DURABILITY TESTING OF BARRIER TREATED HIGH - DENSITY POLYETHYLENE SMALL OFF-ROAD ENGINE FUEL TANKS (June 2002)

Engineering and Certification Branch
Monitoring and Laboratory Division

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HIGH - DENSITY POLYETHYLENE
SMALL OFF-ROAD ENGINE FUEL TANKS

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Introduction

In an effort to determine the possible abrasive effects of fuel slosh on barrier treated High-Density Polyethylene (HDPE) fuel tanks, California Air Resources Board (CARB) staff measured the average permeation rates of three fluorinated and three sulfonated fuel tanks. The rates were measured before and after subjecting each tank to 1.2 million slosh cycles over a 7-day period. Average permeation rates were then determined gravimetrically.

Test Protocol

In February of 2002, CARB staff selected six identical one-quart small off-road engine fuel tanks for testing. Staff chose these tanks based on their volume and uniform geometry. The internal surface area of each tank, 106 square inches, was calculated from CAD drawings. Three tanks were fluorinated to Level 5 by Fluoro-Seal at their Ontario, California plant. The remaining three tanks were sulfonated by Sulfo Technologies LLC at their plant in Michigan until a surface concentration of 300 µg of sulfur trioxide per square inch was reached. In March of 2002, the barrier treated tanks underwent preconditioning at CARB's test facility in El Monte, California. The tanks were initially filled with commercial pump fuel containing MTBE and soaked at ambient temperature and pressure for a minimum of four weeks. After soaking, the tanks were emptied, dried with compressed zero air, and immediately refilled to 50% capacity with California CERT fuel. Each tank was then sealed using a hand-held fusion welder and a 1/4" thick HDPE coupon and visually inspected for leaks.

After preconditioning, an initial permeation test was performed on the six sealed barrier treated fuel tanks. Weight loss was used to determine average permeation rates. All tanks were weighed using a 6,200-gram balance with sensitivity of $\pm$ 0.01 grams. After initial weighing, the tanks were placed in a Sealed Housing for Evaporative Determination (SHED) and exposed to multiple 1-day/24-hour/1440-minute variable temperature profiles (see Attachment 1). The tanks were then post weighed after each 24-hour cycle and the weight loss calculated.

Each tank was weighed every 24-hours until the standard deviation of the average daily weight loss was below 0.04-grams. The fuel tanks were then transported to CARB's test facility in Sacramento and 'sloshed' using an orbital shaker table set to two cycles per second. The orbital shaker subjected the fuel tanks to 1.2 million slosh cycles over a seven-day period. During sloshing, the fuel inside the tanks was subjected to a centripetal acceleration of 0.49 g.

Following the slosh testing, the sealed tanks were transported back to El Monte to measure any change in the average permeation rates. As before, the tanks were exposed to multiple 1-day/24-hour/1440-minute variable temperature profiles. The tanks were then post weighed after each 24-hour cycle and the weight loss calculated.

Results

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 diurnal cycles, 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. Figure 1 and Tables 1 and 2 summarize the permeation results before and after sloshing.

Figure 1

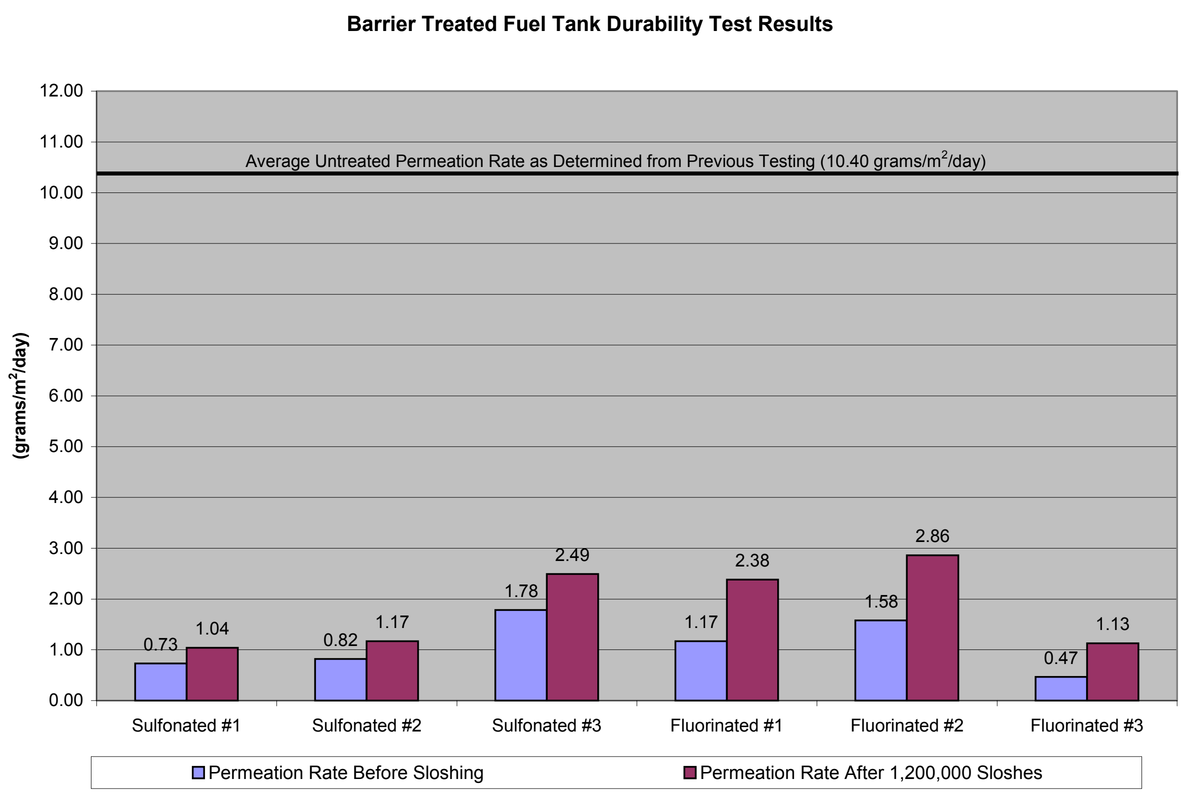

Table 1

	Avg. Untreated Perm. Rate (grams/m²/day)	Perm. Rate Before Sloshing (grams/m²/day)	% Reduction from Untreated
Sulfonated #1	10.4	0.73	93.0%
Sulfonated #2	10.4	0.82	92.1%
Sulfonated #3	10.4	1.78	82.8%
	Average	1.11	89.3%
Fluorinated #1	10.4	1.17	88.8%
Fluorinated #2	10.4	1.58	84.8%
Fluorinated #3	10.4	0.47	95.5%
	Average	1.07	89.7%

Table 2

	Avg. Untreated Perm. Rate (grams/m²/day)	Perm. Rate After Sloshing (grams/m²/day)	% Reduction from Untreated
Sulfonated #1	10.4	1.04	90.0%
Sulfonated #2	10.4	1.17	88.8%
Sulfonated #3	10.4	2.49	76.1%
	Average	1.57	84.9%
Fluorinated #1	10.4	2.38	77.1%
Fluorinated #2	10.4	2.86	72.5%
Fluorinated #3	10.4	1.13	89.2%
	Average	2.12	79.6%

Conclusion

The test results indicate that both types of surface treatments initially provide an effective permeation barrier (~90%). The data also indicates that fuel slosh degrades barrier effectiveness an average of 5% for sulfonated tanks and 10% for fluorinated tanks. However, both processes provide significant benefit by reducing permeation emissions by approximately 80% even after this exhaustive durability simulation

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