California Environmental Protection Agency

Air Resources Board

Small Off-Road Engine and Equipment Evaporative Emissions Test Procedure

Honda's alternative
TP - 902

Test Procedure for Determining Diurnal Evaporative Emissions from Small Off-Road Engines and Equipment

Adopted: July 26, 2004

Honda's Alternative TP – 902 proposed: January 26, 2006

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Small Off-Road Engine and Equipment Evaporative Emissions Test Procedure

TP-902 (Honda's Alternative Procedure)

Test Procedure for Determining Diurnal Evaporative Emissions from Small Off-Road Engines and Equipment

A set of definitions common to all Certification and Test Procedures are in Title 13, California Code of Regulations (CCR), Section 2752 et seq.

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

1. APPLICABILITY

This Test Procedure, TP-902, is used by the Air Resources Board to determine the diurnal and resting loss evaporative emissions from small off-road engines and equipment less than or equal to 19 kilowatts. Small off-road engines are defined in Title 13, California Code of Regulations (CCR), section 2401 et seq. 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 small off-road engines are sold, supplied, offered for sale, or manufactured for use in the State of California.

1.1 Requirement to Comply with All Other Applicable Codes and Regulations

Certification or approval of any engine or evaporative emission control system by the Executive Officer does not exempt the engine or evaporative emission control system from compliance with other applicable codes and regulations such as state and federal safety codes and regulations.

1.2 Safety

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

2. PERFORMANCE STANDARDS

The minimum performance standards for certification of evaporative emission control systems on small off-road engines or equipment that use small off-road engines is defined in CCR Title 13, Chapter 15, Article 1, Section 2754.

3. PRE-CERTIFICATION REQUIREMENTS

3.1 Durability

A demonstration of durability of the applicant's evaporative emission control system is required prior to performing an evaporative emissions test.

Prior to the commencement of a durability demonstration, the applicant is required to submit and obtain approval of an evaporative emission durability test procedure. Once approved, a manufacturer is not required to obtain a new approval for an evaporative emission durability demonstration unless changes result in new testing requirements.

Tanks that have a secondary operation for drilling holes for insertion of fuel line and grommet system may have these eliminated for purposes of durability demonstration.

Components shall be deemed acceptable if they remain functional after the durability demonstration prescribed below. Fuel tanks utilized for certification must have pressure/vacuum (if applicable) and slosh testing prior to certification testing.

The Executive Officer shall review the method based on the following requirements:

(a) The durability test must actuate control valves, cables, and linkages, where applicable, for a minimum of 5000 cycles.

(b) The Pressure/Vacuum test is performed prior to any preconditioning of the fuel tank. Determine the fuel tank system's high pressure and vacuum limits, which are expected to occur under normal operating conditions including engine stop condition, considering the influence of any associated pressure/vacuum relief components. Pressurize the empty tank, sealed with the OEM fuel cap, or a modified OEM fuel cap as required, to within 10% of the system's normal high pressure operating limit and then evacuate to within 10% of the system's normal vacuum operating limit. If the fuel tank has no features that would cause positive or negative pressures during normal operation including engine stop condition, then pressure/vacuum cycling is not required. [

] The tank pressure/vacuum cycling shall be performed in a 49º C+/- 3º C ambient with compressed air of no less than 21º C. Repeat the pressure/vacuum process until the tank has been subjected to not less than 1000 cycles in 8 hours +/- 1 hour.

(c) The durability test must include a slosh test of the engines fuel tank (except steel fuel tanks are exempt from slosh testing). The slosh test can be performed during the preconditioning period. A slosh test must be performed on a fuel tank filled to 50 percent capacity with CERT fuel. The fuel tank must be sealed with the OEM fuel cap. A laboratory orbital shaker table or similar device is then used to subject the tank to a peak horizontal centripetal acceleration of at least 2.4 meter/second^2 at a frequency of 2 cycles per second +/- 0.25 for one million cycles. As an alternative, slosh testing may be performed using the method specified in 40 CFR Part 1051 §1051.515 (c).

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

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

(A) Heat and hold at 60ºC ± 2ºC for 30 minutes. (Up to 10 minutes is allowed for the temperature to rise and stabilize.)

(B) Cool and hold at 0ºC ± 2ºC for 30 minutes. (Up to 20 minutes is allowed for the temperature to reach 0ºC during the cooling period.)

(2) For vibration exposure, at a minimum, the canister must be placed in a suitable test fixture while maintaining its specified orientation (as designed). Subject the fixture to a peak horizontal vibration force of 4.5G x 60Hz x 10^7 times.

3.2 Canister Working Capacity

(a) For evaporative emission control systems that only use a carbon canister and do not pressurize the fuel tank, the carbon canister must have a working capacity of at least 1.4 grams of vapor storage capacity per liter of nominal fuel tank volume for tanks greater than or equal to 3.78 liters, and 1.0 grams of vapor storage capacity per liter of nominal fuel tank volume for tanks less than 3.78 liters. For evaporative emission control systems that use a carbon canister and pressurized fuel tank, the working capacity must be specified by the applicant. For all systems utilizing actively purged carbon canisters, running loss emissions must be controlled from being emitted into the atmosphere.

(b) Working capacity is determined following the procedure in Attachment 1 of this test procedure. In lieu of the loading and purge rates specified in Attachment 1, the canister manufacturer's maximum loading and purge rates may be used.

3.3 Engine Purge

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4. GENERAL SUMMARY OF TEST PROCEDURE

A Sealed Housing for Evaporative Determination (SHED) is used to measure diurnal emissions. This method subjects test engines to a preprogrammed temperature profile while maintaining a constant pressure and continuously sampling for hydrocarbons with a Flame Ionization Detector (FID). The volume of a SHED enclosure can be accurately determined. The mass of total hydrocarbons that emanates from a test engine over the test period is calculated using the ideal gas equation.

This test procedure measures diurnal emissions from engines or equipment with complete evaporative emission control systems as defined in 13 CCR 2752 (a)(8) by subjecting them to a hot soak and diurnal test sequence. The engine with complete evaporative emission control system can be tested without the equipment chassis. The basic process is as follows:

- Fill the engine fuel tank with fuel and operate at maximum governed speed for 5-minutes
- Precondition the evaporative emission control and fuel delivery system
- Drain and fill fuel tank to 50% capacity with California certification fuel
- [*]*, purge carbon canister with 400 bed volumes of nitrogen or dry air at the canister manufacturer's recommended rate
- Operate engine at the maximum governed speed for fifteen minutes
- Subject engine/equipment to a one-hour constant 95°F hot soak
- Soak engine/equipment for two hours at 65°F
- Subject engine/equipment to a 24-hour variable (65°F - 105°F - 65°F) temperature diurnal profile

The mass of total hydrocarbons measured by the SHED over the 24-hour diurnal profile is compared with the performance standards in CCR Title 13, Chapter 15, Article 1, Section 2754. Engines or equipment that meet the appropriate performance standard shall be considered compliant.

5. INSTRUMENTATION

The instrumentation necessary to perform evaporative emission testing for small off-road engines is the same instrumentation used for passenger cars and light duty vehicles, and is described in 40 CFR 86.107-96. The ARB will consider data generated with mini-SHEDs as valid if approved as an alternative test procedure.

5.1 Diurnal Evaporative Emission Measurement Enclosure

References to methanol in this test procedure can be disregarded.

The diurnal evaporative emissions measurement enclosure shall be equipped with an internal blower or blowers coupled with an air temperature management system (typically air to water heat exchangers and associated programmable temperature controls) to provide for air mixing and temperature control. The blower(s) shall provide a nominal total flow rate of 0.8 ± 0.2 ft^3/min per ft^3 of the nominal enclosure volume, V_n. The inlets and outlets of the air circulation blower(s) shall be configured to provide a well-dispersed air circulation pattern that produces effective internal mixing and avoids significant temperature or hydrocarbon and alcohol stratification. The discharge and intake air diffusers in the enclosure shall be configured and adjusted to eliminate localized high air velocities which could produce non-representative heat transfer rates between the engine fuel tank(s) and the air in the enclosure. The air circulation blower(s), plus any additional blowers if required, shall maintain a homogeneous mixture of air within the enclosure.

The enclosure temperature shall be taken with thermocouples located 3 feet above the floor at the approximate mid-length of each side wall of the enclosure and within 3 to 12 inches of each side wall. The temperature conditioning system shall be capable of controlling the internal enclosure air temperature to follow the prescribed temperature versus time cycle as specified in 40 CFR §86.133-90 as modified by paragraph III.D.10 (diurnal breathing loss test) of the "California Evaporative Emission Standards and Test Procedures for 2001 and Subsequent Model Motor Vehicles" within an instantaneous tolerance of ± 3.0°F and an average tolerance of ± 2.0°F as measured by side wall thermocouples. The control system shall be tuned to provide a smooth temperature pattern, which has a minimum of overshoot, hunting, and instability about the desired long-term temperature profile.

The enclosure shall be of sufficient size to contain the test equipment with personnel access space. It shall use materials on its interior surfaces, which do not adsorb or desorb hydrocarbons, or alcohols (if the enclosure is used for alcohol-fueled vehicles). The enclosure shall be insulated to enable the test temperature profile to be achieved with a heating/cooling system, which has minimum surface temperatures in the enclosure no less than 25.0^{o}F below the minimum diurnal temperature specification. The enclosure shall be equipped with a pressure transducer with an accuracy and precision of ± 0.1 inches H_2O. The enclosure shall be constructed with a minimum number of seams and joints, which provide potential leakage paths. Particular attention shall be given to sealing and gasketing of such seams and joints to prevent leakage.

The enclosure shall be equipped with features, which provide for the effective enclosure volume to expand and contract in response to both the temperature changes of the air mass in the enclosure, and any fluctuations in the ambient barometric pressure during the duration of the test. Either a variable volume enclosure or a fixed volume enclosure may be used for diurnal emission testing.

A variable volume enclosure shall have the capability of latching or otherwise constraining the enclosed volume to a known, fixed value, V_n. The V_n shall be determined by measuring all pertinent dimensions of the enclosure in its latched configuration, including internal fixtures, based on a temperature of 84^{o}F, to an accuracy of ± 1/8 inch (0.5 cm) and calculating the net V_n to the nearest 1 ft^3. In addition, V_n shall be measured based on a temperature of 65^{o}F and 105^{o}F. The latching system shall provide a fixed volume with an accuracy and repeatability of $0.005xV_n$. Two potential means of providing the volume accommodation capabilities are; a moveable ceiling which is joined to the enclosure walls with a flexure, or a flexible bag or bags of Tedlar or other suitable materials, which are installed in the enclosure and provided with flowpaths which communicate with the ambient air outside the enclosure. By moving air into and out of the bag(s), the contained volume can be adjusted dynamically. The total enclosure volume accommodation shall be sufficient to balance the volume changes produced by the difference between the extreme enclosure temperatures and the ambient laboratory temperature with the addition of a superimposed barometric pressure change of 0.8 in. Hg. A minimum total volume accommodation range of ± $0.07xV_n$ shall be used. The action of the enclosure volume accommodation system shall limit the differential between the enclosure internal pressure and the external ambient barometric pressure to a maximum value of ± 2.0 inches H_2O.

The fixed volume enclosure shall be constructed with rigid panels that maintain a fixed enclosure volume, which shall be referred to as V_n. V_n shall be determined by measuring all pertinent dimensions of the enclosure including internal fixtures to an accuracy of ± 1/8 inch (0.5 cm) and calculating the net V_n to the nearest 1 ft^3. The enclosure shall be equipped with an outlet flow stream that withdraws air at a low, constant rate and provides makeup air as needed, or by reversing the flow of air into and out of the enclosure in response to rising or falling temperatures. If inlet air is added continuously throughout the test, it must be filtered with activated carbon to provide a relatively constant hydrocarbon and alcohol level. Any method of volume accommodation shall maintain the differential between the enclosure internal pressure and the barometric pressure to a maximum value of ±2.0 inches of water. The equipment shall be capable of measuring the mass of hydrocarbon, and alcohol (if the enclosure is used for alcohol-fueled equipment) in the inlet and outlet flow streams with a resolution of 0.01 gram. A bag sampling system may be used to collect a proportional sample of the air withdrawn from and admitted to the enclosure. Alternatively, the inlet and outlet flow streams may be continuously analyzed using an on-line Flame Ionization Detector (FID) analyzer and integrated with the flow measurements to provide a continuous record of the mass hydrocarbon and alcohol removal.

An online computer system or strip chart recorder shall be used to record the following parameters during the diurnal evaporative emissions test sequence:

- Enclosure internal air temperature
- Diurnal ambient air temperature specified profile as defined in 40 CFR
- §86.133-90 as modified in paragraph III.D.10 of the "California evaporative Emission Standards and Test Procedures for 2001 and Subsequent Model Motor Vehicles" (diurnal breathing loss test).
- Enclosure internal pressure
- Enclosure temperature control system surface temperature(s)
- FID output voltage recording the following parameters for each sample analysis:
- zero gas and span gas adjustments
- zero gas reading
- enclosure sample reading
- zero gas and span gas readings

The data recording system shall have a time resolution of 30 seconds and shall provide a permanent record in magnetic, electronic or paper media of the above parameters for the duration of the test.

Other equipment configurations may be used if approved in advance by the Executive Officer. The Executive Officer shall approve alternative equipment configurations if the manufacturer demonstrates that the equipment will yield test results equivalent to those resulting from use of the specified equipment.

5.2 Calibrations

Evaporative emission enclosure calibrations are specified in 40 CFR §86.117-90. Methanol measurements may be omitted when methanol-fueled engines will not be tested in the evaporative enclosure. Amend 40 CFR §86.117-90 to include an additional subsection 1.1, to read:

The diurnal evaporative emission measurement enclosure calibration consists of the following parts: initial and periodic determination of enclosure background emissions, initial determination of enclosure volume, and periodic hydrocarbon (HC) and methanol retention check and calibration. Calibration for HC and methanol may be conducted in the same test run or in sequential test runs.

5.2.1 The initial and periodic determination of enclosure background emissions shall be conducted according to the procedures specified in §86.117-90(a)(1) through (a)(6). The enclosure shall be maintained at a nominal temperature of 105.0°F throughout the four-hour period. Variable volume enclosures may be operated either in the latched volume configuration, or with the variable volume feature active. Fixed volume enclosures shall be operated with inlet and outlet flow streams closed. The allowable enclosure background emissions of HC and/or methanol as calculated according to 40 CFR §86.117-90(a)(7) shall not be greater than 0.05 grams in 4 hours. The enclosure may be sealed and the mixing fan operated for a period of up to 12 hours before the initial HC concentration reading (C_{HCi}) and the initial methanol concentration reading (C_{CH3OHi}) is taken and the four-hour background measurement period begins.

5.2.2 The initial determination of enclosure internal volume shall be performed according to the procedures specified in paragraph I.A.1.3 of the "California Evaporative Emission Standards and Test Procedures for 2001 and Subsequent Model Motor Vehicles." If the enclosure will be used for hot soak determination, the determination of enclosure internal volume shall also be performed based on 105°F.

5.2.3 The HC and methanol measurement and retention checks shall evaluate the accuracy of enclosure HC and methanol mass measurements and the ability of the enclosure to retain trapped HC and methanol. The check shall be conducted over a 24-hour period with all of the normally functioning subsystems of the enclosure active. A known mass of propane and/or methanol shall be injected into the enclosure and an initial enclosure mass measurement(s) shall be made. The enclosure shall be subjected to the temperature cycling specified in paragraph III.D.10.1.7 of the "California Evaporative Emission Standards and Test Procedures for 2001 and Subsequent Model Motor Vehicles" (revising 40 CFR §86.133-90(l)) for a 24-hour period. The temperature cycle shall begin at 105 F (hour 11) and continue according to the schedule until a full 24-hour cycle is completed. A final enclosure mass measurement(s) shall be made. The following procedure shall be performed prior to the introduction of the enclosure into service and following any modifications or repairs to the enclosure that may impact the integrity of this enclosure; otherwise, the following procedure shall be performed on a monthly basis. (If six consecutive monthly retention checks are successfully completed without corrective action, the following procedure may be determined quarterly thereafter as long as no corrective action is required.)

(A) Zero and span the HC analyzer.

(B) Purge the enclosure with atmospheric air until a stable enclosure HC level is attained.

(C) Turn on the enclosure air mixing and temperature control system and adjust it for an initial temperature of 105.0°F and a programmed temperature profile covering one diurnal cycle over a 24 hour period according to the profile specified in paragraph III.D.10.1.7. Of the "California Evaporative Emission Standards and Test Procedures for 2001 and Subsequent Model Motor Vehicles" (revising 40 CFR §86.133-90). Close the enclosure door. On variable volume enclosures, latch the enclosure to the enclosure volume measured at 105°F. On fixed volume enclosures, close the outlet and inlet flow streams.

(D) When the enclosure temperature stabilizes at 105.0°F ± 3.0°F seal the enclosure; measure the enclosure background HC concentration (C_{HCe1}) and/or background methanol concentration (C_{CH3OH1}) and the temperature (T_1), and pressure (P_1) in the enclosure.

(E) Inject into the enclosure a known quantity of propane between 2 to 6 grams and a known quantity of methanol in gaseous form between 2 to 6 grams. For evaporative emission enclosures that will be used for testing equipment subject to the standards shown in Table 2-1, use a known amount of propane or gaseous methanol between 0.5 to 1.0 grams. The injection method shall use a critical flow orifice to meter the propane and/or methanol at a measured temperature and pressure for a measured time period. Techniques that provide an accuracy and precision of ± 0.5 percent of the injected mass are also acceptable. Allow the enclosure internal HC and/or methanol concentration to mix and stabilize for up to 300 seconds. Measure the enclosure HC concentration (C_{HCe2}) and/or the enclosure methanol concentration (C_{CH3OH2}). For fixed volume enclosures, measure the temperature (T_2) and pressure in the enclosure (P_2). On variable volume enclosures, unlatch the enclosure. On fixed volume enclosures, open the outlet and inlet flow streams. Start the temperature cycling function of the enclosure air mixing and temperature control system. These steps shall be completed within 900 seconds of sealing the enclosure.

(F) For fixed volume enclosures, calculate the initial recovered HC mass (M_{HCe1}) according to the following formula:

$$M_{HCe1} = (3.05 \times V \times 10^{-4} \times [P_2 (C_{HCe2} - rC_{CH3OH2})/T_2 - P_1 (C_{HCe1} - rC_{CH3OH1})/T_1])$$

Where:

V is the enclosure volume at 105°F (ft^3)
P_1 is the enclosure initial pressure (inches Hg absolute)
P_2 is the enclosure final pressure (inches Hg absolute)
C_{HCen} is the enclosure HC concentration at event n (ppm C)

C_{CH3OHn} is the enclosure methanol concentration calculated according to 40 CFR §86.117-90 (d)(2)(iii) at event n (ppm C)
r is the FID response factor to methanol
T_1 is the enclosure initial temperature (°R)
T_2 is the enclosure final temperature (°R)

For variable volume enclosures, calculate the initial recovered HC mass and initial recovered methanol mass according to the equations used above except that P_2 and T_2 shall equal P_1 and T_1.

Calculate the initial recovered methanol mass (M_{CH3OH1}) according to 40 CFR §86.117-96(d)(1), as amended March 24, 1993.

If the recovered HC mass agrees with the injected mass within 2.0 percent and/or the recovered methanol mass agrees with the injected mass within 6.0 percent, continue the test for the 24 hour temperature cycling period. If the recovered mass differs from the injected mass by greater than the acceptable percentage(s) for HC and/or methanol, repeat the enclosure concentration measurement in step (E) and recalculate the initial recovered HC mass (M_{HCe1}) and/or methanol mass (M_{CH3OH1}). If the recovered mass based on the latest concentration measurement agrees within the acceptable percentage(s) of the injected mass, continue the test for the 24-hour temperature cycling period and substitute this second enclosure concentration measurement for C_{HCe2} and/or C_{CH3OH2} in all subsequent calculations. In order to be a valid calibration, the final measurement of C_{HCe2} and C_{CH3OH2} shall be completed within the 900-second time limit outlined above. If the discrepancy persists, the test shall be terminated and the cause of the difference determined, followed by the correction of the problems(s) and the restart of the test.

(G) At the completion of the 24-hour temperature cycling period, measure the final enclosure HC concentration (C_{HCe3}) and/or the final enclosure methanol concentration (C_{CH3OH3}). For fixed-volume enclosures, measure the final pressure (P_3) and final temperature (T_3) in the enclosure.

For fixed volume enclosures, calculate the final recovered HC mass (M_{HCe2}) as follows:

$$M_{HCe2} = [3.05 \times V \times 10^{-4} \times (P_3 (C_{HCe3} - rC_{CH3OH3})/T_3 - P_1 (C_{HCe1} - rC_{CH3OH1})/T_1)] + M_{HC,out} - M_{HC, in}$$

Where:

V is the enclosure volume at 105^{o}F (ft^3)
P_1 is the enclosure initial pressure (inches Hg absolute)
P_3 is the enclosure final pressure (inches Hg absolute)
C_{HCe3} is the enclosure HC concentration at the end of the 24-hour temperature cycling period (ppm C)
C_{CH3OH3} is the enclosure methanol concentration at the end of the 24-hour temperature cycling period, calculated according to 40 CFR §86.117-90 (d)(2)(iii) (ppm C)
r is the FID response factor to methanol
T_1 is the enclosure initial temperature (^{o}R)
T_3 is the enclosure final temperature (^{o}R)
$M_{HC,out}$ is mass of HC exiting the enclosure, (grams)
$M_{HC,in}$ is mass of HC entering the enclosure, (grams)

For variable volume enclosures, calculate the final recovered HC mass and final recovered methanol mass according to the equations used above except that P_3 and T_3 shall equal P_1 and T_1, and $M_{HC, out}$ and $M_{HC, in}$ shall equal zero.

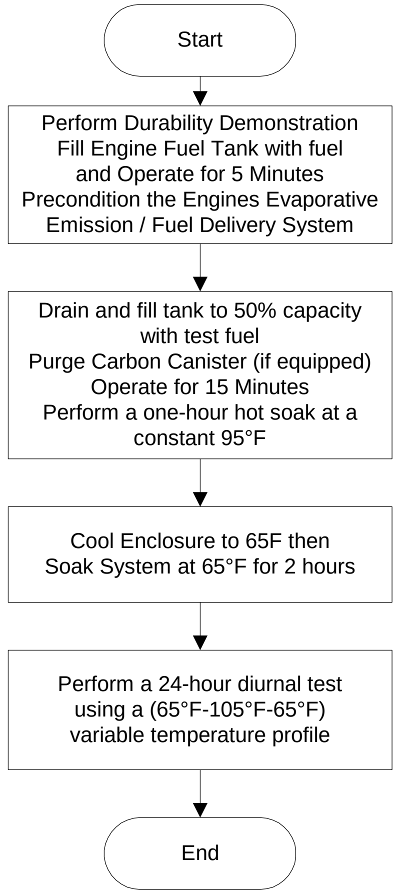
Calculate the final recovered methanol mass (M_{CH3OH2}) according to 40 CFR §86.117-96(d)(1), as amended March 24, 1993.

(H) If the calculated final recovered HC mass for the enclosures is not within 3 percent of the initial enclosure mass, or if the calculated final recovered methanol mass for the enclosures is not within 6 percent of the initial enclosure mass, then action shall be required to correct the error to the acceptable level.

6. TEST PROCEDURE

The test sequence is shown graphically in Figure 1. Methanol measurements may be omitted when methanol-fueled equipment will not be tested in the evaporative enclosure. The temperatures monitored during testing shall be representative of those experienced by the equipment. The equipment shall be approximately level during all phases of the test sequence to prevent abnormal fuel distribution. The temperature tolerance of a soak period

Figure 1.



may be waived for up to 10 minutes to allow purging of the enclosure or transporting the equipment into the enclosure.

Testing a representative piece of equipment for each evaporative family and comparing the results to the appropriate performance standard determines compliance with requirements of CCR Title 13, Chapter 15, Article 1, Section 2754.

The 24-hour diurnal test sequence is shown in Figure 1.

6.1 Fuel Tank / Fuel System Preconditioning

The purpose of the preconditioning period is to introduce gasoline into the fuel system and precondition all fuel system components. Precondition the tank and other fuel delivery system components by filling the tank to its nominal capacity with fresh test fuel as specified in Section 7 of these procedures. After filling the tank start the engine and allow it to run at rated speed (unloaded or blade load) for approximately five minutes. Soak the tank and other components at 30º C ± 10º C for not less than 140 days. Data documenting that the tank has reached equilibrium must be provided for tanks soaked less than 140 days. The period of slosh testing may be considered part of the preconditioning period provided each tank and all fuel system components tested remain filled with fuel and are never empty for more than one hour over the entire preconditioning period.

As an alternative, accelerated preconditioning of the tank and components can be accomplished by soaking both at an elevated temperature. Precondition the tank and other fuel delivery system components by filling the tank to its nominal capacity with fresh test fuel as specified in Section 7 of these procedures. After filling the tank start the engine and allow it to run at maximum governed speed (unloaded or blade load) for approximately five minutes. Begin soaking the tank and other components at 40º C ± 2º C. For engines with fuel tanks that have a nominal wall thickness of not greater than 0.15", soak the tank and all fuel system components for not less than 30 days. For engines with fuel tanks that have a nominal wall thickness of greater than 0.15" but less than or equal to 0.2", soak the tank and all fuel system components for not less than 60 days. For engines with fuel tanks that have a nominal wall thickness of greater than 0.2" data documenting that the tank and components have reached equilibrium must be provided for tanks soaked less than 140 days. If manufacturer must transport evaporative system components from the place of preconditioning to another location to perform evaporative testing, the system should continue to contain fuel during transportation. Manufacturer should take appropriate measures to assure that temperature variations during transportation will not significantly affect test results.

6.2 Refueling and Hot Soak

Following the preconditioning period, drain the fuel tank and promptly refill to 50 percent of its nominal capacity with test fuel. For evaporative emission control systems that use any type of carbon canister, the canister must be purged following the preconditioning period but prior to initiating the hot soak test. Purging consists of drawing 400 bed volumes of nitrogen or dry air through the canister at the canister manufacturer's recommended purge rate. Operate the engine at its maximum governed speed for fifteen minutes. Immediately place the engine in the SHED enclosure preheated to 95°F. Perform a one-hour hot soak at a constant 95°F.

6.3 Forced Cooling

After the hot soak test, purge the enclosure to reduce the hydrocarbon concentration to background levels. Cool the enclosure to attain a wall temperature of 65°F. After cooling the enclosure to 65°F, soak the engine in the enclosure for two hours at 65°F.

6.4 24-Hour Diurnal Test

Immediately after soaking for two hours at 65°F, purge the enclosure to reduce the hydrocarbon concentration to background levels and perform a 24-hour diurnal test using the temperature profile shown in Table 6-1.

Table 6-1.
Diurnal Temperature Profile

Hour	0	1	2	3	4	5	6	7	8	9	10	11	12
(°F)	65.0	66.6	72.6	80.3	86.1	90.6	94.6	98.1	101.2	103.4	104.9	105.0	104.2
Hour	13	14	15	16	17	18	19	20	21	22	23	24	--
(°F)	101.1	95.3	88.8	84.4	80.8	77.8	75.3	72.0	70.0	68.2	66.5	65.0	--

6.5 Calculation of Mass of Diurnal Evaporative Emissions

The calculation of the mass of the diurnal evaporative emissions is as specified in Part III of the “California Evaporative Emission Standards and Test Procedures for 2001 and Subsequent Model Motor Vehicles.”

7. TEST FUEL

Evaporative emission test fuel is specified in Part II Section 100.3 of the "California Exhaust Emission Standards and Test Procedures for 2001 and Subsequent Model Passenger Cars, Light-Duty Trucks and Medium-Duty Vehicles."

8. ALTERNATIVE TEST PROCEDURES

Test procedures, other than specified above, such as the use of a mini-SHED to measure diurnal evaporative emissions, shall only be used if prior written approval is obtained from the ARB Executive Officer. In order to secure the ARB Executive Officer's approval of an alternative test procedure, the applicant is responsible for demonstrating to the ARB Executive Officer's satisfaction that the alternative test procedure is equivalent to this test procedure.

(1) Documentation of any such approvals, demonstrations, and approvals shall be maintained by the ARB Executive Officer and shall be made available upon request.

(2) Once approved for use, an alternative test procedure may be used and referenced by any manufacturer subject to the limitations and constraints in the Executive Order approving the alternative test procedure.

9. REFERENCES

1. 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, 2000.

2. California Exhaust 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, 2002.

3. 40 CFR Part 86

Attachment 1 to TP-902

Procedure for
Determining Carbon Canister Performance:
Working Capacity

Attachment 1

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Small Off-Road Engine Evaporative Emissions Test Procedure

Attachment 1

Procedure for
Determining Carbon Canister Performance:
Durability Demonstration and Working Capacity

A set of definitions common to all Certification and Test Procedures are in Title 13, California Code of Regulations (CCR), Section 2752 et seq.
For the purpose of this procedure, the term "CARB" refers to the California Air Resources Board, and the term "Executive Officer" refers to the CARB Executive Officer, or his or her authorized representative or designate.

1 APPLICABILITY

This Test Procedure is used by the Air Resources Board to determine the performance of carbon canisters used to control evaporative emission from equipment that use gasoline powered small off-road engines. Small off-road engines are defined in Title 13, California Code of Regulations (CCR), section 2401 et seq. This Test Procedure is proposed pursuant to Section 43824 of the California Health and Safety Code (CH&SC) and applies to engine or equipment manufacturers seeking an Executive Order for a evaporative control system utilizing a carbon canister.

1.1 Requirement to Comply with All Other Applicable Codes and Regulations

Approval of an evaporative emission control component, technology, or system by the Executive Officer does not exempt the same from compliance with other applicable codes and regulations such as state and federal safety codes and regulations.

1.2 Safety

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

2 PRINCIPLE AND SUMMARY OF TEST PROCEDURE

These test procedures are designed to provide consistent methods to evaluate the durability and working capacity of carbon canisters utilized on small engine powered equipment.

Working capacity is a defining parameter expressing the mass of hydrocarbons that can be stored in the canister under controlled conditions. The canister's working capacity is established by repeated canister loading and purging. This procedure involves a cycle that includes a 400 bed volume purge, a 5 minute pause, and then loading the canister with butane mixed 50/50 by volume with air or nitrogen to a measured breakthrough.

3 BIASES AND INTERFERENCES{tc \l1 "3 BIASES AND INTERFERENCES}

To accurately quantify the working capacity the complete test system must be leak tight. Loose fittings and connectors may result in leaks that can significantly affect working capacity determinations.

Care should be taken to minimize or limit the humidity of the air or nitrogen used to purge the canister. Humid purge air can bias canister desorption weight measurements. Dryerite ($CaCl_2$), or other suitable dehumidification methods, must be used to control the humidity of the purge air.

4 SENSITIVITY AND RANGE

The minimum sensitivity of the balance must be selected using good engineering judgment.

5 EQUIPMENT CALIBRATIONS

Mass flow meters must undergo an annual multiple point calibration with a primary standard and have a R^2 coefficient of 0.99 or greater.

The top loading balance must be calibrated with ASTM Class I weights prior to use per the manufacturer specifications. Prior to use the balance must be challenged with weights above and below the range of mass measurements.

6 CARBON CANISTER WORKING CAPACITY DETERMINATION

6.1 Number of Test Cycles

Working capacity is determined through cyclic loading and purging of a carbon canister. Ten or more cycles may be required to stabilize new carbon. A minimum of three cycles is adequate if the carbon has a previous history of stabilization with butane or gasoline vapors. The “working capacity” value is the average of the butane mass supplied to the canister for last two repeatable cycles.

6. 2 Canister Purge

The sequence starts by first purging the canister with 400 bed volumes of dry air or nitrogen in 30 minutes at laboratory conditions. Bed volume is the design volume of the carbon contained in the canister. Purge for all the canister models is defined as a 400 bed volume purge in approximately 30 minutes. The purge rate will therefore vary with canister size. Purge may be accomplished by drawing a vacuum at the tank or purge port, or by pushing air or N2 into the atmospheric vent.

6.3 Pause

Pause testing for approximately 5 minutes between both purge and load and also load and purge sequences.

6.4 Measurement

Weigh the test canister before and after each canister load sequence.

6.5 Canister Load

Load the test canister with butane mixed 50/50 by volume with air or nitrogen until the specified breakthrough criteria has been met. The canister load is accomplished by flowing the butane mixture into the canister via the tank fitting. The butane load rates and breakthrough criteria are determined by canister's bed volume. In order to accommodate the expected wide range of canister bed volumes expected in the small engine powered equipment, four ranges of canister loading and breakthrough criteria are defined: small (< 99cc), medium (100 to 249cc) large (249 to 550cc) and extra large (> 550cc). The load and breakthrough criteria are defined as follows:

Carbon Canister Bed Volume	Small < 99cc	Medium 100 to 249cc	Large 249cc to 550	Extra Large >550
Butane Load Rate [grams C_4H_{10} / hour]	5.0	10.0	15.0	15.0
Break-through limit [grams](*)	2.0	2.0	2.0	2.0

(*). If the canister shows weight loss prior to the 2.0 grams breakthrough then an alternate lower breakthough limit can be used.

7 CALCULATING RESULTS

The working capacity is the average test canister weight gain in grams determined from the last two load cycles. The resultant working capacity is expressed in grams of C_4H_{10}

8 QUALITY ASSURANCE / QUALITY CONTROL (QA/QC)

This section is reserved for future specification.

9 RECORDING DATA

Record data on a form similar to the one shown in Figure 1 (see page 7).

10 FIGURES

Figure 1. Canister Data Sheet

Figure 1
Canister Data Sheet

Canister Manufacturer:

Canister I.D:

Tested By:

Canister Volume [cc]:

Canister Purge Data

Time Start/End		Duration [seconds]	Flow Rate Q [LPM]	Initial Weight W_i [grams]	Final Weight W_f [grams]	Weight Loss W_l [grams]

Canister Load Data

Time Start/End		Duration [seconds]	Butane Rate Q_b [g/hr]	Initial Weight W_i [grams]	Final Weight W_f [grams]	Break-Through W_b [grams]	Weight Gain W_g [grams]
						Working Capacity [grams C_4H_{10}]	