California Environmental Protection Agency

AIR RESOURCES BOARD

Monitoring and Laboratory Division
Engineering and Certification Branch
Vapor Recovery Certification Section

Evaluation Test Report

PHASE II VAPOR RECOVERY BALANCE SYSTEM CHALLENGE MODE STUDY

Project Number: V-05-035

October 25, 2006

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Acknowledgements

The Air Resources Board (ARB) wishes to acknowledge the contributions of the many individuals who participated in this project. In particular, it would not have been possible without the assistance of the following parties:

1. A national retailer granted ARB staff permission to monitor and conduct extensive vapor recovery testing of two gasoline dispensing facilities located in Southern California. The retailer agreed to participate without any financial or economic incentive and helped greatly by making their service contractor available to make any necessary repairs or changes.

2. Three balance system manufacturers (Manufacturer #1, #2, and #3), provided complete sets of prototype hanging hardware. Each manufacturer handled installation and maintenance of the equipment, and covered the permitting expenses with the applicable local regulators. Many of the manufacturers had to work extra long hours to have the equipment available in time for the winter fuel season. Manufacturer #1 and #2 provided free replacement parts when the sites were returned to their original configuration.

3. The California Air Pollution Control Officers Association Vapor Recovery Committee (CAPCOA), Western States Petroleum Association (WSPA), and the Bay Area Air Quality Management District (BAAQMD) provided key comments and had a significant impact on the contents of the final test protocol. We appreciate their time and effort in reviewing the draft and providing written comments.

4. South Coast Air Quality Management District (SCAQMD) staff provided support and guidance to ARB staff during the field testing of the systems. The SCAQMD staff also expedited the permitting process and allowed the installation of uncertified equipment under an exemption by ARB approval.

5. Lastly, Wayne Services, based out of Ontario, California, provided skilled and professional staff to support the installation, maintenance, and testing of the three balance systems. Wayne Services staff also spent many long hours in the field supporting ARB staff during testing.

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1.0 EXECUTIVE SUMMARY

Between October 2005 and February 2006, ARB staff conducted testing of three "balance systems" installed at two retail gasoline dispensing facilities (GDFs) located in Southern California. A "balance system" is a Phase II gasoline vapor recovery system which operates on the principal of positive displacement to collect vapors during vehicle fueling and return them to the underground storage tank (UST). Balance systems require a vapor return path to be established between the dispensing nozzle and the underground storage tank.

The main objective of the study was to determine if balance systems would meet the pressure criteria listed in Section 4.6 of ARB Certification Procedure 201 (CP-201) without the aid of a processor. These criteria limit the daily average pressure and the daily high pressure of the underground storage tank (UST). Staff designed the study to include the following three challenge mode conditions: (1) the sites were located in Southern California, with its higher ambient temperatures relative to the Sacramento region; (2) the test was conducted during the winter months when there are no "Reid Vapor Pressure" (RVP) limits on the fuel in use; and (3) the test was conducted at gasoline dispensing facilities (GDF) with a nine hour nightly shut-down, allowing significant vapor growth in the UST during the idle hours.

The evaluation of each system consisted of two key criteria. First, extensive testing of each balance system was conducted to ensure proper collection and containment of the gasoline vapor. Second, UST pressure was continuously monitored throughout the test period for a minimum of 30 days.

Two of the balance systems were evaluated in succession at one GDF, while the third was evaluated at a second GDF. All three balance systems were designed to comply with ARB's Enhanced Vapor Recovery (EVR) performance standards and specifications listed in CP-201. At the time of this study, all three systems were considered "prototype" and had not been certified by ARB. None of the balance systems evaluated during this study utilized a processor to control positive UST pressures.

Under the conditions tested, all three balance systems failed to comply with the UST pressure criteria listed in Section 4.6 of CP-201. Table 1-1 provides the results of each system along with the requirements of CP-201.

Table 1-1: Summary of ARB UST Pressure Averages (Based on a 30-Day Rolling Average)

Balance System	Daily Average Pressure, in. H_2O	Daily High Pressure, in. H_2O
Manufacturer #1	0.76	2.78
Manufacturer #2	0.78	3.04
Manufacturer #3*	1.03	3.16
CP-201 Pressure Limits	0.25	1.50

*Daily average and Daily High average based on 17 day rolling average due to incomplete data set (unable to collect a full 30 days of valid data).

2.0 INTRODUCTION

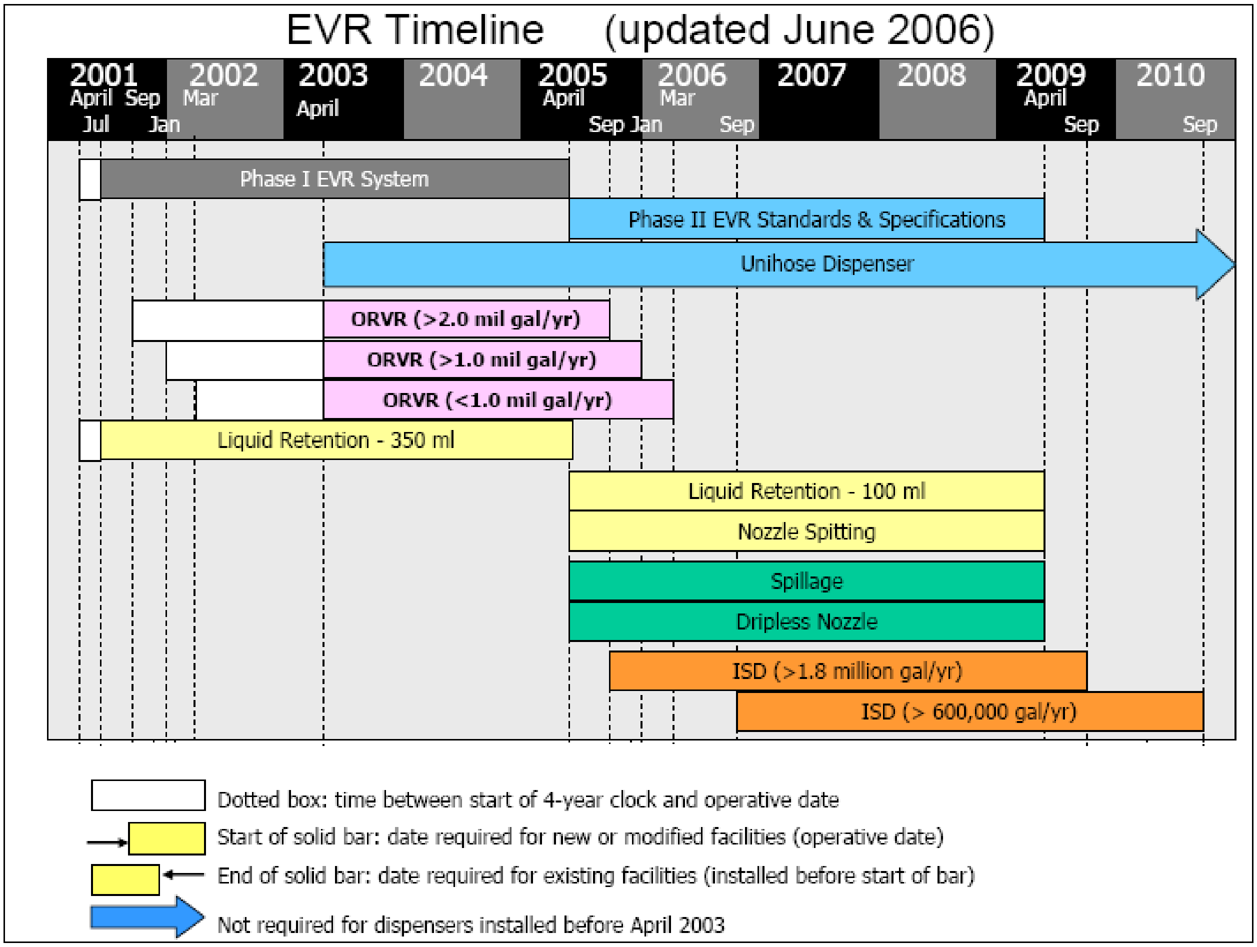
Throughout California, ARB authorizes the sale, installation, and use of vapor recovery equipment at service stations, also referred to as gasoline dispensing facilities (GDFs), through a certification program. Control of gasoline vapors that occur at GDFs is necessary to reduce hydrocarbon emissions that lead to the formation of ozone and to control emissions of benzene, a constituent of gasoline vapor that has been identified by ARB as a toxic air contaminant. On a state-wide basis, Phase II vapor recovery systems control over 100 tons/day of hydrocarbon emissions.

In March of 2000, ARB approved the Enhanced Vapor Recovery (EVR) regulations. The EVR regulations established new standards for vapor recovery systems to further reduce emissions during storage and transfer of gasoline at GDFs that use underground storage tanks for gasoline storage. The EVR standards apply to both new and existing facilities and are being phased in from 2001 to 2010 (see Figure 2-1: EVR Timeline).

GDFs were required to have systems meeting the Onboard Refueling Vapor Recovery (ORVR) compatibility standards by March 1, 2006. Although several ORVR compatible systems were available, the balance system is now the predominant vapor recovery system in California. Additional system upgrades to meet the remainder of the EVR standards are required by April of 2009 (see Figure 2-1: EVR Timeline). One of the remaining EVR standards limits the pressure allowed in the UST in order to reduce fugitive emissions.

The key question for manufacturers seeking to certify EVR balance systems is whether a vapor processor is necessary to meet the EVR pressure limit criteria. If an EVR balance system could be certified without a processor, then EVR Phase II upgrades for the majority of stations in 2009 would likely involve replacing nozzles and hoses on the dispensers, which must be replaced every few years anyway.

Figure 2-1: EVR Timeline



3.0 TEST OBJECTIVE

The primary objective of this study is to determine if balance systems can comply with the EVR pressure profile standards without the aid of a processor under defined challenge mode conditions. Specifically, the study was conducted to determine if such systems can meet the performance standards listed in section 4.6.5 of CP-201, which states the following:

> "A rolling 30 day average of the daily average pressures and the daily high pressures for each day shall be calculated by averaging the most current daily value with the appropriate values for the previous 29 days. These 30-day rolling averages shall meet the following criteria:
>
> The daily average pressure shall not exceed +0.25 inches H_2O.
> The daily high pressure shall not exceed +1.5 inches H_2O."

4.0 TEST PROTOCOL

In August of 2005, ARB posted a draft challenge mode protocol for balance vapor recovery systems on the ARB vapor recovery website. A total of 112 comments were received from stakeholders including trade organizations, equipment manufacturers, and California Air Pollution Control Officer Association (CAPCOA) representatives. Based on stakeholder comments, ARB staff finalized the balance system challenge mode protocol and posted it on the vapor recovery website in November of 2005.

A copy of the challenge mode protocol is attached to this report as Appendix 1. The key challenge mode conditions included monitoring UST ullage pressure at GDFs with nine hours of nightly shut down, testing during the winter fuel season (uncontrolled RVP), and testing in a climate warmer than the Sacramento region. To ensure quality data collection, ARB staff was responsible for all field testing, continuous monitoring of UST pressure data, weekly RVP analysis, and report writing.

The protocol required extensive testing of each vapor recovery system at the beginning, middle, and end of each 30-day test period to ensure collection of valid UST pressure data. Table 4-1 describes the type and frequency of testing conducted on each system.

Table 4-1: Description of Vapor Recovery System/Component Testing

Test Procedure	Description	Frequency
TP-201.1B	Adaptor Torque	Day 1, Day 30
TP-201.1C	Drain Valve/ Drop Tube Integrity	Day 1, Day 30
TP-201.1E	P/V Valve	Day 1, Day 30
TP-201.2B	Nozzle Vapor Valve	Day 1
TP-201.3	Leak Decay	Day 1, Mid-Point, Day 30
TP-201.4	Back Pressure	Day 1, Day 30
TP-201.6C	Liquid Removal	Day 1, Mid-Point, Day 30
TP-201.7	15 point Data-logger Accuracy Check	Pre-Install, Post Install
TP-201.7	Download Data	Twice per Week
ASTM D5191	RVP Analysis	Weekly

5.0 TEST SITE SELECTION

In July of 2005, ARB staff contacted a national retailer and obtained permission to monitor two of their gasoline dispensing facilities (GDFs) in Southern California. Photographs of each are shown in Figures 5-1 and 5-2. In terms of meeting the requirements of the protocol, both sites provide ideal operating conditions. Table 5-1 provides a description of the two sites.

Table 5-1: Description of Test Sites

GDF #1	GDF #2
San Bernardino, CA	Riverside, CA
Wayne Vista Series Unihose Balance Dispensers	Wayne Vista Series Unihose Balance Dispensers
Phil-Tite Phase I EVR System	Phil-Tite Phase I EVR System
Hours of Operation: 6:00 am – 9:00 pm (Mon-Sat) 9:00 am – 7:00 pm (Sun)	Hours of Operation: 6:00 am – 9:00 pm (Mon-Sat) 9:00 am – 7:00 pm (Sun)
Opening Date: 2003	Opening Date: 2002
Monthly Throughput: 400k +	Monthly Throughput: 300k +
12 fueling points	12 fueling points
UST size: 20,000 gallons each	UST size: 20,000 gallons each
Number of USTs: Three	Number of USTs: Three

Figure 5-1: San Bernardino Gasoline Dispensing Facility

Figure 5-2: Riverside Gasoline Dispensing Facility

In addition to site shutdown for at least 9 hours, the protocol also required the study to occur in a climate warmer than the Sacramento region. This was the primary reason for selecting the sites in the Inland Empire region of Southern California. The average maximum temperatures are approximately 10 degrees warmer at the test sites when compared to the Sacramento region as shown in Table 5.2. The combination of warmer ambient temperatures and the presence of uncontrolled RVP fuel provides a desirable challenge mode condition.

Table 5-2: Ambient Temperature Data

Location	Average Maximum Temp (°F) November	Average Minimum Temp (°F) November
Sacramento	63.5	42.7
San Bernardino	74.4	43.4
Riverside	73.1	45.1

Source: Western Regional Climate Center wrcc@dri.edu

6.0 PHASE II PROTOTYPE EVR EQUIPMENT INSTALLED

Three balance system manufacturers, Manufacturer #1, #2, and #3, provided prototype hanging hardware for this study. The manufacturers handled all permitting requirements and fees with the South Coast AQMD and compensated the service contractor "Wayne Services" for all installation, maintenance, and removal of their equipment.

Table 6-1 provides a description of the equipment installed at the test sites. Manufacturer #1 and #2 nozzles utilized lever actuated vapor valves. The lever actuated internal vapor valve design is common among the vacuum assist nozzles certified by ARB throughout the 1990's. The vapor path of the nozzle can only be opened when fuel is flowing out of the nozzle. For balance nozzles, the application of the internal vapor valve is a relatively new concept.

By contrast, Manufacturer #3 nozzle utilized a bellows actuated vapor valve, which is common amongst the currently certified balance nozzles. The bellows actuated vapor valve allows the vapor path to open simply by compressing the bellows. Fuel flow is not required to open the vapor path.

All three systems utilized the same hose configuration, which required liquid removal devices to keep the vapor passage of the hose clear of liquid blockages.

Table 6-1: Description of Prototype EVR Equipment Installed

	Manufacturer #1	Manufacturer #2	Manufacturer #3
Location	GDF#1 San Bernardino	GDF#2 Riverside	GDF#1 San Bernardino
Nozzle	EVR	EVR	EVR
Vapor Valve	Lever actuated	Lever actuated	Bellows actuated
Curb Hose	Listed in G-70-52 AM	Listed in G-70-52 AM	Listed in G-70-52 AM
Breakaway	Listed in G-70-52 AM	Listed in G-70-52 AM	Listed in G-70-52 AM
Whip Hose	Listed in G-70-52 AM	Listed in G-70-52 AM	Listed in G-70-52 AM
Processor?	No	No	No

7.0 PRESSURE MONITORING SYSTEM (DATA LOGGERS)

At each site, UST pressure, ambient temperature, and barometric pressure was continuously collected on a data logger designed, built, and installed by ARB. Both data loggers were self contained, solar powered, intrinsically safe, and permanently mounted above a single dispenser at each site. A ¼ inch insulated Teflon line was routed to a UST pressure tap port which was installed above the shear valve of the vapor return piping of the dispenser. Prior to and at the end of the test period, the pressure transducer within each data logging system was checked for accuracy using a NIST (National Institute of Standards and Technology) traceable calibration secondary standard device (see Section 9). During the test period, the pressure transducers were also checked for accuracy in the field using a NIST traceable calibration secondary standard device (see Section 9).

The data loggers were programmed to record 60 second averages of UST pressure, ambient temperature, and barometric pressure, continuously, 24 hours a day. Twice a week, ARB staff downloaded the information via lap top computer and exported the files into an excel spreadsheet. This enabled ARB staff to graph UST pressure profiles and calculate 30-day rolling averages for both daily high and hourly high criteria. Figure 7-1 is a photograph of the data logging system installed at the Riverside GDF:

Figure 7-1: Data Logging System Installed at Riverside GDF Location

8.0 TEST RESULTS

Due to the amount of data collected, this section of the report is divided into four sections: system performance, UST pressure profiles, calculation of ARB averages, and results of RVP analysis.

8.1 System Performance

Throughout the study period, extensive testing was conducted to verify proper collection and containment of gasoline vapors for each system. All components with allowable leak rates were leak tested individually and as a system. Back pressure and liquid removal testing was conducted to ensure blockages of the vapor return path did not exist. Leak decay tests were conducted at the beginning, mid point, and the end of the 30-day study period for each system. Nozzle vapor valve leak rate testing was conducted on each nozzle prior to installation at each site. The following three sections describe how each system performed in terms of collection and containment.

8.1.1 Manufacturer #1 System Performance

On November 9, 2005, ARB staff initiated challenge mode testing on Manufacturer #1 balance system. Table 8-1 is a summary of the testing conducted and the results.

Table 8-1: Manufacturer #1 System Performance Test Results (11/09/05 -12/13/05)

Test Procedure	Description	Day 1	Mid Point	Day 30
TP-201.1B	Adaptor Torque	PASS	N.A.	PASS
TP-201.1C	Drop Tube / Drain Valve	PASS	N.A.	PASS
TP-201.1E	P/V Valve	PASS	N.A.	*FAIL
TP-201.2B	Nozzle Vapor Valve	PASS	N.A.	N.A.
TP-201.3	Leak Decay	PASS	PASS	PASS
TP-201.4	Back Pressure	PASS	N.A.	PASS
TP-201.6C	Liquid Removal	PASS	PASS	PASS

*Positive leak rate failure of P/V Valve (200cc @ 1.41" H_2O). No ball valve installed. Replaced P/V valve and continued pressure monitoring for several more days. No observed change in pressure profile.

Although a P/V valve positive leak rate failure was documented at day 30, ARB staff has determined by evaluation of the pressure profile before and after, that the leak did not have a significant impact on the pressure profile. The leak was not sufficient to cause a leak decay failure, or bias the results toward compliance. The defective valve was immediately replaced with a new compliant valve and pressure monitoring resumed for several more days.

8.1.2 Manufacturer #2 System Performance

On November 11, 2005, ARB staff initiated challenge mode testing on the Manufacturer #2 balance system. Table 8-2 is a summary of the testing conducted and the results.

Table 8-2: Manufacturer #2 System Performance Test Results (11/11/05 -12/16/05)

Test Procedure	Description	Day 1	Mid Point	Day 30
TP-201.1B	Adaptor Torque	PASS	N.A.	PASS
TP-201.1C	Drop Tube / Drain Valve	PASS	N.A.	PASS
TP-201.1E	P/V Valve	PASS	*****FAIL	PASS
TP-201.2B	Nozzle Vapor Valve	PASS	N.A.	N.A.
TP-201.3	Leak Decay	PASS	PASS	PASS
TP-201.4	Back Pressure	PASS	N.A.	PASS
TP-201.6C	Liquid Removal	PASS	PASS	PASS

*Cracking pressure failure of P/V Valve (+10.56 in H_2O). No ball valve installed. Replaced P/V valve on 11/22/05 and continued testing.

Within one week of beginning of the monitoring period for Manufacturer #2, it was evident that the P/V valve cracking pressure was not in compliance with the specification of 3.0 plus or minus half an inch of water column. Upon review of the daily pressure profile, UST pressures well above 3.5 inches of water column were observed. This suggested that the P/V valve may not be cracking at the certified range. At the mid point testing, the P/V valve was removed, bench tested, and found to be cracking at over 10 inches of water column. The P/V valve was immediately replaced with a new compliant valve and monitoring resumed.

8.1.3 Manufacturer #3 System Performance

On December 30, 2005, ARB staff initiated challenge mode testing on Manufacturer #3 balance system. Table 8-3 is a summary of the testing conducted and the results.

Table 8-3: Manufacturer #3 System Performance Test Results (12/30/05-2/20/06)

Test Procedure	Description	Day 1	Mid-point	Day 58
TP-201.1B	Adaptor Torque	PASS	N.A.	PASS
TP-201.1C	Drop Tube / Drain Valve	PASS	N.A.	PASS
TP-201.1E	P/V Valve	PASS	FAIL(1)	PASS
TP-201.2B	Nozzle Vapor Valve	PASS	N.A.	FAIL(3)
TP-201.3	Leak Decay	PASS	FAIL(2)	FAIL(4)
TP-201.4	Back Pressure	PASS	N.A.	PASS
TP-201.6C	Liquid Removal	PASS	PASS	PASS

1) Positive leak rate failure, replaced with new P/V valve and resumed testing. No ball valve installed.
2) Nozzle vapor valve failure on two nozzles detected by bagging, nozzles replaced and test resumed
3) Three nozzles failed vapor valve leak rate testing, one gross failure
4) Due to nozzle leak rate failure

Unfortunately, several component failures were documented during the evaluation of Manufacturer #3 balance system. Due to the multiple failures of the nozzle vapor valve and P/V valve, ARB was not able to collect valid UST pressure data during the study period. As stated in the protocol, UST pressure data must be bracketed by successful tests. Additional time was added to the evaluation in an effort to collect 30 days of valid pressure data. Although the data collected was not considered valid per the protocol, 17 days of the 58 days monitored were selected as potentially usable data.

8.2 UST Pressure Profiles

The pressure data indicated that significant vapor growth and pressurization of USTs occurred during the nine hour time frame in which the GDFs were closed (idle period). Daily pressure profiles generated from all three balance systems showed a similar trend of negative pressures during the operating hours and positive pressures during the idle period.

During the idle periods, the vapor growth was sufficient to crack the P/V valve at 3.0 inches of water column pressure for several hours. This phenomenon is represented by a flat line on the pressure profile graph at 3.0 inches of water column pressure.

During the operating hours, the presence of ORVR vehicles drove the UST pressure negative because the volume of fuel removed from the USTs exceeded the volume of vapors being returned. However, unlike the positive pressure profile during idle periods, the three systems achieved slightly differing levels of negative UST pressure during the operational hours. These variations may be due to several factors such as collection efficiency of the nozzle, vehicle fill pipe and nozzle faceplate compatibility, ORVR population, station demographics, and fuel dispensing flow rates.

The following three Figures (8-1 through 8-3) provide examples of typical daily pressure profiles for each system. Saturdays were selected to minimize the influence of fuel deliveries.

Figure 8-1: Manufacturer #1 Pressure Profile

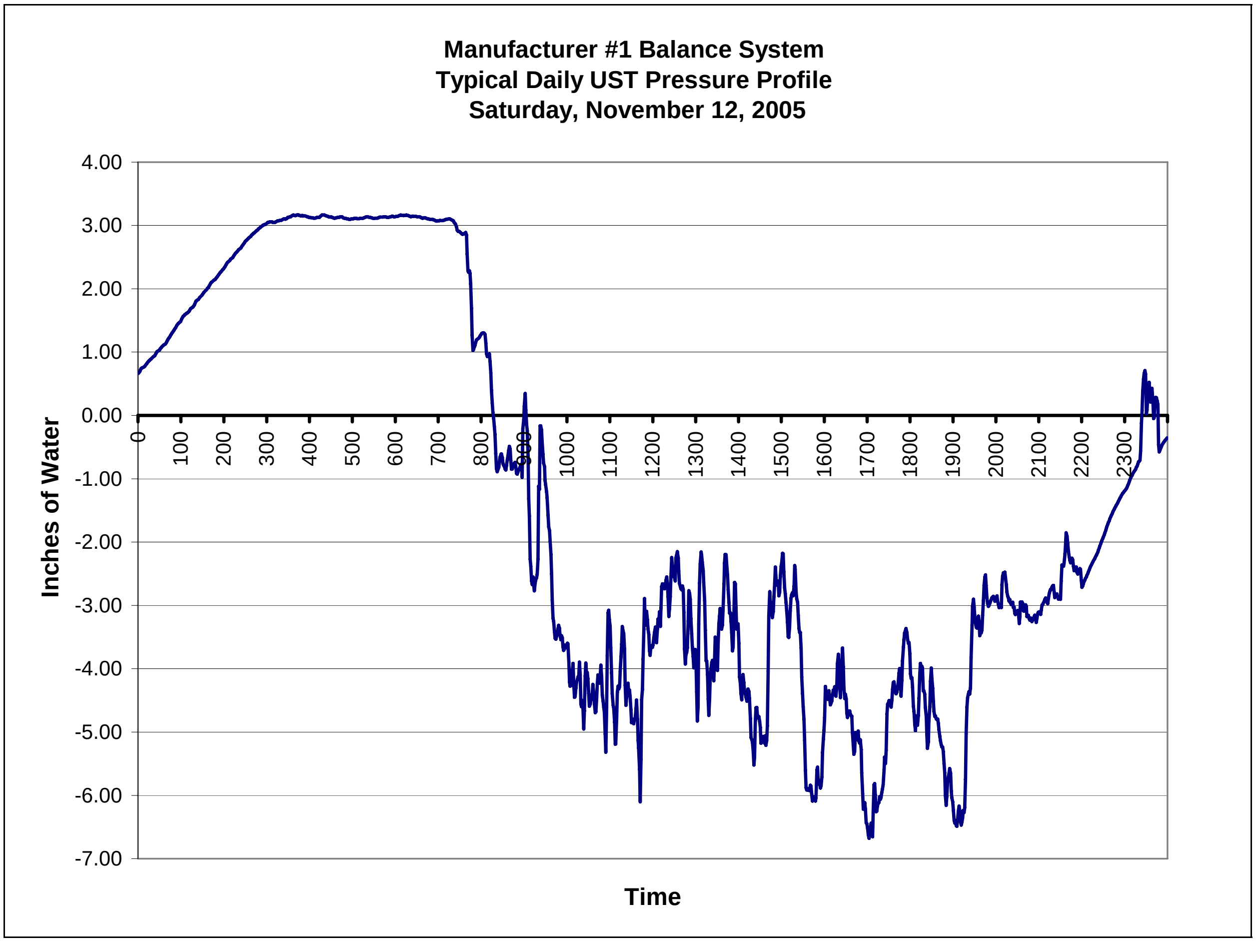


Figure 8-2: Manufacturer #2 Pressure Profile

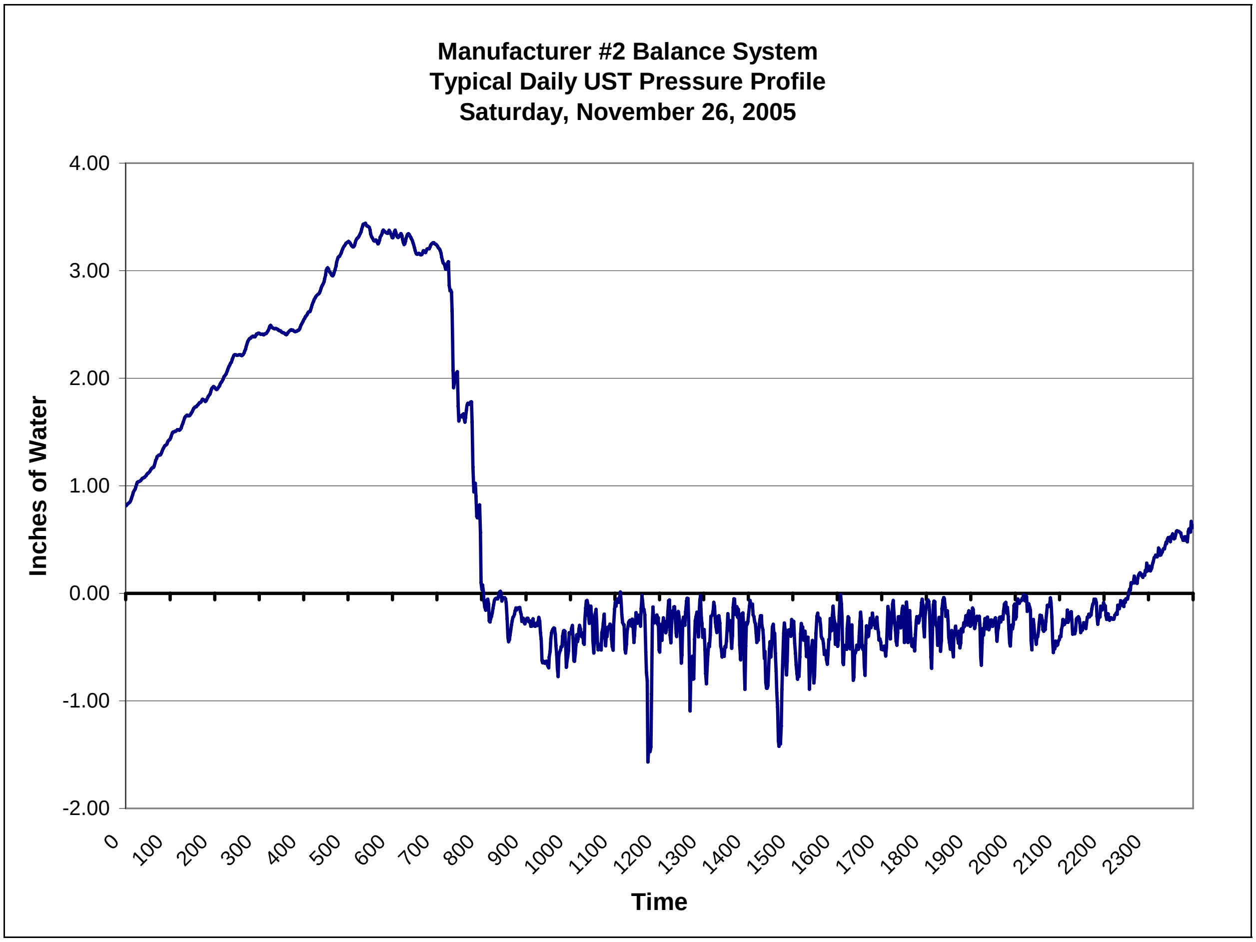
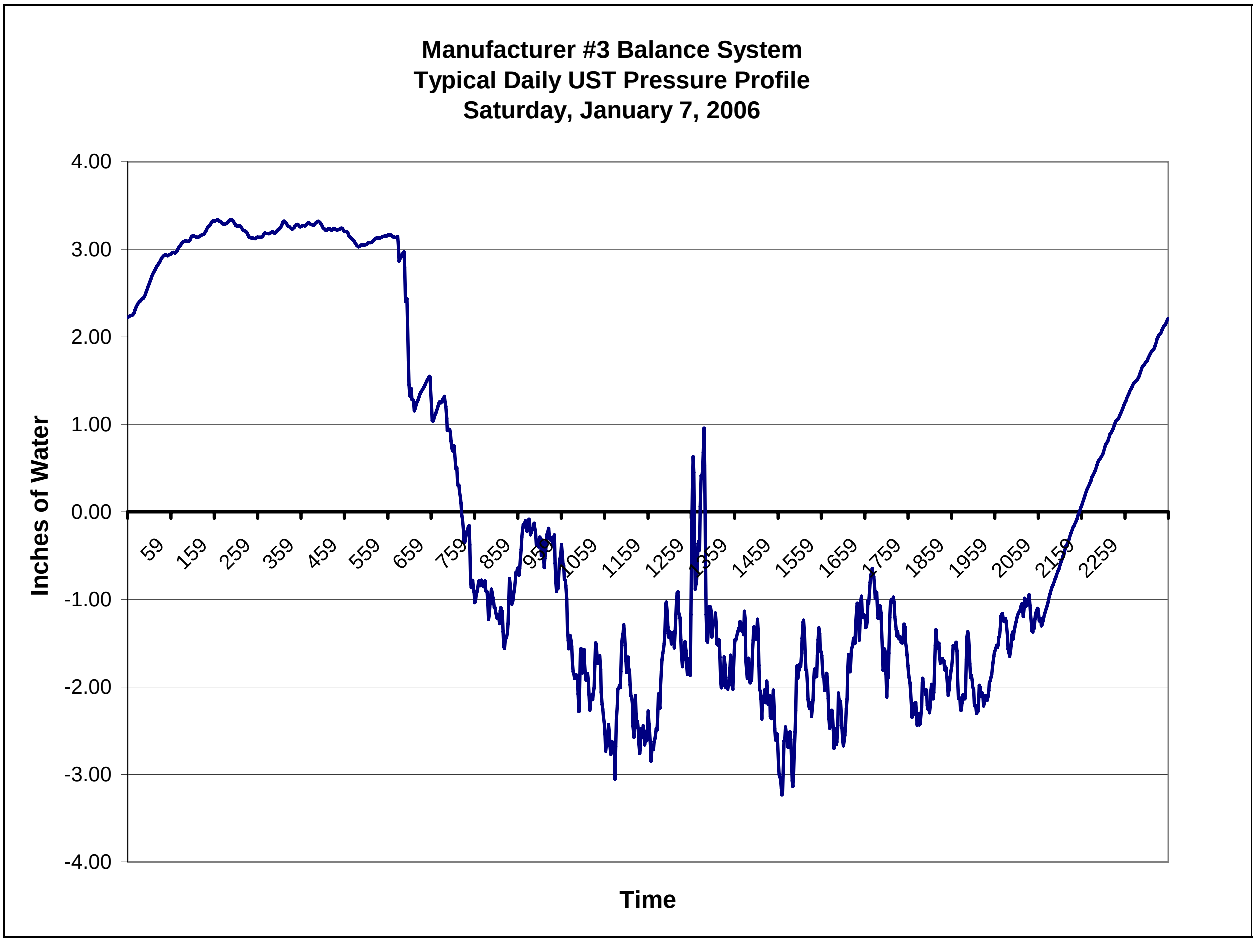


Figure 8-3: Manufacturer #3 Pressure Profile



8.3 Calculation of ARB UST Pressure Averages

Section 4.6 of CP-201, provides the criteria for calculating the daily average and daily high pressure. The calculations are performed as follows:

4.6.3 The daily average pressure shall be computed as follows:

Zero and negative pressure shall be computed as zero pressure; and
Time at positive and zero pressures shall be included in the calculation.
(Example: 6 hours at +1.0 inches H_2O and 18 hours at -1.0inches H_2O yields an average daily pressure of 0.25 inches H_2O.)

4.6.4 The daily high pressure shall be computed as follows:

Zero and negative pressure shall be computed as zero pressure;
Time at positive and zero pressures shall be included in the calculation;
The average positive pressure for each hour shall be calculated; and
The highest hour is the daily high pressure for the day.

4.6.5 A rolling 30 day average of the daily average pressures and the daily high pressures for each day shall be calculated by averaging the most current daily value with the appropriate values for the previous 29 days. These 30-day rolling averages shall meet the following criteria:

The daily average pressure shall not exceed +0.25 inches H_2O.
The daily high pressure shall not exceed +1.5 inches H_2O.

As illustrated in Figures 8-4 and 8-5, the UST pressure calculations show that all three systems routinely exceeded the ARB daily average criteria of 0.25 inches of water. The first chart compares Manufacturer #1 and #2 system daily averages, while the second chart illustrates the Manufacturer #3 daily averages. The Manufacturer #3 daily average calculation was based on an incomplete data set (17 days rather than 30). Although the Manufacturer #3 system did not meet the requirements of the protocol, it was included in this report in order to illustrate the same trend as Manufacturer #1 and #2.

Figure 8-4: Daily Average Values for Manufacturer #1 and #2 Balance Systems

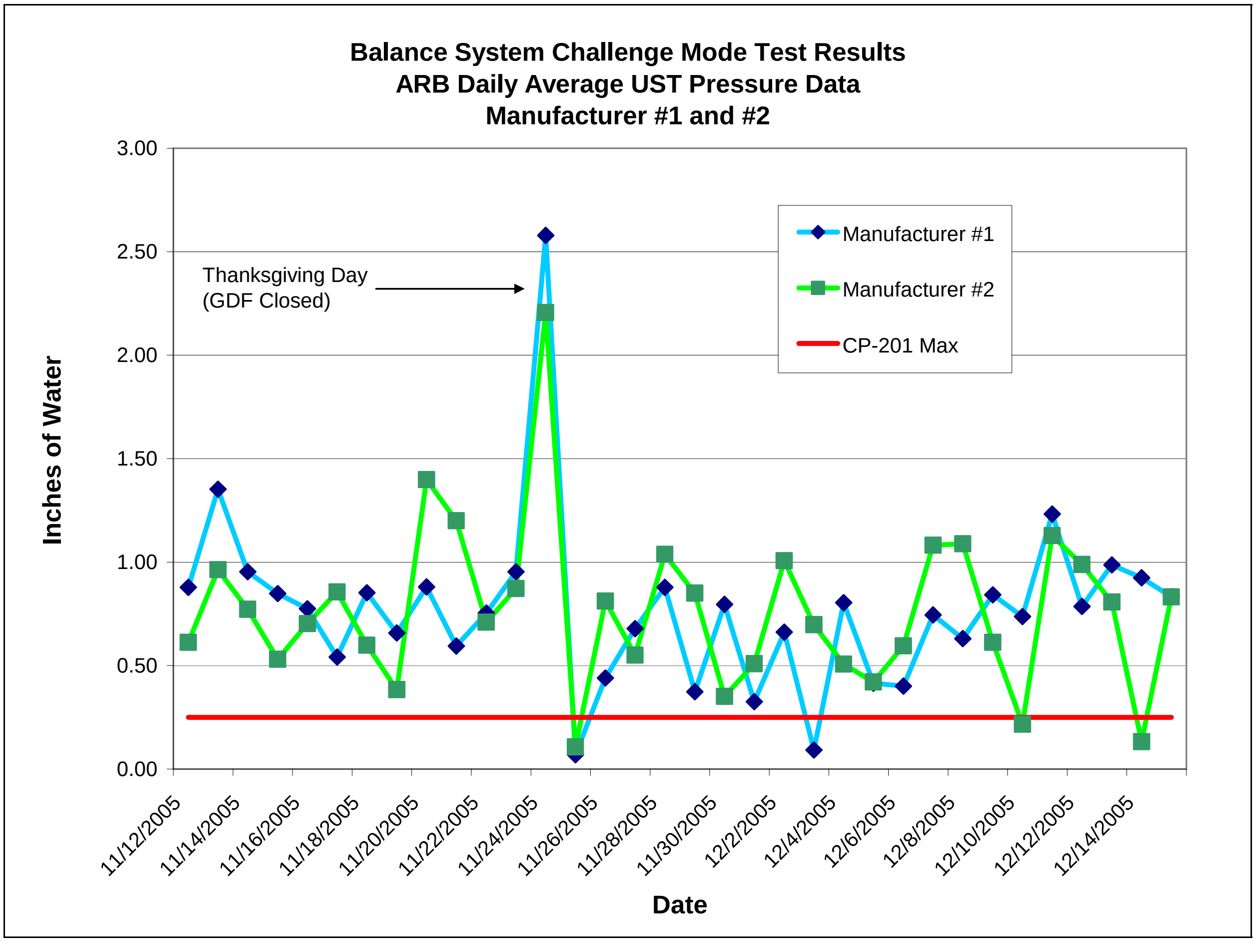
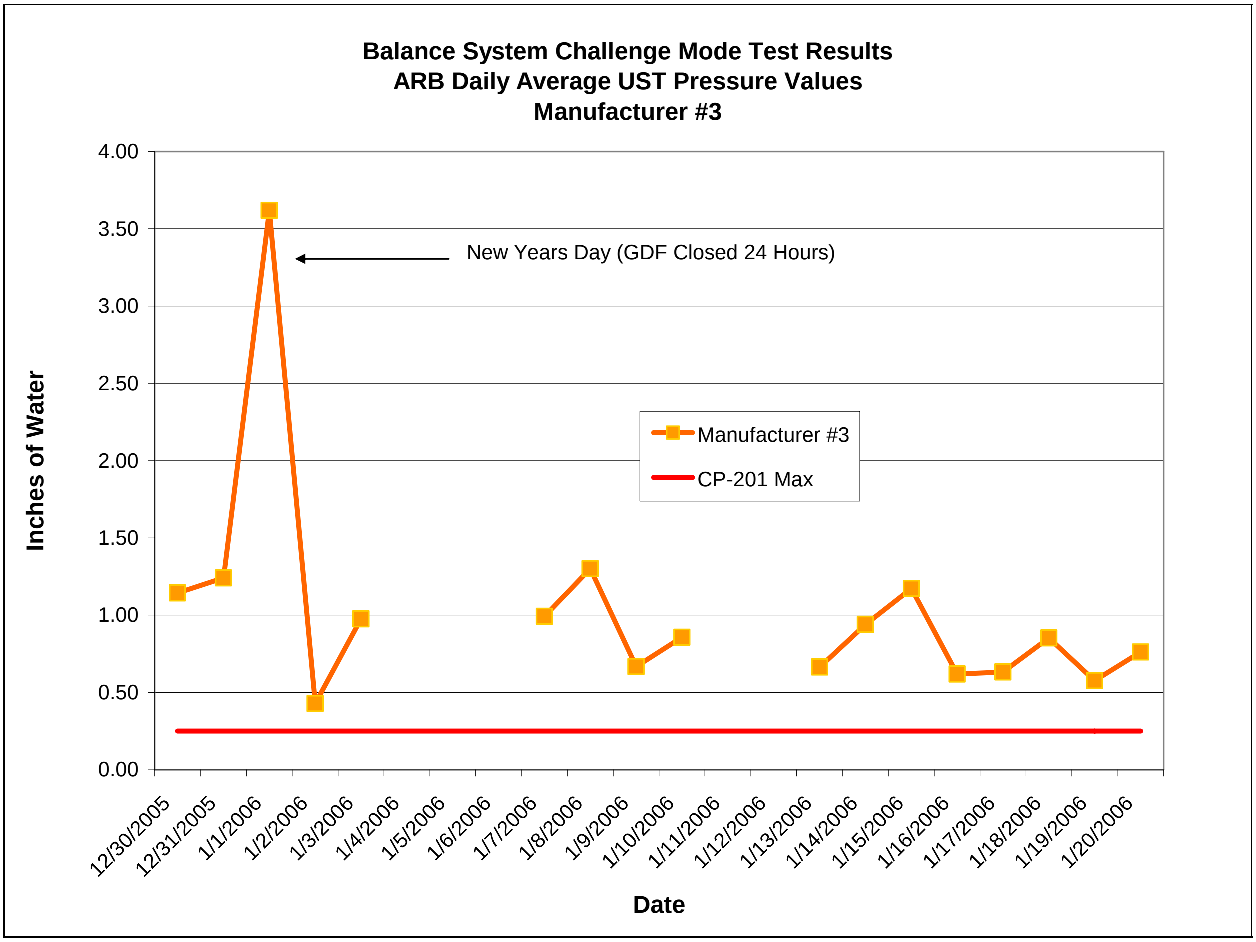


Figure 8-5: Daily Average Values for Manufacturer #3 Balance System



As illustrated in Figures 8-6 and 8-7, the daily high pressure criteria for Manufacturer #1, #2, and #3 balance systems were also exceeded on a regular basis. Manufacturer #3 daily high calculation was based on an incomplete data set (17 days rather than 30). Although the Manufacturer #3 system did not meet the requirements of the protocol, it was included in this report in order to illustrate the same trend as Manufacturer #1 and #2.

Figure 8-6: Daily High Values for the Manufacturer #1 and #2 Balance Systems

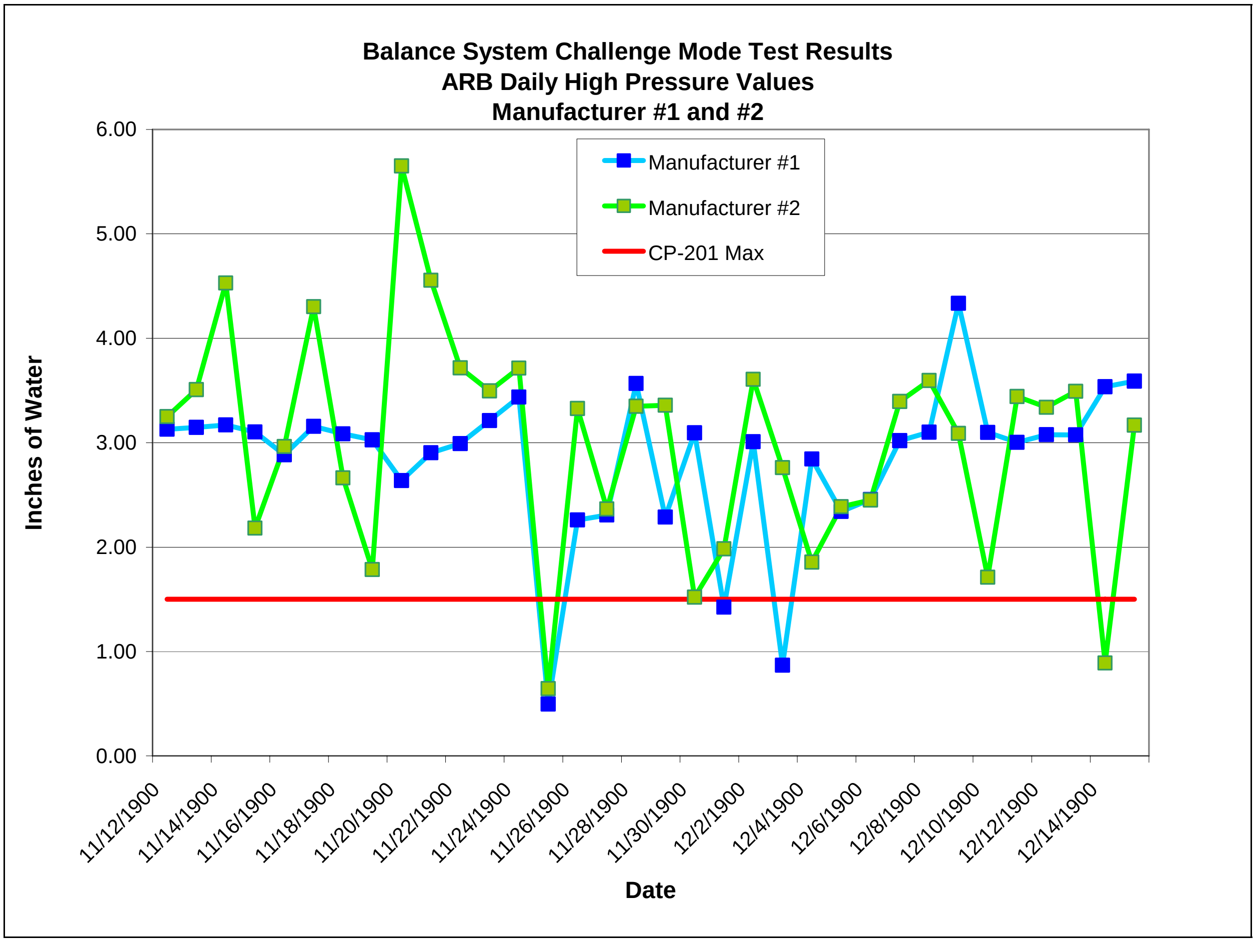
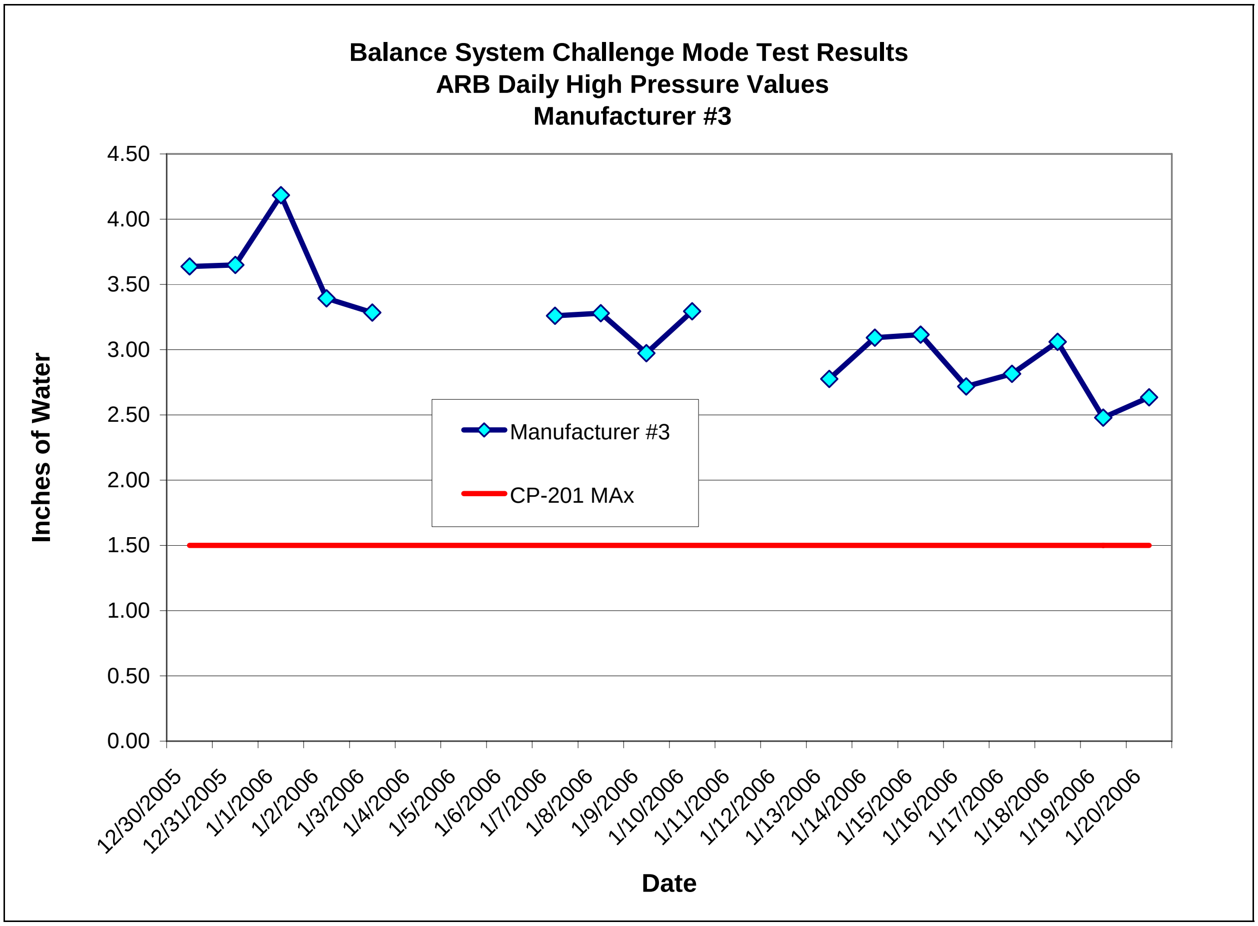


Figure 8-7: Daily High Values for the Manufacturer #3 Balance System



In accordance with Section 4.6.5 of CP-201, rolling 30 day averages of the daily average pressures and the daily high pressures were calculated. The results of calculations are listed in Table 8-4.

Table 8-4: UST Pressure Calculations Per CP-201 (Based on a 30-Day Rolling Average)

Manufacturer	Daily Average Pressure, in. H2O	Daily High Pressure, in. H2O
Manufacturer #1	0.76	2.78
Manufacturer #2	0.78	3.04
Manufacturer #3*	1.03	3.16
CP-201 Pressure Limits	0.25	1.50

*Daily average and daily high average based on a 17 day rolling average due to incomplete data set (unable to collect a full 30 days of valid data).

All three balance systems under evaluation exceeded the pressure profile standards specified in CP-201. Manufacturer #1 and #2 averages are based on 30 days of valid pressure data. The Manufacturer #3 daily average and daily high pressure calculations were based on an incomplete data set (17 days rather than 30). Although the Manufacturer #3 system did not meet the requirements of the protocol, it was included in this report in order to illustrate the same trend as Manufacturer #1 and #2.

8.4 RVP Analysis

Throughout the five month study period, ARB Enforcement Division staff collected and analyzed samples of 87 grade and 91 grade gasoline at each site. The samples were collected on a weekly basis and immediately transported to the ARB laboratory facility in El Monte, California for RVP analysis using ASTM D5191. As required by the protocol, RVP sampling was necessary to verify that winter fuel (uncontrolled RVP) was in use throughout the study period. Winter fuel or uncontrolled fuel has an RVP of 7.0 psi or greater. Figures 8-7 and 8-8 illustrate that during the study period, both sites experienced upward trends in the RVP. The results also show that uncontrolled fuel was present during the study period. More samples were collected at the San Bernardino location because the site served for two nozzle manufacturers from November through February. RVP at the Riverside site ranged from 9.5 to 11.5 psi. RVP at the San Bernardino site ranged from 9.5 to 12 psi.

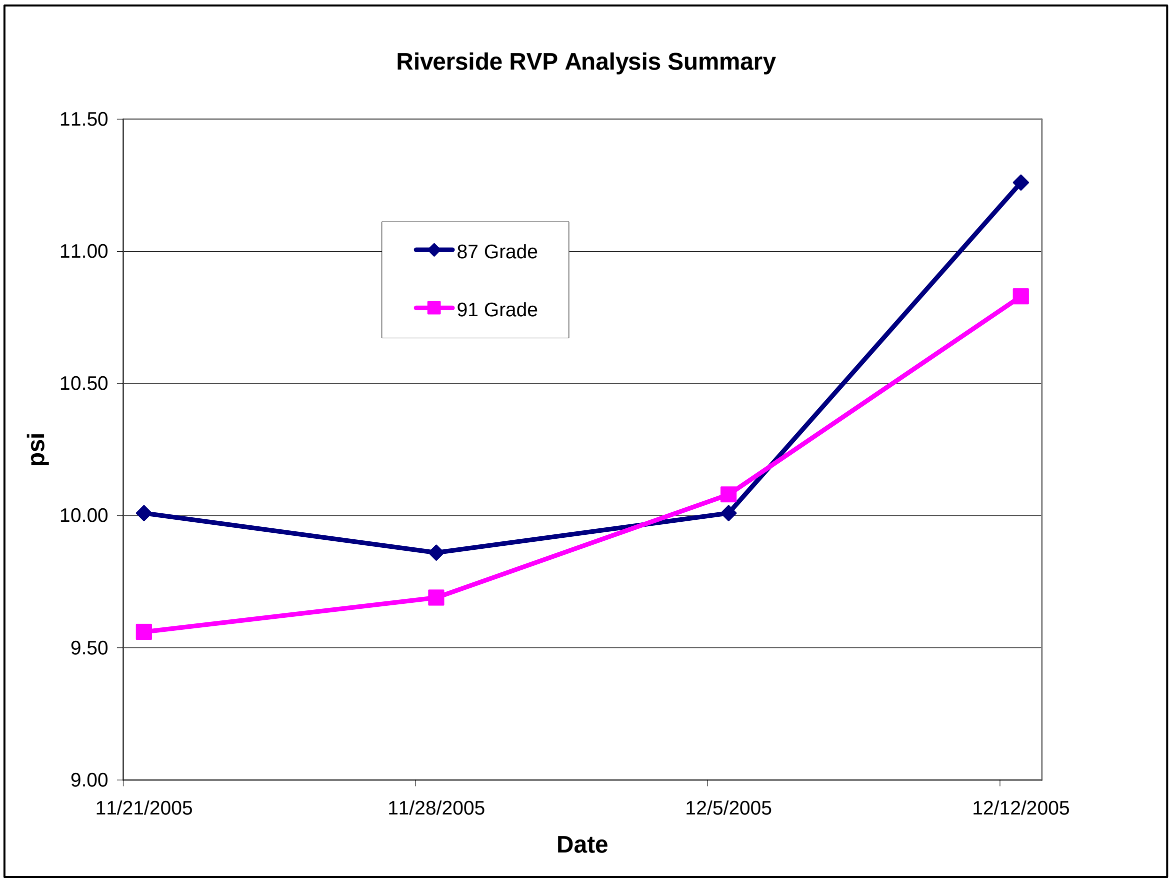


Figure 8-8: Riverside GDF RVP Results

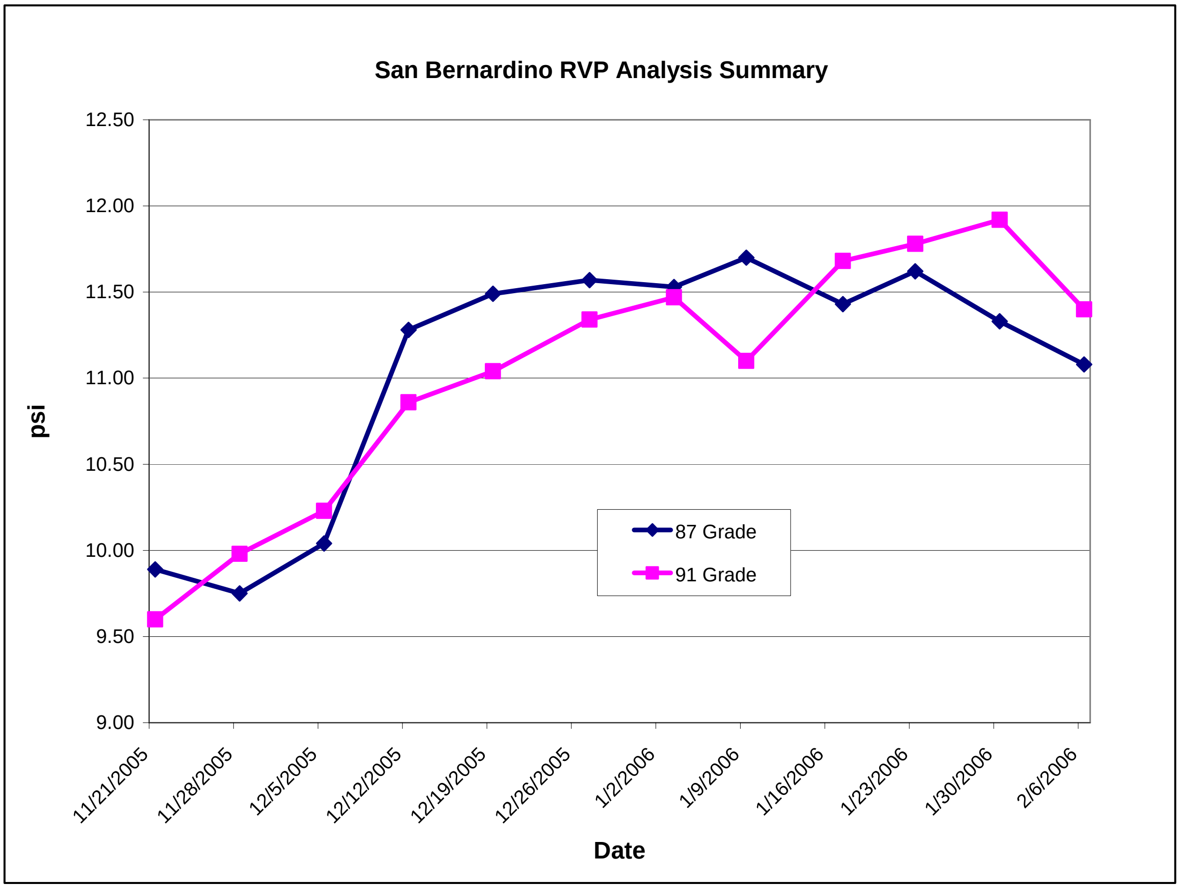


Figure 8-9: San Bernardino GDF RVP Results

9.0 QUALITY ASSURANCE

At each site, UST pressure, ambient temperature, and barometric pressure was continuously monitored by a data logging system designed, built, and installed by ARB staff. The data loggers were programmed to continuously collect and store this information as sixty second averages, 24 hours a day. Data logger “number one” was installed at Riverside GDF, while “number five” was installed at the San Bernardino GDF.

A UST pressure transducer within each data logging system was calibrated in Sacramento prior to installation in the field against a NIST (National Institute of Standards and Technology) traceable calibration secondary standard device (Ashcroft Model ATE-100 Hand Held Calibrator with 0-25” wc pressure transducer). The calibration results are shown in tables 9-2 and 9-3. The linear regressions generated from the calibrations were used to ‘correct’ the raw pressure data.

A post test accuracy check was also conducted, in Sacramento using the same secondary standard device, on each system and the results were acceptable. The two systems, the NIST traceable device, and the Method accuracy requirements are described in Table 9-1.

Table 9-1: Specifications of Pressure Measurement Devices

Description	System #1 (Working Instrument)	System #5 (Working Instrument)	NIST Traceable (Secondary Standard Instrument)
Make	Viatran	Viatran	Ashcroft
Model	IDP10	IDP10	ATE-100
Range	±0-10 inches H_20	±0-10 inches H_20	±0-25 inches H_20
Accuracy %	±0.20% full scale	±0.20% full scale	±0.06% full scale
Accuracy in terms of inches of H_20	± 0.02 inches H_20	± 0.02 inches H_20	± 0.015 inches H_20
Pre Installation Calibration Date	10/11/05	10/11/05	09/25/05
Post Installation Accuracy Check Date	3/15/06	3/13/06	Not applicable
Site Location	Riverside GDF	San Bernardino GDF	Hand Held Portable Unit
Accuracy Requirement per TP-201.3	± 0.05 inches H_20	± 0.05 inches H_20	NA
NIST Traceable?	No	No	Yes (#830051325)

9.1 Application of Correction Factor for UST Pressure Data

A linear regression was generated based on the pre-installation calibration and applied to all raw data collected at each test site. The following two tables, 9-2 and 9-3, provide the results of the calibrations:

Table 9-2: Pre-Installation Calibration San Bernardino Data Logger

Description: ARB Pre-Installation Datalogger Accuracy Check: San Bernardino GDF
Date: 10/11/2005

	Working Instrument	Standard Instrument				
Target Pressure (in H2O)	Datalogger Pressure	Ashcroft Pressure	Difference from Standard	Allowable Discrepancy per TP-201.3	Corrected Value (y=mx+b)	Corrected Difference
10	10.120	10.047	0.073	0.05	10.046	-0.001
8	8.110	8.035	0.075	0.05	8.040	0.005
6	6.130	6.079	0.051	0.05	6.064	-0.015
4	4.110	4.047	0.063	0.05	4.048	0.001
3	3.110	3.055	0.055	0.05	3.049	-0.006
2	2.110	2.051	0.059	0.05	2.051	0.000
1	1.100	1.043	0.057	0.05	1.043	0.000
0	0.150	0.088	0.062	0.05	0.095	0.007
-1	-1.000	-1.055	0.055	0.05	-1.053	0.002
-2	-1.980	-2.043	0.063	0.05	-2.031	0.012
-3	-2.980	-3.043	0.063	0.05	-3.029	0.014
-4	-4.000	-4.044	0.044	0.05	-4.047	-0.003
-6	-5.980	-6.025	0.045	0.05	-6.023	0.002
-8	-8.060	-8.075	0.015	0.05	-8.099	-0.024
-10	-10.000	-10.040	0.040	0.05	-10.035	0.005

Slope: 0.998076232
Intercept: -0.05454611
Correlation: 0.999998595

corrected value =(slope*datalogger value)+intercept

Table 9-3: Pre-Installation Calibration Riverside Data Logger

Description: ARB Pre-Installation Datalogger Accuracy Check: Riverside GDF
Date: 10/11/2005

	Working Instrument	Standard Instrument				
Target Pressure (in H2O)	Datalogger Pressure	Ashcroft Pressure	Difference from Standard	Allowable Discrepancy per TP-201.3	Corrected Value (y=mx+b)	Corrected Difference
10	10.240	10.120	-0.12	0.05	10.126	0.006
8	8.210	8.099	-0.111	0.05	8.100	0.001
6	6.220	6.116	-0.104	0.05	6.115	-0.001
4	4.190	4.086	-0.104	0.05	4.089	0.003
3	3.130	3.036	-0.094	0.05	3.032	-0.004
2	2.180	2.086	-0.094	0.05	2.084	-0.002
1	1.100	1.009	-0.091	0.05	1.006	-0.003
0	0.110	0.014	-0.096	0.05	0.018	0.004
-1	-0.930	-1.025	-0.095	0.05	-1.019	0.006
-2	-1.970	-2.044	-0.074	0.05	-2.057	-0.013
-3	-2.970	-3.063	-0.093	0.05	-3.055	0.008
-4	-3.950	-4.025	-0.075	0.05	-4.033	-0.008
-6	-6.030	-6.095	-0.065	0.05	-6.108	-0.013
-8	-8.030	-8.105	-0.075	0.05	-8.104	0.001
-10	-9.950	-10.034	-0.084	0.05	-10.019	0.015

Slope: 0.997772548
Intercept: -0.0914365
Correlation: 0.999999136

corrected value=(slope*datalogger value)+intercept

9.2 Post Installation Accuracy Checks

As required in the “Post Test Procedures” section of the protocol, an accuracy check of each data loggers system was performed in Sacramento, after they were returned from the field. The following two tables, 9-4 and 9-5, provide the results of these accuracy checks. It should be noted that Riverside data logger exceeded the allowable discrepancy value at the negative three inch target pressure. Because this occurred on a negative reading, it had no impact on the results of this study.

Table 9-4: Post-Installation Accuracy Check: San Bernardino Data Logger

Description: ARB Post-Installation Datalogger Accuracy Check: San Bernardino GDF
Date: 3/16/2006

	Working Instrument	Standard Instrument				
Target Pressure (in H2O)	Datalogger Pressure	Ashcroft Pressure	H2O from True	Allowable Discrepamcy per TP-201.3	Corrected Value (y=mx+b)	Corrected Difference
10	10.090	10.078	-0.012	0.05	10.081	0.003
8	8.060	8.056	-0.004	0.05	8.052	-0.004
6	6.010	6.009	-0.001	0.05	6.004	-0.005
4	4.070	4.073	0.003	0.05	4.065	-0.008
3	3.060	3.060	0.000	0.05	3.056	-0.004
2	2.060	2.051	-0.009	0.05	2.057	0.006
1	1.030	1.022	-0.008	0.05	1.027	0.005
0	0.010	0.000	-0.010	0.05	0.008	0.008
-1	-1.080	-1.087	-0.007	0.05	-1.081	0.006
-2	-2.070	-2.075	-0.005	0.05	-2.070	0.005
-3	-3.010	-3.001	0.009	0.05	-3.010	-0.009
-4	-4.020	-4.026	-0.006	0.05	-4.019	0.007
-6	-6.010	-6.006	0.004	0.05	-6.007	-0.001
-8	-8.070	-8.057	0.013	0.05	-8.066	-0.009
-10	-10.020	-10.014	0.006	0.05	-10.014	0.000

Slope:	0.999254071
Intercept:	-0.00179453
Correlation:	0.999999443

corrected value=(slope*datalogger value)+intercept

Table 9-5: Post-Installation Accuracy Check: Riverside Data Logger

Description: ARB Post-Installation Datalogger Accuracy Check: Riverside GDF
Date:3/15/2006

	Working Instrument	Standard Instrument				
Target Pressure (in H2O)	Datalogger Pressure	Ashcroft Pressure	Difference from Standard	Allowable Discrepancy per TP-201.3	Corrected Value (y=mx+b)	Corrected Difference
10	10.100	10.033	-0.067	0.05	10.031	-0.002
8	8.190	8.122	-0.068	0.05	8.124	0.002
6	6.060	6.000	-0.060	0.05	5.998	-0.002
4	4.010	3.953	-0.057	0.05	3.951	-0.002
3	3.060	2.983	-0.077	0.05	3.003	0.020
2	2.030	1.975	-0.055	0.05	1.974	-0.001
1	1.020	0.961	-0.059	0.05	0.966	0.005
0	0.060	0.008	-0.052	0.05	0.008	0.000
-1	-1.020	-1.075	-0.055	0.05	-1.071	0.004
-2	-1.940	-2.000	-0.060	0.05	-1.989	0.011
-3	-3.030	-3.008	0.022	0.05	-3.077	-0.069
-4	-3.980	-4.035	-0.055	0.05	-4.026	0.009
-6	-6.030	-6.084	-0.054	0.05	-6.072	0.012
-8	-8.040	-8.086	-0.046	0.05	-8.079	0.007
-10	-10.030	-10.072	-0.042	0.05	-10.066	0.006

Slope: 0.998352346
Intercept: -0.05228281
Correlation: 0.99999391

corrected value=(slope*datalogger value)+intercept

9.3 Deviations from TP-201.7

Staff found it necessary to deviate from three sections of ARB Test Procedure TP-201.7: Continuous Pressure Monitoring. The following is a description of those sections and how ARB staff deviated from them.

Section 3.1 of TP-201.7 states:

"The location used for monitoring storage tank pressure shall be at the vent pipe to provide ready access to the storage tank pressure."

Deviation: Rather than locating the pressure transducer at the vent pipe, the inlet of the vapor return riser, above the shear valve, located at a single fueling point, was used.

Section 4.1 of TP-201.7 states:

"Electronic Pressure Transducer. Sensitivity shall be 0.01 inches H2O with minimum differential full-scale range of 15 inches H2O and minimum accuracy of 0.050 percent of full-scale range. Unit shall be intrinsically safe, NEMA 4 rated."

Deviation: According to this statement the accuracy requirement for TP-201.7 is $\pm$ 0.0075 inches H2O (0.05 % of 15 inches). This accuracy requirement is completely unrealistic relative to available equipment and also unnecessary relative to the accuracy needed for this test. This accuracy requirement is also much stricter than the accuracy required for the same purpose in TP-201.3, which states: "If an electronic pressure measuring device is used, the full-scale range of the device shall not exceed 0-10 inches H_2O with a minimum accuracy of 0.5 percent of full-scale. A 0-20 inches H_2O device may be used, provided the equivalent accuracy is not less than 0.25 percent of full-scale". The accuracy requirement listed in TP-201.7 may have been a "typo", but in any case is not appropriate for use for this purpose. The pressure transducer accuracy requirement listed in TP-201.3 was used for the purpose of this study.

Section 5.8 of TP-201.7 states:

"Pressure Port Fitting. Use a 2-inch diameter by 4-inch long factory threaded nipple in which to monitor storage tank pressure. The nipple shall be drilled and tapped with a ¼-inch pipe thread in order to connect a pressure without modifying the GDF."

Deviation: UST pressure monitoring port was installed at the vapor return riser under a dispenser, 1 inch vapor return at the shear valve.

10. PROJECT PARTICPANTS

Personnel participating in the planning and execution of the balance system challenge mode project are identified in the following table:

Table 10-1: Project Participants

Participant	Affiliation	Assignment
Lou Roberto	SCAQMD	Compliance Assistance
Ralph Crawford	SCAQMD	Compliance Assistance
Ray Hernandez	ARB	Data Acquisition, Field Testing
Sam Vogt	ARB	Data Acquisition, Field Testing
Mark Stover	ARB	Enforcement Manager, RVP Sampling
Ken Lewis	ARB	Field Testing, QA/QC
Kevin Mongar	ARB	Field Testing, QA/QC
Oscar Lopez	ARB	Field Testing, QA/QC
Raed Mahdi	ARB	Field Testing, QA/QC
Randy Matsuyama	SCAQMD	Permitting
Lou Dinkler	ARB	Project Lead
Cindy Castronovo	ARB	Review of Documents/Reports
Henry Mano	ARB-El Monte	RVP Sampling and Analysis
Mike Gebel	ARB-El Monte	RVP Sampling and Analysis
Pat Bennett	ARB	Section Manager, Field Testing
Jeff Lynch	Wayne Services	Service Contractor
Warren Lind	Wayne Services	Service Contractor

11. CONCLUSION

Based on the results of the tests, balance systems will need some form of pressure management (processor) to comply with EVR pressure profile requirements.

Appendix 1

Phase II EVR Balance System Challenge Test Protocol

11/08/05

Test Conditions:

- Minimum 30-day test period
- Site located in southern California with relatively higher ambient temperatures when compared to the Sacramento region.
- Testing shall occur during the winter fuel season (uncontrolled RVP greater than 7.0 psi)
- Daily station shutdown of at least 9 hours
- Phase I EVR System and Phase II EVR hanging hardware installed
- Gasoline throughput greater than 150,000 gal/month
- Unusually high UST ullages for an extended period should be avoided
- Nozzles “locked out” with the use of pad locks during shut down period

Pre-Test Procedures:

a. Install data acquisition system (DAS) per TP-201.7: Continuous Pressure Monitoring
b. Conduct TP-201.3: Determination of 2 Inch WC Static Pressure Performance of Vapor Recovery Systems of Dispensing Facilities
c. Conduct TP-201.3C: Determination of Vapor Piping Connections to Underground Gasoline Storage Tanks (Tie-Tank Test)
d. Conduct TP-201.4: Dynamic Back Pressure
e. Conduct TP-201.6C: Compliance Determination of Liquid Removal Rate (87 grade only, high clip setting)
f. Collect and analyze samples of each grade of gasoline to determine RVP
g. Conduct bench testing of certified PV Valves in accordance with TP-201.1E prior to installation at each site
h. Conduct pressure transmitter accuracy check of the data acquisition system (minimum of 15 point check) with a NIST traceable secondary standard instrument
i. Verify integrity of nozzle vapor valve leak rate per TP-201.2B: Flow and Pressure Measurement of Vapor Recovery Equipment

Test Procedures:

a. Daily
    - Print product and ullage volumes from ATG system at opening shift and closing shift of the GDF

- Lock out nozzles at closing and ensure nozzles are hung properly on the dispenser in the locked position.

b. Weekly
   - Collect and analyze samples of each grade of gasoline to determine RVP
   - Download data from data acquisition system (two times per week)
   - Evaluate pressure data, look for anomalies in the pressure profile or indicators which suggest a leaking system

c. Bi-Weekly
   - Conduct system integrity test per TP-201.3
   - Conduct liquid removal testing in accordance with TP-201.6C short version (drain hoses)

Post-Test Procedures:

a. Conduct TP-201.3: Determination of 2 Inch WC Static Pressure Performance of Vapor Recovery Systems of Dispensing Facilities
b. Conduct TP-201.4: Dynamic Back Pressure
c. Conduct TP-201.6C: Compliance Determination of Liquid Removal Rate (87 grade only, high clip setting)
d. Collect and analyze samples of each grade of gasoline to determine RVP
e. Download pressure data from the data logger
f. Conduct accuracy check of pressure transmitter of the data acquisition system (minimum of 15 point check) with a NIST traceable secondary standard instrument

Data Analysis:

1. Calculate the daily average ullage pressure, daily high pressure, and rolling 30-day average of each using section 4.6.3 through 4.6.5 of CP-201 "Certification Procedure for Vapor Recovery Systems at Gasoline Dispensing Facilities"

Pass/Fail Criteria:

1. Successful pass of all tests
2. 30-day rolling average for the following (section 4.6 of CP-201)
   - daily average pressure ≤ +0.25 inches H_2O
   - daily high pressure ≤ +1.5 inches H_2O