B20 to B100 Blends as Heating Fuels

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Review of Field Experience with Biodiesel Blends

Since about 2000 the use of biodiesel blends in the field has been steadily increasing. Initially this was laboratory research and focused field tests. This was followed by fuel marketers providing to their customer base biodiesel blends. The blend levels which have been and continue to be used by marketers vary. Many have been using low blend levels ~ B5. Others have been using B20 for all customers since ~ 2005. Still others have been distributing low blends to some customers and high blend levels to those who request it. This widespread use at different biodiesel blends represents an important experience base that can be used to identify technical concern areas.

Experimental

As part of our work to document field experience with higher biodiesel blends, we have planned and executed a survey of fuel oil marketers who have some involvement with bioheat blends. Our goals were to identify marketers who have significant experience with the use of higher blends and to evaluate clear technical limits which have been realized. The survey was arranged by the BNL Web Services Group, under a NoviSystems platform. The survey invitation was sent out for us by the National Oilheat Research Alliance (NORA) specifically to organizations which have registered to use the Bioheat ® registered logo in order to capture biodiesel specific experience. A total of 85 responses were received. The survey was run in 2013 and the open period was only two weeks.

Of the respondents who reported they were using biodiesel blends, 32% reported they had used biodiesel for 3-5 years and 33% reported they had used this fuel for 6-9 years, indicating a strong historical experience.

Fifty eight percent of the respondents reported they delivered B5 blends and 13% reported they delivered B20 blends. Essentially all the respondents did not change any burner or system components when converting to biodiesel blends.

Table 6-1, below shows the response to a question about service problems related to use of biodiesel blends in the field. The results are very similar to earlier results from fuel surveys with No. 2 oil, indicating the biodiesel blends were performing similar to conventional No. 2 oil.

Table 6-1. Response to Survey Question on Biodiesel-Related Service Problems

Answer	Count	Percent answer
no unusual problems observed	40	55.56%
Fuel storage (sludge)	5	6.94%
Fuel filter blockage due to sludge	11	15.28%
Low temperature flow	4	5.56%
Corrosion	0	0.00%
Pump leakage	3	4.17%
Pump seizing or other pump problems	2	2.78%
Nozzle fouling	5	6.94%
Other	2	2.78%

Table 6-2 shows the results to a question about how many specific homes are at different blend levels. This shows the total number of reported homes across all respondents. It is very interesting to note that, at this time there were some 91,000 homes using B5. For blends between B10 and B40 the total number is 37,284. This shows that the use of biodiesel blends is quite well established and even higher-level blends are being used in a number of homes that is clearly past experimental use.

Table 6-2 Response to Survey Question on Number of Homes on Different Blend Levels.

Answer	Count	Percent answer
Up to B5	90711	68.25
b5-10	5328	4.01
b10-18	24521	18.45
b20	10330	7.77
b20-40	2397	1.80
b40-80	4	0.00
b80-100	380	0.29

As reported in Table 6-2 some 380 buildings were, at the time of the survey, using blend levels in the B80 to B100 range. From follow-up calls we are aware that some of these are on the west coast but a large number are in New York City. It has been reported by fuel marketers that the number of B100 buildings in the city grew more recently to over 2000.

To supplement the field experience survey, samples of fuels were obtained for analysis from several fuel marketers who are using higher blend levels. The first of these is a marketer in Nassau County on Long Island marketing a nominal B20 blend. Fuel samples were taken from the bottom of tanks using a sampling equipment designed specifically for this purpose. Some of the analyses were done at BNL and some (Oxidative Reserve) were sent out to Southwest Research Institute. Table 6-3, below provides a summary of the test results. As shown, the oxidative reserve (Rancimat) test was done only for three of the ten samples.

Table 6-3 Result of Analysis of Biodiesel Blend Samples from Nassau County, Long Island.

Sample	Biodiesel Content	Water	Sediment	Acid No.	Oxidative Reserve (Rancimat)
	%	%	%	mg KOH/g	Hours
1	25.5	.05	.20	0.22	-
2	19.9	.25	1.15	0.21	0.5
3	20.3	0	0.30	0.20	-
4	20.3	0	1.50	0.21	-
5	6.4	.15	0.65	0.08	6.7
6	25.0	0	0.40	0.20	-
7	20.7	0	0.40	0.20	-

8	29.9	0	0.00	0.10	8.6
9	25.2	0	0.01	0.28	-
10	18.9	0	0.05	0.37	-

As shown in this table, the measured biodiesel content ranged from a low of 6.4% to a high of 29.9%. This range of variation, based on discussions with the marketer is simply due to delivery logistics. The marketer needs to take deliveries from a range of sources through the heating season. The acid number for all samples except for number 10 is below the limit of 0.3 in ASTM D396 for B20 blends and well below the acid number of 2 which was demonstrated to have potential issues with elastomers from earlier study. For the three samples tested for oxidative reserve two, sample 5 and sample 8, were above the six-hour as-delivered minimum in D396 for blends up to B20. Sample 2 had an oxidative reserve of 0.2 hours indicating the oxidation reserve had been depleted, but the acid number was still quite low indicating the fuel had not changed to the point of being problematic.

Another sampling effort was undertaken in cooperation with a fuel marketer / service organization in Eastern Pennsylvania. This company was selected specifically because they market blends at levels greater than 20%. The actual blend used depends on market factors and logistical considerations.

Table 6-4 shows the list of samples and some observations provided by the dealer on tank age etc. Also shown is the biodiesel content, measured using an approximate FTIR method at BNL and Acid Number.

Table 6-4 Results of Analysis of Biodiesel Blend Samples from Eastern, Pa.

Sample	Biodiesel Content	Acid No.	Oxidative Reserve (Rancimat)
	%	Mg KOH/g	hrs
1	37.6	0.22	2.8
2	32.8	0.28	-
3	41.1	0.28	-
4	49.9	0.41	7.2
5	26.1	0.30	-
6	31.9	0.42	-
7	34.8	0.37	> 24
8	35.4	0.32	-
9	35.6	0.38	-

In this case the biodiesel content varied from a low of 26.1% to a maximum of 49.9%. The acid number specification for B100 as-produced is 0.5 mg KOH/g, so it is expected fresh blends with high biodiesel content will be between 0.5 and that of the base fuel oil. The base fuel oil acid number is normally low but it is not commonly measured as it is not part of the ASTM D396 specification for B5 and lower. The acid number values all fell below 0.5, far below the potentially problematic value in the range of 2. The as-produced oxidative reserve values for B100 is three hours minimum and for B6-B20 is six hours minimum. The oxidative reserve, measured for three of the samples was above six hours for two of the samples. For one of the samples the oxidative reserve was below six hours. This is an indicator the oxidation reserve had begun to be depleted but the acid number for that sample was low indicating the fuel had not begun to change significantly in-use.

Figure 6-1 shows the appearance of 4 of the samples taken. The two left samples show significant particulate content. The sample on the right has a clear water layer on the bottom. This illustrates the conditions which are not uncommon in the field and that exist for conventional No. 2 oils with or without the presence of biodiesel.

Figure 6-1 Photos of fuel samples taken from Eastern Pennsylvania sites

Most of these tanks had their last deliveries in late winter/early spring so the fuels were in storage for most of the summer. After settling at BNL all samples were found to have solid deposits and/or water at the bottom and, again, this is to be expected with bottom samples. After settling all samples were found to be clear. None of the fuels in either the Long Island or the Pennsylvania study caused significant issues in use vs. that of conventional No. 2 oil according to the suppliers.

7. Conclusions

Based upon all of the studies completed during this project the following conclusions can be drawn:

1. For the specific nitrile material used in shaft seal in the most common oil burner pump on the market a clear limit on biodiesel blend level, above which the seal degradation becomes excessive, was not found. However, if the fuels become extremely acidic (i.e. over 2 mg KOH/g), the fuel can degrade these elastomers. None of the samples from the field had acid numbers over 0.5 mg KOH/g.
2. The long-term cycling pump tests done at Penn State University with the most common pump in the US home heating oil market showed that the leakage rate was lower with biodiesel blends than with No. 2 petroleum-based heating oil. All of these pumps have lip seals. In follow-on tests at BNL with pumps with carbon face seals, no leakage at all was observed with fuels with a range of biodiesel blend levels.
3. In copper exposure tests at room temperature in this study for six months, simulating summer shutdown, no impact of biodiesel on the copper tubing was found. A strong increase in acid number of fuel samples stored in copper tubes was not found. Further, old copper was not found to have less of an effect than new copper. Work on the copper impact is continuing.
4. At high temperatures, similarly, exposure to copper was not found to have a greater increase in acid number relative to exposure in stainless steel and no significant differences were found between biodiesel and its blends and conventional No. 2 fuel oil (B0).
5. In combustion tests it was found that due to the oxygen in the biodiesel increasing the biodiesel at a fixed burner air shutter setting increases the excess air and the cadmium sulfide photo conductor resistance (less sensor incident light intensity). At a high biodiesel content, the excess air can be tuned to achieve a proper sensor reading. If a burner is tuned at a high biodiesel level and then the fuel is changed to a B0 or very low biodiesel content fuel, it will likely need to be readjusted to maintain adequate CO and smoke levels.
6. Fuel samples of biodiesel blends from bottom samples of home tanks in the field have shown that biodiesel content can vary. Some of the field samples had depleted some of their oxidation reserve but none of the samples had elevated acid numbers indicating the fuel had not changed to the point of being problematic in the field.
7. Reported field experience with biodiesel blends has shown no clear technical issue compared to that of conventional No. 2 oil.

Overall, the results of this work have not identified a clear technical barrier which would limit the use of biodiesel in home heating systems. It should be emphasized that these results are only applicable to biodiesel which has been properly processed from its parent oil/fat into biodiesel and that meets the stringent ASTM D6751 specification for B100 prior to blending.