

**FINAL
INCORPORATED TEST PROCEDURE**

California Environmental Protection Agency



Vapor Recovery Test Procedure

TP-206.4

**Volumetric Efficiency of
Phase I Vapor Recovery Systems
for Aboveground Storage Tanks**

Adopted: May 27, 2014

Note: All text is newly adopted. As permitted by title 2, California Code of Regulations, section 8, for ease of review, underline to indicate adoption has been omitted.

**California Environmental Protection Agency
Air Resources Board**

Vapor Recovery Test Procedure

TP-206.4

**Volumetric Efficiency of Phase I Vapor Recovery Systems
for Aboveground Storage Tanks**

Definitions common to all certification and test procedures are in:

D-200 Definitions for Vapor Recovery Procedures

For the purpose of this procedure, the terms "ARB" or "CARB" refer to the Air Resources Board, and the term "Executive Officer" refers to the CARB Executive Officer, or his or her authorized representative or designee.

1 PURPOSE AND APPLICABILITY

The purpose of this procedure is to quantify the transfer efficiency when a bulk gasoline delivery is made between a cargo tank and a gasoline dispensing facility (GDF) with an aboveground storage tank. This procedure is used to determine compliance with the Phase I transfer efficiency performance standard specified in Vapor Recovery Certification Procedure 206, CP-206, "Certification and Testing Procedures for Gasoline Vapor Recovery Systems at Gasoline Dispensing Facilities Using Aboveground Storage Tanks," (Adopted: May 2, 2008, as last amended May 27, 2014).

2 PRINCIPLE AND SUMMARY OF TEST PROCEDURE

During a gasoline delivery, the cargo tank and GDF are instrumented with test equipment in order to determine the amount of vapor returned to the cargo tank and the amount of vapor discharged through the GDF vent pipe. Upon conclusion of the fuel delivery, if the ullage pressure in the AST is greater than 1.00 inches water column, the amount of vapor discharged through the GDF vent pipe is monitored for one hour.

For a one hour time frame immediately prior to the fuel delivery, the amount of vapor discharged through the GDF vent attributed to standing losses (also known as breathing losses) is determined by way of direct measurement using a volume meter. The amount of vapor discharged from the GDF vent pipe attributed to standing losses is deducted from the amount of vapor discharged through the GDF vent pipe during and after the fuel delivery.

From these parameters the Phase I transfer or volumetric efficiency is determined. If a Phase I system fails to meet the volumetric efficiency performance standard referenced in CP-206, the cargo tank shall be tested in accordance with TP-204.2, Determination of One Minute Static Pressure Performance of Vapor Recovery Systems of Cargo Tanks,

for compliance with the daily static pressure standard for cargo tanks as specified in CP-204 to determine if the failure can be attributed to the cargo tank.

3 BIASES AND INTERFERENCES

3.1 Standing Losses (also known as breathing losses)

Aboveground gasoline storage tanks, particularly those constructed with a single wall of steel (non-insulated), are prone to diurnal standing loss emissions which occur daily when solar radiation and ambient temperatures increase, causing the formation of vapors which will increase ullage pressures. When the ullage pressure reaches the positive relief setting of the pressure vacuum vent valve, vapors are discharged into the air through the vent pipe. These standing loss emissions occur during idle periods (periods of no fuel transfer) and are not attributed to the design of the Phase I system. Because standing loss emissions can bias the results of this test toward non-compliance, they must be measured and deducted from the efficiency calculation.

3.2 Establishing Baseline Standing Loss Vent Volume

- 3.2.1 The volume and rate of vapor discharged through the GDF vent pipe associated with standing losses will vary significantly based on ambient temperature, exposure to sunlight, tank capacity, and tank color and construction (insulated versus non-insulated). This volume can be measured directly by using a volume meter specified in section 5 of this procedure.
- 3.2.2 Baseline standing loss vent volume should only be measured when the ambient temperature is stable (temperature changes no greater than 10°F from beginning to end of the monitoring period), during full sun exposure. Early morning and late afternoon should be avoided due to rising and falling temperatures and exposure to solar radiation.
- 3.2.3 Baseline standing loss vent volume should only be measured when the aboveground storage tank ullage pressure is at, or greater than, the pressure vacuum vent valve relief setting (between positive 2.5 and positive 6.0 inches water column) per CP-206; and when the aboveground storage tank ullage volume is constant, with no dispensing or delivering activities during the monitoring period.
- 3.2.4 In order to establish baseline standing loss vent volume, the pressure vacuum vent valve used during the test must have zero flow at pressures less than the positive relief setting. Currently, the only pressure vacuum vent valve to meet this requirement is the "PV-Zero" manufactured by Franklin Fueling Systems (PV-Zero). Due to the unique design of the PV-Zero, when the ullage pressure reaches the positive relief setting and vapors are discharged to atmosphere, a distinct vent volume can be

captured and recorded by the instrumentation specified in this test procedure.

3.2.5 If the positive relief setting of the "PV Zero" pressure vacuum vent valve is set higher than the positive relief setting of the existing pressure vacuum vent valve, the results of this test will be bias toward passing. If the positive relief setting of the "PV Zero" pressure vacuum vent valve is set lower than the positive relief setting of the existing pressure vacuum vent valve, the results of this test will be biased toward failure. To eliminate this bias, the positive relief setting of the PV Zero must be within +/- 1.00 inch water column pressure within the existing pressure vacuum vent valve.

3.2.6 Ambient temperature differences of 10°F or greater between the establishment of the baseline and the Phase I delivery and waiting period will preclude the use of this procedure.

3.3 Leaks Within the Vapor Containment and Collection System

3.3.1 Any vapor leaks exceeding 100% of the Lower Explosive Limit (LEL) during the gasoline bulk delivery precludes the use of this procedure.

3.3.2 Gasoline cargo tanks exceeding the allowable daily static performance pressure-decay standard as defined in CP-204 preclude the use of this procedure.

3.3.3 The presence of vapor leaks in the GDF, greater than the allowable leak decay limits specified in Section 4.2 of CP-206 preclude use of this procedure.

3.4 Liquid Volumes and Headspace

3.4.1 Unusually large cargo tank headspace volumes may cause low volumetric efficiency under certain conditions. Conversely, unusually small cargo tank headspace volumes may result in unusually high efficiency. During the Certification Process for a Phase I system, the cargo tank headspace volumes should be between 3.0 and 10.0 percent of the total cargo tank capacity prior to the delivery.

3.4.2 Ullage volumes of greater than 80% may cause low volumetric efficiency under certain conditions. Conversely, ullage volumes of less than 20% may result in unusually high efficiency.

3.5 Location of Instrumentation

3.5.1 The location chosen to measure storage tank pressure may not represent the pressure that is present in every location of the vapor recovery system. In order to avoid this bias and to provide consistency, the

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

3.5.2 Ambient temperature measurements may be biased depending on the location of the temperature probe. Ambient temperature shall be installed within a radiation shield at least five (5) feet above the surrounding grade.

3.5.3 Digital manometers installed in direct sunlight or in a location that is exposed directly to the local environment (i.e., wind, rain) can produce erroneous results and/or produce a potentially dangerous condition. Care should be taken to protect/shield the digital manometers from environmental conditions.

3.6 Taking a fuel level measurement via manual gauge port (stick port) should be performed without venting the storage tank ullage pressure. A fuel level measurement taken from a stick port, particularly on single-wall aboveground storage tanks, can be biased if the ullage space is at positive pressure or under vacuum. If the ullage pressure is positive, the measurement stick reading will be biased high as the pressure pushes the fuel up the drop tube. In order to correct this measurement, obtain an ullage pressure reading using a digital manometer (inches of WC) and multiply that value by 1.28 to convert inches of WC into inches of gasoline. Then, subtract the inches of gasoline from the value obtained from the measurement stick reading. If the tank is under vacuum, add the inches of gasoline to the number obtained off the stick gauge.

For example, if a single wall aboveground storage tank is at 3.5 inches of water column positive pressure and the value obtained by the measurement stick is 30 inches of gasoline, the following correction factor would be applied:

Corrected Reading = inches of gasoline from stick reading – (positive pressure of ullage x conversion factor of 1.28)

= 30 inches of gasoline – (3.5 inches of water x 1.28)

= 25.52 inches of gasoline

The conversion factor of 1.28 is obtained by dividing the density of water (8.34 lb/gallon water) by the density of gasoline (6.5 lb/gallon gasoline).

4 SENSITIVITY, PRECISION AND RANGE

4.1 Digital Manometer. The maximum full-scale range of the device shall not exceed 20 inches water column (WC) with minimum sensitivity of 1.00 inches WC and minimum accuracy of 0.5 percent of full scale. Digital manometers shall be calibrated as described in Section 5 of this procedure.

3.3 Volume Meter, Vapor Return. Minimum full-scale range shall be 5,000 CFH with a maximum rated back pressure less than 1.10 inches WC. The meter shall have an internal diameter of 3 inches, equal to that of a cargo tank vapor return hose.

- 4.3 Volume Meter, Vent Pipe. Minimum full-scale range shall be 800 CFH with a maximum rated back pressure less than 0.26 inches WC. The meter shall have an internal diameter of at least 1.5 inches.
- 4.4 Temperature Gauges. Maximum range of 0 to 150°F and accurate to within 2°F.
- 4.5 Barometric Pressure Gauge. Minimum accuracy of 0.08 inches of mercury (1.0 inches WC or 2.7 millibar).

5 EQUIPMENT

- 5.1 Vent Pipe Volume Meter. Use a volume meter with minimum specifications described in Section 4 to measure the amount of vapor discharged through the vent pipe(s). The meter shall be equipped with a pressure gauge and temperature probe as described in Section 4 on the inlet side. The meter shall be connected to the GDF in a fashion as to maintain intrinsic safety, as shown in Figures 2 and 3.
- 5.2 Vapor Return Volume Meter(s). Use a volume meter with minimum specifications described in Section 4 to measure the amount of vapor returned to the cargo tank from the aboveground storage tank. The meter shall be equipped with a pressure gauge and temperature probe as described in Section 4 on the inlet side. The meter shall be connected to the GDF in a fashion as to maintain intrinsic safety, as shown in Figure 2 (direct fill Phase I configuration) or Figure 3 (remote fill configuration).
- 5.3 The volume meters shall be proofed against a standard reference meter prior to its initial use in the field or at intervals not to exceed 180 days. Calibration shall be performed at a minimum of three flow rates representing 25, 50 and 75 percent of rated capacity. An official statement of proofing is required.
- 5.4 Leak Detection
 - 5.4.1 Liquid Leak Detection Solution. Phase I components are not certified with an allowable leak rate and shall not leak. Compliance shall be verified by the use of commercial liquid leak detection solution when the vapor containment space of the aboveground storage tank is subject to non-zero pressure, or
 - 5.4.2 Alternatively use Combustible Gas Detector. Use a Bacharach Instrument Company Model 0023-7356®, or equivalent, to quantify any vapor leaks occurring during the gasoline bulk drop.
- 5.5 Barometer. Use a mercury, aneroid, or equivalent barometer with minimum specifications described in Section 4.5 to measure the barometric pressure during testing. The result shall be used to correct the volume of vapor returned or discharged.

- 5.6 Temperature Gauges. Use a minimum of three thermometers, Thermocouples™, temperature gauges, or equivalent, to measure the vapor temperature at each meter. The results shall be used to correct the volume of vapor returned or discharged.
- 5.7 Stopwatch. Use a stopwatch accurate to within 0.1 seconds to time the delivery rate.
- 5.8 Franklin Fueling Systems “PV-Zero” pressure vacuum vent valve. A PV-Zero is used to establish baseline standing loss vent volume. See Figures 1A and 1B for a typical PV-Zero installation configurations.

Figure 1A: Typical Installation of PV-Zero on Single Wall AST



**Figure 1B: Typical Installation of PV-Zero on Single Wall AST
(with vapor meter above)**



6 PRE-TEST PROCEDURES

- 6.1 At least 24 hours prior to, but no more than seven days before testing, remove the existing pressure vacuum vent valve and install the PV-Zero. Skip the installation portion of step if the GDF is already equipped with a PV-Zero. After the installation, the PV-Zero shall be tested for leak tightness and cracking pressure in accordance with TP-201.1E CERT. See Figure 1 for a typical PV-Zero installation configuration.
- 6.2 Connect the vent pipe volume meter to the aboveground storage tank vent pipe(s) such that the inlet side of the meter is attached to the outlet side of the PV-Zero pressure vacuum vent valve. The meter can be attached to outlet side of the PV-Zero vent valve using camlock fittings, threaded connections, or equivalent. A temporary manifold may be constructed of steel where multiple vent pipes are connected to a single outlet and a single meter is installed. See Figure 2 or 3 for a typical vent pipe volume meter and PV-Zero installation configuration. See Figure 4 for a typical vent pipe manifold.
- 6.3 The GDF shall be pre-tested for leak integrity as described in TP-206.3 at least 24 hours prior, and no longer than 7-days before testing. If a manifold is to be used at the vent pipe, the manifold shall be installed prior to conducting leak integrity testing.
- 6.4 Record tank capacity, existing fuel level, and ullage volume on the field data sheet. An example field data sheet is provided at the end of this procedure

(see Form 1). A fuel measurement is needed to determine ullage volume for the pre-test leak decay. The ullage volume is calculated by subtracting the total volume of gasoline in the tank from the total tank capacity. If the fuel level cannot be measured without venting the AST (see section 3.6 of this test procedure), then the fuel volume at the time of the leak integrity test must be the volume for the Phase I efficiency test. No product dispensing can occur after this measurement is taken. To minimize disruption of the operation of the GDF, conduct the leak integrity test as close to the minimum 24-hour period prior to the Phase I efficiency as possible.

7 TESTING

7.1 Establish Baseline Standing Loss Vent Volume

- 7.1.1 At least one hour prior to the fuel delivery, measure the ullage pressure of the aboveground storage tank. If the ullage pressure is less than 1.00 inch of water column pressure, enter a zero in the calculation 9.2 for baseline and proceed to section 7.2. If the ullage pressure is equal to or greater than 1.00 inch of water column pressure, establish baseline standing loss vent volume for a one hour time frame. For single wall tanks, establishing a baseline is required unless it is determined unnecessary by the Executive Officer.
- 7.1.2 Standing loss vent volume can be measured through the vent pipe volume meter. Prior to the one hour monitoring period, reset the digital totalizer on the vent pipe volume meter to zero. Record the volume on the display after one hour on the field data sheet.
- 7.1.3 Upon initiation and conclusion of the one hour monitoring period, make note of the start time and end time on the field data sheet, as well as the volume of vapor that was vented. This volume, cubic feet or gallons, is the baseline standing loss vent volume.
- 7.2 Taking caution to avoid venting the storage tanks; connect the vapor return meter(s) to the appropriate Phase I vapor connection(s) using metal fittings in order to maintain intrinsic safety. Use a metal vapor poppet if required to avoid venting. Connect the cargo tank vapor return hose to the outlet side of the meter. The meter will be in line between the Phase I connection and the cargo tank vapor return hose.
- 7.3 Connect the product line from the cargo tank to the aboveground storage tank. Verify that the appropriate fuel transfer coupler is being utilized.
- 7.4 With no product dispensing, record the product grade, tank capacity, and volume of fuel to be delivered on the field data sheet where provided. An example of the field data sheet is provided at the end of this procedure, see "Form 1".

- 7.5 Record the cargo tank CARB decal number and delivery company name on the data sheet where provided.
- 7.6 Stabilization. Open the corresponding cargo tank internal vapor valve(s) prior to delivering product. Once the vapor valve(s) is opened, wait a period of at least 1 minute to allow for pressure stabilization between the AST and cargo tank. If the totalizer on the vent line vent meter has registered flow, wait until the system has stabilized and then clear the totalizer out before continuing on with the test. The totalizer is stable when flow is not detected for a period of five minutes
- 7.7 Record the stabilized, vapor return volume and vent pipe volume meter reading(s) on the field data sheet where provided.
- 7.8 Start the gasoline bulk drop. Using the stopwatch, time each gasoline drop to determine the delivery rate for each compartment.
- 7.9 At minimum, record the following parameters for each gasoline bulk drop:
 - 7.9.1 Initial and final meter readings for each volume meter;
 - 7.9.2 Average vapor pressure at each volume meter;
 - 7.9.3 Average vapor temperature at each volume meter.
- 7.10 Repeat Sections 7.1 through 7.3 for each gasoline delivery/compartment of the cargo tank delivered.
- 7.11 Continue to monitor the vent pipe meter for a minimum of 15 minutes.
 - 7.11.1 If the aboveground storage tank ullage pressure is less than 1.00 inch water column, testing shall be concluded. When calculating the results per Equation 9.2, the baseline standing loss vent volume equals zero.
 - 7.11.2 If the aboveground tank storage pressure is 1.00 inches water column or greater, continue to monitor the vent pipe volume meter for an additional 45 minutes (1-hour total). These measurements are to be included in the Phase I efficiency calculation as part of the total volume vented.

8 POST TEST PROCEDURES

- 8.1 At conclusion of the bulk delivery, ensure that each of the cargo tank internal vapor valves is closed prior to removing connections.
- 8.2 Disconnect the vapor return hose from the outlet side of the vapor return meter.
- 8.3 Disconnect the vapor return meter(s) from the storage tank(s) taking care to avoid venting pressure.
- 8.4 Verify the quantity of gasoline delivered to each aboveground storage tank using the facility tank gauge monitor or with a manual tank gauging stick.

- 8.5 The static pressure integrity of the vapor recovery system as determined by TP-206.3 shall be verified no less than three hours after, but not more than 48 hours after completion of the delivery. Failure of the static pressure integrity test shall invalidate the results from this test procedure.
- 8.6 Remove the temporary manifold (if constructed) and disconnect the vent volume meter from the outlet of the PV-Zero.
- 8.7 If the PV-Zero is not the original pressure vacuum vent valve being utilized on the tank, then, remove the PV-Zero and re-install the original pressure vacuum vent valve.

9 CALCULATING RESULTS

9.1 Baseline Standing Loss Vent Volume

The total baseline standing loss vent volume is the volume vented over a one hour time frame directly prior to the fuel delivery. The value obtained from the roots meter will be in cubic feet. To convert this volume to gallons, multiply by the conversion factor of 7.481 gallons/cubic feet.

- 9.2 The measured volume of vapor passed through the vapor return to the cargo tank and vent pipe shall be corrected to standard conditions as follows:

$$V_{\text{corr}} = \frac{(V_{\text{vi}})(528)[P_b + \Delta h/13.6]}{(T_{\text{vi}})(29.92)} \quad \text{Equation 9.1}$$

Where:

V_{corr}	=	Volume of vapor, corrected to 68°F (528°R) and 29.92" Hg, cubic feet
P_b	=	Barometric Pressure, inches Hg
V_{vi}	=	Uncorrected volume of vapor (raw meter reading), cubic feet
T_{vi}	=	Average temperature at vent meter, °R
Δh	=	Average pressure at vent meter, inches WC
13.6	=	Conversion from inches WC to inches Hg
528	=	Standard ambient temperature, 68°F, converted to degrees Rankine
29.92	=	Atmospheric pressure, inches Hg

9.3 The collection efficiency shall be calculated as follows:

$$E = (100) \left[\frac{V_{\text{returned}} - (V_{\text{vent}} - V_{\text{baseline vent}})}{V_{\text{returned}}} \right] \quad \text{Equation 9.2}$$

Where:

E = Phase I Volumetric Efficiency, percent

V_{returned} = Vapor Return: from Equation 9.1 (V_{corr})

V_{vent} = Corrected Vent Pipe Discharge: from Equation 9.1 (V_{corr})

$V_{\text{baseline vent}}$ = Baseline Standing Loss Vent Volume: from Section 9.1

If $V_{\text{vent}} - V_{\text{baseline vent}} < 0$, then $V_{\text{vent}} - V_{\text{baseline vent}} = 0$

10 REPORTING RESULTS

Results shall be reported as shown on the data sheets where provided. The Executive Officer may allow use of alternate field data sheets provided they include, at minimum, the same parameters identified on Form 1.

11 ALTERNATE PROCEDURES

This procedure shall be conducted as specified. Modifications to this test procedure shall not be used to determine compliance unless prior written approval has been obtained from the ARB Executive Officer, pursuant to Section 15 of Certification Procedure CP-206.

Figure 2

Vent Pipe Volume and Vapor Return Volume Meter Arrangement for Direct Fill Phase I EVR Systems for AST

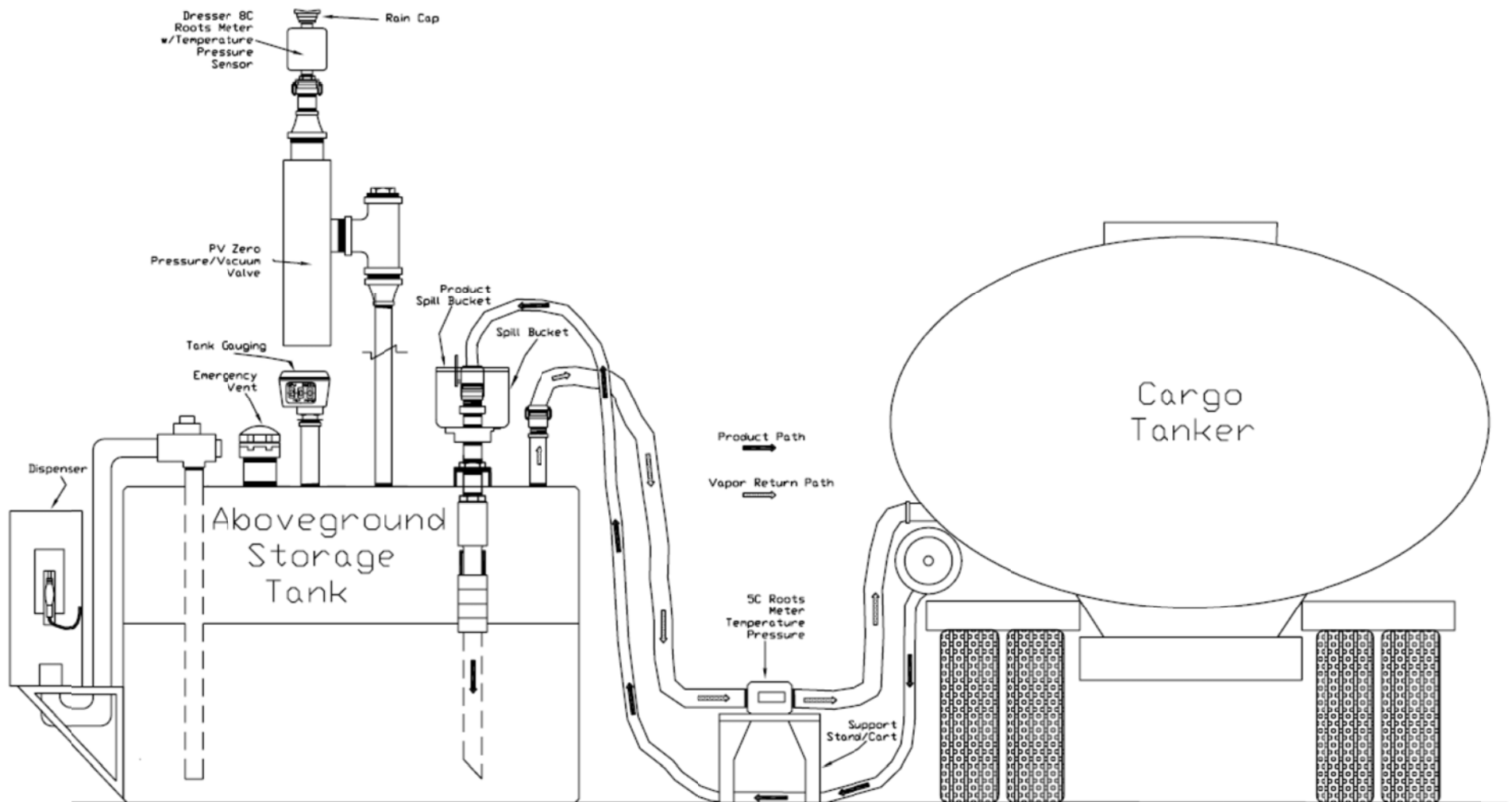
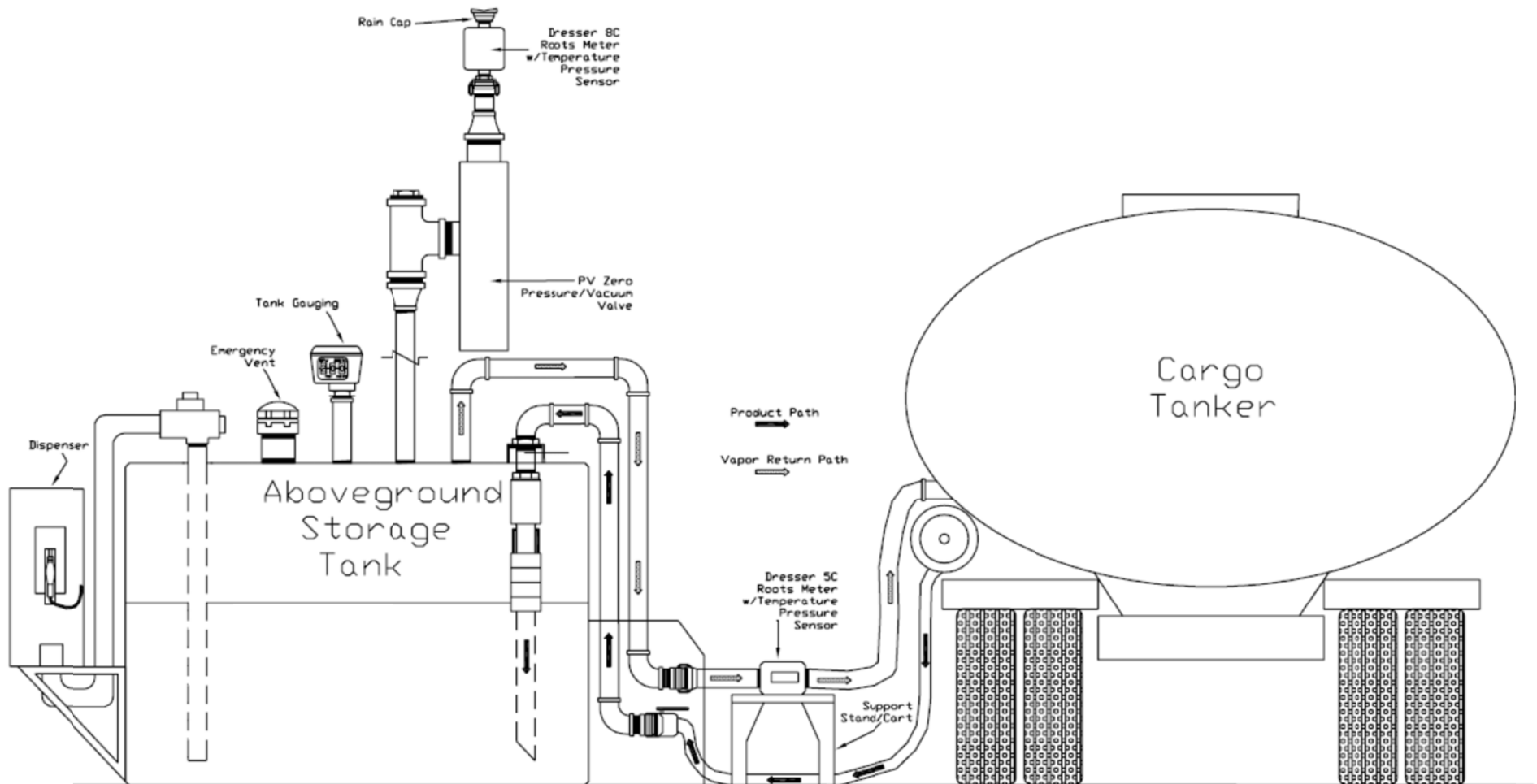
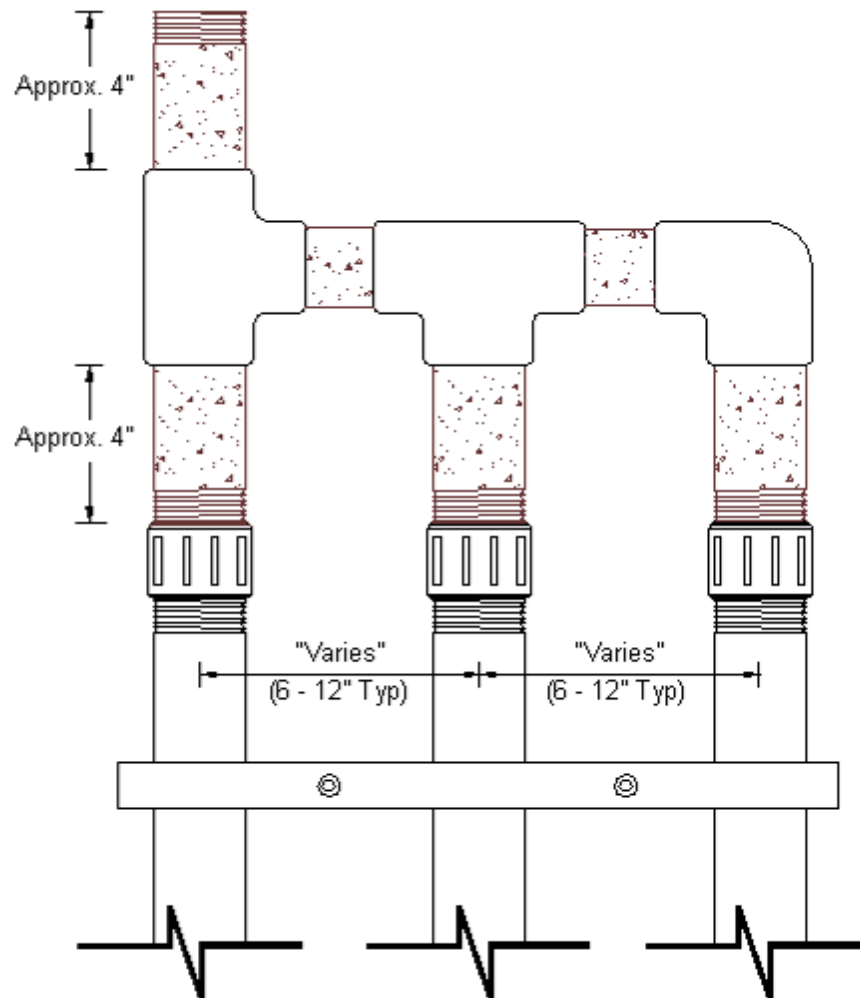


Figure 3

Vent Pipe Volume Meter and Vapor Return Volume Meter Arrangement for Remote Fill Phase I EVR Systems for AST



Example of a Steel Vent Pipe Manifold



Form 1: TP-206.4-AST Example Field Data Sheet

DATE:	ARB STAFF:
--------------	-------------------

FACILITY GDF:	
Name:	Location:

CARGO TANK:		
Company:	Truck #:	Trailer #:

AMBIENT CONDITIONS:		
Temperature (°F):	Barometric ("Hg):	Wind:
Other:		

SYSTEM DESCRIPTION:		
Tank Make/Model:	Tank Capacity (gallons):	Fuel Volume (gallons):
Ullage Volume (gallons):	Stick Reading (inches):	
Phase I System Description:		

PRE-BASELINE CHECKLIST:	
Leak Integrity Test:	PV Zero Installed:
Vent Pipe Volume Meter Installed:	

ESTABLISH 1-HOUR STANDING LOSS VENT VOLUME BASELINE:	
Time Start:	Time Finish:
Initial Flow Meter Reading (ft ³):	Final Flow Meter Reading (ft ³):
Notes:	

PRE-DELIVERY OBSERVATIONS:		
AST Fuel Temp (°F):	Amount to Deliver (gallons):	Fuel Grade:
Initial Vent Pipe Volume Meter Reading (ft ³):	Initial Vapor Meter Reading (ft ³):	
AST Pressure ("WC):		
Notes:		

DELIVERY OBSERVATIONS:

Time Start:	Time Stop:
Average Temp @ Vent Line Meter (°F):	Average Temp @ Vapor Meter (°F):
Average Pressure @ Vent Line Meter ("WC):	Average Pressure @ Vapor Meter ("WC):
Fuel Delivered (gallons):	AST Pressure at End of Delivery ("WC):
Final Vapor Meter Reading (ft³):	Vent Line Meter Reading (ft³):
Notes:	

15-MINUTE POST DELIVERY OBSERVATION:

AST Pressure ("WC):	Vent Line Meter Reading (ft ³):
---------------------	---

60- MINUTE POST DELIVERY OBSERVATION: (IF AST PRESSURE IS > 1.0 "WC)

AST Pressure ("WC):	Vent Line Meter Reading (ft ³):
---------------------	---

CALCULATIONS:

Baseline Standing Loss Vent Volume:
Total Vented During Delivery and Waiting Period:
Collection Efficiency: