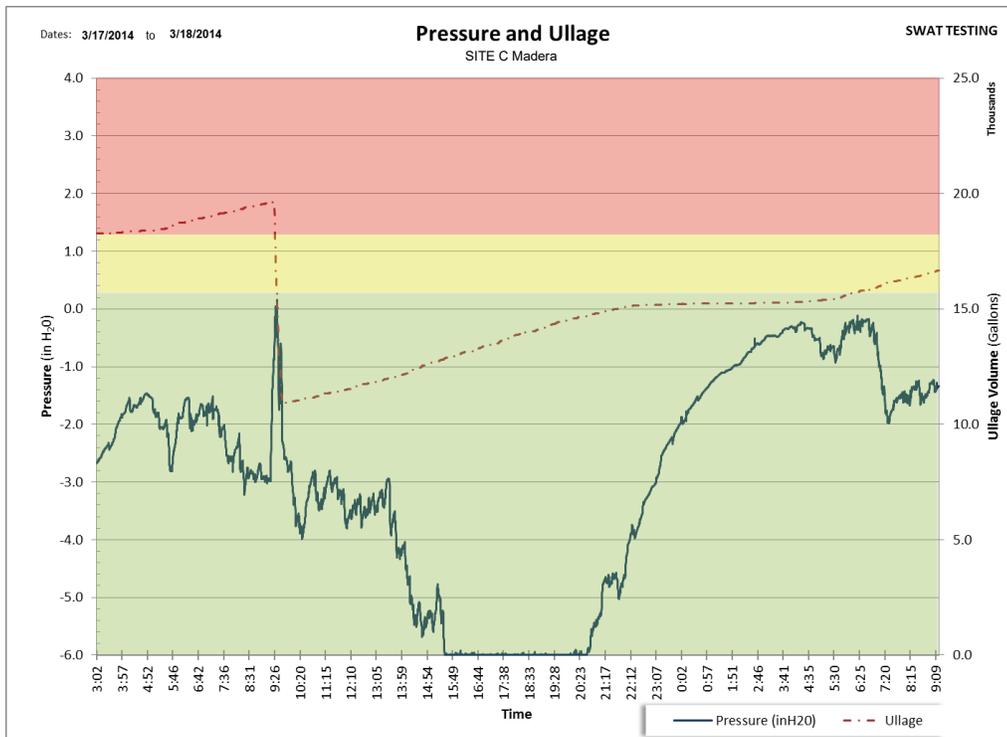


<sup>4</sup> This pressure ullage chart dictates that there has been a change in RVP. Once the fuel was dropped the site went from overpressure / PWD status to a non-overpressure / non-PWD status. This site's hours of operations are from 11:00 PM to 6:00 AM, which is shown on the chart. The pressure is increasing during the non-operational hours. Also it can be said based on the chart that from 6:00 AM to 9:00 AM the as the ullage increased (fueling is occurring), the pressure is also increasing, behavior of PWD station.

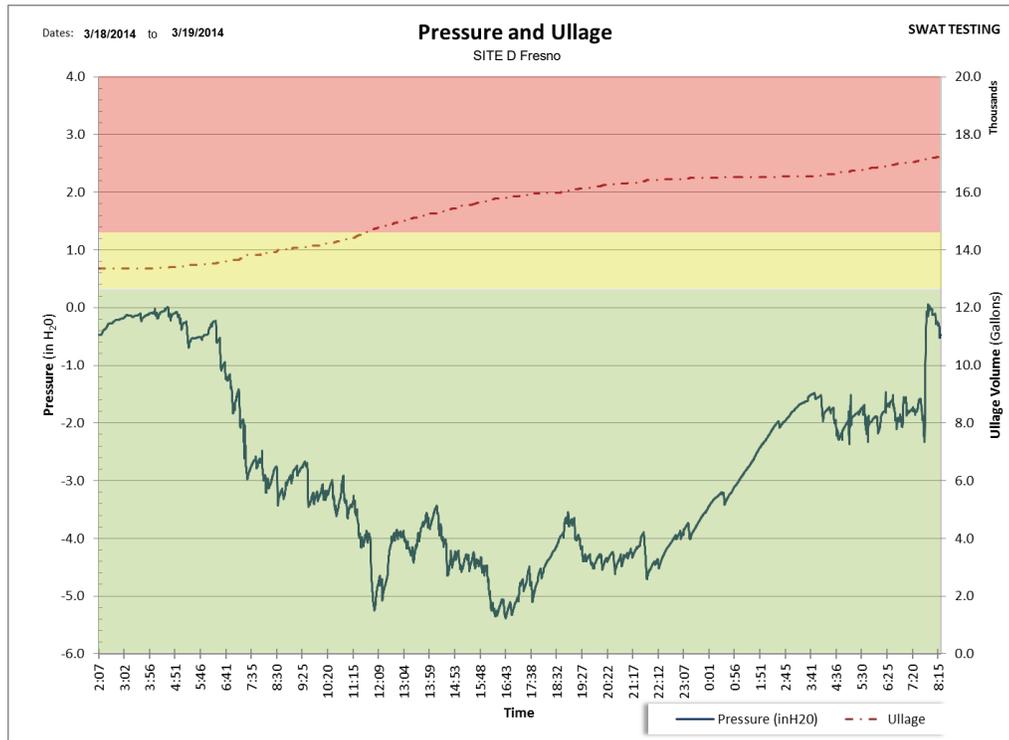
**Figure IV-2: Pressure Ullage Chart – SITE B Redwood City**



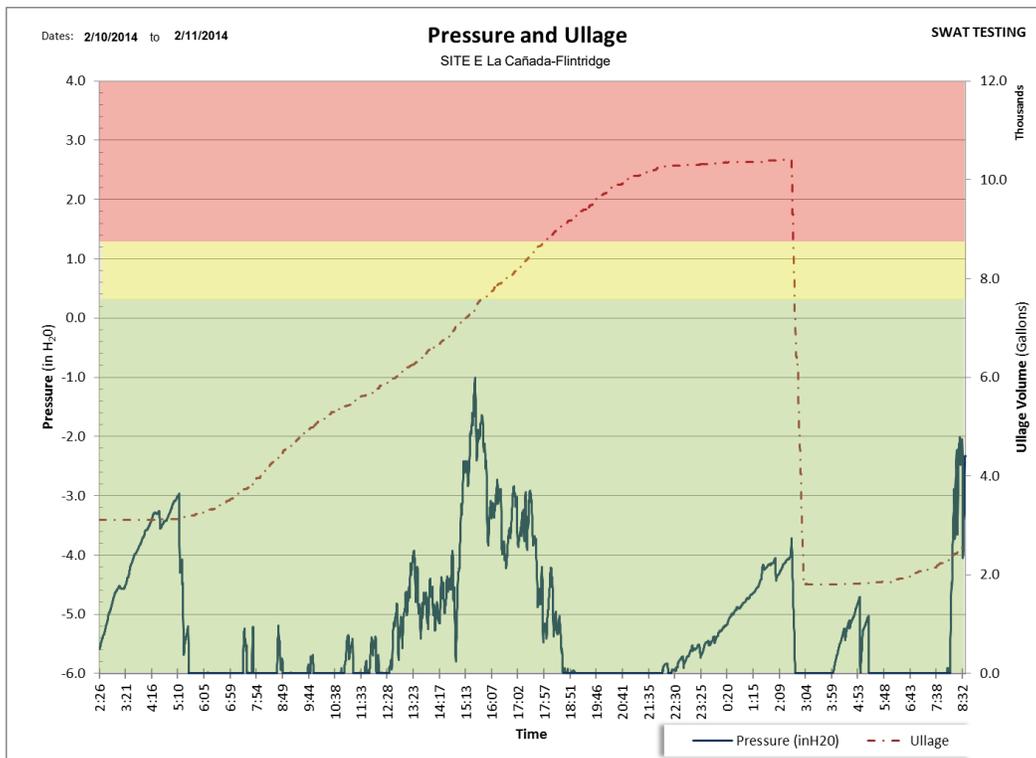
**Figure IV-3: Pressure Ullage Chart – SITE C Madera**



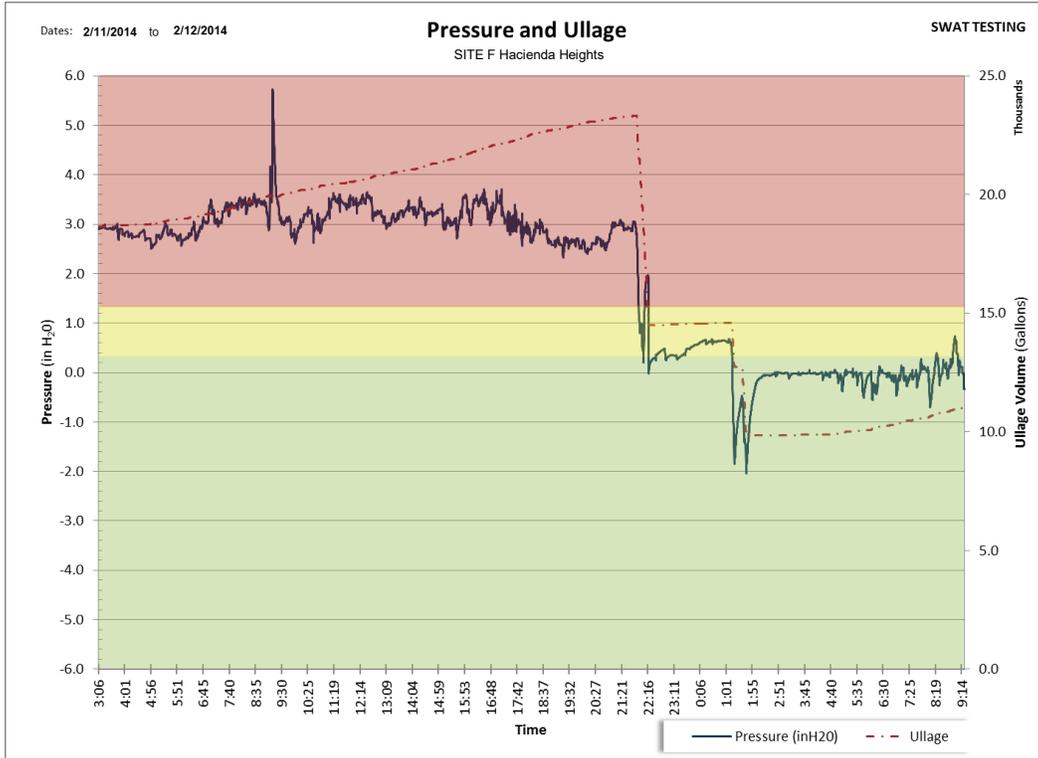
**Figure IV-4: Pressure Ullage Chart – SITE D Fresno**



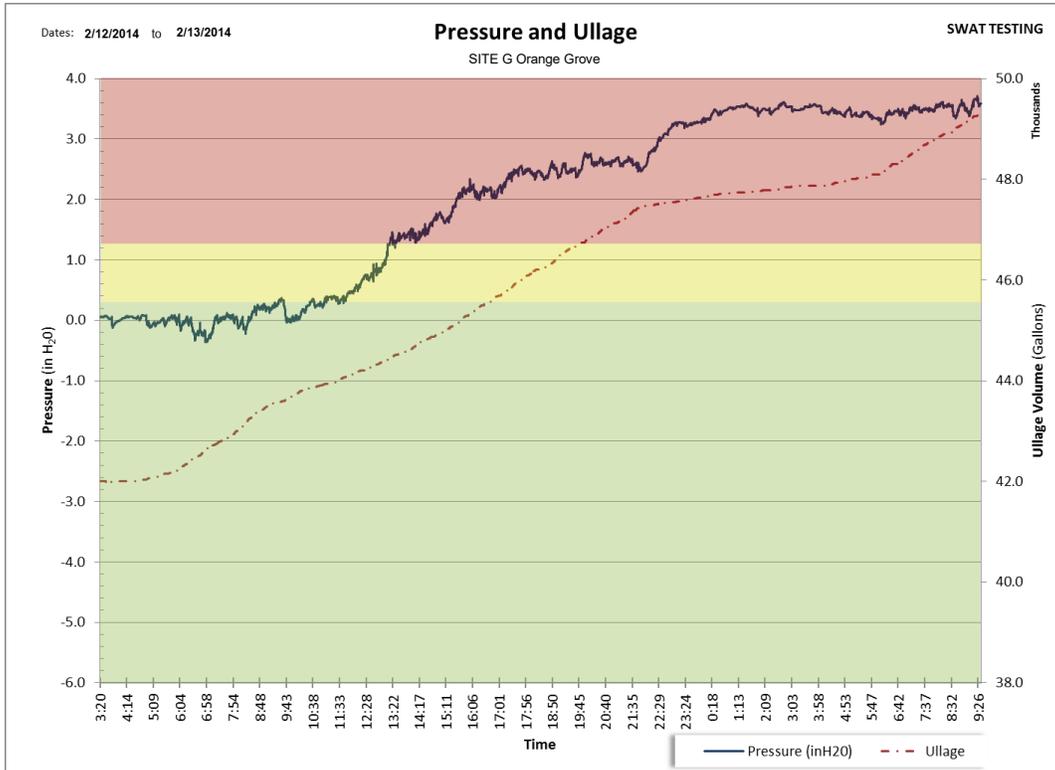
**Figure IV-5: Pressure Ullage Chart – SITE E La Cañada-Flintridge**



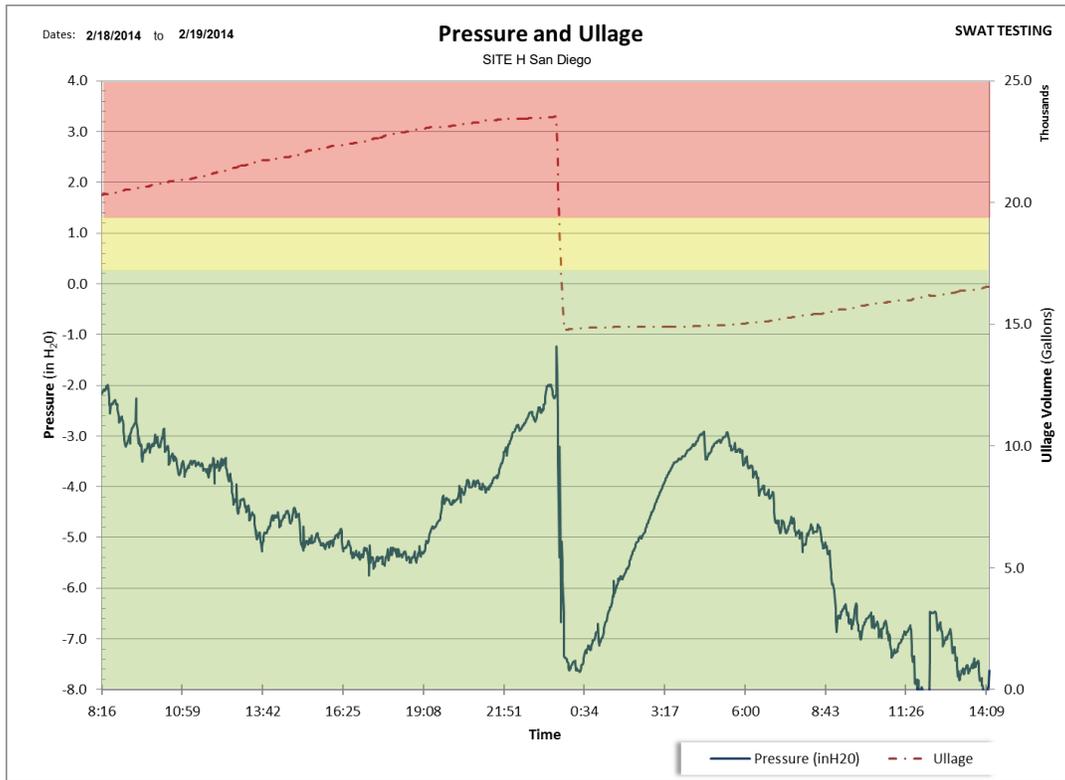
**Figure IV-6: Pressure Ullage Chart – SITE F Hacienda Heights**



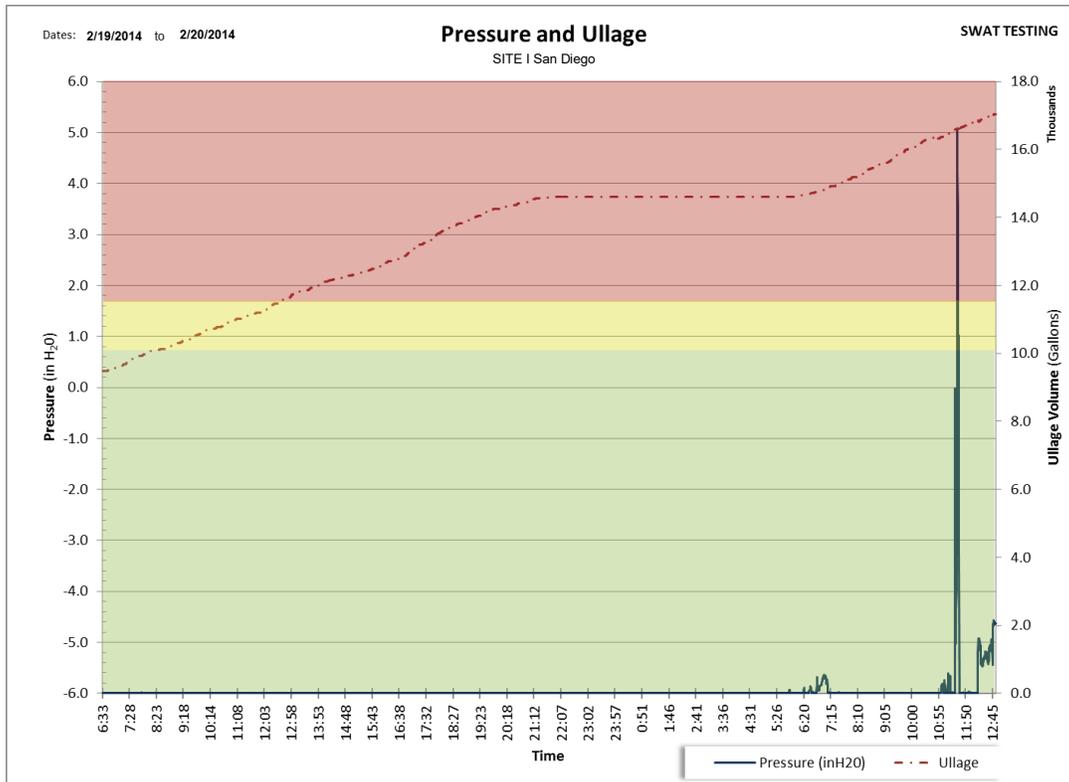
**Figure IV-7: Pressure Ullage Chart – SITE G Garden Grove**



**Figure IV-8: Pressure Ullage Chart – SITE H San Diego**



**Figure IV-9: Pressure Ullage Chart – SITE I San Diego**



## B. Accuracy of ISD Components<sup>5</sup>

### i. ISD Vapor Pressure Sensor

According to ARB Executive Order VR-202, accuracy of the ISD vapor pressure sensor must be validated once per year per Exhibit 9 or Exhibit 10 (depending upon which ISD system is installed), which is called the ISD operability test procedure. Under normal compliance testing situations, Exhibit 9 and 10 require a “two-point” field accuracy check of the vapor pressure sensor. This is accomplished by subjecting the sensor to atmospheric pressure via use of a ball valve and at “as found” conditions within the headspace of the UST. At the nine GDFs selected for this experiment, ARB staff conducted a more rigorous “ten-point” field accuracy check of the vapor pressure by connecting a portable device called a variator. This was necessary because ARB staff wanted high degree of confidence that the vapor pressure sensor was reading accurately throughout the full scale range. A vapor pressure sensor out of compliance at a GDF will invalidate any data collected.

In terms of acceptance criteria, the ISD vapor pressure sensor must be within plus or minus 0.2 inches water column (WC) from ARB’s hand held digital manometer reading. If difference is not within plus or minus 0.2 inches WC, the ISD vapor pressure sensor is not in compliance with the requirements of Exhibit 2. As indicated in Table V-2, the ISD vapor pressure sensors at seven of the nine GDFs were found to be in compliance.

**Table IV-2: Performance Summary of ISD Pressure Sensor**

<b>GDF Info</b>	<b>Percent Difference Between ISD UST Pressure Sensor and ARB Digital Manometer</b>	<b>Allowable Difference per Exhibit 9/10 of VR-202</b>	<b>Pass or Fail</b>
SITE A Campbell	5%	±0.2 Inches WC 20%	PASS
SITE B Redwood City	4%	±0.2 Inches WC 20%	PASS
SITE E La Cañada-Flintridge	6%	±0.2 Inches WC 20%	PASS
SITE F Hacienda Heights	4%	±0.2 Inches WC 20%	PASS
SITE G Garden Grove	2%	±0.2 Inches WC 20%	PASS
SITE H San Diego	5%	±0.2 Inches WC 20%	PASS
SITE I San Diego	2%	±0.2 Inches WC 20%	PASS

<sup>5</sup> Two of the sites (Site C in Madera and Site D in Fresno) had excessive leaks and were excluded from the analysis.

**ii. ISD Vapor Flow Meter**

According to ARB Executive Order VR 202, the accuracy of the ISD vapor flow meter must be validated once per year per Exhibit 9 or Exhibit 10 (depending upon which ISD system is installed), which is called the ISD operability test procedure. This test was deemed necessary because ARB staff wanted a high degree of confidence that the ISD vapor flow meter was reading accurately. If the vapor flow meter was found out of compliance at any of the GDF's, it will invalidate any data collected.

In terms of acceptance criteria, the ISD vapor flow meter V/L must read within plus or minus 0.15 of the reference meter specified in Exhibit 5 of VR-202. If the difference is not within plus or minus 0.15, the ISD vapor flow meter is not in compliance and any data collected will be deemed invalid. As indicated in the Table V-3, ISD vapor flow meters were found fully operational and accurate at all seven GDFs. Please note, two of the nine GDFs were not tested due to the presence of dispenser leaks.

**Table IV-3: Performance Summary of ISD Flow Meter**

<b>GDF Info</b>	<b>Percent Difference Between ISD Flow Meter and ARB Reference Meter</b>	<b>Allowable Difference per Exhibit 9/10 of VR-202</b>	<b>Pass or Fail</b>
SITE A Campbell	6%	±0.15 15%	PASS
SITE B Redwood City	3%	±0.15 15%	PASS
SITE E La Cañada-Flintridge	3%	±0.15 15%	PASS
SITE F Hacienda Heights	2%	±0.15 15%	PASS
SITE G Garden Grove	6%	±0.15 15%	PASS
SITE H San Diego	4%	±0.15 15%	PASS
SITE I San Diego	4%	±0.15 15%	PASS

The ISD components (vapor pressure sensor and vapor flow meter) at all seven the GDFs were observed between 2% and 6% difference when compared to the ARB reference instrument which is within the specified allowable difference per Exhibit 9/10 of VR-202. The ISD component failure rate of all seven GDFs was zero.

### C. Vapor-to-Liquid Ratios and Fuel Dispensing Rates <sup>6</sup>

According to Exhibit 2 of ARB Executive Order VR-202, the proper vapor to liquid ratio of range the assist nozzle is between 0.95 to 1.15. In addition, the fuel dispensing rate must be between six to ten gallons per minute. Exhibit 5 of Executive Order VR-202 is the test procedure used to for compliance determination. Table V-4 below summarizes the results of the test.

**Table IV-4: Summary of Dispensing (Flow Rate & V/L Ratio) Performance**

<b>GDF Info</b>	<b>Fuel Dispensing Rate</b> (Gallons Per Minute)	<b>GDF Average V/L Ratio</b> Based on ARB Test Method Exhibit 5	<b>Allowable V/L Range</b> Specified in Exhibit 2 of VR-202	<b>Pass or Fail</b>
SITE A Campbell	7.9	0.95	0.95 – 1.15	PASS
SITE B Redwood City	7.8	0.95	0.95 – 1.15	PASS
SITE E La Cañada-Flintridge	8.8	0.89	0.95 – 1.15	FAIL
SITE F Hacienda Heights	8.5	1.01	0.95 – 1.15	PASS
SITE G Garden Grove	7.9	0.94	0.95 – 1.15	FAIL
SITE H San Diego	8.7	1.03	0.95 – 1.15	PASS
SITE I San Diego	8.3	0.99	0.95 – 1.15	PASS

The average V/L for all seven GDFs was 0.97. The average V/L for the four GDFs that continued to exhibit PWD was 0.96. The average V/L for the three GDFs that no longer exhibited PWD was 0.97. The fuel dispensing rate for all GDFs was between six and ten gallons per minute.

### D. Dispenser Integrity

According to ARB approved Installation, Operation and Maintenance Manual (IOM), Section 18 of Executive Order VR-202, dispenser integrity testing is conducted upon startup of newly constructed facilities, and as a troubleshooting tool to check vapor tightness of the plumbing from vapor pump to the nozzle.

ARB staff sought to minimize disturbance to the GDF owner and customers as much as possible. Rather than complete Test Procedure (TP) 201.3, Determination

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<sup>6</sup> Two of the sites (Site C in Madera and Site D in Fresno) had excessive leaks and were excluded from the analysis.

of 2-Inch WC Static Pressure Performance of Vapor Recovery Systems, ARB staff decided to analyze the 30-hour pressure profile (Figure V-1 to V-9) and the results of the dispenser integrity test to determine the leak integrity of the GDFs. The pressure profile would show if the any possible leaks are present at the GDF; and the dispenser integrity test would provide us information on the leak integrity of each dispenser. Table V-5 summarizes the results of the dispenser integrity test.

**Table IV-5: Summary of Dispenser Integrity Test**

<b>GDF Info</b>	<b>Number of Dispensers Per GDF</b>	<b>Allowable Vacuum Drop in 60Sec</b>	<b>Pass Rate</b>
SITE A Campbell	4	4 inches WC	75%
SITE B Redwood City	4	4 inches WC	100%
SITE E La Cañada-Flintridge	4	4 inches WC	50%
SITE F Hacienda Heights	4	4 inches WC	75%
SITE G Garden Grove	4	4 inches WC	50%
SITE H San Diego	4	4 inches WC	100%
SITE I San Diego	4	4 inches WC	100%

Total of 28 dispensers were tested at the seven GDFs at which, 22 experienced vacuum-drop less than 4 inches in period of 60 seconds. The average passing rate of all seven GDFs was about 78.6%. The four GDFs which continued to exhibit PWD had a passing rate of 75% (12 out of 16 dispensers passed); the three GDFs which no longer exhibited PWD had a passing rate of 83% (10 out of 12 dispensers passed).

**E. Clean Air Separator Operability<sup>7</sup>**

According to ARB Executive Order VR-202, Exhibit 4 determines the vapor tightness of the Clean Air Separator (CAS) pressure management system. The CAS prevents excess emissions and product loss by controlling UST pressure by expanding an internal bladder when the UST is pressurized, and collapsing the internal bladder when the UST is in a state of vacuum. ARB staff determined that it was necessary to conduct this test to verify the integrity of the internal bladder. If

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<sup>7</sup> Two of the sites (Site C in Madera and Site D in Fresno) had excessive leaks so there test results were removed from the analysis.

the CAS did not pass the test, then there may be a possibility of air ingestion causing premature vapor expansion, leading towards UST pressurization.

The CAS, while isolated from the vapor recovery system, is evaluated for vapor integrity by using (1) a vacuum decay procedure, or (2) a positive pressure decay procedure. The vacuum decay after five minutes is compared with an allowable value. The allowable value is based upon the initial vacuum level when conducting the test using the table provided in the test procedure. A positive decay procedure is included, and it conducts the same evaluation as the vacuum decay but with positive pressure. This test is conducted if there is insufficient vacuum (not greater than negative 2.00 inches WC) to conduct the vacuum decay. Table V-6 below summarizes the results of the test.

**Table IV-6: Summary of Clean Air Separator (CAS) Integrity**

GDF Info	Integrity Status (Pass / Fail)
SITE A Campbell	PASS
SITE E La Cañada-Flintridge	PASS
SITE G Garden Grove	PASS
SITE I San Diego	PASS

The CAS passing rate for all seven GDFs was 100%.

**F. Distribution of Vapor to Liquid Ratios from ISD Fueling Transaction Records**

For each fueling transaction, a V/L ratio is recorded by the ISD system at each dispenser installed at each GDF. There are two types of ISD system: (1) Veeder Root ISD system, which records the last 1,000 transactions per dispenser; and (2) INCON ISD system, which records the last 1,000 transactions per fueling point. Each GDF evaluated was equipped with four dispensers, therefore a total of 4,000 fueling transaction records per GDF were available for eight GDFs with a Veeder

Root ISD system, and 8,000 for the single GDF with an INCON ISD system. This data was downloaded from the ISD system and populated into an Excel spreadsheet for staff analysis. Key metrics can be calculated from this data include GDF average V/L, percentage of fueling events within a specific range, and average volume of fuel dispensed per fueling transaction. The percentage of fueling events were calculated simply by sorting the data and filtering commands and categorized into two types: (1) ORVR vehicles ( $0.1 \leq V/L \leq 0.5$ ), and (2) Conventional (non-ORVR) vehicles ( $0.95 \leq V/L \leq 1.15$ ), which are shown as shaded regions in Figure V-10 to V-18. Table V-7 displays the results of analysis specific to distribution of V/L ratios for each GDF.

**Table IV-7: Summary of ISD Fueling Transactions**

GDF Info	Number of Records <sup>8</sup> In Data Set	Vapor over Liquid (V/L)				Normal Distribution Yes / No
		0.1 ≤ and ≤0.5	0.5 < and <0.95	0.95 ≤ and ≤1.15	>1.15	
SITE A Campbell	3126	46.0%	23.2%	18.1%	12.7%	Yes
SITE B Redwood City	3197	55.9%	18.5%	19.4%	6.1%	Yes
SITE C Madera	2797	50.9%	17.9%	16.9%	14.4%	Yes
SITE D Fresno	3058	58.8%	16.5%	14.4%	10.3%	Yes
SITE E La Cañada-Flintridge	2891	56.1%	19.0%	19.8%	3.4%	Yes
SITE F Hacienda Heights	2852	47.6%	15.7%	23.0%	13.7%	Yes
SITE G Garden Grove	2722	48.4%	29.2%	17.0%	5.3%	Yes
SITE H San Diego	6818	50.2%	19.1%	18.3%	12.2%	Yes
SITE I San Diego	2903	60.4%	15.6%	12.5%	11.4%	Yes

As indicated in the Table V-7, all nine GDFs had a relatively normal distribution of V/L ratios. Of the fueling transactions, 52.3% were in the ORVR category, and 17.7% was in the non-ORVR category. The detailed percentages of fueling transaction are displayed in Figures V-10 to V-18. It is important to note that staff observed that six GDFs have a percentage of greater than 10 of V/L above 1.15, which could have led to possible air ingestion. Only 2 of those GDFs displayed PWD.

<sup>8</sup> All fueling transactions are included in the original set of 4,000. However for data analysis simultaneous fueling transactions and fueling events with less than three gallons were filtered out to the date set.

Figure IV-10: V/L Histogram – SITE A Campbell

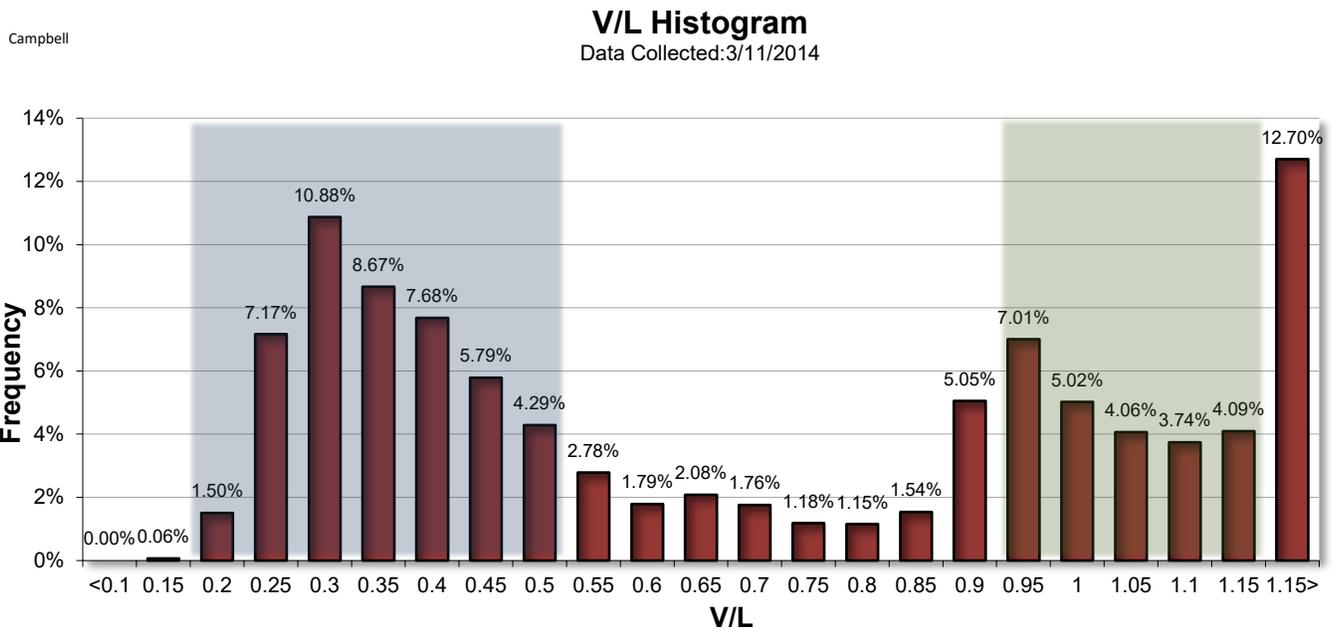
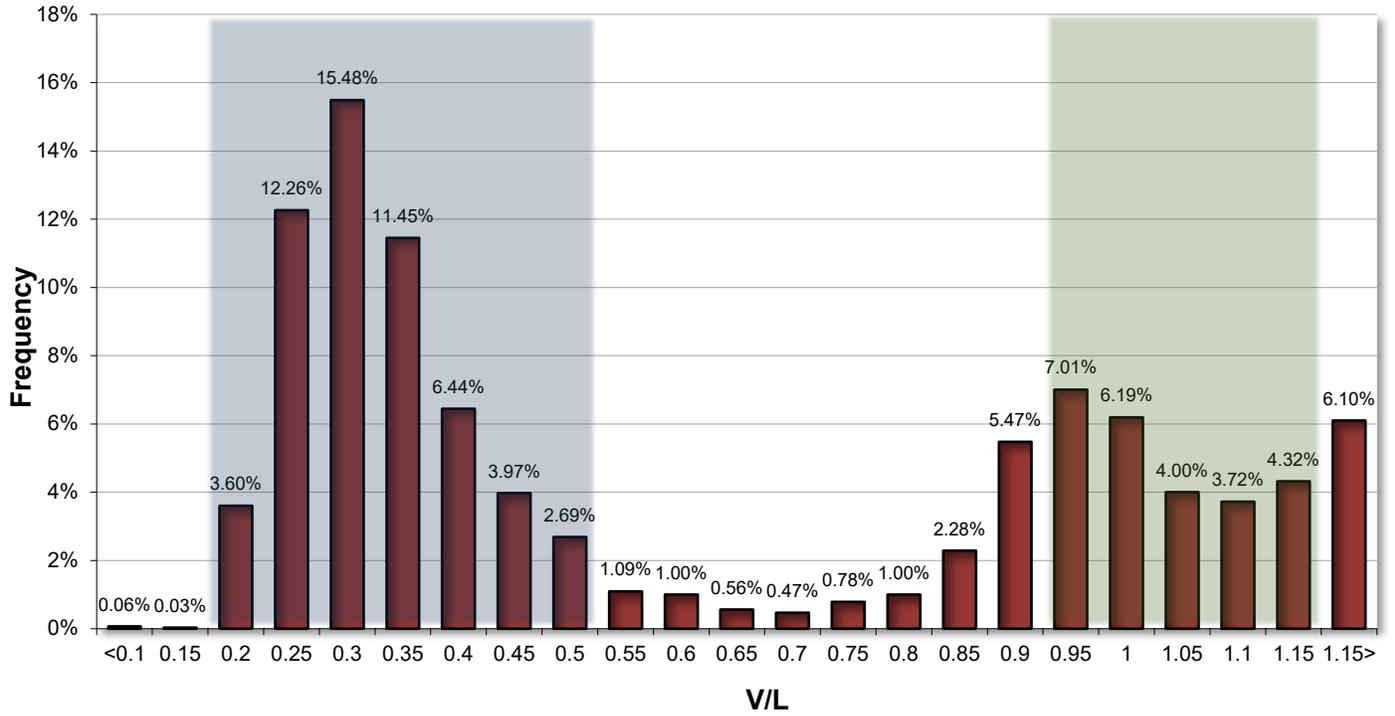


Figure IV-11: V/L Histogram – SITE B Redwood City

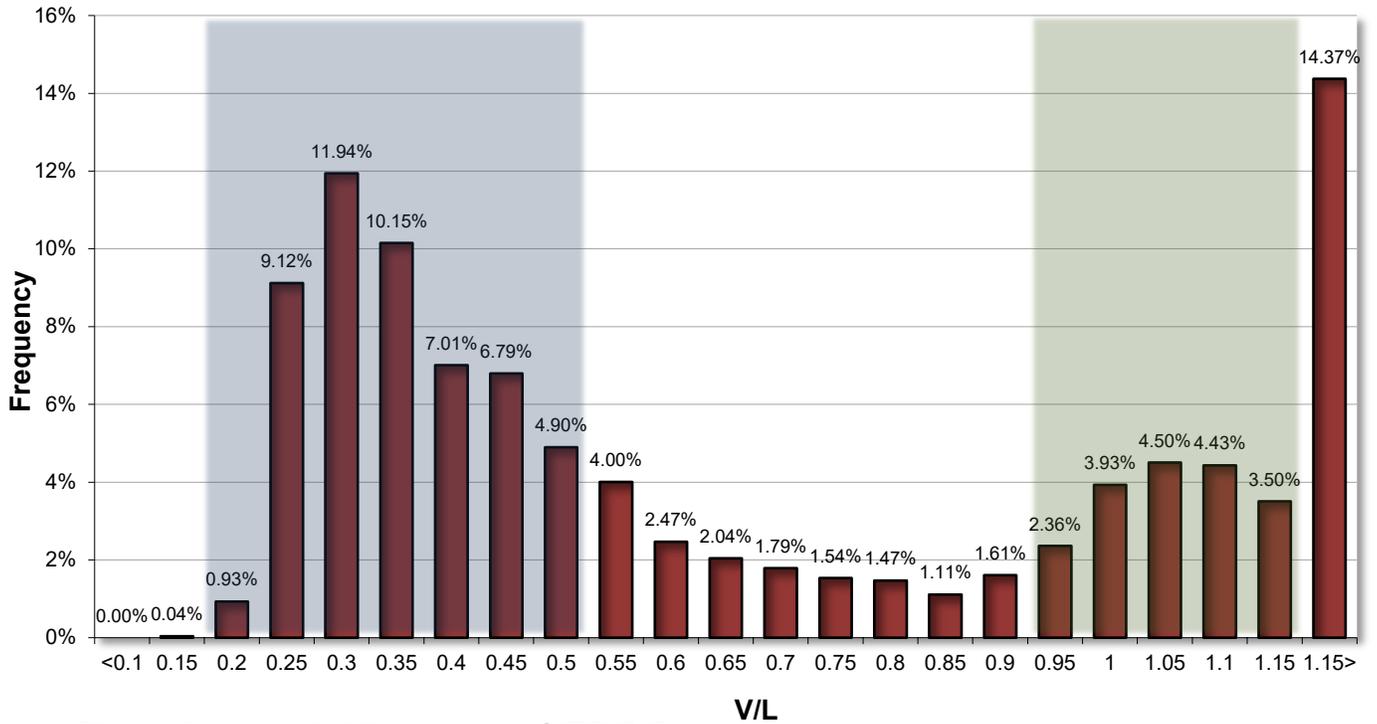
V/L Histogram  
Data Collected: 3/12/2014

Total Fueling Events: 3197



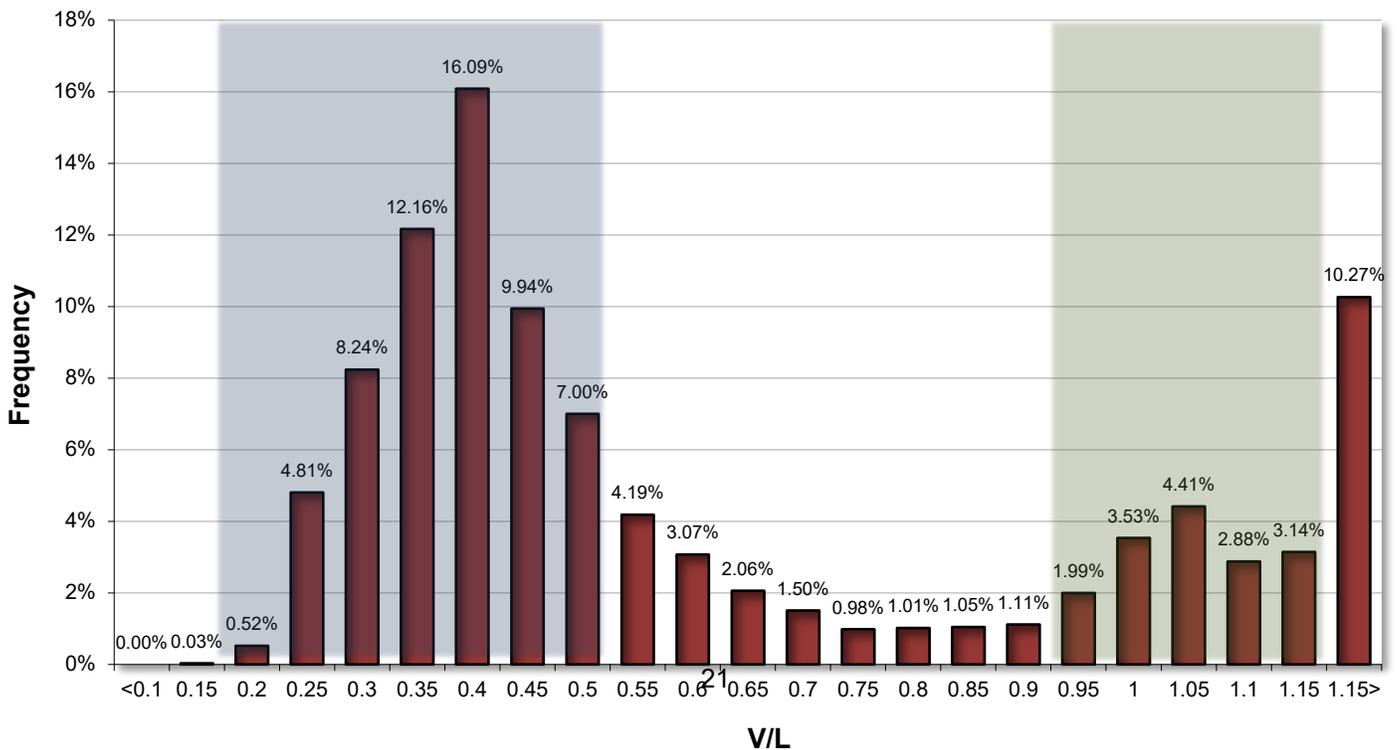
**Figure IV-12: V/L Histogram – SITE C Madera**

Total Fueling Events: **2797**



**Figure IV-13: V/L Histogram – SITE D Fresno**

Total Fueling Events: **3058**



**Figure IV-14: V/L Histogram – SITE E La Canada-Flintridge**

8

Total Fueling Events: **2891**

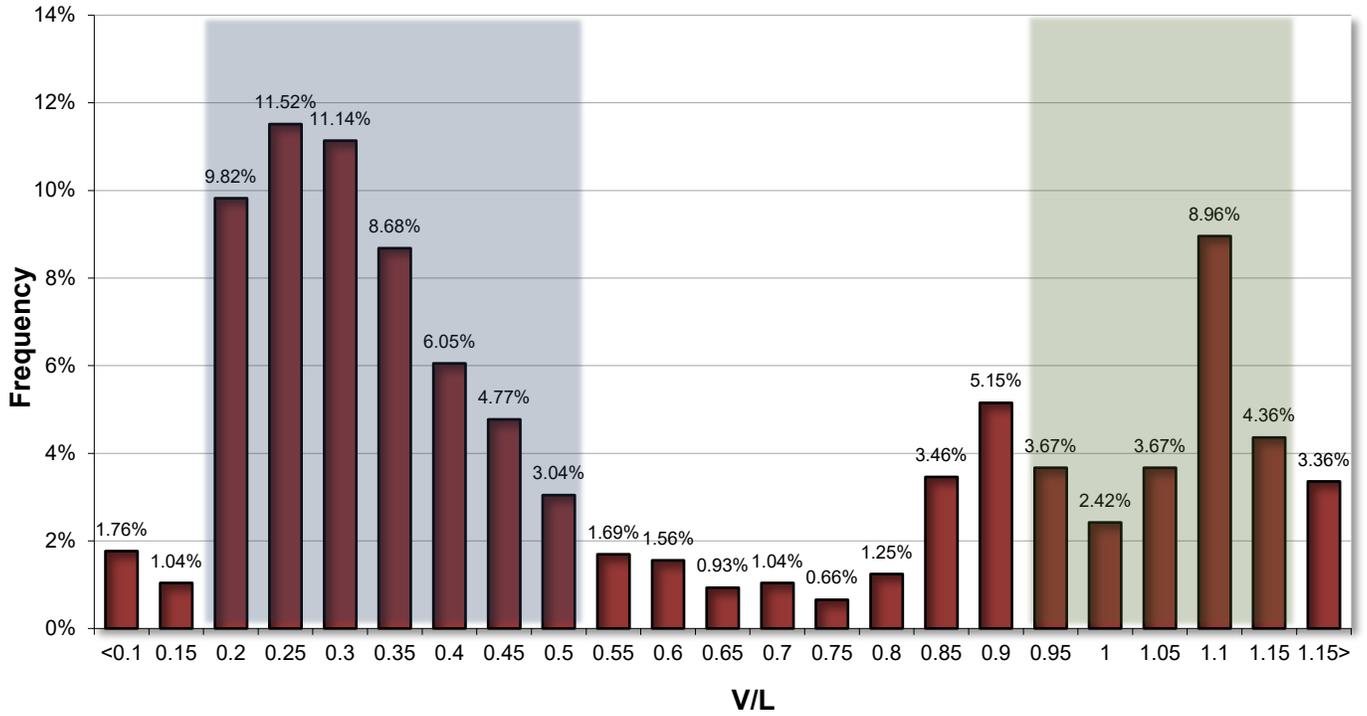
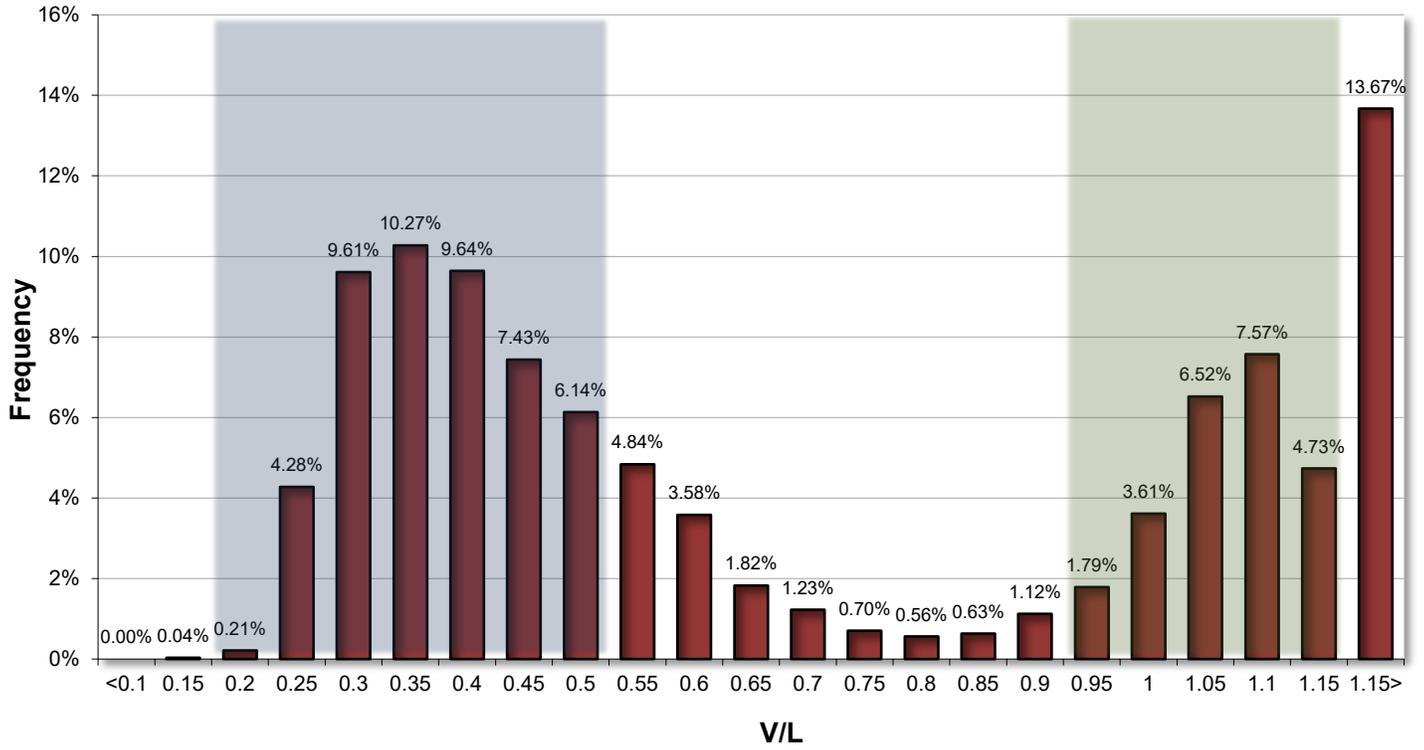


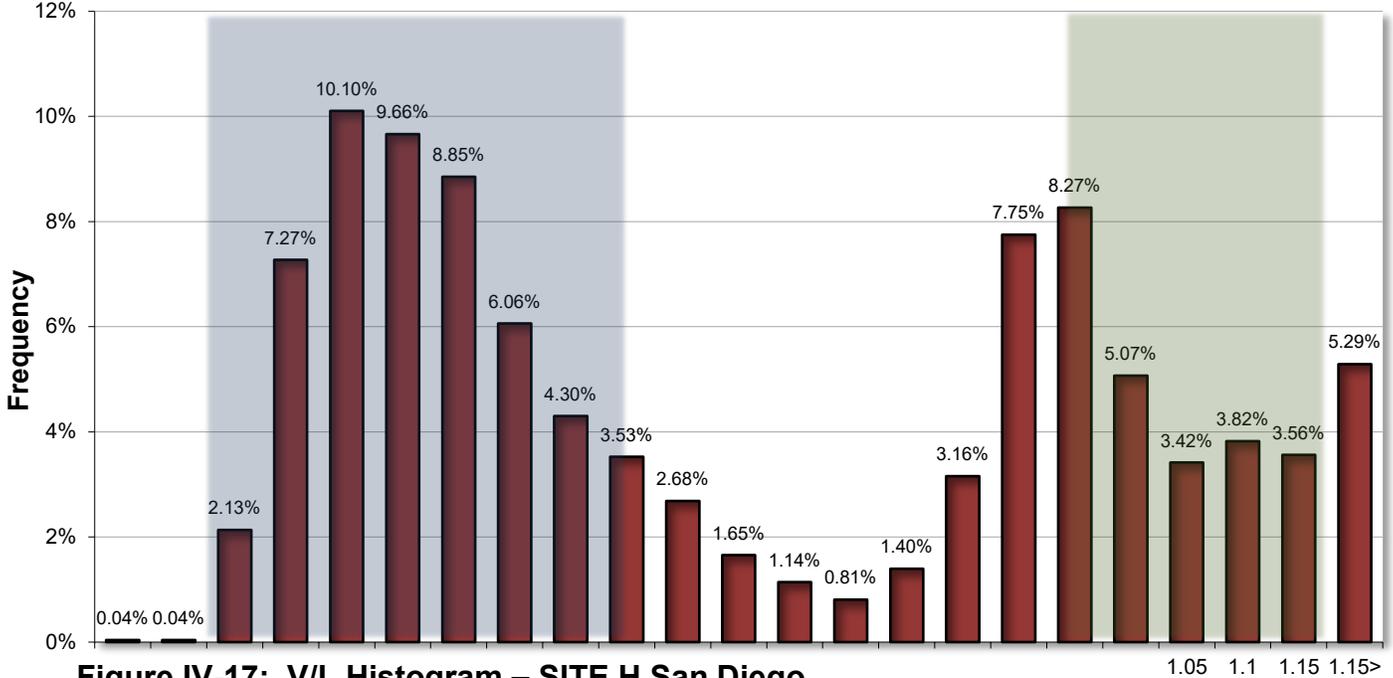
Figure IV-15: V/L Histogram – SITE F Hacienda Heights

Total Fueling Events: 2852



**Figure IV-16: V/L Histogram – SITE G Garden Grove**

Total Fueling Events: **2722**



**Figure IV-17: V/L Histogram – SITE H San Diego**

Total Fueling Events: **6818**

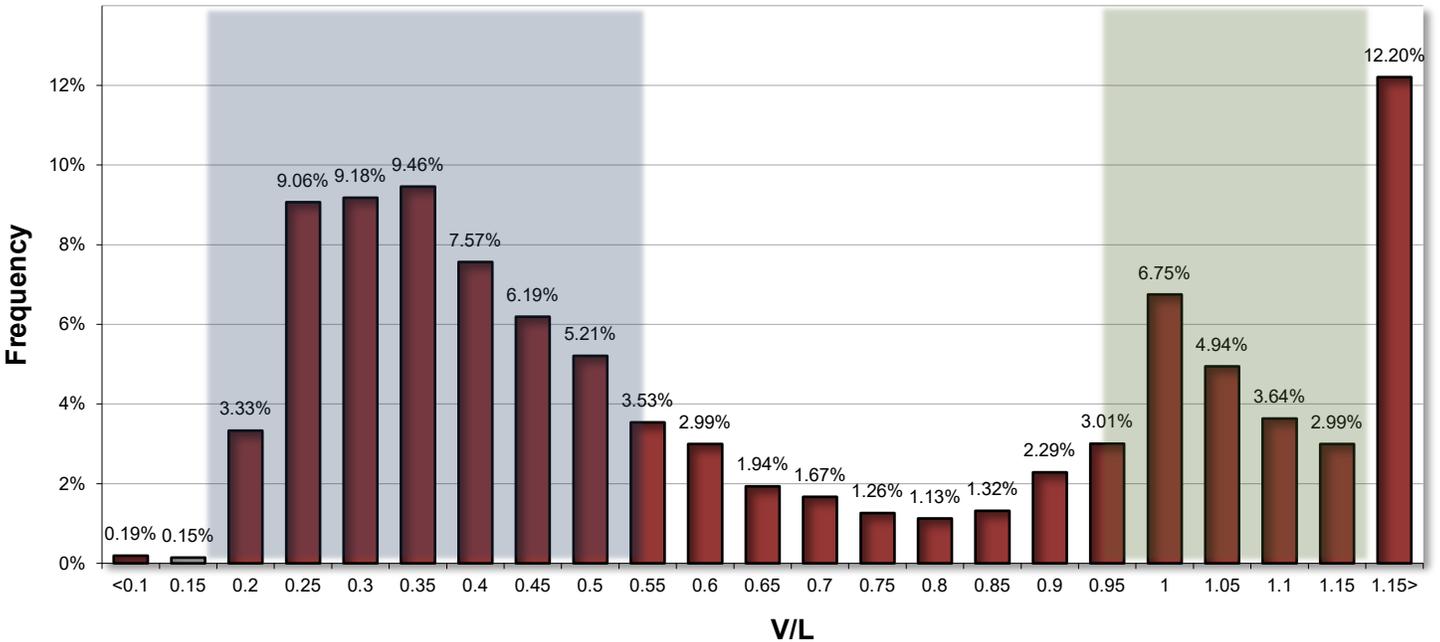
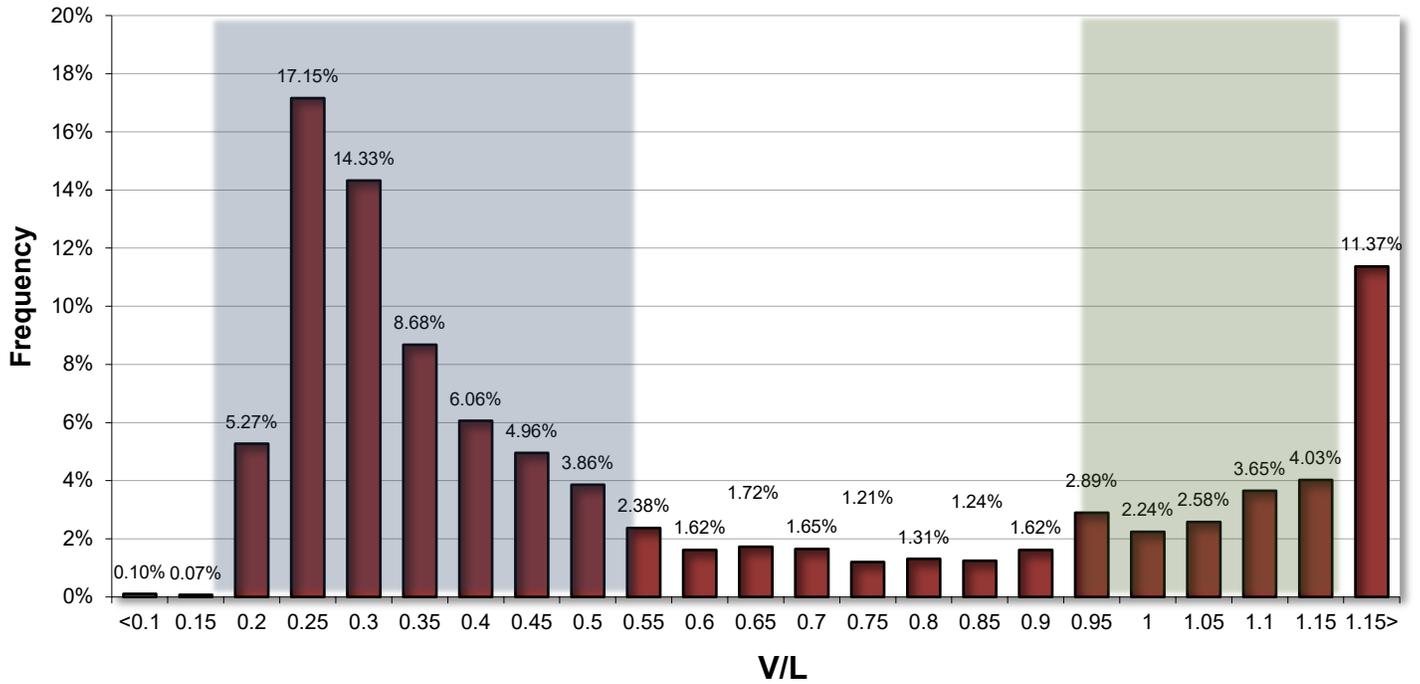


Figure IV-18: V/L Histogram – SITE I San Diego

Total Fueling Events: 2903



## V. DISCUSSION

As previously stated in Section III of this report, the objective of this evaluation was to determine if readily identifiable vapor recovery component failures are responsible for the occurrence of PWD at GDFs equipped with the Assist Phase II EVR systems. Based upon review of test results from seven of the nine GDFs and analysis of ISD data collected at nine GDFs, which previously exhibited PWD, answers are provided below:

**Question 1:** Are low fuel dispensing rates observed at GDFs that routinely exhibit PWD?

**Answer:** No, low flow rates were not observed at all seven GDFs, yet all exhibited PWD either in December or February. The range of flow rates observed was between 7.5 gallons per minute and 9.0 gallons per minute which is within normal operating parameters for the assist nozzle.

**Question 2:** Are GDFs that routinely exhibit PWD equipped with assist nozzles with V/L ratios being adjusted excessively high?

**Answer:** No, V/L ratios observed at all seven GDFs indicate that the nozzles were adjusted on the low end of the allowable range, or slightly below the acceptable range (0.95-1.15). This suggests that over collection on non-ORVR vehicles need not occur for a GDF to exhibit PWD.

**Question 3:** Are GDFs that routinely exhibit PWD equipped with ISD components that have malfunctioned, or are out of calibration, which ultimately lead to false alarms?

**Answer:** No, ISD vapor pressure sensors and ISD vapor flow meters at all seven GDFs were found perfectly operational and well within acceptable calibration range and settings.

**Question 4:** Are GDFs that routinely exhibit PWD experiencing a high number of leaks within the vapor return piping of the dispensers?

**Answer:** Four GDFs were found with dispenser leaks and three GDFs were not. The one of the four GDFs that continued to exhibit PWD had a passing rate of 75% (12 out of 16 dispensers passed); the three GDFs which no longer exhibited PWD had a passing rate of 83% (10 out of 12 dispensers passed). Dispenser leaks can contribute PWD, but due to the absence of leaks at three GDFs, a solid conclusion cannot be drawn.

**Question 5:** Are common or readily identified vapor recovery equipment failures observed at GDFs that exhibit PWD? In other words, is there a common trend or “smoking gun” which would explain why PWD is present?

**Answer:** Based on the results of this testing and analysis of ISD data, a total of four GDFs were found to be operating optimally which means no equipment

failures were observed. This suggests that a fully optimized Phase II vapor recovery system can still exhibit PWD. This finding suggests that either ARB's existing test methods are not capable of detecting the "smoking gun," or that other operating characteristics (such as vehicle fill pipe interface compatibility) should be explored. There was not common equipment defect identified.

**Question 6:** Do GDFs that routinely exhibit PWD also exhibit an irregular distribution of V/L ratios for individual fueling transaction?

**Answer:** No, GDFs which routinely exhibit PWD do not exhibit an irregular distribution of V/L ratios for individual fueling transactions.

Appendix I, II, and III provides the full test results and the raw ISD data captured at each GDF included in this experiment. Overall, the majority of vapor recovery components tested performed within the defined requirements of Executive Order VR-202.

## **VI. CONCLUSION**

Upon review and analysis of the test results and data collected from the ISD system at each GDF, ARB staff has concluded that PWD is not caused by a readily identifiable vapor recovery equipment failure and that existing compliance test procedures and troubleshooting techniques are unable to identify a common characteristic or "smoking gun" which can explain the occurrence of PWD at some GDF and the absence at others.

The experiment does however confirm that uncontrolled Reid Vapor Pressure (RVP) winter blend gasoline is a primary contributor to PWD and overpressure, and that new field studies and additional investigative work is needed to identify key secondary and tertiary contributors.

## **VII. APPENDICES**

### **Appendix I: Pressure Ullage Data for Nine GDFs**

- Appendix I-1: SITE A Campbell
- Appendix I-2: SITE B Redwood City
- Appendix I-3: SITE C Madera
- Appendix I-4: SITE D Fresno
- Appendix I-5: SITE E La Cañada Flintridge
- Appendix I-6: SITE F Hacienda Heights
- Appendix I-7: SITE G Garden Grove
- Appendix I-8: SITE H San Diego
- Appendix I-9: SITE I San Diego

### **Appendix II: Field Test Data for Seven GDFs**

- Appendix II-1: SITE A Campbell
- Appendix II-2: SITE B Redwood City
- Appendix II-3: SITE E La Cañada Flintridge
- Appendix II-4: SITE F Hacienda Heights
- Appendix II-5: SITE G Garden Grove
- Appendix II-6: SITE H San Diego
- Appendix II-7: SITE I San Diego

### **Appendix III: ISD Data for Histogram for Nine GDFs**

- Appendix III-1: SITE A Campbell
- Appendix III-2: SITE B Redwood City
- Appendix III-3: SITE C Madera
- Appendix III-4: SITE D Fresno
- Appendix III-5: SITE E La Cañada Flintridge
- Appendix III-6: SITE F Hacienda Heights
- Appendix III-7: SITE G Garden Grove
- Appendix III-8: SITE H San Diego
- Appendix III-9: SITE I San Diego

Appendices will be provided upon request