

California Environmental Protection Agency

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**Test Procedure for Determining Diurnal Emissions from  
Portable Fuel Containers**

**TP-502**

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## TABLE OF CONTENTS

<b>1. APPLICABILITY</b> .....	<b>3</b>
1.1 Requirement to Comply with All Other Applicable Codes and Regulations .....	3
1.2 Safety .....	3
<b>2. PRINCIPLE AND SUMMARY OF TEST PROCEDURE</b> .....	<b>3</b>
<b>3. BIASES AND INTERFERENCES</b> .....	<b>4</b>
<b>4. SENSITIVITY AND RANGE</b> .....	<b>5</b>
<b>5. EQUIPMENT</b> .....	<b>5</b>
<b>6. CALIBRATION PROCEDURE</b> .....	<b>5</b>
<b>7. DURABILITY DEMONSTRATION</b> .....	<b>6</b>
<b>8. PRECONDITIONING</b> .....	<b>7</b>
<i>Ambient Condition Soak</i> .....	7
<i>Elevated Temperature Soak</i> .....	7
<b>9. DIURNAL TEST WITH TRIP BLANK CORRECTION</b> .....	<b>8</b>
<b>10. CALCULATING RESULTS</b> .....	<b>10</b>
<i>Calculating Weight Loss Using Trip Blank</i> .....	10
<i>Diurnal Rate Calculation</i> .....	10
<i>Elevated Temperature Data Point Correlation</i> .....	10
<b>11. RECORDING DATA</b> .....	<b>11</b>
<b>12. QUALITY ASSURANCE / QUALITY CONTROL</b> .....	<b>11</b>
<b>13. ALTERNATIVE TEST PROCEDURES</b> .....	<b>11</b>
<b>14. REFERENCES</b> .....	<b>11</b>
<i>Figure 1 Diurnal Test Data Sheet</i> .....	13

**California Environmental Protection Agency  
Air Resources Board**

**Test Procedure for Determining Diurnal Emissions from  
Portable Fuel Containers**

The definitions in Section 2467.1, Article 6, Chapter 9 of Title 13, California Code of Regulations (CCR) applies to this test procedure.

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

**1. APPLICABILITY**

This Test Procedure is used by the ARB to determine the diurnal emission rate from portable fuel containers as defined in Certification Procedure 501. This procedure is applicable in all cases where portable fuel containers are subject to the maximum allowable diurnal emission standard for portable fuel containers that are manufactured for sale, advertised for sale, sold, or offered for sale in California or that are introduced, delivered or imported into California for introduction into commerce.

**1.1 Requirement to Comply with All Other Applicable Codes and Regulations**

Certification or approval of a portable fuel container by the Executive Officer does not exempt the container from compliance or with other applicable codes and regulations such as local, State or 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. PRINCIPLE AND SUMMARY OF TEST PROCEDURE**

This procedure is used to determine the diurnal emission rate of a portable fuel container (PFC) sealed with a spill-proof spout. Testing includes a preconditioning period to demonstrate permeation rate equilibrium, a durability demonstration, and a three-day diurnal test using a variable temperature profile. The durability demonstration requires that the spout be actuated while exposed to certification fuel as defined in Section 5.7 of this test procedure.

Equilibrium is defined as the state where gasoline permeates through the container at a

constant, steady state rate. During preconditioning, equilibrium can be demonstrated by soaking the container with fuel for 140 days. Equilibrium may also be demonstrated by subjecting the container to an elevated temperature and obtaining a weight loss correlation coefficient of 95% or greater as measured over ten consecutive daily weighings. Once equilibrium is demonstrated, the container is subjected to three consecutive diurnal cycles and weighed before and after each cycle. Each daily weighing shall be corrected for moisture, temperature and pressure with use of a trip blank. The diurnal emission rate shall be calculated using the highest recorded daily weight loss divided by the container's rated storage capacity.

### **3. BIASES AND INTERFERENCES**

- 3.1** Certification fuel is required for testing. Currently certification fuels do not contain alcohol. Fuels containing alcohol may increase the diurnal rate. Only the fuel specified in Section 5.7 shall be used for testing.
- 3.2** Moisture, temperature and pressure can bias mass measurements. In order to eliminate bias, a sealed trip blank shall be used to correct for atmospheric conditions.
- 3.3** The trip blank may absorb hydrocarbons and gain weight if stored in close proximity to high levels of gasoline vapor. Care shall be taken to purge the temperature enclosure at regular frequencies to limit gasoline vapor buildup and potential bias.
- 3.4** Incorrectly installed spill-proof spouts can bias the reported results.
- 3.5** Calibration frequency and calibration standard(s). In order to obtain accurate weight measurements, the balance listed in Section 4 shall be calibrated by an independent agency using National Institute of Standards and Technology (NIST) mass standards every six months. The balance must also be checked using NIST mass standards both prior to and following mass measurements (25 containers maximum). At minimum, the balance shall be checked at 80%, 100% and 120% of the containers test mass. If the readability drifts more than +/- 0.2 grams between initial and final measurements, the balance shall be recalibrated or a different balance that is within specification shall be used.
- 3.6** Care shall be taken to ensure no bias occurs as a result of static electricity. Some electronic balances are sensitive to the effects of small static charges produced by permeating plastic fuel containers. If small amounts of static electricity influence the balance, the container shall either be statically discharged or the balance shall be shielded from the effects of static electricity.

#### **4. SENSITIVITY AND RANGE**

The range of the mass measurement of filled containers is approximately 1,750 grams to 26,000 grams depending on the container capacity. A top loading balance, capable of a maximum weight measurement of not less than 2,000 grams greater than the weight of the largest filled container, with a minimum readability of 0.1 gram and reproducibility of  $\pm 0.2$  grams, must be used to perform mass measurements.

#### **5. EQUIPMENT**

- 5.1** A top loading balance that meets the requirements of Section 4 above.
- 5.2** NIST mass standards. A sufficient number of mass standards to verify the measurements listed in Section 3.5.
- 5.3** A ventilated, temperature-conditioning enclosure capable of controlling the internal air temperature from 65 °F to 105°F,  $\pm 2^\circ\text{F}$ . The enclosure shall be capable of producing a variable temperature profile as specified in Table 9-1.
- 5.4** A temperature instrument capable of measuring the internal temperature of the temperature conditioning enclosure with a sensitivity of  $\pm 2^\circ\text{F}$ .
- 5.5** A barometric pressure instrument capable of measuring atmospheric pressure at the location of the balance to within  $\pm 0.02$  inches of mercury.
- 5.6** A relative humidity measuring instrument capable of measuring the relative humidity (RH) at the location of the balance with a sensitivity of  $\pm 2\%$  RH.
- 5.7** Certification fuel as described in Part II, Section 100.3 of the Air Resources Board "California Exhaust Emissions Standards and Test Procedures for 2001 and Subsequent Model Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles," adopted August 5, 1999, which is incorporated by reference herein.

#### **6. CALIBRATION PROCEDURE**

- 6.1** All instruments and equipment used to conduct this procedure shall be calibrated prior to use per the manufacturer's specifications.
- 6.2** The balance shall be checked using NIST traceable mass standards prior to and following mass measurements (25 containers maximum). At minimum, the balance shall be checked at 80%, 100% and 120% of the containers test weight. Refer to Section 3.5.

## **7. DURABILITY DEMONSTRATION**

A durability demonstration is required at the beginning and at conclusion of the preconditioning period (Section 8). This requires at least two weeks of testing at both the beginning and end of the preconditioning period. This test exposes the spout, seals and mechanisms to fuel in order to demonstrate durability.

- 7.1** Use a permanent marker to identify the container(s). Use a unique ID number for each container. Record the ID number on the data sheet.
- 7.2** Fill the container to 50% of the rated capacity (+/- 1%) with certification fuel and install the spill-proof spout. Record the amount of fuel dispensed into the container.
- 7.3** Install the spill-proof spout per the manufacturer's instructions. Check the leak tightness of the spout by raising the ambient temperature 30°F +/- 5°F for a minimum of two hours. This should slightly expand the container. If the container does not expand, there may be a leak.

Submerge in a water bath large enough to submerge the entire container to a depth of least six (6) inches. Tilt the container back and fourth while submerged to dislodge any air from external cavities. Wait at least thirty (30) seconds. Any bubbles coming from the container denotes a leak.

No repairs may be performed unless documentation from the manufacturer is provided. Leaks, repairs or adjustments shall be listed on the data sheet. For containers with leaks that cannot be repaired without the use of tools, sealant, etc., those containers and spouts shall be removed from testing and the failure documented on the data sheet. Remove the container from the water bath and dry off all excess water from the exterior surfaces.

- 7.4** Slowly invert the container for at least five (5) seconds to ensure that the spout and mechanisms become saturated with fuel. Any fuel leaking from any part of the container will denote a leak and shall be reported on the data sheet. Once completed, place the container on a flat surface in the upright position.
- 7.5** Actuate the spout by fully opening and closing without dispensing fuel. The spout shall return to the closed position without the aid of the operator (i.e., pushing or pulling the spout closed, etc.). Repeat for a total of ten (10) actuation's.
- 7.6** Repeat steps 7.4 and 7.5.
- 7.7** After twenty (20) actuation's are completed, remove and replace the spout to simulate filling the container.

- 7.8** Repeating steps 7.4 through 7.7 four (4) more times until one hundred (100) actuation's and five (5) spout replacements are completed in a minimum seven (7) day period.
- 7.9** Repeat steps 7.4 through 7.8 until at least two-hundred (200) actuation's and ten (10) spout replacements are completed in a minimum two week period.
- 7.10** The durability demonstration shall be repeated (an additional 200 actuation's) during the time periods specified below:
- a. If the ambient condition equilibrium demonstration is used, repeat steps 7.4 through 7.9 near conclusion of the 140-day soak (i.e., the period starting prior to day 126 and ending on day 140).
  - b. If the elevated temperature equilibrium demonstration is used, repeat steps 7.4 through 7.9 after a total of 126-days has lapsed where the container is continuously stored with certification fuel (i.e., the period starting prior to day 126 and ending on day 140).
- 7.11** Record the dates and number of cycles on the data sheet where provided.

## **8. PRECONDITIONING**

A preconditioning period is required to demonstrate permeation equilibrium. Equilibrium occurs when the container's walls have become saturated with fuel. Preconditioning may be combined with the durability demonstration listed above. In order to achieve equilibrium, the container can be soaked with fuel at ambient or elevated temperatures.

### **Ambient Condition Soak**

- 8.1** Store the container at ambient conditions for at least 140 days with the spill-proof spout installed.

### **Elevated Temperature Soak**

- 8.2** The leak check described in Section 7.3 shall be repeated on the container prior to this portion. The container shall be tested at elevated temperature with the same fuel as used for durability testing.
- 8.3** The balance shall be checked using NIST traceable mass standards both prior to and following mass measurements (25 containers maximum). At minimum, the balance shall be checked at 80%, 100% and 120% of the containers test weight. Refer to Section 3.5.
- 8.4** Ensure that the exterior surface of the container is clean, dry, and free of dirt or debris. Carefully place on the balance. Record the date, initial weight, start

time, relative humidity and barometric pressure on the data sheet (Figure 1).

- 8.5** Check that the balance has not deviated using the NIST traceable mass standards. Refer to Section 3.5.
- 8.6** Place the container into the temperature enclosure and begin soaking at a constant temperature of 105°F +/- 2°F. Alternate constant temperatures (i.e., 90°F +/- 2°F or 140°F +/- 2°F, etc.) may also be used. Document the temperature applied on the data sheet.
- 8.7** Continue soaking at elevated temperature until equilibrium is reached. The results of 10 consecutive daily weigh-ins (one weigh-in per 24-hour period) identifying constant weight loss with a cumulative weight loss correlation coefficient of 95% or greater shall demonstrate equilibrium. See Section 10 for calculation.

## **9. DIURNAL TEST WITH TRIP BLANK CORRECTION**

The diurnal test is used to determine the emission rate when the container is subjected to a minimum of three (3) consecutive diurnal cycles as specified in Table 9-1. This test measures evaporative emissions (permeation and vented) when a container is subjected to California's summertime temperature profile after permeation equilibrium has been reached.

- 9.1** The leak check described in Section 7.3 shall be repeated on the CERT fuel container prior to this portion. The container may continue being tested with the same CERT fuel as used for durability and equilibrium testing.
- 9.2** Install an identical spout on an identical new container (trip blank). This container shall remain empty and shall not have been previously subject to gasoline or gasoline vapors. Using a compressed air source, slowly pressurize the trip blank to 5.0 psig. Submerge in a water bath large enough to submerge the entire container to a depth of least six (6) inches. Tilt the container back and fourth while submerged to dislodge any air from external cavities. Observe the container for leaks for at least thirty (30) seconds. Leaks are determined through the evidence of any bubbles coming from the container. If any evidence of leaks is observed, remove the trip blank from testing. Record observations on the field data sheet. Remove the trip blank from the water bath and dry off all excess water from the exterior services.
- 9.3** Place the trip blank and CERT fuel containers into a temperature enclosure acclimated at 105°F +/- 2°F for a minimum of 24-hours to remove excess hydrocarbon buildup that may have resulted from preconditioning.
- 9.4** Clean the exterior surface of the containers with Alconox or another hydrocarbon dissolving solution that effectively removes hydrocarbon residue

from the outer surfaces of the containers. This step shall only be conducted following Section 9.3 and shall not be repeated for the remainder of testing.

- 9.5** Place the trip blank and CERT fuel containers into a temperature enclosure acclimated at a 65°F +/- 2°F for a minimum of 6 to a maximum of 36 hours to eliminate potential temperature bias that may occur from Section 9.3.
- 9.6** The balance shall be checked using NIST traceable mass standards prior to and following mass measurements (25 containers maximum). At minimum, the balance shall be checked at 80%, 100% and 120% of the containers test weight. Refer to Section 3.5
- 9.7** Carefully place each container on the balance. Record the date, initial weight, start time, relative humidity and barometric pressure on the data sheet. No more than fifteen (15) minutes shall lapse between the temperature stabilization period (section 9.5) and replacing the containers into the temperature enclosure after weighing. Precautions should be taken to ensure the containers remain at 65°F +/- 2°F.
- 9.8** Check that the balance has not deviated using the NIST traceable mass standards. Refer to Section 3.5.
- 9.9** Begin the variable temperature profile (diurnal cycle) as shown in Table 9-1.
- 9.10** At conclusion of the diurnal cycle, place each container on the balance and record the final weight, date, end time, relative humidity and barometric pressure on the field data sheet. If the containers are removed from the enclosure for weighing, no more than fifteen (15) minutes shall lapse before being replaced into the enclosure. Repeat Section 9.8 and Section 9.9.
- 9.11** Repeat Section 9.10 until three (3) consecutive diurnal cycles is completed.
- 9.12** The leak checks described in Section 7.3 and Section 9.3 shall be repeated at the conclusion of diurnal testing. Any leak check failure(s) shall be recorded on the data sheet and the containers removed from testing.
- 9.13** Correct each mass measurement using the daily trip blank measurements. Refer to Section 10 for calculations. Calculate the diurnal rate using the highest recorded daily weight loss observed of the three diurnal cycles.

**Table 9-1 Diurnal Temperature Profile**

Hour	0	1	2	3	4	5	6	7	8	9	10	11	12
(°F)	65	66.5	72.7	80.2	86.2	90.7	94.6	98.1	101.1	103.5	104.9	105.1	104.2
Hour	13	14	15	16	17	18	19	20	21	22	23	24	--
(°F)	101.1	95.4	88.9	84.4	80.8	77.7	75.4	72.0	70.0	68.2	66.5	65	--

## 10. CALCULATING RESULTS

The diurnal rate is calculated by using the highest recorded daily weight loss of the three diurnal cycles tested. The diurnal rate and elevated temperature correlation coefficient (if used) shall be calculated using the equations listed below.

### Calculating Weight Loss Using Trip Blank

$$L = W_i - C_T$$

Where:

- $L$  = The corrected weight loss (grams)
- $W_i$  = Initial weight of full container (grams)
- $C_T$  =  $W_f + D_T$  (Trip Blank Correction) (grams)

Where:

- $W_f$  = Final weight of full container (grams)
- $D_T$  =  $T_i - T_f$  (Difference in Trip Blank weight) (grams)

Where:

- $T_i$  = Initial weight of Trip Blank (grams)
- $T_f$  = Final weight of Trip Blank (grams)

### Diurnal Rate Calculation

$$D_{rate} = A_{Loss} / C_{container}$$

Where:

- $D_{rate}$  = The diurnal rate (grams/gal-day)
- $A_{Loss}$  = The average corrected weight loss (grams/day)
- $C_{container}$  = The rated capacity of the container (gallons)

### Elevated Temperature Data Point Correlation

If elevated temperature was used in the equilibrium demonstration, plot the cumulative daily weight loss (grams) against the sampling time (days). Perform a linear regression

of ten consecutive data points (spreadsheet or hand calculation) as shown. If the correlation coefficient is 95% or greater, the container is considered to have reached equilibrium.

$$r = \frac{n(\sum XY) - (\sum X)(\sum Y)}{\sqrt{[n\sum X^2 - (\sum X)^2][n\sum Y^2 - (\sum Y)^2]}}$$

Where:

- $r$  = The correlation coefficient
- $n$  = The number of samples (10)
- $X$  = The Day Number (i.e., 1-10)
- $Y$  = The cumulative weight loss per day (grams)

## 11. RECORDING DATA

Record data on the field data sheet shown in Figure 1. Alternate test forms may be used provided they list the same minimum parameters as shown in Figure 1.

## 12. QUALITY ASSURANCE / QUALITY CONTROL

All data must be carefully recorded on the field data sheet during the test. Any unusual occurrences in the process operation, unusual test instrument readings or items that could possibly affect the test results should be noted on the data sheet. It is recommended that a checklist, in addition to the data sheet be used to assure all data needed for calculation or process information are obtained.

## 13. 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) Such approval shall be granted on a case-by-case basis only.
- (2) Documentation of any such approvals, demonstrations, and approvals shall be maintained by the ARB Executive Officer and shall be made available upon request.

## 14. REFERENCES

Certification fuel as described in Part II, Section 100.3 of the Air Resources Board "California Exhaust Emissions Standards and Test Procedures for 2001 and Subsequent Model Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles," adopted August 5, 1999.

**Figure 1 Diurnal Test Data Sheet**

Container Manufacturer: \_\_\_\_\_ Test Company: \_\_\_\_\_

CERT Fuel Container I.D.: \_\_\_\_\_ Trip Blank Container ID: \_\_\_\_\_

Container Model: \_\_\_\_\_ Spout Model: \_\_\_\_\_ Rated Capacity: \_\_\_\_\_ (gal)

**Durability Testing**      Gallons of CERT fuel Placed in Container: \_\_\_\_\_ gallons

Initial Trip Blank Weight: \_\_\_\_\_ ( $T_i$ ) grams      Weigh-In Date: \_\_\_\_\_

Date	Number of Cycles	Date	Number of Cycles

**Ambient Condition Soak**      Start Date: \_\_\_\_\_      End Date: \_\_\_\_\_

**Elevated Temperature Soak**      Constant Temperature Applied: \_\_\_\_\_      Correlation Coefficient: \_\_\_\_\_%

Date/Time Start	Date/Time End	Initial Weight $W_i$ (grams)	Final Weight $W_f$ (grams)	Difference (grams)	%RH	Barometric Pressure

**Diurnal Test Results (Trip Blank Container)**

Date/Time Start	Date/Time End	Final Weight $T_f$ (grams)	Difference $D_T$ (grams)	%RH	Barometric Pressure

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**Diurnal Test Results (CERT Fuel Container)**

Date/Time Start		Date/Time End		Initial Weight $W_i$ (grams)	Final Weight $W_f$ (grams)	Trip Blank Correction $C_T$	Corrected Loss $L$ (grams)

\*Relative Humidity and Barometric Pressure Recorded under Trip Blank

Average Corrected Daily Weight Loss: \_\_\_\_\_ g/day

Container Capacity: \_\_\_\_\_ gallons

Diurnal Rate: \_\_\_\_\_ g/gal/day

**Documentation of Performance**

Date: \_\_\_\_\_ Description of Repair, Adjustment or Failure: \_\_\_\_\_

_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

Comments:

\_\_\_\_\_

\_\_\_\_\_