CALIFORNIA AIR RESOURCES BOARD

Monitoring and Laboratory Division
Vapor Recovery and Fuel Transfer Branch

Project Number: VR-19-15

Technical Support Document:
Determination of Pressure-Up Time for Phase I Drop Tubes at Gasoline Dispensing Facilities Equipped with Remote Fill Configurations

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EXECUTIVE SUMMARY

South Coast Air Quality Management District (SCAQMD) staff requested California Air Resources Board (CARB) staff investigate a gasoline dispensing facility (GDF) that failed to meet the maximum pressure-up time[1] as prescribed in section 7.9 of CARB Test Procedure TP-201.1D, Leak Rate of Drop Tube Overfill Prevention Device and Spill Container Drain Valves at Gasoline Dispenser Facilities. The GDF in question was equipped with a “remote fill” Phase I drop tube configuration. Remote fill is defined as the transfer of gasoline from a cargo tank to a gasoline storage tank where the Phase I product and/or vapor return pathways (including product and/or vapor adaptors) are offset some horizontal distance from the vertical product and vapor risers installed on the tank openings. As currently written, TP-201.1D is applicable to GDF equipped with Phase I drop tubes that are directly above, or close to (within 50 horizontal feet or less), the vertical product risers of the underground storage tank.

In the past, the remote fill configuration has been utilized at a small number (~20 statewide) of low throughput GDF typically located in in densely populated regions of California where space is limited for cargo tank access. For these low throughput GDF, the remote fill piping run was typically offset less than 50 feet away from the vertical risers of the storage tank. As such, the currently written test procedure yielded passing results. However, in this case with SCAQMD, a high volume retail facility installed a remote fill configuration with longer piping runs (~120 feet) which resulted in a false failure of the test procedure. For high volume facilities, the remote fill configuration is desirable because it allows cargo tankers to drop fuel into the storage tanks from an alternate location without disrupting customer vehicle dispensing operations.

To address to the failure of the pressure-up time at this specific GDF and to ensure TP-201.1D is more broadly applicable to other GDF using remote fill configurations, CARB staff developed an equation to calculate the maximum pressure-up time for any remote configuration as a function of known pressure, remote fill product pipe diameter (in inches) and pipe length (in feet).

The maximum pressure-up time determined, shown in Table 1, includes a safety factor based on the following two criteria: (1) add 50% of the calculated pressure-up time, and (2) round up to the nearest multiple of five. This table was developed based on multiple field and laboratory tests completed by CARB staff to verify that the calculated results were within the maximum pressure-up times.

The field and laboratory test results confirmed that the maximum pressure-up time in Table 1 provides sufficient time to pressurize longer piping distances, while yielding practical assessment of whether the system has leaks. Therefore, CARB staff recommends that TP-201.1D be amended to accommodate remote fill configurations where the pressure-up time is based on the time frames listed in Table 1.

[1] The maximum pressure-up time, noted in TP-201.1D is five minutes.

TABLE 1: Maximum Time to Pressure-Up GDF Equipped with Remote Fill Drop Tube Configurations

Horizontal Remote Fill Pipe Length (feet)	**Max Pressure-Up Time*** (minutes)
≤ 50	5
>50 but ≤ 100	10
>100 but ≤ 150	15
>150 but ≤ 200	20
>200 but ≤ 250	25

* Max Pressure-Up time is based on a pressure of 2 inches water column, 4 inch diameter pipe and a flow rate of 200 cc/min

I. BACKGROUND

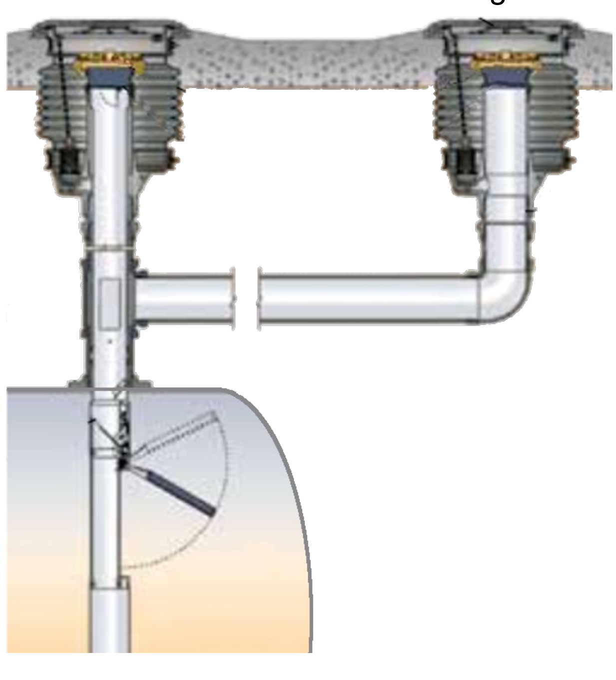
In 2018, CARB staff received a request from the SCAQMD to investigate a gasoline dispensing facility (GDF) that failed to meet the pressure-up time limit per section 7.9 of CARB Test Procedure TP-201.1D; Leak Rate of Drop Tube Overfill Prevention Device and Spill Container Drain Valves at Gasoline Dispensing Facilities (TP 201.1D).

According to annual compliance test result records, the vapor recovery (VR) service technician was not able to pressurize the Phase I drop tube to the 2.0 inches of water column within five minutes as prescribed in TP 201.1D. Rather than five minutes, it took approximately 20 minutes at 0.17 cubic feet per hour (CFH) (0.17 CFH is equivalent to 80 cc/min) flow rate to reach 2.0 inches water column. Once pressurized, the drop tube assembly subsequently met the leak rate performance threshold of ≤ 0.17 CFH at +2.0 inches water column as specified in CARB Certification Procedure for Vapor Recovery Systems at Gasoline Dispensing Facilities (CP-201).

Upon investigation, it was determined that the GDF was equipped with a Phase I “remote fill” configuration (see Figure 1) with secondary product and vapor return pathways and adaptors located in an alternate sump approximately 120 feet away from the primary product and vapor risers installed directly on top of the underground storage tanks (UST).

As depicted in Figure 1, remote fill configurations allow the transfer of gasoline from a cargo tank to the underground storage tank where the Phase I product and/or vapor return pathways are offset some horizontal distance from the vertical product and vapor risers installed on the tank openings. Remote fill configurations are desirable when the vertical tank risers are not easily accessible due to space or traffic limitations.

FIGURE 1: Typical Remote-Fill Access Point Configuration (Product Only)



II. OBJECTIVE

The objective of this evaluation is to determine and validate the appropriate pressure-up time for GDFs equipped with remote fill configurations, including various lengths of product piping runs. In addition, this document seeks to provide supporting information for the amendment of CARB Test Procedure TP-201.1D to account for the additional time needed to pressurize the additional pipe volume. This document describes the methodology utilized by CARB staff, results of testing conducted by CARB staff, and concludes with a recommendation for amendment of the test procedure.

III. METHODOLOGY

A. Development of Pressure-Up Time Equation

As previously described, GDF's with remote fill configuration's may have various lengths of product piping to accommodate site specific needs. As currently written, TP-201.D requires a pressure-up time of the drop tube assembly to be less than five minutes. However, for piping lengths greater than 50 feet, the amount of time to pressurize the product piping and drop tube assembly, would take longer than the prescribed time, resulting in a potential false failure of the test procedure.

In response to this issue, CARB staff developed a practical equation (see Equation 1) to determine how much additional time is needed to pressurize a product pipe run from zero pressure gauge to 2.0 inches water column gauge.

Equation 1 is derived from the theoretical equation, Boyle's Law ($\Delta P_1 \Delta V_1 = \Delta P_2 \Delta V_2$), with a couple of practical assumptions; (1) the local temperature is constant, (2) there are no leaks in the drop tube system. Applying the volume (ΔV_1) of a cylinder, pressure of one atmosphere (atm) (ΔP_1), and known change of pressure of 2.0 inches water column (ΔP_2) to Boyle's law, will equate the volume of nitrogen (ΔV_2) needed to fill the drop tube assembly including remote fill piping. Apply the volume of nitrogen to the flow rate equation, using flow rate of 0.42 CFH (200 cubic centimeter per min (cc/min)), to develop the equation for the time needed to pressurize the drop tube of a certain length (L). Figure 2 provides full details on how Equation 1 was derived.

$$t = 0.0613 \ x \ L, \qquad \textbf{[Equation 1]}$$

where

L (feet) is the length of the drop tube.

t (minutes) is the time to achieve 2 inches water column of pressure

FIGURE 2: Derivation of Equation 1 - Time Needed to Pressurize Drop Tube Volume at a flowrate of 0.424 CFH (200 cc/min), and Drop Tube Diameter of 4 Inches

Volume of 4 inch Drop Tube of Length (cubic feet) **(STEP 1)**

$$V = \pi r^2 \times L = \pi \left(\frac{D}{2}\right)^2 \times L, \text{ where } D = 4\ in$$

$$= \pi \left(\frac{4\ in \times \frac{1\ ft}{12\ in}}{2} \right)^2 \times L$$

$$= .0873\ \times L\ (ft^3)$$

Volume of Nitrogen Needed to Pressurize Drop Tube to 2.0 inWC **(STEP 2)**

Boyles Law: $\Delta P_1 \Delta V_1 = \Delta P_2 \Delta V_2$,

$$\Delta V_2 = \left(\frac{\Delta P_2}{\Delta P_1}\right) \Delta V_1,$$

$$= \left(\frac{2\ inWC}{1\ atm} * \frac{1\ atm}{407.2\ inWC}\right) (.0873\ x\ L)$$

$$= (4.288 \times 10^{-4}) \times L\ \ (ft^3)$$

Time Needed to Pressurize Drop Tube Volume at a Flow Rate of 0.42 CFH

$$t = \frac{\Delta V_2}{Flow\ Rate}$$

$$= \frac{(4.288 \times 10^{-4}) \times L\ (ft^3)}{0.42\ \frac{ft^3}{hr}} \times 60 \frac{min}{hr}$$

$$= 0.0613 \times L\ \ (min)$$

B. Verification of Time to Pressure-Up Equation

CARB staff conducted field and laboratory tests to verify and validate the accuracy of Equation 1 by documenting the amount of time needed to pressurize a drop tube system to 2.0 inches water column.

The field test and laboratory test results were then compared to the calculated pressure-up times (determined by Equation 1) for the respective pipe lengths.

C. Test Site and Description of Baseline Vapor Recovery Performance Tests

With the assistance of SCAQMD staff, CARB staff selected a GDF located in Temecula, California as an ideal test site. This site previously failed to pressurize and meet the 2.0 inches water column pressure-up time within the allotted 5-minute time limit as specified in section 7.9 of TP-201.1D. The GDF has remote fill piping run distances of approximately 120 feet for 91 grade underground storage tanks and 94 feet for 87 grade underground storage tank respectively. Four other potential test sites were evaluated in the SCAQMD region, but were not selected because their remote fill piping run lengths were not as long as the Temecula GDF.

On January 22 and 23 of 2019, CARB staff observed VR service technicians conduct various Phase I and Phase II vapor recovery system performance testing in order to establish baseline operating conditions of the facility. The VR performance tests, listed in table 2, were completed to verify that the existing vapor recovery system was operating in accordance with regulatory performance standards and specifications. Table 2 provides a description and qualitative results of the baseline testing.

CARB staff involved in the baseline testing included: Ken Lewis (KL) and Oscar Lopez (OL). The VR service technicians (VRST) were also involved in testing.

TABLE 2: Phase I and Phase II Baseline Testing

Date	Tests Conducted	Test Result	Tester
01/22/19	**TP-201.3** Determination of Pressure Integrity (Leak Decay)	Pass	VRST
	TP-201.1B Static Torque of Phase I Rotatable Adaptors	Pass	VRST
	TP-201.1E Leak Rate and Cracking Pressure of P/V Vent Valves	Pass	VRST
	TP-201.1D Leak Rate of Drop Tube Overfill Prevention Devices and Spill Container Drain Valves	Pass	VRST
	VR-201/202 Exhibit 4 Clean Air Separator Integrity	Pass	VRST
	VR-201/202 Exhibit 5 Vapor to Liquid Ratio	Pass	VRST
	VR-202 Exhibit 9 ISD Operability Test	Pass	VRST
01/23/19	**TP-201.1** Volumetric Efficiency for Phase I Vapor Recovery Systems	Pass	KL, OL
	TP-201.1E Leak Rate and Cracking Pressure of P/V Vent Valves	Pass	VRST
	TP-201.3 Determination of Pressure Integrity (Leak Decay)	Pass	KL, OL

IV. RESULTS

Three separate tests were conducted to validate the accuracy and repeatability of the pressure-up time equation shown in Equation 1. The following paragraphs describe the results of each test.

Issue Encountered:

CARB staff was not able to obtain the accurate length of the pipe run for the 87 product grade. CARB staff had requested from the GDF owner and the service contractor the true lengths of the pipe run, but they did not have any record of the pipe length. As previously stated, the pressure-up time is a function of the pipe length, CARB staff decided not to incorporate the results in Table 3 and 4 for 87 product grade.

A. Trial Number One: Field Test Temecula, CA

The first test was conducted at the remote fill GDF located in Temecula, CA on January 23, 2019. CARB staff observed a VR service technician conduct TP-201.D, and the results were recorded by CARB staff. As shown in Table 3, the actual pressure-up time was well within 10% of the calculated pressure-up time.

TABLE 3: Results of Field Testing Conducted by VR Service Technician and Witnessed by CARB Staff on 01/23/2019

Product Grade	**Flow Rate** (cc/min)	**Length** (ft)	**Pressure-up Time**		**Percent Difference**[2]
			Field Test Result (min)	**Equation 1 Result** (min)	
91	200	~120	7.40	7.35	0.6%

B. Trial Number Two: Field Test Temecula, CA

CARB staff conducted the second field test on December 11, 2019 by using CARB equipment at the same remote fill GDF located in Temecula, CA. As indicated in Table 4, the actual pressure-up time was well within 10% of the calculated pressure-up time. To ensure repeatability, CARB staff conducted the test a total of six times. Three tests were conducted on the 91 grade underground storage tank.

TABLE 4: Results of Field Testing Conducted By CARB Staff on 12/11/2019

Product Grade	**Flow Rate** (cc/min)	**Length** (ft)	**Pressure-up Time**		**Percent Difference**[3]
			Field Test Result (min)	**Equation 1 Result** (min)	
91	200	~120	7.47	7.45	1.5%
91	200	~120	7.42	7.45	0.9%
91	200	~120	6.98	7.45	5.3%

[2] See footnote number three below.

[3] The methodology and exact values used to calculate percent difference are contained in the appendices that accompany this report. For example, additional significant figures are used for the "pressure-up time equation" value and "the field test result" is used as the divisor when calculating percent difference.

C. Trial Number Three: Laboratory Testing Sacramento, CA

CARB staff conducted the final test at CARB's laboratory facility located in Sacramento on January 27, 2020. This test was conducted using a 20 foot in length, 4-inch diameter pipe (cargo tank hose) to simulate field conditions and validate the calculations in Equation 1 at various flow rates. The results of this test are provided in Table 5 below. A total of nine tests were conducted at various flow rates. The calculated pressure-up time was within 10 percent of the actual pressure-up time.

TABLE 5: Lab Test Conducted by CARB Staff on 01/27/2020

Run Number	**Flow Rate** (cc/min)	**Length** (ft)	**Pressure-up Time**		**Percent Difference**[4]
			Lab Test Result (min)	**Equation 1 Result** (min)	
1	200	20	1.22	1.21	0.3%
2	200	20	1.20	1.21	1.1%
3	200	20	1.22	1.21	0.3%
1	150	20	1.65	1.62	1.9%
2	150	20	1.63	1.62	0.9%
3	150	20	1.65	1.62	1.9%
1	100	20	2.53	2.43	4.2%
2	100	20	2.50	2.43	2.9%
3	100	20	2.52	2.43	3.6%

In summary, the results from field and laboratory tests validated and confirmed the calculated time using the pressure-up time equation (Equation 1) are within 10% percent difference.

[4] The methodology and exact values used to calculate percent difference are contained in the appendices that accompany this report. For example, additional significant figures are used for the "pressure-up time equation" value and the "lab test result" is used as the divisor when calculating percent difference.

V. DISCUSSION

Upon analysis of the results of the three trials, it is evident that additional time is needed to conduct TP-201.1D on GDFs equipped with various length remote fill configurations. CARB staff acknowledges that the pressure-up time equation is suitable when testing is conducted in a controlled environment with constant temperature and no leaks in the system. The results provided in Tables 3 through 5 indicate that the maximum percent difference between the observed time and the calculated time is less than 10 percent. The test results indicate that field variables (ie. ambient temperature, RVP of gasoline, solar heat at remote fill access point) are taken into account by assuming that the calculated pressure-up time can be increased by 50 percent and then rounding the results to nearest multiple of five. Table 6 shows the pressure-up time as a function of remote fill length then the assumptions are taken into account

TABLE 6: Maximum Pressure-Up Time for GDF Equipped with Remote Fill Drop Tube Configurations

Horizontal Remote Fill Pipe Length (feet)	**Max Pressure-Up Time*** (minutes)
≤ 50	5
>50 but ≤ 100	10
>100 but ≤ 150	15
>150 but ≤ 200	20
>200 but ≤ 250	25

* Max Pressure-Up time is based on a pressure of 2 inches water column, 4 inch diameter pipe and a flow rate of 200 cc/min

VI. CONCLUSION

CARB staff recommends that the test procedure be amended to account for GDF's equipped with remote fill configurations and that the pressure-up time be based on the time frames listed in Table 6.

VII. APPENDICES

Appendix I: Field Data Forms and Pressure-Up Calculation for Drop Tube Testing Conducted by VR Service Technician on 01/23/19

Appendix II: Field Data Forms and Pressure-Up Calculation for Drop Tube Testing Conducted by CARB Staff on 12/11/2019

Appendix III: Laboratory Data Forms and Pressure-Up Calculation for Bench Testing Conducted by CARB Staff on 01/27/2020

Appendix IV: Documentation Pertaining to Length of Remote Fill Piping Runs at Temecula Test Site

Note: Due to large file size, the above appendices are available upon request via email to vapor@arb.ca.gov.