Diurnal Emissions From an 18’ Runabout

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ABSTRACT – A test program was conducted in the late summer of 2002 to evaluate the evaporative emissions from a contemporary runabout. The boat selected was an eighteen foot 2003 Four Winns Horizon with a thirty-two gallon plastic fuel tank. This vehicle was selected as the largest boat that would fit in the available Variable Temperature Sealed Enclosure for Evaporative Determination (VT-SHED). Two companion SHEDs were used, one for permeation determination from the boat and the second to measure the fuel tank venting losses generated during two three day diurnal (72 - 96º F) tests.

The venting losses normalized for tank size was 0.9 and 1.0 g/gal/day for the two tests run, which meets the requirements. The permeation from the boat were 1.6 grams for the first test when the boat had never seen fuel, and 11 grams after the boat had soaked for 30 days. This indicates the permeation emissions are substantial and do reflect the soak.

TEST PLAN – This testing was funded by the National Marine Manufacturers Association. Automotive Testing Laboratories in Mesa, Arizona was selected for the testing, as it has been a major source for evaporative testing by both the Environmental Protection Agency and the California Air Resources Board for years.

The conventional VT-SHED measures 10 ft. wide by 10 ft. high and 20 ft. deep. This was the primary constraint on the boat to be selected. We also wanted as small a tank as possible to experience the largest effect of temperature cycling. Fuel temperature in a small (one quart) lawn mower tank will closely follow ambient temperature changes. It has demonstrated that on a car, there is a time lag of several hours and two to four degrees on peak fuel temperature. Thirty-two gallons is not considered a large tank for this size boat. The tank was plastic, which was thought to be appropriate.

To maximize what we could learn, it was decided to use two companion SHEDs simultaneously for this program. We measured the permeation emissions from the boat in one SHED where the temperature was cycled from 72 - 96º F. The fuel tank vent line was extended through a bulkhead fitting into the adjacent SHED. Using this approach we were able to measure real-time venting losses separate from the permeation emissions from the boat.

The boat was tested on two occasions. The boat had not seen gasoline before the first test in August, and we anticipated low permeation emissions. After 30 days of soaking while filled with federal test fuel, the test was repeated. A thermocouple failure of the control mechanism was experienced on the first retest, so a second retest was conducted.

DISCUSSION – The boat selected is shown below in Photo 1.

Photo 1. 2003 Four Winns boat as received at ATL.

Photo 2. shows the fuel fill at the aft of the boat. This system utilizes the Perco Combo vent. Both the fill hose and tank vent are located below the fuel cap.

Photo 2. Fuel fill – starboard, aft (right, rear)

The next photo (Photo 3.) is a view looking down at the production fuel tank installation. The large diameter hose extends from the tank to the fill cap location (lower left in photo). The smaller vent hose comes from the upper right tank to the fill cap location. Also visible is the fuel gauge sending unit and fuel suction (feed) line. This is a keel-mounted tank, which is about a foot wide and four feet long to achieve a 32-gallon capacity.

Photo 3. Production Fuel Tank and Lines

Photo 4. below shows the instrumented fuel tank.

Photo 4. Instrumented Fuel Tank

As can be seen, the fuel fill hose was removed and the tank capped with a test adapter equipped with a thermocouple installed to obtain liquid fuel temperatures during the test. The fuel fill hose was sealed with a non-permeable hard plastic plug. The vent

line was removed and replaced with a 3/8" Teflon venting tube that ran over the side of the boat and through a bulkhead fitting into the companion SHED.

Photo 5. shows the technicians into the SHED. As can be seen, it just fit! The removable tongue was very helpful.

Photo 5. Vehicle Insertion Into the SHED

When the boat was in the SHED, circulation fans were positioned to direct air flow under the keel of the boat (Photo 6.). The fans used are the same as used in automotive testing.

Photo 6. Boat in SHED, Circulation Fans in Position

It was assumed that the intent of the test was not to dismantle the boat and direct air down into the hull. See the citation below.

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Subpart F—Test Procedures

§ 1045.501 What equipment and general procedures must I use to test my vessels?

(a) *Diurnal testing.* Use the equipment specified in 40 CFR part 86 subpart B (*i.e.*, the procedures used to measure diurnal evaporative emissions for gasoline-fueled highway vehicles). Use the procedures specified in § 1045.505 to measure diurnal emissions.

(1) These provisions require placing your vessel or fuel system within a sealed, temperature-controlled enclosure called a SHED (Sealed Housing for Evaporative Determination).

(2) You must include a fan to maintain a minimum wind speed of 5 miles per hour across the tank.

(b) *Permeation testing.* Use the following equipment and procedures for measuring permeation emissions:

(1) For fuel tank permeation, see § 1045.506.

(2) For fuel line permeation, see SAE J1527 (incorporated by reference in § 1045.810). Alternatively, you may use the equipment and procedures specified in SAE J1737 (incorporated by reference in § 1045.810), except that all tests must be conducted at 23°C ± 2°C.

(c) *Special or alternate procedures.* You may use special or alternate procedures, as described in § 1065.010 of this chapter.

TESTING RESULTS –

Temperature - Figure 1. displays the ambient temperature and the liquid fuel temperature response during the three day diurnal events. The blue diamonds show the ambient temperature varying from 72 to 96º F. The solid red triangles are the fuel temperature for the first test and the open red circles are the fuel temperatures for the third test (test 2 was aborted due to equipment problems mentioned earlier).

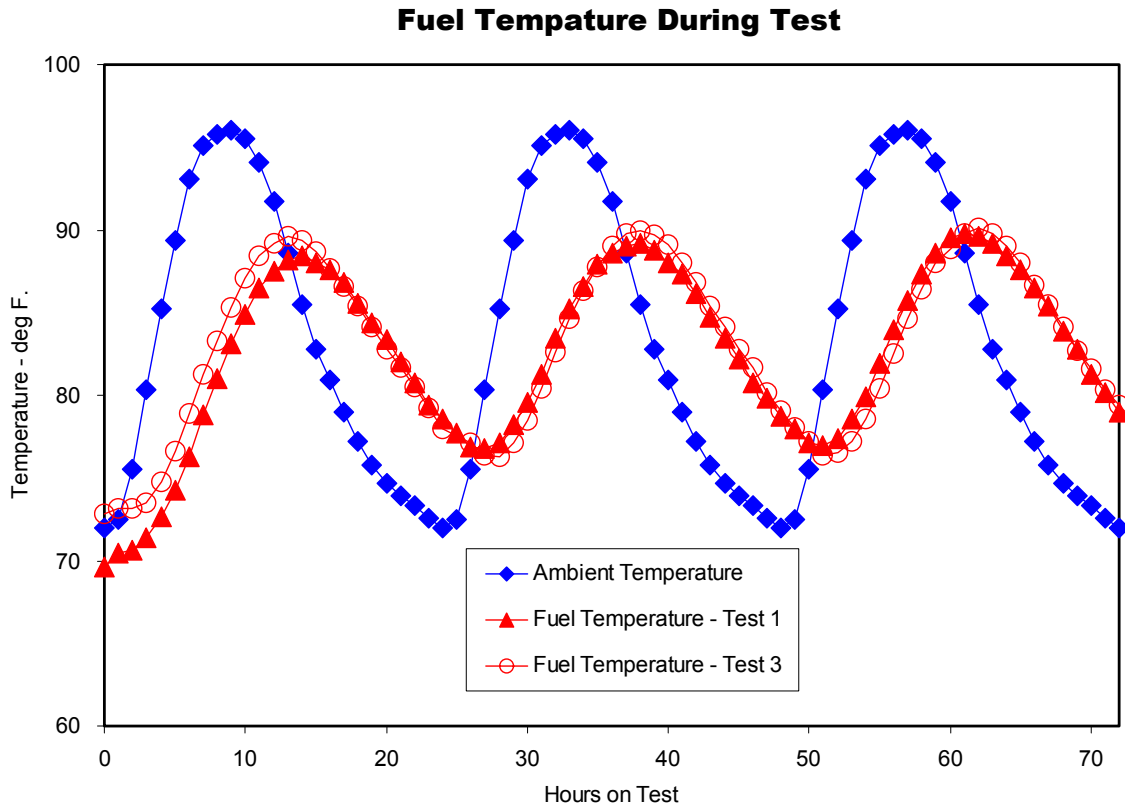

Figure 1.

The day one fuel temperature starts at 70º F and cycles for the next 72 hours.

One comment about the test procedure needs to be made. The procedure specifies that the fuel temperature is to be stabilized at 72º F. As a result, the first day fuel temperature rise will be the largest of any of the three days. In practice, the first day temperature rise is from 72 to 88º F (16º F), while for days two and three is from 78 to 89º F (11º F). With this as an observation, why would we consider a three day test.

Because of the way the test is configured, it appears that day one fuel temperature and resulting diurnal emissions will always be the largest.

The next figure (Figure 2.) is an overlay of the daily temperatures and shows this situation a little more clearly. The day one temperature starts low then peaks about five hours after the ambient. Days two and three start about 8º F higher, and peak at about the same point as day one, which reinforces that day one diurnal emissions will be the highest.

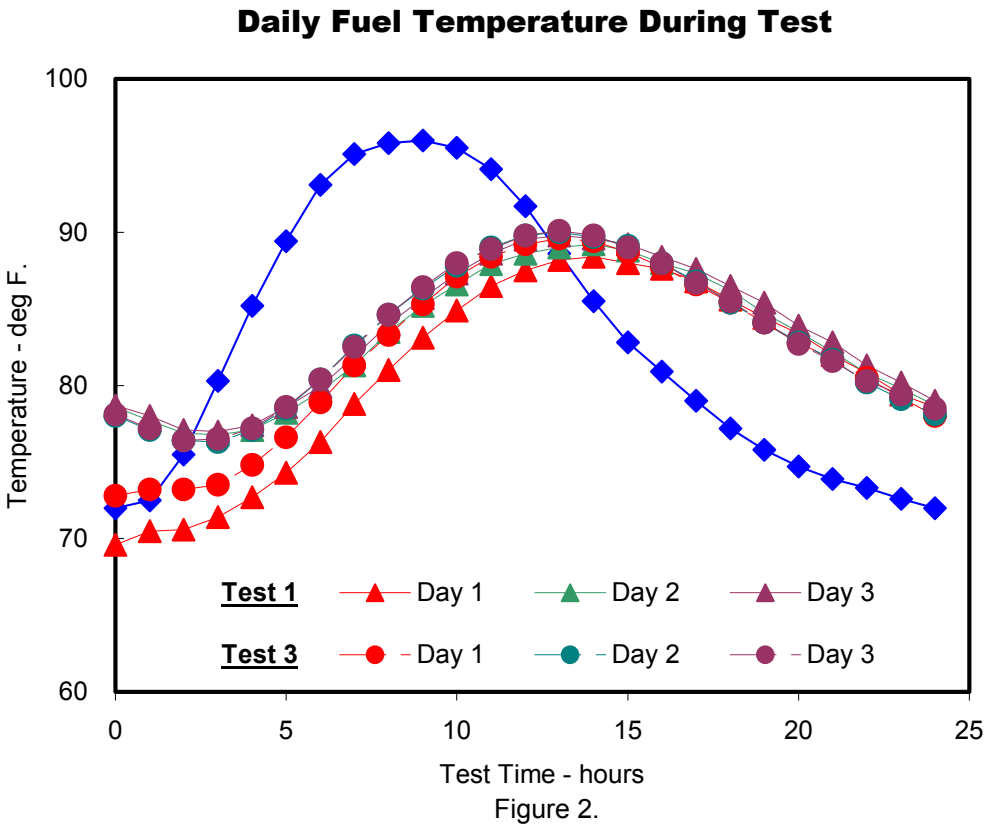

Figure 2.

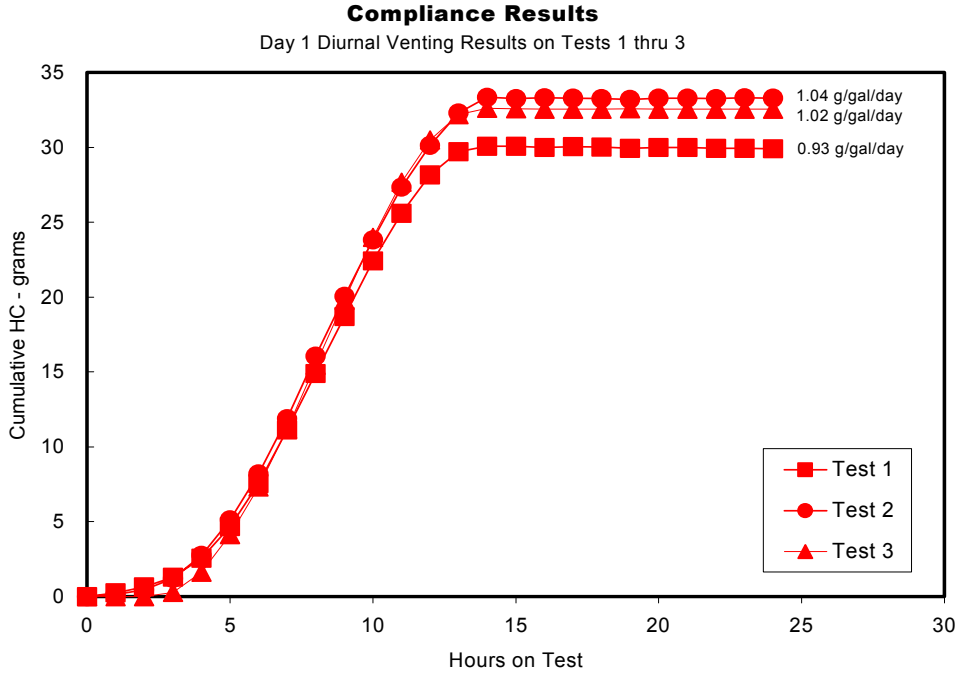

Figure 3.

Diurnal Venting Emissions - The venting emissions for day one of all three tests are shown in Figure 3 on the previous page. The emissions on test one was 29.9 grams and was 33.3 and 32.5 grams for tests two and three, respectively. Test repeatability is shown in the test two and three results. When normalized for tank size, these venting results are 0.9 and 1.0 gms/gallon/day, which meets the requirement.

Diurnal Summary –

- Actual data measured with the tank in the boat gave emissions lower than the proposed 1.1 gm/gal/day diurnal venting requirement.

- The diurnal control seen on this boat, which is very typical of the population, met the objective without the need of pressurizing the fuel system.

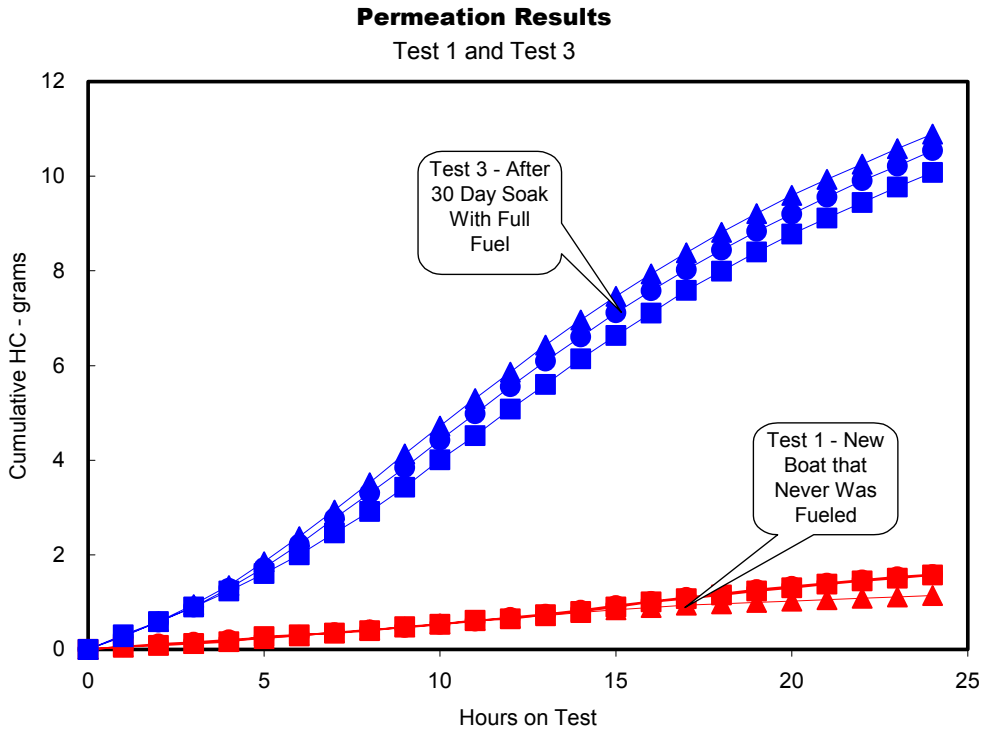

Figure 4.

Diurnal Permeation Emissions – As can be seen in Figure 4., when the boat had not seen gasoline, the permeation results were 1.6 grams, probably due primarily to the tires and boat upholstery, not the tank and hoses. After the boat had soaked for 30 days with the tank filled with federal test fuel, permeation was measured at 11 grams (.34 gms/gal/day).