

Results... Survey on Mechanical Issues Related to Biodiesel Blending

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ABSTRACT

Increasingly, biodiesel is being used as a blend stock in home heating oil. Currently, 5% biodiesel blends (B-5) are being used seamlessly across the market. Some fuel marketers are delivering B-20 to all of their customers and a few are delivering much higher blends. This strong change in the fuel mix in this market leads to concerns about the impact on reliability and service.

Biodiesel is a well-defined standard fuel with quality programs in place and the stability of this fuel has been studied. However, it is a relatively new fuel. To evaluate the impact that biodiesel use is having on service requirements, an on-line survey was completed in 2016. This is an update of a similar study conducted in 2012-2013.

The 2016 use survey was sent to three identified groups, including companies which have registered as users of the Bioheat® (biodiesel blends for heating applications) logo; company owners, presidents and general managers; and service managers. A total of 139 responses were received.

Overall, the responses do not indicate a clear technical area of concern with biodiesel use. Some respondents indicated increased service requirements, but the distribution of the technical areas was similar to those observed in surveys conducted before biodiesel use in this market.

Contents

ABSTRACT.....	i
Introduction	1
Fuel Quality Study Conducted in 1990 (pre-biodiesel).....	1
Fuel Quality Survey Conducted in 2012-2013	3
Fuel Quality Survey Conducted in 2016.....	5
Group 1. NORA Bioheat® Group	5
Group 2. Company Owners, Presidents or General Managers	6
Group 3. Service Managers.....	8
Analysis of the Composite Data Set	10
Discussion.....	11
Conclusions	12
References	12

Introduction

Over the past decade, the fuel used in the heating oil market has been strongly evolving, including the trend toward the use of ultralow sulfur fuel. This leads to reduced particulate emissions, reduced efficiency degradation of heat exchanger surfaces over time, and accelerates the market adaptation of compact, high-efficiency, condensing heating appliances.

Another important trend is the displacement of petroleum fuel with biodiesel and potentially, other biofuels in the future. Biodiesel is an oxygenated fuel derived from vegetable oil, used cooking oil and other sources such as tallow and in the future, algae.

The first tests with biodiesel in heating systems began in and around 1993. Several lab and field studies were conducted leading to fuel marketers commercially distributing biodiesel heating oil blends to customers.

For the home heating market sector, the quality of fuel has long been an important area of focus. Fuel quality-related factors are the prime source of service costs associated with oil home heating.

A survey completed of fuel marketers in 1990 (pre-biodiesel)^[1] highlighted many of the common field problems related to fuel quality. Another study, in 2012-2013, (post biodiesel introduction) highlighted that, at that time, there was a very significant penetration of biodiesel in the market place and that service issues associated with biodiesel were modest. In this report, a brief summary of the results of these surveys was first presented. This report is primarily focused on recent survey results and how they compare to the 2012-2013 biodiesel use survey.

Fuel Quality Study Conducted in 1990 (pre-biodiesel)

For this survey, letters were sent to oilheating service managers nationwide. *Figures 1, 2 and 3* provide the results of the survey. Overall, these results serve to document that fuel related service problems had been present in the industry well before the introduction of biodiesel. Typically, home heating tanks are not cleaned before biodiesel blends are introduced. While residential tank cleaning equipment is available, it is only used in cases where a persistent fuel quality problem cannot be resolved by other means. Biodiesel blends are introduced into pre-existing layers of products resulting from long-term degradation of heating oil (sludge).

What is the rate of occurrence of these fuel quality problems?

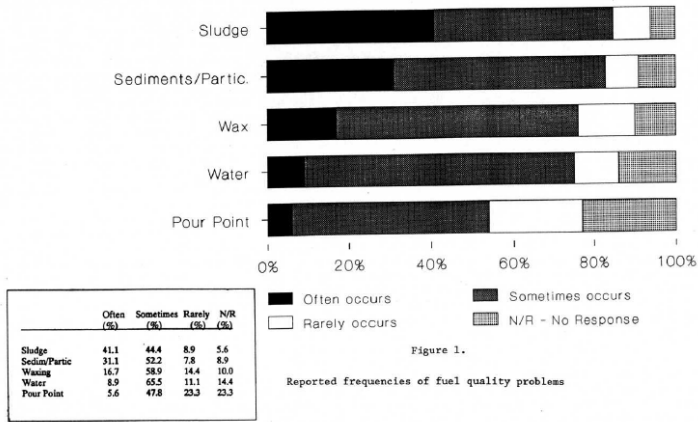


Figure 1. Results of survey completed in 1990 - frequency of service problems

What is the rate of occurrence of these heating equipment problems?

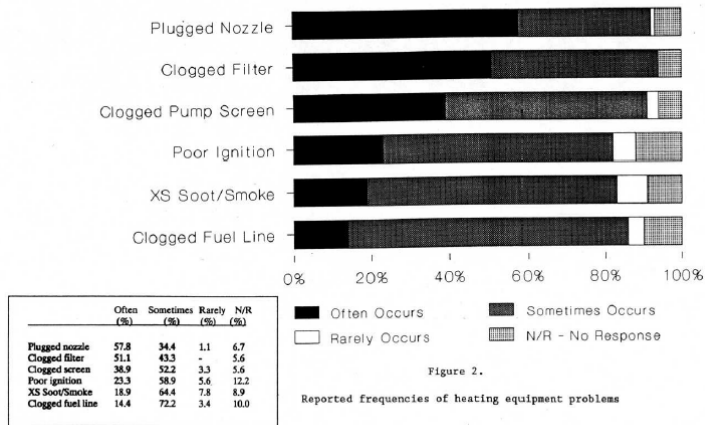


Figure 2. Frequency of equipment problems

What is the frequency of use of additives to improve fuel quality?

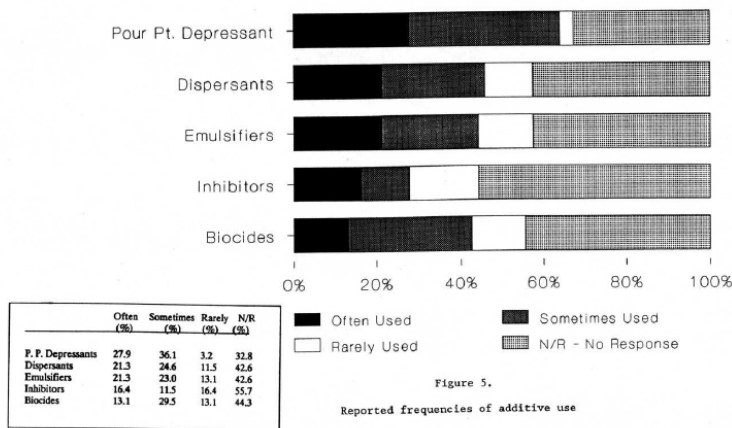


Figure 3. Results of Survey from 1990 - additive use to address fuel quality problems

Another pre-biodiesel survey, interesting for historical purposes, was conducted in 1958 to evaluate the need for the addition of a stability specification for heating oil [2]. The common metric used in the survey was the evaluation of rate-of-pump screen blockages by degradation products. It was concluded that a stability standard should be added only if the cost was modest. The historical survey serves primarily to illustrate that the industry has been concerned about fuel degradation and related service problems for a long time.

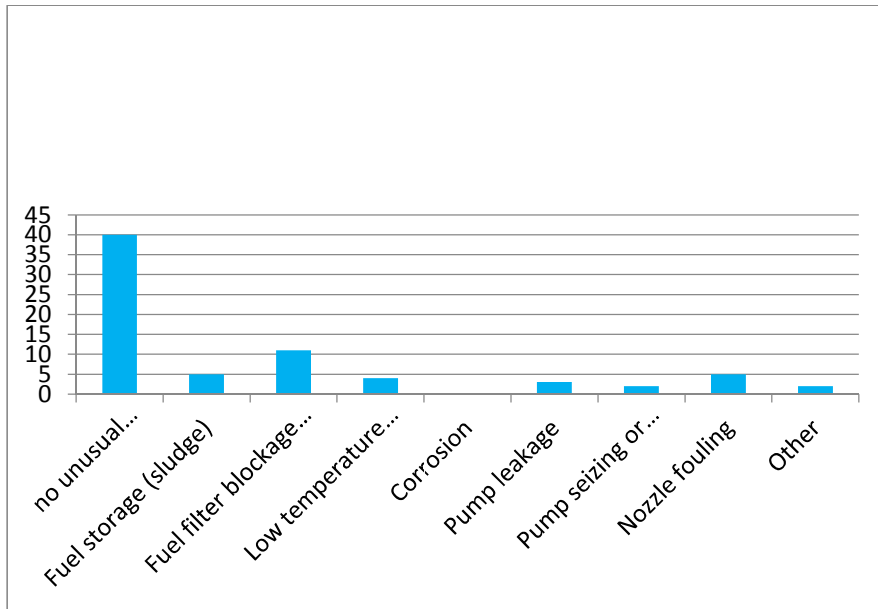
Fuel Quality Survey Conducted in 2012-2013

This fuel quality survey was conducted specifically to identify the breadth of biodiesel use in home heating oil and to capture the experience to date with this relatively new fuel. The survey was implemented on-line and was sent to individuals who had registered with the National Oilheat Research Alliance (NORA) for use of the NORA-owned Bioheat® trademark. This specific group was selected for this survey simply because they would be the group most likely to have strong experience with this fuel. A total of 75 responses were received and 80% of these reported having marketed biodiesel blends. Those who had not marketed biodiesel reported a variety of reasons for not doing so including: cost, technical concerns, lack of interest, lack of fuel availability or had no clear dominant reason.

Of those who reported that they had used biodiesel in their customer set, 93% reported they were still using it. Most of the respondents reported they had been using biodiesel for at least 5 years. One reported having used biodiesel for 10 years.

When asked if they replaced any system components when converting to biodiesel, 95% reported that they did not.

Figure 4 shows the results to a question about the impact of biodiesel on service problems. Overall, the dominant response was “no unusual problems observed”. The chart shows other concern areas including fuel filter blockages. It should be considered, however, that these types of problems existed before biodiesel use started and it is not clear if the respondents could differentiate between problems related to the base oil and use of the biodiesel blends.



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%

Figure 4. Survey from 2012-2013 - response to question about biodiesel related service concerns

Fuel Quality Survey Conducted in 2016

The survey, conducted in 2012-2013, was found to be very impactful— beyond what was originally expected. In 2016, the survey was conducted again but, some changes were made as a result of the impact from the earlier survey. This included reaching out to a broader audience. The questions were more focused and “skip logic” was employed to ensure that the intent and responses were clear. The survey was reviewed by the oilheating/biodiesel community for clarity and structure.

The survey was sent separately to three groups as follows:

Group 1. Individuals registered to use the NORA-owned Bioheat® trademark. There were 25 respondents in this group.

Group 2. Individuals who are oil marketing/service company owners/presidents/general managers. This was the largest group with 92 respondents.

Group 3. Individuals who are service managers at oil marketing/service companies. This group had 22 respondents.

In Groups 2 and 3, the survey was not sent only to those who were biodiesel blend users and, for this reason, there was overall a higher percentage of non-biodiesel users in the survey set.

The total number of respondents, including all three groups, was 139. A summary of the responses for each of the groups individually is provided in the subsections below followed by a summary of the responses for the combined groups.

Group 1. NORA Bioheat® Group

Among the Bioheat® logo users group, 76% responded they had used biodiesel blends and nearly all reported that they were still. Of those who reported they were not using biodiesel, the responses were again very varied relative to the reasons. However, the number of respondents in this group was small, providing no clear barrier to biodiesel use.

Respondents in this category include B-5 users and B-20 users. No impact on equipment or operations, including fuel filters, pumps, and nozzles were reported. One user of B-20 reported improved heat exchanger cleanliness. One of the respondents in this category is a terminal operator distributing B-5 to retail service organizations.

One retail organization reported exploring the use of blends at levels greater than 20%. They reported concerns with fuel filter blockage and low temperature performance.

Group 2. Company Owners, Presidents or General Managers

Of the 92 respondents in this category, 41.3% reported that they either currently or have in the past deliberately delivered biodiesel blends to their customers. *Figure 5* provides a summary of reasons why the balance of the respondents have not used biodiesel blends. The reasons clearly vary over a wide range. Of those reporting they have started using biodiesel blends, 94% reported they are continuing to do so.

When asked about blend levels delivered, 48% of those responding reported delivering B-5, 18% reported delivering B-20 to all customers, 9% reported delivering B-20 to some customers and 15.2% reported delivering blends over B-20 to at least some customers.

Reasons you have not delivered heating oil blended with biodiesel.		
	Number of Response(s)	Response Ratio
Cost	16	35.5%
Technical concerns	25	55.5%
Lack of interest by customers	23	51.1%
Lack of interest in your company	11	24.4%
Lack of knowledge in your company	5	11.1%
Heating Equipment manufacturers' recommendations	7	15.5%
Fuel availability	14	31.1%
Other	3	6.6%
Total	45	100%

Figure 5. Group 2. Reasons for not using biodiesel blends

For respondents delivering up to B-5 to all customers, Figure 6 shows the response to a question about the impact of biodiesel use on equipment and service.

For the following performance parameters, please indicate if the use of biodiesel has had a clear effect on the following. (up to B5 to all customers)

1 = Improved, 2 = More problems, 3 = No observed impact

Top number is the count of respondents selecting the option. Bottom % is percent of the total respondents selecting the option.

	1	2	3
Fuel filter blockage	3 23%	1 8%	9 69%
Heat exchanger cleanliness	8 62%	0 0%	5 38%
Low temperature flow	1 8%	2 15%	10 77%
Corrosion	3 23%	1 8%	9 69%
Fuel pump leakage	2 15%	3 23%	8 62%
Fuel pump seizing or other pump problems?	2 15%	1 8%	10 77%
Nozzle fouling	2 15%	2 15%	9 69%
Odors	3 23%	0 0%	10 77%

Figure 6. Group 2. Responses to question about biodiesel and service. B-5 to all customers.

Because of the number of respondents in each category, strong conclusions are difficult to reach from just this data. For most of the areas of concern the dominant response is no observed impact. For heat exchanger cleanliness, the dominant response is improved with no responses indicating more problems. For fuel pump leakage, 23% reported more problems but 15% reported improved.

For the Group 2 respondents using B-20, Figure 7 shows the results to the same questions. Here the responses clearly indicate either an improved situation or no impact. However, the number of respondents is only 5.

For the following performance parameters, please indicate if the use of biodiesel has had a clear effect on the following. (up to B20 all customers)

1 = Improved, 2 = More problems, 3 = No observed impact

Top number is the count of respondents selecting the option. Bottom % is percent of the total respondents selecting the option.

	1	2	3
Fuel filter blockage	3 60%	0 0%	2 40%
Heat exchanger cleanliness	4 80%	0 0%	1 20%
Low temperature flow	1 20%	1 20%	3 60%
Corrosion	1 20%	0 0%	4 80%
Fuel pump leakage	1 20%	0 0%	4 80%
Fuel pump seizing or other pump problems?	1 20%	0 0%	4 80%
Nozzle fouling	3 60%	0 0%	2 40%
Odors	2 40%	0 0%	3 60%

Figure 7. Group 2. Responses to question about biodiesel and service. B-20 to all customers.

In submitted comments, respondents raised concern about the low temperature flow properties of blends higher than 20% if stored outside. Generally, this is not recommended. Several respondents submitted comments related to more frequent filter blockages following a conversion from no biodiesel to a higher biodiesel blend. No clear data was reported on this point however.

Group 3. Service Managers

Of the 22 responses in this category, only 13 responded that they have or still use biodiesel blends. Of the 9 responded they had not, only 7 responded to the question about why they have not used biodiesel. Results to this question are provided in *Figure 8*. Again, there is no clear single reason but, the number of respondents is small.

Reasons you have not delivered heating oil blended with biodiesel. (select all that apply)

	Number of Response(s)	Response Ratio
Cost	2	28.5%
Technical concerns	3	42.8%
Lack of interest by customers	3	42.8%
Lack of interest in your company	2	28.5%
Lack of knowledge in your company	0	0.0%
Heating Equipment manufacturers' recommendations	0	0.0%
Fuel availability	0	0.0%
Other	0	0.0%
Total	7	100%

Figure 8. Group 3. Service Managers - reasons for not using biodiesel blends

For the service managers group using up to B-5, responses to the question about service issues and biodiesel are shown in Figure 9.

For the following performance parameters, please indicate if the use of biodiesel has had a clear effect on the following. (up to B5 to all customers)

1 = Improved, 2 = More problems, 3 = No observed impact

Top number is the count of respondents selecting the option. Bottom % is percent of the total respondents selecting the option.

	1	2	3
Fuel filter blockage	1 17%	2 33%	3 50%
Heat exchanger cleanliness	3 50%	0 0%	3 50%
Low temperature flow	0 0%	2 33%	4 67%
Corrosion	0 0%	1 17%	5 83%
Fuel pump leakage	0 0%	1 17%	5 83%
Fuel pump seizing or other pump problems?	0 0%	2 33%	4 67%
Nozzle fouling	1 17%	0 0%	5 83%
Odors	0 0%	0 0%	6 100%

Figure 9. Group 3. Service Managers - Up to B-5, service concerns

The responses in Figure 9 could indicate some areas of concern including fuel filter blockage or fuel pump seizing but the number of respondents in this category is too small to draw conclusions.

Analysis of the Composite Data Set

The results shown above for the individual groups show some consistent patterns but also considerable differences. Such variability could be expected where the number of respondents to specific questions is small. To provide further insight, the results of all three groups are combined across all biodiesel users — B-5, B-20 and higher. *Figure 10* shows the impact of biodiesel use on service for all of the categories.

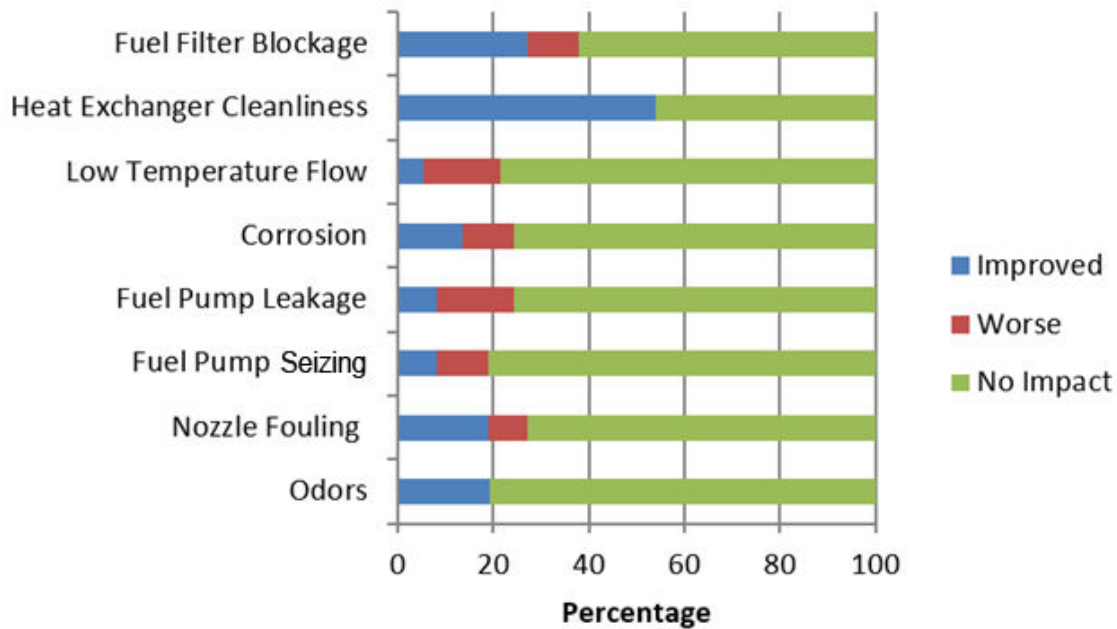


Figure 10. All Groups Combined. Impact of Biodiesel Use on Service Requirements

Figure 11 shows the same results but the “improved” and “no impact” responses have been combined.

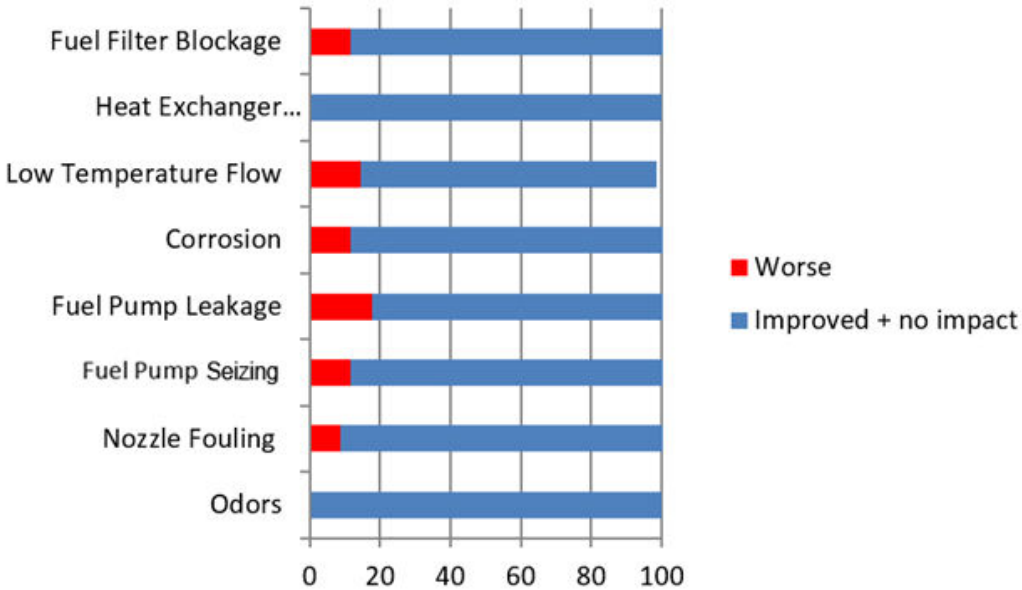


Figure 11. All Groups Combined. Impact of Biodiesel Use on Service Requirements. For this chart the Improved and No Impact responses have been combined.

Discussion

One of the objectives of this survey was to allow identification of technical service areas in which the use of biodiesel has clearly led to increased service requirements. Based on the data collected, a clear single area of concern cannot be identified. The results from the individual groups provide important insights but suffer from a small number of responses in the detailed questions. *Figures 10 and 11* (the composites) provide the best opportunity to achieve the effort objective.

From *Figures 10 and 11*, it can be concluded that odors and heat exchanger cleanliness are seen as improved with biodiesel use. For the low temperature flow concern, it is well documented that biodiesel has a negative impact on low temperature flow properties and high biodiesel blend levels, particularly with some feedstocks, require inside or at least controlled temperature storage. The results of the survey are consistent with this.

For the other problems identified, the situation is not so clear. Regarding fuel filter blockage, for example, *Figure 11* shows that 10% of the respondents indicated more fuel filter blockage with biodiesel use. However, from *Figure 10* many more respondents reported fuel filter blockage is reduced with biodiesel use. Fuel pump seizing can be considered a possible area of concern (*Figure 11*), but *Figure 10* shows that about as many respondents consider the situation to be better and not worse with biodiesel use.

The results show similar responses regarding nozzle fouling and corrosion. With fuel pump leakage (*Figure 10*), it can be concluded that more respondents are reporting increased leakage

with biodiesel than less. Referring again to *Figure 2*, it can be noted that similar fuel-related service concerns have been noted with heating oil, long before the use of biodiesel was started.

A comparison can also be made with the 2012-2013 biodiesel use survey with results illustrated in *Figure 4*. Taken together, both surveys indicate that most users of biodiesel blends are not reporting service concerns. Further, where concerns are being reported, a single symptom of a biodiesel related service concern is not demonstrated. The distribution of service concerns is as broad as was reported in pre-biodiesel service surveys.

Conclusions

During 2016, an on-line survey of the oilheat fuel marketing industry was undertaken to identify areas where biodiesel use is leading to increased service. The survey was conducted with three specific groups: Users of the Bioheat® logo; company owners, presidents and general managers; and Service Managers. A total of 139 responses were received. Based on these, and a comparison with earlier surveys, the following can be concluded:

1. Most users of biodiesel blends for heating are not experiencing increased service requirements;
2. Respondents clearly indicated reduced heat exchanger fouling and reduced concern about heating oil odors in homes;
3. Some of the respondents reported increase fuel-related problems with biodiesel but the response across different categories of concerns was broad. It is not possible to conclude that one area of concern is dominant;
4. For many of the concern areas identified, there was roughly an equal response of improved vs. a worse situation relative to petroleum-based heating oil. One possible exception is fuel pump leakage amongst biodiesel users where the number of those reporting increased problems with fuel pump leakage was about twice the number who indicated reduced problems with fuel pump leakage.

References

1. R.T. Coughlin, W.G., J. Sanchez, and J. Strasser, *An Overview of Residential Heating Fuel Quality - Interim Report*. 1990, Brookhaven National Laboratory: Upton, N.Y.
2. Gray, R., *Do we need a stability specification for No. 2 heating oil?*, in *Symposium on Stability of Distillate Fuel Oils*. 1959, ASTM: Boston. p. 21-25.