California Environmental Protection Agency

Air Resources Board

TP - 933

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

Adopted: ____ __, ____

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

1 APPLICABILITY

TP-933 is used by the Air Resources Board to determine OHRV evaporative emissions generated by off-angle spillage, fuel hose and tank permeation, running loss test, hot soak test, and diurnal tests. This test procedure is proposed pursuant to Section 43824 of the California Health and Safety Code (CH&SC) and is applicable in all cases where OHRVs are made available for sale, sold, or introduced into commerce in the State of California.

1.1 Terms and Definitions

This test procedure incorporates by reference the definitions set forth in the "CALIFORNIA EVAPORATIVE EMISSION STANDARDS AND TEST PROCEDURES FOR 2001 AND SUBSEQUENT MODEL MOTOR VEHICLES;" as amended March 22, 2012, and Title 13, California Code of Regulations (CCR) section 2417, including the incorporated definitions therein from the Code of Federal Regulations (CFR) and the CCR. In addition, the following definitions apply:

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

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

1.1.3 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.

1.1.4 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.

1.1.5 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, the term "travel axis" shall mean the axis defined by the direction the vehicle travels while in normal use defined by the points where the center front and rear tires contact the horizontal plane with the tires inflated to normal manufacturer recommendations. For vehicles with more than one front or rear tire, midpoints between the front and/or rear sets of tires shall be used. Under normal use conditions, this axis will rest in the horizontal plane.

1.1.7 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 as adopted March 22, 2012.

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 Principal and Summary of Test Procedures

This test procedure measures evaporative emissions from a compete vehicle or piece of equipment with complete evaporative emission control systems as defined in 13 CCR 2752 (a)(8) by subjecting them to a tip test, running loss, hot soak, and diurnal evaporative test sequence as described in section 6 of this procedure. The engine with complete evaporative emission control system must be tested as a complete vehicle except where a test rig is explicitly allowed.

The purpose of the tip test is to visually ensure the integrity of the fuel system against leakage during non-level orientations of the vehicle that are anticipated during normal operation.

A testing enclosure and hydrocarbon analyzer are used to measure running loss, hot soak, and diurnal evaporative emissions. This method subjects test equipment to a preprogrammed temperature profile while maintaining an atmospheric pressure and sampling for hydrocarbons with a hydrocarbon analyzer. The volume of the enclosure must be accurately determined whenever hydrocarbons are being measured. The total mass of hydrocarbons from a test vehicle over the test period is calculated based on concentration, molecular weight, and volume.

The mass of total hydrocarbons measured by the hydrocarbon analyzer over all three portions of the running loss test, hot soak test, and diurnal test may be compared against emissions standards for each individual test or a comprehensive standard for the entire test sequence.

As an alternative to the running loss enclosure method, a vehicle may undergo a point source test designed to measure evaporative emissions from the fuel system without the use of a sealed enclosure. An activated carbon trap with a BWC of at least twice the emissions measured may also be used to measure emissions from a canister vent in lieu of SHED testing on fuel injected vehicles, or carbureted vehicles subject to SHED testing for diurnal emissions, if the canister vent is the only source of running loss emissions.

As an alternative to the running loss test, a fuel injected vehicle may employ a gasoline tank that is vented to the intake system in such a way that any escaping vapors are burned in the engine and tank fuel temperature does not increase by more than 15°C when the vehicle is operated for a minimum of 46 minutes on a chassis dynamometer or test track using the Urban Dynamometer Driving Schedule at an ambient temperature of 68 - 95°F.

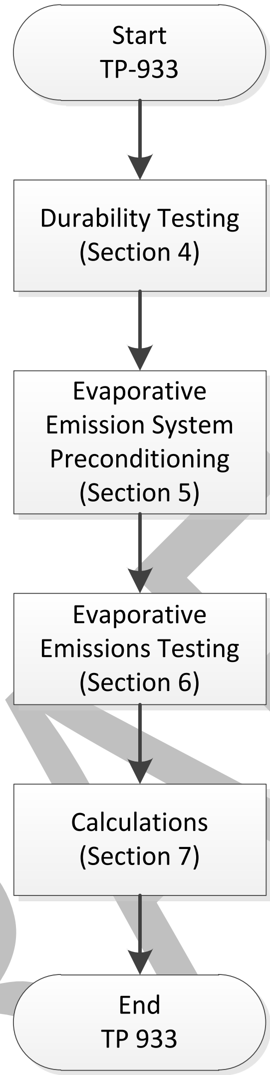
As an alternative to the diurnal evaporative emissions test, a vehicle may employ a tank vent pressure relief valve which seals the vehicle fuel system to a minimum pressure of 2 psig.

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. Durability testing is described in section 4 of this procedure. Durability testing will include physical and chemical aging of the fuel system components in a way that represents full useful life.

Except for the tip test specified in section 6.1, the vehicle shall be approximately level during all phases of the test sequence to prevent abnormal fuel distribution.

An overview of the procedure is shown in the following flow chart:

Figure 2-1 TP-933 Summary Flowchart



3 Instrumentation

Equipment used during this testing shall, at a minimum, meet the requirements set forth in this section.

3.1 Vehicle Test Enclosure

Refer to "CALIFORNIA EVAPORATIVE EMISSION STANDARDS AND TEST PROCEDURES FOR 2001 AND SUBSEQUENT MODEL MOTOR VEHICLES" adopted August 5, 1999, amended March 22, 2012, Parts III. A and III.B, included here by reference, for evaporative emission measurement enclosure requirements and calibrations with the following exception(s):

3.1.1 The hot soak and running loss temperature requirement is 95 °F (35 °C) or 86 °F (30 °C) for this procedure, depending on the standard being used. All references to a constant temperature of 105 °F with a given acceptable error range within Part III.A.2, Part III.A.3, and Part III B shall be replaced with 95 °F where the error range will remain unchanged. For vehicles being certified to the standards applicable for 30°C testing, all references to a constant temperature of 95°F shall be replaced with 86°F where the error range will remain unchanged. The diurnal temperature range of 65-105 °F will be replaced with the federal 72-96 °F temperature range.

3.1.2 For running loss, hot soak, diurnal evaporative tests, and tip test the fuel tank temperature is not controlled in this procedure. Fuel tank temperature is only controlled for the alternative point source method described in section 6.2. Therefore, disregard all sections pertaining to fuel tank temperature monitoring and fuel tank temperature management systems except as they relate the alternative point source method.

3.1.2.1 If performing the alternative point source method, fuel tank temperature must still be measured. Revise subparagraph 40 CFR §86.107-90(a)(5) (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 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 typical ambient temperature of 75°F ± 5°F.

3.3 Fuel Vapor Hydrocarbon Analyzer

The fuel vapor hydrocarbon analyzer shall meet the requirements specified in 40 CFR §86.107-90(a)(2)(i) and the fuel vapor alcohol analyzer shall meet the requirements specified in 40 CFR §86.107-90(a)(2)(ii). As described in Appendix II, 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:

- Cell/enclosure ambient temperature
- If applicable temperatures of vehicle fuel tank liquid (T_{liq}) and vapor space (T_{vap})
- If applicable vehicle fuel tank headspace pressure
- Dynamometer roll speed (if applicable)

- FID output voltage recording the following parameters for each sample analysis:
    - zero gas and span gas adjustments
    - zero gas reading
    - dilute sample bag reading (if applicable)
    - dilution air sample bag reading (if applicable)
    - zero gas and span gas readings
- Ethanol sampling data including:
    - the volumes of deionized water introduced into each impinge
    - the rate and time of sample collection
    - the volumes of each sample introduced into the gas chromatograph
    - the flow rate of carrier gas through the column
    - the column temperature
    - the chromatogram of the analyzed sample

3.5 Carbon Canister Bench Aging Equipment

Carbon canister bench aging equipment shall meet the requirements specified in section 4.2 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 0 of this procedure.

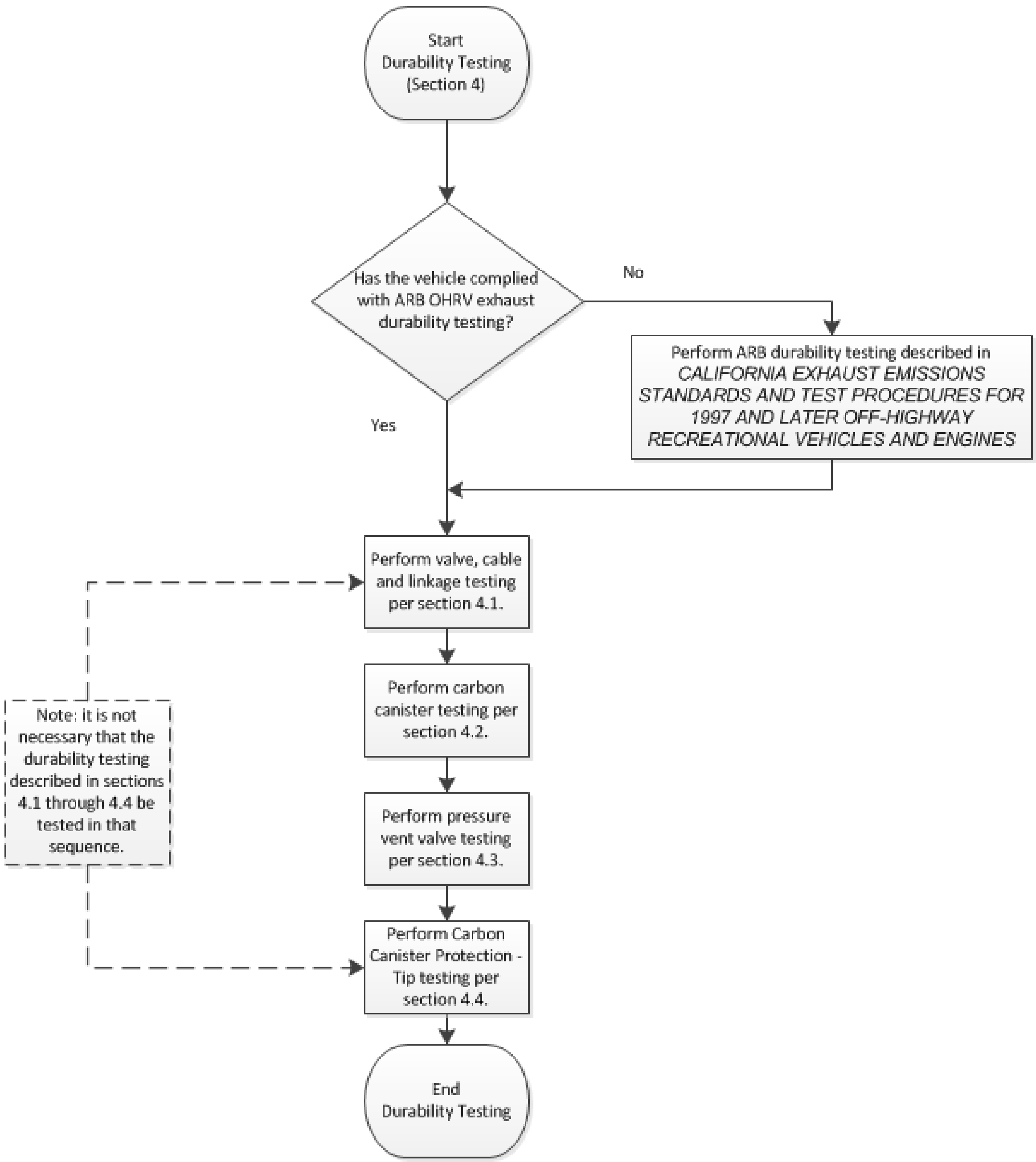
4 Durability Testing

Certification of an OHRV evaporative emission control system requires that the manufacturer demonstrate the durability of each evaporative emission control system family. A demonstration of durability of the applicant's evaporative emission control system is required prior to performing the evaporative emissions test described in section 6. Completing a durability demonstration prior to evaporative emissions testing ensures that the vehicle will meet evaporative emissions standards over the useful life of the vehicle. In the case where a vehicle has not undergone durability testing for exhaust testing as prescribed in the *CALIFORNIA EXHAUST EMISSIONS STANDARDS AND TEST PROCEDURES FOR 1997 AND LATER OFF-HIGHWAY RECREATIONAL VEHICLES AND ENGINES* as amended July 16, 2007, that vehicle must satisfy the applicable durability requirements of that procedure before proceeding to the durability testing section of this procedure unless each evaporative emissions-related part has undergone durability testing for exhaust testing in another model of vehicle.

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 ask to exclude any of the durability tests in this section if they can clearly demonstrate that the test does not affect the evaporative or permeation emissions.

The durability test is demonstrated by the flow chart below and shall include the following steps:

Figure 4-1 Durability Testing Flowchart


Start
Durability Testing
(Section 4)
Has the vehicle complied with ARB OHRV exhaust durability testing?
No
Perform ARB durability testing described in
CALIFORNIA EXHAUST EMISSIONS STANDARDS AND TEST PROCEDURES FOR 1997 AND LATER OFF-HIGHWAY RECREATIONAL VEHICLES AND ENGINES
Yes
Perform valve, cable and linkage testing per section 4.1.
Perform carbon canister testing per section 4.2.
Perform pressure vent valve testing per section 4.3.
Perform Carbon Canister Protection - Tip testing per section 4.4.
Note: it is not necessary that the durability testing described in sections 4.1 through 4.4 be tested in that sequence.
End
Durability Testing

4.1 Valves, Cables, Linkages

The durability test must actuate control valves, cables, and linkages, where applicable, for a minimum of 5,000 cycles.

4.2 Carbon Canister Test

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

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

- 4.2.1.1 Heat and hold at 60 ºC ± 2 ºC for 30 minutes. (Up to 10 minutes is allowed for the temperature to rise and stabilize.)
- 4.2.1.2 Cool and hold at 0 ºC ± 2 ºC for 30 minutes. (Up to 20 minutes is allowed for the temperature to reach 0 ºC during the cooling period.)

4.2.2 For the vibration test the canister must be subject to a peak horizontal force of 4.5G at 60Hz with a total of 10^7 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 the conduct of the test.

4.3 Pressure Vent Valve

If the fuel system employs a fuel vapor pressure vent valve, at 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 UV light, ozone, vibration and dust. Once approved, a manufacturer is not required to obtain a new approval for an evaporative emission durability demonstration unless changes to the evaporative system result in new testing requirements for that evaporative family.

4.4 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% of nominal capacity with certification fuel.

4.4.1 Orient the vehicle such that the travel axis is tilted +and- X degrees above the horizontal plane. See Figure 6-2 below. Hold this position in both the positive and negative position for at least 1 minute each. 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.

4.4.2 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 6- below. Hold this position in both the positive and negative position for at least 1 minute each. Y shall be as defined as follows:

a) Unsupported position on either side for off-road motorcycles.

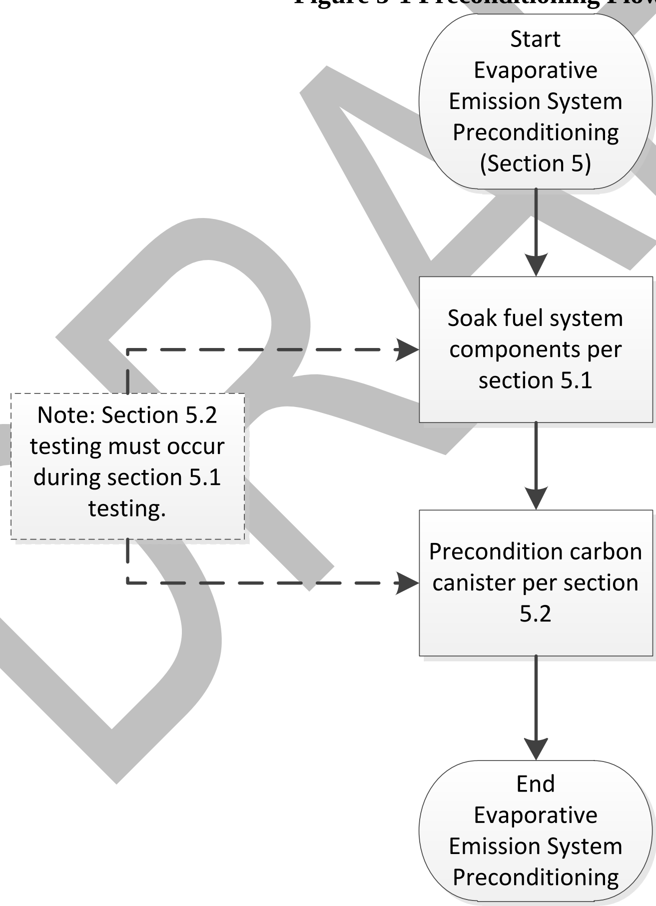
b) 15± 2° for all other OHRVs.

Vehicles must measure canister weight before and after the tests specified in this section to determine weight gain. If the weight gain is 10% of the butane working capacity or more, the vehicle fails the test.

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, 10% ethanol) fuel in it for a total 140 days. The preconditioning procedure is demonstrated by the flow chart below and shall include the following steps:

Figure 5-1 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 and cap within one minute of filling. After filling the tank start the engine and allow it to run at an 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 TP-901 (CARB SORE evap) or 40 CFR 1060.520 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 3360 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 up to 105°F for up to 14 days.

5.2 Precondition Carbon Canister

For systems that utilize carbon canisters, preconditioning of the carbon canister must be completed no sooner than 96 hours preceding the beginning of the evaporative emission test procedure described in section 6.

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:

- 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.
- 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.

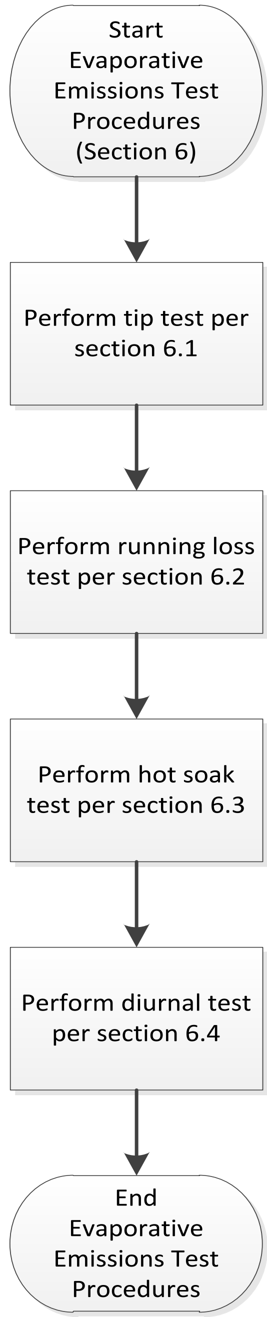
5.2.3 The canister purge shall be performed with ambient air of humidity controlled to 50±25 grains per pound of dry air. This may be accomplished by purging the canister in a room that is conditioned to this level of absolute humidity. The flow rate of the purge air shall be maintained at a nominal 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 are demonstrated by the flow chart below and shall include the following steps:

Figure 6-1 Evaporative Emissions Testing Flowchart



6.1 Fuel System Leakage - Tip Test

The fuel system leakage tip test shall be performed no more than 24 hours prior to the running loss test described in section 6.2. The fuel tank must be filled to 50% 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.

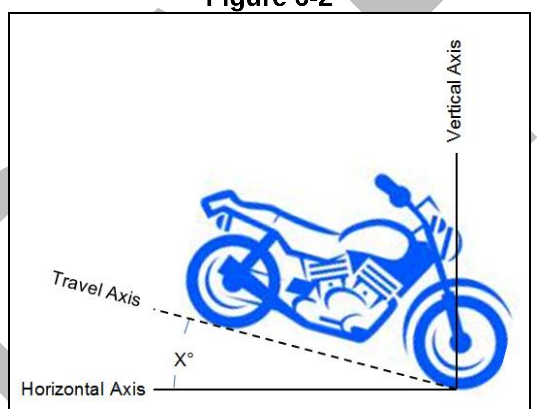
Engineering Analysis may be performed as an alternative to the tests described in this section. The analysis must demonstrate that zero liquid leakage will occur within one minute when the vehicle, with the gasoline tank filled to 50% of rated capacity, is tipped as specified in 6.1. To perform the analysis, a 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% 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 vehicle on a level surface as follows:

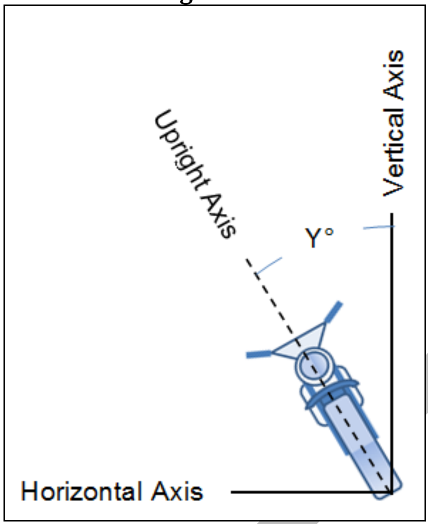
6.1.1 Orient the vehicle such that the travel axis is tilted +and- X degrees above the horizontal plane. See Figure 6-2 below. Hold this position in both the positive and negative position for at least 1 minute each. Note any visible signs of fuel leakage. X shall be as defined as follows:
a) 30± 2° for off-road motorcycles.
b) 30± 2° for all other OHRVs.

Figure 6-2



6.1.2 Orient the vehicle such that the upright axis is tilted +and- Y degrees from the vertical axis with rotation being about the travel axis. See Figure 6-3 below. Hold this position in both the positive and negative position for at least 1 minute each. Y shall be as defined as follows:
a) 30± 2° for off-road motorcycles.
b) 15± 2° for all other OHRVs.

Figure 6-3



6.2 Running Loss Test

The running loss test is designed to determine running loss emissions during simulated high-temperature urban driving.

6.2.1 The following steps shall be performed before prior to 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% with test fuel.

6.2.1.2 Soak at least 6 hours after being refueled. Following this soak period, operate the test vehicle through one UDDS driving cycle on a dynamometer. 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 the UDDS drive.

6.2.1.3 Drain and refill the fuel tank of the vehicle to 50% with test fuel.

6.2.1.4 Soak the vehicle with the key off for 12 to 36 hours at 68°F -86°F between the end of the refueling and the start of the cold start preconditioning cycle.

6.2.1.5 During the soak period, purge and load the evaporative control system canister using the procedures defined in sections 5.2.2, 5.2.3 and 5.2.4.

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

6.2.1.7 Following completion of the UDDS the test vehicle shall be soaked for a period of 6-36 hours at an ambient temperature of 95 ±3 °F or 86 ±3 °F, depending on the standard being used.

6.2.1.8 A cooling fan location and speed must comply with the requirements in Appendix III.

6.2.2 The OHRV will now be subjected to the running loss test or point source test as it is described in 40 CFR §86.134-96, with the following exceptions:

6.2.2.1 When the word "methanol" or the term C_{CH3OH} (methanol concentration) is used, it shall mean respectively ethanol or the term C_{C2H5OH} (ethanol concentration).

6.2.2.2 All references to the calculations performed in 40 CFR §86.143 shall reference the calculations performed in appendix II of this procedure instead.

6.2.2.3 Revise section (a) to read as follows, "Overview. Gasoline- and methanol-fueled vehicles are to be tested for running loss emissions during simulated high-temperature urban driving. If the vehicle is determined to have exceeded the standard before the end of the running loss test, the test may be terminated without invalidating the data. The test can be run either in a sealed enclosure or with the point-source method, as specified in paragraph (g) of this section. Measurement of vapor temperature is optional during the running loss test; however, if testing by the Executive Officer shows that a vehicle has exceeded an emission standard without measurement of vapor temperatures, the manufacturer may, utilizing its own resources, conduct subsequent testing on that vehicle to determine if the exceedance is attributable to inadequate control of vapor temperatures."

6.2.2.4 Revise section (b) to read as follows, "Driving schedule. Conduct the running loss test by operating the test vehicle through one EPA Urban Dynamometer Driving Schedule (UDDS) as specified in 40 CFR 86.115-78. Alternatively, the driving schedule in Appendix 1 may be followed."

6.2.2.5 Revise section (f) to read as follows, "Temperature stabilization discussed in this section is only required if the point source method in section (g)(2) is selected to satisfy the running loss testing requirements. The fuel may be heated or cooled to stabilize fuel temperatures, but the fuel heating rate must not exceed 5 °F in any 1-hour interval during this soak period. A manufacturer may use a faster heating rate or a longer period for stabilizing fuel temperatures if the needed heating cannot be easily accomplished in the 6-hour soak period, subject to prior approval."

6.2.2.6 Revise section (g)(1)(iv) to read as follows, "The test vehicle, with the engine off, shall be moved onto the dynamometer in the running loss enclosure and secured."

6.2.2.7 Revise section (g)(1)(v) to read as follows, "Fans shall be positioned as described in appendix III"

6.2.2.8 Omit sections (g)(1)(vi) and (g)(1)(x).

6.2.2.9 Revise section (g)(1)(xii) to read as follows, "When the ambient temperature is 95±5 °F (35±3 °C) or 86 ±3 °F (30 ±3 °C), depending on the alternative standard being used, the running loss test may begin. Measure the initial ambient temperature and pressure."

6.2.2.10 Omit sections (g)(1)(xv) and (g)(1)(xvi).

6.2.2.11 Revise section (g)(1)(xiX) to read as follows, "The running loss test ends with the completion of the EPA Urban Dynamometer Driving Schedule (UDDS) in section (b) of the running loss test."

6.2.2.12 Omit section (g)(1)(xx)(C).

6.2.2.13 Revise section (g)(2) to read as follows, "Point-source method. (i) The test vehicle, with the engine off, shall be moved onto the dynamometer."

6.2.2.14 Omit section (g)(2)(vi).

6.2.2.15 Revise section (g)(2)(xiii) to read as follows, “The running loss test ends with completion of the EPA Urban Dynamometer Driving Schedule (UDDS)in section (b) of the running loss test.”

6.2.2.16 Omit section (g)(3) and (h).

Following the completion of the running loss test or point source test drive, the vehicle will be tested for hot soak emissions as specified in 6.3.

6.3 Hot Soak Test

The hot soak evaporative emission test shall be performed within 7 minutes of the completion of the running loss test, performed in step 6.2. For vehicles exempt from the running loss test, the vehicle may be run over a single UDDS cycle outside of a SHED. During the time between the end of the dynamometer operation and the beginning of the hot soak test, the engine is allowed to be shut off no more than 4 minutes immediately preceding the start of the hot soak test.

6.3.1 This test is described in 40 CFR §86.138-96, with the following exceptions:

6.3.1.1 When the word "methanol" or the term C_{CH3OH} (methanol concentration) is used, it shall mean respectively ethanol or the term C_{C2H5OH} (ethanol concentration).

6.3.1.2 Omit section (a)(2).

6.3.1.3 Revise section (b)(2)(vi) to read as follows, “The cooling fan shall be moved, the vehicle shall be disconnected from the dynamometer and any sampling system, and pushed to the enclosure for the hot soak test. These steps should be done as quickly as possible to minimize the time needed to start the hot soak test.”

6.3.1.4 Omit section (b)(2)(ix).

6.3.1.5 Revise sections (f) and (j) to such that the test time will be 90±0.5 minutes instead of 60±0.5 minutes.

6.3.1.6 Omit sections (k) and (l).

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

6.4 Diurnal Test

Upon completion of the Hot Soak Test the Diurnal Test shall begin. The vehicle may forgo the diurnal test if the tank vent is sealed with a pressure relief valve rated with a value of no less than 2 psig.

Begin the 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.

6.4.1 Perform the diurnal test procedure described in 40 CFR §86.133-96, with the following exceptions:

6.4.1.1 When the word "methanol" or the term C_{CH3OH} (methanol concentration) is used, it shall mean respectively 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 shall mean the hot soak test previously described in section 6.3 of this procedure.
6.4.1.3 All references to the calculations performed in 40 CFR §86.143 shall reference the calculations performed in appendix II of this procedure instead.
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."
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 appendix II 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 …".

7 Calculations: Evaporative Emissions

To determine emissions, apply the calculations given in appendix II to the data collected in sections 6.2 through 6.4 of this test procedure.

8 List of Terms

ARB	California Air Resources Board
C_{C2H5OH}	Ethanol concentration
CFM	Cubic Feet per Minute
CFR	Code of Federal Regulations
CH&SC	California Health and Safety Code
HC	Hydro- Carbon
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-933	Test Procedure for determining evaporative emissions from off-highway recreational vehicles
UV	Ultra Violet
UDDS	EPA Urban Dynamometer Driving Schedule

9 References

1. Fuel System Evaporative Loss Control Devices, California Health and Safety Code §43824

2. California Evaporative Emission Standards and Test Procedures for 2001 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles, California Environmental Protection Agency, Air Resources Board, El Monte, CA, as amended on March 22, 2012.

3. Definitions, Title 13, CCR §2417

4. 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, as amended on March 22, 2012

5. Definitions, 13 CCR §2752

6. Sampling and analytical system; evaporative emissions, 40 CFR §86.107-90

7. Dynamometer, 40 CFR §86.108-00

8. Dynamometer calibration, 40 CFR §86.118-78

9. 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, as amended on July 16, 2007.
10. Running loss test, 40 CFR §86.134-96

11. EPA urban dynamometer driving schedule, 40 CFR §86.115-78

12. Sampling and analytical systems; evaporative emissions, 40 CFR §86.107-96

13. Diurnal emission test, 40 CFR §86.133-96

14. Hot soak test, 40 CFR §86.138-96

15. Calculations; evaporative emissions, 40 CFR §86.143

16. Test sequence; general requirements, 40 CFR §86.130-96

10 Appendix

10.1 Appendix I - Power Integrated Profile Load Profile

Overview:
To allow manufacturers flexibility in order to reduce the testing burden, an alternative load profile has been designed using the UDDS as a starting point. The UDDS speed profile is

converted to steady state load profile. While doing this the loads and wind speeds will be averaged.

1. Convert the UDDS speed profile into a force profile using force = mass x acceleration (F=MA.)
2. Road loads (given by a force in the CFR) are added to the force calculated in step 1 above.
3. The two forces found in step 1 and 2 above can be added together and converted into a power using the following equation Power = Force X Velocity.
4. The total power profile as calculated in step 3 is averaged over similar sections.
5. Wind speed is calculated by averaging the UDDS speed profile over the same time periods as used in step 4.

The UDDS can be found in 40CFR part 86 Appendix I. There are two separate speed profiles depending on OHRV displacement. For OHRVs with displacements over 170 cc use speed profile "b". For OHRVs with displacements under 170cc use speed profile "c". See Figure 10-1 below for a graphical representation of the two speed profiles

Figure 10-1 UDDS Speed Profiles

1. **Converting the UDDS into a force profile.**
   The UDDS is converted into a force profile using Newton' second law of motion, F=MA where F = force, M = mass and A= Acceleration. For these calculations mass is the mass of the OHRV and rider (80kg rider) being tested and acceleration is calculated from the change is velocity on a second by second basis from the UDDS. For running loss tests deceleration is assumed to not generate heat, so all negative acceleration values are set to zero. The actual equation used is:

   $\text{Force(N)} = \text{mass (kg)}*\Delta V(\text{km/h})*(1(\text{m/km})/3.6(\text{s/h}))$ where $\Delta V= V_{t+1} - V_t$

2. **Adding road loads to the power profile**

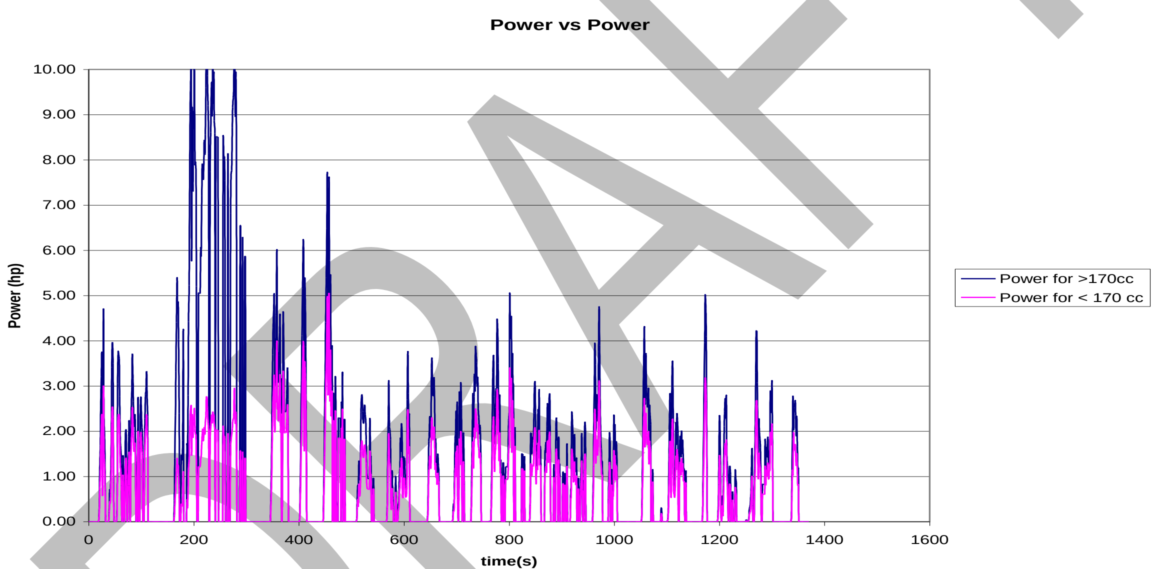
The CFR has an additional factor added to the total load on the vehicle being tested on the UDDS. The additional factor is road force which includes the load due to aerodynamics and road friction. The equation is given in 40 CFR part 86 section 529-98 as $F = A + CV^2$ where A and C are coefficients that are can be found in section 529-98 Figure f98-9 and where V = Velocity in km/h

3. **Converting the force profile into a power profile.**
Converting the force profile into a power profile is relatively simple since power is simply force times speed where speed is the average speed of the two points used to calculate ΔV. The equation used is:

Power (hp)= (road force (N) + Acceleration force (N))*average speed* (km/h)/3600(s/h)*1.341hp/kw Where average speed = $(V_{t+1}+V_t)/2$

See Figure 2 below for a sample load profile assuming OHRV weights of 500 lbs and 250 lbs for the <170 cc and >170 cc OHRVs respectively.

Figure 10-1 Load profiles for OHRVs Over and Under 170 cc



4. **Where to average the power profile**
In order to turn the dynamic load profile into a steady state load profile the loads are averaged over time periods with similar characteristics. Looking at Figure 10-1 for OHRVs over 170 cc there are three distinct time periods. The first is between 0 and 190 seconds and is characterized by relatively low engine loads. The second time period is from 191 to 310 seconds where the loads are characterized by relatively high loads. The third time period is from 310 seconds to the final test point at 1371 seconds. If the average power is calculated from those time periods the result is Figure 10-3 below. The load profile for OHRVs under 170 cc will be averaged over the same time periods.
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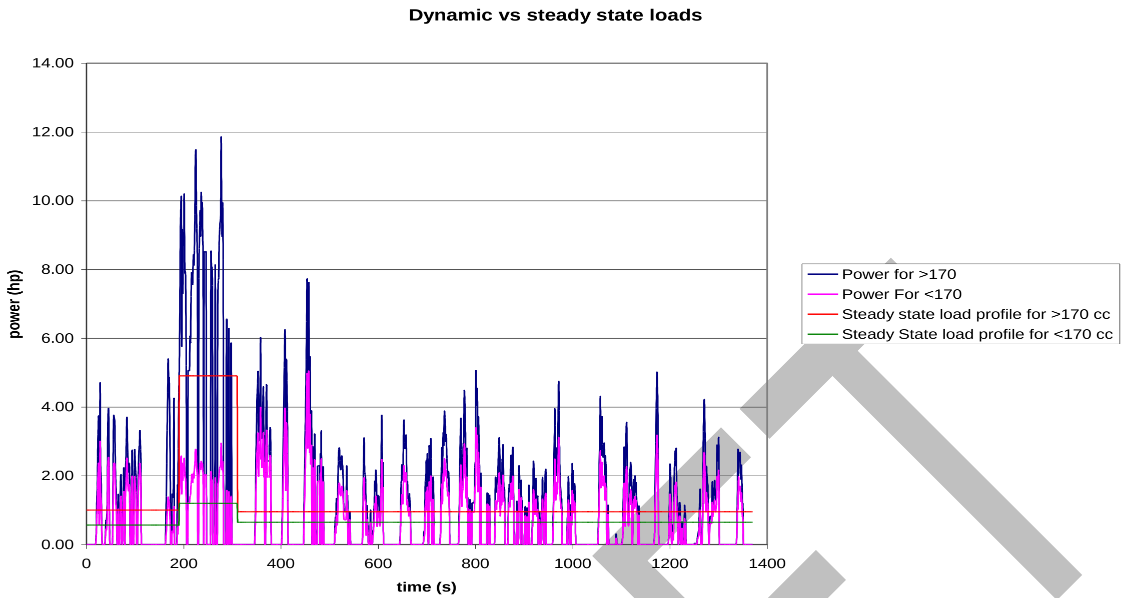
Figure 10-2 Dynamic vs. Steady State Loads



5. How to calculate wind speeds.

For a steady state test wind speed steady state as well. Wind speed is calculated by averaging the speeds from the UDDS over the same time periods as used to calculate steady state loads. Those time periods are:

1. 0 to 190 seconds
2. 191 to 310 seconds
3. 311 to 1371 seconds

See Figure 10-4 for graphical representation of average vs. dynamic wind speeds
See Figure 10-5 for actual steady state wind speeds

Figure 10-3 Dynamic vs. Steady State Wind Speeds

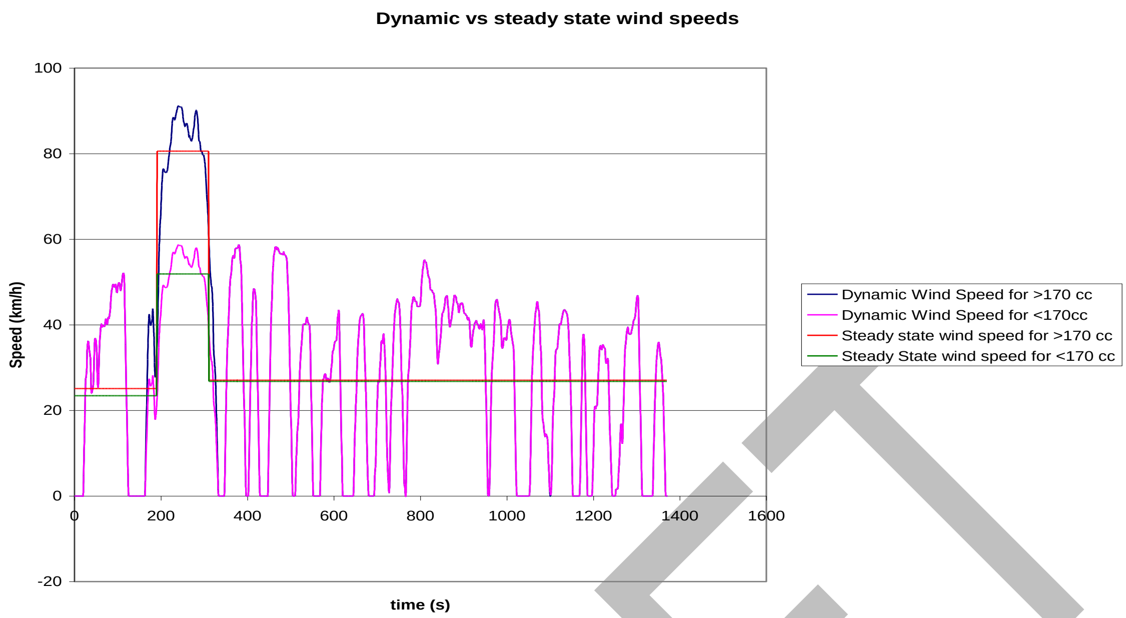


Figure 10-4 Steady State Wind Speeds

Time Period (s)	>170cc Wind Speed	<170cc Wind Speed
0-190	25.11	23.44
191-310	80.59	51.88
311-1371	27.05	26.78

10.2 Appendix II - Calculations

Evaporative Emissions[Update for Ethanol]

(a) The following equations are used to calculate the evaporative emissions from gasoline- and ethanol-fueled vehicles, and for gaseous-fueled vehicles.

(b) Use the measurements of initial and final concentrations to determine the mass of hydrocarbons and ethanol emitted. Alternatively, ethanol measurements may be omitted if the calculated mass of hydrocarbon emissions is multiplied by a percentage adjustment factor equal to: (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%)

(1) For enclosure testing of diurnal, hot soak, and running loss emissions:

(i) Ethanol emissions:

$$M_{C_2H_5OH} = V_n \times \left(\left[\frac{(C_{MS1f} \times AV_{1f}) + (C_{MS2f} \times AV_{2f})}{V_{E_f}} \right] - \left[\frac{(C_{MS1i} \times AV_{1i}) + (C_{MS2i} \times AV_{2i})}{V_{E_i}} \right] \right) + M_{C_2H_5OH,out} - M_{C_2H_5OH,in}$$

Where:

(A) M_{C2H5OH} = Ethanol mass change, µg.

(B) V_n= Net enclosure volume, ft^3, as determined by subtracting 5 ft^3 (1.42 m^3) from the enclosure volume. A manufacturer may use the measured volume of the vehicle (instead of the nominal 5 ft^3) with advance approval by the Administrator: Provided, the measured volume is determined and used for all vehicles tested by that manufacturer.

(C) V_E = Volume of sample withdrawn, ft^3. Sample volumes must be corrected for differences in temperature to be consistent with determination of V_n, prior to being used in the equation.

(D) C_{MS} = GC concentration of sample, µg/ml.
I
(E) AV = Volume of absorbing reagent in impinger.

(F) P_B = Barometric pressure at time of sampling, in. Hg.

(G) i = Initial sample.

(H) f = Final sample.

(I) 1 = First impinger.

(J) 2 = Second impinger.

(K) $M_{C2H5OH,out}$ =mass of ethanol exiting the enclosure, in the case of fixed-volume enclosures for diurnal emission testing, µg.

(L) $M_{C2H5OH,in}$ = mass of ethanol entering the enclosure, in the case of fixed-volume enclosures for diurnal emission testing, µg.

(ii) Hydrocarbon emissions:

$$M_{HC} = (kV_n \times 10^{-4}) \times \left(\frac{\left(C_{HC_f} - rC_{MC_2H_5OH_f}\right) P_{B_f}}{T_f} - \frac{\left(C_{HC_i} - rC_{MC_2H_5OH_i}\right) P_{B_i}}{T_i} \right) + M_{HC,out} - M_{HC,in}$$

Where,

(A) M_{HC} = Hydrocarbon mass change, g.

(B) C_{HC} = FID hydrocarbon concentration as ppm including FID response to methanol (or methane, as appropriate) in the sample.

(C) C_{C2H5OH} = Ethanol concentration as ppm carbon.

$$C_{C2H5OH} = \frac{1.501 \times 10^{-3} \times T}{P_B \times V_E} \times \left[\left(C_{S1} \times AV_1\right) + \left(C_{S2} \times AV_2\right) \right]$$

(D) V_n =Net enclosure volume ft^3 (m^3) as determined by subtracting 5 ft^3 (1.42 m^3) from the enclosure volume. A manufacturer may use the measured volume of the vehicle (instead of the nominal 5 ft^3) with advance approval by the Administrator, provided the measured volume is determined and used for all vehicles tested by that manufacturer.

(E) r = FID response factor to ethanol.

(F) P_B = Barometric pressure, in Hg (Kpa).

(G) T = Enclosure temperature, °R(°K).

(H) I = initial reading.

(I) f = final reading.

(J) 1 = First impinger.

(K) 2 = Second impinger.

(L) Assuming a hydrogen to carbon ratio of 2.3:

(1) k = 2.97; and

(2) For SI units, k = 17.16.

(M) $M_{HC,out}$ = mass of hydrocarbons exiting the enclosure, in the case of fixed-volume enclosures for diurnal emission testing, g.

(N) $M_{HC,in}$ = mass of hydrocarbons entering the enclosure, in the case of fixed-volume enclosures for diurnal emission testing, g.

(iii) For variable-volume enclosures, defined in 40 CFR §86.107(a)(1)(i), the following simplified form of the hydrocarbon mass change equation may be used:

$$(2) \qquad M_{HC} = \left(\frac{kP_B V_n \times 10^{-4}}{T}\right) \times \left[\left(C_{HC_f} - rC_{C_2H_5OH_f}\right) - \left(C_{HC_i} - rC_{C_2H_5OH_i}\right)\right]$$

(2) For running loss testing by the point-source method, the mass emissions of each test phase are calculated below, then summed for a total mass emission for the running loss test. If emissions are continuously sampled, the following equations can be used in integral form.

(i) Ethanol emissions:

$M_{C2H5OH} = \rho_{C2H5OH} \times V_{mix} \times (C_{C2H5OH,rl} - C_{C2H5OH,d})$

Where,

(A) M_{C2H5OH} = Ethanol mass change, µg.

(B) $\rho_{C2H5,OH}$ = 37.71 g/ft^3 , density of pure vapor at 68 °F.

(C) V_{mix} = total dilute sample volume, in ft^3 , calculated as appropriate for the collection technique used.

(D) $C_{C2H5OH,rl}$ = Ethanol concentration of diluted running loss sample, in ppm carbon equivalent.

(E) $C_{C2H5OH,d}$ = Ethanol concentration of dilution air, in ppm carbon equivalent.

(ii) Hydrocarbon emissions:

$M_{HC} = \rho_{HC} V_{mix} 10^{-6} \times (C_{HC,rl} - C_{HC,d})$

Where,

(A) M_{HC} = hydrocarbon mass change, g.

(B) ρ_{HC} = 16.88 g/ft^3, density of pure vapor at 68 °F (for hydrogen to carbon ratio of 2.3).

(C) V_{mix} = total dilute sample volume, in ft^3, calculated as appropriate for the collection technique used.

(D) $C_{HC,rl}$ = hydrocarbon concentration of diluted running loss sample, in ppm carbon equivalent.

(E) $C_{HC,d}$ = hydrocarbon concentration of dilution air, in ppm carbon equivalent.

(c) Calculate the adjusted total mass emissions for each test segment.

(1) $$M_{DI} = \left(M_{HC} + \frac{14.3594}{32.042} \times 10^{-6}\ M_{C_2H_5OH}\right)_{DI}$$

where M_{DI}=mass emissions from the diurnal emission test (see 6.4), g.

(2) $$M_{HS} = \left(M_{HC} + \frac{14.2284}{32.042} \times 10^{-6}\ M_{C_2H_5OH}\right)_{HS}$$

where M_{HS}=mass emissions from the hot soak test (see 6.3), g.

(3) $$M_{RL} = \left(M_{HC} + \frac{14.2284}{32.042} \times 10^{-6}\ M_{C_2H_5OH}\right)_{RL}$$

where M_{RL} = mass emissions from the running loss test in (see 6.2), g.

(d)(1) For the full three-diurnal test sequence, there are two final results to report:

(i) The sum of the adjusted total mass emissions for the diurnal and hot soak tests (M_{DI}+M_{HS}); and

(ii) The adjusted total mass emissions for the running loss test, on a grams per mile basis = M_{RL}/D_{RL}, where D_{RL} = miles driven for the running loss test in section 6.2(see 40 CFR §86.134–96(c)(6)).

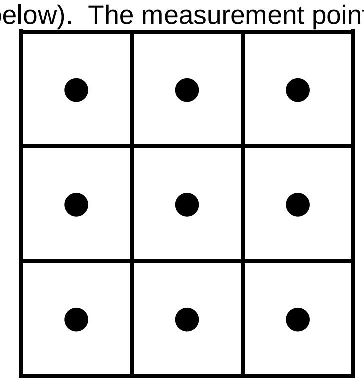
10.3 Appendix III – Fan Speed Measurement

1. Variable speed cooling blower must direct air to the vehicle.
2. Blower outlet must be at least 0.4 meter^2 (4.31 feet^2).
3. Blower outlet must be squarely positioned 0.3 ± 0.05 meter (11.8 ± 1.97 inch) in front of the vehicle.
4. Blower outlet lower edge height must be 0.1 meter (3.94 inch) to 0.2 meter (7.87 inch) above the ground.
5. Cooling air speed produced by the blower must be within the following limits (as a function of roll speed):

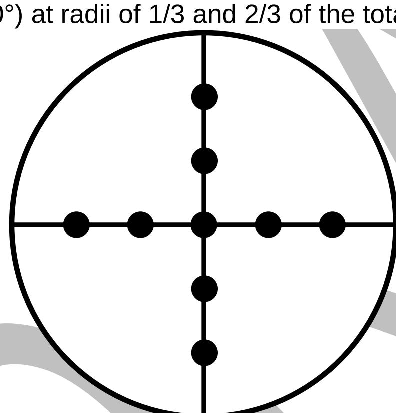
Actual roll speed	Allowable cooling air speed
0 km/h	0 km/h
0 km/h to 5 km/h	0 km/h to roll speed + 2.5 km/h

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

6. The cooling air speed above must be determined as an averaged value of 9 measuring points.
   a. 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.



   b. 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.



7. 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.
8. Cooling air speed must be measured linearly at a distance of 0.3 meter (11.8 inch) ± 2 percent from the blower outlet.
9. Cooling air speed measurements must be made with no vehicle or other obstruction in front of the blower outlet.
10. Instrument used to measure and verify cooling air speed must have an accuracy of 2 percent.