California Environmental Protection Agency

Air Resources Board

Small Off-Road Engine and Equipment Evaporative Emissions Test Procedure

TP - 901

Test Procedure for Determining Permeation Emissions from Small Off-Road Engines and Equipment Fuel Tanks

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TP-901

TABLE OF CONTENTS

Section		Page
1	APPLICABILITY	1
1.1	Requirement to Comply with All Other Applicable Codes and Regulations	1
1.2	Safety	1
2	PERFORMANCE STANDARDS	1
3	PRINCIPAL AND SUMMARY OF TEST PROCEDURE	2
4	BIASES AND INTERFERENCES	2
5	SENSITIVITY AND RANGE	2
6	EQUIPMENT	2
7	CALIBRATION PROCEDURE	3
8	DURABILITY DEMONSTRATION	3
9	PRECONDITIONING PROCEDURE	4
10	SEALING PROCEDURE	4
11	TEST PROCEDURE WITH TRIP BLANK CORRECTION	4
12	QUALITY ASSURANCE/ QUALITY CONTROL	5
13	RECORDING DATA	5
14	CALCULATING PERMEATION RATE USING TRIP BLANK CORRECTION	5
15	ALTERNATIVE TEST PROCEDURES	6
16	REFERENCES	6
17	FIGURES	6

LIST OF FIGURES

FIGURE		Page
1	FIELD DATA SHEET (Trip Blank Correction)	7

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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-901, is used by the Air Resources Board to determine the permeation rate from fuel tanks of equipment that use spark ignited small off-road engines and equipment. Small off-road engines (SORE) 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 equipment with fuel tanks subject to the maximum allowable permeation performance standard 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 an equipment fuel tank by the Executive Officer does not exempt the fuel tank 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 are defined in CCR Title 13, Chapter 15, Article 1, Section 2755 and Section 2754.

3. PRINCIPLE AND SUMMARY OF TEST PROCEDURE

Prior to permeation testing of the fuel tank, durability testing is performed. Durability testing exposes the fuel tank to pressure and vacuum extremes, and fuel sloshing. After durability testing, the fuel tank outlet(s) are sealed and the tank is then filled with Phase II California Reformulated Certification (CERT) fuel or Indolene. Once filled, the tank is allowed to precondition at ambient temperature and pressure for a minimum of 20 weeks or until equilibrium is reached. Once preconditioning is complete, the tank is emptied, immediately refilled with CERT fuel, and allowed to equilibrate at 40 °C.

After the fuel temperature reaches 40 °C +/- 2 °C, an additional coupon of the same material as the tank is used to seal the tank inlet in place of the fuel cap. The tank is then leak tested, weighed, and subjected to a constant (40 °C) temperature. At the end of each 24-hour period, the tank is re-weighed and the weight loss in grams is calculated. The permeation rate is defined as the average steady state weight loss over time divided by the tank's internal surface area.

4. BIASES AND INTERFERENCES

To accurately quantify the losses attributable solely to permeation, each tank tested must be completely sealed. Tanks incorrectly sealed will emit evaporative emissions, which can affect the final weight loss calculations.

To ensure the losses attributed to permeation are accurately quantified during this test procedure, the tanks must remain exposed to the constant 40 °C temperature for each 24-hours ± 30 minutes period.

CERT fuel is required for both preconditioning and testing. CERT fuel does not contain alcohol. Fuels containing alcohol can significantly bias permeation results.

Relative humidity greater than 20% can bias the permeation results for certain plastics such as nylon. To identify bias due to humidity, relative humidity must be recorded daily.

5. SENSITIVITY AND RANGE

Range of mass measurement of filled tanks is approximately 100 grams to 32,000 grams depending on tank volume. For mass measurements more then 6200 grams, the minimum sensitivity of the balance must be 0.1 grams. For mass measurement between 1000 and 6200 grams, the minimum sensitivity of the balance must be 0.01 grams. For mass measurements less than 1000 grams, the minimum sensitivity of the balance must be 0.001 grams.

6. EQUIPMENT

6.1 A hand held thermostatically controlled teflon coated aluminum hot plate (hand held fusion welder) and coupons of the same material as the tank. Both the hand held fusion welder and coupons must be of sufficient diameter to completely cover the opening(s) of the tank. An alternative method to seal the tank may be used.

6.2 A top loading balance that meets the requirements of section 4-5 above.

6.3 A vented enclosure with a temperature conditioning system capable of controlling the internal enclosure air temperature to an average tolerance of +/-2.0°C over the duration of the test. Additionally, the instantaneous temperature shall not exceed +/- 3.0°C for more than 15 minutes each day of the test. Data confirming this performance shall be recorded at a rate no slower than once every 5 minutes.

6.4 A barometric pressure transducer capable of measuring atmospheric pressure to within 2.0 millimeters of mercury.

6.5 A temperature instrument capable of measuring ambient temperature to within +/- 0.2°C.

7. CALIBRATION PROCEDURE

All instruments and equipment used to measure permeation shall be calibrated prior to use per the manufacturer's specifications.

8. DURABILITY DEMONSTRATION

A durability demonstration is required prior to any testing to determine the performance of a fuel tank. These durability tests are designed to ensure that the fuel tank assembly remains effective throughout the useful life of the equipment. A durability demonstration consists of the following tests:

Pressure/Vacuum Test

The Pressure/Vacuum test is performed prior to any preconditioning of the fuel tank. Determine the fuel tank system's design pressure and vacuum limits under normal operating conditions 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, then pressure/vacuum cycling is not required. The tank pressure/vacuum cycling shall be performed in a 49°C +/- 3°C ambient with compressed air of no less than 21°C. Repeat the pressure/vacuum process until the tank has been subjected to not less than 1000 cycles in 8 hours +/- 1 hour.

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 and permeation testing.

Slosh Test

The Slosh test can be performed during the preconditioning period. Perform a slosh test by filling the tank to 50 percent capacity with CERT fuel. Seal the tank using the OEM fuel cap or modified fuel cap and metal plugs for the fuel tank outlet(s). Use a laboratory sample orbital shaker table or similar device to subject the tank to a 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).

Following these durability tests, each tank must be preconditioned to ensure a stable permeation rate. The period of slosh testing may be considered part of the preconditioning period provided each tank tested remains at least half filled with fuel and is never empty for more than one hour over the entire preconditioning period.

9. PRECONDITIONING PROCEDURE

After performing the durability tests, ensure that the fuel tank and any vent outlets are sealed and leak tight. This can be accomplished by fusion welding a coupon over the fuel outlet(s) or by inserting and clamping metal plugs into each outlet. Once sealed, fill the tank to its nominal capacity with CERT fuel and attach the OEM fuel cap. Place the tank in a suitable vented enclosure. Record the preconditioning start date on the field data sheet. Soak the tank at 30° C ± 10° C for not less than 140 days. Accelerated preconditioning of the tank can be accomplished by soaking the tank at an elevated temperature. Data documenting that the tank has reached equilibrium must be provided for tanks soaked less than 140 days.

10. SEALING PROCEDURE

10.1 After preconditioning, remove the tank from the enclosure to a well-ventilated area. Record the preconditioning end date on the field data sheet. Remove the cap and empty the tank. The tank must not remain empty for more than fifteen minutes. Immediately refill the tank to its nominal capacity with CERT fuel. Place the unsealed tank in a heated enclosure and allow it to equilibrate to 40° C ± 2° C for a minimum of two hours. After the fuel temperature has equilibrated to 40° C ± 2° C, seal the tank by fusion welding a coupon over the fuel fill neck opening to make a seal. Perform a leak check by submerging each tank in a water bath large enough to completely cover the tank plus six inches. Observe the tank for any leaks. Leak points will be visible as a bubble or stream of bubbles while immersed in the water bath. Alternative methods may be used to verify that the tank is sealed other than water submersion. If leaks are observed, remove and dry the tank and repair all leaks. Continue this process until no leaks are observed.

10.2 For materials that cannot be sealed using fusion welding, good engineering practices should be used to seal the tank. As an alternative, the technique used to seal tanks described in SAE 920164 "Permeation of Gasoline-Alcohol Fuel Blends Through High-Density Polyethylene Fuel Tanks with Different Barrier Technologies" may be used.

11. TEST PROCEDURE WITH TRIP BLANK CORRECTION

11.1 Two identical sealed tanks, one containing fuel and one remaining empty, are weighed concurrently. The mass changes documented by the empty tank are used to correct the tank containing fuel. Ensure that the exterior surface of each tank is clean, dry, and free of dirt and debris. Carefully place the full tank on the high capacity balance. Record the initial weight (W_{if}), date, relative humidity, barometric pressure, and start time on the field data sheet (Figure 1). Next, carefully place the empty tank on the high capacity balance. Record the initial weight (W_{ie}), date, and start time on the field data sheet.

11.2 Immediately place the two sealed tanks in the enclosure. Begin the 24-soak at 40° C ± 2° C. If more than thirty minutes elapses between the time the sealed tank was weighed and the initiation of the 24-hour soak, then both tanks must be re-weighed.

11.3 At the conclusion of the 24-hour soak period, immediately remove the tanks from the enclosure and ensure that the exterior surface is clean, dry, and free of dirt and debris. Carefully weigh each tank on the high capacity balance. Record the final weights (W_{ff}), (W_{fe}), date, relative humidity, barometric pressure, and end time on the field data sheet. If more than thirty minutes elapses between the conclusion of the 24-hour soak period and the final weighing of the sealed tank, the final weight is invalid and should not be used in future calculations. If this occurs, the test procedure must be reinitiated.

11.4 Calculate the difference between the initial weight (*Wi*) and the final weight (*Wf*) for each tank. Record the difference on the field data sheet. Refer to Section 14 for calculation.

11.5 Repeat this process until the correlation coefficient (R^2), from a plot of the cumulative daily weight loss versus time for ten consecutive 24-hour cycles, is 95% or greater.

12. QUALITY ASSURANCE / QUALITY CONTROL (QA/QC)

This section is reserved for future specification.

13. RECORDING DATA

Record data on field data sheet shown in figure 1.

14. CALCULATING PERMEATION RATE USING TRIP BLANK CORRECTION

The daily weight loss in grams is calculated for each 24-hour cycle as follows:

$$Wl = W_{if} - D_f$$

Where:

Wl	=	The weight loss in grams
W_{if}	=	The initial weight of the full tank in grams
W_{ff}	=	The final weight of the full tank in grams
D_f	=	$W_{ff} + D_e$
D_e	=	$W_{ie} - W_{fe}$
W_{ie}	=	The initial weight of the empty tank in grams
W_{fe}	=	The final weight of the empty tank in grams

Plot the cumulative daily weight loss (in grams) against the sampling time (days). Perform a linear regression on ten consecutive data points.

If the correlation coefficient is at least 95%, the permeation rate in grams per square meter per day is calculated by dividing the slope of the regression line (grams/day) by the tanks internal surface area (obtained from the tank manufacturer).

$$P_{rate} = Slope / A_{tank}$$

Where:

P_{rate}	=	The permeation rate in grams/meter^2/day
$Slope$	=	The slope of the regression line in grams/day
A_{tank}[1]	=	The tank's internal surface area in meter^2

[1] Report the tank's internal surface area in square-meters to at least three significant figures. The tank internal surfaces are those surfaces that are subjected to fuel liquid or vapor under normal operating conditions and have an opposing surface through the wall section that is in communication with the atmosphere. Internal webs and strengthening structures not in communication with the atmosphere are not considered internal surfaces for the purposes of this testing.

15. ALTERNATIVE TEST PROCEDURES

Test procedures, other than specified above, 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.

16. REFERENCES

Permeation of Gasoline-Alcohol Fuel Blends Through High-Density Polyethylene Fuel Tanks with Different Barrier Technologies, SAE Technical Paper Series 920124, International Congress & Exposition, Detroit Michigan, February 1992

17. FIGURES

Figure 1. Field Data Sheet (Trip Blank Correction)

Figure 1
Field Data Sheet
(Trip Blank Correction)

Tank Manufacturer:____

Tank I.D:____

Tested By:____

Water Bath Test (pass/fail):____

Tank Internal Surface Area (meter^2):____

Full Tank Data

Date/Time Start		Date/Time End		Initial Weight W_{if} (grams)	Final Weight W_{ff} (grams)	Difference D_f (grams)	Weight Loss Wl (grams)

$Wl = (W_{if} - D_f)$, $D_f = (W_{ff} + D_e)$, $D_e = (W_{ie} - W_{fe})$

Empty Tank Data

Date/Time Start		Date/Time End		Initial Weight W_{ie} (grams)	Final Weight W_{fe} (grams)	Difference D_e (grams)	%RH	Baro. Pres.