California Environmental Protection Agency

Air Resources Board

Spark-Ignition Marine Watercraft Diurnal Venting Emissions Test Procedure

TP - 1503

Test Procedure for Determining Diurnal Vented Emissions from Installed Marine Fuel Tanks

Adopted Date: December 21, 2015

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A set of definitions common to all certification and test procedures is in California Code of Regulations (Cal. Code Regs.), title (tit.) 13, section 2752 et seq. These definitions apply 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 designee.

1. APPLICABILITY

This test procedure, TP-1503, is used to determine the diurnal vented emissions from installed marine fuel tanks on spark-ignition marine watercraft (SIMW). Spark-ignition marine engines (SIME) are defined in Cal. Code Regs., tit. 13, §2853 et seq. This test procedure is proposed pursuant to sections 43013 and 43018 of the California Health and Safety Code (CH&SC), and the references cited in section (9) of this document. TP-1503 is applicable in all cases where SIMW 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 evaporative emissions control system by the Executive Officer does not exempt the engine or evaporative emissions control systems 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 possibly hazardous operations and should only be conducted by, or under the supervision of, those familiar and experienced in the safe use of such materials and operations. Appropriate safety precautions should be observed at all times while performing the test sequences in this test procedure.

2. PERFORMANCE STANDARDS

The minimum performance standards for certification of evaporative emissions control systems on SIMW is contained in Cal. Code Regs., tit. 13, §2855.

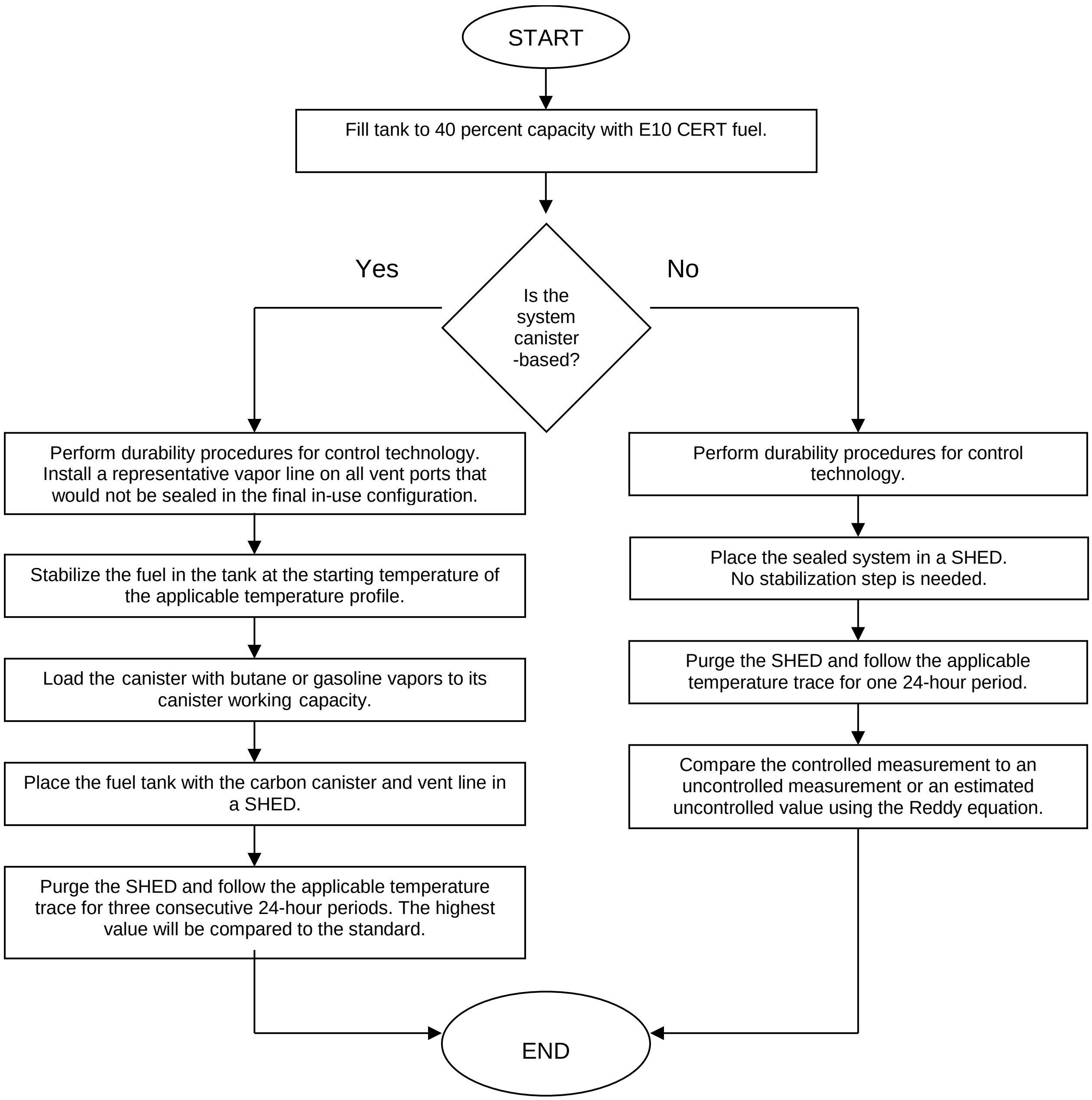
3. GENERAL SUMMARY OF TEST PROCEDURE

A sealed housing for evaporative determination (SHED) is used to measure diurnal vented emissions from installed marine fuel tanks. This method subjects installed marine fuel tanks to a fuel temperature profile while maintaining a constant pressure and continuously sampling for hydrocarbons (HC) with a flame ionization detector (FID). 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."

The three-day diurnal test sequence is shown graphically in Figure 3.1. All temperatures monitored during the test are tank fuel temperatures. The fuel tank shall be approximately level during all phases of the test sequence to prevent abnormal fuel distribution.

Testing a representative fuel tank for each evaporative family and comparing the results to the appropriate performance standard determines compliance with requirements of Cal. Code Regs., tit. 13, §2855.

Figure 3.1: Summary of Determination of Diurnal Vented Emissions from Installed Marine Fuel Tanks



4. INSTRUMENTATION

The instrumentation necessary to perform evaporative emissions testing for SIMW is the same instrumentation used for passenger cars and light duty vehicles, and is described in title 40, Code of Federal Regulations (CFR), Part 86, section 86.107-96.

4.1 Calibrations

Evaporative emissions enclosure calibrations are specified in title 40, CFR, Part 86, section 86.117-90, as incorporated by reference amended with the following:

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

- All test fuels must be tested to ensure they meet ARB specification for E10 CERT fuel. Fuel analysis certification results from a fuel supplier are sufficient to meet this requirement.
- The SHED must be capable of controlling temperature to within the specification of this test procedure while keeping pressure constant.

4.2 Calculation of HC Mass

Calculate the final recovered HC mass (M_{HC}) according to title 40, CFR, Part 86, section 86.117-96(d)(1), as incorporated by reference.

5. DURABILITY REQUIREMENTS

A durability demonstration is required prior to any testing to determine the performance of a carbon canister or pressure relief valve. These durability tests are designed to ensure that the carbon canister or pressure relief valve remains effective throughout the useful life of the equipment on which it is being used.

5.1 Carbon Canister Durability Requirements

5.1.1 Maximum Pressure

Apply 4.9 psi (34 kPa) of pressure at the tank port with all other ports plugged for a minimum of 60 seconds. Run test at a minimum of 194°F (90°C). At the end of the test, the carbon canister must meet leak specification as defined in 5.1.2 Leakage.

5.1.2 Leakage

The carbon canister shall have a maximum allowable leak rate of 1.5 cubic inches (25cc) per minute at 4.9 psi (34 kPa) gauge pressure, and when installed, shall show no evidence of leakage when subject to systems pressure test per H-24.18 Systems Test.

5.1.3 Flow Restriction

The allowable air tube pressure drop across the carbon canister shall be less than 0.145 psi (1.0 kiloPascals (kPa)) at an air flow of 60 SLPM (Standard Liters Per Minute) for canisters that vent refueling vapors, or 0.508 psi (3.5 kPa) at an air flow of 60 SLPM for canisters that do not vent refueling vapors.

5.1.4 Canister Connection Strength

The canister ports shall have sufficient strength to withstand a minimum load of 50 lbs. (22.7 kg). Pull the connection in its most vulnerable direction at a 90º angle to the connection opening at a rate of 1 inch per minute until the port breaks. The load shall be greater than 50 lbs. (22.7 kg).

NOTE: Female threaded ports shall have a barb installed to perform this test.

5.1.5 Fire Resistance

Canisters intended to be mounted inside an engine compartment, shall be capable of withstanding a 2-1/2 minute exposure to free burning fuel (N-Heptane) as required by title 33, CFR, Part 183, section 183.590, and in ABYC H-24, Gasoline Fuel Systems. The canister shall be tested void of liquid and/or fuel vapor. After the canister returns to ambient temperature, the canister sample shall be examined, and pressure checked with 1/4 psi (1.8 kPa) of aerostatic pressure. Pressure shall be applied gradually by means of a suitable regulator so as not to strain the canister due to pressure surge, and maintained at test pressure for a minimum of five minutes. The canister fails the test if leakage is detected in the canister.

5.1.6 Thermal Cycle

Canisters shall meet leakage and flow restriction requirements of 5.1.2 and 5.1.3 after being exposed to 40 temperature cycles as follows:

- 1 hour at -40ºF (-40ºC).
- 1 hour transition.
- 1 hour at 176ºF (80ºC).
- 1 hour transition.

5.1.7 Corrosion Resistance

External metallic parts of the canister shall be tested to 168 hours of Salt Fog per ASTM B117. These parts shall not exhibit any functional material degradation or deterioration. Components required for installation and hose connection must be installed for testing.

5.1.8 Humidity Preconditioning

The canister shall be purged with ambient air at a temperature of 75°F +/- 5°F with a relative humidity of 75 percent +/- 5 percent (absolute humidity of approximately 100 grains water vapor/pound of dry air). The purge rate shall be 0.4 cubic feet per minute (cfm) +/- 0.1 cfm. There is no specification or limit on the number of canister bed volumes of purge air required to achieve stabilization. Measure the mass of the canister (initial) and at periodic intervals until the mass gain from water vapor stabilizes. Stabilization means that the weight of the canister (as defined by measured weight lees the initial weight) does not vary by more than 1 percent over three consecutive measurements that are 30 minutes apart. Between these measurements the purge with humid air as described above must continue. This last measurement when stabilization is reached is considered the final mass value. Record the initial and final mass values and the total cfm needed to achieve stabilization.

After the test is complete all the ports are to be capped and allowed to equilibrate for at least 12 hours. This canister will be used for the vibration test and the diurnal venting evaporative emissions test as prescribed in section 6.

5.1.9 Vibration

Following the humidity preconditioning, canisters shall meet the performance requirements of 5.1.9 when exposed to random vibration, rough water shock, and towing shock. Rigidly mount the canister to the shaker table using the canister mounting provisions.

5.1.9.1 Random Vibration

Table 5.1 contains the random vibration profiles. Each profile shall be run for a duration of 20 hours for a total of 60 hours to completely test the durability of the component. Testing shall occur with a temperature profile transposed over the test time per axis test. The temperature profile shall be a dwell of 0.5 hours at -40°F (-40°C), transition consistently from -40°F (-40°C) to 176°F (80°C) in 4.5 hours, and then dwell at 176°F (80°C) for 1 hour. This profile can be run in either sequence. All vibration shall occur at 75°F± 5°F (23°C ± 2.5°C). A vacuum shall be drawn on the vapor inlet port sufficient to maintain 5 SLPM flow throughout the entire vibration test. The flow out of the vapor inlet shall be filtered to capture any carbon that leaves the canister. The maximum carbon particle size lost shall not exceed 500 microns.

5.1.9.2 Rough Water Shock

Apply 2,250 half-sine shock pulses with a 15g amplitude and a duration of 12 milliseconds in the vertical direction. In addition, apply 250 half-sine shock pulses with a 22g amplitude and a duration of 14 milliseconds in the vertical direction.

5.1.9.3 Towing Shock

Apply 1,125 half-sine shock pulses with a 15g amplitude and a duration of 6 milliseconds in the vertical direction. Canisters shall not permit particles greater than 500 microns to migrate out of any canister port, under any condition. Pressure drop across the canister after completion of vibration and shock tests shall not increase by more than 0.0725 psi (0.5 kPa) from virgin samples at 60 SLPM. The carbon canister mounting and bracketry shall be validated using the application specific vibration profile. If the profile is unavailable, use the profile in Table 5.1. Hoses shall be installed and supported per the canister manufacturer’s specification. Run the vibration test above without flow to the canister or tubes capped.

Table 5.1: Random Vibration Profiles

Longitudinal

Freq Hz	Level (g²/Hz)
10	0.0021
14	0.0022
18	0.0010
26	0.0055
52	0.0027
60	0.0009
76	0.0079
92	0.0022
114	0.0206
150	0.1538
170	0.0043
260	0.0463
302	0.0286
376	0.4968
414	0.0793
490	0.0425
526	0.0051
602	0.0542
680	0.0366
750	0.2925
790	0.0124
902	0.0349
940	0.0024
1050	0.0572
1350	0.0027
1500	0.0409
1540	0.0016
2000	0.0005
Grms =	7.98

Lateral

Freq Hz	Level (g²/Hz)
10	0.0011
12	0.0027
18	0.0006
24	0.0066
32	0.0009
38	0.0061
46	0.0072
58	0.0010
76	0.1035
150	0.0348
194	0.0053
278	0.2060
332	0.0073
374	0.0044
452	0.0176
676	0.0175
748	0.1920
792	0.0310
976	0.0090
1052	0.0510
1090	0.0042
2000	0.0042
Grms =	6.12

Vertical

Freq Hz	Level (g²/Hz)
10	0.0031
12	0.0045
18	0.0022
26	0.0150
34	0.0029
38	0.0205
50	0.0078
58	0.0023
74	0.0120
92	0.0056
114	0.0656
150	0.1025
188	0.0063
260	0.4648
330	0.0241
376	0.0328
414	0.0027
570	0.0081
602	0.0588
680	0.0252
792	0.0014
902	0.0178
976	0.0055
1050	0.0361
1660	0.0015
2000	0.0015
Grms =	6.34

5.1.10 Carbon Performance

A maximum loss of 12 percent or less of total working capacity is required following 150 load/purge cycles as well as preconditioning and purge with warm 77°F± 9°F (25°C± 5°C) room air with ambient relative humidity. A common cycle is measuring the change in working capacity according to title 40, CFR, Part 1060, section 1060.240(e)(2)(i), doing the load/purge using 150 cycles of load with a mixture of 50 percent gasoline vapor/air loaded at 40 grams/hr, and purged each time with 300 bed volumes of room air at 22.7 liters/minute. Finally, the canister working capacity must be recalculated following title 40, CFR, Part 1060, section 1060.240(e)(2)(i).

5.2 Pressure Relief Valve Durability and Reliability Requirements

The pressure relief valve durability and reliability requirements may be performed on a sealed fuel tank only or on a sealed fuel system (manufacturer tank not required). Unless otherwise specified, all testing may be performed at ambient temperature. All testing temperatures must be within ± 5°F (± 3°C) of the required temperature.

5.2.1 Thermal Cycle

The pressure relief valve is placed in an environment where it is subjected to temperature changes for one cycle in the sequence below:

- 86°F (30ºC) for 15.5 hours,
- 77°F (25 ºC) for 0.5 hours,
- 68ºF (20ºC) for 7.5 hours,
- 77°F (25ºC) for 0.5 hours,
- 86°F (30ºC) for 15.5 hours,
- 77°F (25ºC) for 0.5 hours,
- 68ºF (20ºC) for 7.5 hours, and
- 77°F (25ºC) for 0.5 hours.

Up to 5 minutes is allowed for the temperature to rise/descend and then stabilize. A total of ten (10) cycles are required.

5.2.2 Pressure/Vacuum

The Pressure/Vacuum test is performed under both high 86°F (30ºC) and low 68°F (25ºC) temperature. Determine the pressure relief valve's design pressure limit (must be at least 7.35 kPa) under normal operating conditions. Connect the pressure relief valve to a sealed empty tank. Pressurize the empty tank until the valve opens and then evacuate to at least 0 kPa. Flow rates must be no less than 1 L/min. The pressure/vacuum cycling shall be performed with compressed air at 86ºF +/- 5ºF (30ºC +/- 3ºC) ambient and at 68ºF+/- 5ºF (20ºC +/- 3ºC) ambient. Repeat the pressure/vacuum process until the valve has been subjected to not less than 8,300 cycles in each temperature condition.

5.2.3 Vibration

The vibration test can be performed either according to 5.1.9 (in replacement of a carbon canister) following the vibration profile in Table 5.1, or performed at a vibration frequency of 11 Hz at an acceleration of 29.4 m/s^2 to continuous sinusoidal vibration in its vertical and horizontal (radial and axial) direction for 2.5×10^4 times each.

5.2.4 Dust

The dust test is performed in a test room filled by dust indicated by JIS (Japanese Industrial Standards) Z8901 type 15 with a concentration of 100 $\mu g/m^3$. The valve is pressured to open and then close when the tank is evacuated to a maximum of -2.94 kPa +/- 0.1kPa. Three hundred (300) pressure/vacuum cycles are required.

5.2.5 Ozone

The ozone test is a static test performed in an environment that can produce ozone to the specified level and temperature. The pressure relief valve must be subjected to a continuous exposure of 150 ppb +/- 5 ppb (parts per billion) of ozone at 86°F (30°C) for 120 hours.

6. TEST PROCEDURE

- This test procedure measures diurnal vented emissions from installed marine fuel tanks. The basic process is as follows:

- o Diurnal measurements are based on representative temperature cycles, as follows:

  - ▪ Diurnal fuel temperatures for marine fuel tanks that will be installed in nontrailerable boats must undergo repeat temperature swings of 4.7°F (2.6°C) between nominal values of 81.7°F and 86.4-°F (27.6°C and 30.2°C).

  - ▪ Diurnal fuel temperatures for other installed marine fuel tanks must undergo repeat temperature swings of 11.9°F (6.6°C) between nominal values of 78.1°F and 90.0°F (25.6°C and 32.2°C).

Table 6.1: Fuel Temperature Profile for Installed Marine Fuel Tanks in Trailerable Boats

Hour	0	1	2	3	4	5	6	7	7.5	8	9	10	11
(°F)	78.1	78.3	79.7	82.2	84.6	86.7	88.5	89.6	90.0	90.0	90.0	89.8	89.1
Hour	12	13	14	15	16	17	18	19	20	21	22	23	24
(°F)	87.8	86.4	84.7	83.5	82.4	81.5	80.6	79.9	79.3	79.0	78.6	78.3	78.1

Hour	0	1	2	3	4	5	6	7	7.5	8	9	10	11
(°C)	25.6	25.7	26.5	27.9	29.2	30.4	31.4	32.0	32.2	32.2	32.2	32.1	31.7
Hour	12	13	14	15	16	17	18	19	20	21	22	23	24
(°C)	31.0	30.2	29.3	28.6	28.0	27.5	27.0	26.6	26.3	26.1	25.9	25.7	25.6

Table 6.2: Fuel Temperature Profile for Installed Marine Fuel Tanks in Non-Trailerable Boats

Hour	0	1	2	3	4	5	6	7	7.5	8	9	10	11
(°F)	81.7	81.9	82.2	83.3	84.2	85.1	85.8	86.2	86.4	86.4	86.4	86.4	86.0
Hour	12	13	14	15	16	17	18	19	20	21	22	23	24
(°F)	85.5	84.9	84.4	83.9	83.3	82.9	82.6	82.4	82.2	82.0	81.9	81.7	81.7

Hour	0	1	2	3	4	5	6	7	7.5	8	9	10	11
(°C)	27.6	27.7	27.9	28.5	29.0	29.5	29.9	30.1	30.2	30.2	30.2	30.2	30.0
Hour	12	13	14	15	16	17	18	19	20	21	22	23	24
(°C)	29.7	29.4	29.1	28.8	28.5	28.3	28.1	28.0	27.9	27.8	27.7	27.6	27.6

- o Fill the fuel tank to 40 percent of nominal capacity with E10 CERT fuel. A metal fuel tank of the approximate size and shape (volume and ullage) must be used during this test procedure to eliminate any permeation emissions.

- o Install a vapor line from ports that would vent to atmosphere in the final in-use configuration. Use a length of vapor line representing the largest inside diameter and shortest length that would be expected for in-use installations of that tank.

- Stabilize the fuel tank to be within 3.6°F (2.0°C) of the nominal starting temperature specified. Install a thermocouple meeting the requirements of 40 CFR 86.107-96(e) in the approximate mid-volume of fuel and record the temperature at the end of the stabilization period to the nearest 0.2°F (0.1°C). For sealed fuel systems, do not seal the system until the fuel reaches equilibrium at the appropriate starting temperature.

- If the fuel tank is equipped with a carbon canister, the carbon canister must meet the durability requirements of section 5 before testing. Load the canister with butane or gasoline vapors to its *canister working capacity* as specified in 40 CFR §1060.240(e)(2)(i) and attach it to the fuel tank in a way that represents a typical in-use configuration. The canister is only certified for use on tanks of equal or lesser volume to the test tank used for certification.

- Prepare the tank for mass measurement using one of the following procedures:

    - Place the stabilized fuel tank with the carbon canister and vent line in a SHED meeting the specifications of title 40, CFR, Part 86, section 86.107–96(a)(1) that is equipped with a FID analyzer meeting the specifications of title 40, CFR, Part 1065, section 1065.260. Take the following steps in sequence:

        - Purge the SHED.
        - Close and seal the SHED.
        - Zero and span the FID analyzer.
        - Within ten minutes of sealing the SHED, measure the initial HC concentration. This is the start of the sampling period.

      Follow the applicable temperature trace from Table 6.1 or 6.2 of this procedure for a 24-hour period. You need not measure emissions during this stabilization step.

    - If your testing configuration involves mass emissions at the standard of 2 grams or more, you may alternatively place the stabilized fuel tank in any temperature-controlled environment and establish mass emissions as a weight loss relative to a reference fuel tank using the procedure specified in title 40, CFR, Part 1060, section 1060.520(d) instead of calculating it from HC concentrations in the SHED. Follow the applicable temperature trace from Table 6.1 or 6.2 of this procedure for a 24-hour period. You need not measure emissions during this stabilization step.

- Control temperatures as follows:

    - If the fuel tank is a nominal capacity of 100 gallons or less, you must use the temperature procedure as described in (a)(7)(ii). Supply heat to the fuel tank for continuously increasing temperatures such that the fuel reaches the maximum temperature as shown in Table 6.1 or 6.2, as appropriate in approximately eight hours. Set the target temperature by adding the temperature swing specified in this section (Table 6.1 or 6.2 for trailerable and non-trailerable boats) to the recorded starting temperature. The increase in fuel temperature over the 8 hours should approximately follow the cycle and delta temperatures in Table 6.1 or 6.2, as appropriate. Hold the tank for approximately 60 minutes at a temperature no less than 0.2°F (0.1°C) below the target temperature. For example, if the recorded starting fuel temperature for a fuel tank that will be installed in a nontrailerable boat is 80.8°F (27.1°C), the target temperature is 85.5°F (29.7°C) and the fuel must be stabilized for 60 minutes with fuel temperatures not falling below 85.3°F (29.6°C). For testing, fuel temperatures may not go +/-2.0°F (1.0°C) away from the target temperature for any given hour at any point during the heating or stabilization sequence. Measure the HC concentration in the SHED at the end of the high-temperature stabilization period. Calculate the diurnal emissions for this heating period based on the change in HC concentration over this sampling period as measured by the FID analyzer. Allow the fuel temperature to cool sufficiently to stabilize again at the starting temperature without emissions sampling. Repeat the heating and measurement sequence for three consecutive days, starting each heating cycle no more than 26 hours after the previous start. Use the highest of the three 24-hour emissions sampling periods to determine whether your fuel tank meets the diurnal emissions standard.

- Follow the applicable temperature trace of this procedure for three consecutive 24-hour periods for the applicable tank type. Temperatures should follow the trace within +/- 2°F and when stabilized in the eighth and ninth hours must be within 1°F of the target value. Start measuring emissions when you start the temperature profile. The end of the first, second, and third emissions sampling periods must occur at 1,440 ± 6, 2,880 ± 6, and 4,320 ± 6 minutes respectively, after starting the measurement procedure. Use the highest of the three 24-hour emissions sampling periods to determine whether your fuel tank meets the diurnal emissions standard.

o For emissions control technologies that rely on a sealed fuel system utilizing a pressure relief valve (PRV), you may omit the stabilization step of this procedure and the last two 24-hour periods of emissions measurements of this procedure. The PRV must meet the durability requirements of Section 5.2 prior to conducting the SHED test. Purge the SHED and follow the applicable temperature trace of this procedure for one 24-hour period. The end of this 24-hour sampling period must occur at 1,440 ± 6 minutes. The 24-hour sampling period emissions must meet the venting control efficiency standard of 65 percent. To determine the venting control efficiency, a venting control test must be conducted according to TP-1503 with E10 CERT fuel and then compared to the average emissions value derived from the diurnal venting SHED test results. As an alternative, an estimated uncontrolled diurnal venting value derived from the fuel tank vapor generation equation in SAE Technical Paper 892089, *Prediction of Fuel Vapor Generation From a Vehicle Fuel Tank as a function of Fuel RVP and Temperature* (Reddy, 1989) can be compared to the Diurnal SHED test results.

- You may subtract your fuel tank's permeation emissions from the measured diurnal emissions. For the purpose of this test procedure, permeation emissions must be measured as specified in TP-1504 using the same test fuel as used in TP-1503 and conducted at 82.4°F± 3.6°F (28°C± 2°C). Use appropriate units and corrections to subtract the permeation emissions from the fuel tank during the diurnal emissions test. You may not subtract a greater mass of emissions under this section than the fuel tank would emit based on meeting the applicable emissions standard for permeation.

7. TEST FUEL

E10 CERT fuel is 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, as incorporated by reference herein.

8. ALTERNATIVE TEST PROCEDURES

Test procedures, other than specified above, shall only be used if prior written approval is obtained from the Executive Officer. In order to obtain approval of an alternative test procedure, the applicant is responsible for demonstrating to the Executive Officer that the alternative test procedure is equivalent to this test procedure.

- Documentation of any such approvals and demonstrations shall be maintained by the Executive Officer and shall be made available upon request.
- Demonstration of equivalency must include a minimum of three (3) test results each from TP-1503 and from the submitted alternative test procedure. The application must also include a comparison of the results demonstrating that the submitted alternative test procedure yields results equivalent to this test procedure. The applicant must submit the test procedure in detail for an engineering review and clearly identify any modifications to TP-1503.
- 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. *ABYC H-24: Gasoline Fuel Systems*, American Boat and Yacht Council, Inc. Annapoilis, MD, July 2012.

2. *ASTM B117-11: Standard Practice for Operating Salt Spray (Fog) Apparatus,* ASTM International, West Conshohocken, PA, October 2011.

3. *California Evaporative Emission Standards and Test Procedures for 2001 and Subsequent Model Motor Vehicles*, California Environmental Protection Agency, Air Resources Board, El Monte, CA, March 2012.

4. *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, August 1999.

5. *Control of Emissions from New and In-use Highway Vehicles and Engines*, Code of Federal Regulations Part 86, June 1995.

6. SAE Technical Paper 892089, *Prediction of Fuel Vapor Generation From a Vehicle Fuel Tank as a function of Fuel RVP and Temperature* (Reddy, 1989).