California Environmental Protection Agency

Air Resources Board

In-Station Diagnostic Evaluation Field Study Report

October 31, 2008 Draft

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I. EXECUTIVE SUMMARY

The California Air Resources Board (ARB) and the California Air Pollution Control Officer's Association (CAPCOA) agreed to conduct an 18 month In-Use In-Station Diagnostic (ISD) Evaluation Field Study (ISD Field Study) on the first ISD system certified by ARB. The Healy Phase II Enhanced Vapor Recovery (EVR) including Veeder-Root ISD (Healy including Veeder-Root ISD) was the first system certified. CAPCOA represents the California Air Pollution Control /Air Quality Management Districts (Districts).

The ISD Field Study took place from July 2006 through December 2007. The overall objective was to determine whether performance of in-use ISD systems installed in California is similar to the performance of the ISD system tested during certification. Monthly tests were conducted by District staff at five evaluation test sites located throughout the state.

Test results show that the in-use ISD systems tested perform similarly to the ISD system that passed the certification tests.

II. INTRODUCTION

The California Air Resources Board (ARB) and the California Air Pollution Control Officer's Association (CAPCOA) agreed to conduct an 18 month In-Use In-Station Diagnostic (ISD) Evaluation Field Study (ISD Field Study) on the first ISD system certified by ARB. The Healy Phase II Enhanced Vapor Recovery (EVR) including Veeder-Root ISD (Healy including Veeder-Root ISD) was the first system certified.

ISD monitors the collection and containment of gasoline vapors by vapor recovery equipment installed at GDFs. ISD issues warnings and alarms when these systems fail to meet established performance standards and specifications specified in Section 9 of the certification procedure CP-201. Under certain alarm conditions, ISD can automatically shut down gasoline dispensing.

The ISD Field Study was conducted to evaluate in-use ISD performance compared to the certified ISD system. The field study took place from July 2006 through December 2007. Five gasoline dispensing facilities were selected by the California Air Pollution Control /Air Quality Management District (District) staff in different parts of the state as test sites.

III. TEST PROGRAM

A. Goals

The overall ISD Field Study objective was to determine whether performance of in-use ISD systems is similar to performance of the Healy including Veeder-Root ISD system tested in certification. In order to meet the overall objective, specific goals and testing methods were defined. These goals were:

- Determine how closely the Healy including Veeder-Root ISD system compares to the Vapor to Liquid (V/L) Exhibit 5 method of Executive Order VR-202-A.
- Determine whether the V/L malfunction criteria for gross and degradation failures can be tightened without compromising the reliability of the ISD assessment.
- Determine if the Healy including Veeder-Root ISD System effectively identifies Onboard ORVR and non-ORVR vehicles.
- Determine how closely the Healy including Veeder-Root ISD system pressure sensor value compares to the UST pressure value.
- Verify that the Healy including Veeder-Root ISD vapor pressure sensor is operating properly.

- Verify that the Healy including Veeder-Root ISD vapor flow meter is operating properly.

B. Test Sites

Five evaluation test sites were selected by District staff as listed in Table III-1.

Table III-1
ISD Field Study Test Site Information

Site Name	Address	District	District Contact
7-Eleven	9600 Brimhall Road Bakersfield, CA 93312	San Joaquin Valley APCD	Morgan Lambert
7-Eleven	35015 Fremont Blvd. Fremont, CA 94536	Bay Area AQMD	John Marvin
7-Eleven	7801 Clairemont Mesa Blvd San Diego, CA 92111	San Diego APCD	Randy Smith
Arco	27727 East Baseline Road Highland, CA 92346	South Coast AQMD	Lou Roberto
Chevron	7966 Walerga Road Antelope, CA 95843	Sacramento Metropolitan AQMD	Isam Boulad

C. Testing

The ISD Field Study testing was conducted by District staff. Access to ISD data was obtained in cooperation with Veeder-Root from the TLS console of the Veeder-Root's ISD system. Five different sets of tests (listed below) were conducted at each site, once a month, during the 18 month ISD Field Study. Testing protocol is detailed in the ISD In-Use Evaluation Protocol (Appendix A).

a. V/L Ratio Testing per Exhibit 5 of VR-202-A

b. Identification of ORVR and non-ORVR equipped vehicles

c. Pressure sensor verification per Exhibit 9 of VR-202-A

d. Vapor pressure sensor ambient operability test per Exhibit 9 of VR-202-A

e. Vapor flow meter operability test per Exhibit 9 of VR-202-A

D. Data Submission

District staff recorded necessary information and data onto data sheets/forms. Examples of the data sheets are found in the ISD In-Use Evaluation Protocol

(Appendix A). These data forms were submitted to ARB and compiled by ARB staff. The compiled data were made available at http://www.arb.ca.gov/vapor.

Any corresponding readings from the TLS console of the Veeder-Root ISD system were made available by Veeder-Root to ARB staff in order for the compilation of all test data. The compiled data was again made available at http://www.arb.ca.gov/vapor.

IV. FINDINGS

A. V/L Ratio Testing: Exhibit 5 V/L compared to ISD V/L

The ISD Field Study included the V/L testing per Exhibit 5 of Executive Order VR-202-A to determine how closely the Healy including Veeder-Root ISD V/L values compared.

Testing times were synchronized to the ISD system time to ensure proper correlation between the same data sets. It was only necessary to determine the V/L accuracy on one side of the dispenser since only one flow meter was installed in each dispenser. The side not being tested was removed from service to prevent dispensing of gasoline during the test.

At least 10 Exhibit 5 V/L tests were conducted by District staff at each site per month. V/L tests included using different gasoline grades, and different fueling points if available at the time. Test protocol required the nozzle be returned to the dispenser after each test with a time of at least one minute between tests. This ensures the ISD system recognized each test as a separate fueling event. Data was recorded on the Healy V/L Field Data sheet. (Appendix A).

Statistical analysis performed on the data comparisons between the Exhibit 5 V/L and the real time ISD V/L showed that 95 percent of the ISD Data was within 0.12 of the Exhibit 5 VR-202-A data and met the criteria (±0.15) of Exhibit 9 VR-202-A. (Appendix B).

B. V/L Ratio Testing: Malfunction Criteria

Malfunction criteria for gross failure requires the ISD system to assess, on a daily basis, based on a minimum of 15 non-ORVR fueling events, when the V/L ratio is at least 75 percent below the lower certified V/L ratio threshold or at least 75 percent above the upper certified V/L ratio threshold, shall activate a warning alarm, and shall record the event. When two such consecutive failed assessments occur, the ISD system shall activate a failure alarm, record that event, and prohibit fuel dispensing from the affected fueling point(s). The ISD system shall have the capability of re-enabling dispensing, and shall record that event.

Malfunction criteria for V/L degradation requires the ISD system to assess, on a weekly basis, based on a minimum of 30 non-ORVR fueling events, when the V/L ratio is at least 25 percent below the lower certified V/L ratio threshold or at least 25 percent above the upper certified V/L ratio threshold, shall activate a warning alarm, and shall record the event. When two such consecutive failed assessments occur, the ISD system shall activate a failure alarm, record that event, and prohibit fuel dispensing from the affected fueling point(s). The ISD system shall have the capability of re-enabling dispensing, and shall record that event.

The ISD V/L certified range is 0.95 to 1.15. The gross failure criteria and the degradation criteria are listed in Table IV-1.

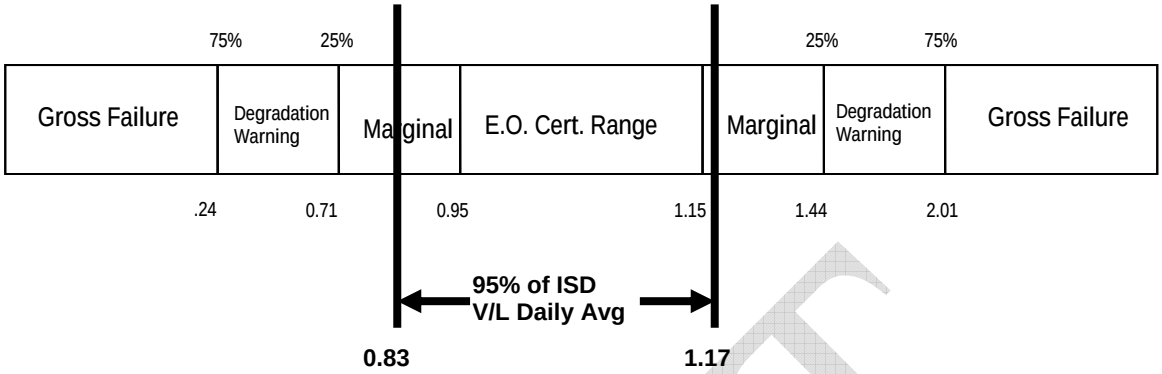
Table IV-1
Gross Failure & Degradation Criteria

Criteria	Gross Failure	Degradation
Assessment Frequency	Daily	Weekly
Minimum number of non-ORVR Vehicles	15	30
V/L Percent Above/Below the Certified Range (Resulting Limits)	75% (0.24 and 2.01)	25% (0.71 and 1.44)
Detecting Warning Alarm Probability	95%	95%
Probability False Alarm	≤1%	≤1%
Warning Alarm	1 Failed Assessment	1 Failed Assessment
Failure Alarm	2 Failed Assessments	2 Failed Assessments

The analysis used the previous day ISD V/L daily average readings to determine whether the V/L malfunction criteria for gross failures and degradation [Section 9.2.1 (b) and (c) of CP-201] could be modified to be more stringent without compromising the reliability of the system.

A statistical analysis indicated 95 percent of the ISD V/L daily averages are within the certification range or marginal range limits, but not in the degradation warning or the gross failure limits as shown in Figure IV-1.

Figure IV-1
V/L Certification Range and ISD Warning and Failure Limits



Since 95 percent of the data is within the certified or marginal range, this would suggest the malfunction criteria could be tightened without compromising the reliability of the assessment. The thresholds used by Veeder-Root ISD are already more stringent to ensure the system meets the 95 percent probability of detecting failures (Degradation ≤0.81 or ≥1.32, Gross ≤0.33 or ≥1.90). Any changes to the limits would require additional testing and a determination of whether the system is still capable of detecting failure with a 95% probability with no more than a 1 percent probability of false alarms. In addition such change will require a new rulemaking. Details of the analysis are found in Appendix C.

C. Identification of ORVR and non-ORVR Vehicles

District staff collected data that identified vehicles as ORVR or non-ORVR at GDFs while the vehicles refueled. ORVR identification protocol and the Vehicle Determination Data Sheet are detailed in ISD In-Use Evaluation Protocol (Appendix A). The Healy Phase II EVR system identifies ORVR and non-ORVR vehicles by responding to pressure changes at the vehicle fillneck. The Healy system maintains the pressure in the nozzle bellows within specific limits by regulating the vapor flow through the nozzle. When an ORVR vehicle is fueled the vapor flow must be restricted to prevent a vacuum in the nozzle bellows that is outside the desired range.

The Veeder-Root ISD system identifies refueling events as either blocked or unblocked. The ISD system collects V/L data from all fueling events at a GDF including V/L values from ORVR vehicles. V/L values less than 0.51 are classified as blocked events. The ISD system applies statistical algorithms to determine if the blocked events are actually caused by equipment failures or can be attributed to ORVR vehicle refueling events. If the system is not compromised by equipment failures the typical V/L value for non-ORVR vehicles is greater than 0.51. If an equipment failure leads to an actual blockage and V/L values less than 0.51 then significant quantities of gasoline vapors from non-ORVR vehicles will not be recovered at the nozzle. In this case the non-ORVR fueling events will be classified

as blocked events by the Veeder-Root ISD system. If the percentage of blocked events exceeds the expected percentage of ORVR fueling events by a statistically determined level the ISD system will issue an alarm.

Each test site was evaluated at monthly intervals for 18 months to determine the ISD system responses to blockages, ORVR and non-ORVR vehicles. These responses were compared to the identification by district staff of a vehicle as ORVR or non-ORVR. During vehicle refueling, the opposite side of the dispenser was removed from service to prevent dispensing during the test. Vehicle refuelings that were three gallons or less were excluded. ARB staff matched the vehicle fueling time and the number of gallons dispensed to the corresponding V/L readings from the Veeder-Root TLS. The data was posted at http://www.arb.ca.gov/vapor.

Table IV-2 shows the transition years for installation of ORVR for each vehicle classification. Vehicles manufactured before transition years generally do not have ORVR. Vehicles manufactured after ORVR transition years must have ORVR. The evaporative code on the emissions label, located on the inside of the vehicle's hood or engine compartment specifies if a vehicle is required to have ORVR. However, some manufacturers voluntarily installed ORVR ahead of the federal and state mandated schedule. Thus, some vehicles with a non-ORVR emissions code may have been equipped with ORVR.

If a vehicle was manufactured during the ORVR transition years, the emission label must be checked to determine if ORVR is installed. In particular, the ORVR status of trucks should be verified from the emissions label, because the ORVR transition years vary by gross vehicle weight rating (GVWR).

Table IV-2
ORVR Transition Years

Light Duty Autos	Light Duty Trucks GVWR<5751 Lbs	Medium Duty & Light Heavy Duty GVWR 5751-10,000Lbs
1998, 1999	2001, 2002	2004, 2005

District staff collected data on 1490 vehicles through the ISD Field Study. The non-ORVR vehicles consistently showed V/L values greater than 0.51 and were classified by the Veeder-Root ISD system as non-blocked events. The ISD V/L (≤0.51) determinations were consistent with 78 percent of the vehicles the District identified as ORVR. The ISD V/L (>0.51) determinations were consistent with 96 percent of the vehicles the District staff identified as being non-ORVR. Of the 193 (22 percent) inconsistent ORVR vehicles, 84 were light duty, medium duty and light heavy duty trucks. Approximately 44 percent of those ORVR vehicles were trucks in the transition years.

Some of these trucks may have been incorrectly identified by district staff as being ORVR. These trucks had V/L values greater than 0.51 and their model year are part of the transition years. With the questionable trucks omitted from the study, the percentage of vehicles being consistent for ORVR increased from 78 percent to 86 percent.

Table IV-3
ORVR and Non-ORVR Determinations by District Staff

	ORVR	Non-ORVR
ISD V/L Consistent w/ District Staff ID	78%	96%
ISD V/L Inconsistent w/ District Staff ID	22% (V/L >0.51)	4% (V/L ≤0.51)

As part of a separate analysis of the ORVR and non-ORVR vehicles, the light duty vehicles were classified strictly by their model year, and trucks were classified by model year and GVWR, if known, with the transition years omitted for both autos and trucks. This separate analysis did not use the district staff determinations of ORVR and non-ORVR. This analysis resulted in a smaller subset of vehicles. The subset compared 1185 records of V/L values against the ORVR and non-ORVR status with similar results to the original analysis. Of the vehicles identified as ORVR, the ISD V/L confirmed 83 percent as blocked or low V/L values. Of the vehicles identified as non-ORVR, the ISD V/L confirmed 95% of the vehicles unblocked or high V/L values.

Table IV-4
ORVR and Non-ORVR Determinations by MY and GVWR

	ORVR	Non-ORVR
ISD V/L Consistent w/ MY & GVWR	83%	95%
ISD V/L Inconsistent w/ MY & GVWR	17% (V/L >0.51)	5% (V/L ≤0.51)

There are other possible explanations for inconsistencies in the V/L values and ORVR and non-ORVR vehicles. Cool fuel being dispensed into a hot vehicle tank can result in low V/L values on non-ORVR vehicles if there is a good vapor to liquid contact in the vehicle tank and fill neck. Another possible explanation is that mechanical seals were used for on the early ORVR European vehicles. With this design there is no restriction on the amount of air that could be pulled into the nozzle, so a vacuum never forms in the bellows and the vapor flow rate is not restricted. This could cause these ORVR vehicles to appear as non-ORVR with V/L values near 1.0. Another possible explanation for inconsistencies was the possibility of disconnected hoses, or damaged ORVR equipment that would result in V/L values (>0.51) since the nozzle bellows would not be able to be under vacuum as required to activate the restriction of the vapor flow rate. Although the percentages of correctly identified vehicles is relatively high, staff suggests additional testing that correctly identifies vehicles as ORVR and non-ORVR.

D. Pressure Sensor Verification

The ISD Field Study compared pressure sensor values of underground storage tanks between the TLS reading of the Veeder-Root ISD system to actual manometer readings taken by District staff. TLS is limited to pressure readings of ±6.00 IWC. Data was recorded on the Pressure Sensor Verification Data Sheet and followed the test protocol (Appendix A).

The average difference of the ISD reading compared to the manometer reading was 0.12 IWC. A regression analysis identified the best fit line matches closely to the perfect agreement line (slope equal to one). The ISD Field Study data analysis concluded the Veeder-Root ISD system pressure sensor value closely compares to the monitored value (Appendix E).

E. Vapor Pressure Sensor Operability Test

The ISD Field Study also evaluated the vapor pressure sensor's ability to properly record data in accordance with the Veeder-Root ISD specifications. The pressure sensor criteria was ±0.2 IWC. Results were recorded on the Vapor Pressure Sensor Ambient Reference Test data form and followed test protocol detailed in Appendix A. All vapor pressure sensor tests passed (Appendix F).

F. Vapor Flow Meter Operability Test

The Vapor Flow Meter Operability Test, as defined in Exhibit 9 of Executive Order VR-202-A was performed once monthly for 18 consecutive months at each site as detailed in the ISD In-Use Evaluation Protocol (Appendix A). The analysis used the previous day's gross ISD V/L daily average and compared it to the calculated V/L values determined by VR-202-A Exhibit 5. The ISD vapor flow meter operating criteria is ±0.15 of the test value. If the ISD value was not within those limits, further V/L tests were performed.

The vapor flow meter operability test passing rate was 99.1 percent and the results concluded that the flow meters were operating properly (Appendix G).

V. CONCLUSION

During the ISD Field Study, five different tests were conducted over an 18 month period at five test sites located throughout the state. The objective of the ISD Field Study was to evaluate the ability of the Healy including Veeder-Root ISD system to meet the performance standards and specifications of certification. The ISD Field Study data demonstrated that the in-use performance of the Healy including Veeder-Root ISD system is similar to the performance standards and specifications the system was certified to meet.

VI. APPENDICES

Appendix A. ISD In-Use Evaluation Protocol

Appendix B. Analysis: V/L Ratio Testing – ISD Vs. V/L Method

Appendix C. Analysis: V/L Ration Testing – Malfunction Criteria

Appendix D. Analysis: ORVR and Non-ORVR Vehicles

Appendix E. Analysis: Pressure Sensor Verification

Appendix F. Analysis: Vapor Pressure Sensor Operability Test

Appendix G. Analysis: Vapor flow Meter Operability Test

Appendix H. ISD In-Use Evaluation Test Data: July – September 2006

Appendix I. ISD In-Use Evaluation Test Data: October – December 2006

Appendix J. ISD In-Use Evaluation Test Data: January – March 2007

Appendix K. ISD In-Use Evaluation Test Data: April – June 2007

Appendix L. ISD In-Use Evaluation Test Data: July – September 2007

Appendix M. ISD In-Use Evaluation Test Data: October – December 2007