ADDENDUM TO:

DURABILITY TESTING OF BARRIER TREATED HIGH-DENSITY POLYETHYLENE SMALL OFF-ROAD ENGINE FUEL TANKS (March 2003)

Stationary Source Testing Branch
Monitoring and Laboratory Division

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Introduction

In early 2002 staff of the California Air Resources Board (CARB) conducted tests to determine the possible abrasive effects of fuel slosh on barrier treated High-Density Polyethylene (HDPE) fuel tanks. After determining that the results were biased due to the addition of a UV inhibitor, CARB staff decided to repeat these tests. In September of 2002, CARB staff selected nine identical two-quart small off-road engine fuel tanks for follow-up testing. Staff chose these tanks based on their material composition, volume, and uniform geometry. A variable temperature profile was used to determine average permeation rates both before and after subjecting each tank to 1.2 million ‘slosh’ cycles. The results of these tests were made available to the public in the report entitled Durability Testing of Barrier Treated High-Density Polyethylene Small Off-Road Engine Fuel Tanks.

Immediately following the collection of the final daily weight loss data using the variable temperature profile, all nine fuel tanks were placed in an adjacent Sealed Housing for Evaporative Determination (SHED) and maintained at a constant 40 degrees Celsius (40°C). This addendum provides the details and results of these constant temperature tests. In March 2003, CARB staff measured the average permeation rates of three fluorinated, three sulfonated, and three untreated fuel tanks maintained at a constant 40°C.

Test Protocol

The study began with the selection of nine identical two-quart small off-road engine fuel tanks for testing. These tanks were molded from an HDPE resin that contained a 2 percent mixture of carbon black and each had an internal surface area of 0.115 square meters. Three tanks were fluorinated and three were sulfonated. The remaining three tanks were left untreated to serve as a control group.

Each tank underwent standard preconditioning procedures including 1000 pressure/vacuum cycles and a ninety-day soak period prior to testing. After preconditioning, an initial permeation test was performed on the fuel tanks. Weight loss was used to determine average permeation rates and all tanks were exposed to multiple 1-day/24-hour/1440-minute variable temperature profiles (see Attachment 1). After the initial permeation tests, the tanks were subjected to 1.2 million ‘slosh’ cycles over a seven-day period. Following the sloshing, the tanks were again exposed to multiple 1-day/24-hour/1440-minute variable temperature profiles to measure any change in average permeation rates.

Immediately following the collection of the last weight loss data, all nine tanks were placed in an adjacent SHED stabilized at 40°C. The fuel tanks were soaked at 40°C and removed every 24-hours and weighed using a 6,200-gram balance with a sensitivity of ± 0.01 grams. The tanks were weighed at the same time each day (± 30 minutes) to reduce variability and after each 24-hour cycle the data were recorded and the weight losses calculated.

Results

As with the previous tests, permeation rates for each tank were calculated by dividing the average daily weight loss by the tank's internal surface area. Although each tank underwent multiple 24-hour soak periods, results are calculated using only the average of the last five 24-hour cycles. The initial cycles of test data were not used in determining individual per container permeation rates due to variability. In addition, it should be noted that during the fourth 24-hour soak period the fuel tanks were subjected to a temperature excursion of 53.3°C for a period of six hours due to a SHED malfunction. Staff was able to correct to problem and elected to continue the test. However, due to the malfunction the data are useful for research purposes only. Figure 1 provides a comparison of the 'after-sloshing' average permeation rates and the constant temperature average permeation rates. In addition, Table 1 shows the actual weight loss data collected during the constant 40°C soak period.

Figure 1

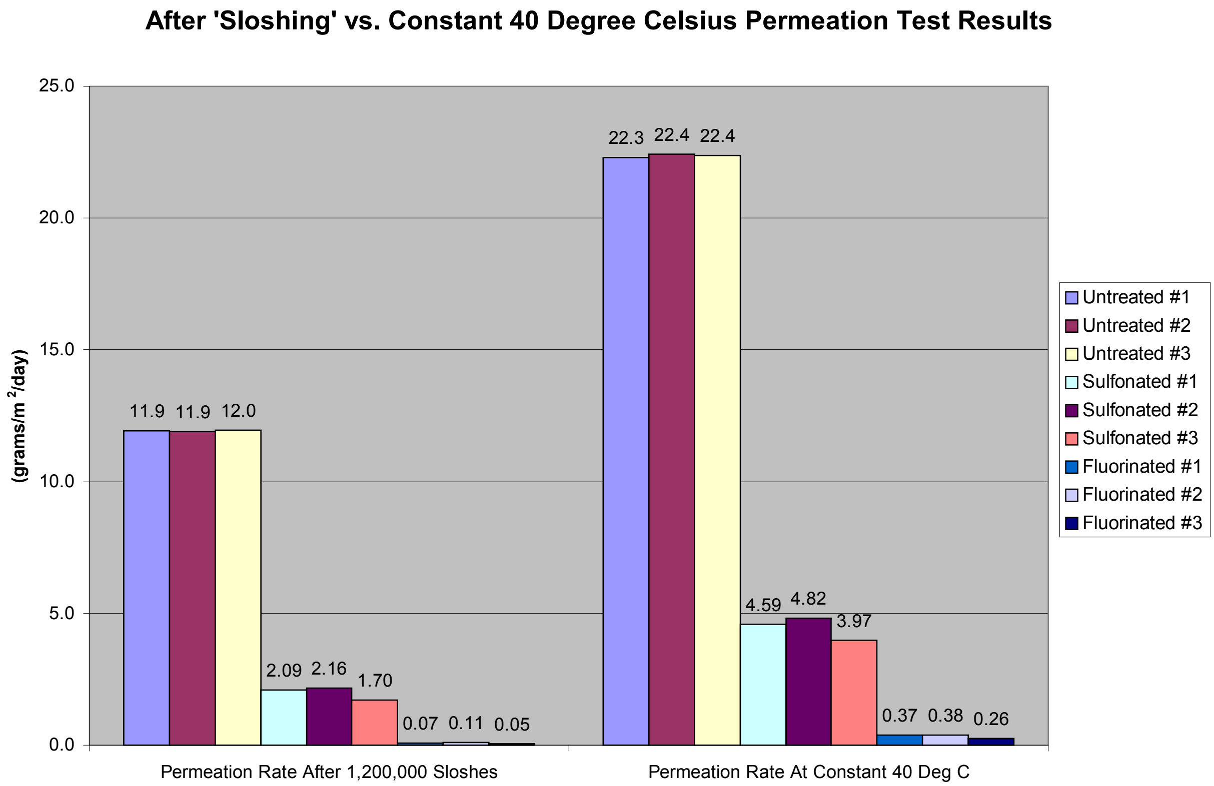

Table 1
Daily Weight Loss at 40°C (grams)

Date	3/7	3/8	3/9	3/10*	3/11	3/12	3/13	3/14
Untreated 1	2.42	2.22	2.23	3.60*	2.20	2.42	2.37	2.31
Untreated 2	2.46	2.21	2.26	3.63*	2.23	2.40	2.37	2.29
Untreated 3	2.39	2.25	2.25	3.63*	2.20	2.44	2.35	2.33
Sulfonated 1	0.55	0.44	0.43	0.74*	0.44	0.52	0.51	0.49
Sulfonated 2	0.59	0.48	0.43	0.79*	0.45	0.58	0.52	0.53
Sulfonated 3	0.50	0.39	0.35	0.65*	0.37	0.46	0.45	0.42
Fluorinated 1	0.15	0.09	0.01	0.08*	0.01	0.06	0.05	0.03
Fluorinated 2	0.12	0.08	0.01	0.10*	0.01	0.07	0.03	0.04
Fluorinated 3	0.13	0.07	-0.01	0.07*	0.01	0.06	0.02	0.02

*** Temperature excursion of 53.3°C for a period of six hours due to a SHED malfunction.**

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