Biodiesel for Heating of Buildings in the United States

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Abstract
Bioheat blends of biodiesel and heating oil have been tested in the laboratory and at several field demonstration sites in the United States. Laboratory measurements have included viscosity, pour point, flash point, NOx emissions, and PM 2.5 emissions. Field testing of B20 blends has been performed in several hundred homes in the northeastern United States without any significant problems. Bioheat blends of up to B20 biodiesel concentration have been used successfully without heating system adjustment or cold weather problems. Many oilheat dealers in the United States are now offering bioheat blends in concentrations of B2 to B20 for residential and commercial heating.

1. Introduction

In the United States, biodiesel is made primarily from soybean oil. Other feedstock sources, such as recycled vegetable oils, are also used, although to a smaller extent.
Biodiesel is a renewable energy fuel with properties that are generally similar to heating oil. ASTM standard D 6751 establishes requirements for several physical properties of biodiesel. Commercial biodiesel manufacturers are usually required to meet ASTM standard D 6751 regardless of the feedstock material used for biodiesel production.
Bioheat blends in the United States are made by mixing biodiesel with heating oil. Both the biodiesel and heating oil components must meet their respective ASTM standards. The two can be blended successfully in all percentage concentrations without subsequent separation. However, bioheat blends containing a high percentage of biodiesel (e.g., over 20%), require attention to transport and storage of the fuel to avoid crystallization due to cold temperatures. With higher percentage bioheat blends, attention must also be paid to certain burner issues including flame detection and fuel pump seal durability.

2. Laboratory Testing of Bioheat Blends

Brookhaven National Laboratory (BNL) has studied the use of bioheat blends in oil-fired heating systems for several years. BNL is the national leader in the United States for testing of fuels and heating equipment for the oilheat industry.

Figure 1: Oilheat and Biodiesel Laboratory Testing Facility at Brookhaven National Laboratory

One focus of the research at BNL has been to determine if bioheat blends could be substituted for conventional heating oil without modification or adjustment to existing oil-fired heating systems. The results have shown that nearly identical, and even somewhat improved, combustion performance can be achieved with bioheat blends of up to approximately 30 percent concentration without any changes.

However, it was observed that, with blends of over 30% biodiesel concentration, the cadmium sulfide flame sensor would sometimes not see the flame sufficiently and, hence, the control system would shut down the burner as a safety precaution. This occurrence was a function of the system, the airflow settings, the control system parameters, the bioheat blend ratios, etc., and was not seen in all the systems tested. Caution is therefore suggested in the use of bioheat blends with high biodiesel concentrations.

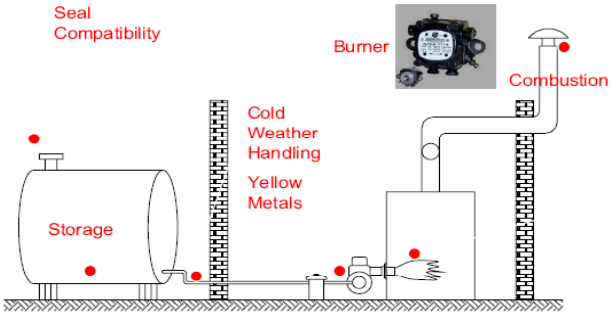

Figure 2: Schematic of Oil-fired Heating System Showing Areas of Attention with Biofuels

BNL has studied the storage stability of bioheat blends, interactions with metal materials used in tanks and fuel lines, and combustion performance including emissions. Individual categories of test results are shown and discussed below, see Figures 3-6.

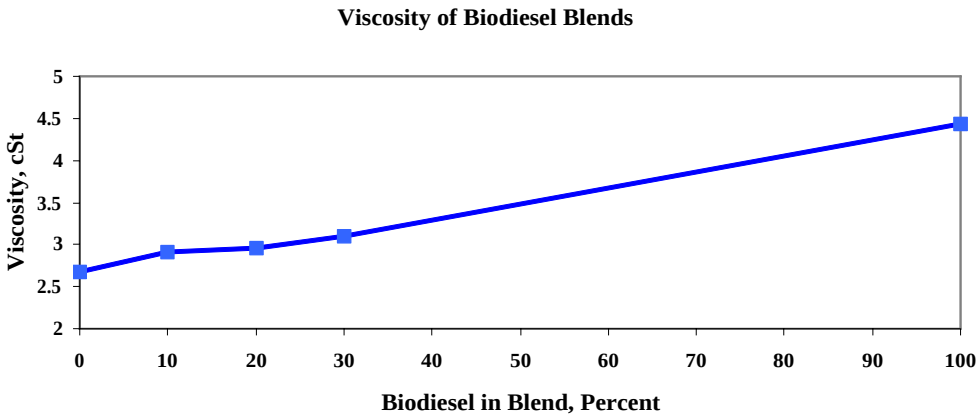

Figure 3: Bioheat Blend Viscosity

The primary finding of laboratory testing of bioheat blends was that the viscosity increases as the biodiesel concentration increases, and that the upper limit of viscosity as defined by the ASTM standard for heating oil is reached at a biodiesel concentration of approximately 30 to 40 percent.

Laboratory testing was also performed to determine the pour point of bioheat blends to identify and evaluate possible temperature-related, fuel storage and handling problems. The primary finding of pour point, as well as CFPP, testing in the United States has been that the pour point of bioheat blends does indeed increase with increasing biodiesel concentration, but that proper cold weather additives can more than offset any such increase.

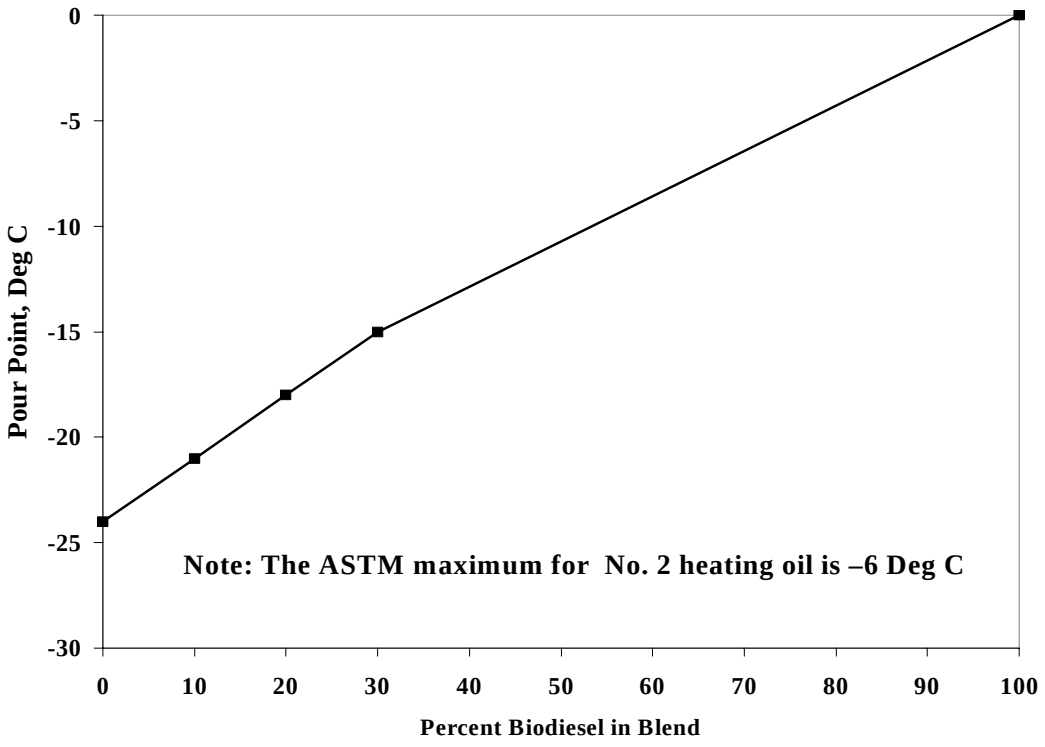

Figure 4: Pour Point of Biodiesel Blends

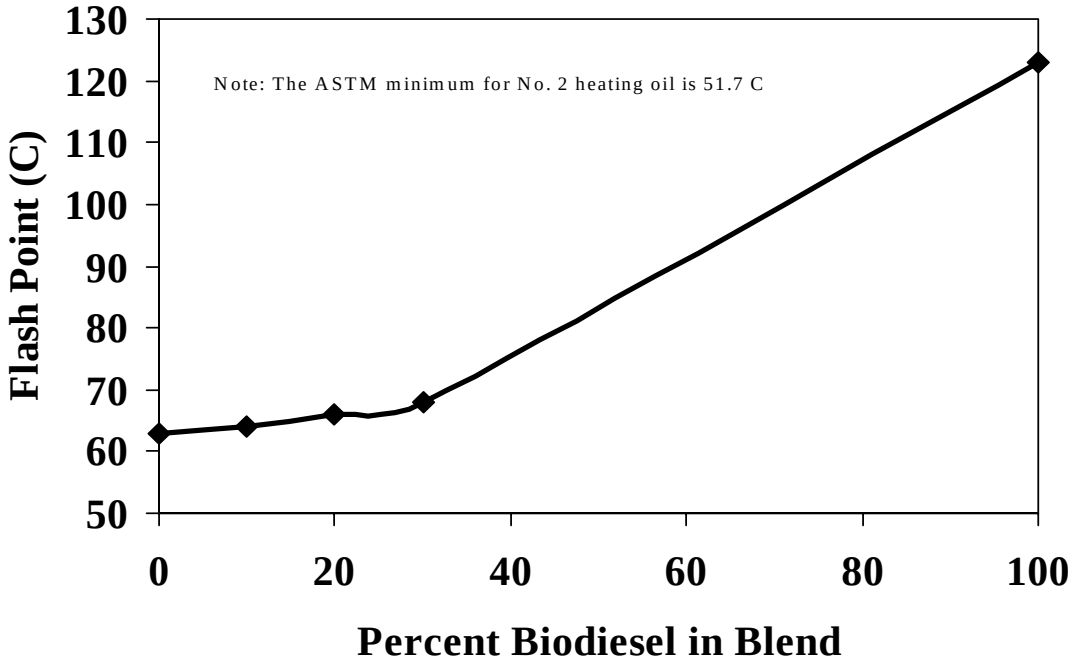

Figure 5: Flash Point of Biodiesel Blends

As has been known from previous testing of biodiesel blends for use in diesel engines, the flash point of bioheat blends shows an increase as the biodiesel concentration increases. This indicates a somewhat improved fuel characteristic in regard to fire safety.

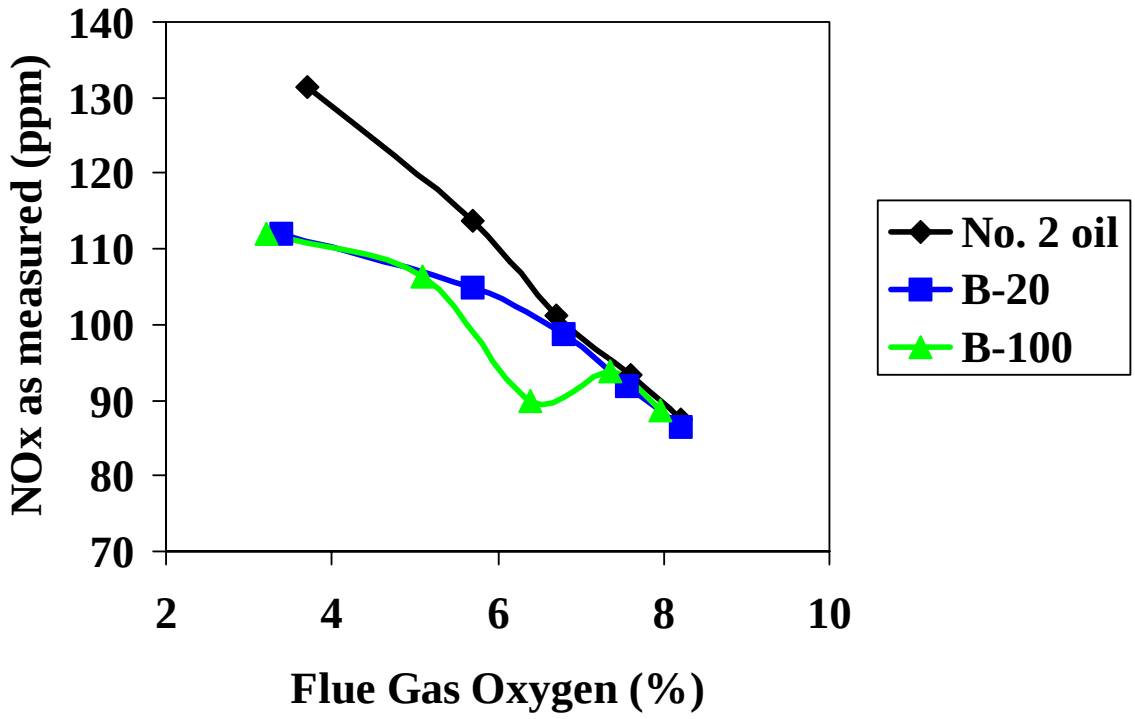

Figure 6: NOx Emissions with Biodiesel Blends

Another, initially surprising, result that was seen often in laboratory tests was that the addition of biodiesel to heating oil led to a reduction in the emission of nitrogen oxides (NOx) from the heating systems. This was in contrast to what had been reported earlier about the negative effect of biodiesel (increase) on NOx emissions from diesel engines.

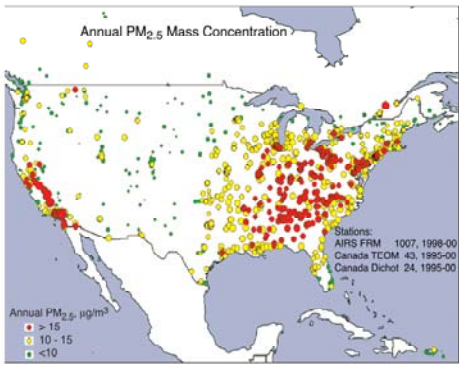

Figure 7: Regions in United States with High PM 2.5 Concentrations

With increasing environmental concerns about particulate concentrations in the air in the United States, BNL also measured PM 2.5 emissions from oil-fired heating systems. The testing was performed with a dilution tunnel sampling and filtering apparatus as shown below. The apparatus mixes heating system exhaust with additional air at an approximate 1:10 ratio (i.e., ten volume units of additional air for each volume unit of exhaust). Such additional, dilution air is intended to model the effect of outside air in diluting heating system exhaust and triggering the condensing of sulfate-based aerosols.

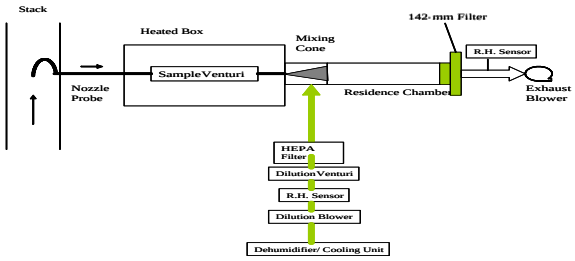

Figure 8: Schematic Diagram of Dilution Tunnel Sampling System for PM 2.5 Testing

The PM 2.5 testing showed that particulate emissions were directly and primarily dependent on the sulfur content of the fuel. Initial laboratory testing data has indicated decreasing PM 2.5 emissions with increasing biodiesel concentrations in the bioheat blends.

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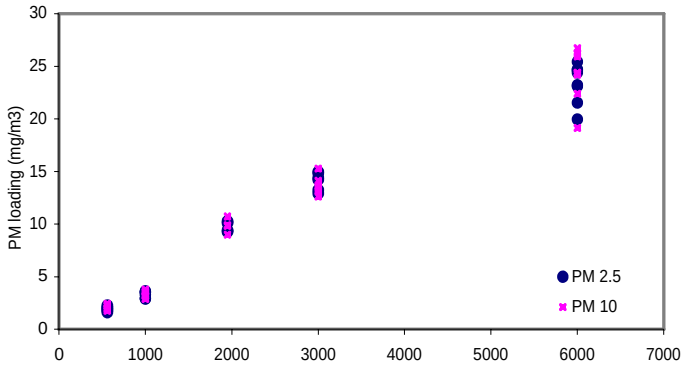

Figure 9. PM 2.5 Emissions Concentrations vs. Sulfur Content in Fuel

Because biodiesel contains little or no sulfur, increased use of bioheat blends should therefore be expected to contribute to reduced smog in major urban areas.
Additionally, it is known that biodiesel has better lubrication properties than conventional, petroleum-based fuels. Its use as a lubricating additive for ultra-low sulfur (15 ppm) diesel fuel has been suggested. Biodiesel is also known to negatively affect certain elastomers (natural rubbers, neoprene) used in seals, o-rings, and gaskets. Steps must therefore be taken to prevent use of such materials in the presence of high biodiesel concentrations and to substitute instead materials such as Viton.

3. Field Testing of Bioheat Blends

Brookhaven National Laboratory (BNL) has also participated in the field testing of bioheat blends in residential equipment. Abbott and Mills, Inc., a major oilheat retail dealer in Newburgh, New York, completed four years of successful B20 bioheat blend use in approximately 100 homes. They blended 20% of biodiesel with both conventional (0.15%) and lower, 500 ppm, sulfur heating oil. The homes had different types of equipment and tanks. No fuel related problems were identified during the four years of tests.

Figure 9. Fuel Sampling and Filter/Nozzle Inspection During Field Testing of Bioheat Blends

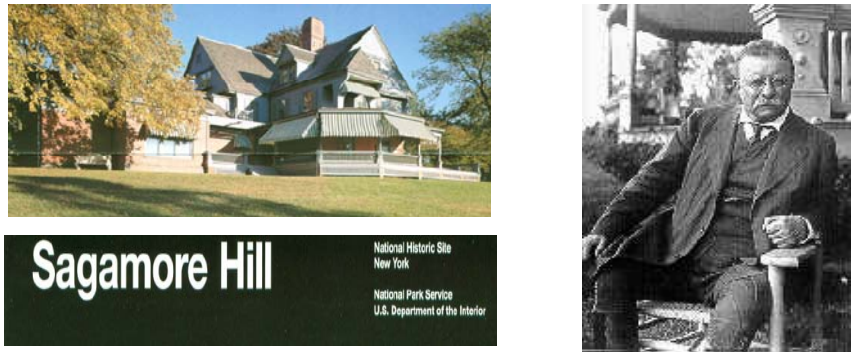

Figure 10. Field Testing of Bioheat Blends at Sagamore Hill National Historic Site

BNL is also supporting the field testing of a B20 bioheat blend at the Sagamore Hill National Historic Site, home of former U.S. president Theodore Roosevelt. The B20 bioheat blend is delivered by a commercial supplier and is a blend of biodiesel in lower sulfur (500 ppm) heating oil. The field testing has thus far not experienced any significant problems. There are plans to convert some of the buildings there to B100 as well.

4. Marketing of Bioheat Blends

There are a number of petroleum fuel suppliers in the northeastern United States that are offering bioheat blends to their retail oilheat customers. A partial list of the suppliers can be found at the National Biodiesel Board's (NBB) website at www.biodiesel.org.

Photographs of some of the bioheat dealers are shown below.

Figure 11: Photos of Bioheat Dealers

Sprague Energy is opening biodiesel terminals in the New York City and Albany areas to supply biodiesel and bioheat products in various concentrations. Schildwachter and Sons, Inc., also operates a biodiesel terminal in New York City. A number of fuel oil suppliers, including Sclafani Petroleum, Barry Collins Oil, Abbott and Mills, Clickable Oil, and many others are offering, or planning to offer, bioheat blends ranging in concentration from B5 to B20 to their heating customers.

5. Biodiesel Production Quality Control and Education

Quality control is of critical importance during biodiesel production and distribution. The National Biodiesel Board has established the BQ-9000 quality control program for biodiesel manufacturers. Under the BQ-9000 quality control program, all production batches of biodiesel must be tested for compliance with the ASTM D 6751 standard. All biodiesel deliveries to wholesale distributors must be tracked to enable tracing of downstream problems back through the supply chain to the original producer.

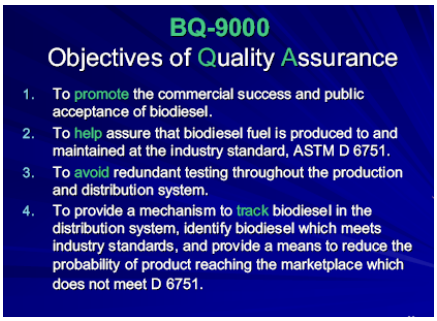

Figure 12: National Biodiesel Board BQ-9000 Quality Control Program

The National Biodiesel Board in the United States also offers a wide variety of technical assistance to the diesel fuel and oilheat industries. Producers, distributors, retail dealers, and end-use customers can take advantage of educational materials, technical reports, training programs and conferences to use biodiesel effectively in their respective operations.

The National Biodiesel Board (http://www.biodiesel.org/) has a section (http://biodiesel.org/askben/) for questions on heating applications. Interested persons can submit via e-mail questions about biodiesel and receive responses within 24 hours or less.

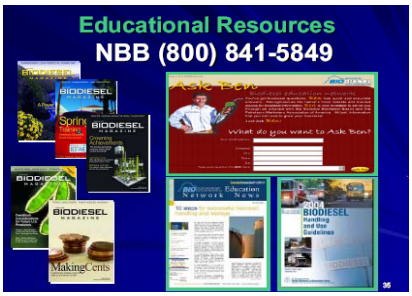

Figure 13: Educational Resources on National Biodiesel Board Website