DIURNAL EMISSIONS TESTING OF WALK-BEHIND MOWERS CONFIGURED WITH FUEL TANK PRESSURE RELIEF VALVES
(September 2002)

Stationary Source Testing Branch
Monitoring and Laboratory Division

September 17, 2002

DIURNAL EMISSIONS TESTING OF WALK-BEHIND MOWERS CONFIGURED WITH FUEL TANK PRESSURE RELIEF VALVES

(September 2002)

Introduction

In the fall of 2001 the ARB tested 3 pairs of walk-behind mowers configured with evaporative emission control equipment designed to isolate gasoline vapors within the fuel tank during hot soak and diurnal periods. When the emission reduction test data were shared with industry, two fundamental questions were raised. What is the maximum pressure inside a sealed fuel tank when exposed to a 65 – 105º F rise in ambient temperature? And, how would the diurnal evaporative emissions be affected by the inclusion of a pressure relief valve on a sealed equipment fuel tank?

Test Protocol

Maximum Pressure Testing

A one-quart Briggs & Stratton Intek fuel tank was configured with a pressure transducer and two thermocouples (one thermocouple to measure liquid fuel temperature and one thermocouple to measure fuel tank skin temperature). The fuel tank was filled with one-pint of California certification fuel (6.7 RVP, 65º F). The tank was checked for leaks and placed in a Sealed Housing for Evaporative Determination (SHED) pre-cooled to 65º F. The sealed tank was subjected to multiple 24-hour (65 – 105 -65º F) and one (65 – 120 -65º F) diurnal profiles. A data logging system recorded the pressure within the tank, liquid fuel temperature, fuel tank skin temperature, and the temperature of the SHED.

Pressure Relief Testing

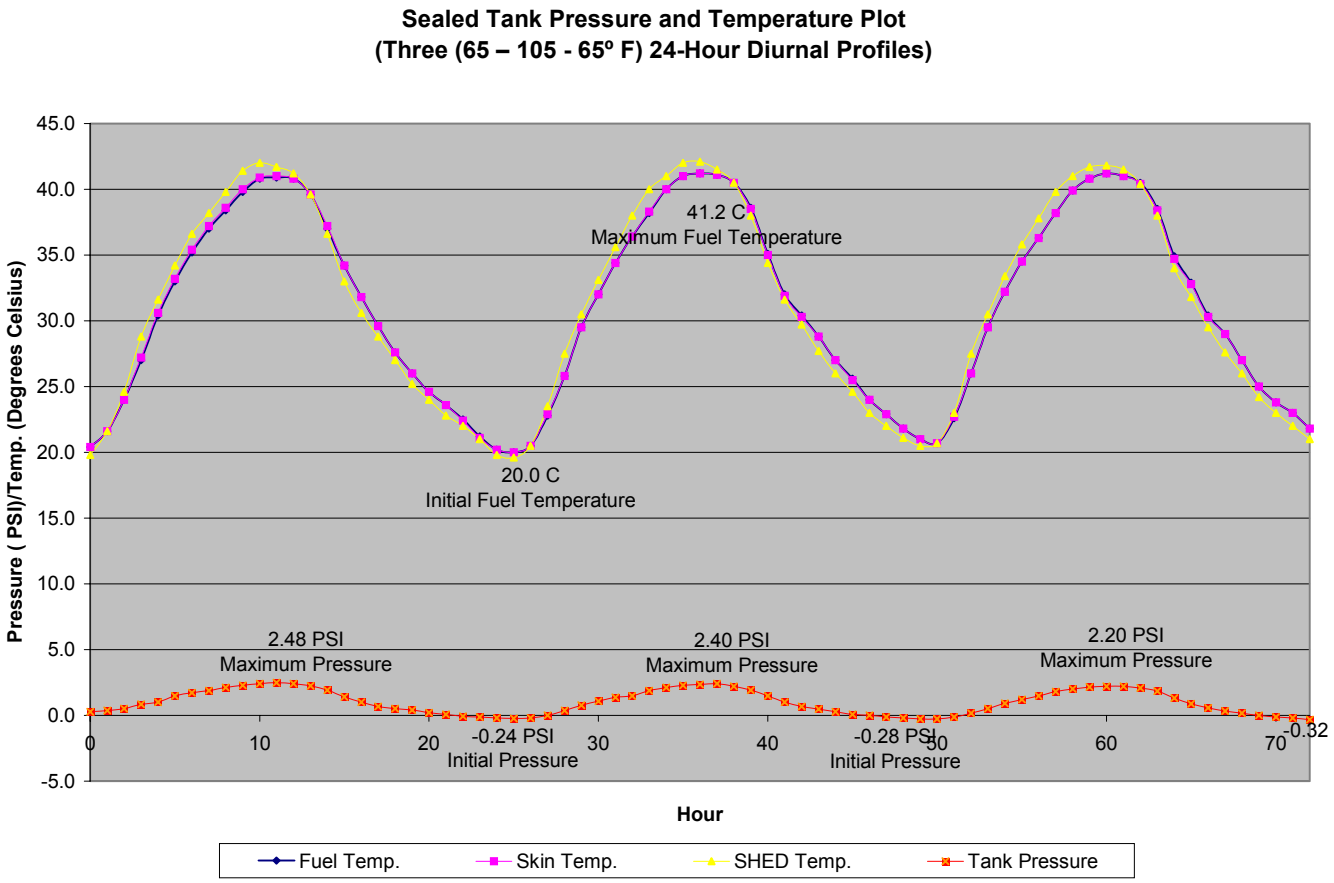
An Intek mower modified with evaporative emission control equipment to isolate gasoline vapors within the fuel tank was outfitted with an adjustable pressure relief valve. The test procedure required the tank to be drained and the pressure relief valve adjusted to 4, then 3, and finally 2 pounds per square inch (PSI). In all, three tests were performed and the pressure relief valve setting was verified prior to the start of each test. For each test the tank was filled with one pint of California summer pump fuel (6.9 RVP, 65º F) and placed in a SHED and subjected to a one-hour hot soak test at 95º F. After the hot soak test, the SHED was force cooled to 65º F. The mower was then soaked for two hours at 65º F then subjected to a 24-hour (65 – 105 -65º F) diurnal temperature profile (attachment 1).

Results

Maximum Pressure

The following graph details pressure and temperature readings for the sealed tank over three 24-hour (65 – 105 -65º F) diurnal test periods:

Figure 1

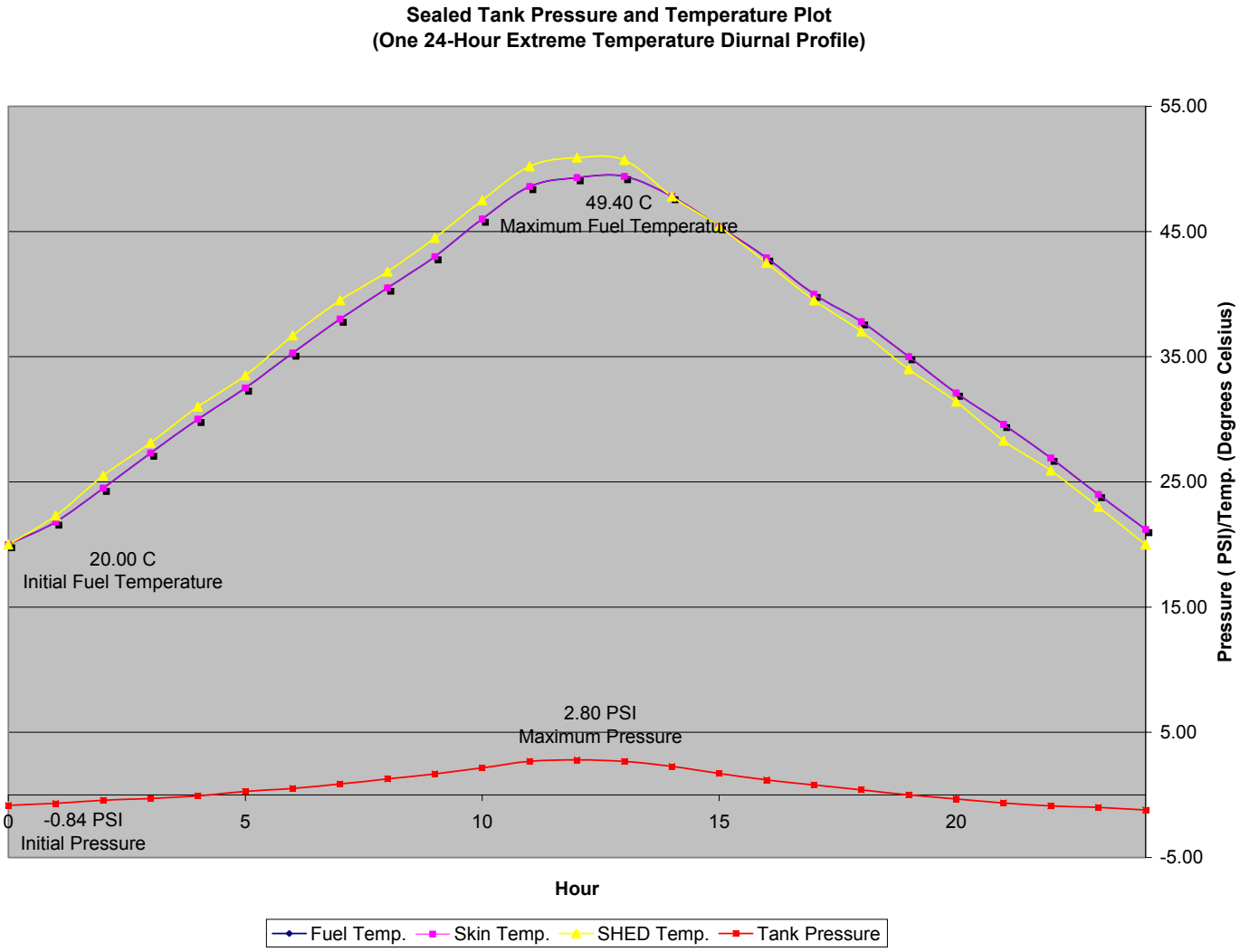


As shown in Figure 1, increasing the fuel temperature from 68º F to 106º F increased the pressure within the tank by 2.64 PSI. The skin temperature of the fuel tank and the liquid fuel temperature were nearly indistinguishable and were both lower than the ambient SHED temperature during the rise in the temperature profile. The skin temperature of the fuel tank and the liquid fuel temperature were higher than the ambient SHED temperature during the fall in the temperature profile.

A sealed tank was also subjected to a (65 – 120 -65º F) diurnal profile to measure maximum tank pressure under extreme conditions. Figure 2 plots the

results of the extreme temperature testing. The skin temperature of the fuel tank and the liquid fuel temperature followed a similar pattern and were lower than the ambient SHED temperature during the rise in SHED temperature and higher during the fall in SHED temperature. The test measured an increase in tank pressure of 3.64 PSI as the fuel temperature rose from 68º F to 121º F.

Figure 2



Pressure Relief Testing

The following figure and table details the SHED results for various pressure relief settings:

Figure 3

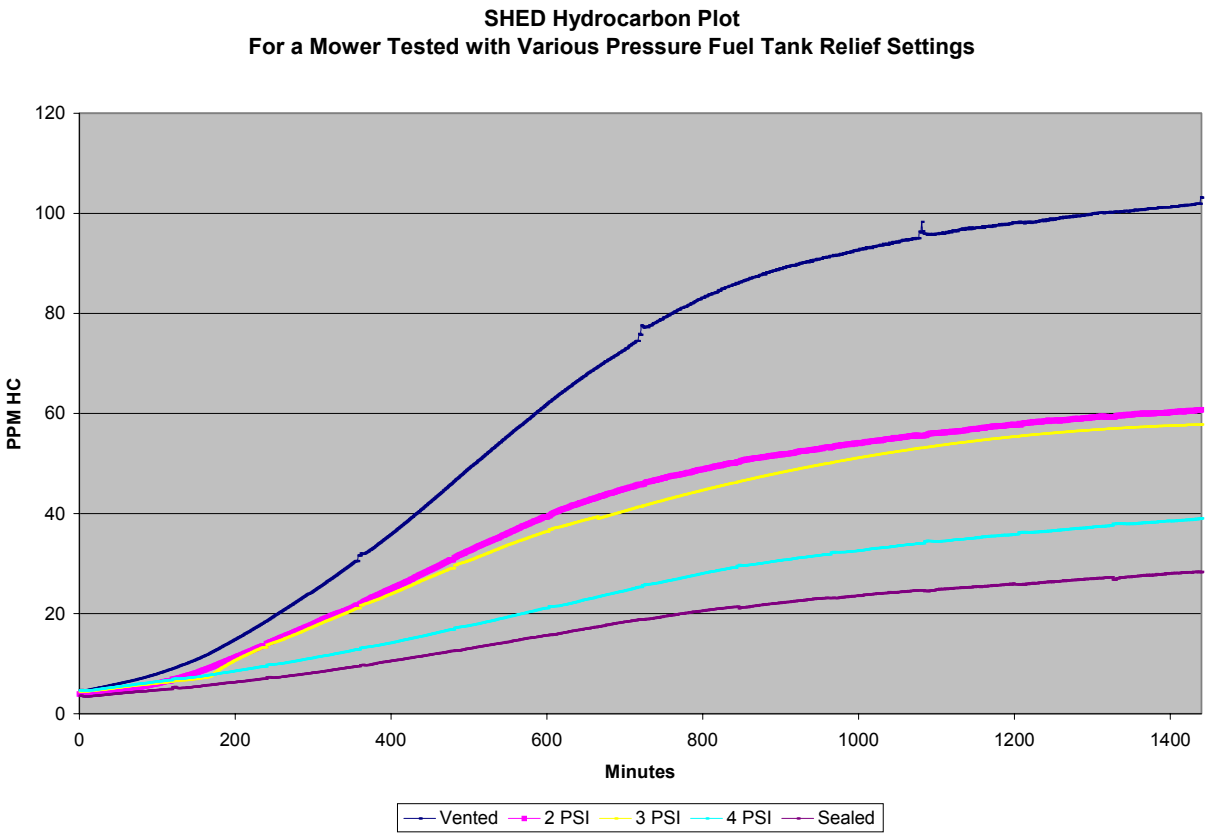


Table 1

Level of Control	Hot Soak Results (grams/hour)	Diurnal Results (grams/day)	% Diurnal Control
Uncontrolled (Vented)	0.515	2.849	0.0%
2 PSI Relief	0.455	1.617	43.2%
3 PSI Relief	0.500	1.634	42.6%
4 PSI Relief	0.113	1.069	62.5%
Full Control (Sealed)	0.118	0.695	75.6%

A comparison of the 4 PSI and 2 PSI test results show a 0.548 difference. This result was expected because the pressure within the fuel rises above 2 PSI during a diurnal test. The result also agrees with data from a previous study that measured the diurnal emissions of a vented one-quart tank filled to 50% of capacity with Certification fuel at 0.500 grams. Data for the 3 PSI test suggests that the pressure within the tank exceeded 3 PSI.

Conclusion

The test results indicate that pressure with a sealed tank does not exceed 4 PSI when the fuel temperature is raised by 38º F. Even under extreme conditions, such as a 53º F rise in fuel temperature, the associated rise in tank pressure for a typical one-quart HDPE tank is less than 5 PSI.

The testing indicates that allowing a 4 PSI pressure relief setting achieves significant emission reductions (62.5%) and should reduce safety concerns associated with pressurized tanks.

Attachment 1

1 Day / 24 Hour / 1440 Minute Variable Temperature Profile

HOUR	MINUTE	TIME REMAINING (MINUTES)	TEMPERATURE (°F)
0	0	1440	65.0
1	60	1380	66.6
2	120	1320	72.6
3	180	1260	80.3
4	240	1200	86.1
5	300	1140	90.6
6	360	1080	94.6
7	420	1020	98.1
8	480	960	101.2
9	540	900	103.4
10	600	840	104.9
11	660	780	105.0
12	720	720	104.2
13	780	660	101.1
14	840	600	95.3
15	900	540	88.8
16	960	480	84.4
17	1020	420	80.8
18	1080	360	77.8
19	1140	300	75.3
20	1200	240	72.0
21	1260	180	70.0
22	1320	120	68.2
23	1380	60	66.5
24	1440	0	65.0