TP-933

Test Procedure for Determining Evaporative Emissions from Off-Highway Recreational Vehicles

Adopted: June 6, 2014

California Air Resources Board

Monitoring and Laboratory Division

Note: This is a newly adopted test procedure shown without underline as permitted by California Code of Regulations.

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TP-933

Test Procedure for Determining Evaporative Emissions from Off-Highway Recreational Vehicles (OHRVs)

1 APPLICABILITY

Test Procedure 933 (TP-933) is used by the Air Resources Board (ARB) to determine OHRV evaporative emissions. This test procedure is proposed pursuant to Section 43824 of the California Health and Safety Code (CH&SC).

1.1 Terms and Definitions

In addition to the following definitions, the definitions set forth in the incorporated "California Evaporative Emission Standards and Test Procedures for 2001 and Subsequent Model Motor Vehicles" as last amended December 6, 2012, and title 13, California Code of Regulations (CCR), section 2417, apply:

1.1.1 For the purpose of this procedure, when the term "Administrator" is used in any federal regulations referenced within this document, it shall mean the ARB Executive Officer or his or her authorized representative or designate.

1.1.2 For the purpose of this procedure, the term "ARB" refers to the California Air Resources Board.

1.1.3 For the purpose of this procedure, the term “Deterioration factor” means the ratio of emissions after and before durability testing or the value of any positive increase in emissions from before or after durability testing.

1.1.4 For the purpose of this procedure, the term "Executive Officer" refers to the ARB Executive Officer or his or her authorized representative or designate.

1.1.5 For the purpose of this procedure, the term "horizontal plane" shall mean:

1.1.5.1 For vehicles with two wheels, the plane which contains the line defined by the points where the vehicle’s front and rear tires are in contact with the testing surface when positioned in normal upright riding position on the level testing surface and which is parallel to the axis of the wheel axles.

1.1.5.2 For vehicles with three or more wheels, the plane defined by the points where the vehicle’s tires contact the testing surface while the vehicle is positioned in normal upright riding position on the level testing surface with the tires inflated to normal manufacturer recommendations.

1.1.6 For the purpose of this procedure, when the term "methanol" is used in any federal regulations referenced within this document, it shall mean methanol and/or ethanol, except as otherwise indicated in this test procedure.

1.1.7 For the purpose of this procedure, the term "travel axis" shall mean the axis defined by the direction the vehicle travels while in normal use and located in the horizontal plane that the vehicle sits.

1.1.8 For the purpose of this procedure, the term "upright axis" shall mean a line passing through the travel axis which is perpendicular to the horizontal plane. Under normal use conditions, this is the same as the vertical axis.

1.2 Test Data Availability

The manufacturer shall provide the specific information that supports its assurance of the system's performance with the requirements within this procedure within 30 days of a written request by the Executive Officer.

1.3 Safety

This test procedure involves the use of flammable materials and should only be used by, or under the supervision of, those familiar and experienced in the use of such operations and materials. Appropriate safety precautions should be observed at all times while performing this test procedure.

1.4 Test Fuel Specification

The test fuel used for all parts of this procedure, unless otherwise specified, shall be California certification gasoline as specified in "California 2015 and Subsequent Model Criteria Pollutant Exhaust Emission Standards and Test Procedures and 2017 and Subsequent Model Greenhouse Gas Exhaust Emission Standards and Test Procedures for Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" Section II.A.100.3.1.2, adopted March 22, 2012, as last amended December 6, 2012, is incorporated by reference herein.

1.5 Alternative Test Procedures

With prior approval alternative test procedures can be used. It must be demonstrated that the alternative method is equivalent to or more stringent than the method set forth in this test procedure.

2 PRINCIPLE AND SUMMARY OF TEST PROCEDURES

This test procedure measures evaporative emissions from a complete vehicle or piece of equipment with complete evaporative emission control systems as defined in 13 CCR 2752 (a)(8) by subjecting them to durability tests, preconditioning, and a diurnal evaporative test as described in Section 6 of this procedure. The engine with a complete evaporative emission control system must be tested as a complete vehicle except where a test rig is explicitly allowed. Where not otherwise specified, the vehicle shall be in an approximately level position during all phases of the test sequence.

Prior to evaporative emissions testing, the vehicle's evaporative emissions control system must undergo durability testing to ensure that the emissions control devices continue to function as designed for the useful life of the vehicle. Real world end of useful life emissions are simulated during vehicle preconditioning.

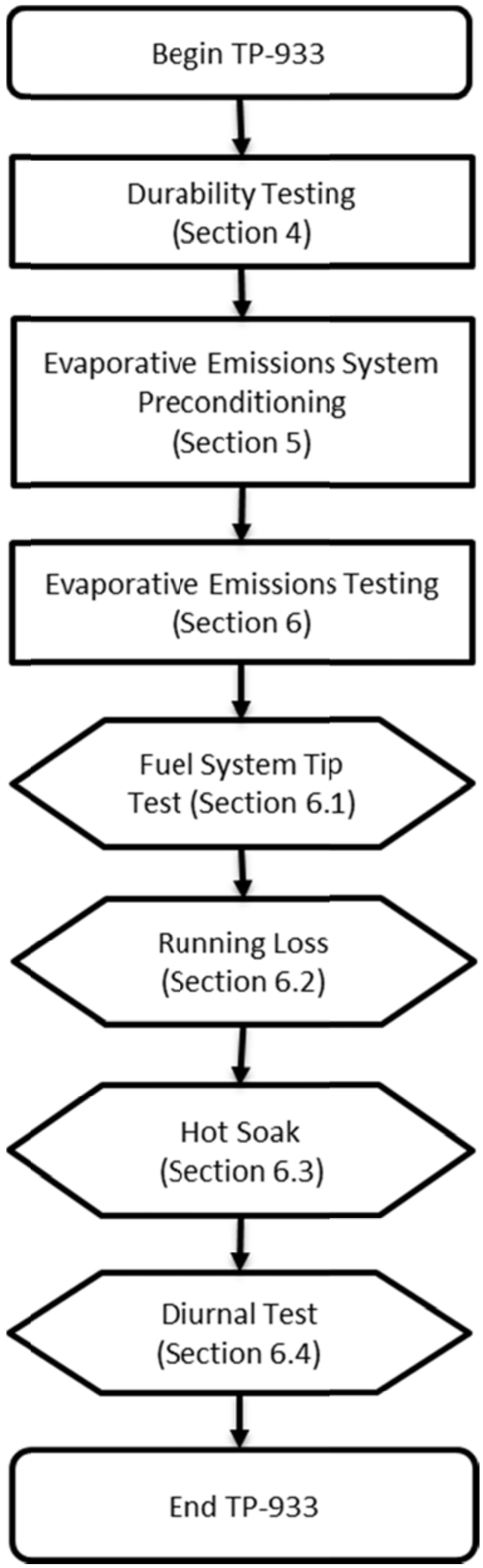
Evaporative emissions are quantified by direct measurement or by a combination of direct measurement and calculation. Evaporative emissions are directly measured with a hydrocarbon analyzer in a sealed testing enclosure following a defined temperature profile and maintaining atmospheric pressure. The volume of the enclosure must be accurately determined whenever hydrocarbons are being measured. The total mass of hydrocarbons emitted from a test vehicle over the test period is calculated based on measured concentration, known molecular weight, and volume of the testing enclosure.

The vehicle shall demonstrate adequate control of diurnal emissions through one of the following test sequences:

Vehicle may undergo a 72-hour diurnal evaporative emissions test with variable temperature as defined in Section 6.4.1.

Alternatively, a steady state diurnal test may be used to show compliance. The vehicle's evaporative emissions control system is demonstrated to be adequately designed and constructed by performing a 24-hour diurnal test in conjunction with the vented emissions requirements as described in Section 6.4.2. The steady state diurnal test must be conducted with the testing enclosure maintained at a constant temperature of 86°±3°F, with a vent connecting the evaporative vent of the vehicle to the atmosphere outside the testing enclosure. The purpose of the steady state diurnal test is to evaluate fuel permeation and verify the construction of the evaporative emissions control system. Compliance is shown with the vented emissions requirement using the Calculation Method as described in Appendix A or by using a pressure relief valve that opens at 2 pounds per square inch (psi) or greater, or which does not release vapor from the tank during the second of two consecutive 24-hour diurnal temperature cycles from 72° to 96°F. A flowchart summarizing the procedure is shown in Figure 1.

Figure 1: TP-933 Summary Flowchart



3 INSTRUMENTATION

Equipment used during this testing shall, at a minimum, meet the requirements set forth in this section. This document incorporates by reference Title 40, Code of Federal Regulations (CFR), Part 86 – CONTROL OF EMISSIONS FROM NEW AND IN-USE HIGHWAY VEHICLES AND ENGINES, Subpart 107-96, 108-79, 108-00, and 508-78 (2012).

3.1 Vehicle Test Enclosure

This test procedure incorporates by reference "CALIFORNIA EVAPORATIVE EMISSION STANDARDS AND TEST PROCEDURES FOR 2001 AND SUBSEQUENT MODEL MOTOR VEHICLES" as last amended December 6, 2012, Parts III.A and III.B, for evaporative emission measurement enclosure requirements and calibrations with the following exceptions:

3.1.1 The fuel tank temperature is not controlled in this procedure for the diurnal evaporative tests and the tip tests. Fuel tank temperature is only controlled for the pressure relief option in Section 6.4.2. Therefore, disregard all sections pertaining to fuel tank temperature monitoring and fuel tank temperature management systems except as required.

3.1.1.1 If showing compliance with a pressurized fuel tank, revise subparagraph 40 CFR §86.107-96(e), (Temperature Recording System) to read: In addition to the specifications in this section, the vapor temperature in the fuel tank must be measured. When the fuel or vapor temperature sensors cannot be located in the fuel tank to measure the temperature of the prescribed test fuel or vapor at the approximate mid-volume (e.g. saddle tank), sensors shall be located at the approximate mid-volume of each fuel or vapor containing cavity. The average of the readings from these sensors shall constitute the fuel or vapor temperature. The Executive Officer may approve alternate sensor locations where the specifications above cannot be met or where tank symmetry provides redundant measurements.

3.2 Dynamometer

3.2.1 The chassis dynamometer shall meet the requirements of 40 CFR §86.508-78, 40 CFR §86.108-00, or 40 CFR §86.108-79 (2012) as long as it is capable of accurately simulating the test weight of the vehicle.

3.2.2 The chassis dynamometer shall be calibrated according to the requirements used in 3.2.1 above. The calibration shall be conducted at a temperature of 86°F ±3°F.

3.3 Fuel Vapor and Alcohol Hydrocarbon Analyzer

The fuel vapor and alcohol hydrocarbon analyzer shall meet the requirements specified in 40 CFR §86.107-96(b). As described in Section 7, ethanol measurements may be omitted if the calculated mass of hydrocarbon emissions is multiplied by an adjustment factor that accounts for alcohol vapor.

3.4 Test Data Recording System

An on-line computer system or strip-chart recorder shall be used to record the following parameters during the test sequence:

a) Cell/enclosure ambient temperature
b) If applicable, temperatures of vehicle fuel tank liquid (T_{liq}) and vapor space (T_{vap})
c) If applicable, vehicle fuel tank headspace pressure
d) If applicable, dynamometer roll speed
e) Flame Ionization Detector (FID) output voltage recording the following parameters for each sample analysis:
    1) zero gas and span gas adjustments
    2) zero gas reading
    3) If applicable, dilute sample bag reading
    4) If applicable, dilution air sample bag reading
    5) zero gas and span gas readings
f) Ethanol sampling data including the:
    1) volumes of deionized water introduced into each impinger
    2) rate and time of sample collection
    3) volumes of each sample introduced into the gas chromatograph
    4) flow rate of carrier gas through the column
    5) column temperature
    6) chromatogram of the analyzed sample

3.5 Carbon Canister Bench Aging Equipment

Carbon canister bench aging equipment shall meet the requirements specified in Section 4.1 of this procedure.

3.6 Carbon Canister Test Bench

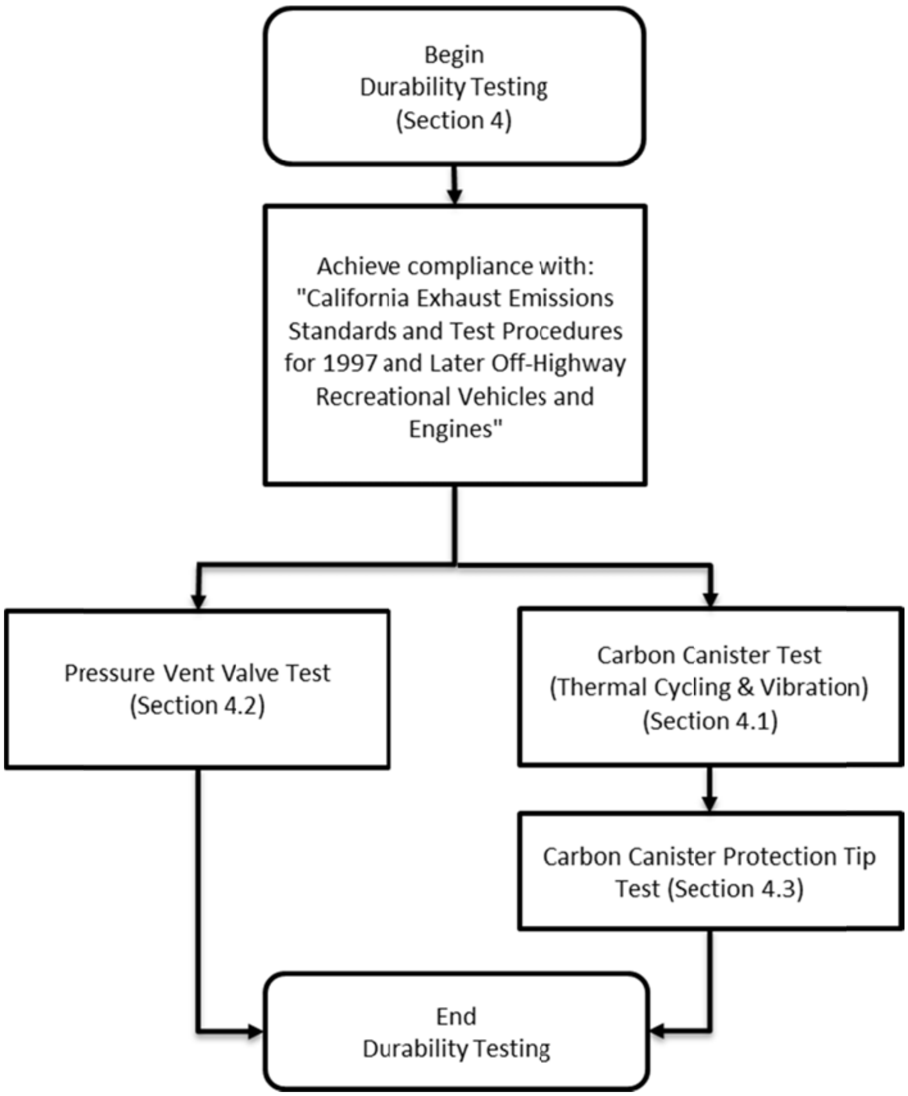
The carbon canister test bench or associated combination of testing equipment shall meet the requirements specified in Section 5.2 of this procedure.

4 DURABILITY TESTING

Certification of an OHRV evaporative emission control system requires a manufacturer to first demonstrate the durability of each evaporative emission control system family. This is required prior to performing the evaporative emissions test described in Section 6 to ensure the vehicle will meet evaporative emissions standards over the useful life of the vehicle. The evaporative emission control system must satisfy durability requirements as prescribed in “TP-901 – Test Procedure for Determining Permeation Emissions from Small Off-Road Engines and Equipment Fuel Tanks,” as adopted July 26, 2004, and incorporated by reference herein. This must be done before proceeding to the durability testing section of this procedure, unless each evaporative emissions-related part has undergone durability testing for exhaust in another model of the same vehicle as specified in *California Exhaust Emissions Standards And Test Procedures For 1997 And Later Off-Highway Recreational Vehicles And Engines*, California Environmental Protection Agency, Air Resources Board, El Monte, CA, October 25, 2012 which is incorporated by reference herein.

In addition, OHRV manufacturers must comply with the durability requirements in Sections 4.1 through 4.3 of this test procedure or get approval for ARB for an alternative durability procedure. Carry-over and carry-across of deterioration factors may be allowed for systems using components that have successfully completed durability testing. Applicants shall be allowed to proceed to Section 5 of this test procedure if they remain free of defects after the durability tests prescribed below. An applicant may propose modifications to the durability tests in this section if they can clearly demonstrate that the alternative durability test procedures are representative of end of useful life. Durability testing shall include the steps outlined in Figure 2.

Figure 2: Durability Flow Chart



4.1 Carbon Canister Test

For systems that utilize a carbon canister, the durability test procedures shall include thermal cycling and vibration exposure of the canister.

4.1.1 For thermal cycling, the test must subject the canister to 100 cycles of the following temperature profile:

4.1.1.1 Heat and hold at 140ºF ±4ºF for 30 minutes. (Up to 10 minutes is allowed for the temperature to rise and stabilize)

4.1.1.2 Cool and hold at 32ºF ±4ºF for 30 minutes. (Up to 20 minutes is allowed for the temperature to reach 32ºF during the cooling period)

4.1.2 For the vibration test, the canister must be subject to a peak horizontal acceleration of 4.5 x gravitational acceleration (g – 9.8 meters per second squared) at 60 Hertz (Hz) with a total of 10,000,000 cycles. The orientation of the canister, while being subject to vibration, must be the same as when mounted on the vehicle during normal use. If the canister is mounted on the vehicle using a vibration isolation system, the canister may be mounted in a test rig using the same vibration isolation system for conducting the test.

4.2 Pressure Vent Valve

If the fuel system employs a fuel vapor pressure vent valve, prior to the time of submission of a certification application, the applicant is required to submit and obtain approval of an evaporative emission durability test procedure for the pressure vent valve. The procedure shall have provisions to demonstrate durability after exposure to ultraviolet (UV) light, ozone, vibration and dust. Once approved, the pressure vent valve durability procedure may be used by any applicant using a similar pressure vent valve.

4.3 Carbon Canister Protection - Tip Test

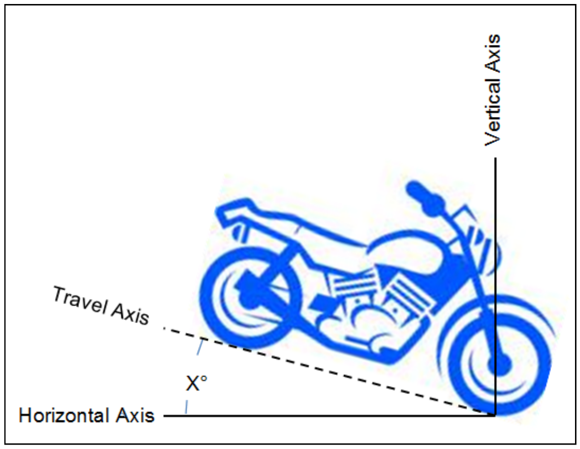
The carbon canister protection tip test can be conducted with a vehicle or with a test rig that represents the actual position and orientation of the fuel system components. The fuel tank must be filled to 100 percent of nominal capacity with certification fuel.

4.3.1 In less than 2 seconds, orient the vehicle such that the travel axis is tilted X degrees above and below the horizontal plane. See Figure 3 for a schematic. Hold the vehicle for 60 to 70 seconds, or such longer period of time as a manufacturer may choose, in both the positive and the negative position. X shall be as defined as follows:

a) 30° ±2° for off-road motorcycles.

b) 30° ±2° for all other OHRVs.

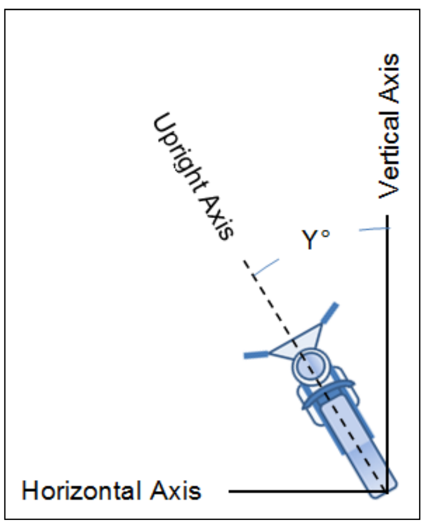
Figure 3: Horizontal Tilt



4.3.2 In less than 2 seconds, orient the vehicle such that the upright axis is tilted Y degrees from the vertical axis with rotation being about the travel axis. See Figure 4 for a schematic. Hold this position in both the positive and the negative position for 60 to 70 seconds, or such longer period of time as a manufacturer may choose. Y shall be as defined as follows:

a) Unsupported position on either side for off-road motorcycles (i.e., vehicle lying on its side).
b) 15° ±2° for all other OHRVs.

Figure 4: Vertical Tilt



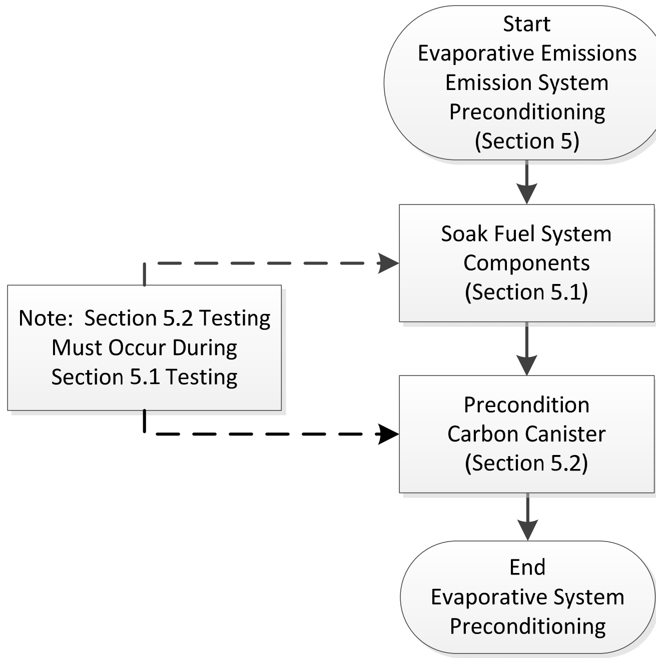
The weight of the vehicle's carbon canister must be measured before and after the tests specified in this section to determine weight gain. If the weight gain is 10 percent of the butane working capacity or more, the vehicle fails the test.

Alternative carbon canister protection tip tests may be submitted for approval. All proposed alternatives to the carbon canister protection tip test must show that the carbon canister functions as it should at the end of useful life, while subjecting it to the potential for liquid gasoline contamination consistent with vehicle usage. As a guideline, all alternative carbon canister tip tests should include real world liquid fuel exposure (e.g. volumes, rates, and total events), real world purges (e.g., rates and bed volumes), and use of a damaged canister during testing as described in this procedure.

5 EVAPORATIVE EMISSIONS SYSTEM PRECONDITIONING

The purpose of the preconditioning period is to introduce test fuel into the fuel system and condition all fuel system components to in-use conditions. Evaporative system preconditioning can be done in conjunction with mileage accumulation for exhaust testing as long as the fuel system has continuously held evaporative test fuel E10 (Commercial Pump Fuel containing 10 percent ethanol) for a total 140 days. E10 pump fuel may only be used for the portion of the soaking period; however, fuel must be switched to E10 certification fuel for a minimum of 30 days prior to testing. The preconditioning procedure shall include the steps outlined in Figure 5.

Figure 5: Preconditioning Flowchart



5.1 Soak Fuel System Components

Precondition the tank and other fuel delivery system components by filling the tank to its nominal capacity with fresh test fuel. Cap the tank within one minute of filling. After filling the tank, start the vehicle engine and allow it to idle for approximately fifteen minutes. Soak the tank and other components continuously for a total of 3,360 hours while maintaining an ambient temperature between 68ºF and 86ºF. Alternatively, components may be preconditioned using a fuel system test rig. The test rig must include all the components of the fuel and evaporative emissions control system connected and oriented as they would be installed in the vehicle. The tank and fuel lines must be filled with certification fuel at the beginning of the test. A fuel system may be soaked for less than 3,360 hours if data is provided using one of the following two documents incorporated by reference: “TP-901 - Test Procedure for Determining Permeation Emissions from Small Off-Road Engines and Equipment Fuel Tanks” adopted July 26, 2004 or 40 CFR §1060.520 (2012) that shows steady state permeation has been reached. If slosh testing is required, the slosh time may be considered part of the preconditioning period, provided all fuel system components tested remain filled with fuel, and are never empty for more than one hour over the entire preconditioning period.

If the fuel system is allowed to sit more than 6 weeks at 68°F to 86°F, a 1-week presoak must be conducted with fresh fuel before testing begins. The fresh fuel presoak can be counted as part of the 3,360-hour soak, so long as the fuel system is empty less than one hour.

Prior to beginning any test sequence to measure running loss, hot soak, or diurnal emissions, a vehicle may, at the manufacturer’s option, be preconditioned to minimize non-fuel emissions by being soaked at an elevated temperature prior to testing. To ensure steady state permeation rates, the vehicle must be soaked for at least 7 days at a temperature no higher than 95°F immediately prior to emissions testing.

5.2 Precondition Carbon Canister

For systems that utilize carbon canisters, Subsections 5.2.2 through 5.2.4 of the preconditioning sequence must be completed no sooner than 96 hours preceding the beginning of the evaporative emission test procedure described in Section 6 at 86° ±3°F.

For vehicles with multiple canisters in a series configuration, the set of canisters must be preconditioned as a unit. For vehicles with multiple canisters in a parallel configuration, each canister must be preconditioned separately. If production evaporative canisters are equipped with a functional service port designed for vapor load or purge steps, the service port shall be used to precondition the canister.

The following steps shall be performed in preconditioning the carbon canister:

5.2.1 Determine the canister's nominal working capacity based on the average capacity of no less than five canisters. These five canisters shall be the same as the canister on the vehicle undergoing testing. A manufacturer may use the butane working capacity provided by the canister vendor; if the vendor certifies that the working capacity has been determined using the following procedures:

a) Each canister must be loaded no less than 10 times and no more than 100 times, to 2 gram breakthrough with a 50/50 mixture by volume of butane and nitrogen, at a rate of 15 ±2 grams butane per hour per liter of canister volume. Each canister loading step must be preceded by canister purging with 300 canister bed volume exchanges at 0.8 cubic feet per minute (cfm) per liter of canister volume.
b) Each canister must first be purged with 300 canister bed volume exchanges at 0.8 cfm per liter of canister volume. The working capacity of each canister shall be established by determining the mass of butane required to load the canister from the purged state so that it emits 2 grams of hydrocarbon vapor; the canister must be loaded with a 50/50 mixture by volume of butane and nitrogen, at a rate of 15 ±2 grams butane per hour per liter of canister volume.

5.2.2 Prepare the vehicle’s evaporative emission canister for the canister purging and loading operation. The canister shall not be removed from the vehicle, unless access to the canister in its normal location is so restricted that purging and loading can only reasonably be accomplished by removing the canister from the vehicle. Special care shall be taken during this step to avoid damage to the components and the integrity of the fuel system. A replacement canister may be temporarily installed during the soak period while the canister from the test vehicle is preconditioned.

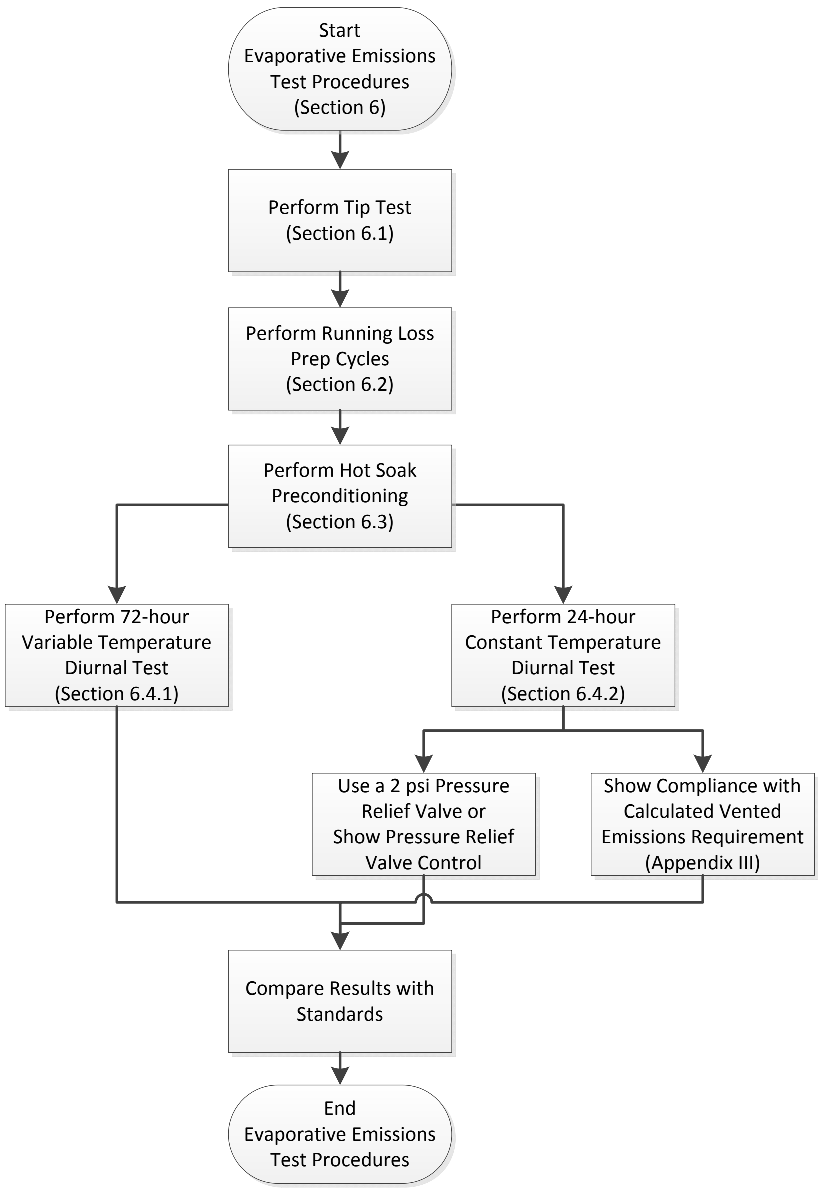
5.2.3 The canister purge shall be performed with ambient air of humidity controlled to 50 ±25 grains per pound of dry air. This may be accomplished by purging the canister in a room that is conditioned to this level of absolute humidity. The flow rate of the purge air shall be maintained at a nominal flow rate of 0.8 cfm per liter of canister volume and the duration shall be determined to provide a total purge volume flow through the canister equivalent to 300 canister bed volume exchanges. The bed volume is based on the volume of adsorbing material in the canister.

5.2.4 The evaporative emission canister shall then be loaded by sending to the canister an amount of commercial grade butane vapors equivalent to 1.5 times its nominal working capacity. The canister shall be loaded with a mixture composed of 50 percent butane and 50 percent nitrogen by volume at a rate of 15 ±2 grams butane per hour per liter of canister volume. If the canister loading at that rate takes longer than 12 hours, a manufacturer may determine a new rate, based on completing the canister loading in no less than 12 hours. The new rate may be used for all subsequent canister loading within this preconditioning. The time of initiation and completion of the canister loading shall be recorded.

6 EVAPORATIVE EMISSIONS TEST PROCEDURES

The Evaporative Emissions Test Procedures shall include the steps outlined in Figure 6.

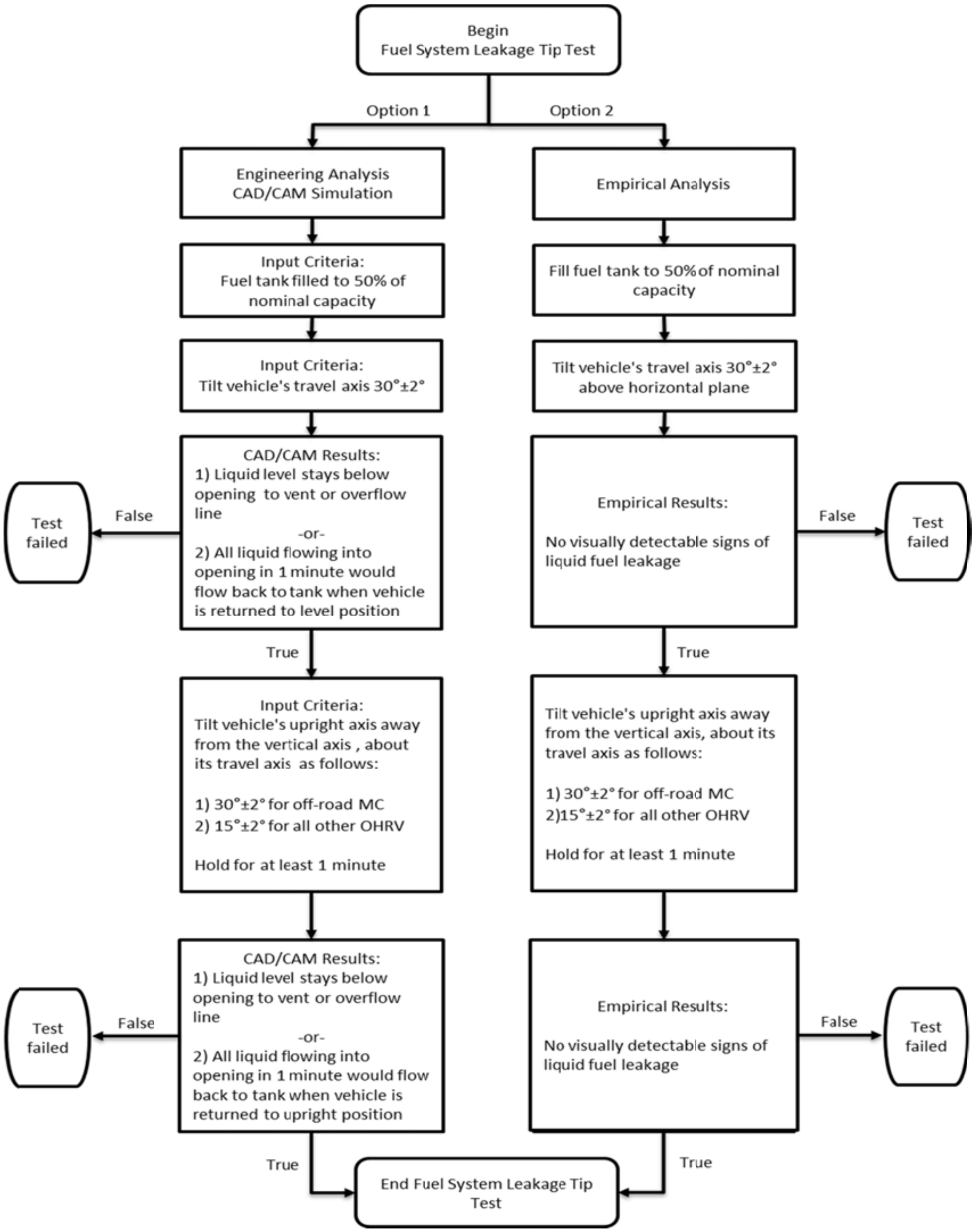
Figure 6: Evaporative Emissions Testing Flowchart



6.1 Fuel System Leakage Tip Test

The fuel system leakage tip test shall be performed during the soak specified in Subsection 6.2.1.5. The fuel tank must be filled to 50 percent with certification fuel. During the test the vehicle is tipped to inspect for visible signs of liquid leakage. If any test fuel leakage is observed, then the vehicle fails the test. See Figure 7 for a summary of the steps in the fuel system leakage tip test.

Figure 7: Fuel System Leakage Tip Test Flow Chart



An engineering analysis may be performed as an alternative to the tests described in this section. The analysis must demonstrate that zero liquid leakage will occur within one minute when the vehicle, with the gasoline tank filled to 50 percent of rated capacity, is tipped as specified in Subsection 6.1.

To perform the analysis, a Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM) design program may be used to determine the level of fuel in the system that would occur when the tank is filled to 50 percent of its nominal capacity. To demonstrate compliance, the height of the fuel surface when the vehicle is tilted must be below the height of any opening to a vent or overflow line or it must be demonstrated that the total volume of fuel flowing into the opening in one minute would flow back into the fuel tank when the vehicle is returned to a level surface.

All tip measurements shall be made to an accuracy of ±1° of arc.

The tip test shall be conducted with the vehicle on a level surface as described below:

6.1.1 In less than 2 seconds, orient the vehicle such that the travel axis is tilted X degrees above and below the horizontal plane. See Figure 3 for a schematic. Hold the vehicle for 60 to 70 seconds, or such longer period of time as a manufacturer may choose, in both the positive and the negative position. Note any visible signs of fuel leakage. X shall be as defined as follows:

a) 30° ±2° for off-road motorcycles.
b) 30° ±2° for all other OHRVs.

6.1.2 In less than 2 seconds, orient the vehicle such that the upright axis is tilted Y degrees from the vertical axis with rotation being about the travel axis. See Figure 4 for a schematic. Hold this position in both the positive and the negative position for 60 to 70 seconds, or such longer period of time as a manufacturer may choose. Y shall be as defined as follows:

a) Unsupported position on either side for off-road motorcycles (i.e., vehicle lying on its side).
b) 15° ±2° for all other OHRVs.

6.2 Running Loss Conditioning

The running loss test is designed to simulate vehicle operation and canister purging during operation. Follow the dynamometer schedules in 40 CFR §86.515-78 (2012), which is hereby incorporated by reference. For the purpose of this running loss conditioning, all soak and test temperatures are 86° ±3°F.

6.2.1 The following steps shall be performed before beginning the running loss test:

6.2.1.1 The fuel tank of the vehicle to be tested shall be drained and refilled to 50 percent with test fuel.

6.2.1.2 Soak for at least 6 hours after being refueled. Following this soak period, conduct a refueling cycle by running the test vehicle through one Urban Dynamometer Driving Schedule (UDDS) driving cycle. The drain and fill and 6-hour soak may be omitted on subsequent tests of the vehicle if the vehicle remains under laboratory temperatures between tests. The later test preconditioning will begin with Subsection 6.2.1.5.

6.2.1.3 Install fuel temperature sensors as needed.

6.2.1.4 Drain and refill the fuel tank of the vehicle to 50 percent with test fuel.

6.2.1.5 Soak the vehicle with the key off for 12 to 36 hours between the end of the refueling and the start of the cold start preconditioning cycle.

6.2.1.6 During the soak period, perform the tip test specified in Subsection 6.1 and purge and load the evaporative control system canister using the procedures defined in Sections 5.2.2, 5.2.3, and 5.2.4. The evaporative control system canister is not required to be installed while performing the tip test specified in Subsection 6.1.

6.2.1.7 The location and speed of a fan used to cool the vehicle must comply with the requirements described in Appendix B.

6.2.1.8 The speed profile is the U.S. Environmental Protection Agency (U.S. EPA) UDDS as specified in 40 CFR §86.515-78 (2012). The same cycle (Class I or Class II) must be used as is required for exhaust emissions certification. The steady state engine test for All-Terrain Vehicles (ATV) is not allowed for this test procedure.

6.2.1.9 Perform a cold start UDDS preconditioning cycle on the dynamometer.

6.2.1.10 Perform a hot start UDDS preconditioning cycle on the dynamometer.

Following the completion of the running loss preconditioning, a hot soak preconditioning must be conducted as specified in Subsection 6.3.

6.3 Hot Soak Preconditioning

The hot soak evaporative emission preconditioning is designed to soak the OHRV after operation. The test temperature for the hot soak is 86° ±3°F.

6.3.1 The hot soak must be performed within 7 minutes of the completion of the UDDS hot start cycle, performed in Subsection 6.2.

6.3.2 Turn off all engine cooling fans when the engine is turned off.

6.3.3 During the time between the end of the UDDS hot start cycle and the beginning of the hot soak preconditioning, the engine is allowed to be shut off for no more than 4 minutes immediately preceding the start of the hot soak preconditioning.

6.3.4 Soak the OHRV at 86° ±3°F for 90 ±0.5 minutes.

6.3.5 If the Calculation Method is to be used for the diurnal test, the carbon canister must be removed immediately following the hot soak test and the butane working capacity must be determined by loading the canister to 2 grams breakthrough with a 50/50 mixture by volume of butane and nitrogen, at a rate of 15 ±2 grams butane per hour per liter of canister volume.

6.3.6 Upon completion of the hot soak test, proceed to the diurnal test in Subsection 6.4.

6.4 Diurnal Test

Upon completion of the hot soak, the diurnal test shall begin. The diurnal test can be conducted by direct measurement of three consecutive 24-hour diurnal tests (72-hour diurnal test) or by measuring emissions for a single 24-hour diurnal test and showing vented emissions compliance (steady state diurnal test) as described in Sections 6.4.1 and 6.4.2, respectively.

6.4.1 72-Hour Diurnal Test - Begin the 3-day diurnal test by lowering the temperature of the enclosure in which the diurnal test will be performed to 72° ±3°F within 60 minutes of completing the hot soak test. Diurnal soak period is 6 to 36 hours at 72° ±3°F. Perform the diurnal test procedure described in 40 CFR §86.133-96 (2012), which is hereby incorporated by reference with the following exceptions.

6.4.1.1 When the word "methanol" or the term C_{CH3OH} (methanol concentration) is used, it shall be replaced by ethanol or the term C_{C2H5OH} (ethanol concentration).

6.4.1.2 All references to the hot soak test performed in 40 CFR §86.138-96 (2012) shall mean the hot soak conditioning previously described in Section 6.3 of this procedure.

6.4.1.3 All references to the calculations performed in 40 CFR §86.143 (2012) shall be replaced with the calculations performed in Section 7 of this procedure.

6.4.1.4 Omit the following language from Section (a)(1), "The diurnal emission test may be conducted as part of either the three-diurnal test sequence or the supplemental two-diurnal test sequence, as described in 40 CFR §86.130-96 (2012)."

6.4.1.5 Omit Section (a)(3), and all of Sections (j), (o) and (p).

6.4.1.6 Omit the following language from Section (e), "…and the test vehicle windows and luggage compartment(s) opened…"

6.4.1.7 Revise Section (i)(5) as follows, "Within 10 minutes of closing and sealing the test enclosure doors, analyze enclosure atmosphere for hydrocarbons and record. This is the initial (time=0 minutes) hydrocarbon concentration, CHC_i, required in Section 7 of this procedure. The final hydrocarbon measurement shall be conducted no more than 60 seconds from the end of the test."

6.4.1.8 Omit the following language from Section (n), "…the test vehicle windows and luggage compartments may be closed …".

6.4.2 Steady State Diurnal Test

The purpose of the steady state diurnal test is to demonstrate control of permeation emissions and to verify proper evaporative emissions system construction.

6.4.2.1 Perform the diurnal test as defined in Subsection 6.4.1 except:

6.4.2.2 Attach vent line(s) to air-port(s) of carbon canister(s), if so equipped, that will direct any air/vapor exiting the canister to the exterior of the test enclosure. This air/vapor need not be measured.

6.4.2.3 The test shall be conducted at a constant temperature of 86° ±3°F.

6.4.2.4 A single steady state 24-hour diurnal is required.

6.4.2.5 Compliance is shown if the emissions measured in this section are lower than the standard and one of the following can be shown:

a) Calculate maximum gasoline vapor loading and show that the carbon canister is operating in the range where it is at least 99.5 percent effective (0.5 percent bleed emissions) based on best modeling practices. The best modeling practices method must be accepted by ARB staff prior to certification or follow the requirements in Appendix A of this test procedure.

b) The OHRV uses a pressure relief valve which does not release vapor from the tank up to 2 pounds per square inch gauge (psig).

c) The OHRV uses a pressure relief valve which does not release vapor from the tank during the second of two consecutive 24-hour diurnal temperature cycles from 72°F to 96°F. The fuel temperature must be below the boiling point for test fuel and the pressure relief valve must not open during both the running loss and hot soak conditioning or it has to vent to the intake.

7 CALCULATIONS: EVAPORATIVE EMISSIONS

Total mass emissions from Subsection 6.4.1 must be calculated using the measurements of initial and final concentrations to determine the mass of hydrocarbons and ethanol emitted pursuant to "California Evaporative Emission Standards and Test Procedures for 2001 and Subsequent Model Motor Vehicles" as last amended December 6, 2012, Parts III.D.11. Alternatively, ethanol measurements may be omitted if the calculated mass of hydrocarbon emissions is multiplied by a percentage adjustment factor equal to:

E10 adjustment factor = (100% - 0.5 x % fuel alcohol content) x (1 + (%ethanol x 3))

(e.g., for E10 adjustment factor = (100% - 0.5 x 10%) x 1.3= 124%)
For OHRVs, the vehicle volume is assumed to be 5 cubic feet (1.42 cubic meters) unless the manufacturer provides a measured OHRV volume.

8 LIST OF TERMS

ARB	California Air Resources Board
ATV	All-Terrain Vehicle
CAD/CAM	Computer-Aided Design/Computer-Aided Manufacturing
C_{C2H5OH}	Ethanol concentration
C_{CH3OH}	Methanol concentration
CCR	California Code of Regulations
CFM	Cubic Feet per Minute
CFR	Code of Federal Regulations
CH&SC	California Health and Safety Code
ºC	Degrees Celsius
ºF	Degrees Fahrenheit
E10	Commercial Pump Fuel containing 10 percent ethanol
HC	Hydrocarbon
HZ	Hertz
KM/H	Kilometers per Hour
MC	Motorcycle
MPH	Miles Per Hour
OHRV	Off-Highway Recreational Vehicle
PSIG	Pounds per Square Inch – Gauge
T_{liq}	Fuel tank liquid temperature
T_{vap}	Fuel tank vapor space temperature
TP	Test Procedure

TP-933	Test Procedure for determining evaporative emissions from off-highway recreational vehicles
UV	Ultraviolet
UDDS	U.S. EPA Urban Dynamometer Driving Schedule

9 DOCUMENTS INCORPORATED BY REFERENCE

California 2015 and Subsequent Model Criteria Pollutant Exhaust Emission Standards and Test Procedures and 2017 and Subsequent Model Greenhouse Gas Exhaust Emission Standards and Test Procedures for Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles, California Environmental Protection Agency, Air Resources Board, El Monte, CA, adopted March 22, 2012, as last amended December 6, 2012.

California Evaporative Emission Standards and Test Procedures for 2001 and Subsequent Model Motor Vehicles, California Environmental Protection Agency, Air Resources Board, El Monte, CA, adopted August 5, 1999, as last amended December 6, 2012.

California Exhaust Emissions Standards And Test Procedures For 1997 And Later Off-Highway Recreational Vehicles And Engines, California Environmental Protection Agency, Air Resources Board, El Monte, CA, adopted November 22, 1994, as last amended October 25, 2012.

Control of Emissions from New and In-Use Highway Vehicles and Engines. Title 40, Code of Federal Regulations, Part 86. United States Environmental Protection Agency, 40 CFR §86.107-96 (2012), 40 CFR §86.108-79 (2012), 40 CFR §86.108-00 (2012), 40 CFR §86.130-96 (2012), 40 CFR §86.133-96 (2012), 40 CFR §86.138-96 (2012), 40 CFR §86.143-96 (2012), 40 CFR §86.508-78 (2012), and 515-78 (2012).

Control of Evaporative Emissions from New and In-Use Nonroad and Stationary Equipment. Title 40, Code of Federal Regulations, Part 1060. United States Environmental Protection Agency, 40 CFR §1060.520 (2012).

Reddy, S. Raguma. Prediction of Fuel Vapor Generation From a Vehicle Fuel Tank as a Function of Fuel RVP and Temperature. SAE Technical Paper 892089, September 25-29,1989. Copyrighted.

Test Procedure for Determining Permeation Emissions from Small Off-Road Engine Equipment Fuel Tanks, TP-901, California Environmental Protection Agency, Air Resources Board, Sacramento, CA, as adopted July 26, 2004.

10 APPENDICES

10.1 Appendix A - Calculation Method for Demonstrating the Adequacies of the Vented Evaporative Emissions System

The calculations in this section are based on the ideal gas law, and equations generated in *SAE 892089- Prediction of Fuel Vapor Generation from a Vehicle Fuel Tank as a Function of Fuel RVP and Temperature* adopted September 25-28, 1989 and incorporated here by reference. All final results should be calculated to two significant figures.

Figure A-1: Calculations Flow Chart

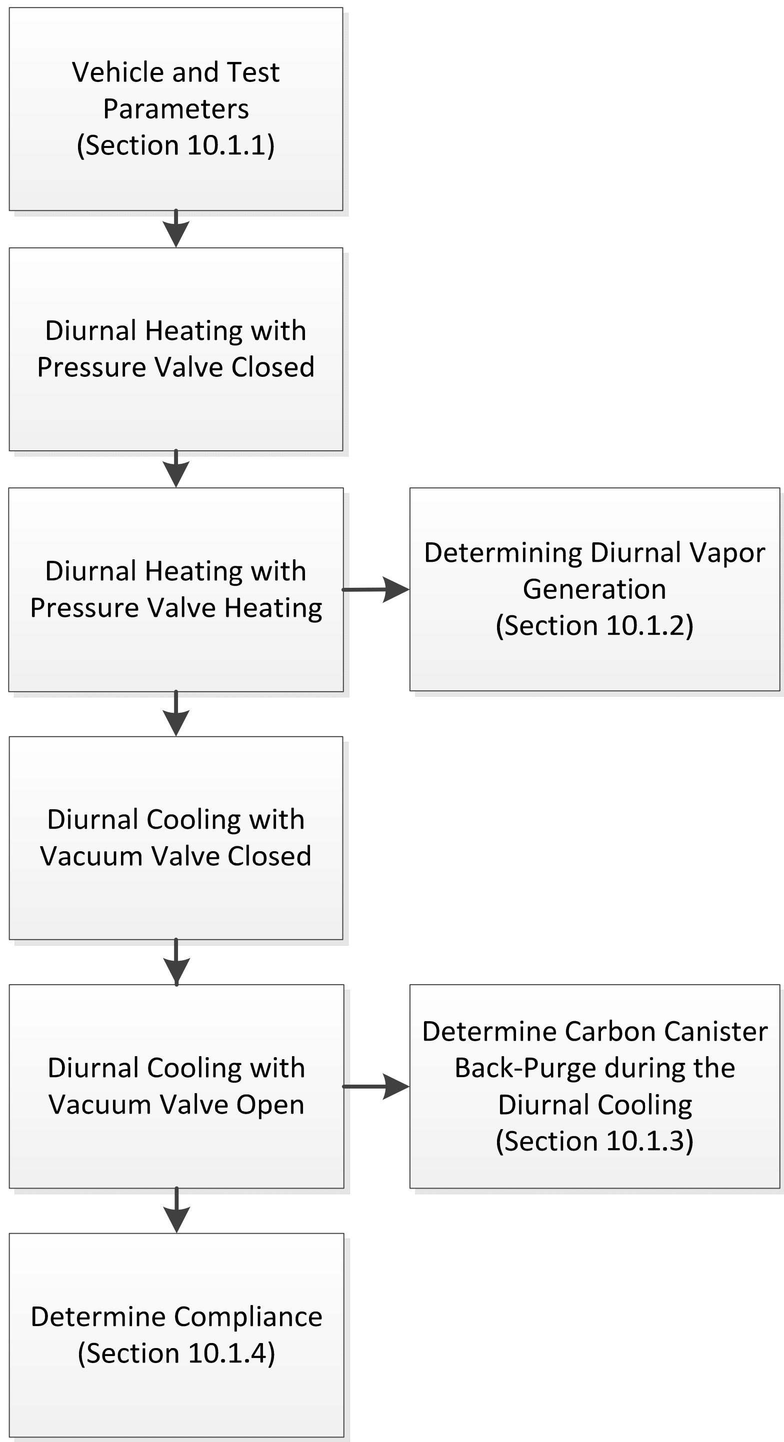
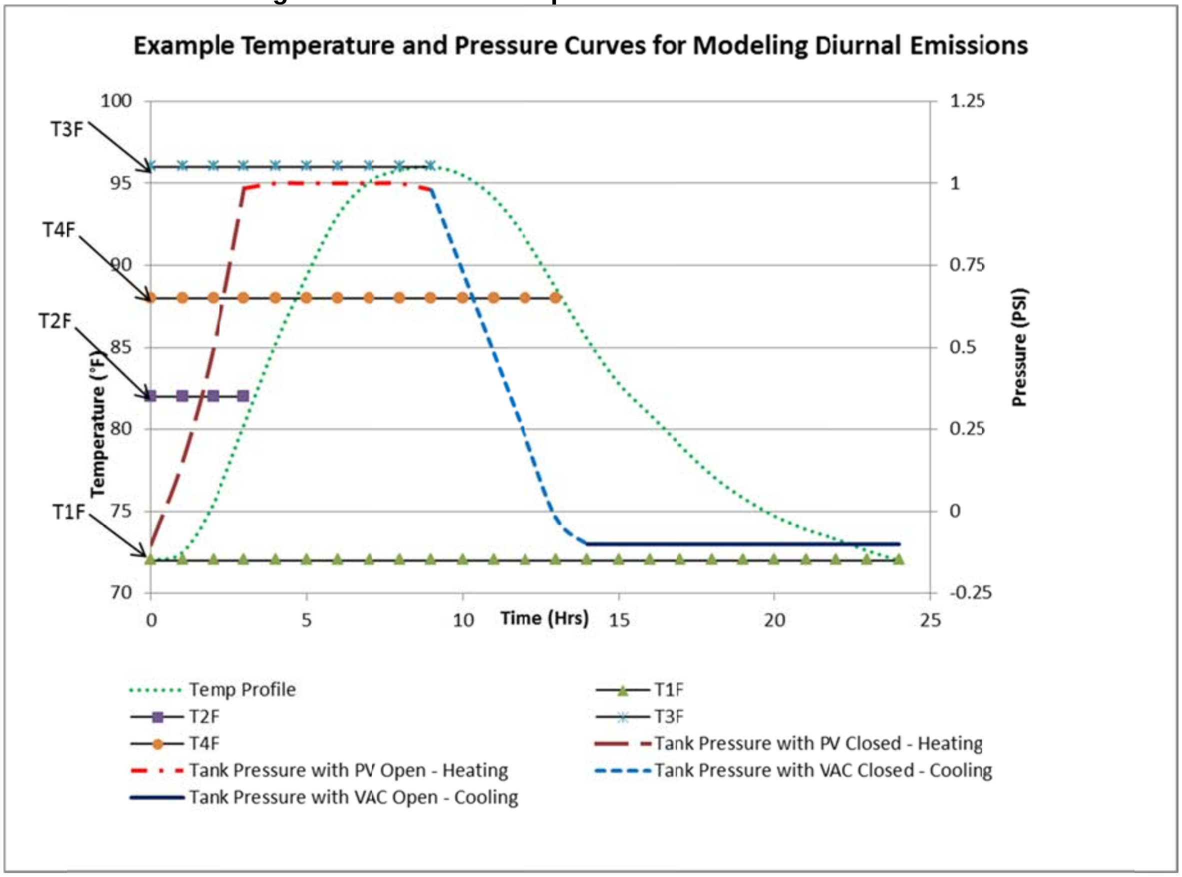


Figure A-2: Diurnal Temperature and Pressure Curves



10.1.1 Vehicle and Test Parameters

a. Fuel Volume Information

________	(gal)	V_t	Total Volume of Fuel Tank
________	(gal)	V_u	Usable Volume of Fuel Tank
________	(gal)	V_i	Initial Fill Volume of Fuel Tank
________	(gal)	V_{FP}	Fuel Used During Prep
________	(gal)	V_{FR}	Fuel Used During Run Loss

EXAMPLE:

2.1	*(gal)*	V_t	*Total Volume of Fuel Tank*
2	*(gal)*	V_u	*Usable Volume of Fuel Tank*
1	*(gal)*	V_i	*Initial Fill Volume of Fuel Tank*
0.1	*(gal)*	V_{FP}	*Fuel Used During Prep*
0.1	*(gal)*	V_{FR}	*Fuel Used During Run Loss*

b. List of Temperatures

T1K = Initial/Final Diurnal Temperature (°K)
T2K = Temperature where Pressure Relief Valve Opens (°K)

T3K = Highest Diurnal Temperature (°K)
T4K = Temperature at which vacuum valve opens (°K)

c. Pressure Control Settings

________	(psig)	P_{VO}	Opening Pressure
________	(psig)	VAC_{VO}	Vacuum Opening Pressure

EXAMPLE:

1	*(psig)*	P_{VO}	*Opening Pressure*
0.1	*(psig)*	VAC_{VO}	*Vacuum Opening Pressure*

d. Fuel Reid Vapor Pressure (RVP)

________	(psi)	RVP

EXAMPLE:

7	*(psi)*	*RVP*

e. Preconditioned Carbon Canister Specifications
The carbon canister must be preconditioned as specified in subsection 5.2. Butane working capacity of a carbon canister must be established at 2 grams breakthrough using “California Evaporative Emission Standards and Test Procedures for 2001 and Subsequent Model Motor Vehicles" as amended March 22, 2012, with the flow rates and temperatures specified in subsection 5.2.

________	(cc)	BV	Carbon Bed Volume
________	(g/canister)	TBWC	Total Equilibrated Butane Working Capacity
________	(g/100cc)	BWC	Butane Working Capacity of Carbon
________	(g/100cc)	GWC	Gasoline Capacity per Volume of Carbon

EXAMPLE:

122	*(cc)*	*BV*	*Carbon Bed Volume*
9.5	*(g/canister)*	*TBWC*	*Total Equilibrated Butane Working Capacity*
7.8	*(g/100cc)*	*BWC*	*Butane Working Capacity of Carbon*
8.2	*(g/100cc)*	*GWC*	*Gasoline Capacity per Volume of Carbon*

f. Determine the Total Gasoline Working Capacity (TGWC) of Canister

The TGWC is the total mass of gasoline vapor that a purged canister can expect to hold. TGWC is determined by direct measurement similar to TBWC but using an aged canister vapor from gasoline at 96°F instead of butane, or by calculating TGWC using canister bed volume, BWC and GWC.

TGWC of Canister

TGWC= TBWC * GWC / BWC = ______*______/______

Where,
GWC, TBWC, BWC = (From Section 10.1.1.e)

EXAMPLE:
*TGWC= 9.5*8.2/7.8 = 10g/canister*

g. Determine Vapor Space Volume of Fuel Tank at end of all Prep Cycles (V_p)

$V_p = V_t – V_i + V_{FP} + V_{FR}$

V_p = _____ – _____ + _____ + _____

Where,
V_t, V_i, V_{FP}, V_{FR} = (From Section 10.1.1.a)

EXAMPLE:

V_p=2.1-1+0.1+0.1=1.3

h. Determine Carbon Canister Gasoline Vapor Capacity at Beginning of Diurnal Test ($TGWC_{di}$)

The carbon canister gasoline vapor capacity at the beginning of the diurnal test is the total mass of gasoline vapor that the canister can expect to hold at the beginning of the diurnal test. $TGWC_{di}$ is determined by direct measurement similar to BWC (Section 6.3.5) but using vapor from gasoline at 96°F instead of butane, or calculate using canister bed volume and measured butane capacity at the beginning of the diurnal test ($TBWC_{di}$).

$TGWC_{di}$ = measured gasoline vapor capacity at beginning of diurnal test
$TGWC_{di}$ = (GWC/BWC)*$TBWC_{di}$ = ______/______*______

$TGWC_{di}$ = _____

EXAMPLE:
$TGWC_{di}$ *Measured to be = 7g*

10.1.2 Determining Diurnal Vapor Generation

Vapor generation occurs as a result of temperature increase of the fuel in the fuel tank. Vapor emissions occur when the generated vapor is able to exit the fuel tank. If the system does not use a pressure relief system, vapor emissions will occur during the entire diurnal heating stage from 72°F to 96°F. If the system uses a pressure relief system, the emissions occur only at temperatures where fuel tank pressures exceed the relief pressure. If such a tank system is employed, the temperature at which the relief valve opens must be determined.

a. Calculate gasoline vapor pressure at lowest temperature of diurnal cycle (72°F or 22.2°C)

Vapor pressure

$$P_{tgasoline}(T1K) = A * T1K * RVP * \ e^{\frac{-B}{T1K}}$$

Where,
T1K = 22.2° C + 273.2 K = 295.4 K
$A = 25.61$
$B = 2789.78$
RVP = (From Section 10.1.1.d)

EXAMPLE:

$P_{tgasoline}(72°F) = 25.61 * 295.4 * 7 * \ e^{\frac{-2789.79}{295.4}} = 4.19\ psi$

b. Determine partial pressure of air in the fuel tank at lowest temperature of diurnal cycle.

$P_{air}(72°F) = P_{atm} – VAC_{VO} – P_{tgasoline}(72°F)$

$P_{air}(72°F)$ = _____ – _____ – _____

Where,
P_{atm} = 14.7 psi
VAC_{vo} = (From Section 10.1.1.c)
$P_{tgasoline}$ (72ºF) = (From Section 10.1.2.a)

EXAMPLE:
$P_{air}(T1)$ = 14.7 - 0.1 - 4.19 = 10.4 psi

Find the temperature (T2) at which the relief valve opens. This will be where the internal tank pressure equals atmospheric pressure plus the pressure relief valve. If no pressure control system is used T2 equals 72°F.

Solve using numerical analysis to find a value for T2K where:

P_{tank}(pres. Open) = $P_{atm} + P_{vo} = P_{tgasoline}(T2K) + P_{air}(T2K)$

Where,

$P_{tgasoline}(T2K) = A * T2K * RVP * \ e^{-\frac{B}{T2K}}$

$P_{air}(T2K) = \frac{T2K * P_{air}(T1K)}{T1K}$

RVP = (From Section 10.1.1.d)
P_{vo}= (From Section 10.1.1.c)

EXAMPLE:
Assume T2F is 82°F (301°K)
*$P_{tgasoline}$(301K) = 25.61*301*7*e^(2789.78/301)=5.1 psi*
*P_{air}(301K) = (301*10.4)/295.4 = 10.6*

$P_{tgasoline}$(301K) + P_{air}(301K) = 10.6 + 5.1 = 15.7psi = 14.7+1
Therefore, T2F=82°F

c. Using the Reddy Vapor Generation equation, determine the vapor generation in grams per gallon for a diurnal cycle from T2, for systems with pressure relief, to T3.

$$\mathrm{VAPOR_{diurnal}} = \mathrm{C} * \mathrm{e}^{\mathrm{D*RVP}} * (\mathrm{e}^{\mathrm{E*T3}} - \mathrm{e}^{\mathrm{E*T2}})$$

Where,
$\mathrm{C} = 0.00817$
$\mathrm{D} = 0.2357$
$\mathrm{E} = 0.0409$
T2 (F) = (From Section 10.1.2.c, converted to °F)
T3 (F) = max diurnal (96°F)
V_p = (From Section 10.1.1.g)
RVP = (From Section 10.1.1.d)

Vapor generation for a non-I'pressurized system using a 72°F to 96°F temperature profile at sea level with 7 RVP fuel simplifies to:

$\mathrm{VAPOR_{diurnal}}$= 1.35 g/gal

EXAMPLE:
*$VAPOR_{diurnal}$ = 0.00817*e^(0.2357*7)*(e^(0.0409*96)-e(0.0409*82)) = 0.94g/gal*

10.1.3 Determine Carbon Canister Back-Purge During the Diurnal Cooling

The weight of hydrocarbon vapor back purged (passively purged) from the canister during diurnal cooling steps is a function of the volume of air drawn into the fuel tank as it cools. The amount of air purging the canister will be the difference between the air volume in the fuel tank at the end of cooling less the amount in the tank when the air first begins to enter the tank. In a system that does not employ a pressure relief/vacuum valve system, the flow of air begins as soon as the cooling starts. In a system that employs pressure control, the air flow begins when the in tank pressure equals atmospheric pressure less the opening pressure of the vacuum relief valve. The following calculations provide a calculation method appropriate for either type of system.

a. Calculate gasoline vapor pressure at the highest temperature of the diurnal cycle (96°F or 36.6°C)

Vapor pressure

$$\mathrm{P_{tgasoline}}(96°\mathrm{F}) = \mathrm{A} * \mathrm{T3K} * \mathrm{RVP} * \mathrm{e}^{\frac{-\mathrm{B}}{\mathrm{T3K}}}$$

Where,
$\mathrm{T3K} = 35.6°\mathrm{C} + 273\mathrm{K} = 308.75\mathrm{K}$
$\mathrm{A} = 25.61$
$\mathrm{B} = 2789.78$

RVP = (From Section 10.1.1.d)

EXAMPLE:

$P_{tgasoline}(96°F) = 25.61 * 308.75 * 7 * e^{\frac{-2789.79}{308.75}} = 6.59\ psi$

b. Determine partial pressure of air in the fuel tank at the highest temperature of the diurnal cycle.

$$\mathrm{Pair}(96°\mathrm{F}) = \mathrm{P_{atm}} + \mathrm{P_{vo}} - \mathrm{P_{tgasoline}}\ (96\ \mathrm{F})$$

Where,
$\mathrm{Patm} = 14.7\ \mathrm{psi}$
P_{vo} = (From Section 10.1.1.c)

P_{air} (96°F) = 14.7+_______-6.59 =

EXAMPLE:
P_{air} (96°F) = 14.7 + 1 - 6.59 = 9.11 psi

Find the temperature (T4) at which the vacuum relief valve opens. This will be where the internal tank pressure equals atmospheric pressure less the vacuum valve setting. This temperature may be found using numerical analysis to determine the temperature where the tank pressure plus the relief valve pressure is equal to atmospheric pressure. If no pressure control system is used this temperature will be 96°F.

$$\mathrm{P_{tank}}(\mathrm{vac\ open}) = \mathrm{P_{atm}} - \mathrm{VAC_{vo}} = \mathrm{P_{tgasoline}}(\mathrm{T4K}) - \mathrm{P_{air}}(\mathrm{T4K})$$

Where,

$$\mathrm{P_{tgasoline}}(\mathrm{T4K}) = \mathrm{A} * \mathrm{T4K} * \mathrm{RVP} * \ \mathrm{e}^{-\frac{\mathrm{B}}{\mathrm{T4K}}}$$

$$\mathrm{P_{air}}(\mathrm{T4K}) = \frac{\mathrm{T4} * \mathrm{P_{air}}(\mathrm{T3K})}{\mathrm{T3K}}$$

Where,
RVP = (From Section 10.1.1.d)
P_{air}(T3) = (From Section 10.1.3.b)
VAC_{vo} = (From Section 10.1.1.c)

Solve for T4K
T4K = ______

EXAMPLE:
Assume T4F is 88°F (304.1°K)
*$P_{tgasoline}$(304.1K) = 25.61*304.1*7*e^(2789.78/304.1)=5.6 psi*
*P_{air}(304.1K) = (304.1*10)/308.56 = 9.0 psi*
$P_{tgasoline}$(304.1K)+P_{air}(304.1K) = 9.0 + 5.6 = 14.6psi = 14.7 - 0.1
Therefore T4F = 88°F

c. Determine the volume of air in the fuel tank in gallons at the temperature when the vacuum valve opens.

$$V_{air}(T4K) = \frac{V_p * P_{air}(T4K)}{(P_{atm} - VAC_{vo})}$$

Where,
$P_{tgasoline}(T4)$ = (From Section 10.1.3.c)
VAC_{vo} = (From Section 10.1.1.c)
V_p = (From Section 10.1.1.g)

EXAMPLE:

$$V_{air}(T4K) = \frac{1.3 \quad * 9.1}{(14.7\text{-}0.1)} = 0.8 \text{ gal}$$

d. Determine the volume of air in the fuel tank in gallons at the minimum temperature of the diurnal cycle (T1=72°F).

$$V_{air}(T1) = \frac{V_p * P_{air}(T1K)}{(P_{atm} - VAC_{vo})}$$

Where,
$P_{air}(T1) = P_{air}(72F)$ (From Section 10.1.2.b)
VAC_{vo} = (From Section 10.1.1.c)
V_p = (From Section 10.1.1.g)

EXAMPLE:

$$V_{air}(T1K) = \frac{1.3 \quad * \ 10.43}{(14.7 - 0.1)} = 0.92 \ gal$$

e. The volume of air purging the carbon canister in gallons is the difference between these volumes.

$V_{airpurge} = V_{air}(T1) - V_{air}(T4)$

$V_{airpurge}$ = ________ – ________

Where,
$V_{airpurge(cc)} = V_{airpurge}$* 3785.4cc/gal
$V_{air}(T4)$ = (From Section 10.1.3.e)
$V_{air}(T1)$ = (From Section 10.1.3.f)

EXAMPLE:
$V_{airpurge} = V_{air}(T1) - V_{air}(T4)$ =0.92 - 0.8 = 0.12 gal
*$V_{airpurge}(cc)$ = 0.13ga*3785.4cc/gal = 454.2cc*

f. Calculate the purge in carbon bed volume(s).

$$BV_{purge} = \frac{V_{airpurge}(cc)}{BV}$$

Where,
BV = Total Volume of Carbon in Canister (From Section 10.1.1.e)
$V_{airpurge(cc)}$ = (From Section 10.1.3.e)

EXAMPLE:
BV_{purge}= 454.2/120 = 3.8 bed volumes

The efficiency of the back purge is a function of canister loading or canister saturation. Empirical data must be generated for the conditions at the beginning of the diurnal test.

EXAMPLE:
A purge efficiency of 0.15% of the total canister TBWC per bed volume purged.

$VAPOR_{backpurge} = 0.0015*TBWC*(GWC/BWC)* BV_{purge}$
$VAPOR_{backpurge} = 0.0015*9.4*(8.2/7.8)*3.8 = 0.056g$

Where,
TBWC = (*From Section 10.1.1.e)*
BWC = (*From Section 10.1.1.e)*
GWC = (*From Section 10.1.1.e)*
BV_{purge}= (from Section 10.1.3.g)

10.1.4 Calculating Compliance

a. Total diurnal vapor loading:

$VL_{diurnaltot} = 3*(VAPOR_{diurnal} * V_p) – (2 * VAPOR_{backpurge})$
$VL_{diurnaltot}$ = 3*(_____ * _____) – (2 * _____)

Where,
$VAPOR_{diurnal}$ = (From Section 10.1.2.d)
$VAPOR_{backpurge}$ =(From Section 10.1.3.g)

EXAMPLE:
$VL_{diurnaltot}$= 3(0.94*1.3)-(2*0.056) = 3.6g*

b. Total Canister Loading is equal to Canister loading prior to diurnal test plus diurnal vapor load:

$VL_{total} = TGWC – TGWC_{di} + VL_{diurnaltot}$

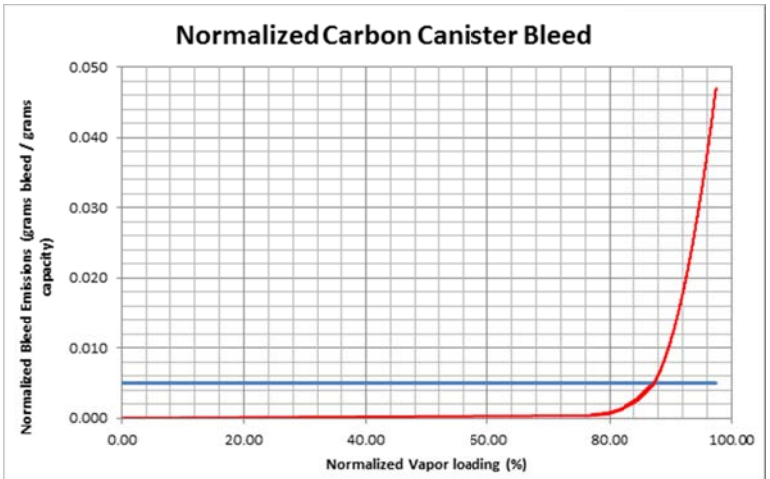
Where,
TGWC = (From Section 10.1.1.f)
$TGWC_{di}$ = (From Section 10.1.1.h)
$VL_{diurnaltot}$ = (From Section 10.1.4.a)

VL_{total} = _______ – _______ + _______ = ________

EXAMPLE:
VL_{total}= 10 – 7 + 3.6 = 6.6g

Criteria for approval of Certification- A graph similar to the one shown below, but appropriate for the carbon canister actually used, must be submitted. The x axis must show the loading of the canister as a percentage of its working capacity. The y axis must show the bleed emissions in grams of bleed per grams of working capacity when the canister is loaded at the rate defined in Section 5.2.1 (50/50 mixture by volume of butane and nitrogen at a rate of 15 ±2 grams butane per hour per liter of canister volume).

Figure A-3: EXAMPLE plot



Acceptable design (sizing) of the canister shall be demonstrated by a calculated total canister loading (VL_{total}) that is the lesser of 75 percent of the Normalized Loading or that Normalized Loading where the efficiency of the canister to control Bleed Emissions exceeds 0.005 grams of bleed emission / gram of total canister capacity (NVL%).

Normalized Load Limit Percentage:
NVL% = ________
Normalized Load:
NVL = NVL% * TGWC

Where,
TGWC = (From Section 10.1.1.f)

<u>EXAMPLE:</u>
NVL% = 75
*NVL=0.75*10 = 7.5g*

c. The design is acceptable if:

$NVL \geq VL_{total}$

_______ ≥ _______

<u>EXAMPLE:</u>
7.5g ≥ 6.6g……PASS!

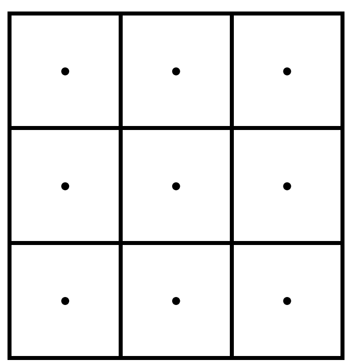
10.2 Appendix B – Variable Speed Cooling Blower

a) Variable speed cooling blower must direct air to the vehicle.
b) Blower outlet must be at least 0.4 square meters (4.31 square feet).
c) Blower outlet must be squarely positioned 0.3 ±0.05 meters (11.8 ±1.97 inch) in front of the vehicle.
d) Blower outlet lower edge height must be 0.1 meter (3.94 inch) to 0.2 meter (7.87 inch) above the ground.
e) Cooling air speed produced by the blower must be within the following limits (as a function of dynamometer roll speed):

Actual dynamometer roll speed	Allowable cooling air speed
0 km/h	0 km/h
Above 0 km/h to 5 km/h	0 km/h to roll speed + 2.5 km/h
Above 5 km/h to 25 km/h	Roll speed ± 2.5 km/h
25 km/h to 80 km/h	Roll speed ± 10 percent
Above 80 km/h	At least 72 km/h

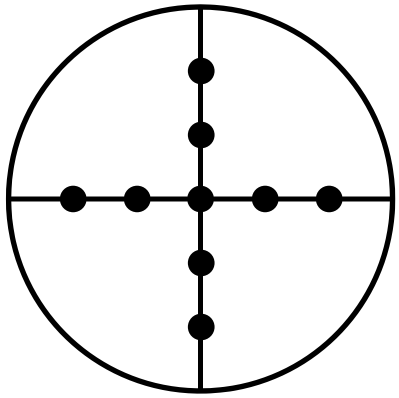
f) The cooling air speed above must be determined as an averaged value of 9 measuring points.
   1) For blowers with rectangular outlets, both horizontal and vertical sides of the blower outlet must be divided into 3 equal parts yielding 9 equal rectangular areas (see the diagram below). The measurement points are located at the center of each rectangular area.

Figure A-4



   2) For blowers with circular outlets, the blower outlet must be divided into 4 equal sectors defined by a vertical line and a horizontal line (see diagram below). The measurement points include the center of the blower outlet and locations on the radial lines (0°, 90°, 180°, and 270°) at radii of 1/3 and 2/3 of the total radius.

Figure A-5



g) In addition to the averaged cooling air speed requirements, each measuring point must be within ± 30 percent of actual roll speeds above 5 km/h.
h) Cooling air speed must be measured linearly at a distance of 0.3 ±0.05 meter (11.8 ±1.97 inch) from the blower outlet.
i) Cooling air speed measurements must be made with no vehicle or other obstruction in front of the blower outlet.
j) Instrument used to measure and verify cooling air speed must have an accuracy of 2 percent.