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AIR RESOURCES BOARD

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

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Overpressure Study

Technical Support Document
Nozzle Replacement Study at Gasoline Dispensing Facility Equipped with Assist Phase II Enhanced Vapor Recovery System Exhibiting Pressure Increase While Dispensing

December 6, 2016

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Executive Summary

In November of 2014, Air Resources Board (ARB) staff conducted a nozzle replacement study at a retail gasoline dispensing facility (GDF) equipped with the Healy Assist Phase II Enhanced Vapor Recovery System (Assist System) located in Torrance, California. The purpose of the study was to determine whether or not replacement of existing, presumably worn/fatigued "in-use" nozzles with new, presumably optimized nozzles would help reduce the frequency of In-Station Diagnostics (ISD) overpressure alarms.

The GDF selected for this study routinely exhibited a severe form of overpressure known as "pressure increase while dispensing" or "PWD"[1] throughout the winter period, when gasoline sold is not subject to ARB regulations which limit Reid vapor pressure.

Prior to installing new nozzles, ARB staff conducted performance tests at the facility to verify the vapor recovery system was operating in compliance with applicable regulatory performance standards and specifications. Other than five of the existing nozzles being below the allowable range for vapor to liquid ratio, the vapor recovery system was found to be in compliance with all applicable standards.

Within 24 hours of conducting the performance tests, new nozzles were installed at each fueling position. The vapor to liquid (V/L) ratio of each nozzle was then adjusted between 0.95 and 1.01 which is at the low end of the allowable range of 0.95 and 1.15. Pertinent ISD data including underground storage tank pressure, individual fueling transactions, and ISD overpressure alarm frequency was collected for 72 hours before and for 72 hours after nozzle replacement.

Upon review and analysis of the data collected, the installation of new nozzles was not effective in reducing the frequency of overpressure alarms or eliminating PWD. This finding is based on three observations. First, there was no significant change in underground storage tank pressure. Second, there was no significant change in the vapor to liquid ratio performance of the nozzles. Third, there was no change in ISD overpressure alarm frequency at the facility.

The results of this study suggest that factors other than the condition of "in-use" nozzles (aged or worn nozzles) should be investigated as key contributors to overpressure conditions at GDFs equipped with the Assist System. This study also suggests that adjusting the V/L ratio to the lower end of the allowable range did not reduce the frequency of overpressure alarms or mitigate PWD.

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[1] PWD indicates that pressure within the headspace of the underground storage tanks was sufficient to open/crack the pressure relief valve for extended periods of time. PWD is observed at GDF equipped with the assist system primarily during the winter blend fuel season. PWD is of concern because gasoline vapors are released directly to atmosphere from the underground storage tank emergency vent valve.

I. Introduction

In November of 2014, Air Resources Board (ARB) staff conducted a field study to determine if the installation of new, presumably fully optimized, nozzles would help mitigate overpressure conditions which commonly occur at gasoline dispensing facilities (GDF) equipped with the Healy Assist Phase II Enhanced Vapor Recovery System (Assist System). Several stakeholders have suggested that replacement of existing “in-use” nozzles should help mitigate overpressure conditions because existing nozzle performance may have diminished over time due normal wear and tear and/or component fatigue that commonly occurs in the often abusive environment of retail GDFs. The condition of the vapor boot, spout latch ring, vapor valve, and ORVR[2] recognition diaphragm of the assist nozzle are considered critical components which if compromised, can contribute to overpressure. The theory being tested by this study was that the installation of new nozzles should provide improved performance and thus help mitigate the overpressure condition.

II. Background

In California, GDFs with an annual gasoline throughput of greater than 600,000 gallons per year are required to install an ARB certified ISD system. The ISD system monitors a range of vapor recovery operating parameters and alerts the operator to equipment problems so that corrective action can be taken in a timely manner. Among the parameters monitored by ISD is the pressure within the headspace of the GDF underground storage tanks (UST). If the pressure exceeds a certain threshold which could lead to atmospheric venting, an overpressure alarm is triggered, alerting the station operator to call a service technician. Beginning in 2008, ARB became aware of that an unusually high number of ISD overpressure alarms were being reported by GDF operators during the winter months with no readily identifiable equipment problem.

In the fall of 2013, ARB staff initiated an extensive field study to better understand the underlining causes of ISD overpressure alarms and the occurrence of PWD. This field study involved downloading ISD data from approximately 400 GDF throughout the state and was conducted in close collaboration with local air districts. One of the key findings from this study was that GDF equipped with the Assist System which exhibit PWD also exhibit an elevated vapor to liquid (V/L) ratio site average. This elevated V/L ratio suggests that the assist nozzle is ingesting excess air due to a poor seal at the vehicle fill pipe interface.

For the assist system to work properly, the Healy nozzle must limit the amount of air ingestion when refueling vehicles equipped with On-Board Refueling Vapor Recovery or ORVR[2]. This is referred to as ORVR vehicle recognition and relies upon a tight seal being formed at the nozzle and vehicle fill pipe interface. A tight seal can be

[2] On-Board Refueling Vapor Recovery (ORVR) was introduced in 1998 model year vehicles. By the 2006 model year, ORVR fully implemented throughout the vehicle fleet. The ORVR system consists of a carbon canister which collects the vapors displaced from the filling of the vehicle tank. The collected vapor is then combined with air and combusted by the engine when the vehicle is driven.

compromised by worn or improperly maintained nozzle components, such as the boot and spout latch ring. Additionally, the assist nozzle relies upon a diaphragm to contract when refueling ORVR vehicles. If this diaphragm is inoperable due to age/fatigue, excess air will be ingested by the nozzle.

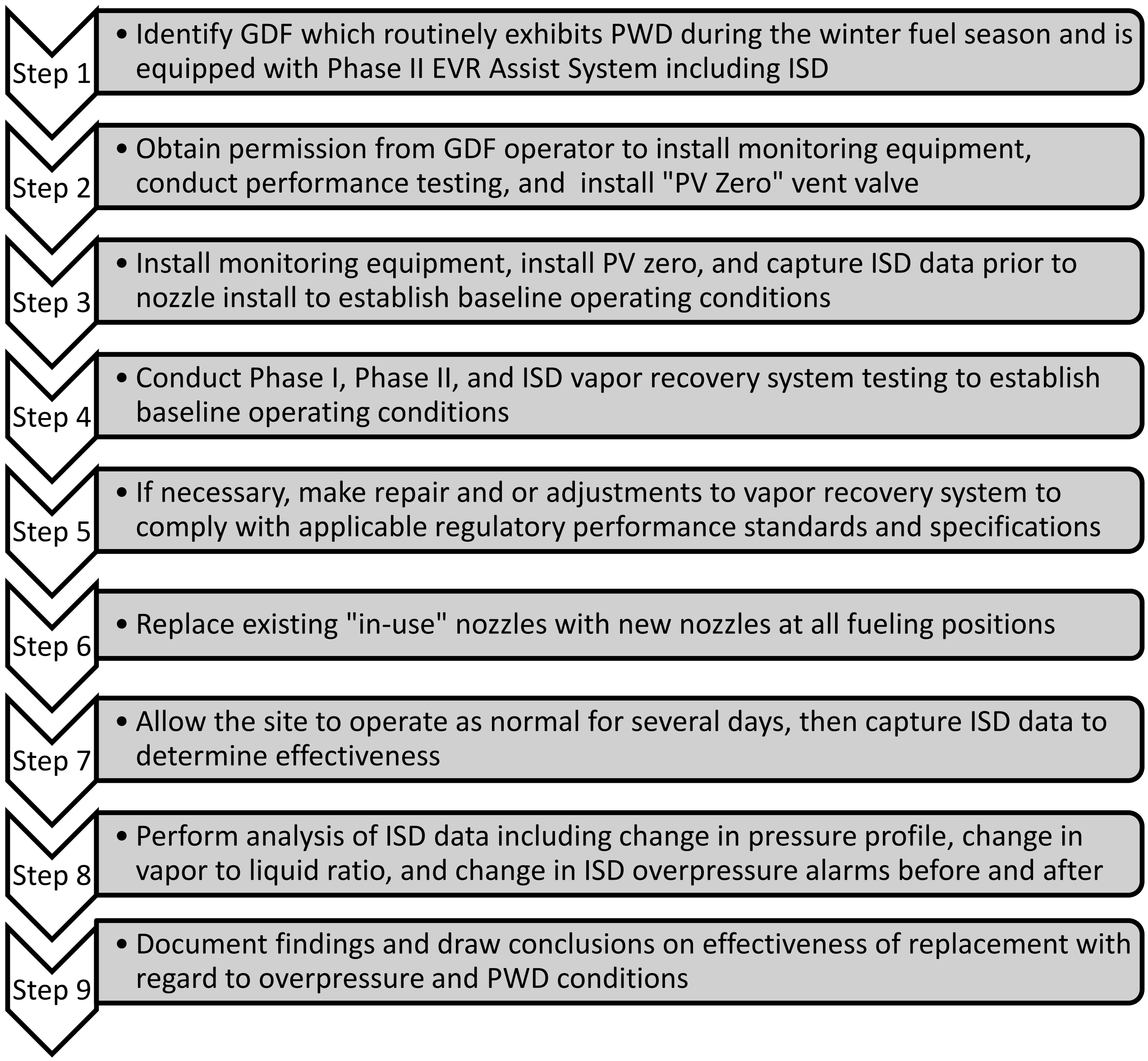
In May, 2014, ARB staff formed a "Working Group" with the California Air Pollution Control Officers Association (CAPCOA) Vapor Recovery Subcommittee to assist with analyzing the field study data and identifying potential causes and solutions to the overpressure phenomena.

For these reasons, the Working Group identified "in-use" assist nozzle wear and tear and/or component fatigue as a potential primary contributor to overpressure. If proven correct, the solution to overpressure would be very straightforward, simply replace or better maintain existing "in-use" nozzles.

III. Methodology

ARB staff with input from the CAPCOA Working Group, developed a multi-step methodology for the nozzle replacement study. The assist nozzle would be the "manipulated variable" while all other vapor recovery system components were considered "controlled variables" and were not to be altered with the exception of bringing them into compliance with regulatory performance standards and specifications. As depicted in Figure 1, the methodology involved identification of a GDF which exhibits PWD, installation of an ISD data acquisition system, validation a properly operating vapor recovery system, replacement of nozzles, capture of pertinent ISD data, and lastly, comparison of key benchmarks before and after nozzle replacement.

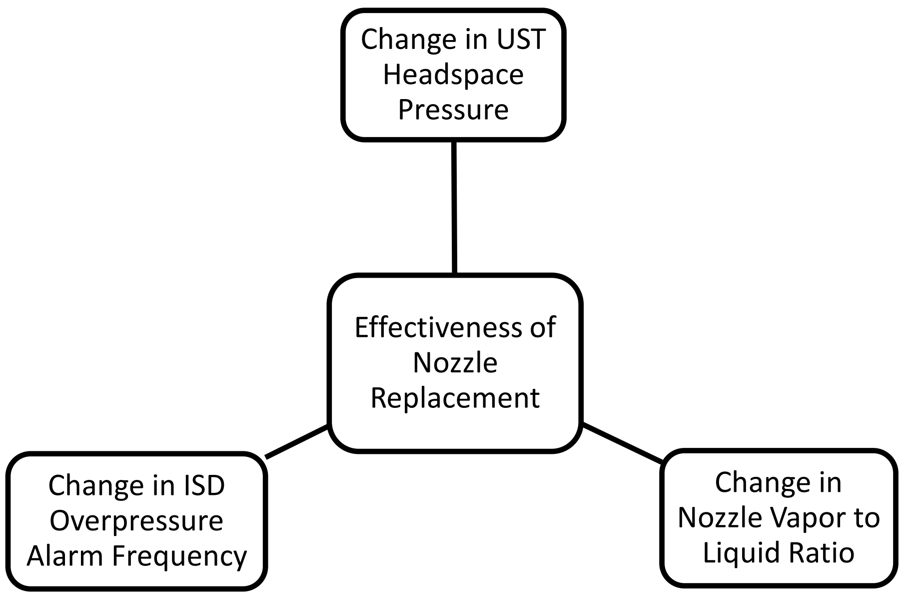
Figure 1: Multi Step Methodology for Nozzle Replacement Study



III.1: Determining Effectiveness of Replacing Nozzles

Three benchmarks were identified as a means to measure the effectiveness of the nozzle replacement with regard to overpressure mitigation. These benchmarks include: 1) change in UST headspace pressure (relies on data captured by the ISD vapor pressure sensor); 2) change in vapor to liquid ratios observed on individual fueling transactions (relies on the fueling transaction information captured by the ISD vapor flow meter); and 3) change in ISD overpressure alarm frequency (relies on the ISD system monthly report). For ease of comparison, these benchmark calculations were conducted 72 hours before and 72 hours after the nozzle replacement.

Figure 2: Benchmarks Used to Determine Effectiveness of Nozzle Replacement



III.2: Chronology of Events

The nozzle replacement study was conducted over the course of three weeks during the month of November of 2014. November 1st is a significant date for any overpressure related field study because that's when RVP controls for gasoline are lifted at the GDF. November 1st represents the beginning of the winter fuel season. Permission from the GDF operator was granted on November 3, 2014. Baseline ISD data was captured on November 7th. Vapor recovery system testing, repair, and nozzle replacement occurred over a three day period from November 10 to 12. ISD data was again downloaded on November 17, 2014 following nozzle replacement. Additional details are provided in the table below.

Table 1: Chronology of Events

Date	Description of Activity
11/03/14	Permission received from GDF operator to conduct experimentation at retail facility in Torrance known to routinely exhibit PWD during winter fuel season
11/07/14	Remotely downloaded ISD pressure ullage data and fueling transaction data Conducted analysis to verify existence of PWD and document baseline operating conditions
11/10/14	Conducted leak decay test (TP-201.3) at GDF to ensure containment system was properly maintained
11/11/14	Conducted dispenser integrity test (IOM Section 18) Conducted V/L testing on all 8 fueling points (Exhibit 5 of VR-202) Conducted ISD flow meter operability on each dispenser (Exhibit 9 of VR-202) Downloaded ISD (Pressure/Ullage and Fueling Event)
11/12/14	Replaced existing "in-use" nozzles with new nozzles Adjusted new nozzle V/L to lower end of allowable range, 0.95 to 1.01 (Exhibit 5 of VR-202) Manually downloaded ISD
11/17/14	Remotely downloaded ISD pressure ullage data and fueling transaction data and conducted analysis to verify existence of PWD

III.3: Test Site Selection and Description

The gasoline dispensing facility listed in Table 2 was selected by ARB staff as an ideal study site for three compelling reasons. First, ARB staff had previously installed a data acquisition system which enables continuous capture and storage of desired ISD data. Secondly, ARB staff had previously installed a “PV Zero” pressure vacuum vent valve on the underground storage tank vent lines to eliminate potential leak issues which commonly occurred with mechanical valves. Third, for reasons not yet fully understood, this facility consistently exhibited PWD upon introduction of the winter fuel season.

In terms of vapor recovery system, the test site was equipped with the Phil Tite Phase I EVR and Assist Phase II EVR system including Veeder-Root ISD with version 1.04 software. The facility had 8 uni-hose fueling points, three underground gasoline storage tanks, and had a monthly gasoline throughput of about 115,000 gallons. Additional GDF operating parameters are detailed in the table below.

Table 2: Description of Assist Nozzle Replacement Test Site

GDF Location	Torrance, CA
Monthly Gasoline Throughput	~115,000 gallons
Number of Fueling Points	8 (unihose)
Number of UST	2 Unleaded Regular 1 Unleaded Premium
Vapor Recovery System	Phase I: Phil Tite EVR Phase II: Healy Assist EVR
ISD System	Veeder-Root with Software Version 1.04
Secondary Containment	Non-VPH
Turbine Configuration	Variable Speed, FE Petro
Hours of Operation	24 hours/ 7 days per week
PWD History	Observed in 2012, 2013, 2014
Pressure Vacuum Vent Valve	“PV Zero”
ISD Data Acquisition System	Inform Software Version 4.1

IV. Results of Vapor Recovery System Performance Testing

On November 10 and 11, ARB staff conducted Phase I and Phase II vapor recovery system performance testing (including ISD operability) in order to establish baseline operating conditions of the facility. This testing was deemed necessary to determine if the existing vapor recovery system was operating in accordance with regulatory performance standards and specifications. If vapor recovery equipment were found not operating within regulatory standards and specifications, the results of installing new nozzles would be invalid. In addition to ARB staff, South Coast Air Quality Management District and Franklin Fueling Systems personnel were on-site to observe testing, document results, and assist with the proper installation and initial adjustment of the new nozzles.

The following table provides a description and results of the baseline vapor recovery system testing conducted prior to nozzle replacement. Other than vapor to liquid ratios (V/L) found slightly below allowable range on five of the existing nozzles, the existing Phase I, Phase II and ISD system were each found to be in full compliance with the regulatory performance standards and specifications. Because data collected by the ISD vapor pressure sensor and the ISD vapor flow meters are relied upon to evaluate the effectiveness of nozzle replacement, the full test results are provided in dedicated tables below. In addition, because nozzle dispensing rates and vapor to liquid ratios are critical contributors to overpressure (if improperly adjusted, can cause excess air ingestion) the full data set is provided in Appendix I of the report.

Table 3: Summary of Baseline Vapor Recovery System Performance Testing Before Nozzle Replacement

ARB Test Method	Description	Result
TP-201.3	Leak Decay	PASS
VR-202 IOM 18	Dispenser Integrity	PASS
VR-202 Exhibit 5	Vapor to Liquid Ratio of Existing Nozzles	**FAIL** (see discussion and data table below)
	Vapor to Liquid Ratio of New Replacement Nozzles	PASS (see discussion and data table below)
VR-202 Exhibit 5	Nozzle Dispensing Rate	PASS
VR-202 Exhibit 4	Clean Air Separator	PASS
VR-202 Exhibit 9	ISD Operability: Vapor Flow Meter	PASS (see discussion data table below)
VR-202 Exhibit 9	ISD Operability: Vapor Pressure Sensor	PASS (see data table below)
TP-201.1E	Pressure Vacuum Vent Valve	PASS - Visual inspection of fluid level

IV.1. Vapor to Liquid (V/L) Ratios of Existing Nozzles

On November 11, ARB staff conducted Exhibit 5 of Executive Order VR-202: Vapor to Liquid (V/L) Ratio on the existing nozzles. According to Exhibit 2 of Executive Order VR-202, the proper V/L ratio of range of the assist system is 0.95 to 1.15. In addition, the fuel dispensing rate of each nozzle must be greater than six but less than ten gallons per minute.

The site average of the V/L ratio for the existing nozzles was 0.94. The site average dispensing rate was 8.2 gallons per minute. Three of the existing nozzles were found to be within proper range and five of the existing nozzles were found to be out of range, slightly less than 0.95. From an overpressure standpoint, being at the lower end of the range is believed to help mitigate overpressure. As liquid is displaced from the underground storage tank (UST), headspace is created if the V/L is less than one, more and more headspace is created which in turn, creates a vacuum condition in the UST.

In terms of nozzle age, the serial numbers of the existing nozzles indicate a manufacturer date range from 2008 to 2014. Three of the nozzles were manufactured in 2013, two in 2012, one in 2014, one in 2010 and one in 2008. The average age of the nozzles was approximately two years old. See Table 4 below.

Table 4: Results of Vapor to Liquid Ratio Testing on Existing Nozzles

Fueling Point	Nozzle Serial Number	Year Manufactured	Fuel Dispensing Rate (GPM)	Vapor to Liquid Ratio (V/L)[1]	Pass/Fail[2]
1	1614	2014	8.9	0.95	Pass
2	0113	2013	8.6	**0.92**	**Fail**
3	5013	2013	8.4	**0.89**	**Fail**
4	4310	2010	8.1	1.00	Pass
5	3413	2013	7.9	**0.89**	**Fail**
6	0812	2012	7.7	1.03	Pass
7	4712	2012	8.4	**0.88**	**Fail**
8	0408	2008	7.2	**0.92**	**Fail**

[1]As found condition, no adjustment to V/L ratio made by ARB staff.
[2]Allowable V/L range per Executive Order VR-202 is 0.95 to 1.15.

IV.2. Accuracy of Veeder-Root ISD Vapor Pressure Sensor

According to ARB Executive Order (EO) VR 202, the accuracy of the Veeder-Root ISD vapor pressure sensor must be validated once per year per Exhibit 9, the ISD operability test procedure. The ISD vapor pressure sensor was installed at the vapor return line at the dispenser labeled fueling point three and four. Under normal compliance testing situations, Exhibit 9 requires 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 underground storage tank. As indicated in the table below, 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 a high degree of confidence that the vapor pressure sensor was reading accurately throughout the full scale range. If the vapor pressure sensor was reading out of compliance, such finding would invalidate any data collected as part of this study.

In terms of acceptance criteria, the ISD vapor pressure sensor must be within ±0.2 inches WC from a recently calibrated and highly accurate portable digital manometer reading. If difference is not within ±0.2 inches WC, the ISD vapor pressure sensor is not in compliance with the requirements of Exhibit 2. As indicated in the table below, the ISD vapor pressure sensor was fully operational and sufficiently accurate to proceed with the nozzle replacement study.

Table 5: Results of ISD Vapor Pressure Sensor Operability Test

Target Pressure Value	ARB Digital Manometer Value *(inches WC)*	ISD Vapor Pressure Sensor Value *(inches WC)*	Difference	Allowable Difference	Pass/Fail
+ 5	5.01	4.95	0.06	0.20	Pass
+ 4	4.02	3.96	0.06	0.20	Pass
+ 3	3.01	2.95	0.06	0.20	Pass
+ 2	2.01	1.95	0.06	0.20	Pass
+ 1	1.00	0.94	0.07	0.20	Pass
0	-0.02	-0.04	0.02	0.20	Pass
- 1	-0.99	-1.02	0.03	0.20	Pass
- 2	-2.04	-2.02	-0.02	0.20	Pass
- 3	-3.01	-3.03	0.02	0.20	Pass
- 4	-4.02	-4.04	0.02	0.20	Pass
- 5	-5.00	-5.02	0.02	0.20	Pass

IV.3. Accuracy of Veeder-Root ISD Vapor Flow Meter

According to Executive Order VR-202, the accuracy of the Veeder-Root ISD vapor flow meter must validated once per year per Exhibit 9, the ISD operability test procedure. At this site, a total of four ISD vapor flow meters (one per dispenser) were installed. 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 reading out of compliance, such finding would invalidate any data collected as part of this study.

In terms of acceptance criteria, the ISD vapor flow meter V/L must read within ±0.15 of the reference meter specified in Exhibit 5 of EO VR-202. If difference is not within ±0.15, the ISD vapor flow meter is not in compliance and any data collected would be deemed invalid. As indicated in the table below all ISD vapor flow meters were found fully operational and sufficiently accurate to proceed with the nozzle replacement study.

Table 6: Results of ISD Vapor Flow Meter Operability Testing

Fueling Point	ISD Flow Meter	Vapor to Liquid Ratio (V/L)					
		Run	ARB Reading	ISD Reading	Difference	Allowable Difference	PASS / FAIL
1	1	1	0.95	0.94	0.01	0.15	PASS
2	1	2	1.01	0.96	0.05	0.15	PASS
3	2	2	0.95	0.92	0.03	0.15	PASS
4	2	1	0.99	0.98	0.01	0.15	PASS
5	3	1	0.92	0.91	0.01	0.15	PASS
6	3	1	1.08	1.07	0.01	0.15	PASS
7	4	3	0.98	0.96	0.02	0.15	PASS
8	4	1	0.91	0.91	0.00	0.15	PASS

IV.4. Vapor to Liquid Ratios of Replacement Nozzles (New Nozzles)

All eight new nozzles were installed and V/L setting adjusted to the lower end of the allowable range on the morning of November 12. After the nozzle replacement and adjustment, the site average of vapor to liquid ratio for the new nozzles was 0.97. The site average fuel dispensing rate was 8.2 gallons per minute. In terms of nozzle age, the serial numbers of the new nozzles indicate a manufacturer date between the 32nd and 36th week in calendar year 2014. The table below provides the results of the installation and adjustment of each nozzle's vapor to liquid ratio.

Table 7: Results of Vapor to Liquid Ratio Testing on Replacement Nozzles

Fueling Point	Nozzle Serial Number	Fuel Dispensing Rate	Vapor to Liquid Ratio (V/L)*	Allowable V/L Range Per VR-202	Pass/Fail
1	3614	8.4	0.95	0.95-1.15	Pass
2	3614	8.4	1.01	0.95-1.15	Pass
3	3614	8.6	0.95	0.95-1.15	Pass
4	3214	8.2	0.99	0.95-1.15	Pass
5	3214	7.7	0.96	0.95-1.15	Pass
6	3214	7.2	0.99	0.95-1.15	Pass
7	3314	8.7	0.98	0.95-1.15	Pass
8	3214	8.4	0.96	0.95-1.15	Pass

*After installation, adjustments were made to nozzle by ARB staff to the lower end of the allowable V/L range. This data set reflects the final adjustment value and does not include the baseline value of the new nozzle prior to adjustment, for full data set, see Appendix I.

V. Results of ISD Data Analysis Before and After Replacement

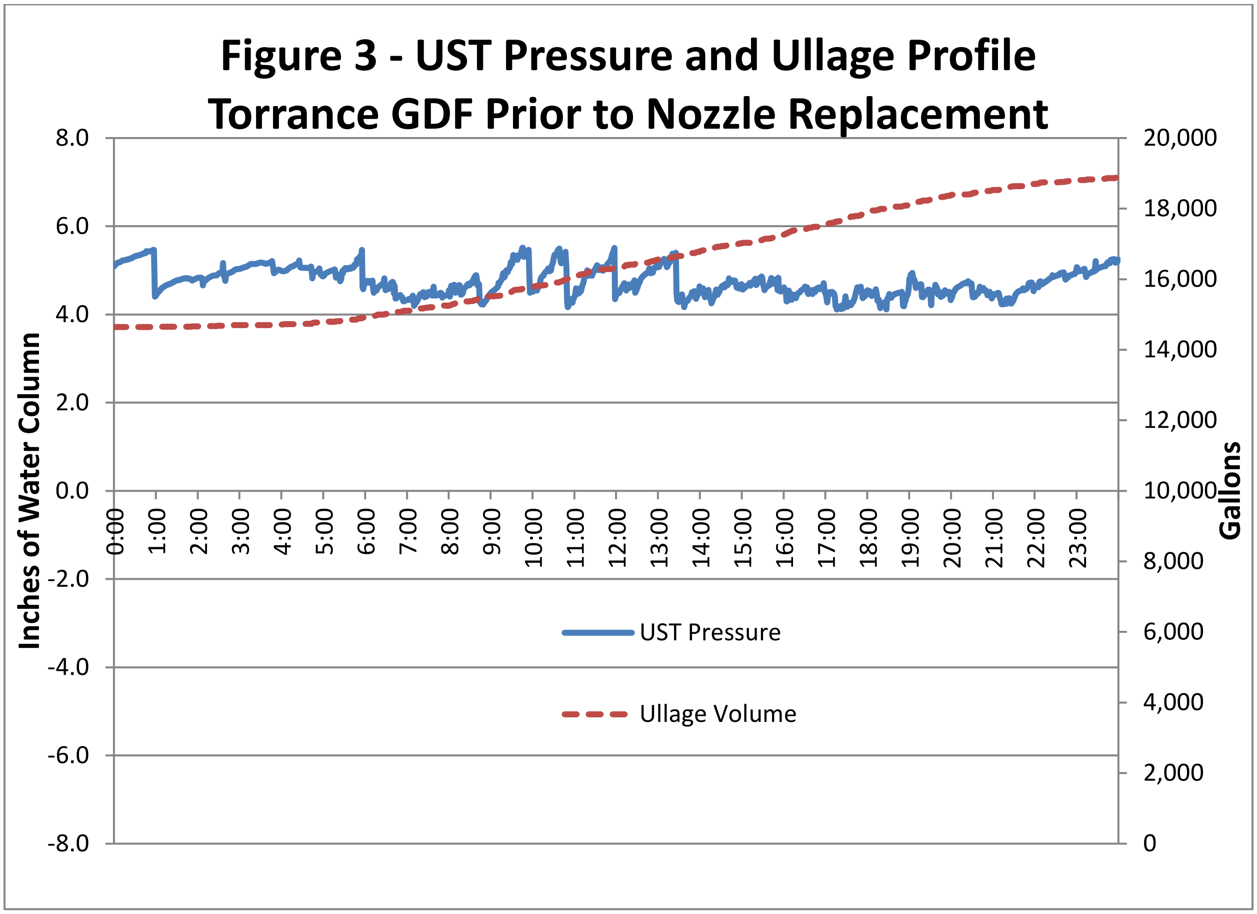
As indicated in Section 3 of this document (methodology), three benchmarks (all three captured by the ISD system) were used to evaluate the effectiveness of the nozzle replacement with regard to overpressure mitigation: change in UST pressure, change in nozzle vapor to liquid ratio performance, and change in ISD alarm response. This section of the report provides the results of data analysis with regard to all three benchmarks. For ease of reporting, data tables are used extensively throughout this section.

V.1. Change in Underground Storage Tank Pressure

The Veeder-Root ISD system records UST pressure and ullage volume once every 20 seconds and stores it for the most recent 30 hours of GDF operation. The installation of ARB's ISD data acquisition system allowed ARB staff to collect this information on a daily basis. As depicted in the Figure 3 and indicated in Table 8 below, an analysis of the UST pressure data between November 5 and November 7 reveals positive pressure conditions sufficient to open the pressure/vacuum vent valve on a near continuous basis throughout the 72 hours. This is confirmed by the graph in Figure 3, which shows the UST pressure hovering consistently near positive five (+5) inches water column, which indicates opening of the pressure/vacuum vent valve to relieve pressure. From an experimental stand point, this data provides evidence that proper site selection had been achieved because PWD was active. The supporting data for these calculations are available in Appendix III.

Table 8: UST Pressure Data Analysis Before Nozzle Replacement

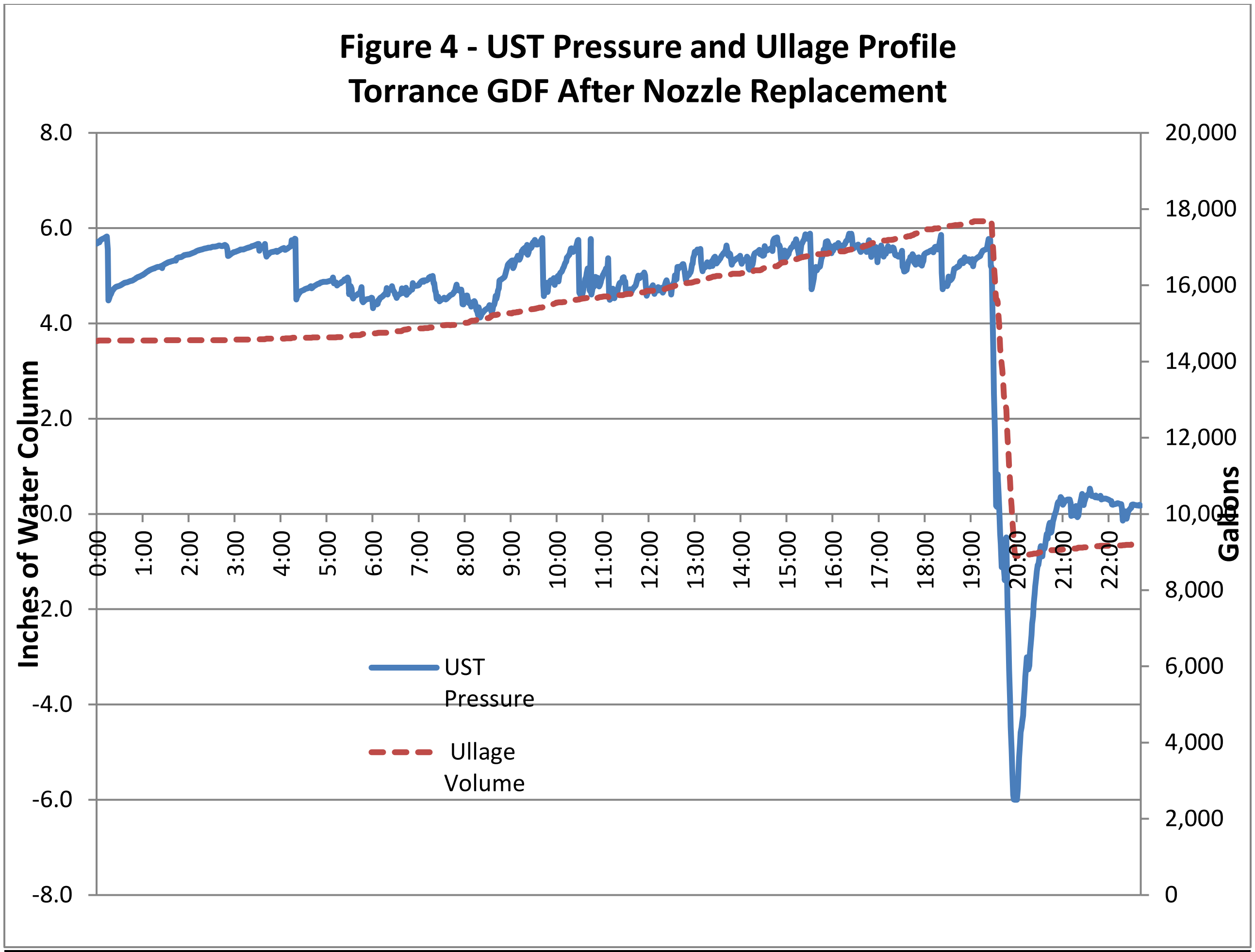
Date	Daily Min (inches water column)	Daily Max (inches water column)	Daily Average (inches water column)	PWD ?
11/5/2014	1.2	5.9	4.1	Yes
11/6/2014	1.6	5.6	3.7	Yes
11/7/2014	4.1	5.5	4.7	Yes



As depicted in the Figure 4 and indicated in Table 9 below, an analysis of the pressure data captured by the ISD system from November 12 through November 14 revealed that positive pressure conditions persisted for 72 hours immediately following the nozzle replacement. The daily average pressure values were still around 5 inches water column which indicates the pressure/vacuum vent valve was opening to relieve pressure. This suggests that replacing the nozzle did not affect the UST pressure.

Table 9: UST Pressure Data Analysis After Nozzle Replacement

Date	Daily Min (inches water column)	Daily Max (inches water column)	Daily Average (inches water column)	PWD?
11/12/2014	-6.0	5.9	4.3	Yes
11/13/2014	-0.1	5.8	3.6	Yes
11/14/2014	3.6	5.7	4.8	Yes



A side by side comparison of the average daily UST pressure before and after nozzle replacement is provided in Table 10. The average UST pressure for 72 hours immediately prior to nozzle replacement was positive 4.2 inches water column. The average UST pressure for the 72 hours immediately following the nozzle replacement (which occurred on 11/12/14) was 4.3 inches water column. The installation of new nozzles did not change the average daily UST pressure. This provides evidence that nozzle replacement was not effective in mitigating or preventing overpressure.

Table 10: Percent Change Before and After Nozzle Replacement

Description	Date Range of Data	UST Ullage Pressure Average (Inches water column)
Existing Nozzles	11/05/14 – 11/07/14	+4.2
Replacement Nozzles	11/12/14 – 11/14/14	+4.3
% Difference (existing nozzle considered baseline)		2% higher with new nozzle

V.2. Change in Vapor to Liquid Ratios

In addition to UST pressure data collected by the ISD system, vapor to liquid ratios for the most recent 1,000 fueling transactions are recorded by the ISD system for each dispenser installed on site. The test site was equipped with four dispensers, therefore, a total of 4,000 fueling transaction records were available for analysis. The data were downloaded from the ISD system and populated into an excel spread sheet. Key metrics can be calculated from this data including site average vapor to liquid (V/L) (all transactions liquid volume and vapor volume summed and divided), percentage of fueling events with a V/L less than 0.5 (calculated simply by sorting the data and filtering commands), percentage of fueling events with V/L greater than 0.5, and average volume of fuel dispensed per fueling transaction. A V/L ratio of less than 0.5 is presumed to be refueling an ORVR vehicle and a V/L of greater than 0.5 is fueling a non-ORVR vehicle. The following tables provide the results of analysis specific to vapor to liquid ratio before (Table 11) and after (Table 12) nozzle replacement.

Table 11: Analysis of Vapor to Liquid Ratios Before Nozzle Replacement

Date Range	11/05/14 - 11/07/14
Number of Fueling Transactions	1,017
Site Average V/L	0.61
% of Events V/L < 0.5	48%
% of Events V/L > 0.5	51%
Average Volume Per Fueling Transaction	8.61

Table 12: Analysis of Vapor to Liquid Ratios After Nozzle Replacement

Date Range	11/12/14 - 11/14/14
Number of Fueling Transactions	713
Site Average V/L	0.66
% of Events V/L < 0.5	45%
% of Events V/L > 0.5	55%
Average Volume Per Fueling Transaction	9.11

As indicated in the above tables, the replacement of the existing nozzles with new did not yield the results many stakeholders expected. The hypothesis being tested by this study was that the new nozzles would have improved ORVR vehicle recognition, thus a higher percentage of fuel events with a V/L less than 0.5 and a lower site average V/L. However, upon review of this data, the site average V/L actually increased from 0.62 to 0.66 which indicates slightly higher air ingestion. The percentage of fueling events with a V/L less than 0.5 decreased from 48% to 45%, this is also indicative of slightly higher air ingestion. These differences are likely attributed to the fact that the several (five/eight) of the existing nozzles were found with a V/L ratio slightly below the allowable range. When the new nozzles were installed, all eight nozzles were adjusted up into the allowable range. This data provides evidence that the installation of new nozzles did not improve ORVR recognition nor did it lower site average vapor to liquid ratio. The supporting data for these calculations are available in Appendix II.

V.3. Change in ISD Alarm Frequency

Throughout the month of November, 2014, a total of ten warning alarms (five overpressure related and five nozzle collection related) were recorded by the ISD system. Weekly overpressure alarms were triggered on November 2, 9, 16, 23, and 30. These alarms occur at a regular interval, once every seven days. Collection alarms (called A/L ratio degradation) were recorded on fueling position eight (FP8) on November 7, 8, 9, 10, and 11. The installation of the new nozzles on November 12th proved effective at eliminating the collection alarm on fueling position number eight as it never returned. However, the installation of new nozzles was not effective at mitigating the overpressure alarm. As shown in the data table below (obtained from the monthly ISD report for November 2014), overpressure alarms were recorded on November 16, 23 and 30 which are all dates after the installation of new nozzles.

Table 13: ISD Warning Alarms November 2014

DATE	TIME	DESCRIPTION	READING	VALUE
11/02/14	9:03:28	CONTAINMENT	GROSS OVER PRESSURE WEEKLY 95%	5.00
11/07/14	9:01:20	A/L RATIO	DEGRADATION FP 8	0.81
11/08/14	9:01:09	A/L RATIO	DEGRADATION FP 8	0.80
11/09/14	9:01:09	A/L RATIO	DEGRADATION FP 8	0.78
11/09/14	9:01:09	CONTAINMENT	GROSS OVER PRESSURE WEEKLY 95%	5.00
11/10/14	9:01:09	A/L RATIO	DEGRADATION FP 8	0.79
11/11/14	9:01:09	A/L RATIO	DEGRADATION FP 8	0.79
REPLACEMENT NOZZLES INSTALLED AND ADJUSTED ON 11/12/14				
11/16/14	9:01:09	CONTAINMENT	GROSS OVER PRESSURE WEEKLY 95%	5.00
11/23/14	9:01:12	CONTAINMENT	GROSS OVER PRESSURE WEEKLY 95%	5.00
11/30/14	9:01:09	CONTAINMENT	GROSS OVER PRESSURE WEEKLY 95%	4.94

Table 14: ISD Failure Alarms November 2014

DATE	TIME	DESCRIPTION	READING	VALUE
NONE				

Throughout the month of November, 2014, no failure alarms were recorded by the ISD system. This is because the operator took advantage of ARB Advisory 405-C which allows self-clearing of ISD overpressure alarms during the winter fuel season. This overpressure alarm clearing sequence was evident upon review the "Shutdown and Miscellaneous Event" log which is available in the monthly ISD report. As show in table 15 below, overpressure alarms were cleared both before and after the new nozzle installation, November 2, 9, 16, 23, and 30.

Table 15: ISD Shutdown and Miscellaneous Events

DATE	TIME	DESCRIPTION	ACTION/NAME
11/02/14	11:50:56	CONTAINMENT GROSS & DEGRD	TEST MANUALLY CLEARED[1]
11/09/14	13:12:30	CONTAINMENT GROSS & DEGRD	TEST MANUALLY CLEARED[1]
11/11/14	15:28:12	COLLECTION TEST HH08 GRADE	TEST MANUALLY CLEARED[2]
REPLACEMENT NOZZLES INSTALLED AND ADJUSTED ON 11/12/14			
11/16/14	12:26:38	CONTAINMENT GROSS & DEGRD	TEST MANUALLY CLEARED[1]
11/19/14	9:01:09	READINESS ISD:PP EVR:PP	ISD & EVR READY[4]
11/19/14	8:28:38	READINESS ISD:PP EVR:NN	EVR READINESS PENDING[4]
11/19/14	8:28:38	ISD STARTUP	STARTUP[4]
11/19/14	8:28:33	ISD SHUTDOWN	SHUTDOWN[3]
11/23/14	12:05:21	CONTAINMENT GROSS & DEGRD	TEST MANUALLY CLEARED[1]
11/30/14	14:02:21	CONTAINMENT GROSS & DEGRD	TEST MANUALLY CLEARED[1]

[1] This means that the GDF operator performed a "Clear Test After Repair" sequence upon activation of several overpressure warning alarms which are labeled by ISD as "containment gross & degradation". This resets the ISD alarm assessment pertaining to overpressure. This is allowed per ARB Advisory 405 as previously mentioned in this report.
[2] ARB staff performed a "Clear Test After Repair" sequence upon installation and adjustment of the new nozzle on fueling point number eight.
[3] This means that the ISD system installed at the GDF experienced an interruption in power supply. This is not an uncommon occurrence in the winter due to winter conditions resulting in power outages. This is also a common occurrence in urban areas due to electrical grid maintenance or upgrades.
[4] These actions result any time power is interrupted to the ISD console which occurred on 11/19/14.

VI. Conclusions and Recommendations

Upon review and analysis of the data collected, it is evident that installation of new nozzles was not effective in preventing overpressure alarms from occurring nor did it mitigate the PWD condition. In addition, adjusting the nozzle vapor to liquid ratios to the lower end of the allowable range did not mitigate overpressure or PWD. This conclusion is based upon the measurement of three benchmarks which are summarized below;

1. The installation of new nozzles did not lower the pressure within the headspace of the underground storage tanks.
2. The installation of new nozzles did not lower the site average vapor to liquid ratio.
3. The installation of new nozzles did not decrease the frequency of ISD overpressure alarm occurrence in November of 2014

These conclusions suggest that ARB staff and members of the CAPCOA Overpressure Working Group should proceed with investigation of other variables which are assumed to contribute to the overpressure phenomena.

VII. Appendices:

Appendix I. Results of Vapor Recovery Performance Testing

Appendix II. Analysis of Vapor to Liquid Ratios of Fueling Transactions

Appendix III. Analysis of Pressure and Ullage Data