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MINNESOTA DEPARTMENT OF AGRICULTURE

Report to the Legislature

Petroleum Diesel Fuel and Biodiesel Technical Cold Weather Issues

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Executive Summary

In September 2005, Minnesota began blending 2 percent biodiesel in diesel fuel (B2). The prospect of moving to a 5 percent biodiesel blend (B5) in diesel fuel by May 2009, followed by 10 percent (B10) and 20 percent (B20) biodiesel blends in diesel fuel in 2012 and 2015, respectively,[1] prompted legislation requiring a meeting of technical experts to address various issues related to the use of these blends. Specifically, three subcommittees were formed to address production and distribution, blending, and handling of biodiesel blends in cold weather conditions. To date, the production and distribution subcommittee examined the quantity and quality of biodiesel in the state, as well as distribution issues; the blending subcommittee explored issues related to fuel characteristics; and the handling committee analyzed seasonal handling issues as well as other topics such as contamination.

This status report summarizes the findings of subcommittee work to date. There are some B5 issues to be addressed but the majority of the biodiesel, petroleum and engine manufacturing industry members on a national and state level do not believe that the cold weather impact of B5 blends will be significantly different than the impact of B2 blends has been. There are significant issues to be addressed, however, concerning the impact of higher blends such as B10 and B20. These issues must be addressed along with recent and historic issues related to petroleum diesel fuel and diesel equipment impacts that can be simultaneous and difficult to differentiate from biodiesel issues. These subcommittees, the Cold Weather Technical Team and the Biodiesel Task Force will continue to explore unanswered questions and search for improved products and practices that will help ease the transition to the greater use of domestic renewable fuels like biodiesel in Minnesota.

Definition of abbreviations

ASTM	The American Society for Testing and Materials
ASTM D975	ASTM diesel fuel specification
ASTM D6751	ASTM biodiesel specification
CAFE	Corporate Average Fuel Economy
CFPP	Cold Filter Plugging Point (a test used to determine the lowest temperature for diesel fuel operability in a vehicle)
CP	Cloud Point of Diesel Fuel or Biodiesel
EPA	Environmental Protection Agency
LSD	Low Sulfur Diesel Fuel (500 ppm sulfur)
LTFT	Low Temperature Flow Test (a test used to determine the lowest temperature for diesel fuel operability in a vehicle)
PP	Pour Point of Diesel Fuel or Biodiesel
RIN	Renewable Identification Number (used, among other things, to track compliance and volumes for renewable fuels)
ULSD	Ultra Low Sulfur Diesel Fuel (15 ppm sulfur)

[1] Minnesota Statutes 2008, §239.77, subd. 2.

Introduction

This report is submitted pursuant to Laws of Minnesota 2008, Chapter 297, Article 1, Section 68:

> *[TECHNICAL COLD WEATHER ISSUES] The commissioners of agriculture and commerce shall consult with stakeholders who are technical experts in cold weather biodiesel and petroleum diesel issues to consider and make recommendations regarding improvements in the production, blending, handling, and distribution of biodiesel blends to further ensure the performance of these fuels in cold weather. The commissioners shall issue a report on these issues by February 15, 2009, to the chairs and ranking minority members of the legislature with jurisdiction over agriculture and commerce policy and finance.*

Background

Biodiesel Task Force

The Biodiesel Task Force was appointed by Governor Pawlenty in 2003 to help the state carry out its mandate that nearly all diesel fuel sold in the state contain at least a 2 percent biodiesel blend (B2) by September 2005. In particular, the Task Force was formed to advise the Commissioner of Agriculture on methods to increase the production and use of biodiesel in Minnesota and ensure a smooth introduction of biodiesel into the marketplace.

Since its inception, the Task Force has helped biodiesel developers, marketers, consumers and manufacturers. In 2007, the Governor unveiled a plan for taking the state's biodiesel requirement from the current 2 percent blend to a 20 percent blend (B20) in diesel fuel by 2015, beginning with the requirement that nearly all diesel fuel sold in the state contain at least 5 percent biodiesel (B5) in May of 2009.[2]

Some members of the Task Force have been reappointed and new members were brought in effective July 3, 2007. Current membership includes:

- Douglas Peterson, Minnesota Farmers Union
- Dustin Haaland, CHS Inc.
- Robert Krogman, Minnesota Petroleum Marketers Association
- Kelly Marczak, American Lung Association of Minnesota
- Thomas Byrne, Byrne & Company Ltd.
- Charles Neece, FUMPA
- Kristin Weeks-Duncanson, Minnesota Soybean Growers Association
- Kevin Paap, Minnesota Farm Bureau
- Ron Obermoeller, Minnesota Soybean Processors
- Kelly Strebig, U of M, Center for Diesel Research
- Bill Beukema, Soy Mor
- Jeremy Bezdek, Flint Hills Resources, LP
- John Hausladen, Minnesota Trucking Association
- Lance Peterson, Minnesota Soybean Growers Association

[2] Minnesota Statutes 2008, §239.77.

Cold Weather Technical Team

The 2008 Minnesota Legislature instructed the Commissioners of Agriculture and Commerce to consult technical experts on cold weather issues related to the production, blending, handling and distribution of biodiesel blends to ensure the performance of these fuels in cold weather and report to the legislature by February 15, 2009. Pursuant to this law, the Commissioners convened a meeting of the Cold Weather Technical Team at the Minnesota Department of Agriculture (MDA) on August 26, 2008. Many of the same organizations that participate in the Biodiesel Task Force are represented on the Cold Weather Technical Team, but the personnel assigned to this group provide valuable technical experience. The specific technical experts invited to serve on the Technical Team are:

- Steve Howell, Marc IV
- Scott Fenwick, ADM
- Jerry Higgins, Magellan Midstream Partners, L.P.
- Richard Kadansky, Marathon Petroleum Company, LLC
- Lyle Overloh, MnSP
- Jim Rossbach, CHS
- Hoon Ge, MEG Corp.
- Jay Reinhardt, Flint Hills Resources
- Emily Clark, Donaldson Company
- Dan Card, Minnesota Pollution Control Agency
- Chuck Wurzinger, Metro Transit
- Chuck Neece, FUMPA Biofuels
- Robert Krogman, Minnesota Petroleum Marketers Association
- Bill Beukema, SoyMor
- John Scharffbillig, Minnesota Department of Transportation/City of Minneapolis

State agency personnel with experience and background in technical areas are:

- Julie Quinn, Minnesota Department of Commerce
- Jim Hedman, Minnesota Department of Commerce
- Ralph Groschen, Minnesota Department of Agriculture

Stakeholders discussed various issues at the meeting, resulting in the decision to convene subcommittees to address areas including the production and distribution, blending, and handling of biodiesel blends. Personnel from MDA and Commerce identified chairs and members with appropriate skills and backgrounds for serving on the various committees. A list of issues that were raised during the August 26, 2008 Cold Weather Technical Team meeting was compiled and allotted to the appropriate subcommittee. The list of subcommittee members and topic areas were then sent to subcommittee chairs who were invited to make recommendations. As a result of this process, three subcommittees were established as shown in the following list of subcommittees, subcommittee chairs, members and assigned topic areas:

<u>Production/Distribution Subcommittee</u>

Chair: Jim Rossbach

Members: Scott Fenwick, Steve Howell, Bill Beukema, Lyle Oberloh, Chuck Neece, Richard Kadansky, Bob Krogman

Topic Areas:

- Quantity

- How much biodiesel is necessary to meet each of the mandate levels?[3]
- Is there currently enough biodiesel production to meet each of the mandate levels as they become effective?

- Quality
  - Is there enough *winter quality* biodiesel to meet each of the mandate levels if they were extended year round?[4]
  - Should the 10th percentile temperature recommendations for cold weather properties—Cold Filter Plugging Point (CFPP), Cloud Point (CP), and Pour Point (PP)—in the ASTM D975 diesel fuel specifications be incorporated into law or rule?[5]
    - If so, should all three recommendations be incorporated, or just one?
    - Is Cloud Point meaningful with current winter additives?
  - What can we learn from the Europeans about biodiesel in cold winter climates?
    - Is ASTM's Cold Soak Filter Test specification sufficient for winter blending above B5?
    - Is the ASTM D6751 biodiesel specification sufficient for blends with more than 5 percent biodiesel, or should some of the tighter requirements found in specifications be adopted by rule or statute?
    - If so, which ones?
  - What is known about the proposed ASTM standard for 5 percent to 20 percent biodiesel (B5 to B20) blends?
    - What is the time table for development of this new standard?
- Other Issues
  - Although Minnesota produces enough to meet the current biodiesel mandate, distribution to southwest and parts of northwest Minnesota is difficult, and sometimes impossible. How can this issue be resolved to ensure biodiesel availability not only for B2 but for higher mandated blends as they come into effect?
  - What effect do distribution difficulties have on choice of blend methods for stations and bulk plants?
  - If distribution cannot be significantly improved, how can best blending practices be encouraged when blending does not occur at the terminal?

<u>Blending Subcommittee</u>

Chair: Jerry Higgins

Members: Scott Fenwick, Jim Hedman, Hoon Ge

Topic Areas:

- Fuel Characteristics
  - Are the 2002 blend studies[6] still valid for the new ultra low-sulfur diesel products currently on the market?

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[3] The subcommittee factored in projected increases in fuel usage—based on various factors such as population growth—for the year that each mandated blend of biodiesel becomes effective.

[4] "Winter quality" biodiesel is B100 biodiesel that meets the 200-second Cold Soak Filtration Test specification required for the production of B100 biodiesel that is to be blended with diesel fuel for use in operating conditions at or below 10 degrees Fahrenheit. The Cold Soak test was included in ASTM's D6751specification for B100 biodiesel in 2008 to avoid plugging of fuel filters during cold weather conditions.

[5] The 10th percentile minimum ambient temperatures are outlined in the ASTM diesel fuel specification by state from historical records for various winter months, and are meant as a guide for determining cold temperature properties for users in a given time and place.

[6] The Minnesota Department of Commerce Division of Weights and Measures published a report on the cold weather properties of diesel fuel and various biodiesel blends in 2002. The diesel fuel then was 500ppm sulfur or low-sulfur diesel, whereas diesel fuel since 2006 is ultra low-sulfur diesel with only 15 ppm of sulfur.

- Do the various methods of winterizing diesel affect how the blend performs when biodiesel is added?
  - No. 1 diesel[7]
  - No. 2 diesel with cold-flow additives[8]
  - Blend of No. 1 and No. 2 diesel

- Best Practices
  - What have we learned about blending practices:
    - At the terminal?
    - En route from a terminal?
    - At the bulk plant[9]?
    - At the station?
  - Are there any practices that should be prohibited either by statute or rule during winter months? Conversely, are there practices that should be encouraged through incentives or other means?

Handling Subcommittee

Chair: Hoon Ge

Members: John Scharfbillig, Chuck Wurzinger, Emily Clark

Topic Areas:

- Lessons Learned
  - What has been learned from the experiences of fleets using higher biodiesel blends?
    - Minnesota Department of Transportation
    - Metro Transit
    - Eureka Recycling
    - Others
- Seasonal Handling Issues
  - Winter
    - What temperatures occur in above ground, below ground, indoor, and outdoor tanks?
    - Under what conditions is splash blending acceptable in cold weather?
    - What problems occur when vehicles are kept outside or in unheated garages?
    - Are there any differences between low-sulfur diesel and ultra low-sulfur diesel?
  - Spring:
    - How should rain or melt water be handled when the ground is still frozen?[10]
  - Summer
    - Is there a stockpiling or storage danger?
    - Will people buy summer product thinking it can be kept into winter?
    - Is a labeling system or education program necessary to ensure consumers know to buy product certified for winter temperatures?
  - Fall
    - How to handle the transition from summer biodiesel to winter?
    - When should turnover of tanks begin? Should it be mandated?
    - How can the creation of shortages be avoided?
- Other Handling Issues

[7] No. 1 diesel is light-weight diesel fuel suitable for winter blending.
[8] No. 2 diesel is "regular" diesel fuel that can gel in cold temperatures.
[9] Bulk plants are small rural terminals, usually without biodiesel blending capacity.
[10] Water bonds with glycerin and clogs filters, even when temperatures remain fairly warm. For example, Metro Transit testified to greater troubles in March and April than in January and February.

- How should stations handle water and microbial contamination?
- How should dirty tanks and sediment problems be addressed?
- How should bulk plants handle switch loading, fungible tanks,[11] and water and microbial contamination?
- How should terminals handle fungible tanks, and water and microbial contamination?

Subcommittee meetings were called by the chairs at times appropriate to chairs' and members' schedules. The production/distribution subcommittee and blending subcommittee meetings were held by conference call due to the fact that some members were located outside of Minnesota. The handling subcommittee meetings were held at locations in the Twin Cities area.

Subcommittee Reports

The subcommittee reports that follow reflect the current status of subcommittee activities to date. Subcommittees were assigned a number of issues raised at the Cold Weather Technical Team meeting. Members had to prioritize their efforts to focus first on the most important issues as well as those compatible with the resources and expertise available to the group. For this reason, certain items were addressed and other items listed in the "Topic Areas" described above have yet to be addressed. The Departments of Agriculture and Commerce would like to express their appreciation for the efforts of these professionals and the time they committed to generating the following reports.

Blending Subcommittee Report

Findings

The Blending Subcommittee was tasked with determining whether the blend studies completed in 2002 are still valid for the new ultra low-sulfur diesel (ULSD) products currently in the marketplace, and whether the various methods of winterizing diesel affect how the blend performs when biodiesel is added.

A laboratory study was conducted using: 1) No. 2 diesel fuel (ULSD), 2) No. 1 diesel fuel (ULSD), and 3) a 50/50 blend of No. 1 and No. 2, to determine how cold temperature performance characteristics in terms of pour point (PP), cloud point (CP) and the cold filter plugging point (CFPP) were affected by a 5 percent biodiesel blend. The biodiesel used in the study was soy-based. Graphics showing the test results are included in Appendix B.

One of the studies the blending committee will review in the future is the effect cold flow additives have on 5 percent biodiesel blending. The study will be conduced with additized No. 1 and No. 2 diesel fuel and a 50/50 blend of No. 1 and No. 2 diesel fuels.

Conclusion

The results of the study showed there were no significant changes in the test results when comparing low sulfur diesel fuel to ULSD.

Biodiesel Task Force comments related to this report are included in Appendix A.

[11] Fungible tanks refer to tanks containing product with the same description but that are co-mingled with product from different sources.

Handling Subcommittee Report

The Handling Subcommittee was tasked with considering the experiences of fleets and other levels of the petroleum distribution system in using or handling higher biodiesel blends. The subcommittee was also asked to consider seasonal, storage and supply issues.

The subcommittee convened several meetings to discuss what the members felt were the greatest needs from the point of view of public fleet personnel who are charged with the storage, handling and use of diesel fuel and biodiesel blends in a variety of equipment models and operating conditions. Addressing concerns expressed by fleet managers was identified as a productive way to ensure that real world issues of adapting to current changes in diesel fuel and engine technology would be considered.

As the first order of business, in order to provide an educational and troubleshooting document for use by consumers and providers of diesel fuel, the subcommittee chose to produce a handling guide. The handling guide is meant to offer background, problem descriptions and potential solutions to a variety of issues related to the storage, handling and use of diesel fuel, biodiesel and biodiesel blends. Upon its completion, this guide will be posted in the biodiesel section of the Minnesota Department of Agriculture's web site, www.mda.state.mn.us. A draft version of this unfinished guide is included in Appendix C.

Production/Distribution Subcommittee Report

The Production/Distribution Subcommittee was assigned the responsibility of determining the availability, quantity and quality of biodiesel in Minnesota to meet state mandates. The subcommittee also identified changes or controls that should be recommended to enhance and ensure biodiesel performance in the field.

Quantity

To determine whether there is sufficient biodiesel available to meet Minnesota's mandates, the subcommittee reviewed both the current and future forecast for both distillates[12] usage and biodiesel capacity. Although the numbers are subject to change, the subcommittee determined that the current level of distillate usage in the state for 2008 was between 800 million and 900 million gallons with a projected demand of 900 million gallons in 2009. These numbers do not take into account the downturn in the economy or the decrease in the cost of fuel. In addition, the numbers do not include the impact/reduction that Corporate Average Fuel Economy (CAFE) standards will have on distillate usage in the future. Current Minnesota biodiesel manufacturing capacity is 63 million gallons plus 3 million gallons of new capacity that is expected to come online in 2009, for a total of 66 million gallons. Table 1 below details the projected distillate usage for the period 2003 through 2015, along with the current and future biodiesel requirements.

[12] Distillates refer to both diesel fuel and heating oil.

Table 1: Projected Distillate Usage and Future Biodiesel Requirements, 2003-2015

Projected Distillate Usage		Biodiesel usage at mandated levels in Gallons			
Year	Gallons	2%	5%	10%*	20%*
2003	800 million	16 million			
2009	900 million		45 million		
2012	1.0 billion			80 million 7 months - 59 mil 5 months - 21 mil	
2015	1.2 billion				165 million 7 months - 140 mil 5 months – 25 mil

* At the 10 and 20 percent usage levels, only 50 percent of the total usage must be produced by Minnesota biodiesel producers. Demands reflect seven summer months of biodiesel usage at 10 percent or 20 percent and five winter months at 5 percent biodiesel usage.

Table 1 accounts for the decrease in demand during the winter months when biodiesel usage would be reduced from the mandated 10 percent or 20 percent levels to the 5 percent level. Statute requires that 50 percent of biodiesel production needed to meet the mandate must come from Minnesota plants. Therefore, there is enough current state biodiesel manufacturing capacity (63 million gallons) available to supply 50 percent (40 million gallons) of the biodiesel use level required in 2012.

There also appears to be enough winter quality biodiesel manufacturing capacity available to meet all mandate levels because the requirement for winter performance is capped at the 5 percent level. The subcommittee did not feel it would be necessary to extend the mandate for winter quality biodiesel (product that passes the 200-second Cold Soak Filtration Test[13]) to the entire year. Other concerns at the 20 percent biodiesel level include the fact that the state could be using a significant portion (12 to16 percent) of the U.S. biodiesel capacity.

Quality

The discussion for quality biodiesel centered on the requirements needed to maintain a high level of quality and any additional requirements needed to improve the level of quality.

The inclusion of the cold soak filtration test in ASTM D6751 and the passage of ASTM D7451[14] (B6 to B20 blends) provide the necessary specifications and testing to provide quality biodiesel fuels. The subcommittee did not feel it was necessary to add European requirements on top of the ASTM specifications. In addition, with the inclusion of the cold soak test, the ASTM D6751 specification is at least as stringent as its European counterpart. Incorporating other tests such as the Iodine test for oxidative stability will have little value in improving the quality of biodiesel fuels.

Cold temperature tests such as cloud point (CP), pour point (PP), cold filter plugging point (CFPP) and low temperature flow test (LTFT) are important tests for determining the operability temperature of any biodiesel blend. The team has not determined if all or any of the requirements should be included in the final biodiesel requirements. An alternative to developing separate state specifications is for the state to adopt the pipeline and terminal specifications.

[13] The 200-second Cold Soak test was included in ASTM's D6751specification for B100 biodiesel in 2008 to avoid plugging of fuel filters during cold weather conditions.

[14] This specification is intended to predict the cold weather operability

Questions that require further discussion include: How will the fall to winter and winter to spring transition periods be handled? What impact will these periods have on the customers? Who is going to educate the customer? What are the expected issues with B5, B10 and B20? Given the significant variation in winter fuels, how do we get more accurate information on winter fuels with or without biodiesel in them? How will B5 perform during the winter months when it becomes mandated?

Distribution
Biodiesel blending and fuels are available throughout the entire state except for southwestern Minnesota. The extreme northwestern area of the state has diesel fuel supply difficulties but biodiesel is available in both Fargo and Grand Forks, North Dakota. The southwestern region is entirely different—at present, the only option for customers who want biodiesel is through splash blending. To overcome this lack of biodiesel availability, the 2008 Minnesota Legislature authorized $300,000 for biodiesel blending grants and initiated a request for proposals;[15] however no proposals were submitted. The best solution at this time may be to work with the pipeline and terminal companies to develop a biodiesel solution for this region.

Best Blending Practices
Best blending practices seemed to be outside the scope of the Production/Distribution Subcommittee and should be referred to the Blending Subcommittee. If best blending practices need to be developed the most logical partner may be the National Biodiesel Board. Since biodiesel is available throughout the state except for the southwest, splash blending is not prevalent among customers. The EPA's RIN[16] program and the availability of biodiesel fuels throughout the state has almost 100 percent of the customers purchasing pre-blended biodiesel fuels from pipeline terminals or refiners.

Conclusions
Quantity: Currently there is enough Minnesota biodiesel manufacturing capacity to meet the B5 and B10 mandate requirements.
Quality: ASTM D6751 and ASTM D7467 can provide the quality foundations for biodiesel specifications. Instead of developing separate specifications the state may want to work with the pipeline and terminal companies to develop these specifications.
Distribution: There are no significant distribution problems with the exception of the southwestern region of Minnesota. The state may want to work with the pipeline and terminal companies to develop a solution.
Splash blending: Refer to the Blending subcommittee.

Diesel and Biodiesel Cold Weather Issues Conclusions

A final meeting of the entire Biodiesel Task Force and Cold Weather Technical Team was held on January 30, 2009 to review the findings of the Cold Weather Technical Team subcommittees. Discussion arising from these reports indicated that there were broader fuel issues which could affect winter fuel performance regardless of the level of biodiesel mandated at the time. In addition to conclusions from the subcommittee reports, discussions from the group and subsequent suggestions informed the conclusions that follow.

[15] Laws of Minnesota 2008, Chapter 297, Article 1, Section 72.
[16] Renewable Identification Numbers are used, among other things, to track compliance and volumes for the Renewable Fuels Standard (RFS). The RFS is a national standard established by federal law to increase the use of renewable fuels.

Discussion indicated at least fifteen cases of unusual filter plugging in commercial trucks this winter for which the cause had not been determined. Discussion of possible causes included engine manufacturers' reduction of truck filter sizes (from 10 to15 microns down to 2 to 5 microns), paraffin from diesel, glycerin from biodiesel, water contamination, biotic contamination as a result of ultra-low sulfur diesel levels plus water contamination, and vehicle designs in which the fuel filter is located away from the engine. The desire was expressed for a check list (similar to the Handling Subcommittee's "Handling Guide," located in Appendix C) aimed at vehicle owners and fleet managers that identifies a step-by-step process for diagnosing the most common kinds of filter plugging that may be encountered in their vehicles.

There was also discussion that existing cold flow test procedures are not sufficiently predictive of the cold temperature fuel performance of diesel fuel with or without biodiesel. ASTM International and other organizations at a national level must develop new test methods that are more predictive of the cold weather performance of diesel fuel and biodiesel blends.

Variations in seasonal availability of fuel were also discussed, specifically routine shortages of diesel fuel at terminals in the fall leading to the practice of bulk plants and fleets buying and storing fuel in the late summer for use in the fall and early winter months when shortages of diesel are anticipated. Such stockpiling of B10 or higher could result in problems in above ground tanks. Solutions discussed included moving the date of the annual switch to B5 and back, and education and outreach to end users.

Finally, the suggestion was made that the Task Force discussions should freely address the availability and quality of all winter fuel in the state instead of being confined only to biodiesel. Given recent changes in the diesel industry—including biodiesel, low-sulfur diesel fuel and smaller fuel filter pore diameters—a wide range of issues regarding equipment and diesel fuel with and without biodiesel must be addressed. A venue for the continuation of work in these areas should be maintained by the State of Minnesota.

Concerns have been expressed about the uncertainty of the performance of B5 in Minnesota winter conditions (see Appendix A). There is no evidence to indicate that B5 will perform differently than B2. After significant review, ASTM recently included biodiesel blends up to 5 percent in the Standard Specification for Diesel Fuel Oils D975. Some Minnesota fleets are successfully using even higher blends in winter; however, there remain unanswered questions regarding the cold weather storage and subsequent performance of B10 and B20. It is the conclusion of this committee that there are still issues to be addressed in order to safeguard the quality of winter fuel in Minnesota.

Appendix A: Biodiesel Task Force Comments

Members of the Technical Cold Weather Team and the Biodiesel Task Force, after their review and discussion of subcommittee reports at a January 30, 2009 meeting, were asked to submit their written comments regarding the reports. In addition, MN Statute § 239.77 subd. 5 [Annual Report] calls for an annual biodiesel report to be submitted January 15 of each year. The report was required to include "….any written comments received by members of the biodiesel fuel task force by January 1 of that year designated by them for inclusion in the report." No such comments were received at the time of the publication of the report and so a request was made for comments specific to that request on February 6, 2009. The comments included in this section are a result of these two requests for information.

Comments from Jeremy Bezdek of Flint Hills Resources

Winter operability continues to be a major concern for implementing the mandated Minnesota biodiesel transition from B2 to B5 in 2009. At present, Flint Hills Resources feels the committee has not adequately addressed these Winter B5 operability concerns. Task Force data clearly show a marked degradation in cold temperature properties of the samples containing B5, which is troubling given Minnesota's harsh winter climate. To help achieve minimum operability confidence, we believe the Winter B5 implementation must address the following:

1) New operability testing methodologies which are more relevant to "real world" vehicle configurations and performance requirements;
2) New diesel additive solutions, since historically utilized additives do not show the expected cold flow response in the B5 environment;
3) New #1 fuel oil blending requirements relative to historical Winter B5 performance due to the shift in cold temperature properties as shown in the Task Force data.

Flint Hills Resources appreciates the opportunity to participate on the Minnesota Biodiesel Task Force and looks forward to working with you and the other task force members on ensuring the successful implementation of the B5 transition.

Comments from Dustin Haaland of CHS

CHS shares the concerns that have been raised about the correlation between CFPP[17] and field operability. The subcommittee test data suggests no/minimal change to CFPP when a B5 blend is compared to straight #1 diesel and 50/50 #1/#2 diesel blends. The concern is whether this test method indicates actual fuel performance in "real world" conditions.

Comments from Scott Fenwick of ADM

Winter Operability is a concern, and has been initially addressed within a CRC[18] Study. Their conclusions show that vehicular operation is possible down to the Cloud Point of the blended fuel. Blending and handling issues, however, are separate. Unfortunately, ASTM specifications do not address these types of issues for *any* fuels.

I agree that newer and different testing methodologies may be needed to help determine operability. Unfortunately, the petroleum community was initially adamant against this saying that in order to become incorporated into D975, the existing D975 methodologies had to be used.

Additive solutions are increasingly rare. The biodiesel community is working with numerous additive suppliers, but is increasingly being told "No" to cold-flow additives. The ones historically used for

[17] CFPP refers to the Cold Filter Plugging Point.
[18] CRC refers to the Coordinating Research Council.

LSD[19] may / may not be as effective (at least with the same dosages) as they are for ULSD[20], let alone for Bxx blends. By blending biodiesel from less saturated feedstocks, lower operability limits can often be achieved.

Comments from Jan Homan of Metro Transit/MEG Corp.
Note: Mr. Homan has concerns about dispenser filter plugging problems experienced at the Metro Transit Fleet Headquarters over the past two years as they have used higher blends with #1 diesel fuel. He feels that the sedimentation in his tanks is glycerine. He forwarded the following report from MEG Corp. to be included in this comment section.

The goal of the Biodiesel Blend Study was to determine why Metro Transit was having problems with precipitate dropping out of biodiesel blends with #1 diesel during winter months. This study tested the ability of #1 and #2 diesel fuels to hold biodiesel component in solution at cold temperatures. Three different diesel fuels (#1, #2, and 50/50) were blended at room temperature with 100% soy biodiesel at 5, 10 and 20%. In most sample cases there were more than one of each sample blend made in order to also test the ability of two different additives. It is expected that these additives will increase the ability of the fuel to hold biodiesel when the temperature drops below freezing. Each of these samples was then subjected to cold temperatures for long periods of time and observations were made.

Observations:

Week One
The fuel samples were stored at 40°F for duration of 1 week and then observations were made on the individual samples. At this time the samples contained no sediment and were clear and bright.

Week Two
After the first week of 40°F we lowered the temperature to 18°F for duration of 1 week and observations were made on the fuel samples.

- All B2 blends - no sediment
- All B5 blends - no sediment
- All B10 and B20 blends had sediment dropping out of solution. This sediment was more apparent with #1 than with #2 or the 50/50 blend.

Week Three
The samples were stored for a few more days at the same temperature to see if more sediment would drop out. Observations were made on all the samples and there was little to no change in the appearance of the samples. Based on these observations straight #1 diesel will have sediment dropping out of the blend at lower temperatures with B10 or higher. The 50/50 blends and straight #2 had significantly less sediment and therefore would appear to have a held the homogeneous solution at colder temperatures better than the #1 blends.

The additives were used in all the blends. B2 and B5 additized did not show any difference from the un-additized B2 and B5. Additives in the B10 and B20 blends did appear to help keep biodiesel components in solution; there appeared to be half as much dropout. However the additives did not solve the dropout issue.

We will continue to observe at 18°F for another week. We will lower the temperature to 0°F and -20°F in the weeks ahead.

[19] LSD refers to low-sulfur diesel.
[20] ULSD refers to ultra low-sulfur diesel

The material that was filtered out of the bottom of the storage tank and picked up at the meeting on 1/23/09 has been sent to ADM for an analysis. We are still waiting to hear back from them regarding the testing of that material.

Comments from John Hausladen of Minnesota Trucking Association
The Minnesota Trucking Association appreciates the opportunity to comment on the implementation of the biodiesel mandate in Minnesota. During legislative hearings last spring, our organization voiced a number of concerns about cost, performance and supply. The adopted legislation acknowledged the reality of those concerns by including language assuring their continued review and surveillance. We see three barriers to successfully phasing-in the mandate towards its B20 goals:

1) Testing of biodiesel blends greater than 5% under on-road conditions. The recent cold weather brought home the stark reality that extreme cold temperatures and variable equipment design can yield different fuel performance results than those obtained in the lab. We strongly believe that more emphasis needs to be placed on conducting tests in real-life conditions before blends are increased.

2) More detailed pricing information. We received anecdotal information from members regarding a significant pricing differential between B2 and straight diesel product in Minnesota. While the legislation requires pricing information in the "out" years, we think it would benefit all users if this was reported in detail each year, starting with 2009. By detailed, we mean including a breakout showing the difference between #1 and #2 diesel, as well as B100 pricing.

3) Broad participation by stakeholders. We were disappointed about the lack of stakeholders involvement in subgroups that convened this year. Such exclusion, even if unintentional, works against cooperation and information sharing. We strongly encourage openness and inclusion in all discussions about biodiesel.

We look forward to being a productive partner in the implementation process. We further offer the services of our organization and members to assist in fleet testing to assure performance of higher blends in cold weather before they are mandated.

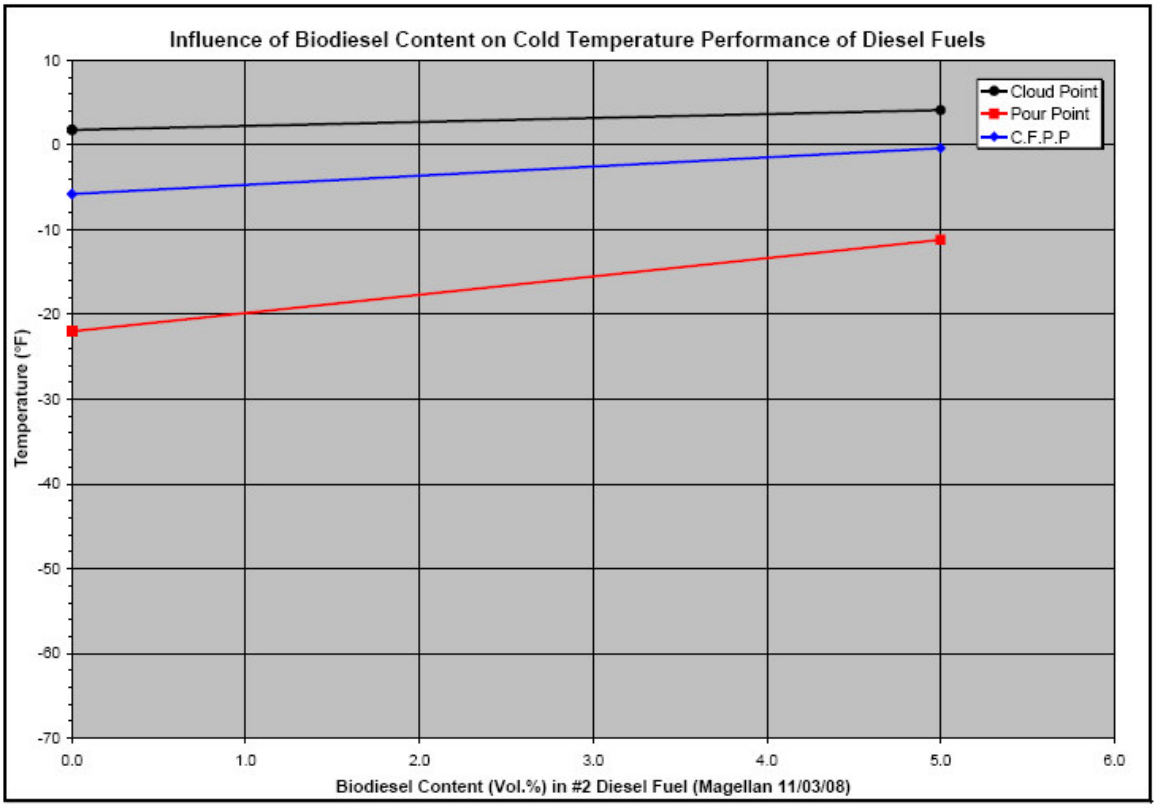
Appendix B: Blending Subcommittee Test Results and Graphs

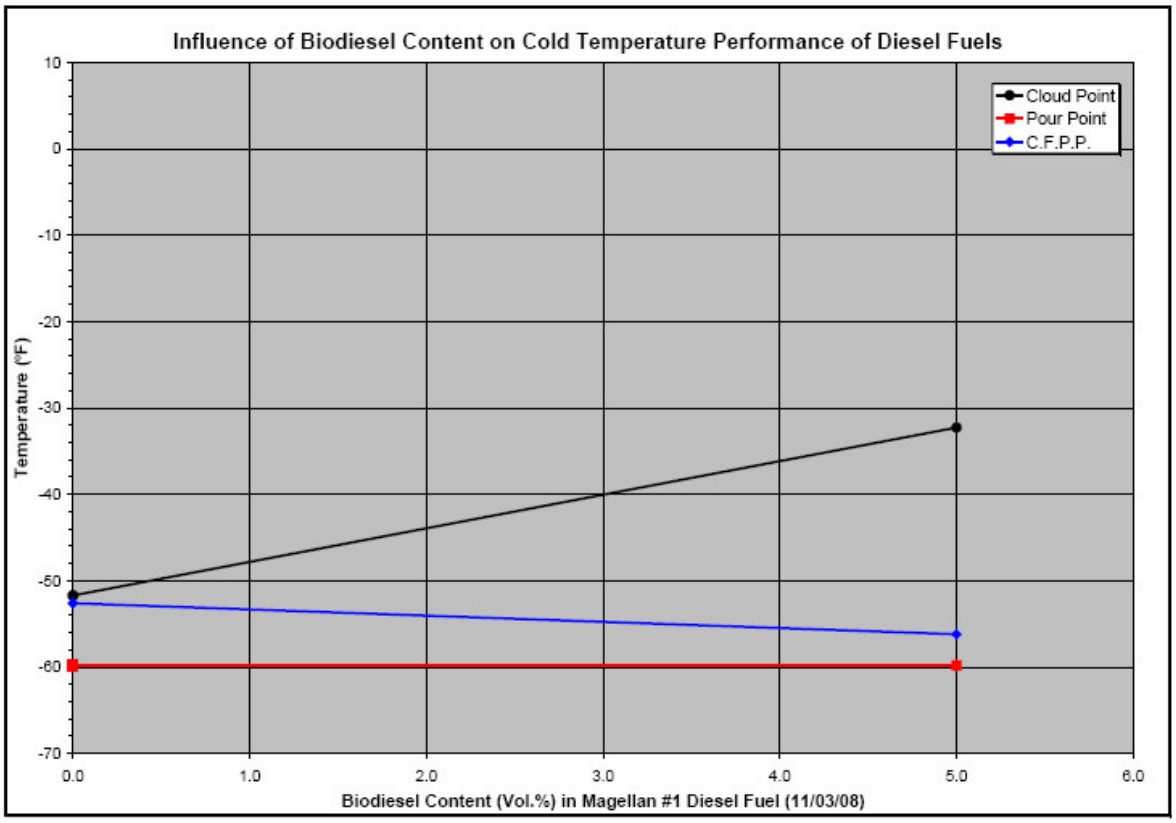
In 2006 the EPA required that, to reduce pollution, the sulfur content of diesel fuel must be reduced from 500 parts per million (ppm) called low sulfur diesel (LSD) to only 15 ppm called ultra low sulfur diesel (ULSD). Jim Hedman of the Minnesota Department of Commerce Weights and Measures Division developed data for blending subcommittee members to use in determining if the effect of biodiesel on cold flow properties of ULSD would be similar to the effect revealed by earlier studies done on LSD.

The graphs below show that cold flow properties data derived by the blending of 5 percent biodiesel in ULSD closely resemble the results of pervious studies done using LSD. Black lines indicate cloud point (CP), red lines indicate pour point (PP) and blue lines indicate cold filter plugging point (CFPP).

The most commonly used cold flow property measure is cloud point. The CP of #1 diesel shows a significant increase from (-55 to - 32ºF) with the addition of 5 percent biodiesel. The CP of #2 diesel and that of a 50/50 blend of #1 and #2 diesel, which is often used during Minnesota winters, reveals only a couple of degrees increase in CP. This is very similar to the results observed in previous tests with LSD.

PP showed no increase in #1 diesel but a 10 degree increase in #2 and 50/50 blends. CFPP showed a slight decrease for #1 diesel, a 5 degree increase for #2 diesel and a 2 degree increase in a 50/50 blend. Again these results were similar to the results shown in previous tests with LSD.




Influence of Biodiesel Content on Cold Temperature Performance of Diesel Fuels
Cloud Point
Pour Point
C.F.P.P.
Temperature (°F)
10
0
-10
-20
-30
-40
-50
-60
-70
0.0
1.0
2.0
3.0
4.0
5.0
6.0
Biodiesel Content (Vol.%) in Magellan #1 Diesel Fuel (11/03/08)

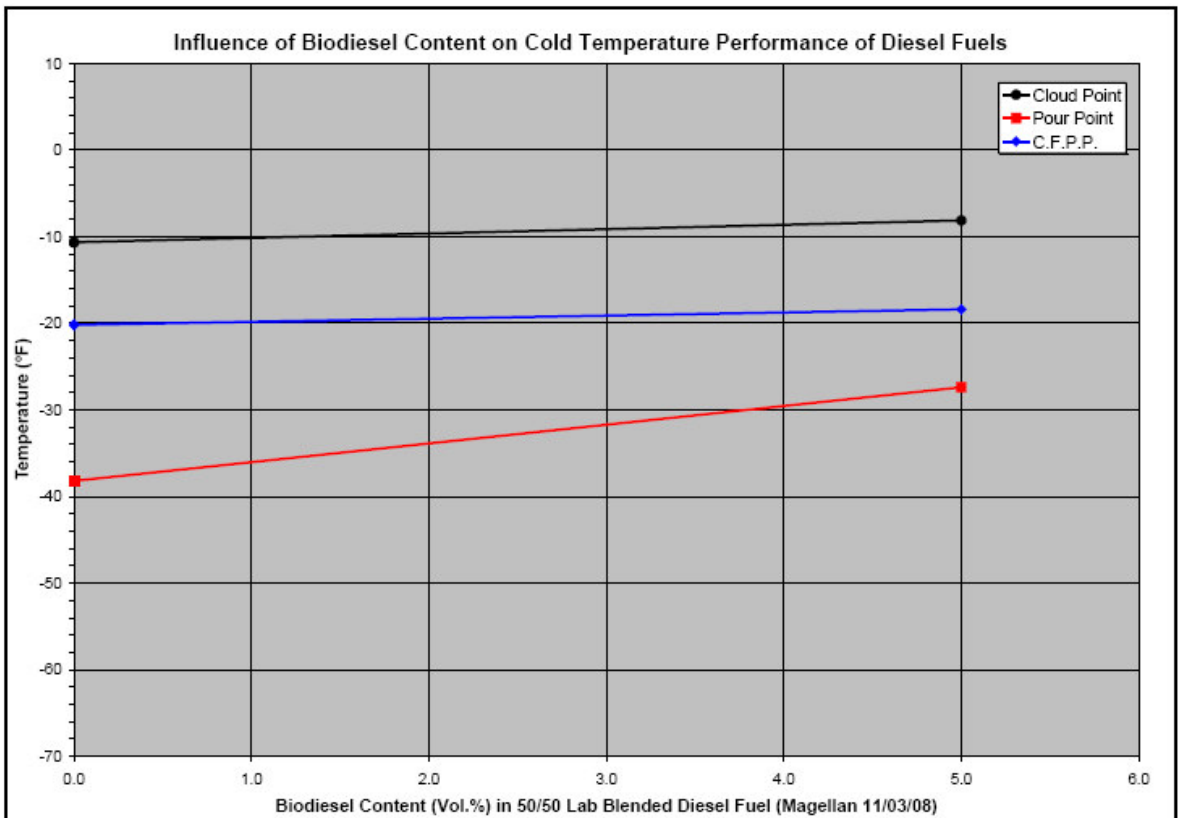

Influence of Biodiesel Content on Cold Temperature Performance of Diesel Fuels
Cloud Point
Pour Point
C.F.P.P.
Temperature (°F)
10
0
-10
-20
-30
-40
-50
-60
-70
0.0
1.0
2.0
3.0
4.0
5.0
6.0
Biodiesel Content (Vol.%) in 50/50 Lab Blended Diesel Fuel (Magellan 11/03/08)

Table 1. Cold Temperature Test Performance of Biodiesel Blends (in Study to Date)

Sample I.D.	Diesel Components		CFI	Bxx	Cold Temperature Test (°F)		
	#1	#2			Cloud Pt.	Pour Pt.	C.F.P.P
034414	0	100	0	0	2	-22	-6
100200	0	95	0	5	4	-11	0
034415	100	0	0	0	-52	-60	-53
100201	95	0	0	5	-32	-60	-56
100202	50.0	50.0	0	0	-11	-38	-20
100203	47.5	47.5	0	5	-8	-27	-18

Table 2. Performance Change of Biodiesel Blend Relative to Neat Counterpart

Sample I.D.	Diesel Components		CFI	Bxx	Cold Temperature Test (°F)		
	#1	#2			Cloud Pt.	Pour Pt.	C.F.P.P
100200	0	95	0	5	2	11	5
100201	95	0	0	5	19	0	-4
100203	47.5	47.5	0	5	3	11	2

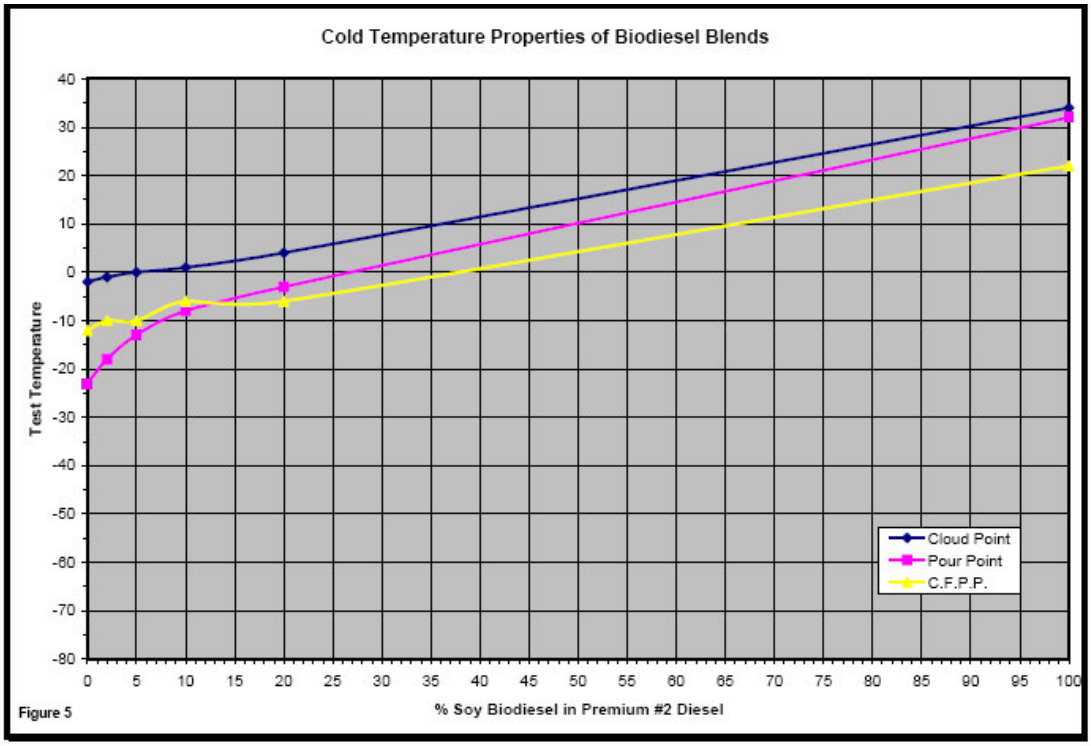


Figure 5

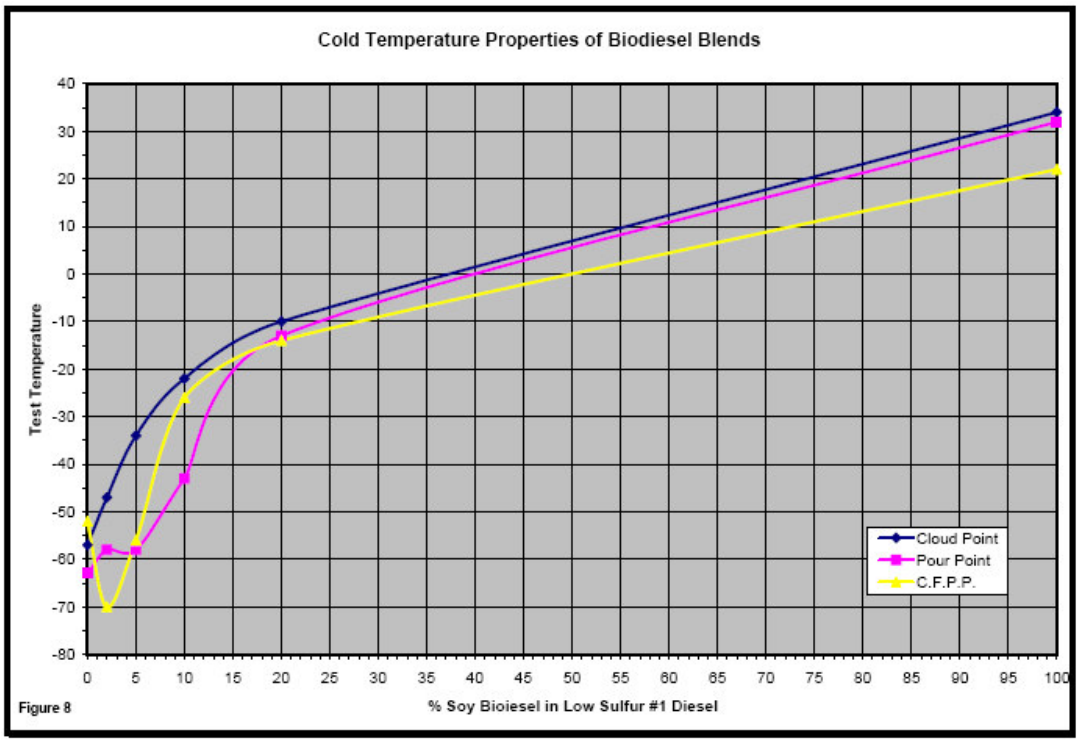

Cold Temperature Properties of Biodiesel Blends
Test Temperature
% Soy Bioiesel in Low Sulfur #1 Diesel
Cloud Point
Pour Point
C.F.P.P.

Figure 8

Appendix C: Biodiesel Handling Guide – DRAFT

Introduction

Biodiesel is a clean-burning alternative fuel made from domestic, renewable resources. In Minnesota it is made primarily from soybean oil, but it can also be made from other vegetable oils, recycled frying oils and animal fats. The term ‘biodiesel' refers to the pure, unblended fuel and is referred to as B100; in this document, ‘diesel’ refers to all petroleum-based diesel fuel. Like petroleum diesel, before biodiesel is accepted into the fuel distribution system, it must meet strict quality standards to ensure trouble-free performance (as required by the American Society for Testing and Materials (ASTM) Biodiesel Specification, D6751). Unprocessed, raw vegetable oils and animal fats are NOT biodiesel — they can cause deposits and engine damage, cannot be used to meet Minnesota's biodiesel requirements and are not registered fuels approved by the U.S. Environmental Protection Agency (EPA).

Biodiesel contains no petroleum, but it can be blended with petroleum diesel in any percentage. Biodiesel blends from 2 percent to 20 percent can be used in most diesel equipment with no or minor modifications. Biodiesel blends are indicated by a “B” with a number following the “B” that represents the percentage of biodiesel in a gallon of fuel. The remainder of the gallon can be No. 1 diesel, No. 2 diesel, kerosene, jet A, heating oil or any other distillate fuel.

Biodiesel blends higher than B20 require special handling and may require equipment modifications. These issues can be managed but because of the special handling required, higher level blends are not recommended except in cases where human exposure to diesel particulate matter (PM) is high and health concerns merit the additional attention to equipment and handling (e.g., underground mining).

Diesel engines are a large and growing segment of our transportation fleet. The EPA’s recent mandate to drastically reduce sulfur content in diesel is expected to result in quieter, smoother running engines that are actually cleaner than gasoline engines. The greater efficiency of diesel engines and higher energy content of diesel fuel promises a more economical source of transportation power for all vehicles. This could all result in a greater number of diesel engines used in light trucks and passenger vehicles.

As diesel fuel is poised for greater usage in the U.S. transportation fleet, it is appropriate that federal policy includes the commercialization of renewable alternatives. One alternative that is ready for the market is biodiesel. The Energy Independence and Security Act of 2007 requires that the United States use 500 million gallons of biodiesel in 2009 with incremental increases to 1 billion gallons in 2012.

In September 2005, Minnesota became the first state to implement a biodiesel mandate of B2, meaning that virtually all diesel sold in Minnesota contains 2 percent biodiesel and 98 percent petroleum diesel. On May 1, 2009 this mandate will increase to B5 (5 percent biodiesel and 95 percent biodiesel). After tracking many consumer and industry events, a pattern of problems surfaced and various solutions were identified. It is the goal of this publication to outline some of these common and uncommon problems, provide possible solutions and recommend handling and use guidelines that have been found to help, reduce or eliminate problems.

Identifying your set of circumstances

It is not uncommon that a specific user may have one or multiple causes to their fuel system problems, including: (1) biodiesel, (2) petroleum diesel fuel, (3) various types of contamination and deposits, and (4) problems with storage vessels and fuel delivery system components including improper filters or the lack of filters in the system or any number of similar problems with vehicles. As you consider your present situation with diesel fuel, consider the following questions and turn to the appropriate section of this guidebook. When switching to biodiesel, there are several things to consider:

- Is the fuel system compatible with the biodiesel blend you will be using?
- Are you going to be operating in cold weather?
- Do you have a reliable source for qualified biodiesel?
- Is the storage tank clean, free of water and compatible with your biodiesel blend?
- Are you going to use up the fuel in your storage tank within six months of the original manufacturing date of the biodiesel?
- What does the Original Equipment Manufacturer (OEM) recommend?

I am using diesel fuel now with no problems, but I want to keep it that way

I am having some problems with diesel fuel filter plugging

It seems like I've tried everything and I'm still having problems

If this guide has not helped you identify and solve your fuel related problem, contact your fuel supplier. They should help you resolve fuel related issues. However, this does not absolve you, the fuel user, from taking the appropriate steps to safeguard the product you purchase. Proper tank maintenance and housekeeping are the responsibility of the fuel purchaser. In an effort to promote the successful use of biodiesel, there is a Minnesota Diesel/Biodiesel Hotline in place to provide technical assistance to answer questions, help diagnose problems and offer recommendations.

Minnesota Diesel/Biodiesel Hotline:
1-800-929-3437
This document is available at the following web site: (www.mda.state.mn.us)

ASTM Standards

D975 No. 2 Diesel Fuel

Biodiesel blends up to 5 percent are considered no different than conventional No. 2 petroleum diesel. These blends will meet the ASTM D975 fuel specification and can be used in any application as if they were pure petroleum diesel. No special labeling is required at retail pumps to inform consumers that biodiesel is contained in the fuel.

Property	ASTM Method	Limits	Units
Flash Point	D 93	125 min.	Degrees F
Water & Sediment	D 2709	0.05 max.	% vol.
Distillation (One of the following must be met)			
(1) Physical Distillation,T90	D 86	640 max.	Degrees F
(2) Simulated Distillation,T90	D 2887	673 max.	Degrees F
Kinematic Viscosity, 104°F	D 445	1.9 - 4.1	mm2/sec.
Ash	D 482	0.01 max.	% mass
Sulfur			
S 15 Grade	D 5453	0.0015 max. (15)	% mass (ppm)
S 500 Grade	D 5453	0.05 max. (500)	% mass (ppm)
Copper Strip Corrosion	D 130	No.3 max.	
Cetane Number	D 613	40 min.	
One of the following must be met			
(1) Cetane Index	D 976-80	40 min.	
(2) Aromaticity	D 1319-03	35 max.	% volume
Ramsbottom Carbon Residue 10% residue	D 524	0.35 max.	% mass
Cloud Point	D 2500	Report	Degrees F
Lubricity, HFRR @ 140°F	D 6079	520 max.	micron

D6751 (B100) 100% Biodiesel

Any biodiesel used in the United States must meet all of these specifications before it can be used for blending and meet the following definition:

> **Biodiesel**, *noun*: a fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oils, animal fats designated B100.

Property	ASTM Method	Limits	Units
Calcium & Magnesium, combined	EN 14538	5 max.	ppm (ug/g)
Flash Point (closed cup)	D 93	199.4 min.	Degrees F
Alcohol Control (One of the following must be met)			
(1) Methanol Content	EN14110	0.2 max.	% volume
(2) Flash Point	D93	266 min.	Degrees F
Water & Sediment	D 2709	0.05 max.	% vol.
Kinematic Viscosity, 104°F	D 445	1.9 - 6.0	mm2/sec.
Sulfated Ash	D 874	0.02 max.	% mass
Sulfur			
S 15 Grade	D 5453	0.0015 max. (15)	% mass (ppm)
S 500 Grade	D 5453	0.05 max. (500)	% mass (ppm)
Copper Strip Corrosion	D 130	No. 3 max.	
Cetane	D 613	47 min.	
Cloud Point	D 2500	Report	Degrees F
Ramsbottom Carbon Residue 100% sample	D 4530	0.05 max.	% mass
Acid Number	D 664	0.50 max.	mg KOH/g
Free Glycerin	D 6584	0.020 max.	% mass
Total Glycerin	D 6584	0.240 max.	% mass
Phosphorus Content	D 4951	0.001 max.	% mass
Distillation, T90 AET	D 1160	680 max.	Degrees F
Sodium/Potassium, combined	EN 14538	5 max.	ppm
Oxidation Stability	EN 14112	3 minimum	Hours
Cold Soak Filtration	Annex to 6751	360 max.	Seconds
For use in temps below 10.4°F	Annex to 6751	200 max.	Seconds

D7467 Biodiesel Blends from B6 to B20

Biodiesel blends that contain 6 to 20 percent biodiesel have a separate specification. These blends can be used in many applications that use diesel fuel with minor or no modifications to equipment. Retail fuel pumps are required to indicate that the fuel contains 6 to 20 percent biodiesel in the fuel.

Property	**ASTM Method**	**Limits**	**Units**
Acid Number	D 664	0.30 max.	mg KOH/g
Viscosity, 104°F `	D 445	1.9 - 4.1	mm2/sec.
Flash Point	D 93	125 min.	Degrees F
Cloud Point	D 2500	Report	Degrees F
Sulfur			
S 15 Grade	D 5453	0.0015 max. (15)	% mass (ppm)
S 500 Grade	D 5453	0.05 max. (500)	% mass (ppm)
Physical Distillation, T90	D 86	650 max	Degrees F
Ramsbottom Carbon Residue 10% residue	D 524	0.35 max.	% mass
Cetane Number	D 613	40 min.	
One of the following must be met			
(1) Cetane Index	D 976-80	40 min.	
(2) Aromaticity	D 1319-03	35 max.	% volume
Ash	D 482	0.01 max.	% mass
Water & Sediment	D 2709	0.05 max.	% vol.
Copper Strip Corrosion	D 130	No. 1 max.	
Phosphorus Content	D 4951	0.001 max.	% mass
Oxidation Stability	EN 14112	6 min	hours
Biodiesel Content	D 7371	6-20%	% volume
Lubricity, HFRR @ 140°F	D 6079	520 max.	micron

Fuel Property Descriptions (from ASTM D975, D6751 and D7467)

Aromaticity – This test indicates the aromatic content of diesel fuel. Increased aromatic content of fuels over specified levels may have a negative impact on emissions.

Ash – This test measures the amount of residual alkali catalyst (chemical used in the production of biodiesel) in the biodiesel as well as any other ash-forming compounds that could contribute to injector deposits or fuel system fouling. Abrasive solids and biodiesel catalyst materials result in wear of fuel system and internal engine components exposed to fuel after injection. Metallic soaps can contribute to deposits in the fuel system. All ash-forming compounds can contribute to the accumulation of materials on diesel particulate filters, requiring increased filter maintenance.

Biodiesel Content – The percentage of biodiesel in volume of B100 in diesel fuel. It is important that the amount of biodiesel utilized in a given fuel blend be identified on the invoice and that the product is uniformly blended.

Cetane – An adequate cetane number is required for good engine performance. Conventional diesel must have a cetane number of at least 40 in the United States. Higher cetane numbers help ensure good cold start properties and minimize the formation of white smoke.

Cloud Point – The temperature at which the first solids form and are visible to the naked eye. This is the most commonly used measure of low-temperature operability; fuels are generally expected to operate at temperatures as low or lower than their cloud point. Biodiesel typically has a higher cloud point than petroleum diesel.

Cold Filter Plugging Point (CFPP) – This is the temperature under a standard set of test conditions (ASTM D6371) at which the filter plugs. The sample is cooled and tested at intervals of 1°C until the wax crystals precipitate out of solution and are sufficient to slow or stop the flow of fuel through the filter.

Cold Soak Filterability – This is the newest requirement. It was added in 2008 in response to data indicating that some B100 could, in blends up to B20, form precipitates above the cloud point. Blends that meet this specification will not form precipitates. This, along with cloud point, is needed to predict low-temperature operability.

Copper Strip Corrosion – The copper strip corrosion test indicates potential compatibility problems with fuel system components made of copper alloys such as brass and bronze.

Flash Point – The flash point as specified is not directly related to engine performance. It is, however, of importance in connection with legal requirements and safety precautions involved in fuel handling and storage, and it is normally specified to meet insurance and fire regulations.

Kinematic Viscosity – A minimum viscosity level is required for some engines because of the potential for power loss caused by injection pump and injector leakage. The maximum viscosity is limited by the design of the engine fuel injections systems. Higher viscosity fuels can cause poor fuel combustion that leads to deposit formation as well as higher in-cylinder penetration of the fuel spray, which can result in elevated engine oil dilution with fuel.

Lubricity – This test measures the wear caused by friction between metal parts. Fuel system components are lubricated by the fuel itself. Wear or scarring is a sign of inadequate lubricity. Poor lubricity can result in shorter life of components.

Magnesium and Calcium – Magnesium and calcium are “alkali metals” utilized as absorbents in the production of biodiesel and should be removed through a biodiesel production process that meets the requirements of ASTM D6751. Residual alkaline metals can form deposits in the fuel injection system components and poison emission control after treatment systems.

Oxidation Stability – Biodiesel can oxidize during storage and handling, leading to the formation of peroxides, acids, gums and deposits. The minimum oxidation stability requirement is intended to ensure the storage stability of B100 and biodiesel blends.

Phosphorous – Phosphorous has been shown to hinder the capability of after treatment systems to reduce exhaust emission. The phosphorous accumulates on the after treatment system. Therefore, very low levels of contamination may lead to deterioration of the after treatment system. The phosphorous limit in the B100 Specification is intended to minimize any potential issues associated with phosphorous' impact on the after treatment devices in blended fuels.

Physical distillation – Distillation provides a measure of the temperature range over which a fuel volatizes or turns to a vapor. Lighter fuels typically have a greater volatility than heavier fuels.

Ramsbottom Carbon Residue – This test is intended to provide some indication of the extent of the carbon residue that results from the combustion of the fuel. Biodiesel blends are required to meet the same ASTM D975 limit.

Sodium and Potassium – Sodium and potassium are "alkali metals" utilized as catalysts in the production of biodiesel and should be removed through a biodiesel production process that meets the requirements of ASTM D6751. Residual alkaline metals can form deposits in the fuel injection system components and poison emission control after treatment systems.

Sulfur – Sulfur levels in fuel are regulated by various governmental agencies to assure compatibility with emission standard requirements. In the United States there are currently three sulfur grades: S5000, S500 and S15 for both No. 1 and No. 2 petroleum diesel fuel. Biodiesel blends are required to meet the same maximum sulfur content for the intended application.

Water and sediment – This refers to free water droplets and sediment particles. The allowable level for B100 and B6 to B20 blends is set at the same level allowed for conventional diesel fuel. Excess water can lead to corrosion and provides an environment for microorganisms. Fuel oxidation can also raise sediment levels, so this test can be used in conjunction with acid number and viscosity to determine if fuels have oxidized too much during storage.

Working with Fuel Suppliers

The vendor and fleet manager should establish a contractual agreement to ensure product quality on a consistent basis. The following guidelines are designed to ensure receipt of a quality product.

<u>General Guidelines</u>

- Ensure that fuel you purchase from your supplier meets ASTM specifications D6751 for B100, D7647 for B6 through B20 and D975 for petroleum diesel, and that it is properly blended to the predefined biodiesel blend target upon receipt. (See pages 3-5 for fuel specifications)
- **Always retain a one-quart sample of fuel**. Look at a sample of the fuel in a clear mason jar. The fuel should be clear and bright. Save this sample until the next load of fuel is received. Discard the sample by adding it to the fuel tank.
- As with any ULSD, biodiesel has a shelf life of 6 months to avoid microbial growth and product degradation. With the proper housekeeping and additives, the shelf life can be extended. Consult your fuel supplier for proper recommendations and testing.
- Ensure biodiesel blends meet cold flow operability and any operational needs prior to purchase. When you receive fuel, determine how long it will be in storage. Fuel purchased in July does not contain cold flow additives. If you will be using this fuel in winter months, you may need to add cold flow additives.

- As an additional level of confidence, choose biodiesel marketers and producers that have attained National Biodiesel Board BQ-9000 quality program accreditation. (See Fuel Quality below)

Fuel Quality

It is important that when you are purchasing fuel you make sure it is high quality by meeting all ASTM specifications. Fuel that is off specification on just one of the ASTM standards can not only cause serious engine problems, but it can void engine warranties if it is determined that the fuel caused damage. This can cause unnecessary costly repairs for vehicles/equipment. In an effort to assure that biodiesel is meeting all the proper specifications, the National Biodiesel Accreditation Commission created BQ-9000 in 2005. This voluntary program establishes quality systems for storage, sampling, testing, blending, shipping, distribution and fuel management practices. If purchasing B100 or a biodiesel blend, ask if the biodiesel is from a BQ-9000 biodiesel producer/marketer. If you are unable to get fuel from a BQ-9000 producer/marketer, the next best thing is to verify with your supplier that the fuel meets all ASTM specifications.

Blending and Storage

Minnesota has a biodiesel mandate – there is no blending required by the end user. The blending process takes place right at the terminal rack by in-line blending. This is the preferred method because it ensures complete blending. In-line blending occurs when the biodiesel is added to a stream of diesel fuel as it travels through a pipe or hose in such a way that the biodiesel and diesel fuel become thoroughly mixed by the turbulent movement through the pipe. This product is sold directly to customers or to a petroleum jobber or a distribution company for further sales to customers. Minnesota is confident there will be few issues with the use of B5 as the D975 specification for diesel fuel now clearly states that biodiesel blends of up to 5 percent fall within the range of D975 specifications.

It is always possible if you want a higher biodiesel blend to ask you supplier. They should be able to deliver/supply any blend of biodiesel that you request. While it is not recommended, if you are going to blend biodiesel into diesel yourself, make sure to follow the blending guidelines. In doing so you will ensure that your fuel is properly blended, causing fewer operational issues.

<u>Blending Your Own Fuel</u>

Biodiesel Stock (B100) and biodiesel blends must be clean in appearance and free of water and sediment. Fuel that is not clear and bright indicates either poor fuel handling or storage practices, or poor fuel quality. Biodiesel blending procedures depend on a variety of factors, including the volume of B100 required to make the blend, the finished blend level, the volume of blended products being sold, tank and space availability, and equipment and operational costs. The temperature of the biodiesel should be a minimum of 50°F or 10°F above the cloud point when being blended.

Splash blending is appropriate for locations where biodiesel and petroleum diesel are loaded separately. If possible, load each at the same time through different incoming sources at a high enough fill rate to sufficiently mix. Further agitation may be necessary to achieve a homogeneous blend. If the entire load is pumped into the customer tank, this action will usually be enough to cause complete mixing. Splash blending is often done in bottom loading tank trucks. **Biodiesel is loaded in the tank truck first, followed by the diesel fuel.** A homogeneous mixture should be obtained if the flow rate of the diesel fuel is adequate (several hundred gallons per minute). When the fuel is pumped from the truck to the storage tank, the final mixing occurs. It is important that the B100 is 10°F above the cloud point and that empty truck tank is not cold.

Biodiesel blends should be used within 6 months of the date of manufacture of the source B100. If the fuel is used beyond this date, it should be monitored for changes in acid number. The acid number will increase as a result of oxidation as the fuel degrades in storage. Out of specification biodiesel will form sediments and other filter plugging products of aging. Stability testing has been incorporated into the B100 specification, ASTM 6751.

Stability additives may be needed if fuel is to be stored for longer than six months. Refer to your biodiesel supplier for specific recommendations.

B100 should be stored at temperatures of at least 50°F or 10°F higher than its cloud point (which can vary depending on the source of base oil) prior to blending with petroleum diesel to ensure adequate blending. Depending on the climate and storage method, insulation, agitation, heating systems or other methods to maintain the targeted temperature may be required.

Storage Tanks and Materials Compatibility

Underground storage tanks are preferred to avoid temperature extremes. Above ground storage tanks should be sheltered or painted with reflective paint. High temperatures during storage accelerate fuel degradation. Brass, bronze, copper, lead, tin and zinc may accelerate the oxidation of diesel and biodiesel fuel and potentially create sediments, gels or salts when reacted with some fuel components. Acceptable storage materials include stainless steel, aluminum, Teflon® and most fiberglass. Lead solders, zinc linings, copper pipes, brass regulators and copper fittings should be avoided. According to a National Renewable Energy Laboratory study, elastomers exposed to blends of B20 or less did not exhibit significant changes in dimensions or volume from those exposed to the baseline diesel fuel. The results indicate that all of the elastomers appear to be compatible with biodiesel blends of B20 or less. There are concerns that as temperatures increase, compatibility can be negatively impacted. This is currently being studied by the elastomers manufacturing industry. Watch for leaks and swelling in gaskets.

Fuel Tank Maintenance

Routine maintenance of your fuel system is the key to avoiding fuel related problems. The monitoring and elimination of water in your fuel system is the best preventative measure to take. Over time, operational problems such as corrosion and sediment build up can also occur in diesel fuel systems. The presence of free water can promote fuel system corrosion and microbial growth. Microbes live in the interface that forms between the fuel and the free water. Since the introduction of ULSD, microbial contamination in diesel fuel has become a more common problem. Blends of biodiesel and diesel fuel and the presence of free water may increase the propensity for microbial growth if water is present in the fuel system. It is recommended that storage tanks have a dispenser filter installed to keep any contamination from being passed along to vehicles.

Checking Tanks for Water and Sediment

To ensure contaminants do not create fuel quality issues it is important to remove them before they buildup. Every fuel system has the potential to experience problems so it is necessary to check frequently for contamination. Every fuel system should be inspected per federal, state and local regulations. In addition to those inspections it is necessary to look for contamination. It is recommended that a storage tank be checked for water and sediment prior to each fuel delivery. If the frequency of the deliveries is such that months go by between them, then check the fuel tank at least once a month. If contamination is found, it should be removed as soon as possible. Water should be removed either by draining water off the tank if it is equipped with a water draw or with a vacuum truck. Whichever method is used, the removal should be done slowly so that free water can travel to the low point in the tank. A visual inspection of the water and fuel should be done at the same time and continued until the fuel is clear and bright.

Checking Tanks for Microbial Contamination

It is recommended that fuel tanks be tested for microbial contamination twice a year, preferably in the fall and spring. To test for microbial contamination, obtain a quart sample from the tank bottom (see page 11 for information about tank sampling). Contact your fuel distributor about performing a microbial test. Many fuel distributors perform this test for a fee or can give a referral to a reputable lab that can perform testing. The costs associated with routine testing is a small price to pay in relation to the cost of fuel in the fuel tank, the cost to have vehicles go down due to filter plugging and the cost of biocide used to treat microbial contamination. (See page 13-15 for more information on microbial contamination)

Tank Cleaning

If sediment is found then a vacuum truck should be used with a scavenger device to effectively navigate around the tank and remove the contamination. Depending on the severity of the contamination, an internal tank cleaning may be necessary to effectively remove contaminates. Tank cleaning should take place one of two ways; (1) with the use of a high pressure hose with fuel, or (2) by physically scrubbing the inside of the tank. Both cleaning methods will use impingement cleaning, meaning all surfaces are cleaned with either high pressure or physical scrubbing.

Housekeeping Tips

The importance of keeping your tank and fuel system free of contaminants has never been more important than with the introduction of ULSD and biodiesel. Water and sediment can cause fuel filters to plug prematurely and/or fuel quality issues. Inspections and basic housekeeping practices will help promote a problem free experience. Tank venting is a source for water and contaminants to enter into the tank. Vents should be inspected for proper operation and to make sure that water cannot enter into the tank. A desiccant drier in the vent is highly recommended so that water does not enter the tank through the vent system.

Another critical source of contamination is the filling pipe to the tank. Underground storage tanks typically have the filling pipe at or below grade. It is very important that the ground around the filling containment pot is sloped in such a manner that water and debris are drained away from the opening. The lids and caps should be secured and have gaskets to maintain tight seals to prevent any leakage into the tank. The containment area (secondary containment for the fill pipe) should always be checked with a stick (approximately 2 to 3 feet long) and water detecting paste. If any contamination is found it should be removed and not allowed to be drained into the storage tank. Any contamination can be removed by a vacuum truck or a hand held pump. This contaminated product should be disposed of per EPA regulations.

The fuel tank should be checked monthly by obtaining a tank bottom sample. This sample should be visually inspected for water and sediment. Use a clear mason jar for visibility. The sample should look clear and bright. If any free water and/or sediment are found or the sample appears hazy, the water should be removed. To effectively remove contamination from the low end of a storage tank, a vacuum truck should be used with a scavenger. This will allow the device to travel around and slowly remove the contamination.

Summary

- Fuel tanks should be kept as full as possible to reduce the amount of air and water entering the tank.
- Desiccant driers are recommended in tank vent openings.
- Monitor hoses, fill/vapor caps, gaskets for leaks.
- Visually check tanks monthly for free water by obtaining a tank bottom sample.
- Check fuel containment area for water regularly. Remove water when needed.
- Always install a dispenser filter on a storage tank. If there are any issues with contaminants, the dispenser filter will plug but keep it from progressing to the vehicle tanks.
- In the fall before colder weather sets in, check tanks for water concentration and microbial contamination. Check again in the spring.

Fuel Tank Sampling

Before attempting to sample a fuel tank it is important to prepare the necessary equipment (sampling device, a drop-line that is as long as the tank is high, and sample containers). Determine what device is going to achieve the best results for the sample being sought. The Bacon Bomb sampler is a very reliable device and is going to retrieve the best bottom sample from a fuel storage tank. It is available in many different sizes to fit almost all tank openings.

Try to make sure that you are sampling the lowest point of the tank. Underground storage tanks can shift and settle over time. Free water and sediment will settle to the lowest point of the tank. It is best if you can sample from both ends of the tank so you can determine which end is the lowest point.

Refer to the sampling device operating instructions. Prepare the sampling equipment by double checking that all equipment is securely fastened and will not be accidentally lost after dropping it down into the tank. Lower the sampling device slowly into the tank to the desired fuel level to obtain the sample. This may have to be repeated several times to achieve the required quantity. Immediately label the sample so it can be identified (tank number, bottom, top, etc.). After retrieving the desired sample, be sure to securely close all lids and double check them; they should be snug to prevent contaminants from entering into the fuel tank. It is preferred to have the sample retrieved directly off of the bottom of the tank, as this is where water/sediment and many fuel contaminants will most likely be located. If the sample is good from the bottom of the tank, the fuel is good throughout. If trying to obtain a sample for further fuel quality testing, make sure that the sample is not full of water and sediment. If the bottom sample is full of water and/or sediment and it is needed for further testing, it may be better to retrieve a fuel sample from a different level in the fuel tank. Samples to be tested should be put in a clean, sealable, high density plastic bottle (PETE – polyethylene terephthalate or similar) or aluminum container filled to 90 percent capacity. The sooner the sample is sent to the lab the more accurate the results. Refrigeration will preserve the sample until it can be sent to the lab.

In order to sample different levels of the fuel, use a chain or small rope attached to the plunger on the Bacon Bomb. Drop the bomb to the desired level and then pull on the plunger until the sampler is filled and then release. If testing a tank that is suspected to have some form of contamination, it is advisable to retrieve a bottom, middle and top sample to determine the extent of contamination and to determine if the fuel was properly blended.

Fuel Filtration

When switching to biodiesel, some users have experienced problems with premature fuel filter plugging. This is not an issue at low level biodiesel blends but more commonly seen with blends of B20 or higher. This section is designed to help troubleshoot fuel filter plugging.

General Information

Fuel filters are designed to remove water and particulate from fuel in order to protect the fuel system. They are designed to eventually plug. You may want to investigate if you have a change in the frequency of filter changing.

The Original Equipment Manufacturer (OEM) has specified filters for each fuel system to provide optimum performance. When replacing the filters, it is strongly recommended to continue to use the OEM filters or the equivalent aftermarket filters. OEM is not the local mechanic. Check with the OEM headquarters.

Common Challenges

Stability – It is recommended that biodiesel be used within six months of the manufacturing date. Biodiesel is less stable than petroleum fuels. Exposure to air, heat, light, water and some metals are contributing factors that will cause it to degrade. A common symptom encountered with degraded fuel is plugged filters. With the proper housekeeping and additives, the shelf life can be extended. Consult your fuel supplier for proper recommendations and testing.

Cold Flow – Biodiesel has a much higher cloud point/pour point than petroleum diesel fuel. Pure biodiesel can start to cloud at 55°F and gel by 32°F. Cold temperatures may lead to other problems. Wax and water present in the fuel can precipitate in cold temperatures. Additionally, cold temperatures accelerate the process of glycerin and sterol glycosides in biodiesel forming particulates and dropping out of solution.

Water Separation – Water is present in fuel and therefore many fuel systems require a method of water removal before it reaches the fuel injectors.

- Biodiesel has a higher capacity to hold dissolved water.
- Removing water from biodiesel is more difficult than petroleum fuel.

- Water in fuel can lead to increased growth of microbes.
- Water can lead to corrosion in the fuel system.

Cleaning/Solvent Effects – Biodiesel (B100) is an excellent solvent for cleaning any hydrocarbon deposits that may have formed in the fuel system. After switching to biodiesel it is expected that fuel filters may plug quickly to begin with and then return to a normal change interval after the fuel system is cleaned. The same solvency effect can also lead to some other material compatibility problems in the fuel system. It is important to check with your OEM to make sure fuel system components are compatible with the desired concentration of biodiesel.

Microbes – Microbes is a broad description for any biological growth that can occur in the fuel with the presence of water. They are becoming a more common problem in diesel fuel because the ultra low sulfur levels do not inhibit their growth as in the days of high sulfur diesel. The microbes can form a film of sediment that can plug fuel filters. This film is usually found on the interface between the fuel and the water. It is very difficult to get rid of the microbes once they are present. First remove all the free water and treat with a reputable biocide. (See page 15-16 for more information on microbial contamination)

Filter Recommendations

When choosing a filter it is important to consider the OEM specifications. It is best to continue to use the same style and efficiency filter. If it is not obvious what the performance level of the current filter is, try searching the internet or calling the manufacturer. Filters are typically rated in either a percentage or a beta ratio. For example a $\beta_{10} = 100$ means that for particles that are equal or greater than 10µm there are 100 times more particles captured by the filter than passing through the filter. The percentage would be listed the same way—for example, 99% of the 10 micron particles are being removed.

The efficiency of the filter is very important because it is the level of filtration that must be maintained to ensure no damage is done by hard or abrasive particles. If a lower efficiency filter is installed it can cause premature engine wear and damage. If a higher efficiency filter is installed, it can cause performance issues such as power loss, fuel flow problems and frequent filter plugging.

It is highly recommended to add a filter to bulk storage tanks. This will help remove water and particulate contamination before they reach the vehicle. There are two ways to add filters to storage tanks, the first is a side filtration loop and the second is in-line with the fuel pump, between the tank and the vehicle fill. A side filtration loop could be a separate recirculation pump that pushes the fuel through a series of filters to keep it clean and then put the fuel back into the tank. A dispenser filter filters all of the fuel that goes into the vehicle so less contaminant reaches the fuel tank on the vehicle. Both types of filtration can be utilized to provide more efficient filtration than the vehicle requires by capturing more contaminant.

For water separation, you can choose either a water stripping filter or a water coalescence filter. Both types of filters should remove the water and allow the separated water to be collected at the bottom of the filter. It is important to drain water from the filter daily to prevent water from going back into fuel, forcing its way through the filter or degrading the fuel. Keep in mind that a water separating filter is generally run in the suction side of the fuel pump, so it cannot handle a high pressure drop. To extend the life of the suction side /primary filter, a larger filter, with the same efficiency, can be installed. The larger filter will be able to spread the contaminant around more effectively and provide less flow resistance due to the larger media surface area.

It is very important to monitor the water separating filter on the truck and drain it daily. On an annual basis it is advised to take fuel samples from the bottom of the tank to look for free water and sediment.

Many OEMs use secondary filters; these filters are on the pressure side of the fuel pump. They come in a variety of particle efficiencies and are determined by the OEMs. By using a secondary filter, the primary filter can be made more open to prevent frequent power losses. The pressure side filter is more efficient and can handle a much higher pressure drop across the filter before any power loss problems are noticed.

Definitions:

Filter Media – paper/synthetic material inside a filter that extracts contaminants from a fluid.

Filtration Efficiency – percentage of contaminants removed by a filter. Filters are rated based on their ability to remove standard dusts of specific particle sizes. To avoid problems make sure the filters chosen follow the OEM specifications for the engine.

Dissolved Water – water which is dissolved in fuel; not visible.

Free Water – water separate from the fuel; will be visibly separated on the bottom of the tank or vessel.

Emulsified Water – small droplets of water that are suspended in the fuel; gives fuel a cloudy appearance.

Diagnosing Filter Plugging Sources

The following are descriptions of filters that experience filter plugging and their probable cause. This list will help determine what may be the cause of your filter plugging.

Description of Plugged Filter	Likely Cause
Swollen, frayed filter media	Water Contamination (page 14)
Swollen filter, may be covered with glycerin	Water Contamination (page 14)
Slimy filter with odor	Microbial Contamination (page 14)
Black slimy filter with or without odor	Microbial Contamination (page 14)
Filter with brown Vaseline-like substance in the folds	Mono/Diglyceride Build Up (page 15) (Biodiesel fallout)
Fine, black sediment on the filter	Oxidation (page 14)
Black, smooth filter looks like colored with a black a magic marker	Oxidation (page 14)
Clean filter, hazy fuel	Paraffin Wax or Water Contamination (page 14 or 15)
Granules, sediment in the folds	Sediment (page 15)
Filter with wax substance in the folds at temperature at or below the cloud point	Paraffin Wax (page 15)

Water Contamination

High water concentration in the fuel can lead to a build up of water in the filters. Accumulating water can cause many different problems. When excess water is present, fuel filters will swell causing a distortion of the filter. This distortion is visible as the media will be swollen and separating from the end caps. Water that builds up in the filter can also cause icing problems. When the temperature of the filter gets below the 32°F, the excess water freezes and blocks the flow of fuel through the filter. Icing in the filter can be hard to diagnose. When the filter is removed and examined the ice has usually melted. The presence of water can also pull solid elements of biodiesel out of solution. When filters swell with water, glycerin can become attracted to the water on the filter. The glycerin builds up until the filter plugs. **Water is the number one cause of filter plugging issues in diesel engines.** Routinely checking and removing water in tanks and filters can help minimize problems with plugging filters. (See page 10 for tips on fuel tank maintenance)

Microbial Contamination

Another common filter plugging issue is microbial contamination. Since the introduction of ULSD in 2006, microbial contamination has become a more common problem associated with diesel fuel. High sulfur used to act as a natural antimicrobial. Bacteria and fungus grow in the water/fuel interface. They can be present in both supply tanks, and vehicle tanks; supply lines and fuel system components. Microbial contamination in filters is often recognized by its smell. Microbial contamination may or may not be accompanied by a brown/black/beige jelly-like byproduct created by the growth. Without water, microbes cannot grow. This issue can be avoided by routine water maintenance. (See page 10 for tips on fuel tank maintenance) If microbial contamination is apparent, it is recommended that you treat the contamination with a reputable biocide at twice the kill/shock rate. It may also be advisable to contact your fuel distributor to perform a microbial test or recommend a lab that can.

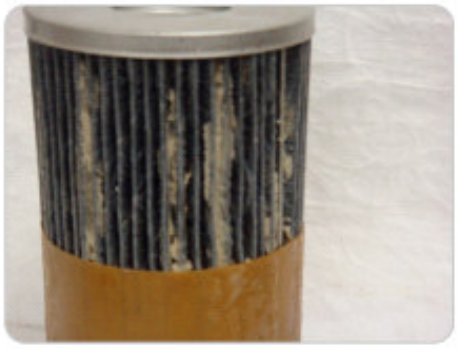
Oxidation

In modern, heavy duty diesel engines, only a portion of the fuel that is circulated to the fuel injectors is actually delivered to the combustion chamber. The remainder of the fuel is circulated back to the fuel tank carrying heat with it. Oxidation is caused by hot fuel returning to the tank and could cause something similar to coking the fuel (burning of the fuel causing it to breakdown and create sediment). In many newer fuel systems, the time it takes to return unused fuel back into the tank has decreased. This fuel, as it comes from the engine, is extremely hot. When this hot fuel enters the cold fuel tank, it will cause the breakdown and oxidation of the fuel. The fuel that is broken down forms sediment that can cause filter plugging. This sediment can be found on the filter element in the form of black granules, which turn the filter black. The first remedy of this situation is to have the fuel system

checked to determine if it is functioning properly. If the system is performing as it should, it may also be necessary to use a stability additive for the fuel.

Paraffin Wax

When the temperature of the fuel is at or below its cloud point, paraffin material can precipitate out and collect on the bottom of the tank. In this situation, filters will often times show no signs of filter plugging which is the tell tale sign. When the filter is brought into a warm location to be examined, the paraffin melts and leaves no evidence. The fuel that is experiencing filter plugging problems will appear hazy. When warmed **to room temperature**, the paraffin wax will go back into **liquid.** High levels of paraffin material could be the result of the way ULSD is processed. **There is no paraffin in biodiesel.** WASA or Wax Anti-Settling Agent additives are used to keep paraffin's suspended in solution rather than collecting at the bottom of the tank where they can cause filter plugging. Contact your fuel distributor if this you think your filters were plugged by paraffin wax.



Mono/Diglyceride Build Up (Biodiesel fallout)

An off specification of the total glycerin limits in the biodiesel specification ASTM D6751 will cause a mono/diglyceride build up on the filter. In this case, the filters are plugged with a brown substance similar to brown Vaseline. If this is the case it is recommended that you check with your fuel distributor to ensure that the fuel meets all specifications; specifically it should be checked for free glycerin. Water absorbing filters hold water on the media and then attract glycerin. Glycerin continues to accumulate and doesn't go back into **liquid**. **Unlike, the wax drop out caused by paraffin, it takes temperatures of 150°F or more to melt glycerin back into liquid**. Sediment on the filter also attracts glycerin. In both of these instances, glycerin may not be the **root** cause of the filter plugging.

Sediment

In many cases tanks and fuel systems can go un-maintained and neglected. Sediment caused by rust, tank scale and other contaminants will plug fuel filters. Filters plugged by sediment are characterized by sediment in the folds of the filter and solid particles in the filter casing. Sediment on the filter also attracts glycerin which further plugs the filter. It is recommended that tanks be monitored and cleaned when necessary in order to reduce tank contaminants. (See page 10 for fuel tank maintenance)

****It is recommended to change fuel filters going into the winter season. Most causes of fuel filter plugging are more pronounced in the cold weather.**

Cold Weather Operability

Like regular diesel fuels, biodiesel blends will gel in very cold temperatures. Typically No.2 diesel fuel has a cloud point in the range of -10 to 20°F and No.1 diesel fuel has a cloud point -40°F or less. That means without the use of cold flow improving additives, No.2 diesel will begin to gel and plug filters at their cloud point. Blends of No.1 and No.2 diesel fuel, the use of cold flow additives and/or fuel heating systems are frequently used to meet cold flow operability requirements for the temperatures expected.

The cold flow properties of biodiesel blends up to 5% will be virtually the same as those of the diesel fuel used in the blend. Biodiesel blends over 5% will begin to have higher cloud points and require the use of cold flow additives or No.1 diesel in order to operate in Minnesota winters. All diesel fuel is different. Neither ASTM D975 nor D7467 have a cloud point specification but do require that it be reported to the customer. **Work with your fuel distributor to achieve the desired cold weather protection.** Get your fuel tested for cloud point and CFPP to determine the level operability. Adjust the ratio of No.1 and additives as needed. Proper tank maintenance and housekeeping practices will further ensure cold weather operability.