

US and EU Market Biodiesel Blends Quality Review – An OEM Perspective

Pat Y. Geng and Andrew E Buczynsky
General Motors Powertrain

Anke Konzack
SGS Germany GmbH

Copyright © 2009 SAE International

ABSTRACT

Biodiesel has become a major alternative fuel for automotive applications demonstrated by its increasing presence in the market place. This paper summarizes test results for recently collected retail samples of biodiesel (B100) and blended biodiesel from the U.S. and the European Union to provide a snap shot of current fuel quality in each market. Properties reported included biodiesel content, oxidation stability, acid number, water, metals, and glycerin content. For B100, only total contamination measured as particulates was significantly lower for the EU than the U.S. For blends containing up to 5% biodiesel, there were significant differences between the U.S. and the EU in sulfur content, oxidation stability (Rancimat), cetane number, and cloud point. For blends higher than B5, present only in the U.S., pump labeling was found to be a poor indicator of biodiesel content. Also, the results showed that Karl Fischer water limit could be substituted for water and sediment without hardship to the industry. While average quality in the EU was generally better than in the U.S., the spread of values in the U.S. showed that its quality could match that found in the EU for any property.

INTRODUCTION

Historical development on biodiesel usage and specifications, US and EU

The first biofuel used in an engine can be traced back to 1900 when peanut oil was used in a diesel engine in France by Rudolf Diesel¹, the inventor of the diesel engine. Biofuels have not been widely used until recently when the steady increase in crude oil price and continued concerns over global warming have drawn tremendous interests globally in them. Biodiesel is appearing more and more in the market place due to tax incentives and because it offers a renewable alternative for diesel vehicle applications.

Biodiesel is defined as a fuel comprised of monoalkyl esters of long-chain fatty acids derived from vegetable oils or animal fats. Raw or refined vegetable oils or recycled greases that have not been processed are not biodiesel. Biodiesel is typically produced by a reaction called trans-esterification, whereby a vegetable oil or animal fat is reacted with an alcohol such as methanol or ethanol in the presence of a caustic catalyst (NaOH, KOH, NaOCH₃) to yield mono-alkyl esters (biodiesel) and glycerin. Glycerin, catalysts, soaps and any excess alcohol are then further separated from the finished biodiesel. Trans-esterification of a vegetable oil to produce biodiesel was first patented in 1937².

Biodiesel quality is dependent on feedstock and processing, and from the original equipment

manufacturers' (OEMs) perspective, the quality of biodiesel blends delivered to the end user is of primary importance. There is a belief that biodiesel quality in the EU is higher than in the U.S because of better feedstocks and more stringent specifications. The purpose of this study was to compare property data from recent surveys of retail biodiesel pumps in the U.S. and the EU to see if there was a basis for this belief.

Brief History of Biodiesel in the United States

The Energy Policy Act of 1992 (EPA³) mandated that 75% of federal government light duty vehicle acquisitions be alternatively fueled vehicles (AFV). The act was amended in 1998 to allow covered fleets to meet up to 50% of their annual AFV acquisition requirements through the use of biodiesel in diesel vehicles over 8,500 pounds gross vehicle weight. The fuel must contain at least 20 volume percent biodiesel to qualify for the credit, and each 450 gallons of biodiesel purchased and consumed provides one AFV credit. As a result, 20% became a de facto concentration for biodiesel blends.

A presidential executive order signed in 2000⁴ required federal fleets to reduce annual petroleum consumption 20% by 2005. As a result, the U.S. Department of Defense (DoD) quickly became the largest volume user of B20 as they strived to meet the requirements of both the executive order and EPA³. Their use of B20 was limited to non-tactical vehicles. In the absence of an ASTM standard, the Defense Energy Supply Center (DESC) developed a commercial item description for B20⁵. Their document later served as a template for development of an ASTM standard.

ASTM Subcommittee D02.E0.02 (diesel fuel oils) formed a biodiesel task group in 1994 to address the need for standards. A provisional standard for B100 was approved in 1999, and an official one was adopted in 2002 as ASTM D6751-02⁶. However, the development of standards for biodiesel blends proved to be more difficult. Uncertainty about the correct property limits, the effects of introducing carbonyl compounds without thorough fuel system validation, and product quality uncovered by government sponsored surveys all contributed to a cautious approach among some stakeholders, not the least being OEMs.

While ASTM worked on development of biodiesel blend standards, OEMs made individual assessments as to what level of biodiesel was acceptable. Based on limited data, up to 5% biodiesel was considered a reasonable compromise between minimizing risk and a desire to promote a renewable fuel. In the early 2000's, most OEMs allowed use of 5% biodiesel blends in their owners' manuals, and some manufactures allowed B20 or even higher blends with contingencies such as use only in centrally fueled fleets, use only in vehicles with

special equipment options, or the fuel meeting certain specifications⁷.

One significant obstacle to engine validation with higher blends such as B20 was the absence of a uniform fuel standard. Although the DESC's commercial item description for B20 provided a starting point, it did not address new information about biodiesel, such as oxidation stability measured by Rancimat. To fill the void, the Engine Manufacturers Association (EMA) in 2006 released a test specification for biodiesel fuel to identify a standard biodiesel blend fuel with consistent properties suitable to be used for engine testing and evaluation⁸.

The assurance of consistent good quality biodiesel had been the primary concern of OEMs. In 2000, the National Biodiesel Board (NBB) created a separate commission whose charge was to develop a certification program for both producers and marketers. The result was the BQ-9000 program, a voluntary program to promote quality systems and best practices within the biodiesel industry⁹. A pillar of the program is adherence to D6751.

Work on higher biodiesel blend standards within ASTM initially focused on B20. However, state tax incentives created interest in blends greater than B5 but less than B20¹⁰. To avoid proliferation of standards, the focus within ASTM shifted to developing one standard for blends containing 6 to 20% biodiesel. After several years of negotiation among stakeholders, an ASTM standard for B6-B20 blends was finally approved in June 2008 and was published as D7467-08 in October 2008¹¹. Also, ASTM D975 was revised to include up to B5 blends.

Biodiesel in the EU - Brief Overview of Official Standards

The first EU B100 standard was introduced in 1994 in Germany as Pre-Norm DIN V 51606. The first (and still valid) EU B100 standard, EN 14214, was introduced in 2003¹². While B100 was used in few countries (mainly Germany), larger use (and demand) of biodiesel originated from introduction of biodiesel blends up to 5%, allowed by EN 590 since 2004, combined with tax reductions¹³. Blends of 4-5% are widely used now. However, the future appears somewhat confusing. EU legislation requires an increase of bio-components over the next ten years, but there is still no agreement on a standard specification for blends higher than B5 (e.g. B7, B10).

Germany legalized B7 blends with specification DIN 51628¹⁴. However, there is very limited use of B7, since warranties from car manufacturers do not allow use of this fuel yet. The discussions concerning revision of EN 590 to include B7 blends have been controversial. The main problem seems to be reaching an agreement on a

stability limit for biodiesel (and higher blends). prEN590:2008¹⁵ states a limit of minimum 20h by EN 15751 (modified Rancimat) for blends containing more than 2% biodiesel. Final version is expected within the next months.

Current US and EU biodiesel comparison and quality

To assess quality in the U.S. market, the National Renewable Energy Laboratory (NREL) conducted several surveys of B100 and B20. The 2004 survey¹⁶ collected twenty seven B100 samples from blenders and distributors nationwide and found that twenty three (85%) met all the requirements of D6751. Although not a specification at the time, the EU Rancimat limit of 6 hours, maximum, was met by only one sample, and the mean Rancimat of all samples was 1.1 hours. Fifty B20 samples were also obtained. Notable results were high peroxide values, emphasizing the need for an oxidation stability limit, and low interfacial tension, indicating that water separators on engine fuel systems would be disarmed.

The 2006 survey¹⁷ collected thirty seven random B100 samples from terminals across the U.S. with the predominance coming from the Midwest. The samples had a failure rate of 59% based on D6751, with total glycerin and flashpoint most often out of specification. The results were not weighted by production volume but still created a significant concern about biodiesel quality.

The 2007 survey¹⁸ collected fifty six B100 samples from biodiesel producers on a voluntary basis, representing 70% of the U.S. volume weighted production. Results were compared to BQ-9000 critical properties, which are a subset of the full D6751 requirements, and were weighted by production volumes to estimate the total volume of out-of-specification biodiesel. Analysis showed that about 90% of the samples met requirements. Large producers hardly had any failures, but medium and small producers had significant failure rates. However, smaller producers accounted for about 11% of the total weighted biodiesel volume.

An independent survey of B2-B20 blends collected at retail in the U.S. was conducted in 2007¹⁹. Results showed that all samples had acid number below 0.3 mg/g KOH; 45% of the samples had Rancimat values of less than 6 hours; and samples in general displayed a disparity between the pump label and the actual biodiesel content of blends.

OEM Perspective on Fuel Quality

OEMs are concerned with fuel quality at the dispenser since this reflects what the consumer puts into his vehicle. In contrast, consensus-derived standards are established to govern quality at the producer level. The gap between producer and retail is where responsibility for fuel quality often breaks down. If there is no quality

enforcement at retail by local government, consumers are left to fend for themselves if fuel quality problems arise. In comparison, European requirements apply quality at the petrol station.

OEMs do not warrant engine problems resulting from poor fuel quality. They warrant engines for “materials and workmanship”, meaning if there is a problem with an engine part or with engine operation due to an error in manufacturing. The problem will be rectified by the OEM within the prescribed warranty period. An OEM will define what fuel the engine was designed for and will recommend the use of that fuel to their customers in their owner manuals. The implicit understanding is that the fuel going into the vehicle meets the respective consensus standard. Even though OEMs do not warrant the engine for problems resulting from poor fuel quality, in reality, they end up bearing much of the financial burden when fuel problems occur as replacing parts is quicker than testing fuel when customer satisfaction is at stake.

All fuel properties are important to the OEMs, but some are more critical than others. Those of primary importance along with their significance are shown in Table 1. OEMs are carefully evaluating and monitoring fuel quality and continue upgrading technologies to ensure that customers are protected with proper fuels being used²⁰.

Table 1: Significance of diesel properties on vehicle performance

Property	Significance
Acid number	Free fatty acids and processing acids can lead to fuel system deposits and/or corrosion. High acid number can also mean biodiesel has oxidized.
CFPP	Biodiesel naturally has worse cold temperature operability properties than diesel fuel. High CFPP relative to ambient temperature will lead to filter plugging.
Glycerin content	Glycerin can cause injector deposits, clogged fuel systems, and plugged filters.
Metals content	Abrasive solids cause wear in injectors, fuel pumps, pistons, and rings and also engine deposits. Soluble soaps contribute to filter plugging and fuel system deposits.
Oxidation stability	Oxidation products are acids or polymers that can cause fuel system deposits and corrosion and lead to filter plugging.
Particulates	Abrasive solids cause wear in injectors, fuel pumps, pistons, and rings and also engine deposits and can lead to filter plugging.
Viscosity	High viscosity causes premature fuel pump failure and is a sign of contamination and/or oxidation.
Water content	High amounts of water lead to corrosion and wear.