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

Project Number: VR-11-11

Report Number: VR-OP-A7

OVERPRESSURE STUDY

Technical Support Document:
Evaluation of Healy Model 900 Assist Vapor Recovery Nozzle with Enhanced On-Board Refueling Vapor Recovery (ORVR) Vehicle Recognition Feature during the Winter of 2016/2017

June 10, 2018

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I. EXECUTIVE SUMMARY

Starting in 2010, California Air Resources Board (CARB) staff conducted a series of studies to investigate the causes of in-station diagnostics (ISD) overpressure alarms in California gasoline dispensing facilities (GDF). ISD was incorporated as part of the vapor recovery system to alert operators of potential failures so that repairs can be done to correct the failures. CARB staff found that overpressure alarms were not associated with any equipment failures, but occur primarily during the winter months, the period in which gasoline is not subject to any volatility limit. Other contributing factors to overpressure alarms include air ingestion, throughput, the shutdown of dispensing at night, and maintenance practices.

In 2015, Franklin Fueling Systems, the manufacturer of the Healy Model 900 assist system, submitted a new nozzle spout design in response to two CARB staff studies[1]. This new design would reduce air ingestions by more securely latching to the vehicle fuel pipe as a means of recognizing vehicles with on-board refueling vapor recovery (ORVR). Misrecognition of ORVR vehicles results in overpressure due to excess air ingestion causing gasoline to evaporate in the headspace of GDF storage tanks.

In the winter of 2015/2016, CARB staff started to evaluate the effectiveness of the new Healy 900 nozzle spout design at three GDFs, with one located in San Diego and two in the Bay Area. The results[2] were deemed inclusive due to limited duration with winter gasoline but suggested that the new designs could reduce overpressure alarms and severity of pressure increases while dispensing (PWD) conditions by improved recognition of ORVR vehicles.

During the next winter period (November 2016 and March 2017), CARB staff conducted a more extensive study involving seven GDFs located in four California geographic regions. These seven stations included two in the Bay Area Air Quality Management District, two in South Coast Air Quality Management District, two in Mojave Desert Air Quality Management District, and one in San Diego County Air Pollution Control District. This study also evaluated if there are performance differences between factory EOR nozzles spouts and installing the EOR spouts as a field retrofit. The results indicated that EOR did not completely resolve overpressure alarms and PWD, but did improve ORVR vehicle recognition, reduce excess air ingestion, reduce the frequency of ISD overpressure alarms, and reduce severity of PWD conditions. CARB staff concludes that installation of EOR spout assembly should be a partial solution to help address the overpressure alarms.

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[1] These studies are available at CARB's website at https://www.arb.ca.gov/vapor/op/studies/assist/vropa3.pdf and https://www.arb.ca.gov/vapor/op/studies/assist/vropa4.pdf.

[2] The results are available at https://www.arb.ca.gov/vapor/op/studies/assist/vropa5.pdf.

II. BACKGROUND

Throughout the winter of 2015/2016, California Air Resources Board (CARB) staff evaluated the performance of Healy Model 900 assist vapor recovery nozzles equipped with a prototype spout design feature called "Enhanced On-Board Refueling Vapor Recovery (ORVR) Vehicle Recognition" (EOR spout assembly). The EOR spout assembly was developed by Franklin Fueling Systems (FFS) in response to a prior field studies conducted by CARB staff, which found that the currently certified Healy Model 900 nozzle experiences excess air ingestion due to a poor seal at the vehicle fill pipe and nozzle interface with approximately 30% of vehicles equipped with ORVR. Excess air ingestion at the nozzle when combined with winter blend gasoline causes the overpressure conditions by enhanced gasoline evaporation, which leads to atmospheric venting of gasoline vapors. In some instances, excess air ingestion results in a severe form of overpressure known as "pressure increase while dispensing" (PWD).

The results of this evaluation was documented in the technical support document titled, "*Evaluation of Healy Model 900 Assist Vapor Recovery Nozzle with Enhanced On-Board Refueling Vapor Recovery (ORVR) Vehicle Recognition Feature during the Winter of 2015/2016.*" Unfortunately, this study was deemed inconclusive due to limited duration with winter blend gasoline (transition from winter to summer blend gasoline occurred during the evaluation) and issues encountered with underground storage tank headspace leak integrity at two of the three test sites. Although inconclusive, the prior evaluation suggested that the EOR spout improved ORVR vehicle recognition and reduced air ingestion which should have the potential to reduce the frequency of overpressure alarms and severity of PWD conditions. Upon consultation with the CAPCOA Vapor Recovery Subcommittee, CARB staff determined that additional study should be conducted the following winter at a larger number of test sites to more accurately assess the ability to mitigate overpressure conditions and reduce ISD alarm frequency.

III. OBJECTIVE

The objective of this evaluation was to determine the effectiveness of the EOR spout assembly with regard to improved ORVR vehicle recognition and mitigation of overpressure conditions including PWD within the underground storage tanks (UST) over the course of a full winter (November 1 - March 31) at seven retail GDFs, each with differing operating conditions, and located in four different regions of California. The secondary objective is to determine if there is a difference between the factory assembled and the field retrofit EOR spout.

This document provides the sequence of events, summary of results, and discussion of key findings pertaining to EOR spout assembly performance.

IV. METHODOLOGY

For each test site at which EOR spouts assemblies were evaluated, a multi-step methodology was followed. The EOR spout assembly was the “manipulated variable” and all other vapor recovery system components were considered “controlled variables” and to the extent possible, were not to be altered. As depicted in Figure IV-1, the methodology consists of several steps which include, identification of a GDF that exhibits overpressure including PWD, installation of an ISD data acquisition system, validation a properly operating vapor recovery system, installation of EOR spouts, capture of pertinent ISD data, and lastly, comparison of key benchmarks before and after installation.

FIGURE IV-1: Multi Step Methodology for Healy Nozzles with EOR Spout Evaluation

Step 1
- Identify GDF which routinely exhibits overpressure (including PWD) during the winter fuel season and is equipped with Phase II EVR assist system including ISD.

Step 2
- Obtain permission from GDF operator to install monitoring equipment, and allow CARB staff to conduct routine vapor recovery system testing and repair.

Step 3
- Install ISD data aquisition equipment, collect data prior to installation of EOR spout assemblies to establish baseline operating conditions.

Step 4
- Conduct Phase I, Phase II, and ISD vapor recovery system testing to ensure baseline data is valid. If necessary, make repairs and or adjustments to vapor recovery system to ensure compliance with applicable performance standards and eliminate biases.

Step 5
- Optimize Phase II vapor recovery system of each GDF *(Lower V/L between 0.95-1.00, ensure flow rates are maintained between 6-10 gpm, ensure dispenser integrity)*

Step 6
- Replace existing Healy 900 Nozzles with EOR spouts assemblies at desired fueling positions. Conduct RVP sample collection to the extent possible.

Step 7
- Allow the site to operate as normal throughout the winter and collect pertinent ISD data on routine basis (site visits once every two weeks)

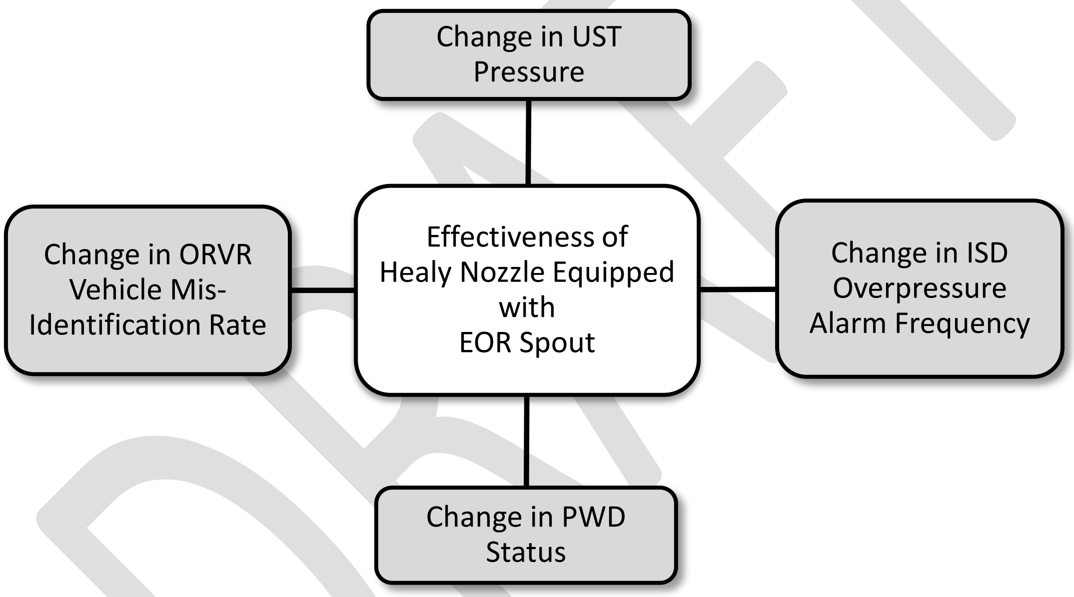
Step 8
- Perform analysis of ISD data, including change in pressure profile, change in V/L ratio, and change in ISD overpressure alarms before and after EOR spout installation.

Step 9
- Document findings and draw conclusions on effectiveness of EOR nozzle

A. Benchmarks Identified to Measure Effectiveness of EOR Spout

As depicted in Figure IV-2, four benchmarks were identified as a means to measure the effectiveness of the EOR spout with regard to overpressure mitigation and improved ORVR vehicle recognition. These benchmarks include: (1) change in UST pressure which relies on data captured by the ISD vapor pressure sensor; (2) change in nozzle vapor to liquid ratios observed on individual fueling transactions which relies on data captured by the ISD vapor flow meter; (3) change in ISD overpressure alarm frequency which relies on the ISD system monthly report, and (4) change in PWD Status.

FIGURE IV-2: Benchmarks Used to Determine Effectiveness of Healy 900 Nozzles with EOR spout



B. Test Site Selection and Optimization of Phase II Vapor Recovery System

From mid-November 2016 to late March 2017, Healy nozzles with EOR spout assemblies were monitored at seven retail GDFs located in four different regions of California. The first test site was located in San Diego and was previously used for the assist nozzle ORVR vehicle recognition study in January 2015. The second and third test sites were located in Campbell and the Gilroy, both within the Bay Area region. The fourth and fifth test sites were located in La Habra and La Cañada-Flintridge, both within the South Coast region. The sixth and seventh test sites were located in Victorville and Apple Valley, both within the Mojave Desert region. All seven sites had an extensive history of exhibiting frequent ISD overpressure alarms and PWD.

Prior to installing the EOR spout assembly at each test site, Phase II vapor recovery system performance testing (including ISD operability) was conducted in order to establish baseline operating conditions and to ensure compliance with applicable performance standards or specifications. If vapor recovery equipment failures were found, repairs were made because such issues could potentially bias the results. For example, leaks within the underground storage tanks, improperly calibrated ISD equipment, or improperly adjusted nozzle vapor to liquid ratio settings can mask true operating conditions. For the evaluation to be successful, the vapor recovery system at each test site must be in proper operating condition and in compliance with applicable performance standards.

The following sections describe each facility's operating characteristics and the steps taken to ensure that the vapor recovery system is "optimized" meaning the vapor recovery system was operating in compliance with applicable standards and specifications listed in the Assist Phase II Vapor Recovery System Executive Order VR-202. Additionally, per IOM 2 of the assist Executive Order, the dispenser integrity testing of the vapor return plumbing was performed. In many cases, repairs were necessary, in particular, the o-ring at the dispenser outlet casting and whip hose. It should also be noted that per suggestion from FFS and CARB staff, vapor to liquid ratios of the nozzles were adjusted between 0.95 and 1.00 which is toward the lower end of the allowable range of 0.95 to 1.15.

1. San Diego Test Site

From ISD data collected by CARB staff during prior site visits, the San Diego test site was selected as an ideal location to evaluate EOR spout assemblies due to an extensive number of overpressure alarms from January, February, November, and December in 2015. Table IV-1 lists frequency of ISD overpressure alarms from years past. Table IV-2 provides a listing of operating characteristics.

TABLE IV-1: ISD Overpressure Alarm History - San Diego

Location	Number of OP Alarms			
	Jan 2015	Feb 2015	Nov 2015	Dec 2015
San Diego	4	4	2	5

TABLE IV-2: Operating Characteristics of GDF – San Diego

Location	San Diego
Hours of Operation	24 Hours/7 Days
EVR System	VR-202 – Healy w/ CAS
ISD System	INCON 1.2.0
# of Fueling Points	12
Monthly Throughput	165,000 gallons
PWD Status	PWD in 2013, 2015, 2016
Nozzle Version Installed	Field Retrofitted EOR spout

After obtaining permission from the GDF operator and notifying San Diego County Air Pollution Control District, FFS provided CARB staff with EOR spouts to retrofit the existing Healy 900, and the following steps were taken

1. Prior to nozzle installation, baseline testing was conducted on the vapor recovery system to ensure that the vapor recovery system complied with applicable regulatory and performance standards.

2. The existing Healy 900 nozzles were retrofitted with the EOR spout assembly during the week of January 24, 2016. (Retrofitting involves replacing the spout assembly of the existing nozzle with an EOR spout assembly.)

3. The nozzles were left in place for the past 10 months and a data logging system was installed to capture ISD information on a daily basis

Upon installation of the EOR spout assemblies, V/L ratios were adjusted to between 0.95 and 1.00. Information on the baseline tests performed at each GDF site is summarized in Table IV-3 and further detailed information is located in Appendix I. Leak decay and PV testing were not conducted at the request of GDF operator to minimize disruption to normal site operation and sales. Issues were encountered at the San Diego test site including a few dispenser integrity failures. All issues was rectified to a passing state before moving forward.

TABLE IV-3: Vapor Recovery Performance Testing Conducted – San Diego

ARB Test Method	Description	Result
VR-202 IOM 8	Dispenser Integrity	PASS
VR-202 Exhibit 5	Vapor to Liquid Ratio of Nozzles	PASS
VR-202 Exhibit 5	Nozzle Dispensing Rate	PASS
VR-202 Exhibit 10	ISD Operability: Vapor Flow Meter	PASS
VR-202 Exhibit 10	ISD Operability: Vapor Pressure Sensor	PASS

2. Campbell Test Site

From ISD data collected by CARB staff during prior site visits, the Campbell test site was selected to evaluate the EOR spout assemblies due to an extensive number of overpressure alarms from February, March, November, and December in 2015. Table IV-4 lists frequency of ISD overpressure alarms from years past. Table IV-5 provides a listing of operating characteristics.

TABLE IV-4: ISD Overpressure Alarm History - Campbell

Location	Number of OP Alarms			
	Feb 2015	Mar 2015	Nov 2015	Dec 2015
Campbell	4	2	3	5

TABLE IV-5: Operating Characteristics of GDF - Campbell

Location	Campbell
Hours of Operation	6am-11pm
EVR System	VR-202 – Healy w/ CAS
ISD System	Veeder Root 1.02
# of Fueling Points	8
Monthly Throughput	100,000 gallons
PWD Status	PWD in 2013, 2015, 2016
Nozzle Version Installed	Factory Assembled EOR spout

After obtaining permission from the GDF operator and notifying the Bay Area Air Quality Management District, FFS provided CARB staff with factory assembled Healy 900 nozzles with EOR spout assemblies, and the following steps were taken:

1. Prior to nozzle installation, baseline testing was conducted on the vapor recovery system to ensure that the vapor recovery system complied with applicable regulatory and performance standards.
2. The Healy 900 Nozzles with EOR spouts were installed on February 24, 2016.
3. The nozzles were left in place for the past 10 months and a data logging system was installed to capture ISD information on a daily basis

Upon installation of the EOR spout assemblies, V/L ratios were adjusted to between 0.95 and 1.00. Information on the baseline tests performed at each GDF site is summarized in Table IV-6 and further detailed information is located in Appendix II. No issues were encountered at the Campbell test site and the results of the performance tests completed were passing.

TABLE IV-6: Vapor Recovery Performance Testing Conducted - Campbell

ARB Test Method	Description	Result
VR-202 IOM 8	Dispenser Integrity	PASS
VR-202 Exhibit 5	Vapor to Liquid Ratio of Nozzles	PASS
VR-202 Exhibit 5	Nozzle Dispensing Rate	PASS
VR-202 Exhibit 9	ISD Operability: Vapor Flow Meter	PASS
VR-202 Exhibit 9	ISD Operability: Vapor Pressure Sensor	PASS

3. Gilroy Test Site

From ISD data collected by CARB staff over the past several years, the Gilroy test site was selected to evaluate the EOR spout assembly due to an extensive number of overpressure alarms from February, March, November and December in 2015. Table IV-7 lists frequency of ISD overpressure alarms from years past. Table IV-8 provides a listing of operating characteristics.

TABLE IV-7: ISD Overpressure Alarm History - Gilroy

Location	Number of OP Alarms			
	Feb 2015	Mar 2015	Nov 2015	Dec 2015
Gilroy	4	4	3	4

TABLE IV-8: Operating Characteristics of GDF - Gilroy

Location	Gilroy
Hours of Operation	24 Hours/7 Days
EVR System	VR-202 – Healy w/ CAS
ISD System	Veeder Root 1.02
# of Fueling Points	12
Monthly Throughput	119,000 gallons
PWD Status	PWD in 2013, 2015, 2016
Nozzle Version Installed	Factory Assembled EOR spout

After obtaining permission from the GDF operator and notifying the Bay Area Air Quality Management District, FFS provided factory assembled Healy 900 nozzle with EOR spout assemblies, and the following steps were taken:

1. Prior to nozzle installation, baseline testing was conducted on the vapor recovery system to ensure that the vapor recovery system complied with applicable regulatory and performance standards.
2. The Healy 900 Nozzles with EOR spouts were installed on February 23, 2016.
3. The nozzles were left in place for the past 10 months and a data logging system was installed to capture ISD information on a daily basis.

Upon installation of the nozzles with EOR spout assemblies, V/L ratios were adjusted to between 0.95 and 1.00. Information on the baseline tests performed are summarized in Table IV-9 and further detailed in Appendix III. No issues were encountered at the Gilroy test site and the results of the performance tests completed were passing.

TABLE IV-9: Vapor Recovery Performance Testing Conducted - Gilroy

ARB Test Method	Description	Result
VR-202 IOM 8	Dispenser Integrity	PASS
VR-202 Exhibit 5	Vapor to Liquid Ratio of Nozzles	PASS
VR-202 Exhibit 5	Nozzle Dispensing Rate	PASS
VR-202 Exhibit 9	ISD Operability: Vapor Flow Meter	PASS
VR-202 Exhibit 9	ISD Operability: Vapor Pressure Sensor	PASS

4. La Habra Test Site

From ISD data collected by CARB staff over the past several years and the help of South Coast Air Quality Management District (AQMD) inspectors, the La Habra site was selected to evaluate the EOR spout assembly due to an extensive number of overpressure alarms from January, February, November, and December in 2015. Table IV-10 lists frequency of ISD overpressure alarms from years past. Table IV-11 provides a listing of operating characteristics.

TABLE IV-10: ISD Overpressure Alarm History - La Habra

Location	Number of OP Alarms			
	Jan 2015	Feb 2015	Nov 2015	Dec 2015
La Habra	4	3	3	5

TABLE IV-11: Operating Characteristics of GDF – La Habra

Location	La Habra
Hours of Operation	24 Hours/7 Days
EVR System	VR-202 – Healy w/ CAS
ISD System	Veeder Root 1.02
# of Fueling Points	12 (six Pack) – 36 Nozzles
Monthly Throughput	140,000 gallons
PWD Status	PWD in 2013, 2015, 2016
Nozzle Version Installed	50% Field Retrofitted EOR spout 50% Factory Assembled EOR spout

After obtaining permission from the GDF operator and notifying the South Coast Air Quality Management District, FFS provided 18 factory assembled Healy 900 Nozzle with EOR spout assemblies and 18 field retrofit EOR spout assemblies and the following steps were taken:

1. Prior to nozzle installation, baseline testing was conducted on the vapor recovery system to ensure that the vapor recovery system complied with applicable regulatory and performance standards.
2. The Healy 900 Nozzles with EOR spouts were installed on November 15, 2016.
3. The nozzles were left in place for at least 30 days and a data logging system was installed to capture ISD information on a daily basis.

Upon installation of the EOR spout assemblies, V/L ratios were adjusted to between 0.95 and 1.00. Information on the baseline tests performed are summarized in Table IV-12 and further detailed in Appendix IV. Issue encountered at the La Habra test site included multiple dispenser leaks. Each issue was rectified to a passing state before moving forward. Additional details on issues encountered are provided in the “Discussion of Results” section of this document.

This test site was selected primarily to compare the factory assembled and the field retrofitted Healy 900 Nozzle with EOR spout.

TABLE IV-12: Vapor Recovery Performance Testing Conducted - La Habra

ARB Test Method	Description	Result
VR-202 IOM 8	Dispenser Integrity	PASS
VR-202 Exhibit 5	Vapor to Liquid Ratio of Nozzles	PASS
VR-202 Exhibit 5	Nozzle Dispensing Rate	PASS
VR-202 Exhibit 9	ISD Operability: Vapor Flow Meter	PASS
VR-202 Exhibit 9	ISD Operability: Vapor Pressure Sensor	PASS

5. La Cañada-Flintridge Test Site

From ISD data collected by CARB staff over the past several years and the help of South Coast AQMD inspectors, the La Cañada-Flintridge site was selected to evaluate the EOR spout due to an extensive number of overpressure alarms from January, February, November, and December in 2015. Table IV-13 lists frequency of ISD overpressure alarms from years past. Table IV-14 provides a listing of operating characteristics.

TABLE IV-13: ISD Overpressure Alarm History - La Cañada-Flintridge

Location	Number of OP Alarms			
	Jan 2015	Feb 2015	Nov 2015	Dec 2015
La Cañada-Flintridge	3	1	3	3

TABLE IV-14: Operating Characteristics of GDF – La Cañada-Flintridge

Location	La Cañada-Flintridge
Hours of Operation	24 Hours/7 Days
EVR System	VR-202 – Healy w/ CAS
ISD System	Veeder Root 1.02
# of Fueling Points	8
Monthly Throughput	224,000 gallons
PWD Status	PWD in 2013, 2015, 2016
Nozzle Version Installed	Field Retrofitted EOR spout

After obtaining permission from the GDF operator and notifying the South Coast Air Quality Management District, FFS provided CARB staff with EOR spout assemblies to retrofit the existing Healy 900 and the following steps were taken:

1. Prior to nozzle installation, baseline testing was conducted on the vapor recovery system to ensure that the vapor recovery system complied with applicable regulatory and performance standards.

2. The Healy 900 Nozzles with EOR spouts were installed on November 16, 2016.

3. The nozzles were left in place for at least 30 days and a data logging system was installed to capture ISD information on a daily basis.

Upon installation of the EOR spout assemblies, V/L ratios were adjusted to between 0.95 and 1.00. Information on the baseline tests performed are summarized in Table IV-15 and further detailed in Appendix V. Issue encountered at the La Cañada-Flintridge test site included multiple dispenser leaks. Each issue was rectified to a passing state before moving forward. Additional details on issues encountered are provided in the “Discussion of Results” section of this document.

TABLE IV-15: Vapor Recovery Performance Testing Conducted - La Cañada-Flintridge

ARB Test Method	Description	Result
VR-202 IOM 8	Dispenser Integrity	PASS
VR-202 Exhibit 5	Vapor to Liquid Ratio of Nozzles	PASS
VR-202 Exhibit 5	Nozzle Dispensing Rate	PASS
VR-202 Exhibit 9	ISD Operability: Vapor Flow Meter	PASS
VR-202 Exhibit 9	ISD Operability: Vapor Pressure Sensor	PASS
TP-201.3	2 inch Static Pressure Decay	PASS

6. Victorville Test Site

From ISD data collected by CARB staff over the past several years and the help of Mohave Desert Air Quality Management District inspectors, the Victorville site was selected to evaluate the EOR spout assembly due to an extensive number of overpressure alarms from January, February, November, and December in 2015. Table IV-16 lists frequency of ISD overpressure alarms from years past. Table IV-17 provides a listing of operating characteristics.

TABLE IV-16: ISD Overpressure Alarm History - Victorville

Location	Number of OP Alarms			
	Jan 2015	Feb 2015	Nov 2015	Dec 2015
Victorville	2	0	2	4

TABLE IV-17: Operating Characteristics of GDF - Victorville

Location	Victorville
Hours of Operation	24 Hours/7 Days
EVR System	VR-202 – Healy w/ CAS
ISD System	Veeder Root 1.04
# of Fueling Points	10
Monthly Throughput	173,000 gallons
PWD Status	PWD in 2013, 2015, 2016
Nozzle Version Installed	Factory Assembled EOR spout

After obtaining permission from the GDF operator and notifying the Mohave Desert AQMD, FFS provided CARB staff with Healy 900 nozzles with factory installed EOR spout assemblies, and the following steps were taken:

1. Prior to nozzle installation, baseline testing was conducted on the vapor recovery system to ensure that the vapor recovery system complied with applicable regulatory and performance standards.
2. The Healy 900 Nozzles with EOR spouts were installed on December 13, 2016.
3. The nozzles were left in place for at least 30 days and a data logging system was installed to capture ISD information on a daily basis.

Upon installation of nozzles with the EOR spout assemblies, V/L ratios were adjusted to between 0.95 and 1.00. Information on the baseline tests performed are summarized in Table IV-18 and further detailed in Appendix VI. Issue encountered at the Victorville test site included multiple dispenser leaks. Each issue was rectified to a passing state before moving forward. Additional details on issues encountered are provided in the “Discussion of Results” section of this document.

TABLE IV-18: Vapor Recovery Performance Testing Conducted - Victorville

ARB Test Method	Description	Result
VR-202 IOM 8	Dispenser Integrity	PASS
VR-202 Exhibit 5	Vapor to Liquid Ratio of Nozzles	PASS
VR-202 Exhibit 5	Nozzle Dispensing Rate	PASS
VR-202 Exhibit 9	ISD Operability: Vapor Flow Meter	PASS
VR-202 Exhibit 9	ISD Operability: Vapor Pressure Sensor	PASS
TP-201.3	2 inch Static Pressure Decay	PASS

7. Apple Valley Test Site

From ISD data collected by CARB staff over the past several years and the help of Mohave Desert AQMD inspectors, the Apple Valley site was selected to evaluate the EOR spout assembly due to an extensive number of overpressure alarms from January, February, November, and December in 2015. Table IV-19 lists frequency of ISD overpressure alarms from years past. Table IV-20 provides a listing of operating characteristics.

TABLE IV-19: ISD Overpressure Alarm History - Apple Valley

Location	Number of OP Alarms			
	Jan 2015	Feb 2015	Nov 2015	Dec 2015
Apple Valley	3	1	3	3

TABLE IV-20: Operating Characteristics of GDF - Apple Valley

Location	Apple Valley
Hours of Operation	24 Hours/7 Days
EVR System	VR-202 – Healy w/ CAS
ISD System	Veeder Root 1.02
# of Fueling Points	6
Monthly Throughput	78,000 gallons
PWD Status	PWD in 2013, 2015, 2016
Nozzle Version Installed	Field Retrofitted EOR spout

After obtaining permission from the GDF operator and notifying the Mohave Desert AQMD, FFS provided CARB staff with EOR spout assemblies to retrofit the existing Healy 900 and the following steps were taken:

1. Prior to nozzle installation, baseline testing was conducted on the vapor recovery system to ensure that the vapor recovery system complied with applicable regulatory and performance standards.

2. The Healy 900 Nozzles with EOR spouts were installed on December 13, 2016.

3. The nozzles were left in place for at least 30 days and a data logging system was installed to capture ISD information on a daily basis.

Upon installation of the EOR spout assemblies, V/L ratios were adjusted to between 0.95 and 1.00. Information on the baseline tests performed are summarized in Table IV-21 and further detailed in Appendix VII. Issues encountered at the Apple Valley test site included multiple dispenser leaks, and underground storage tank containment leaks identified by conducting pressure decay testing. Each issue was rectified to a passing state before moving forward. Additional details on issues encountered are provided in the “Discussion of Results” section of this document.

TABLE IV-21: Vapor Recovery Performance Testing Conducted - Apple Valley

ARB Test Method	Description	Result
VR-202 IOM 8	Dispenser Integrity	PASS
VR-202 Exhibit 5	Vapor to Liquid Ratio of Nozzles	PASS
VR-202 Exhibit 5	Nozzle Dispensing Rate	PASS
VR-202 Exhibit 9	ISD Operability: Vapor Flow Meter	PASS
VR-202 Exhibit 9	ISD Operability: Vapor Pressure Sensor	PASS
TP-201.3	2 inch Static Pressure Decay	PASS
TP-201.1E	Pressure Vacuum Vent Valve	PASS

C. REID Vapor Pressure (RVP) Sampling

To verify that the fuel dispensed at GDFs is of winter blend, gasoline samples were collected on a weekly schedule from mid-November 2016 through the end of March 2017 at each of the seven test sites who participated in this evaluation. Winter blend gasoline is described as gasoline dispensed with RVP varying between 7 and 15 pounds per square inch gauge (psig) and is regulated by the applicable ASTM fuel specification[i] during the winter months. Table IV-22 below displays the air district and the corresponding dates during which the CARB RVP regulation (limit gasoline RVP to a nominal value of 7 psig) applies to gasoline sold at GDFs. Furthermore, the fuel shipped from gasoline producers (refineries) and importers must comply with the RVP limit one month earlier then the dates shown on the map.

Samples were collected for regular (87 Octane) grade gasolines. Fuel Sampling was conducted by staff of the CARB Enforcement Division following the procedures referenced in Title 13 of the California Code of Regulations[ii]. Samples were analyzed by staff of the CARB Emissions Compliance Automotive Regulations and Science Division following CARB Standard Operating Procedure MV-FUEL-125[iii].

TABLE IV-22: RVP Control Dates

Air District	Control Period
San Diego County APCD	April 1- Oct 31
Bay Area AQMD	May 1 - Oct 31
South Coast AQMD	April 1- Oct 31
Mohave Desert AQMD	April 1- Oct 31

V. RESULTS

For ease of reference, this section is organized by test site, and sub section of (1) change in nozzle vapor to liquid ratio and ORVR ID rate (fueling events with a V/L less than or equal to 0.5); (2) change is UST Pressure, (3) change in alarm frequency, and (4) change in PWD status[3]. The results of the RVP sampling are presented in a section of its own for all the test sites, followed by a description pertaining to the effectiveness of optimization. Data tables and charts are utilized in order to present the information in a clear and concise manner. The results of the data analysis are provided in the sections below.

A. San Diego Test site

ISD data was collected from November 2016 through March 2017 and the results are provided below. For reference, the raw ISD data collected from the San Diego test site and weekly analysis are provided in Appendix I.

Change in Nozzle Vapor to Liquid Ratio

In comparing the nozzle vapor to liquid ratios at the San Diego site between the certified nozzle and the Healy 900 nozzle with EOR spout, the site average was 0.70 for the certified nozzle and 0.62 for the Healy 900 nozzle with EOR spout. The EOR had a lower site V/L average. For ORVR ID rate, the percentage increased from 41% to 59% for the certified nozzle compared to the nozzle with EOR spout. See Table V-1 and Figure V-1 below.

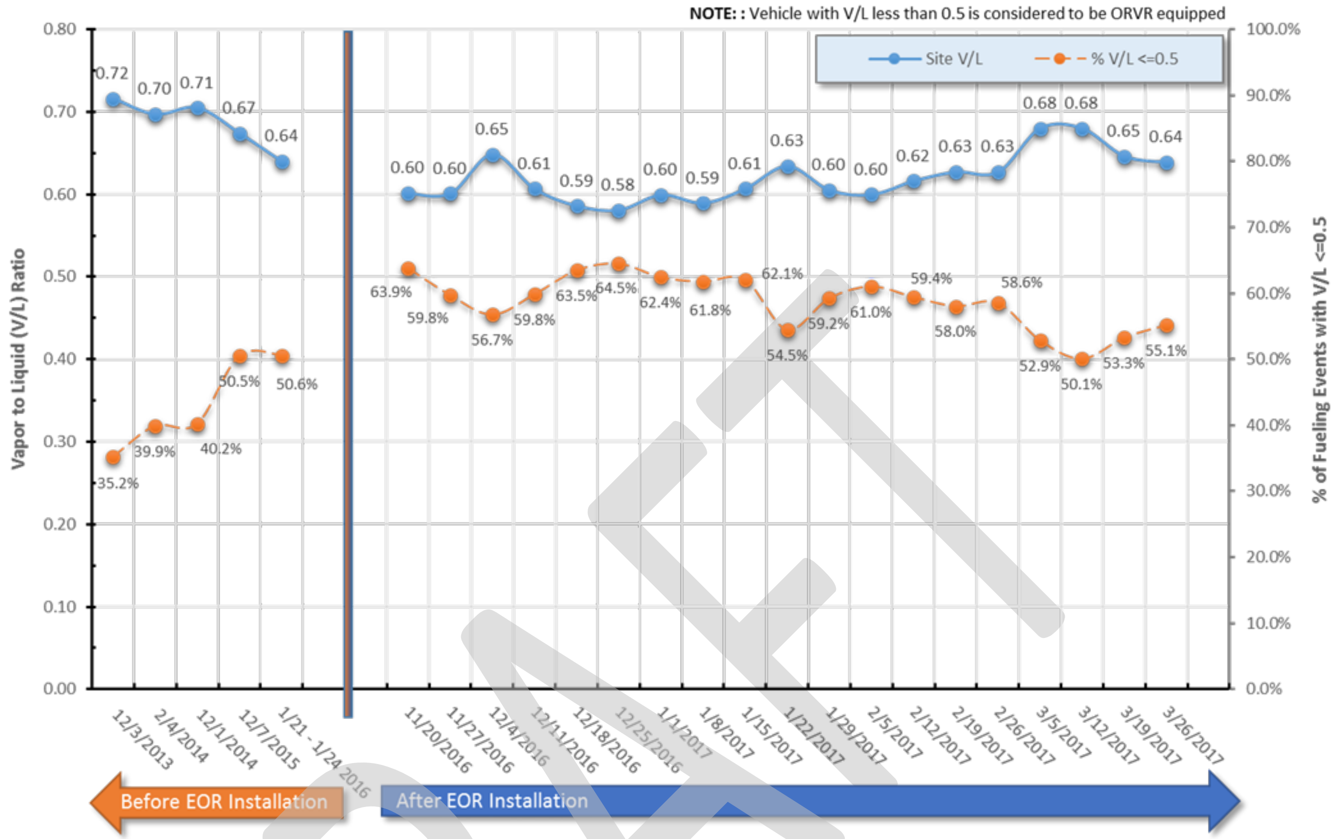
TABLE V-1: Vapor to Liquid Ratio (V/L) and ORVR ID Rate – San Diego

Configuration	V/L Ratio* Site Average	ORVR ID Rate* Fueling Events - V/L ≤ 0.5
Pre EOR spout	0.70	41%
EOR spout	0.62	59%

*Average values for each configuration. Pre EOR spout average based on three separate annual ISD downloads. EOR spout average is based on weekly averages between mid-November to end of March 2017.

3 Definition of PWD is described in Technical Support Document: Mega Blitz of 2013/2014. Section III, Methodology, VR Vapor Pressure Events P/U Plot – PWD Identification

FIGURE V-1: Weekly Site V/L and ORVR ID Rate – San Diego



Change in UST Pressure

Table V-2 provides a comparison of UST pressure data with the currently certified nozzle and UST pressure data with the Healy 900 nozzle with EOR spout. Please note, the timeframes and duration are not identical as the historical data was collected from prior site visits and the EOR nozzle data was collected after the installation of a CARB data acquisition system along with EOR nozzles. The average pressure with the certified nozzle is positive 2.1 inches of water column and the average pressure with the EOR nozzle is negative 3.4 inches of water column. The EOR nozzle shows a lower average. Figures V-2 and V-3 show a graphical representation of the data.

TABLE V-2: UST Pressure – San Diego

Configuration	UST Pressure* (inH_2O)	Overpressure % Pressure Data ≥ 1.3
Pre EOR spout	2.1	65%
EOR spout	-3.4	4%

*Pressure averages for Pre EOR spout is based on 30 hours of data, gathered during the Mega Blitz of 2013/2014/2015. EOR spout average is based on weekly averages between mid-November to end of February 2017

FIGURE V-2: Weekly Average UST Pressure – San Diego

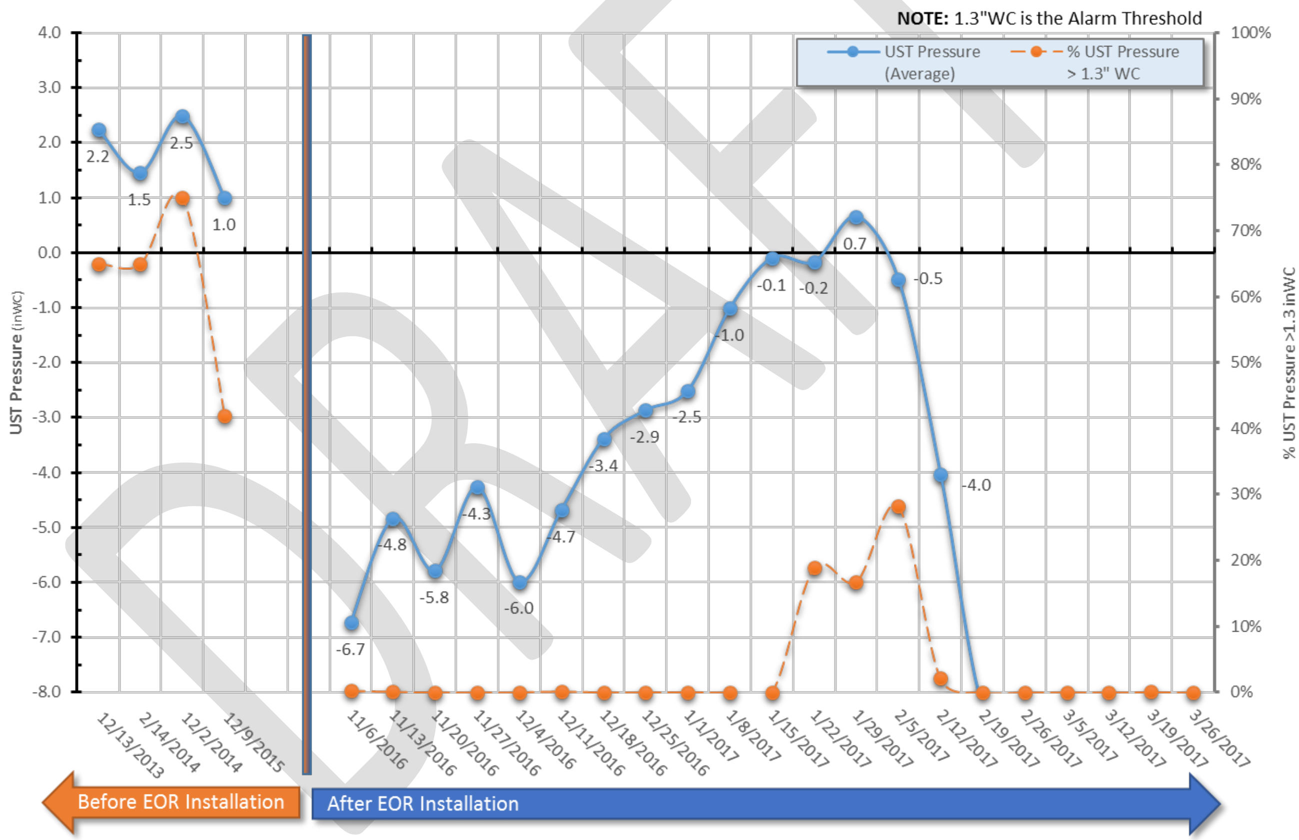
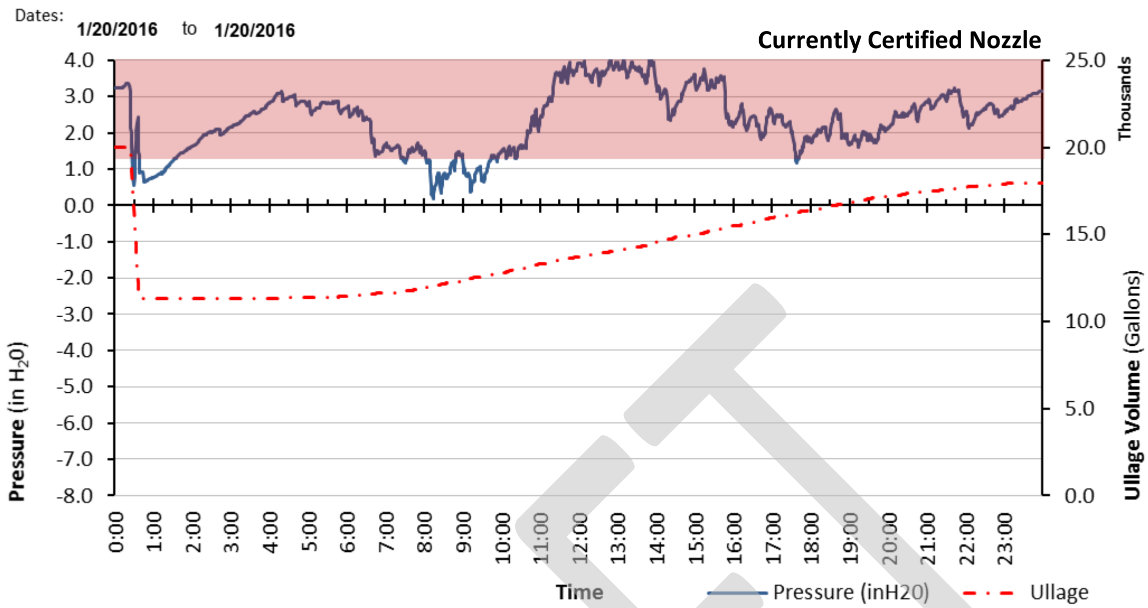
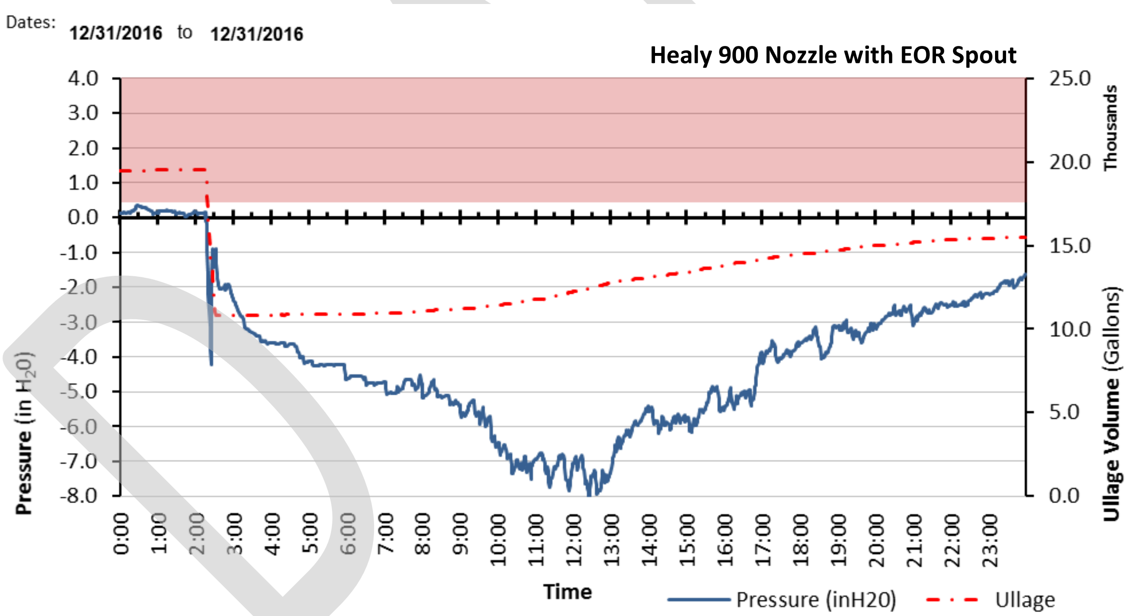


FIGURE V-3 Typical Daily Pressure Profile – San Diego

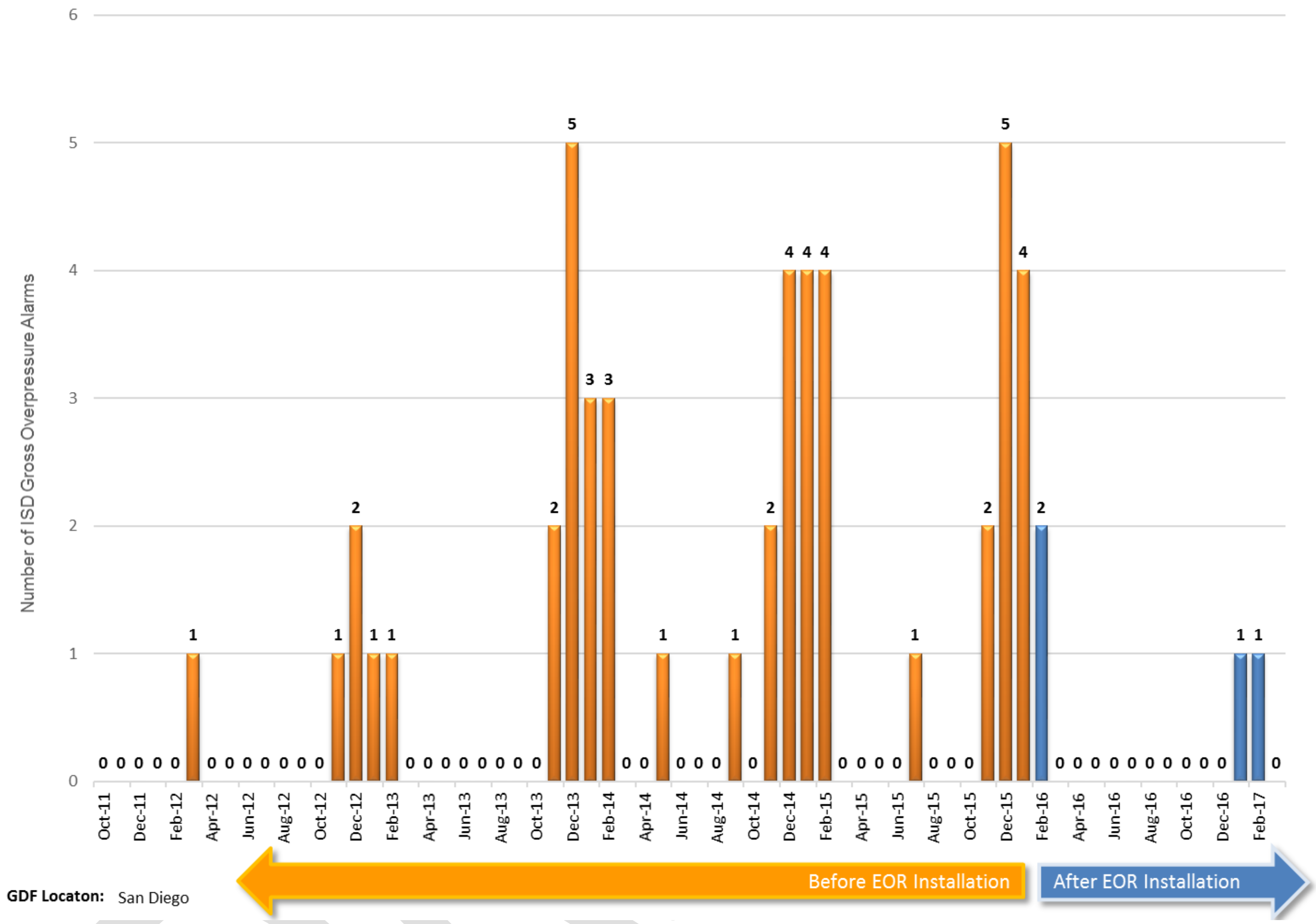




Change in ISD Overpressure Alarm Frequency

At the San Diego test site, frequency of ISD overpressure alarms before and after the installation of EOR nozzles was observed. In the month prior to installation, overpressure alarms were observed on a weekly basis. After installation, the frequency of alarms were reduced by 50%. Figure V-4 provides more information.

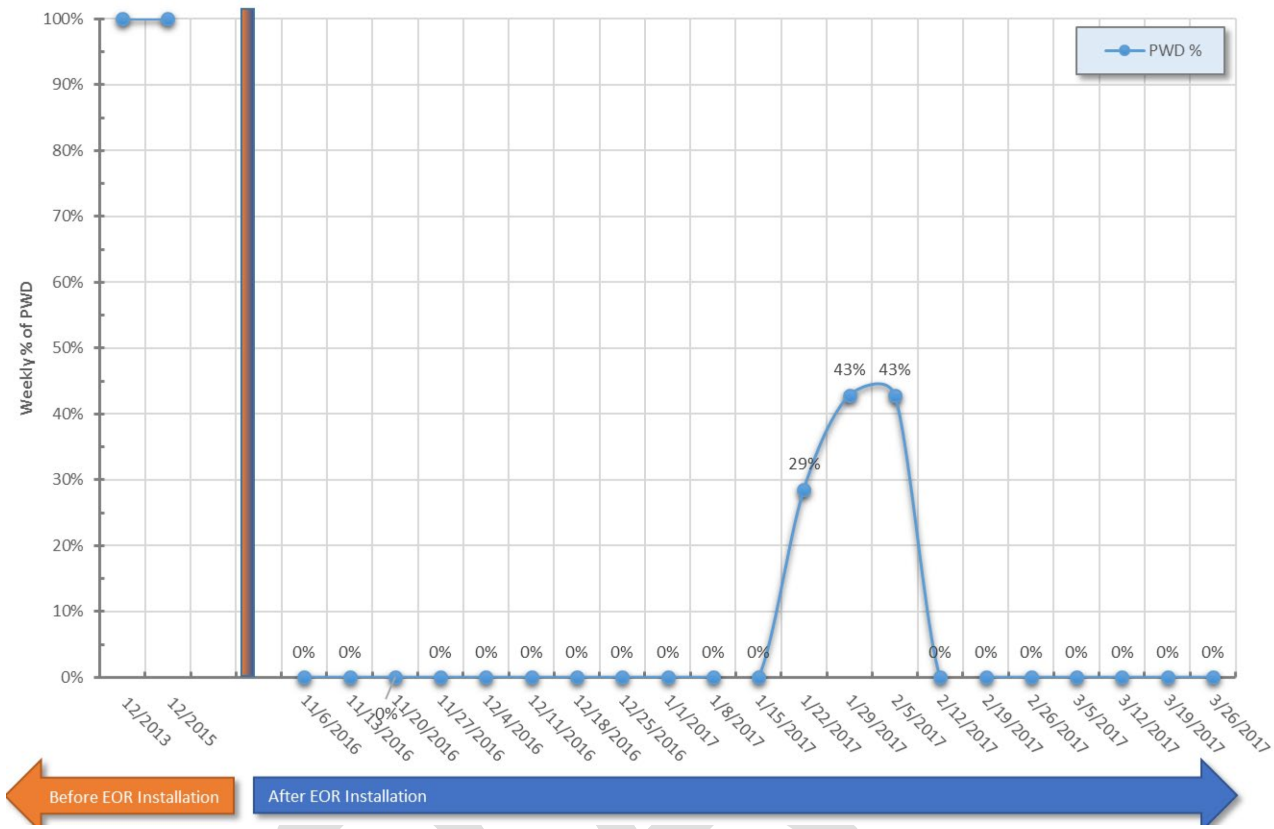
FIGURE V-4: Frequency of ISD Overpressure Alarms – San Diego



Change in PWD Status

The occurrence of PWD at this test site is shown in Figure V-5. The pre-EOR installation, PWD determination was based on 30 hours of pressure data; the post EOR installation, PWD status was based on the number of days in the week PWD was determined. During the period of 01/15/2017 to 02/12/2017, the end of the winter fuel period for San Diego APCD, PWD was occurring at the site.

FIGURE V-5: Pressure while Dispensing (PWD) Status – San Diego



B. Campbell Test site

ISD data was collected from November 2016 through March 2017 and the results are provided below. For reference, the raw ISD data collected from the Campbell test site and weekly analysis are provided in Appendix II.

Change in Nozzle Vapor to Liquid Ratio

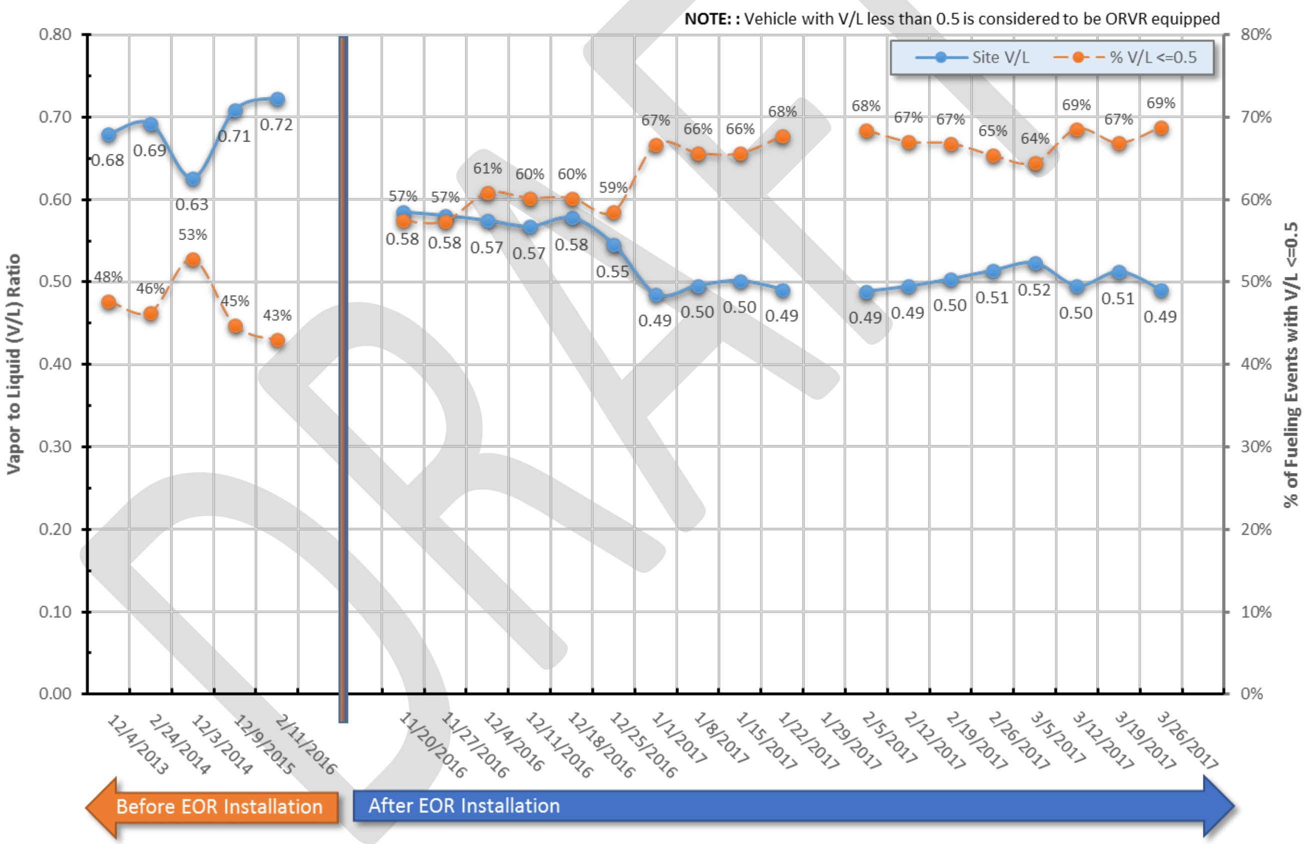
In comparing the nozzle vapor to liquid ratios at the Campbell site between the certified nozzle and the Healy 900 nozzle with EOR spout, the site average was 0.68 for the certified nozzle and 0.53 for the Healy 900 nozzle with EOR spout. The EOR had a lower site V/L average. For ORVR ID rate, the percentage increased from 48% to 64% for the certified nozzle compared to the nozzle with EOR spout. The data can be seen in Table V-3 and Figure V-6 below.

TABLE V-3: Vapor to Liquid Ratio (V/L) and ORVR ID Rate – Campbell

Configuration	V/L Ratio* Site Average	ORVR ID Rate* Fueling Events - V/L ≤ 0.5
Pre EOR spout	0.68	48%
EOR spout	0.53	64%

*Average values for each configuration. Pre EOR spout average based on three separate annual ISD downloads. EOR spout average is based on weekly averages between mid-November to end of March 2017.

FIGURE V-6: Weekly Site V/L and ORVR ID Rate - Campbell



Change in UST Pressure

Table V-4 provides a comparison of UST pressure data with the currently certified nozzle and UST pressure data with the Healy 900 nozzle with EOR spout. Please note, the timeframes and duration are not identical as the historical data was collected from prior site visits and the EOR nozzle data was collected after the installation of a CARB data acquisition system along with EOR nozzles. The average pressure with the certified nozzle is positive 2.5 inches of water column and the average pressure with the EOR nozzle is negative 1.4 inches of water column. The EOR nozzle shows a lower average. A graphical representation can be seen in Figures V-7 and V-8 below.

TABLE V-4: UST Pressure – Campbell

Configuration	UST Pressure* (inH₂O)	Overpressure % Pressure Data ≥ 1.3
Pre EOR spout	2.5	80%
EOR spout	-1.4	27%

*Pressure averages for Pre EOR spout is based on 30 hours of data, gathered during the Mega Blitz of 2013/2014/2015. EOR spout average is based on weekly averages between mid-November to end of February 2017

FIGURE V-7: Weekly Average UST Pressure – Campbell

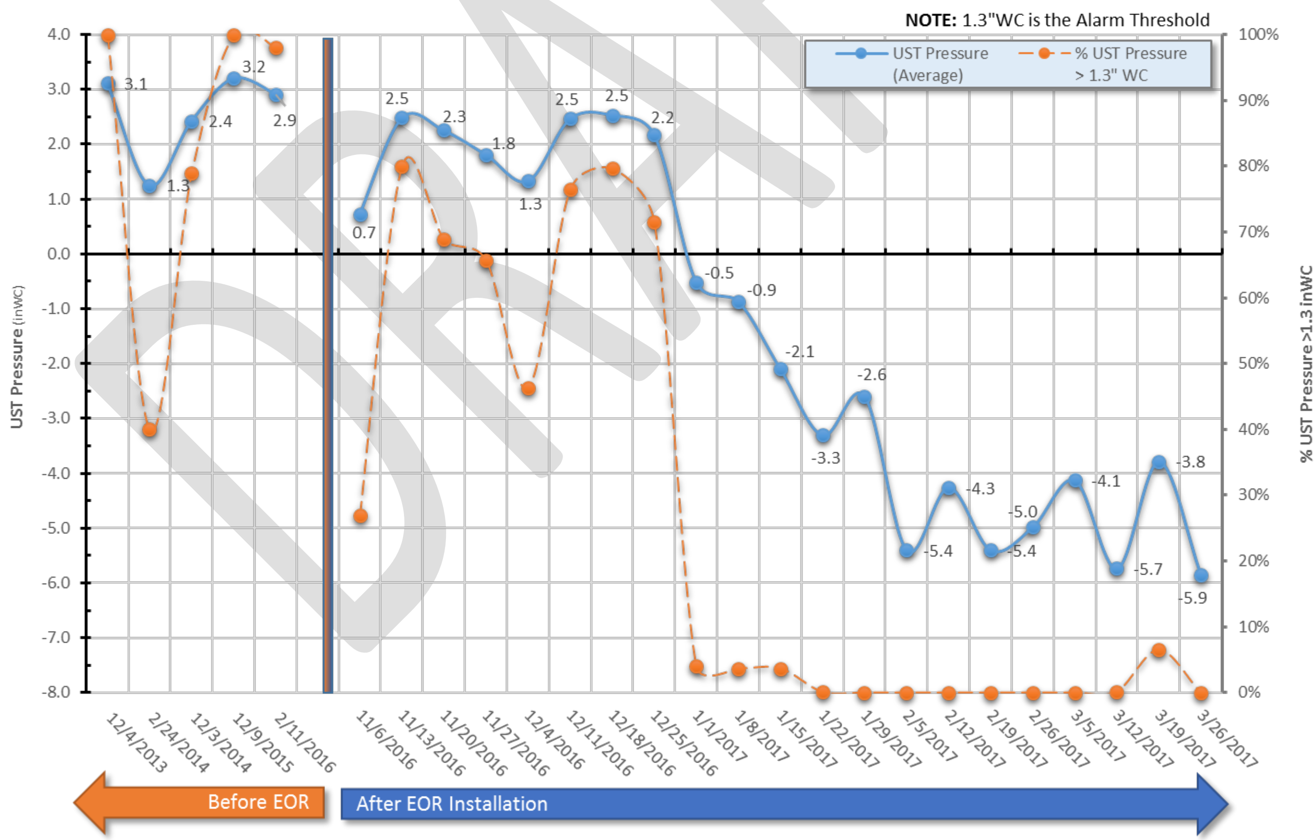
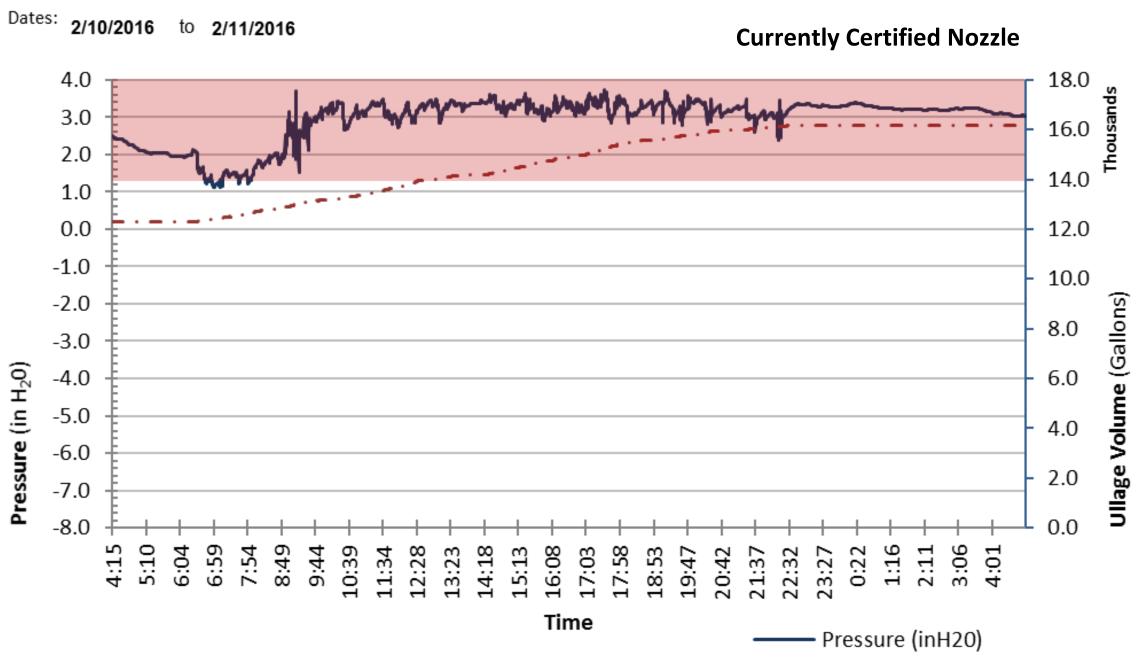
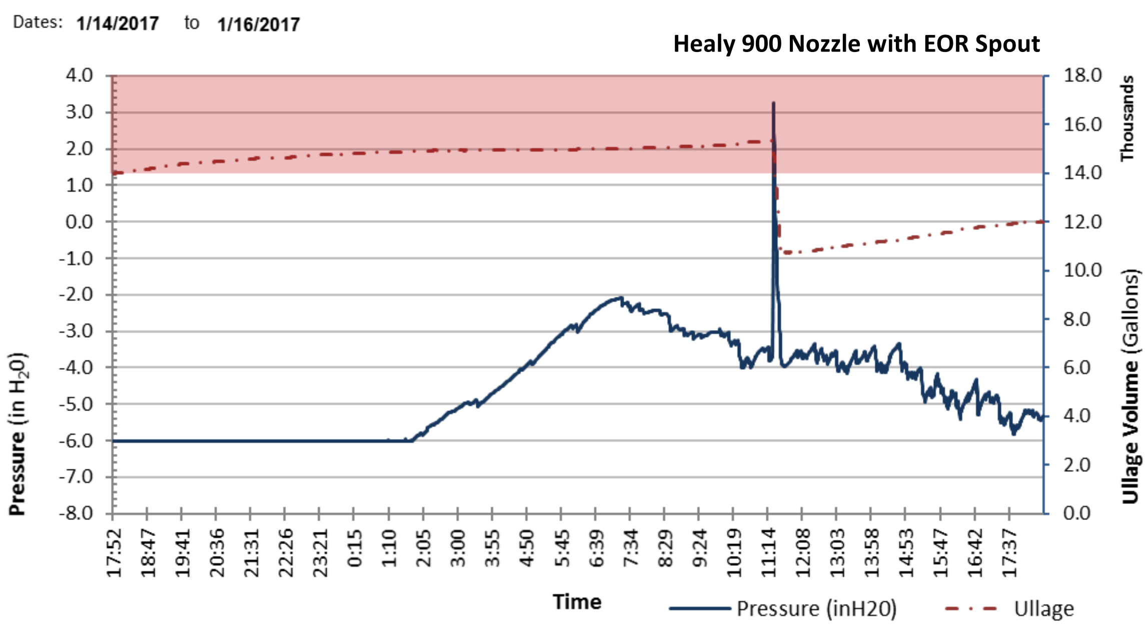


FIGURE V-8 Typical Daily Pressure Profile – Campbell

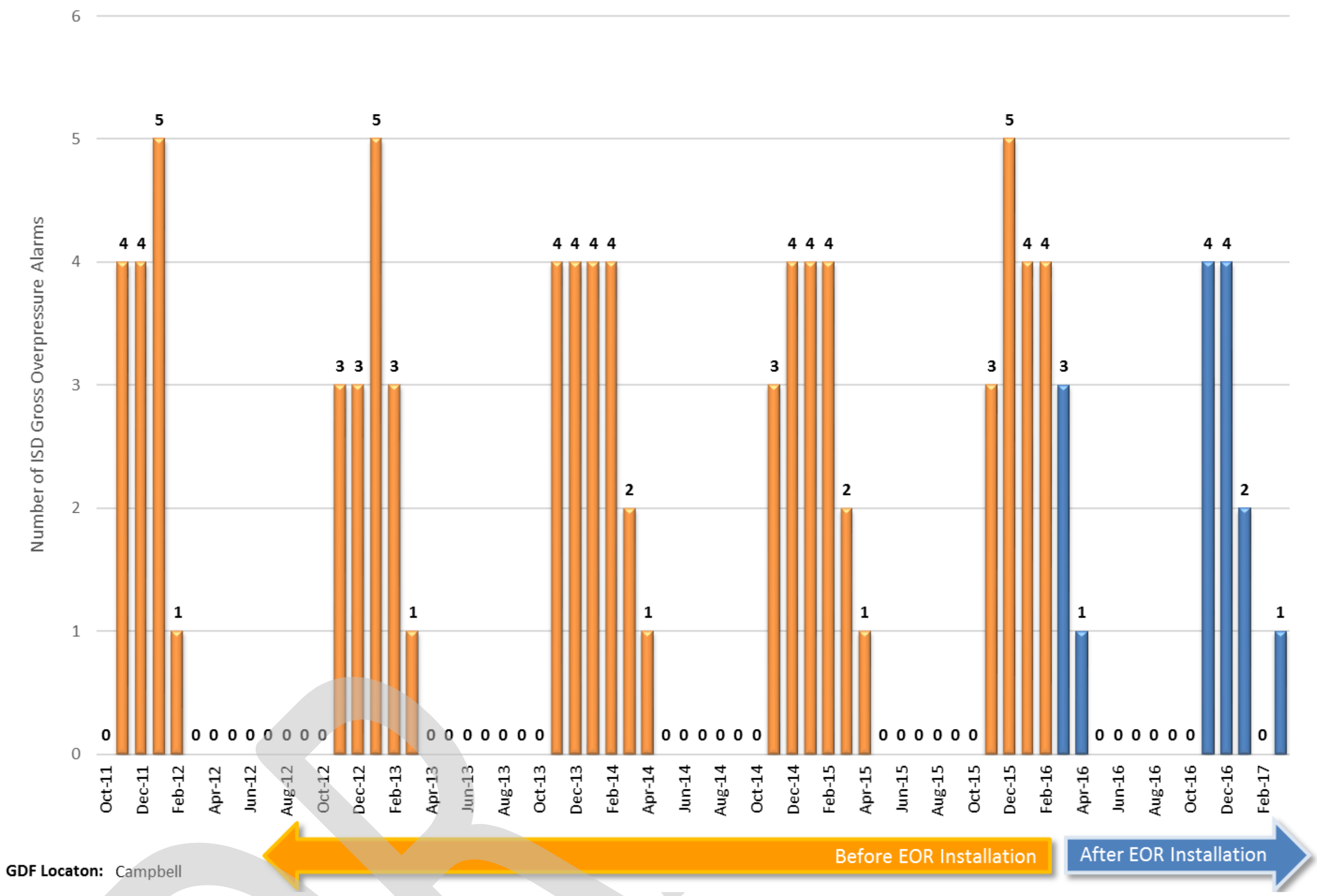




Change in ISD Overpressure Alarm Frequency

At the Campbell test site, frequency of ISD overpressure alarms before and after installation of the EOR nozzle was observed. For the month prior to installation, overpressure alarms occurred four times during the month. After installation, the frequency of alarms displayed no change. Figure V-9 provides more information.

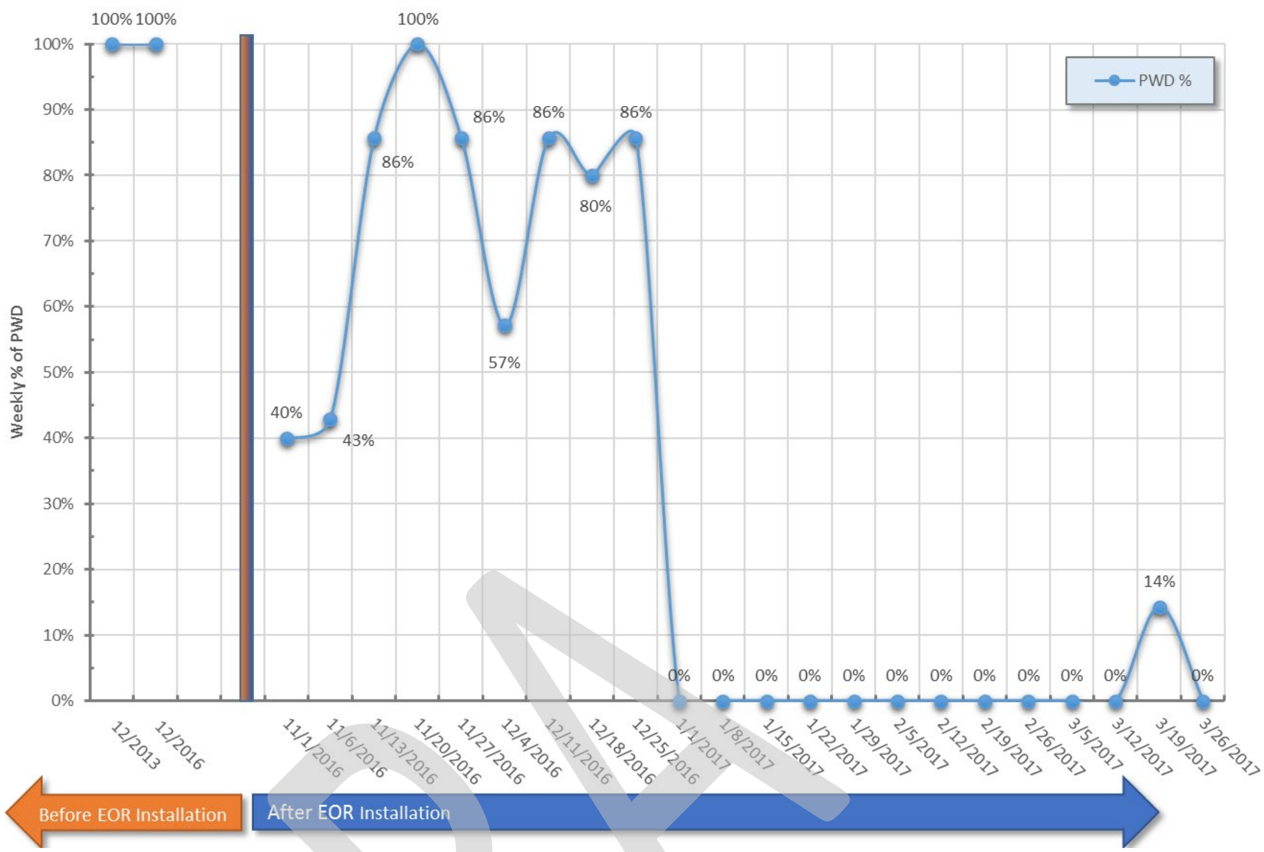
FIGURE V-9: Frequency of ISD Overpressure Alarms – Campbell



Change in PWD Status

The occurrence of PWD at this test site is shown in Figure V-10. The pre-EOR installation, PWD determination was based on 30 hours of pressure data; the post EOR installation, PWD status was based on the number of days in the week PWD was determined. During the period of 11/15/2016 to 01/01/2017, the beginning of the winter fuel period for Bay Area AQMD, PWD was occurring at the site.

FIGURE V-10: Pressure while Dispensing (PWD) Status – Campbell



C. Gilroy Test site

ISD data was collected from November 2016 through March 2017 and the results are provided below. For reference, the raw ISD data collected from the Gilroy test site and weekly analysis are provided in Appendix III.

Change in Nozzle Vapor to Liquid Ratio

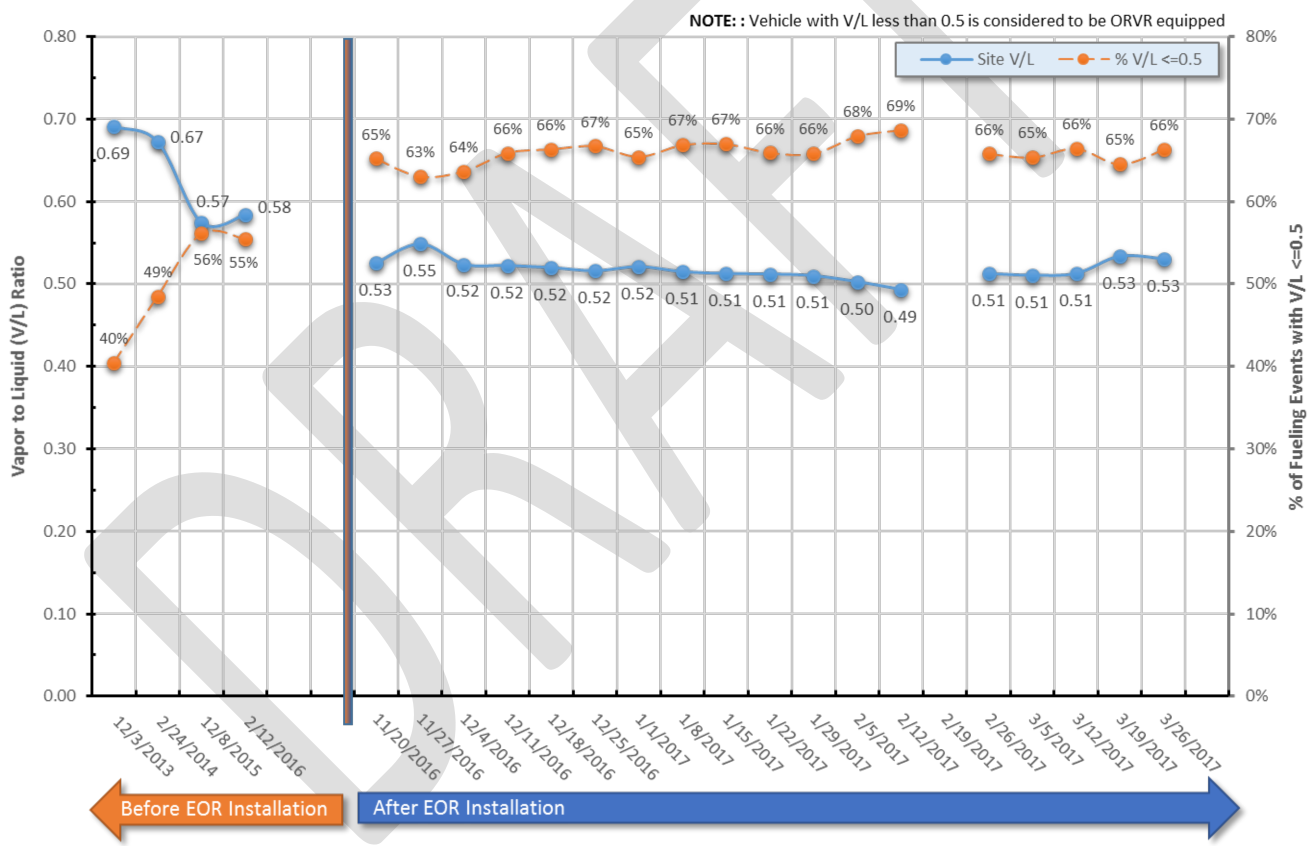
In comparing the nozzle vapor to liquid ratios at the Gilroy site between the certified nozzle and the Healy 900 nozzle with EOR spout, the site average was 0.63 for the certified nozzle and 0.52 for the Healy 900 nozzle with EOR spout. The EOR had a lower site V/L average. For ORVR ID rate, the percentage increased from 50% to 66% for the certified nozzle compared to the nozzle with EOR spout. The data can be seen in Table V-5 and Figure V-11 below.

TABLE V-5: Vapor to Liquid Ratio (V/L) and ORVR ID Rate – Gilroy

Configuration	V/L Ratio* Site Average	ORVR ID Rate* Fueling Events - V/L ≤ 0.5
Pre EOR spout	0.63	50%
EOR spout	0.52	66%

*Average values for each configuration. Pre EOR spout average based on three separate annual ISD downloads. EOR spout average is based on weekly averages between mid-November to end of March 2017.

FIGURE V-11: Weekly Site V/L and ORVR ID Rate – Gilroy



Change in UST Pressure

Table V-6 provides a comparison of UST pressure data with the currently certified nozzle and UST pressure data with the Healy 900 nozzle with EOR spout. Please note, the timeframes and duration are not identical as the historical data was collected from prior site visits and the EOR nozzle data was collected after the

installation of a CARB data acquisition system along with EOR nozzles. The average pressure with the certified nozzle is positive 2.5 inches of water column and the average pressure with the EOR nozzle is negative 1.0 inches of water column. The EOR nozzle shows a lower average. A graphical representation can be seen in Figures V-12 and V-13 below.

TABLE V-6: UST Pressure – Gilroy

Configuration	UST Pressure* (inH_2O)	Overpressure % Pressure Data ≥ 1.3
Pre EOR spout	2.5	81%
EOR spout	-1.0	10%

*Pressure averages for Pre EOR spout is based on 30 hours of data, gathered during the Mega Blitz of 2013/2014/2015. EOR spout average is based on weekly averages between mid-November to end of February 2017

FIGURE V-12: Weekly Average UST Pressure – Gilroy

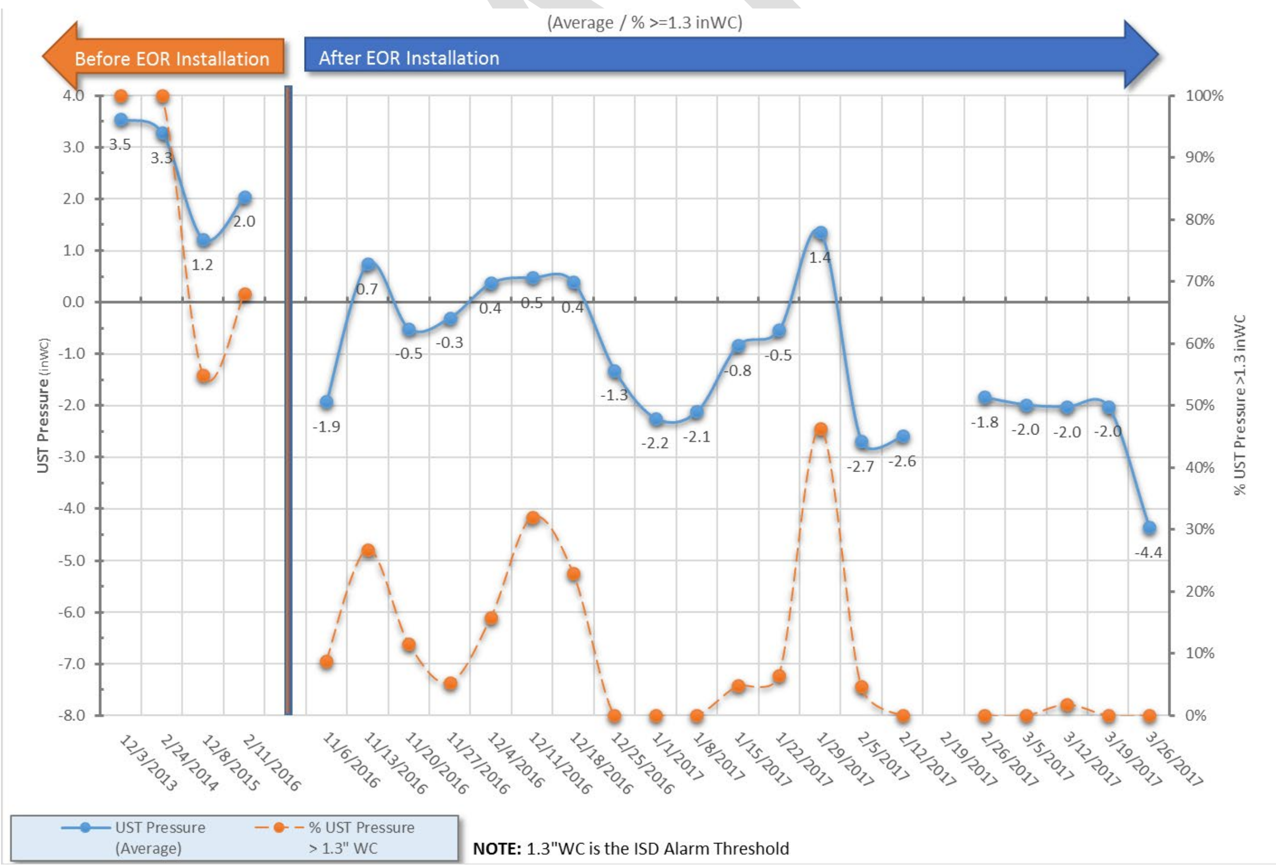
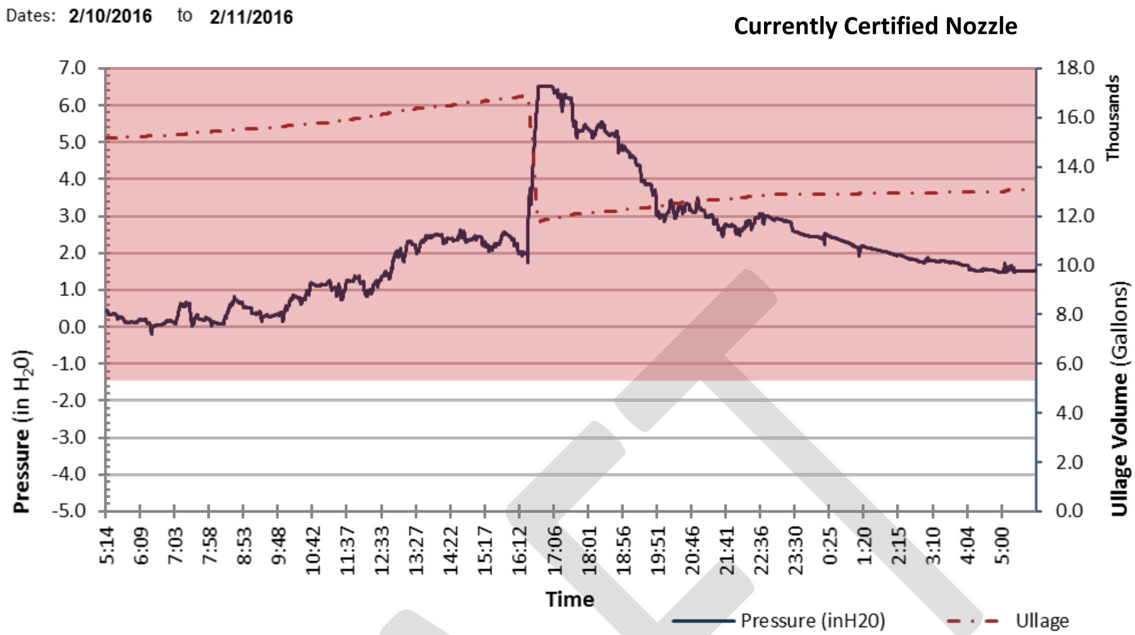
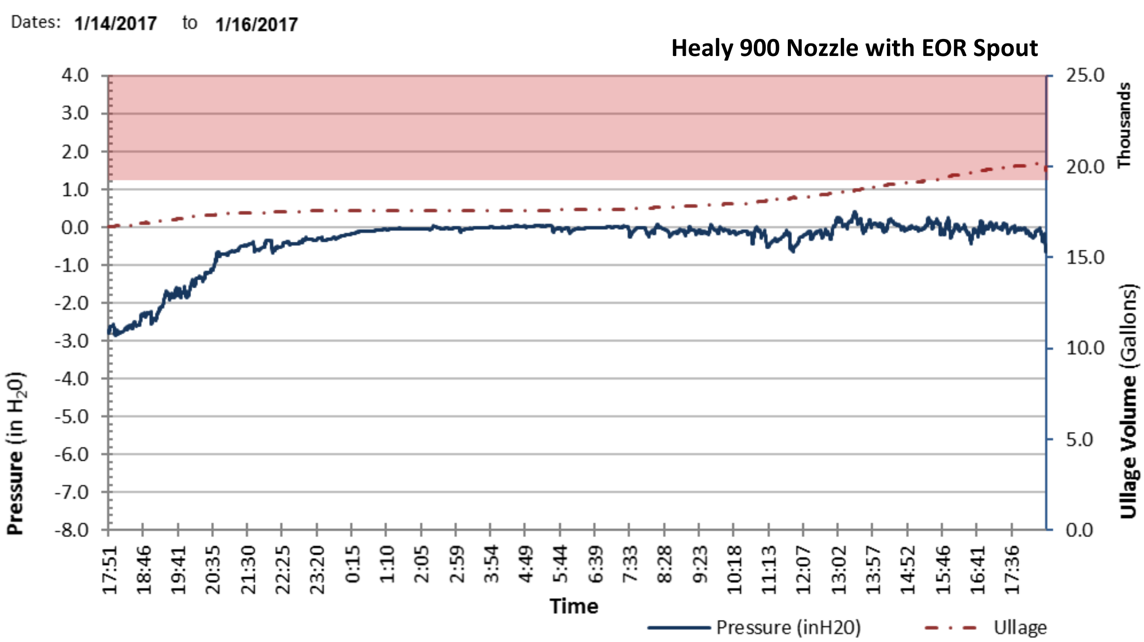


FIGURE V-13 Typical Daily Pressure Profile – Gilroy

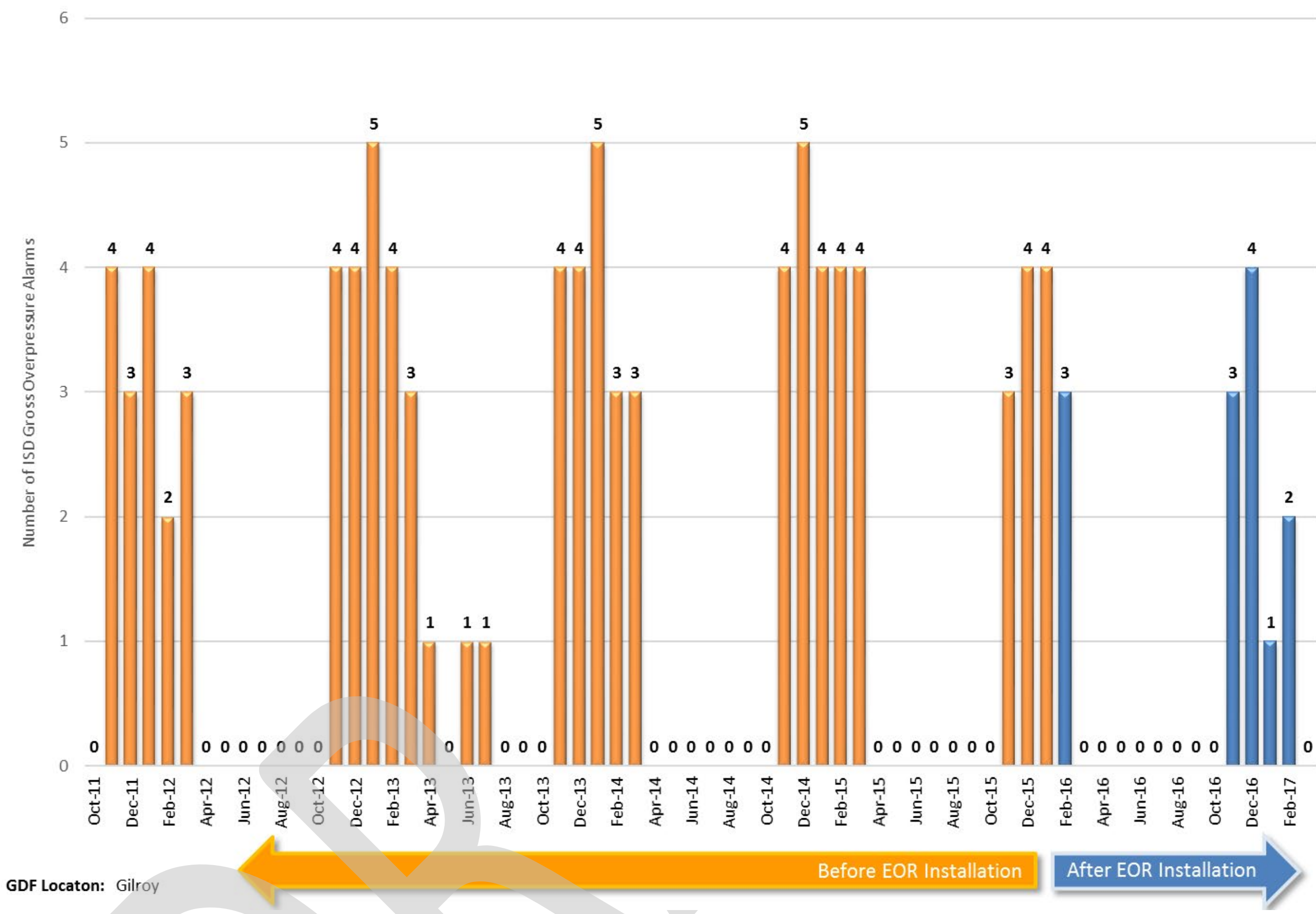




Change in ISD Overpressure Alarm Frequency

At the Gilroy test site, frequency of ISD overpressure alarms before and after installation of the EOR nozzle was observed. For the month prior to installation, overpressure alarms occurred three out of four weeks during the month. After installation, the frequency of alarms reduced by 50%. Figure V-14 provides more information.

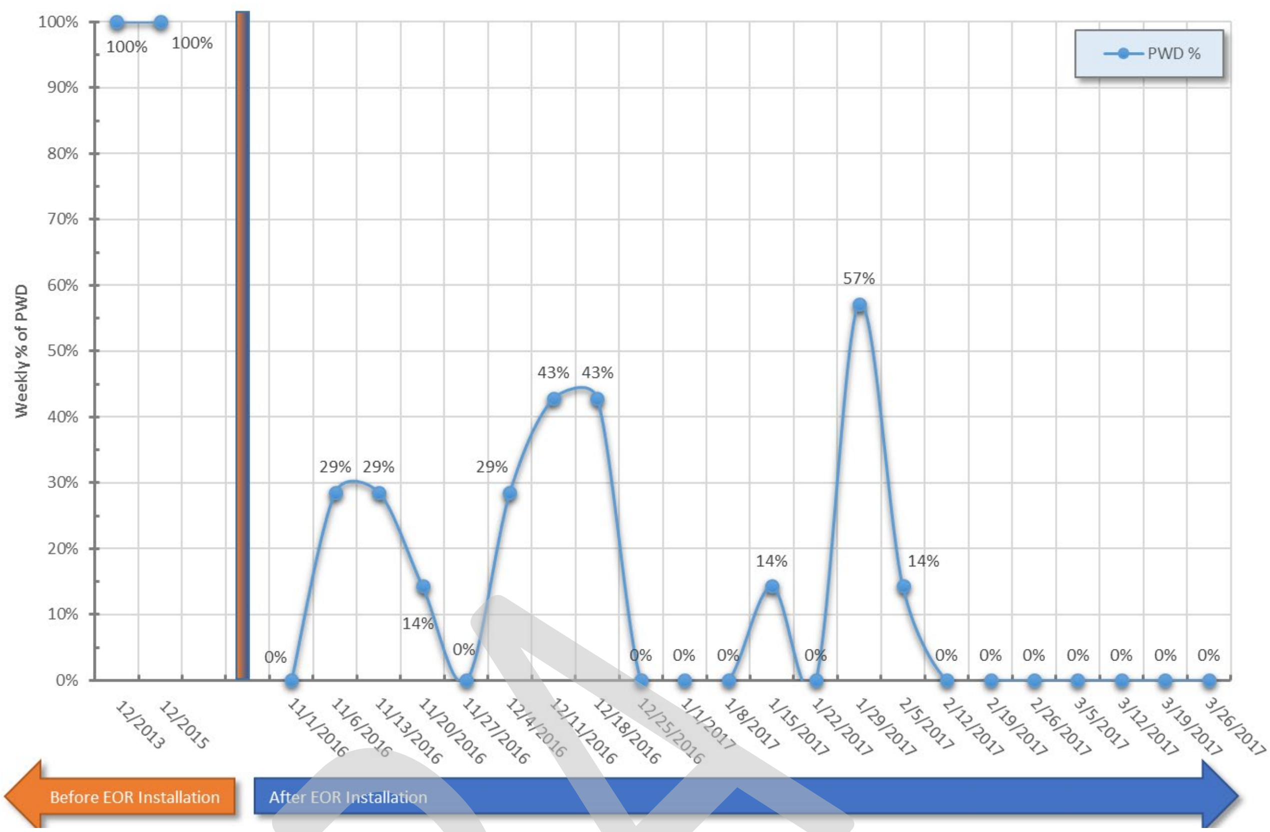
FIGURE V-14: Frequency of ISD Overpressure Alarms – Gilroy



Change in PWD Status

The occurrence of PWD at this test site is shown in Figure V-15. The pre-EOR installation, PWD determination was based on 30 hours of pressure data; the post EOR installation, PWD status was based on the number of days in the week PWD was determined. During the period of 11/01/2016 to 02/12/2017, the during the winter fuel period for Bay Area AQMD, PWD was occurring at the site.

FIGURE V-15: Pressure while Dispensing (PWD) Status – Gilroy



D. La Habra Test site

ISD data was collected from November 2016 through March 2017 and the results are provided below. This test site will show results for both nozzle configurations: (1) factory assembled and (2) field retrofitted EOR spout. For reference, the raw ISD data collected from the La Habra test site and weekly analysis are provided in Appendix IV.

Change in Nozzle Vapor to Liquid Ratio

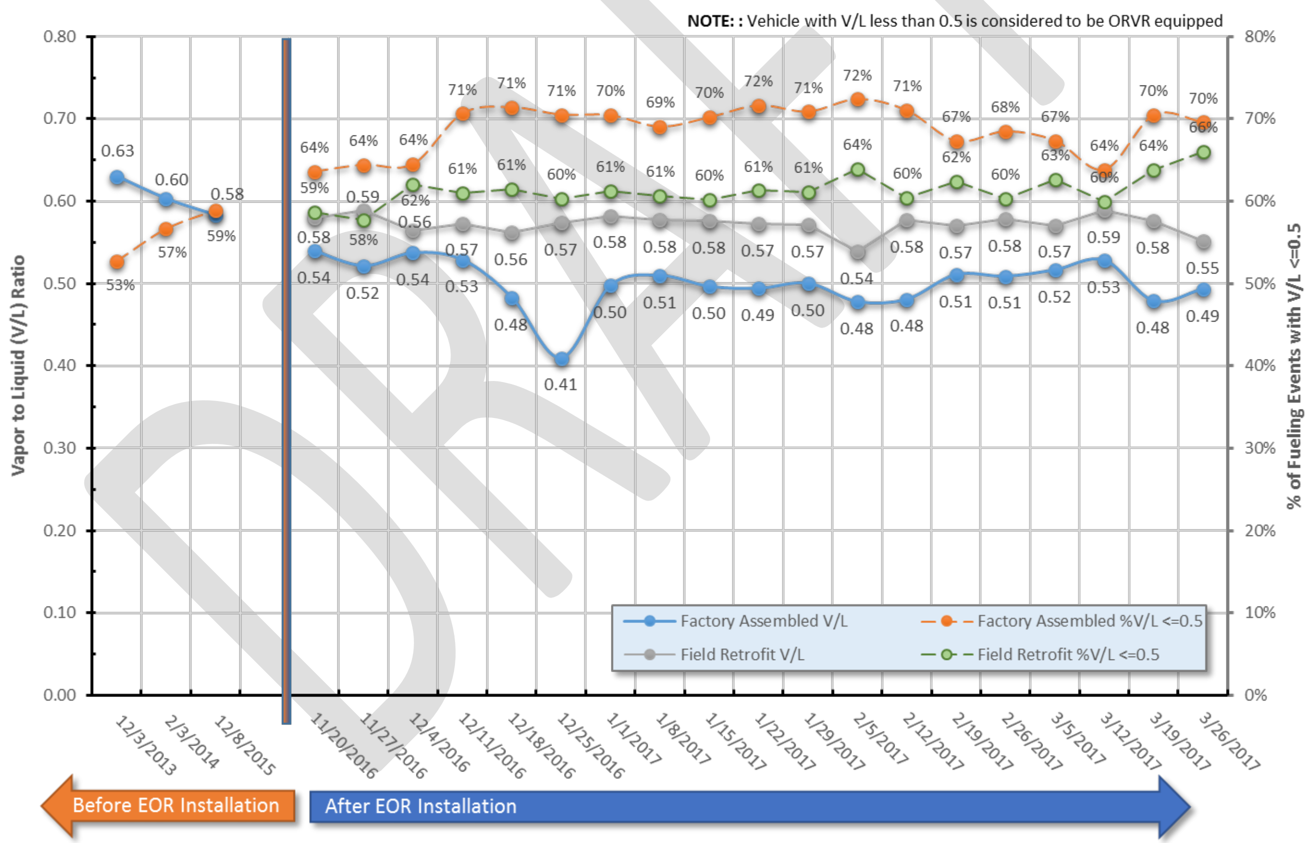
In comparing the nozzle vapor to liquid ratios at the La Habra site between the certified nozzle and the two EOR spout installation to the Healy 900 nozzle, the site average was 0.61 for the certified nozzle, 0.50 for the factory assembled Healy 900 nozzle with EOR spout, and 0.57 for the field retrofitted Healy nozzle with EOR spout. The EOR had a lower site V/L average in both configurations, however the factory assembled performed better. For ORVR ID rate, the percentage increased from 50% for the certified nozzle, to 69% for the factory assembled and 61% for the field retrofitted Healy nozzle with EOR spout. The data can be seen in Table V-7 and Figure V-16 below.

TABLE V-7: Vapor to Liquid Ratio (V/L) and ORVR ID Rate – La Habra

Configuration	V/L Ratio* Site Average	ORVR ID Rate* Fueling Events - V/L ≤ 0.5
Pre EOR spout	0.61	56%
Factory Assembled EOR spout	0.50	69%
Field Retrofitted EOR spout	0.57	61%

*Average values for each configuration. Pre EOR spout average based on three separate annual ISD downloads. EOR spout average is based on weekly averages between mid-November to end of March 2017.

FIGURE V-16: Weekly Site V/L and ORVR ID Rate – La Habra



Change in UST Pressure

Table V-8 provides a comparison of UST pressure data with the currently certified nozzle and UST pressure data with the Healy 900 nozzle with EOR spout. Please note, the timeframes and duration are not identical as the historical data was collected from prior site visits and the EOR nozzle data was collected after the installation of a CARB data acquisition system along with EOR nozzles. The average pressure with the certified nozzle is positive 2.2 inches of water column and the average pressure with both factory assembled and field retrofitted Healy 900 nozzle with EOR spout is positive 0.6 inches of water column. The EOR nozzle configurations had a lower average. A graphical representation is shown in Figures V-18 and V-19.

TABLE V-8: UST Pressure – La Habra

Configuration	UST Pressure* (inH2O)	Overpressure % Pressure Data ≥ 1.3
Pre EOR spout	2.2	70%
EOR spout	0.6	36%

*Pressure averages for Pre EOR spout is based on 30 hours of data, gathered during the Mega Blitz of 2013/2014/2015. EOR spout average is based on weekly averages between mid-November to end of February 2017

FIGURE V-17: Weekly Average UST Pressure – La Habra

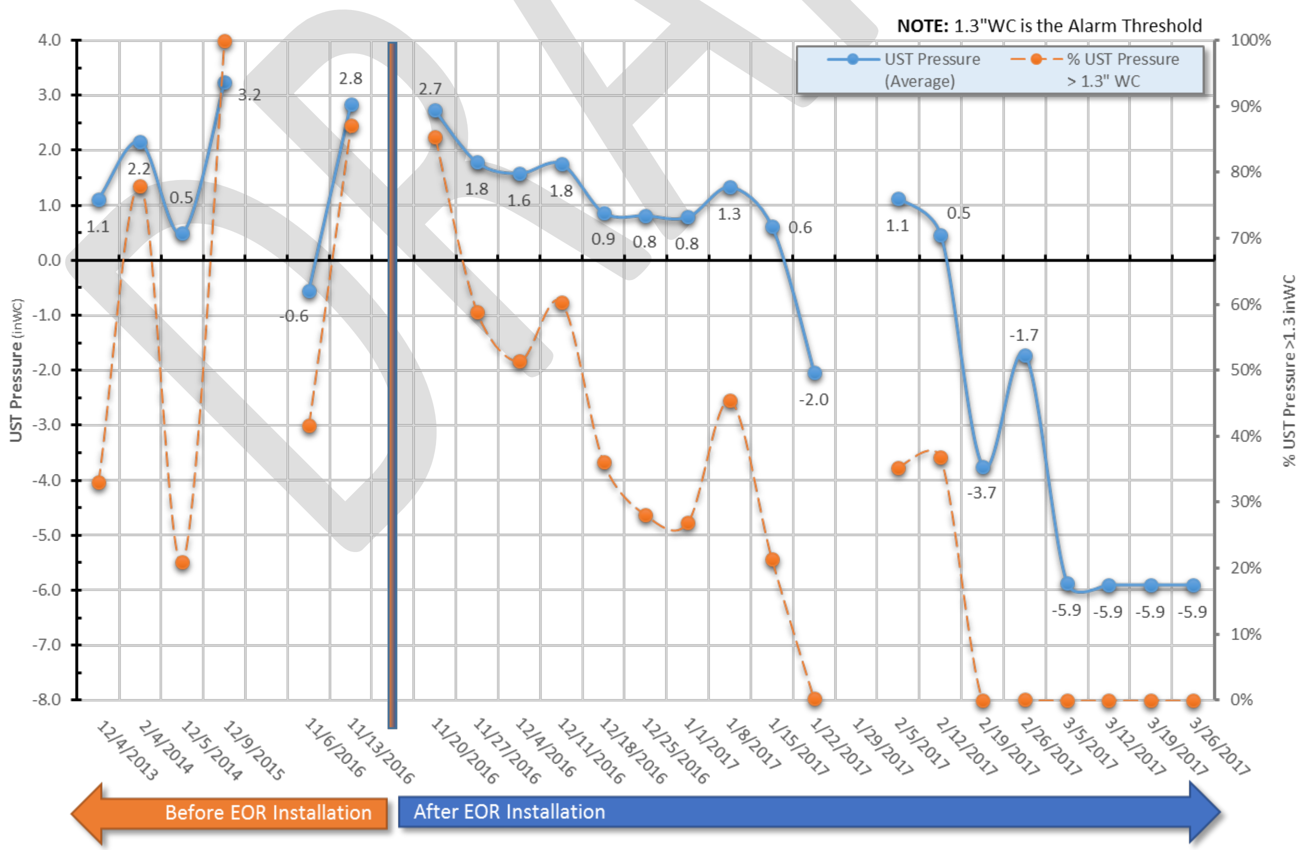
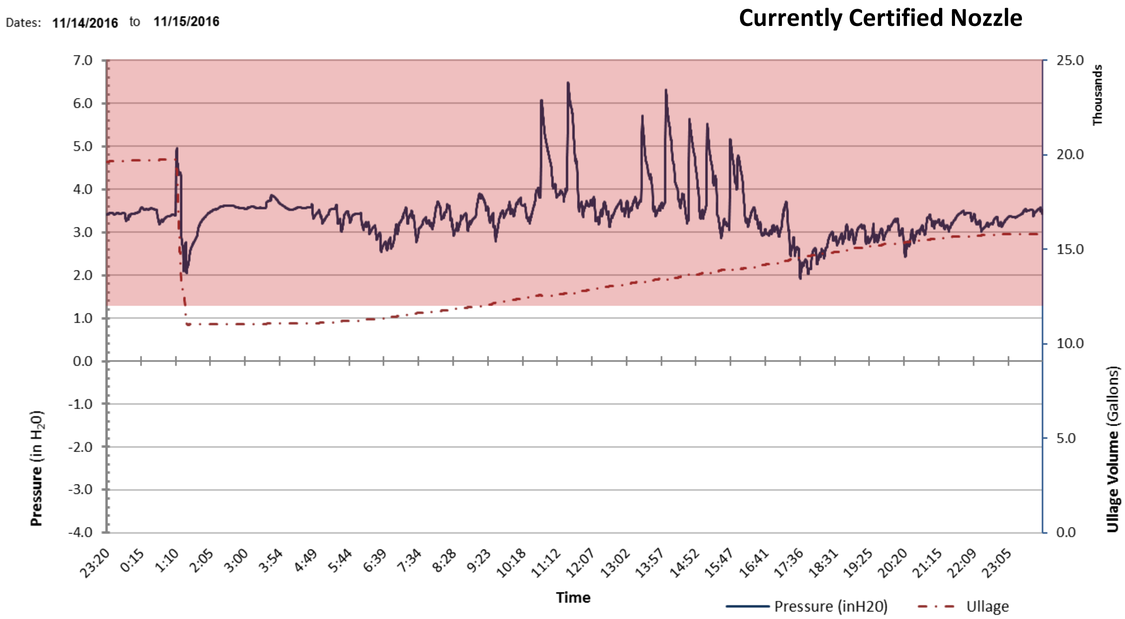
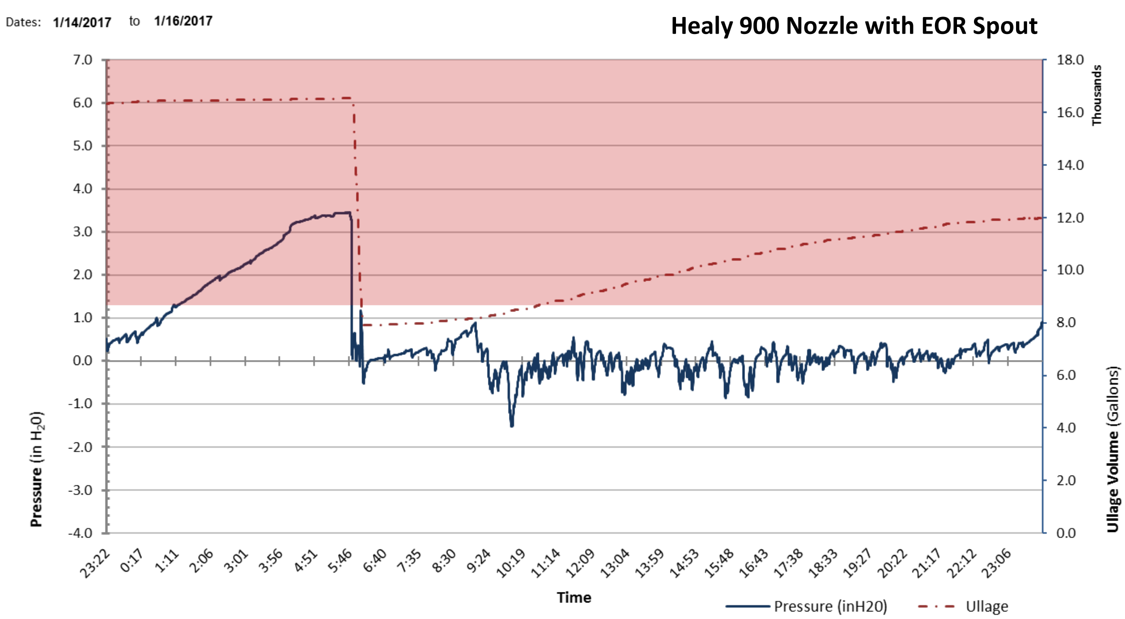


FIGURE V-18 Typical Daily Pressure Profile – La Habra

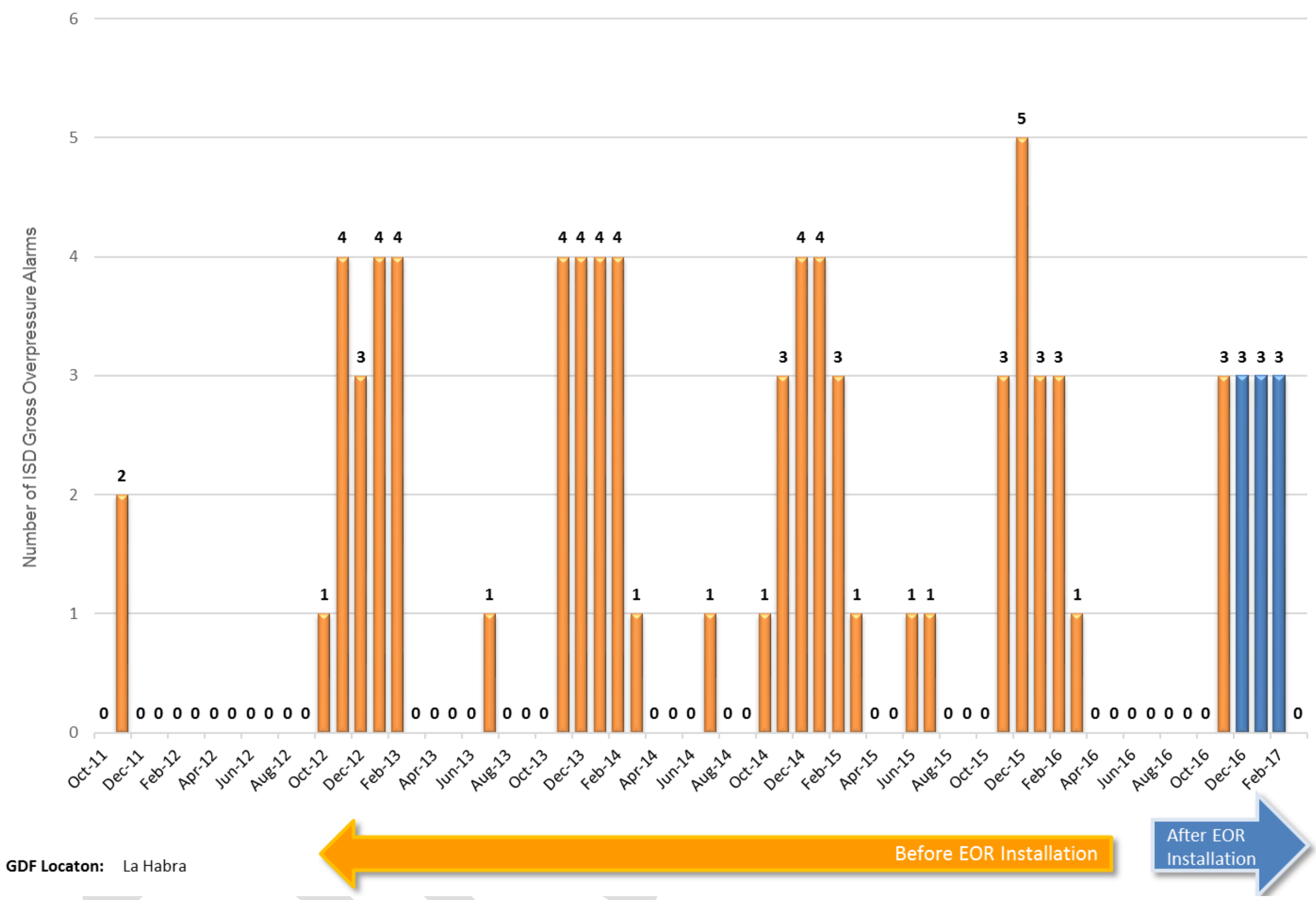




Change in ISD Overpressure Alarm Frequency

At the La Habra test site, frequency of ISD overpressure alarms before and after installation of the EOR nozzle was observed. For the month prior to installation, overpressure alarms occurred three out of four weeks each month. After installation the frequency of alarms, no change was noticed. Figure V-19 provides more information.

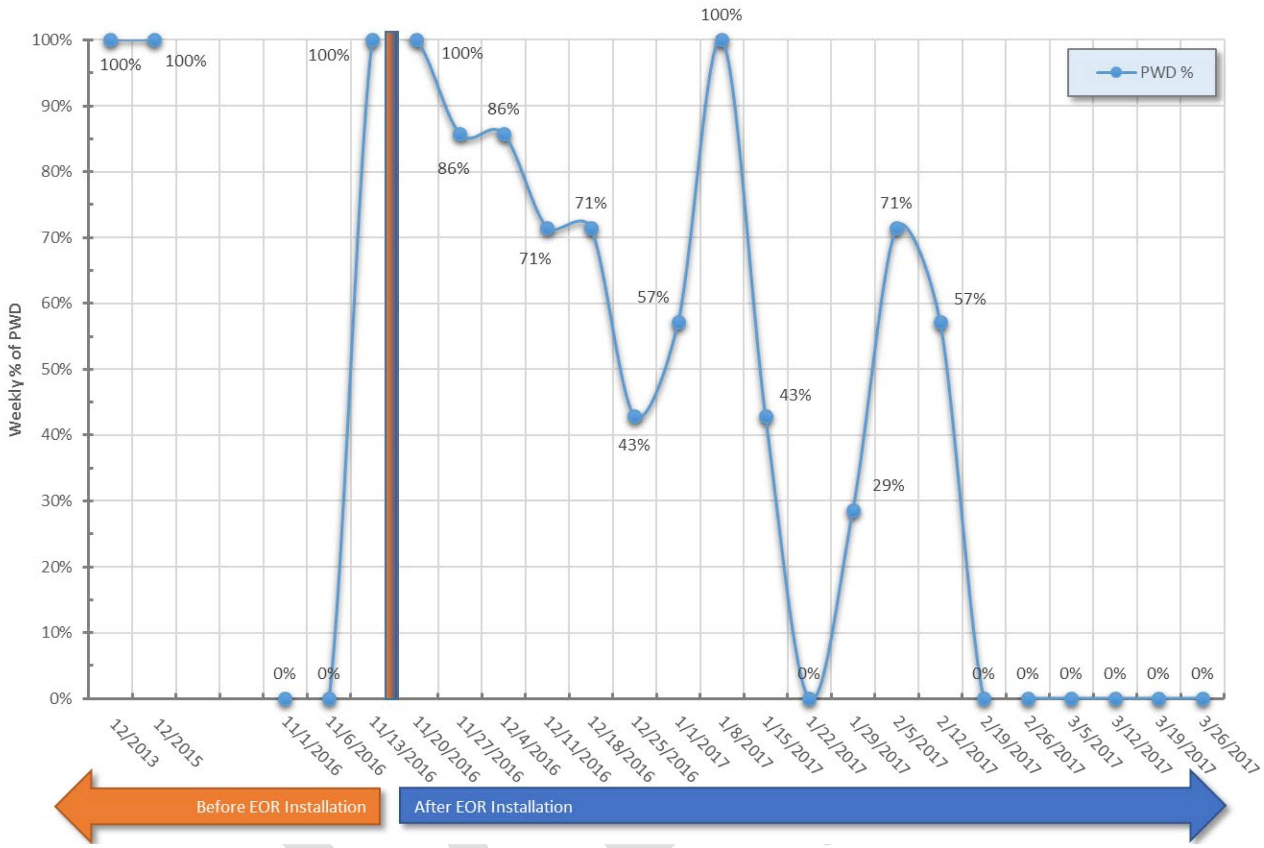
FIGURE V-19: Frequency of ISD Overpressure Alarms – La Habra



Change in PWD Status

The occurrence of PWD at this test site is shown in Figure V-20. The pre-EOR installation, PWD determination was based on 30 hours of pressure data; the post EOR installation, PWD status was based on the number of days in the week PWD was determined. During the period of 11/20/2016 to 02/19/2017, the during the winter fuel period for South Coast AQMD, PWD was occurring at the site.

FIGURE V-20: Pressure while Dispensing (PWD) Status – La Habra



E. La Cañada-Flintridge Test site

ISD data was collected from November 2016 through March 2017 and the results are provided below. For reference, the raw ISD data collected from the La Cañada-Flintridge test site and weekly analysis are provided in Appendix V.

Change in Nozzle Vapor to Liquid Ratio

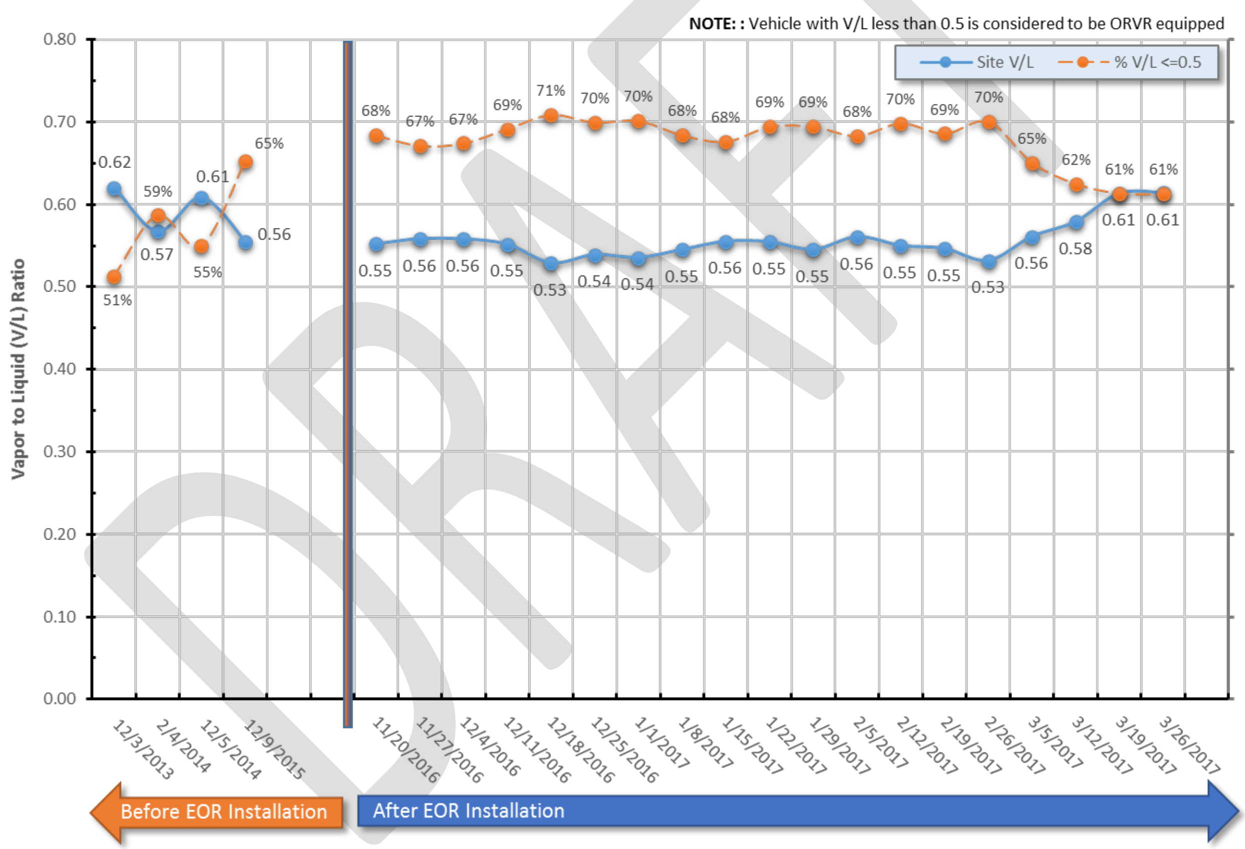
In comparing the nozzle vapor to liquid ratios at the La Cañada-Flintridge site between the certified nozzle and the Healy 900 nozzle with EOR spout, the site average was 0.59 for the certified nozzle and 0.56 for the nozzle with EOR spout (Table V-9). The EOR had a slightly lower site V/L average. For ORVR ID rate, the percentage increased from 58% to 68% for the certified nozzle compared to the nozzle with EOR spout (Figure V-21).

TABLE V-9: Vapor to Liquid Ratio (V/L) and ORVR ID Rate – La Cañada-Flintridge

Configuration	V/L Ratio* Site Average	ORVR ID Rate* Fueling Events - V/L ≤ 0.5
Pre EOR spout	0.59	58%
EOR spout	0.56	68%

*Average values for each configuration. Pre EOR spout average based on three separate annual ISD downloads. EOR spout average is based on weekly averages between mid-November to end of March 2017.

FIGURE V-21: Weekly Site V/L and ORVR ID Rate – La Cañada-Flintridge



Change in UST Pressure

Table V-10 provides a comparison of UST pressure data with the currently certified nozzle and UST pressure data with the Healy 900 nozzle with EOR spout. Please note, the timeframes and duration are not identical as the historical data was collected from prior site visits and the EOR nozzle data was collected after the

installation of a CARB data acquisition system along with EOR nozzles. The average pressure with the certified nozzle is positive 2.3 inches of water column and the average pressure with the EOR nozzle is negative 2.7 inches of water column. The EOR nozzle shows a lower average. A graphical representation is shown in Figures V-22 and V-23.

TABLE V-10: UST Pressure – La Cañada-Flintridge

Configuration	UST Pressure* (inH_2O)	Overpressure % Pressure Data ≥ 1.3
Pre EOR spout	2.3	77%
EOR spout	-2.7	5%

*Pressure averages for Pre EOR spout is based on 30 hours of data, gathered during the Mega Blitz of 2013/2014/2015. EOR spout average is based on weekly averages between mid-November to end of February 2017

FIGURE V-22: Weekly Average UST Pressure – La Cañada-Flintridge

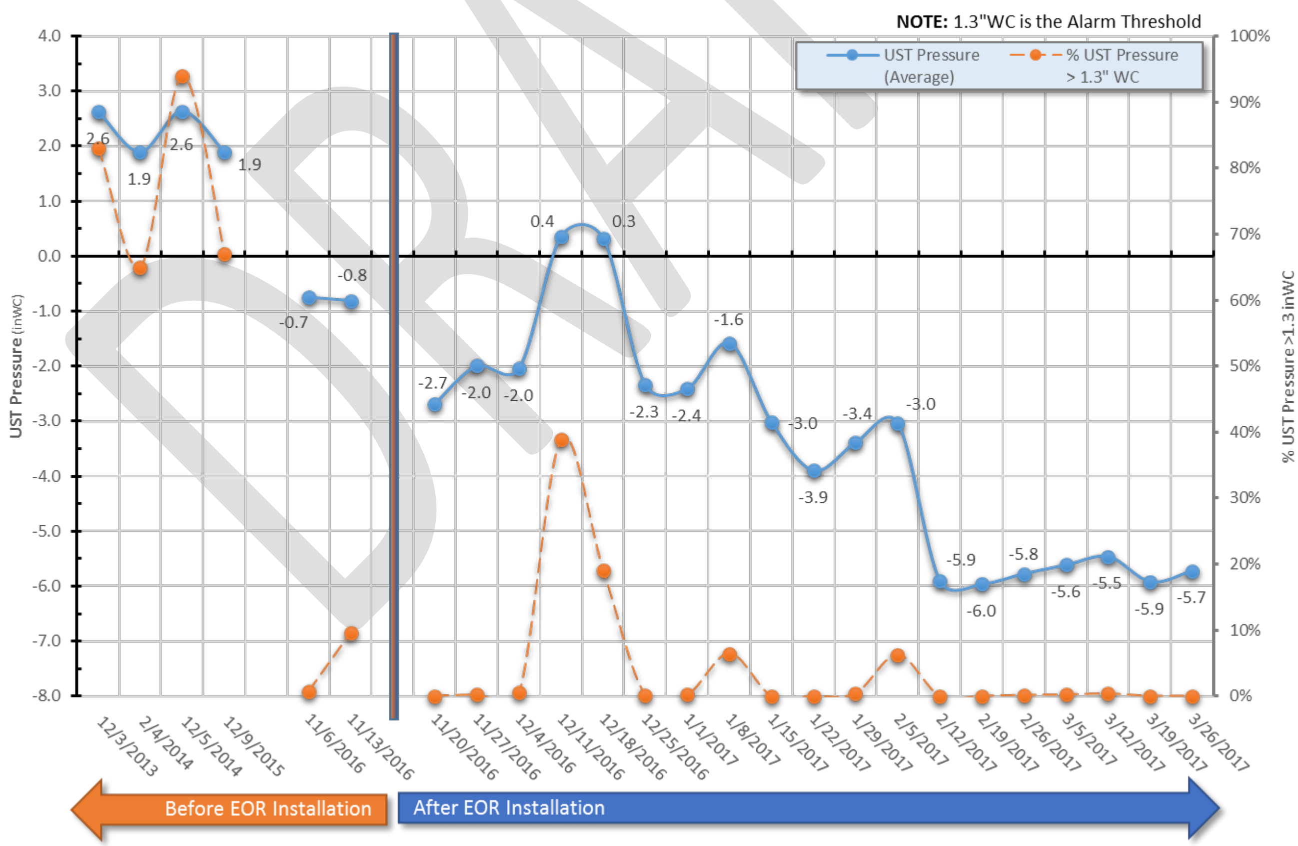
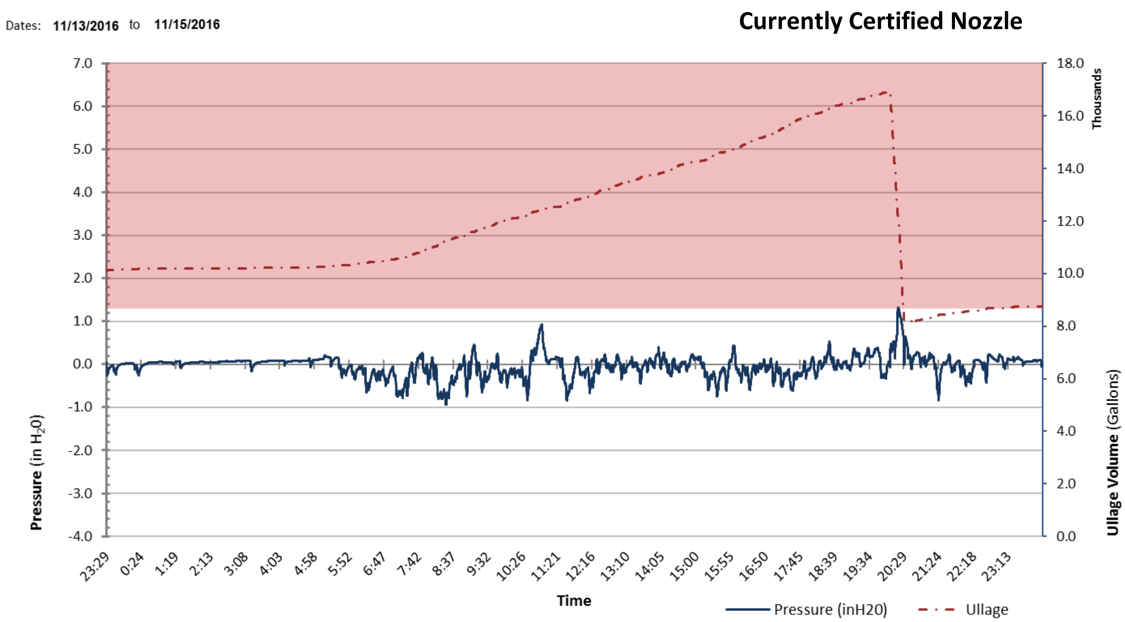
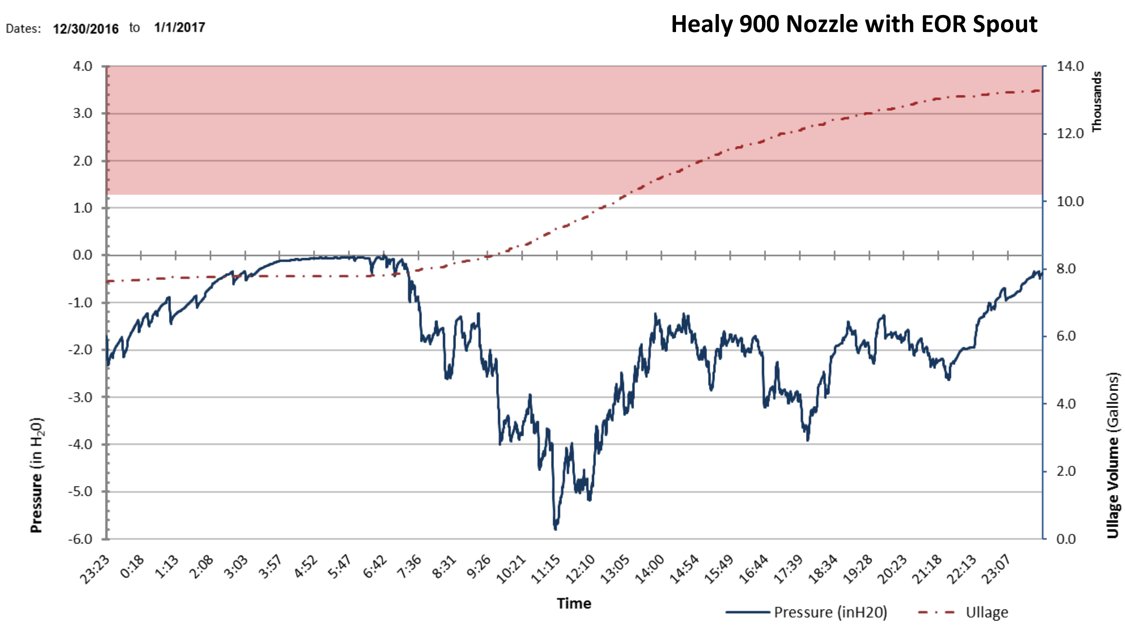


FIGURE V-23 Typical Daily Pressure Profile – La Cañada-Flintridge

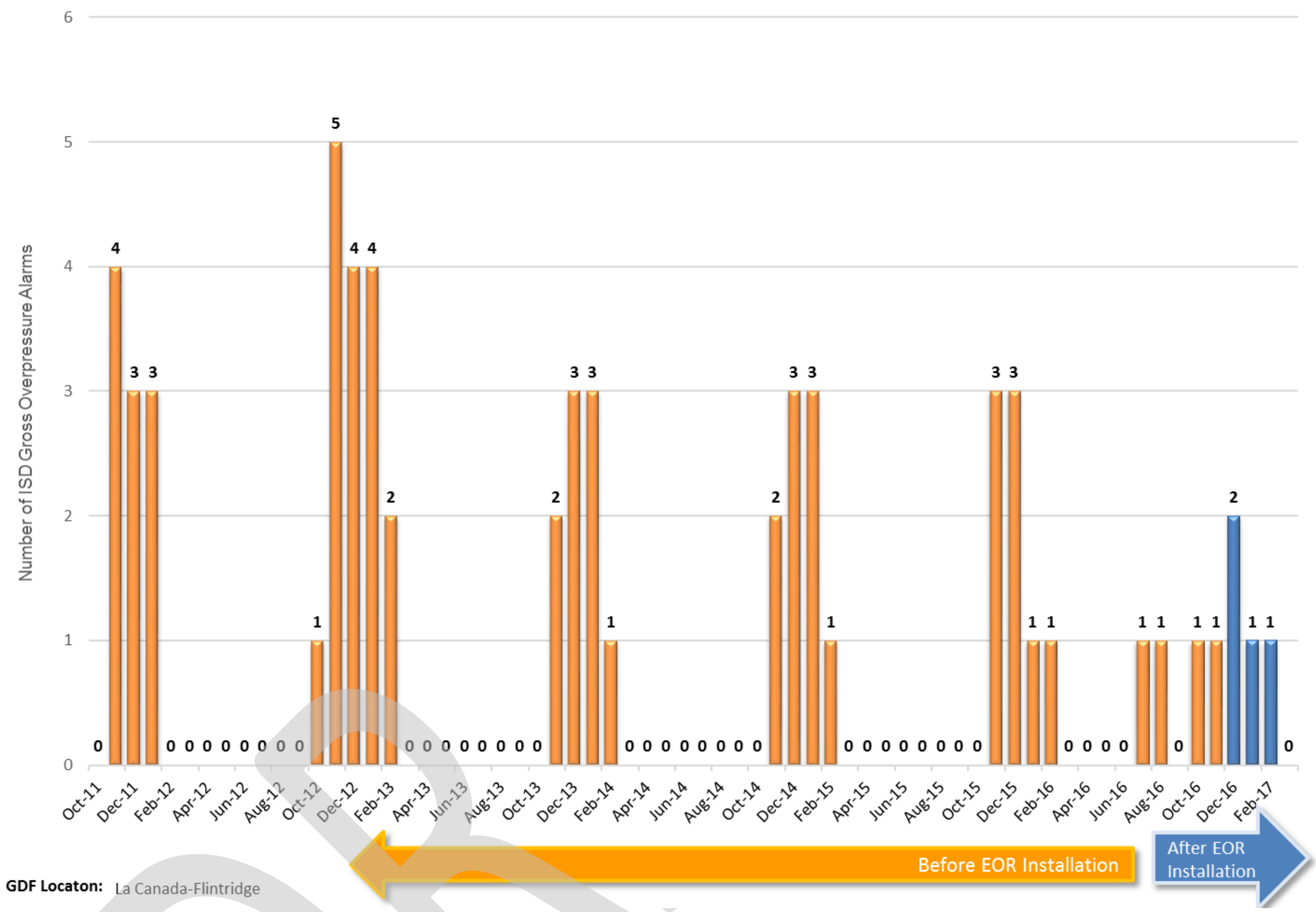




Change in ISD Overpressure Alarm Frequency

At the La Cañada-Flintridge test site, frequency of ISD overpressure alarms before and after installation of the EOR nozzle was observed. For the month prior to installation, overpressure alarms occurred only once during the month. After installation the frequency of alarms, no change was noticed. Figure V-24 provides more information.

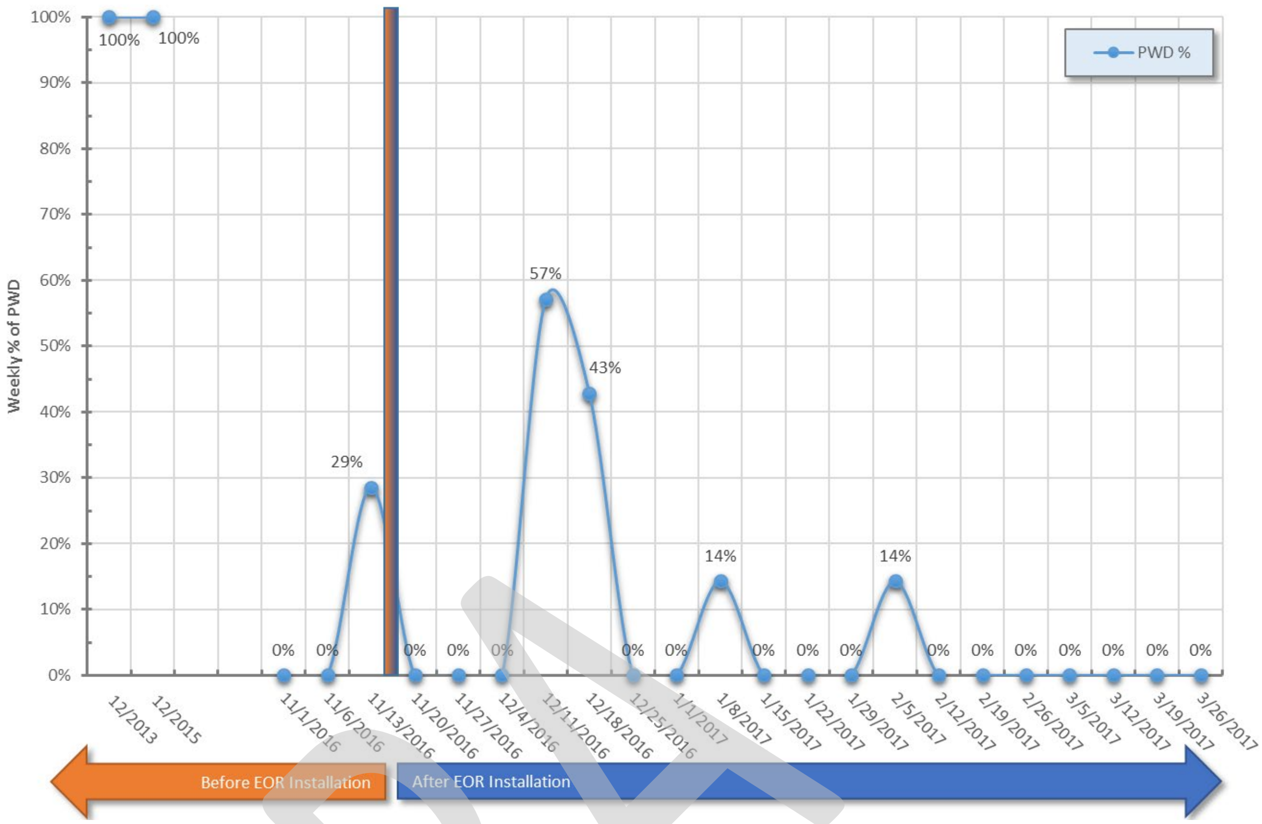
FIGURE V-24: Frequency of ISD Overpressure Alarms – La Cañada-Flintridge



Change in PWD Status

The occurrence of PWD at this test site is shown in Figure V-25. The pre-EOR installation, PWD determination was based on 30 hours of pressure data; the post EOR installation, PWD status was based on the number of days in the week PWD was determined. During the period of 12/04/2016 to 02/12/2017, the during the winter fuel period for Bay Area AQMD, PWD was occurring at the site.

FIGURE V-25: Pressure while Dispensing (PWD) Status – La Cañada-Flintridge



F. Victorville Test site

ISD data was collected from December 2016 through March 2017 and the results are provided below. For reference, the raw ISD data collected from the Victorville test site and weekly analysis are provided in Appendix VI.

Change in Nozzle Vapor to Liquid Ratio

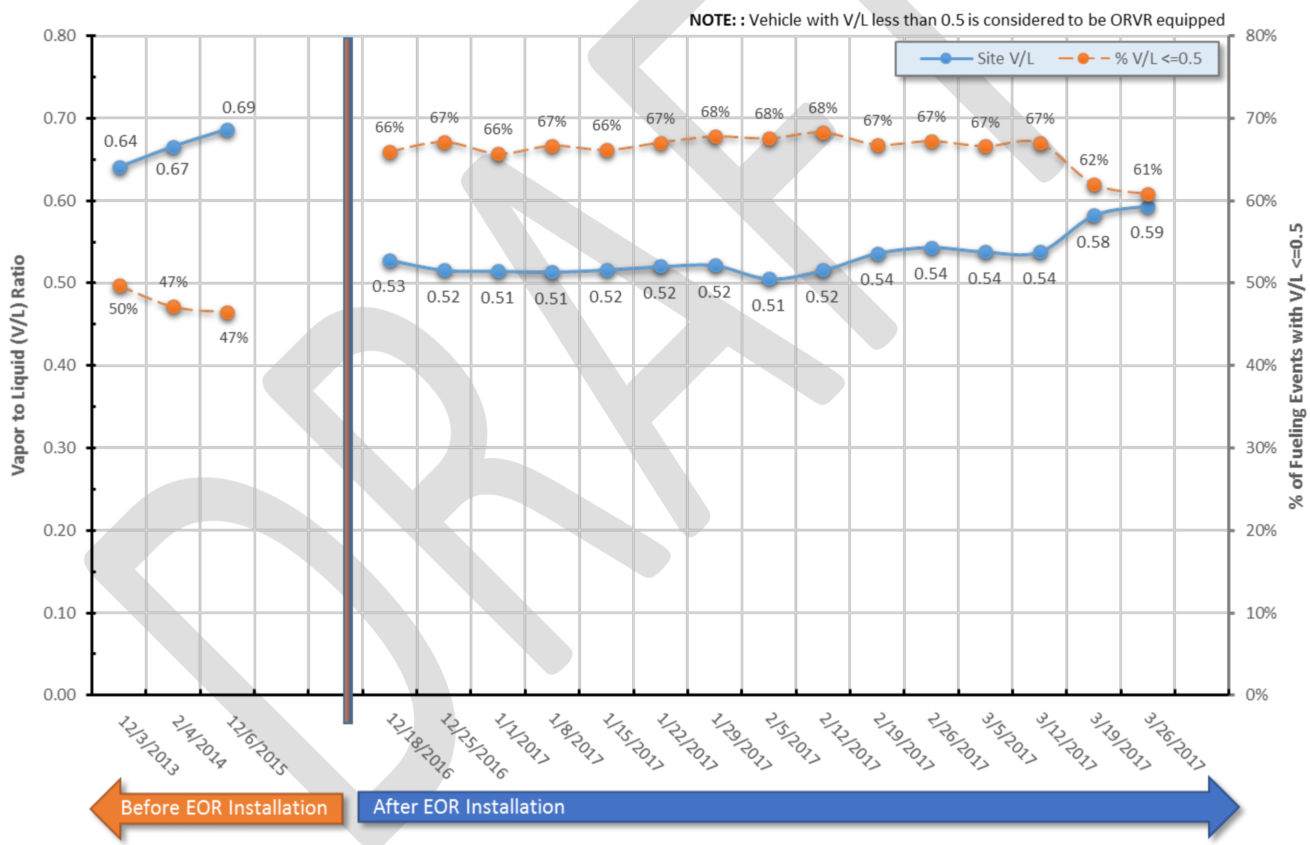
In comparing the nozzle vapor to liquid ratios at the Victorville site between the certified nozzle and the Healy 900 nozzle with EOR spout, the site average was 0.66 for the certified nozzle and 0.53 for the Healy 900 nozzle with EOR spout. The EOR had a lower site V/L average. For ORVR ID rate, the percentage increased from 48% to 66% for the certified nozzle compared to the nozzle with EOR spout. The data can be seen in Table V-11 and Figure V-26 below.

TABLE V-11: Vapor to Liquid Ratio (V/L) and ORVR ID Rate – Victorville

Configuration	V/L Ratio* Site Average	ORVR ID Rate* Fueling Events - V/L ≤ 0.5
Pre EOR spout	0.66	48%
EOR spout	0.53	66%

*Average values for each configuration. Pre EOR spout average based on three separate annual ISD downloads. EOR spout average is based on weekly averages between mid-December to end of March 2017.

FIGURE V-26: Weekly Site V/L and ORVR ID Rate – Victorville



Change in UST Pressure

Table V-12 provides a comparison of UST pressure data with the currently certified nozzle and UST pressure data with the Healy 900 nozzle with EOR spout. Please note, the timeframes and duration are not identical as the historical data was collected from prior site visits and the EOR nozzle data was collected after the installation of a CARB data acquisition system along with EOR nozzles. The average pressure with the certified nozzle is positive 1.2 inches of water column and the average pressure with the EOR nozzle is negative 1.6 inches of water column. The EOR nozzle shows a lower average. A graphical representation can be seen in Figures V-27 and V-28 below.

TABLE V-12: UST Pressure – Victorville

Configuration	UST Pressure* (inH₂O)	Overpressure % Pressure Data ≥ 1.3
Pre EOR spout	1.2	42%
EOR spout	-1.6	8%

*Pressure averages for Pre EOR spout is based on 30 hours of data, gathered during the Mega Blitz of 2013/2014/2015. EOR spout average is based on weekly averages between mid-November to end of February 2017

FIGURE V-27: Weekly Average UST Pressure – Victorville

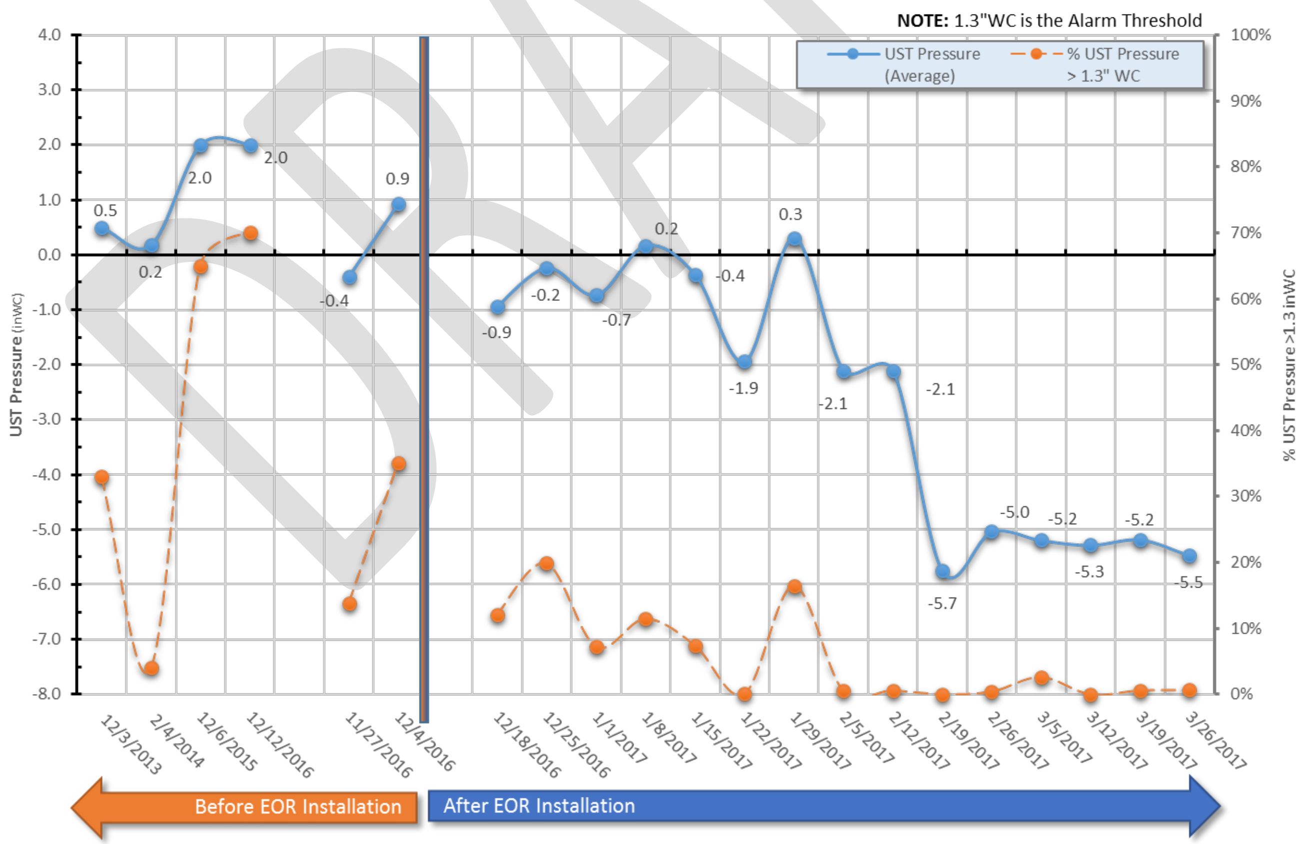
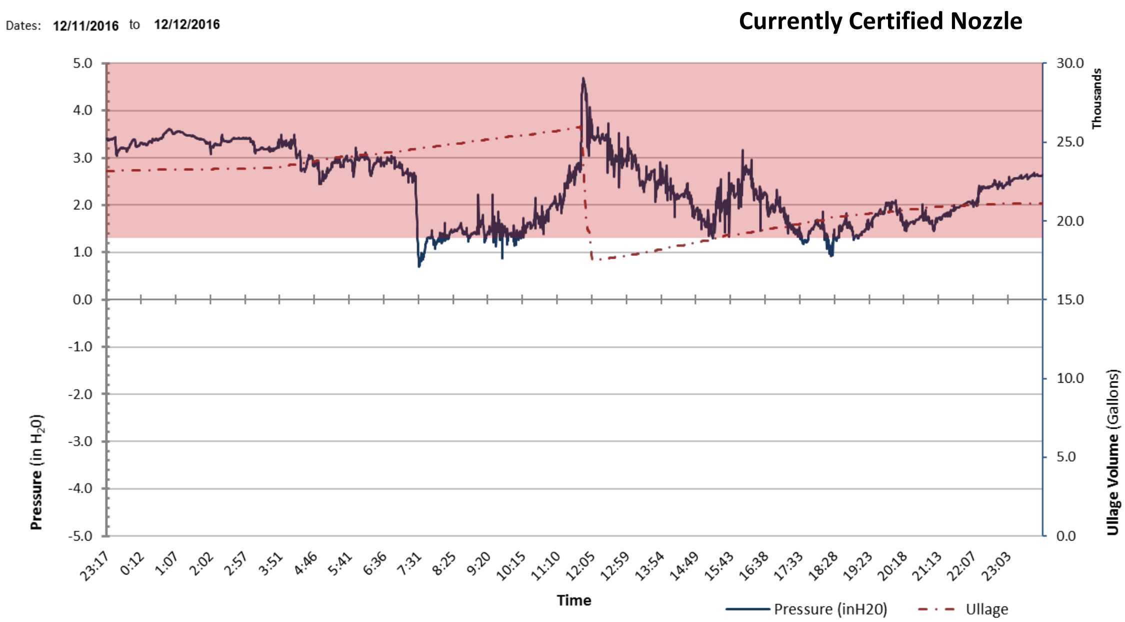
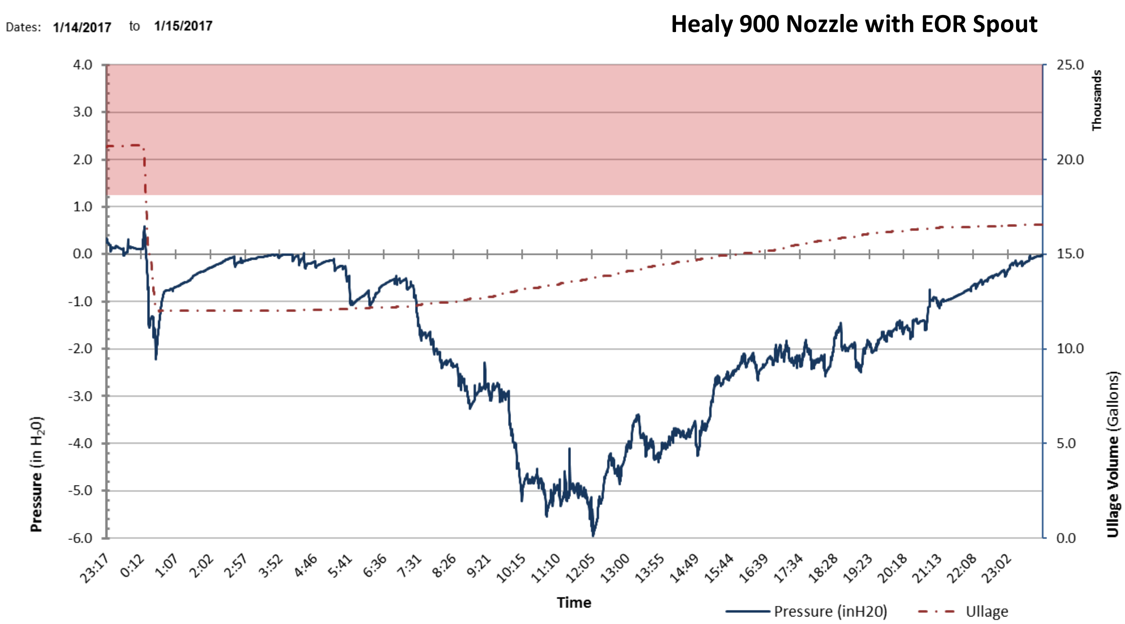


FIGURE V-28 Typical Daily Pressure Profile – Victorville

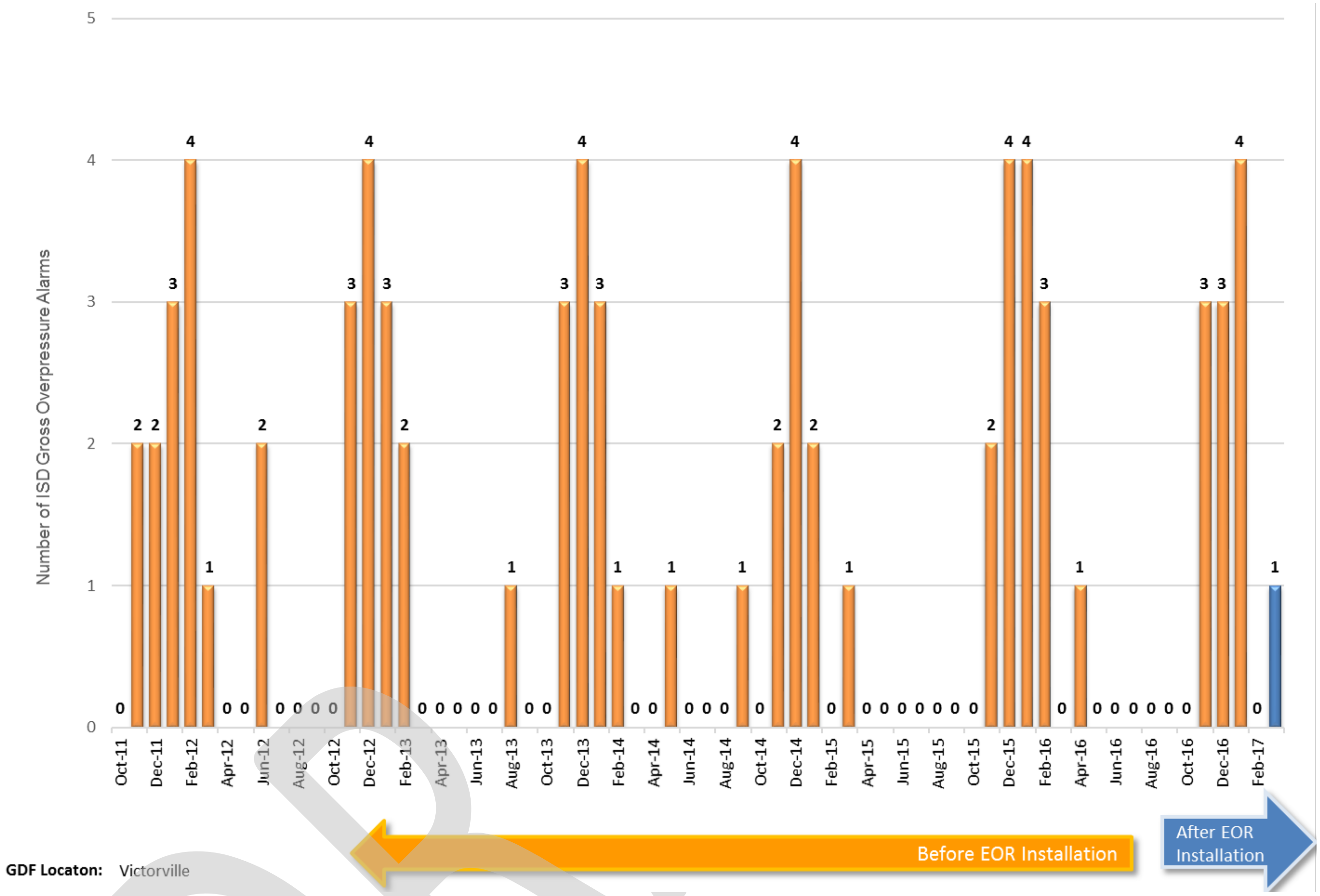




Change in ISD Overpressure Alarm Frequency

At the Victorville test site, frequency of ISD overpressure alarms before and after installation of the EOR nozzle was observed. For the month prior to installation, overpressure alarms were three of four weeks. After installation, the frequency of alarms did not change. Figure V-29 provides more information.

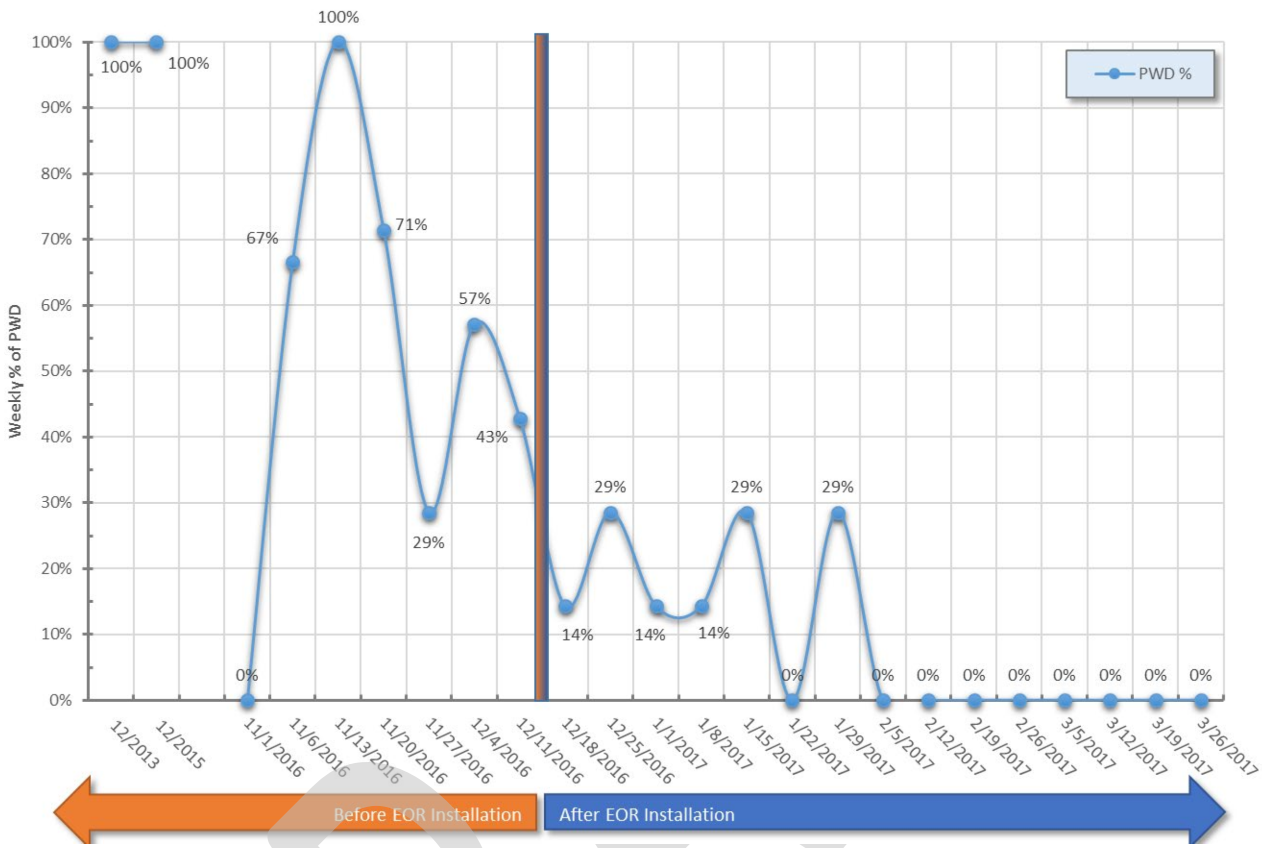
FIGURE V-29: Frequency of ISD Overpressure Alarms – Victorville



Change in PWD Status

The occurrence of PWD at this test site is shown in Figure V-30. The pre-EOR installation, PWD determination was based on 30 hours of pressure data; the post EOR installation, PWD status was based on the number of days in the week PWD was determined. During the period of 12/18/2016 to 02/05/2017, PWD was occurring at the site.

FIGURE V-30: Pressure while Dispensing (PWD) Status – Victorville



G. Apple Valley

ISD data was collected from December 2016 through March 2017 and the results are provided below. For reference, the raw ISD data collected from the Apple Valley test site and weekly analysis are provided in Appendix VII.

Change in Nozzle Vapor to Liquid Ratio

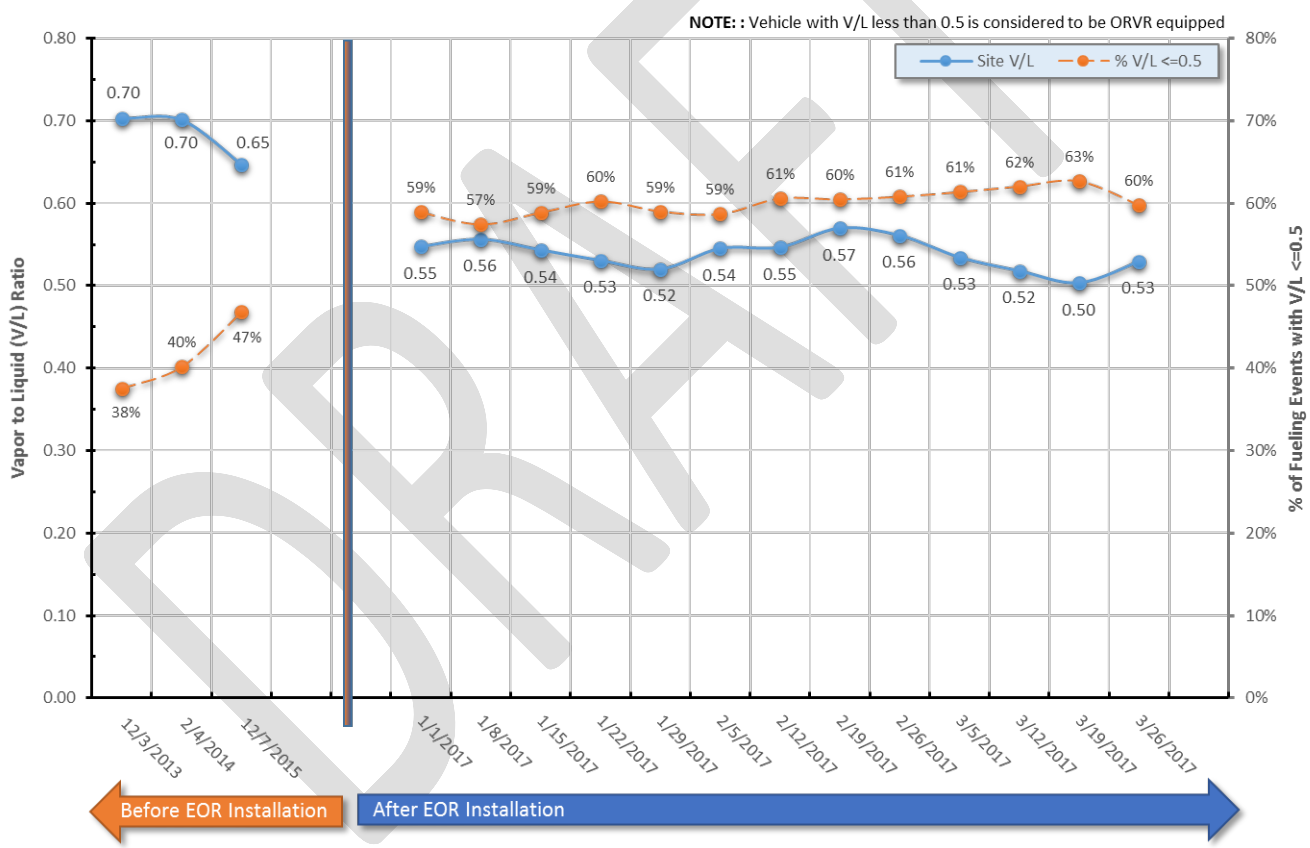
In comparing the nozzle vapor to liquid ratios at the Apple Valley site between the certified nozzle and the Healy 900 nozzle with EOR spout, the site average was 0.68 for the certified nozzle and 0.54 for the Healy 900 nozzle with EOR spout. The EOR had a lower site V/L average. For ORVR ID rate, the percentage increased from 42% to 60% for the certified nozzle compared to the nozzle with EOR spout. The data can be seen in Table V-13 and Figure V-31 below.

TABLE V-13: Vapor to Liquid Ratio (V/L) and ORVR ID Rate – Apple Valley

Configuration	V/L Ratio* Site Average	ORVR ID Rate* Fueling Events - V/L ≤ 0.5
Pre EOR spout	0.68	42%
EOR spout	0.54	60%

*Average values for each configuration. Pre EOR spout average based on three separate annual ISD downloads. EOR spout average is based on weekly averages between mid-December to end of March 2017.

FIGURE V-31: Weekly Site V/L and ORVR ID Rate – Apple Valley



Change in UST Pressure

Table V-14 provides a comparison of UST pressure data with the currently certified nozzle and UST pressure data with the Healy 900 nozzle with EOR spout. Please note, the timeframes and duration are not identical as the historical data was collected from prior site visits and the EOR nozzle data was collected after the

installation of a CARB data acquisition system along with EOR nozzles. The average pressure with the certified nozzle is positive 2.7 inches of water column and the average pressure with the EOR nozzle is negative 1.8 inches of water column. The EOR nozzle shows a lower average. A graphical representation can be seen in Figures V-32 and V-33 below.

TABLE V-14: UST Pressure – Apple Valley

Configuration	UST Pressure* (inH2O)	Overpressure % Pressure Data ≥ 1.3
Pre EOR spout	2.7	84%
EOR spout	-1.8**	0%**

*Pressure averages for Pre EOR spout is based on 30 hours of data, gathered during the Mega Blitz of 2013/2014/2015. EOR spout average is based on weekly averages between mid-November to end of February 2017

**Pressure data not valid due to containment leak

FIGURE V-32: Weekly Average UST Pressure – Apple Valley

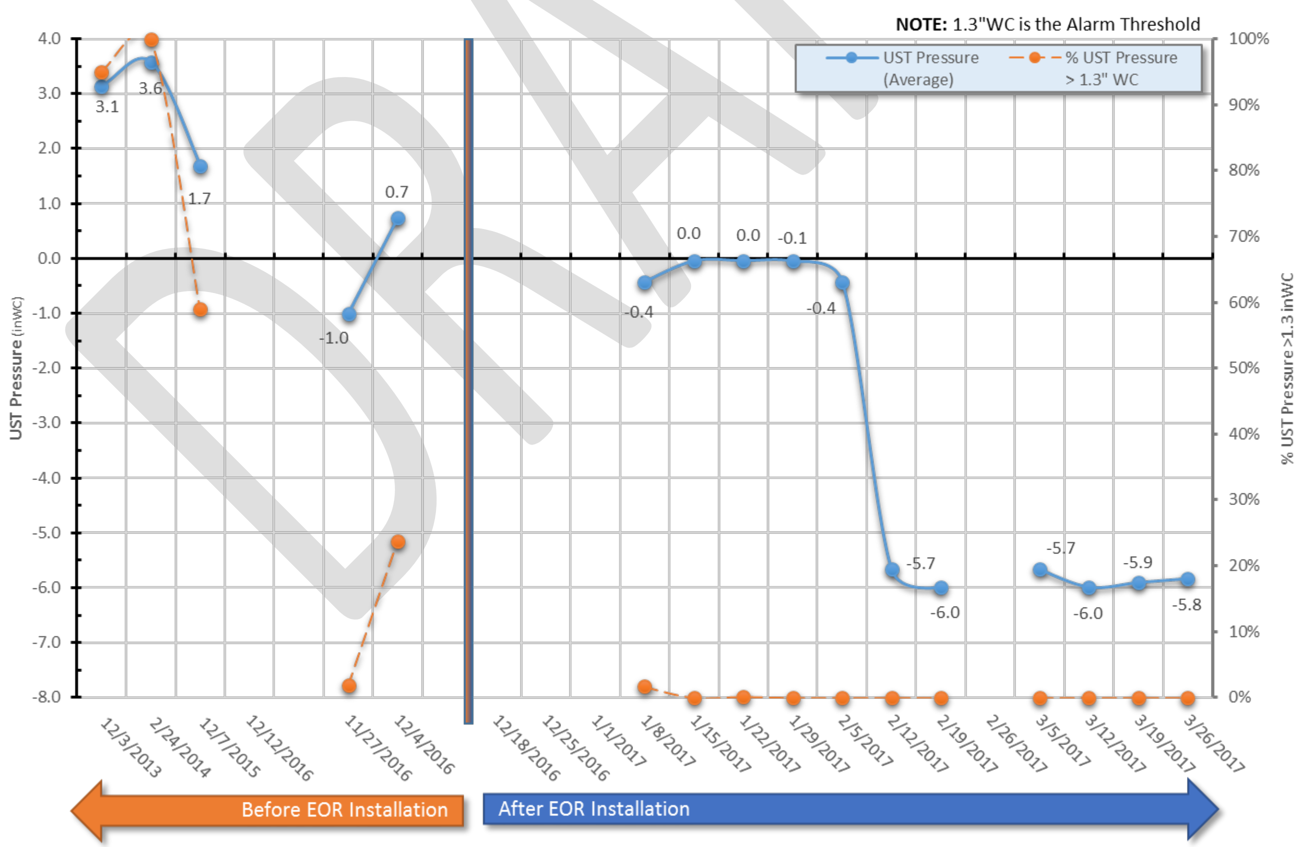
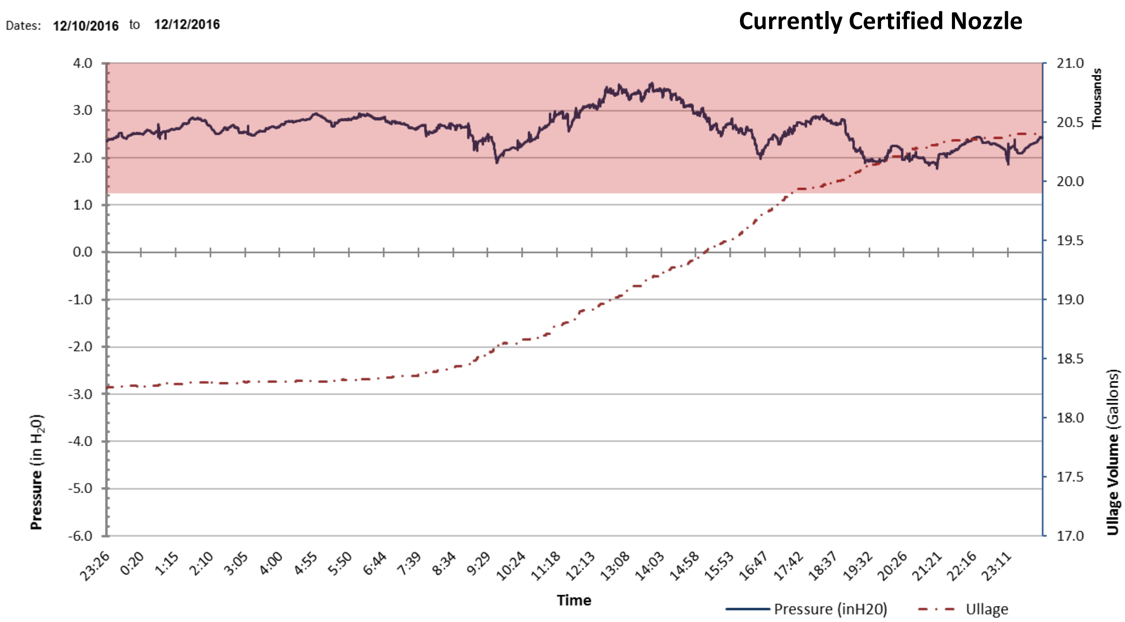
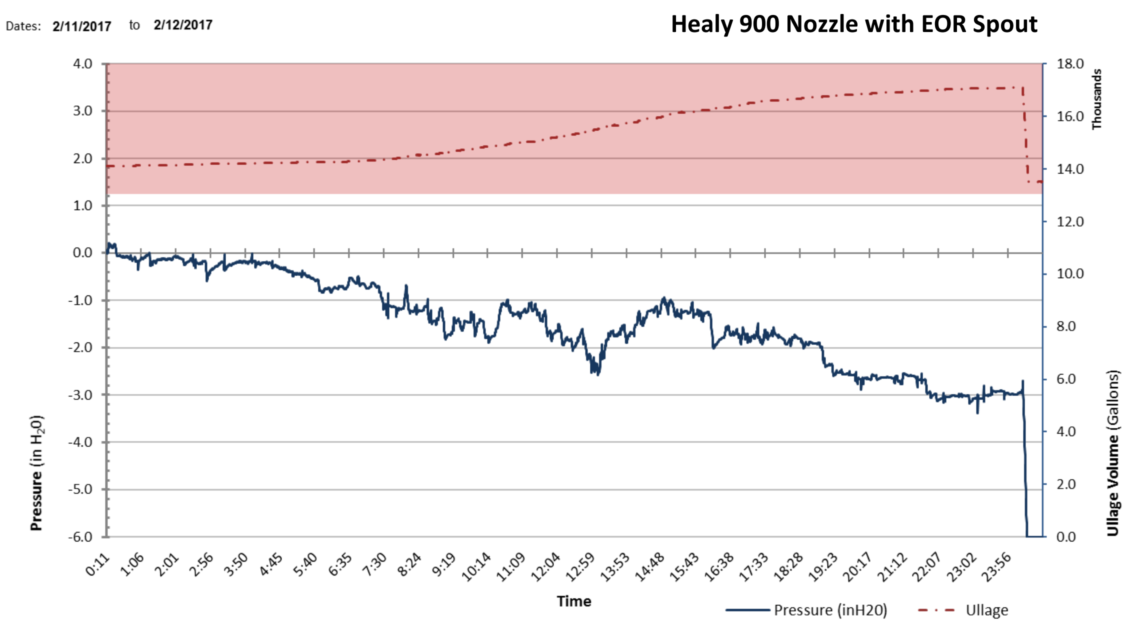


FIGURE V-33 Typical Daily Pressure Profile – Apple Valley

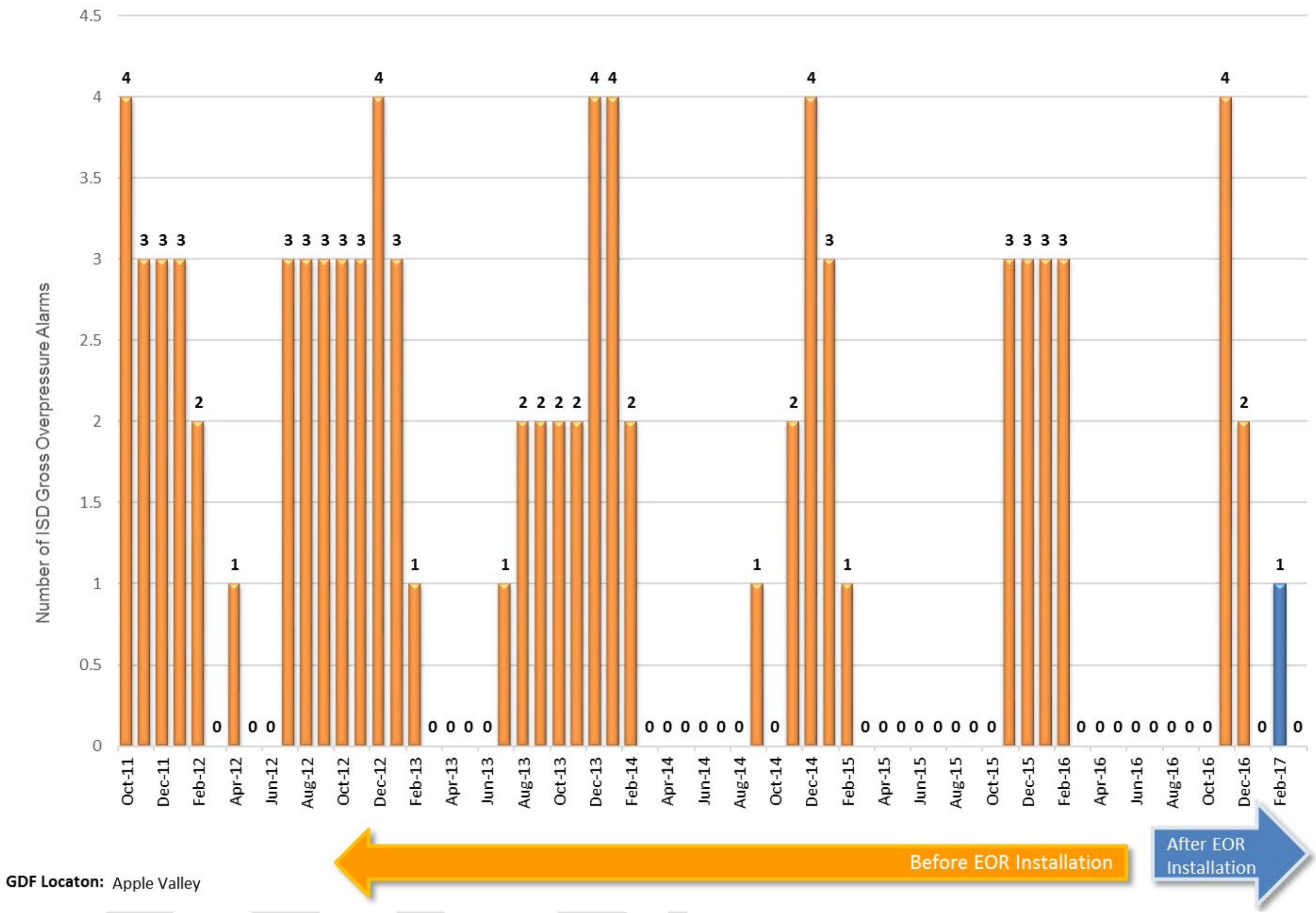




Change in ISD Overpressure Alarm Frequency

At the Apple Valley test site, frequency of ISD overpressure alarms before and after installation of the EOR nozzle was observed. For the month prior to installation, overpressure alarms were active every week. After installation the frequency of alarms, decreased with only one incident during the month of February. Figure V-34 provides more information.

FIGURE V-34: Frequency of ISD Overpressure Alarms – Apple Valley



Change in PWD Status

Pressure data was not valid due to containment leak. Hence overpressure did not occur.

H. Reid Vapor Pressure of Gasoline

All data have been entered into a spreadsheet and are available in Appendix VIII. The data shows that RVP was within the range of 7-15 psig during the time period in which the ISD data was analyzed. Table V–15 displays the average RVP value during mid-November to end of February and the number of samples taken. The details of the RVP analysis are available in Appendix VIII.

TABLE V-15: Reid Vapor Pressure (RVP) of Regular Grade Gasoline at Test Sites

TEST Site	Samples Taken (Nov 23 – Feb 22)	RVP (Average)
San Diego	10	12.3
Campbell	10	13.5
Gilroy	10	13.9
La Habra	12	13.1
La Cañada-Flintridge	5	10.1
Victorville	13	11.5
Apple Valley	11	11.8

VI. DISCUSSION

Over the course of four months during the winter of 2016/2017, Healy 900 nozzle with EOR spout assemblies were evaluated at seven retail GDFs. At each facility, pertinent data was collected from the ISD system before and after installation. Prior to EOR nozzle installation, baseline vapor recovery system testing was conducted and if necessary, repairs were made to bring each facility into compliance with applicable performance standards and specifications, which is defined to as “optimization” of site. To further minimize excess air ingestion, the vapor to liquid ratio of each EOR nozzle was adjusted between 0.95 and 1.00 which is the low end of the allowable range.

For ease of reference, this section is organized by the following sections: (A) change in nozzle vapor to liquid ratio and ORVR ID rate; (B) change in UST Pressure, (C) alarm frequency, (D) change in PWD status, (E) effectiveness of optimization with each section discussing the two nozzle assemblies (Field Retrofit and Factory Assembled) to discuss the results presented in Section V. Under section (F), a discussion is included on suitability of this data set to predict emission reductions on a statewide basis.

A. Change in nozzle vapor to liquid ratio and ORVR ID rate

The installation of the EOR spout assemblies lowered the average site V/L of all seven test sites by 15%. The factory assembled nozzle with EOR spout assembly decreased the site V/L by 19%, while the field retrofit version decreased the site V/L by 11%. This denotes that less fresh air is being ingested at the nozzle; then there is less evaporation expected to occur within the headspace of the USTs. Both nozzle configurations improved performance, however the factory assembled nozzle performed best. Tables VI-1 and VI-2 display the percent change in the individual test sites V/L.

Similarly, the ORVR ID rate, defined as percentage of fueling events with a V/L less than or equal to 0.5, improved with the installation of the EOR spout assembly. The factory assembled configuration increased the ORVR ID rate by 16 percentage points, while the field retrofit configuration increased the ORVR ID rate by 13 percentage points. These results indicate that the EOR spout assembly offers improved performance of recognizing vehicles equipped with ORVR and minimizes excess air ingestion. Tables VI-1 and VI-2 display the change in the ORVR ID rate.

TABLE VI-1: Change in Vapor to Liquid Ratios and ORVR Rate for Factory Assembled Nozzle

	Vapor to Liquid Ratio			ORVR ID Rate		
Test Site	**Pre-EOR Spout**	**Post EOR Spout**	**Percent Change**	**Pre-EOR Spout**	**Post EOR Spout**	**Percentage Point**
Campbell	0.68	0.53	-22.1	48%	64%	16
Gilroy	0.63	0.52	-17.5	50%	66%	16
La Habra	0.61	0.50	-18.0	56%	69%	13
Victorville	0.66	0.53	-19.7	48%	66%	18
		Average:	**-19.3**			**16**

TABLE VI-2: Change in Vapor to Liquid Ratios and ORVR Rate for Field Retrofitted Nozzle

	Vapor to Liquid Ratio			ORVR ID Rate		
Test Site	**Pre-EOR Spout**	**Post EOR Spout**	**Percent Change**	**Pre-EOR Spout**	**Post EOR Spout**	**Percentage Point**
San Diego	0.70	0.62	-11.4	41%	59%	18
La Habra	0.61	0.57	-5.1	56%	61%	5
La Cañada-Flintridge	0.59	0.56	-6.6	58%	68%	10
Apple Valley	0.68	0.54	-20.6	42%	60%	18
		Average:	**-10.9**			**13**

B. Change in UST Pressure,

The installation of the EOR spout assemblies lowered the average weekly UST pressure for six out the seven test sites. As indicated in the Table VI-3, prior to EOR install, all sites exhibited relatively high UST pressures. With EOR nozzle installed, the UST pressure averages dropped to vacuum levels. Data collected from the seventh site, described below, was deemed invalid and was not used for comparison.

Issues Encountered:
The Apple Valley site had a continuous containment leak for majority of the winter fueling months. Its pressure data was deemed invalid, and removed from the pressure data analysis.

TABLE VI-3: Change in UST Pressure

Test Site	UST Pressure (in H_2O) Pre-EOR Spout*	Post EOR Spout
San Diego	2.1	-3.4
Campbell	2.5	-1.4
Gilroy	2.5	-1.0
La Habra	2.2	0.6
La Cañada-Flintridge	2.3	-2.7
Victorville	1.2	-1.6
Average:	**2.1**	**-1.5**

*Pressure averages based on 30 hours of data, gathered during the Mega Blitz of 2013/2014/2015

C. Alarm Frequency

The installation of the EOR spout to the Healy nozzle lowered the weekly overpressure alarm status for six out the seven test sites. As indicated in the Table VI-4, the overall overpressure alarms reduced from 95 alarms during the winter fueling months (November-March) of 2014/2015 and 2015/2016 to 58 alarms during the winter fueling months of 2016/2017, with a reduction of 39 percent. The reduction in the alarm frequency was observed at five of the six sites, however, the Victorville site did not show an improvement.

Issues Encountered:
The Apple Valley site had a continuous containment leak for majority of the winter fueling months. Its pressure data was deemed invalid, therefore removed from the alarm frequency analysis.

TABLE VI-4: Alarm Frequency

Test Site	Number of ISD Overpressure Alarms Pre EOR Spout*	Post EOR Spout	Percent Reduction
San Diego	14	2	86%
Campbell	18	10	44%
Gilroy	18	11	39%
La Habra	15	12	20%
La Cañada-Flintridge	9	5	44%
Victorville	11	11	0%
Total	**85**	**51**	**40%**
Average:	**14**	**8.5**	**39%**

*Average Number of Overpressure Alarms during winter fuel months (Nov-Mar) of 2014/2015, and 20/15/2016

D. PWD status

PWD condition was not fully mitigated. Three of the six sites, PWD was observed less than 10 percent of the days after the installation of the EOR nozzles. Table VI-5 shows percentage of days in which the site was pressurized while dispensing. It is difficult to do a side by side comparison. The pre EOR data was based on a single day of pressure data, while the post EOR data was based on continuous pressure data.

Issues Encountered:
The Apple Valley site had a continuous containment leak for majority of the winter fueling months. Its pressure data was deemed invalid, and removed from the pressure data analysis.

TABLE VI-5: PWD Status

Test Site	Pre EOR Spout*	Post EOR Spout November 2016 Through February 2017
San Diego	The PWD status assumed to be100% based on 30 hours of available pressure data downloaded during December of 2014 and 2015.	7%
Campbell		37%
Gilroy		16%
La Habra		54%
La Cañada-Flintridge		9%
Victorville		12%

E. Optimization of Test Sites

Each Test site was optimized[4] according to the three requirements described in Section B of the Methodology section. To understand the results of the data for optimization, two descriptive phrases are defined:

- **Pre-Optimization**, which means all data documented and collected **prior** to any equipment adjustments and/or fixes.
- **Post-Optimization**, which means all data documented and collected **after** equipment adjustments and/or fixes.

From all seven test sites, only data from two sites were used for the comparison. These two sites, were the only sites were CARB staff was able to collect data during the three configurations described in the above list. These two site are labeled as La Cañada-Flintridge and Victorville. The La Cañada-Flintridge test site was used to evaluate the field-retrofitted EOR spout configuration and the Victorville test site was used to evaluate the factory-assembled EOR spout configuration.

Table VI-6 compares the results of the La Cañada-Flintridge test site before and after optimizing the site. After fixing the leaking dispenser and adjusting the V/L, the

[4] The vapor recovery system is "optimized" when it operates in compliance with applicable standards and specifications listed in the Assist Phase II Vapor Recovery System Executive Order VR-202, dispenser integrity testing of the vapor return plumbing is performed (per IOM 2 of the assist Executive Order), and vapor to liquid ratios of the nozzles are adjusted between 0.95 and 1.00.

average V/L value all the nozzles was increased from 0.93 to 0.99. As a result, the Site V/L improved from 0.70 to 0.67 and the ORVR ID rate jumped from 46.3% to 53.2%.

TABLE VI-6 – Comparison of Pre and Post Optimization at La Cañada-Flintridge

	Date of Test / Optimization	Site V/L	Fueling Events ≤ 0.5	Exhibit 5 V/L	Exhibit 5 Flow Rate (GPM)
PRE Optimization	10/27/2016	0.70	46.3%	0.93	8.6
POST Optimization		0.67	53.2%	0.99	

Table VI-7 compares the results of the Victorville test site before and after optimizing the site. After fixing the leaking dispenser and adjusting the V/L, the average V/L value all the nozzles was decreased from 1.00 to 0.99. As a result, the Site V/L worsened from 0.57 to 0.59 and the ORVR ID rate reduced from 61.5% to 57.2%.

TABLE VI-7 - Comparison of Pre and Post Optimization at Victorville

	Date of Time / Optimization	Site V/L	Fueling Events ≤ 0.5	Exhibit 5 V/L	Exhibit 5 Flow Rate (GPM)
PRE Optimization	10/28/2016	0.57	61.5%	1.00	7.4
POST Optimization		0.59	57.2%	0.99	

Optimization of a GDF does effect the Site V/L and the ORVR recognition. Site 1 shows us that when the nozzle's V/L value is adjusted up the site V/L value decreases and the ORVR ID rate improves. Site 2 shows the opposite results when the nozzle's V/L value is adjusted down the site V/L value increases and the ORVR ID rate worsens.

F. Suitability of Data Collected to Estimate Statewide Emission Reductions

As indicated throughout this document, ISD data collected prior to the installation of EOR spout assemblies was limited in duration to 30-hour segments, collected on a maximum of four different occasions between December 2013 and December 2015. ISD data collected after installation of EOR nozzles was continuously collected over the course of four months via the data acquisition system. In other words, for the purpose of this document, CARB staff relied on two data sets with differing resolution to perform comparison of system performance before and after EOR spout assembly installation. CARB staff initially considered using the results of this study to estimate statewide emission reductions associated with EOR spout assembly performance. Upon careful consideration and review of prior GDF emission techniques, it was determined that the variation in the two data sets are not suitable for use in determining statewide emission reduction calculations. To properly determine emission benefits of EOR installation, CARB staff recommends comparing pre EOR data collected at PWD sites equipped with a data acquisition system with continuous data capture for an entire winter period.

VII. CONCLUSION

Based on data collected at seven test sites, CARB staff concluded that the EOR nozzle was effective in lowering UST pressure, site average V/L ratio, and the frequency of ISD overpressure alarms, however was not 100% effective in mitigating PWD. The EOR nozzle also showed improvement with regard to ORVR vehicle mi-identification rate based on a V/L ratio being less than 0.5. The following table summarizes the findings specific to EOR nozzle.

TABLE VII-1: Summary of Findings Pertaining to EOR Spout Evaluation

Test Site	Change in Site Average V/L[5]	Change in ORVR Mis ID Rate	Change in ISD OP Alarm Frequency ISD?	Change in PWD status
San Diego	Lowered	Lowered	Improved	Mitigated
Campbell	Lowered	Lowered	Improved	Did not fully mitigate
Gilroy	Lowered	Lowered	Improved	Did not fully mitigate
La Habra	Lowered	Lowered	Improved	Did not fully mitigate
La Cañada-Flintridge	Lowered	Lowered	Improved	Mitigated
Victorville	Lowered	Lowered	Improved	Did not fully mitigate
Apple Valley[6]	Lowered	Lowered	Not Applicable	Not Applicable

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[i] ASTM D4814 - 16b Standard Specification for Automotive Spark-Ignition Engine Fuel
https://www.astm.org/Standards/D4814.htm

[ii] CALIFORNIA CODE OF REGULATIONS
Title 13. Motor Vehicles, Division 3. Air Resources Board, Chapter 5. Standards for Motor Vehicle Fuels, Article 4. Sampling and Test Procedures (Refs & Annos), Section 2296. Motor Fuel Sampling Procedures.

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[5] Vapor to Liquid Ratio of all EOR nozzles at each site was intentionally adjusted to 0.95 – 1.00 which is the low end of the allowable range (part of Optimization)

[6] The Apple Valley site had a containment leak for majority of the winter fueling months. Its pressure data was deemed invalid, and removed from the pressure data analysis

https://govt.westlaw.com/calregs/Document/ID99A8290D46911DE8879F88E8B0DAAAE?viewType=FullText&originationContext=documenttoc&transitionType=CategoryPageItem&contextData=(sc.Default)

[iii] PROCEDURE FOR THE DETERMINATION OF THE REID VAPOR PRESSURE EQUIVALENT OF GASOLINE
Standard Operating Procedure MV-FUEL-125
Revision No. 2.3, Effective date: June 1, 2009
http://www.arb.ca.gov/testmeth/slb/sop125v2_3.pdf

VIII. APPENDICES

Appendix I: Field Test / ISD Data for San Diego Test Site

Appendix I-1: Field Test Data (Pre and Post)

Appendix I-2: Compilation of Data for V/L Analysis

Appendix I-3: Compilation of Data for Pressure Ullage Data

Appendix II: Field Test / ISD Data for Campbell Test Site

Appendix II-1: Field Test Data (Pre and Post)

Appendix II-2: Compilation of Data for V/L Analysis

Appendix II-3: Compilation of Data for Pressure Ullage Data

Appendix III: Field Test / ISD Data for Gilroy Test Site

Appendix III-1: Field Test Data (Pre and Post)

Appendix III-2: Compilation of Data for V/L Analysis

Appendix III-3: Compilation of Data for Pressure Ullage Data

Appendix IV: Field Test / ISD Data for La Habra Test Site

Appendix IV-1: Field Test Data (Pre and Post)

Appendix IV-2: Compilation of Data for V/L Analysis

Appendix IV-3: Compilation of Data for Pressure Ullage Data

Appendix V: Field Test / ISD Data for La Cañada-Flintridge Test Site

Appendix V-1: Field Test Data (Pre and Post)

Appendix V-2: Compilation of Data for V/L Analysis

Appendix V-3: Compilation of Data for Pressure Ullage Data

Appendix VI: Field Test / ISD Data for Victorville Test Site

Appendix VI-1: Field Test Data (Pre and Post)

Appendix VI-2: Compilation of Data for V/L Analysis

Appendix VI-3: Compilation of Data for Pressure Ullage Data

Appendix VII: Field Test / ISD Data for Apple Valley Test Site

Appendix VII-1: Field Test Data (Pre and Post)

Appendix VII-2: Compilation of Data for V/L Analysis

Appendix VII-3: Compilation of Data for Pressure Ullage Data

Appendix VIII: RVP Data