IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MINNESOTA

MINNESOTA TRUCKING ASSOCIATION, MINNESOTA AUTOMOBILE DEALERS ASSOCIATION, ALLIANCE OF AUTOMOBILE MANUFACTURERS, AMERICAN PETROLEUM INSTITUTE, and AMERICAN FUEL & PETROCHEMICAL MANUFACTURERS, Plaintiffs, v. JOHN LINC STINE, in his official capacity as Commissioner of the Minnesota Pollution Control Agency, DAVE FREDERICKSON, in his official capacity as Commissioner of the Minnesota Department of Agriculture, MICHAEL ROTHMAN, in his official capacity as Commissioner of the Minnesota Department of Commerce, and JULIE QUINN, in her official capacity as Director, Minnesota Department of Commerce's Weights and Measures Division, Defendants.	**Civil Action No. _____________** **COMPLAINT FOR DECLARATORY AND INJUNCTIVE RELIEF**

Plaintiffs Minnesota Trucking Association, Minnesota Automobile Dealers Association, Alliance of Automobile Manufacturers, American Petroleum Institute, and American Fuel & Petrochemical Manufacturers (collectively, "Plaintiffs"), by and through undersigned counsel, hereby state and allege as follows for their Complaint against Defendants John Linc Stine, in his official capacity as Commissioner of the Minnesota Pollution Control Agency, Dave Frederickson, in his official capacity as Commissioner of the Minnesota Department of Agriculture, Michael Rothman, in his official capacity as Commissioner of the Minnesota Department of Commerce, and Julie Quinn, in her official capacity as Director, Minnesota Department of Commerce's Weights and Measures Division (collectively, "Defendants"):

PRELIMINARY STATEMENT

1. This Complaint seeks declaratory and injunctive relief to protect the rights of Plaintiffs' members under the federal Clean Air Act ("CAA"), the Energy Policy Act of 2005 ("EPACT"), the Energy Independence and Security Act of 2007 ("EISA"), the United States Constitution, and the Minnesota Administrative Procedures Act ("MAPA").

2. Plaintiffs bring this action against Defendants for their violations of federal and state law in imposing a mandate requiring all diesel fuel sold in Minnesota (with limited exceptions) to contain specified minimum amounts of biodiesel ("the Minnesota Mandate").[1] The Minnesota Mandate currently requires all diesel fuel sold in Minnesota (during certain months of the year) to contain at least 10% biodiesel ("B10"). The Minnesota Mandate also requires that if certain conditions are met in the future, starting in 2018, all diesel fuel sold during those same months must contain at least 20% biodiesel ("B20").

3. The Minnesota Mandate causes significant harm to consumers and a broad range of businesses. For example, most diesel-fueled passenger cars were not designed for, and are not warranted to run on, B10. In fact, most diesel-fueled passenger cars in Minnesota, and the U.S. pool of current on-road vehicles as a whole, were designed to run on no greater than 5% biodiesel ("B5"). As a result, diesel car owners face increased maintenance costs and possible

[1] Biodiesel is a fuel or fuel component composed primarily of Fatty Acid Methyl Esters ("FAME") derived from non-petroleum feedstock such as vegetable oils and animal fats. The Minnesota Mandate defines "biodiesel fuel" as "a renewable, biodegradable, mono alkyl ester combustible liquid fuel that is derived from agricultural and other plant oils or animal fats and that meets American Society for Testing and Materials specification D6751-11b for Biodiesel Fuel (B100) Blend Stock for Distillate Fuels." Minn. Stat. § 239.77(1)(b). Pure biodiesel is generally blended with petroleum diesel to produce a petroleum diesel / biodiesel blend. When referring to such a blend, the notation "B" and then a number representing the maximum percentage of the blend that is biodiesel is used. For example, B5 means a blend that is 5% pure biodiesel and 95% petroleum diesel. Likewise, B10 means a blend that is 10% pure biodiesel and 90% petroleum diesel. For ease of reference, Plaintiffs refer to the "biodiesel fuel" mandated by the Minnesota Mandate as "biodiesel" throughout the Complaint.

engine failures because the Minnesota Mandate effectively forces them to fuel their vehicles with B10. These problems will cause some auto dealers and auto manufacturers to lose sales and incur greater costs associated with increased warranty claims. Moreover, auto manufacturers will see erosion of hard-won brand loyalty. Knowing that B10 typically costs more than petroleum diesel and requires additional maintenance to vehicles, interstate truckers already are avoiding fueling in Minnesota. All in all, the State of Minnesota is forcing the sale of a historically more costly fuel that is simply incompatible with most light-duty and passenger vehicles in which it must be used and denying consumers in Minnesota access to the fuels recommended for their particular vehicles.

4. The Minnesota Mandate also harms diesel-fuel manufacturers and those who sell diesel at retail in the state. Diesel producers and suppliers incur additional costs because petroleum diesel is displaced in Minnesota by biodiesel, which forces petroleum diesel to be diverted to other states. Moreover, diesel producers and suppliers incur the increased costs and burdens of obtaining an adequate supply of biodiesel to satisfy the mandate and making sure that each and every gallon of diesel fuel sold in the state (during certain months of the year) contains at least 10% biodiesel.

5. The Minnesota Mandate plainly conflicts with federal law. The federal Renewable Fuels Standard ("RFS") imposes a nationwide biomass-based diesel blending mandate.[2] In 2013, domestic fuel producers and fuel importers were required to make sure that,

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[2] The RFS defines biomass-based diesel as "a renewable fuel that has lifecycle greenhouse gas emissions that are at least 50 percent less than baseline lifecycle greenhouse gas emissions" and "(1)(i) [i]s a transportation fuel, transportation fuel additive, heating oil, or jet fuel," "(ii) [m]eets the definition of either biodiesel or non-ester renewable diesel," and "(iii) [i]s registered as a motor vehicle fuel or fuel additive under 40 CFR part 79, if the fuel or fuel additive is intended for use in a motor vehicle." 40 C.F.R. § 80.1401. Biomass-based diesel includes most, but not all, biodiesel and some renewable diesel. Biodiesel is the primary biofuel

on an annual aggregate basis, at least 1.13% of all motor fuel sold in the United States was biodiesel. The required volume of biodiesel for 2014 has not been finally established, but it will be applied retroactively to January 1, 2014 when the United States Environmental Protection Agency's ("EPA") rulemaking concludes. EPA is responsible for implementing the RFS. As required by law, EPA's RFS regulations implement the RFS using a flexible, market-based trading system that gives diesel producers and importers broad latitude in deciding where to blend biodiesel, how much biodiesel to blend, when to blend biodiesel, and whether to blend any biodiesel at all in response to changing market conditions across the nation. To ensure maximum flexibility for obligated parties to comply with the RFS, the law prohibits EPA from imposing any per-gallon biodiesel content requirements. The Minnesota Mandate flies in the face of the federal program by removing the flexibility that federal law provides to obligated parties—dictating exactly where, when, and how much biodiesel must be blended.

6. As a result, the Minnesota Mandate stands as a clear obstacle to the full and proper implementation of the RFS. As such, the Minnesota Mandate is preempted by the CAA. Under Article VI of the United States Constitution, Defendants may not therefore enforce the Minnesota Mandate, and may not adopt and implement a B20 mandate.

7. Even if federal law did not preempt the Minnesota Mandate, however, violations of the MAPA in imposing the Minnesota Mandate, as set forth below, prohibit its implementation or enforcement.

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that is used for compliance with the RFS, but biodiesel is not specifically required by the RFS. For ease of reference, Plaintiffs refer to biomass-based diesel as "biodiesel" throughout the Complaint.

8. Plaintiffs have filed this action seeking a declaration that the Minnesota Mandate is preempted by federal law, or, in the alternative, violates the MAPA. Plaintiffs also seek an injunction preventing Defendants from enforcing the Minnesota Mandate.

JURISDICTION AND VENUE

9. Jurisdiction is proper in this United States District Court under 28 U.S.C. § 1331 as this case arises under the Constitution and laws of the United States. This Court has supplemental jurisdiction over the state law claims pursuant to 28 U.S.C. § 1367. This Court is authorized to issue a declaratory judgment pursuant to 28 U.S.C. §§ 2201 & 2202.

10. Venue is proper under 28 U.S.C. § 1391 because all of the defendants reside in Minnesota. Moreover, a substantial part of the events or omissions giving rise to Plaintiffs' claims occurred within this judicial district.

PARTIES

11. Plaintiff Minnesota Trucking Association ("MTA") is a non-profit trade association representing the interests of the state's motor carrier industry since 1932. MTA has over 690 members. MTA serves as an advocate for the trucking industry on a variety of public policy issues and promotes highway safety, educating policymakers and the public about the essential role that trucking plays in the economy, and promoting responsible policies that advance the trucking industry's environmental goals. Individual members of MTA operate diesel-powered vehicles in Minnesota. *See* Declaration of John Hausladen, attached as Exhibit 1.

12. Many of MTA's members enter into contracts with fuel providers for the purchase of fuel to refuel their truck fleets. *See* Declaration of Kyle Kottke, at ¶ 3, attached as Exhibit 2. The illegal Minnesota Mandate has caused injury to these MTA members by requiring MTA members to pay higher prices for the diesel/biodiesel blends sold by fuel providers in Minnesota

when compared to the diesel fuel sold by the same fuel providers outside of Minnesota. *Id.* at ¶4; Ex. 1 at ¶ 4. Biodiesel is less energy efficient than petroleum diesel, producing fewer miles per gallon. *See* EPA, "A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions," p. 42 (2002) *available at* http://epa.gov/oms/models/analysis/biodsl/p02001.pdf. Upon information and belief, MTA members must buy more diesel blended with biodiesel than they would petroleum diesel to do the same amount of work. This efficiency penalty multiplies the impact of the higher price per gallon for biodiesel. MTA's members' injuries are traceable to the illegal Minnesota Mandate because their injuries flow directly from purchasing B10 fuel, which the law mandates is the only diesel fuel that can be sold in the state during certain months. The requested declaratory and injunctive relief prohibiting enforcement of the Minnesota Mandate will redress MTA members' injuries by allowing their truck drivers to purchase fuel at lower prices comparable to those found outside of Minnesota for petroleum diesel.

13. MTA has standing to bring this suit on behalf of its members because its members would have standing to sue in their own right and this suit seeks to protect interests germane to MTA's purpose. In this action, MTA seeks only declaratory and injunctive relief on behalf of its members, not damages. As a result, the naming of individual members as plaintiffs is not required.

14. Plaintiff Minnesota Automobile Dealers Association ("MADA") is a statewide, non-profit, voluntary membership organization comprised of franchised new car and truck dealers located throughout the State of Minnesota. MADA has 367 members, which includes all of the franchised new car and truck dealers in the State of Minnesota. MADA was founded in 1927 and advocates the political, legal and regulatory interests of its members. Individual

members of MADA sell diesel-powered vehicles in Minnesota, a large proportion of which are intended to be operated in Minnesota. *See* Declaration of Scott Lambert, attached as Exhibit 3.

15. The illegal Minnesota Mandate causes injury to these MADA members in at least the following ways: (1) devaluing diesel-fueled light duty vehicles that must be sold at a reduced price, (2) diminishing the value of dealer-owned diesel-fueled light duty vehicles, (3) hurting goodwill toward diesel vehicles and particular makes and models, (4) violating and voiding warranties on dealer-owned vehicles by fueling with B10, and (5) increasing administrative costs of processing warranty claims. *Id.* MADA members' injuries are traceable to the illegal Minnesota Mandate because their injuries flow directly from use of B10 fuel, which the law mandates is the only diesel fuel that can be sold in the state during certain months. The requested declaratory and injunctive relief prohibiting enforcement of the Minnesota Mandate will redress MADA's members' injuries by allowing the sale of B5 and lower-level biodiesel blends.

16. MADA has standing to bring this suit on behalf of its members because its members would have standing to sue in their own right and this suit seeks to protect interests germane to MADA's purpose. In this action, MADA seeks only declaratory and injunctive relief on behalf of its members, not damages. As a result, the naming of individual members as plaintiffs is not required.

17. Plaintiff Alliance of Automobile Manufacturers, Inc. ("Alliance") is a non-profit trade association comprised of twelve (12) member companies: BMW Group, FCA US LLC, Ford Motor Company, General Motors LLC, Jaguar Land Rover, Mazda Motor of America, Inc., Mercedes-Benz USA, LLC, Mitsubishi Motors North America, Inc., Porsche Cars North America, Inc., Toyota Motor Sales, Inc., Volkswagen Group of America, Inc., and Volvo Car

Corporation. The Alliance is the leading advocacy group for the auto industry and its members represent 77% of all cars and light truck sales in the United States. The Alliance operates for the purpose of promoting the general commercial, professional, legislative, regulatory, and other common interests of its members. The Alliance advocates on behalf of the auto industry to the public, Congress and the Executive Branch, state governments and the media. The Alliance represents the auto industry in legal proceedings, participates in coalitions and works in partnership with other associations to achieve its members' public policy goals. The Alliance regularly appears in litigation as a party where the issues raised are of widespread importance and concern to the industry. Individual members of the Alliance have sold and continue to sell diesel-powered vehicles into the Minnesota market or may do so in the near future, and diesel-powered vehicles sold in other states are also driven to and operated in Minnesota. *See* Declaration of William Woebkenberg, attached as Exhibit 4; Declaration of Valerie Ughetta, attached as Exhibit 5.

18. The Alliance has standing to bring this suit on behalf of its members because its members would have standing to sue in their own right and this suit seeks to protect interests germane to the Alliance's purpose. The illegal Minnesota Mandate causes injury to some of the Alliance's members because B10 and B20 fuels have been shown to cause harm to the diesel-powered passenger vehicles they sell. *See* Ex. 4. Many of the diesel-powered vehicles they sell, and cover by warranty, were not designed for the use of diesel fuels with a biodiesel content greater than B5. *Id.* Various Alliance members would have to incur increased costs in designing and producing prospective vehicles capable of operation on B10 (or B20, in the future). And even if this could be done, that would not address the needs of the existing or legacy fleet. *Id.* Perceived as well as actual damage to existing and new engines attributed to operating on B10

fuels will result in additional warranty claims made upon various Alliance members. *Id.* Moreover, the damage caused by B10 to existing diesel engines will reduce the demand for diesel-powered vehicles. *Id.* Alliance members' injuries are traceable to the illegal Minnesota Mandate because their injuries flow directly from use of B10 fuel, which the law mandates is the only diesel fuel that can be sold in the state during certain months. The requested declaratory and injunctive relief prohibiting enforcement of the Minnesota Mandate will redress Alliance members' injuries by allowing the sale of B5 and lower-level biodiesel blends. In this action, the Alliance seeks only declaratory and injunctive relief on behalf of its members, not damages. As a result, the naming of individual members as plaintiffs is not required.

19. Plaintiff American Petroleum Institute ("API") is a national trade association that represents all aspects of America's oil and natural gas industry. API's over 625 corporate members, ranging from the largest major oil company to the smallest independents, represent all segments of the industry. API's members include producers, refiners, blenders, pipeline operators and marine transporters, as well as service and supply companies that support all segments of the industry. API advocates on behalf of the petroleum industry to the public, Congress and the Executive Branch, state governments and the media. API also negotiates with regulatory agencies, represents the industry in legal proceedings, participates in coalitions and works in partnership with other associations to achieve its members' public policy goals. In this regard, API regularly appears in litigation as a party where the issues raised in a case are of widespread importance and concern to the industry. *See* Declaration of Robert L. Greco, III, attached as Exhibit 6.

20. API has standing to bring this suit on behalf of its members because its members would have standing to sue in their own right and this suit seeks to protect interests germane to

API's purpose. API members are injured by the Minnesota Mandate because it imposes upon them additional costs and administrative burdens in selling diesel fuel in Minnesota than would be the case in the absence of the mandate. *Id.* API members' injuries are traceable to the illegal Minnesota Mandate because their injuries flow directly from the requirement to blend each gallon of diesel fuel sold in Minnesota to at least 10% biodiesel (during certain months of the year). The requested declaratory and injunctive relief prohibiting enforcement of the Minnesota Mandate will redress API members' injuries by allowing them to avoid incurring the additional costs and administrative burdens in selling diesel fuel in Minnesota imposed by the Minnesota Mandate. In this action, API seeks only declaratory and injunctive relief on behalf of its members, not damages. As a result, the naming of individual members as plaintiffs is not required.

21. Plaintiff American Fuel & Petrochemical Manufacturers ("AFPM") is a non-profit national trade association representing more than 400 companies, including a majority of all United States refiners and petrochemical manufacturers. AFPM members operate 120 U.S. refineries comprising more than 95% of U.S. refining capacity. *See* Declaration of Timothy Hogan, attached as Exhibit 7.

22. AFPM has standing to bring this suit on behalf of its members because its members would have standing to sue in their own right and this suit seeks to protect interests germane to AFPM's purpose. Individual members of AFPM sell diesel fuel and/or gasoline in Minnesota and are therefore subject to the illegal Minnesota Mandate. *Id*. AFPM members are injured by the Minnesota Mandate because it imposes upon them additional costs and administrative burdens in selling diesel fuel in Minnesota than would be the case in the absence of the mandate. *Id.* AFPM members' injuries are traceable to the illegal Minnesota Mandate

because their injuries flow directly from the requirement to blend each gallon of diesel fuel sold in Minnesota to at least 10% biodiesel (during certain months of the year). *Id.* The requested declaratory and injunctive relief prohibiting enforcement of the Minnesota Mandate will redress AFPM members' injuries by avoiding the additional costs and administrative burdens in selling diesel fuel in Minnesota imposed by the Minnesota Mandate. In this action, AFPM seeks only declaratory and injunctive relief on behalf of its members, not damages. As a result, the naming of individual members as plaintiffs is not required.

23. Defendant John Linc Stine is named in his official capacity as the Commissioner of the Minnesota Pollution Control Agency ("Pollution Control"). The Commissioner of Pollution Control and those subject to his supervision, direction, and control are responsible for the rulemaking proceedings to adopt and implement the Minnesota Mandate.

24. Defendant Dave Frederickson is named in his official capacity as the Commissioner of the Minnesota Department of Agriculture ("Agriculture"). The Commissioner of Agriculture and those subject to his supervision, direction, and control are responsible for the rulemaking proceedings to adopt and implement the Minnesota Mandate.

25. Defendant Michael Rothman is named in his official capacity as the Commissioner of the Minnesota Department of Commerce ("Commerce"). The Commissioner of Commerce and those subject to his supervision, direction, and control are responsible for the rulemaking proceedings to adopt and implement the Minnesota Mandate.

26. Defendant Julie Quinn is the Director of the Minnesota Department of Commerce's Weights and Measures Division. The Director and those subject to her supervision, direction, and control are responsible for the interpretation and enforcement of the Minnesota Mandate.

FACTUAL BACKGROUND

The Clean Air Act

The Renewable Fuel Standard

27. In 1970, Congress passed the CAA in an effort to "protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare." 42 U.S.C. § 7401(b)(1). Section 211 of the CAA, 42 U.S.C. § 7545, sets forth the federal statutory framework for regulating motor vehicle fuels and fuel additives. Section 211 authorizes the EPA to regulate the quality of fuels sold for use in cars and trucks in the United States to control vehicle emissions, and to ensure a national market for fuels. *See* 42 U.S.C. § 7545.

28. The Energy Policy Act of 2005 ("EPACT"), Pub. L. No. 109-58, 119 Stat. 594, modified Section 211 of the Clean Air Act by establishing a national renewable fuel standard ("RFS") codified in 42 U.S.C. § 7545(o) ("Section 211(o)"). The RFS established minimum national biofuel blending requirements, which must be met on an aggregate annual basis, and directed EPA to promulgate regulations to ensure that these requirements were met. *See* 42 U.S.C. § 7545(o)(2)(A)(iii).

29. Two years after it passed the EPACT, Congress enacted the Energy Independence and Security Act of 2007 ("EISA"), Pub. L. No. 110-140, 121 Stat. 1492. The EISA amends the RFS by substantially increasing the minimum volumes of renewable fuels that refiners must blend with gasoline and by imposing a specific national biodiesel blending requirement. The EISA was signed into law by the President on December 19, 2007.

30. On May 1, 2007, EPA promulgated regulations implementing the RFS. These rules were substantially amended on March 26, 2010 to incorporate the new EISA requirements. The rules were again amended on May 10, 2010. EPA's regulations set out the requirements of

the RFS (40 C.F.R. § 80.1405; 40 C.F.R. § 80.1406), specify that fuel refiners, blenders and importers are obligated parties under the program (40 C.F.R. § 80.1407), establish a credit trading program (40 C.F.R. § 80.1428), and set a daily monetary penalty that EPA will impose on a refiner, blender or importer that does not meet its renewable fuel obligation (40 C.F.R. § 80.1460 – 80.1461; 40 C.F.R. § 80.1463).

31. Under the credit trading program, 40 C.F.R. § 80.1428, each gallon of renewable fuel is assigned a unique Renewable Identification Number ("RIN"). Refiners, blenders and importers satisfy their biodiesel obligations under the RFS by conveying biodiesel RINs on an annual basis to EPA. EPA specifies in its regulations the number of biodiesel RINs that must be submitted for each gallon of affected fuel produced or imported each year. Thus, the number of biodiesel RINs that a refiner, blender or importer must submit to EPA for a given year is determined by how much affected fuel it produces in or imports into the United States that year and by the biodiesel RIN obligation adopted by EPA in its rules. Refiners, blenders or importers may acquire biodiesel RINs by purchasing biodiesel with RINs from a biodiesel manufacturer or importer that generates the RINs, or may acquire biodiesel RINs by purchasing them from other entities that have acquired biodiesel RINs. Because it is implemented using an allowance-based approach, the RFS does not require obligated parties or any other entity to blend biodiesel into petroleum diesel fuel at any specified proportion. Since biofuels supply and demand can vary over time and across regions, a market has developed for RINs. If a party fails to obtain an adequate number of RINs to satisfy its volume obligation, the refiner, blender or importer is subject to a $37,500 penalty for each day that it fails to satisfy its obligation under the program.

32. To assure maximum flexibility in the credit trading program and to promote market-based mechanisms for promoting the use of renewable transportation fuels, Congress

expressly prohibited EPA from imposing "any per-gallon obligation for the use of renewable fuel." 42 U.S.C. § 7545(o)(2)(A)(iii)(II)(bb).

33. Plaintiffs API and AFPM have members that are refiners that produce gasoline or diesel in some of the 48 contiguous states or Hawaii, blenders that blend gasoline or diesel in some of the 48 contiguous states or Hawaii, importers that import gasoline or diesel into the 48 contiguous states or Hawaii, or all three. As a result, these members are subject to the RFS. *See* 40 C.F.R. § 80.1406(a)(1).

34. The CAA expressly preempts state fuels programs when the state program is (1) intended to achieve vehicle emission control; and (2) EPA has found that no such control is necessary. 42 U.S.C. § 7545(c)(4)(A). State laws are also preempted under the principles of conflict preemption when the state law "stands as an obstacle to the accomplishment and execution of the full purposes and objectives of Congress." *Hines v. Davidowitz*, 312 U.S. 52, 67 (1941). These principles flow directly from the Supremacy Clause of the United States Constitution.

The Minnesota Mandate

35. The Minnesota legislature enacted the statutory basis for the Minnesota Mandate in 2008 (the "Statute").[3] The Statute prescribes effective dates by which all diesel fuel sold in Minnesota must contain B5, B10, and B20 during designated summer months. *See* Minn. Stat. § 239.77(2)(a). The B10 and B20 mandates will not apply in the winter months of October to March; in those months, only B5 will be required. *Id*. § 239.77(2)(a).

36. Under the Statute, the Commissioners of the Minnesota Department of Agriculture, Department of Commerce, and Pollution Control Agency (the "Commissioners")

[3] A B2 mandate was established by the state legislature in 2002 and was effective on September 29, 2005. *See* S.F. 1495.

were authorized to increase to 10% the required biodiesel content of diesel fuel sold or offered for sale in Minnesota during certain months after May 1, 2012, provided the Commissioners published a notice in the Minnesota Register finding that four separate conditions were met[4], and provide at least 270 days written notice to the chairs of the house of representatives and senate committees with jurisdiction over agriculture, commerce, and transportation policy and finance. *Id.* § 239.77(2)(b).

37. One of the conditions for increasing to 10% the required biodiesel content in Minnesota was a finding that Minnesota producers had the capacity to serve at least 50% of the expected biodiesel market.

38. When "assessing and certifying" the conditions under § 239.77(2)(b), the Commissioners are required to consult with the statutorily created Minnesota Biodiesel Task Force. *Id.* § 239.77(2)(c).

39. On July 17, 2013, the Minnesota Biodiesel Task Force met and considered Minnesota's "potential move" to B10. According to the meeting minutes, there was apparent agreement among the attendees that the four conditions were met. *See* Minnesota Department of Agriculture, "Biodiesel Task Force Meeting Minutes - July 17, 2013" (July 17, 2013), *available*

[4] The four conditions enumerated in the statute are: "(1) an American Society for Testing and Materials specification or equivalent federal standard exists for the next minimum diesel-biodiesel blend; (2) a sufficient supply of biodiesel is available and the amount of biodiesel produced in this state from feedstock with at least 75 percent that is produced in the United States and Canada is equal to at least 50 percent of anticipated demand at the next minimum content level; (3) adequate blending infrastructure and regulatory protocol are in place in order to promote biodiesel quality and avoid any potential economic disruption; and (4) at least five percent of the amount of biodiesel necessary for that minimum content level will be produced from a biological resource other than an agricultural resource traditionally grown or raised in the state, including, but not limited to, algae cultivated for biofuels production, waste oils, and tallow." Minn. Stat. § 239.77(2)(b)(1)-(4).

at http://www.mda.state.mn.us/en/renewable/biodiesel/biodieselforce/meetingminjuly2013.aspx. However, no formal finding was issued.

40. Without complying with the Minnesota Administrative Procedure Act's requirements for notice and comment rulemaking, the Commissioners met the next day and "determined" the four conditions were met. *See* Minnesota Department of Agriculture, "Report to the Legislature: Annual Report on Biodiesel," p. 7 (January 14, 2014), *available at* http://www.mda.state.mn.us/~/media/Files/news/govrelations/legrpt-biodies2014.ashx.

41. More than two months later, on September 30, 2013, the Commissioners published a conclusory "official notice" in the *Minnesota Register* "that all four conditions have been satisfied and there [sic] the state of Minnesota will move to a B10 biodiesel mandate."

42. As a result of that notice, the Minnesota Mandate became effective July 1, 2014, requiring that only B10 be sold through September 30, 2014. On April 1, 2015, the season requirement for B10 returned, and will remain in effect through September 30, 2015, absent an order from this Court. Similarly, the B20 requirement is currently scheduled to take effect, subject to similar statutory conditions, on May 1, 2018. *See* 2014 Minn. Sess. Law Serv. Ch. 181, § 9 (H.F. 2746) (pushing B20 mandate back three years).

CLAIMS FOR RELIEF

COUNT ONE: DECLARATORY JUDGMENT
(Violation of the Supremacy Clause of the United States Constitution)

43. The prior paragraphs are incorporated herein by reference.

Conflict Preemption

44. The Minnesota Mandate conflicts with and stands as an obstacle to the purposes and goals of the RFS, as enacted in Section 211(o) of the CAA, 42 U.S.C. § 7545(o), and as implemented by EPA's RFS regulations, by imposing a content-specific, location-specific, and

time-specific biodiesel blending mandate that interferes with full and effective implementation of the federal program.

45. The RFS does not impose any obligations related to the sale of biofuels. A fundamental assumption underlying the RFS is that biofuels that are imported or domestically produced (and not subsequently exported) will be consumed as motor fuels. This allows EPA to establish motor fuel importers and domestic motor fuel producers as the obligated parties under the RFS and avoids the need to regulate biofuel content at the point of sale. In fact, 42 U.S.C. § 7545(o)(2)(A)(iii)(II)(bb) expressly prohibits EPA from imposing "any per-gallon obligation for the use of renewable fuel." These characteristics of the RFS allow for an efficient and effective market-based credit program to be established, as required by statute. For example, under the RFS, obligated parties that sell diesel into or in Minnesota are not required to blend any particular amount of biodiesel (or any amount at all) into the diesel sold in that state. Under this program, obligated parties are not required to meet a per-gallon content requirement; are not subject to any constraints as to where biofuels are sold; and, because RINs are good for two years, can effectively average their compliance obligation over two years. It is even possible for an obligated party to produce and sell fuel that does not contain any renewable fuel at all, so long as the party is able to obtain and retire a sufficient amount of RINs to address its yearly production and/or import of gasoline and diesel.

46. The Minnesota Mandate requires that "all diesel fuel sold or offered for sale" "must contain at least the stated percentage of biodiesel fuel oil by volume." Minn. Stat. § 239.77 Subd. 2(a). The Minnesota Mandate is directly contrary to and interferes with the RFS by imposing biofuel specific constraints (it requires biodiesel to be blended with diesel), geographic constraints (it requires biodiesel to be sold in the state), content constraints (all diesel

must be blended to B10 during certain months of the year), and timing constraints (the content requirements must be met at all times the mandate is in effect) that are patently inconsistent with the RFS.

47. The Minnesota Mandate imposes significant constraints that do not exist under the RFS, which alters where and when biodiesel RINs are generated. This reduces the efficiency and fluidity of the RFS credit trading program.

48. For refiners, blenders and importers that sell diesel in or into Minnesota, the Minnesota Mandate undermines the RFS by imposing geographic, content, and timing obligations that do not exist under the RFS. As a result, such refiners, blenders and importers must alter their RFS compliance strategies.

49. For these reasons, the federal RFS and the Minnesota Mandate are in conflict.

50. The Minnesota Mandate imposes significant burdens on Plaintiffs' members in connection with their compliance with federal laws and regulations. *See* Ex. 7.

51. The Minnesota Mandate is unconstitutional under the Supremacy Clause because it conflicts with and stands as an obstacle to the accomplishment and execution of the full purposes and objectives of the CAA and its related regulations.

Express Preemption

52. The Minnesota Mandate is also expressly preempted by the CAA.

53. The Minnesota legislature intended the Minnesota Mandate to achieve air quality improvements. *See* Minn. Sen., Floor Debate, 82nd Minn. Leg., Reg. Sess. (May 7, 2001), available at: http://www.senate.leg.state.mn.us/media/media_list.php?ls=82&ver=new&archive_year=2001&category=floor&type=video#May2001. Thus, the state statute was adopted "for the purposes of vehicle emission control." 42 U.S.C. 7545(c)(4)(A)(ii).

54. Section 211(c)(4)(A)(ii) of the CAA prohibits states from prescribing or enforcing for the purposes of motor vehicle emission control "any control or prohibition respecting any characteristic or component of a fuel or fuel additive in a motor vehicle or motor vehicle engine (i) if the Administrator has found that no control or prohibition of the characteristic or component of a fuel or fuel additive…is necessary…or (ii) if the Administrator has prescribed…a control or prohibition applicable to such characteristic or component of a fuel or fuel additive…."

55. In setting the 2013 biofuels mandates under the RFS, EPA observed that "[m]ost diesel engines are warranted by their manufacturer to B5." 78 Fed. Reg. 49794, 49815 (Aug. 15, 2013). As a result, EPA concluded that, "[w]hile not a legal limitation on the use of biodiesel, it does present a practical limitation." *Id*. EPA factored this "practical limitation" into its rationale for the 2013 biofuels mandates. Accordingly, EPA found that a biodiesel mandate higher than B5 is not appropriate because it would conflict with warranties for existing diesel engines. The Minnesota Mandate is thus expressly preempted because: (1) it is intended to achieve vehicle emission control; and (2) EPA prescribed a control or prohibition applicable to a characteristic or component of a fuel or fuel additive by finding that B10 is not practically compatible with most existing diesel engines.

56. The Director Defendant is purporting to act within the scope of her authority under state law in enforcing and implementing the Minnesota Mandate.

57. An actual, present and justiciable controversy has arisen between Plaintiffs and the Director Defendant concerning whether the Minnesota Mandate is preempted by federal law.

58. Plaintiffs seek a declaratory judgment from this Court that the CAA preempts the Minnesota Mandate, and the mandate cannot therefore be enforced.

COUNT TWO: DECLARATORY JUDGMENT
(Alternative Claim for Violation of the Minnesota Administrative Procedures Act)

59. The prior paragraphs are incorporated herein by reference.

60. In the alternative to a declaration finding the Minnesota Mandate preempted by the CAA, Plaintiffs seek a declaration that the Defendant Commissioners violated the MAPA in promulgating the Minnesota Mandate, and the mandate cannot therefore be enforced.

61. The MAPA allows citizens to challenge a "rule" if its application, or threatened application, "interferes with or impairs, or threatens to interfere with or impair the legal rights or privileges" of the citizen. Minn. Stat. § 14.44. A "rule" is defined as "every agency statement of general applicability and future effect, including amendments, suspensions, and repeals of rules, adopted to implement or make specific the law enforced or administered by it or to govern its organization or procedure." *Id*. § 14.02 Subd. 4.

62. The Minnesota Statute that provided for the B10 mandate required that the B10 mandate could become effective only if there was a published notice that "all of the [four statutory] conditions have been met and the state is prepared to move to the next scheduled minimum content level.…" Minn. Stat. § 239.77. Thus, the determination published by the Commissioners on September 30, 2013 in the Minnesota State Register falls within the definition of "rule" because such an action constitutes both a "statement of general applicability and future effect" which is "adopted to implement or make specific the law enforced…." Minn. Stat. § 14.02 Subd. 4.

63. All rules must be adopted in accordance with the MAPA. *See* Minn. Stat. § 14.45.

64. The MAPA sets forth the following requirements for rulemaking that are applicable here:

a. Section 14.101: Required Notice. The MAPA requires that the agency shall, at least 60 days before publication of a notice of intent to adopt a rule or a notice of hearing, solicit comments from the public on the subject matter of a possible rulemaking proposal under active consideration within the agency by causing notice to be published in the State Register. *Id.* § 14.101. The notice must include a description of the subject matter of the proposal and the types of groups and individuals likely to be affected, and must indicate where, when, and how persons may comment on the proposal and whether and how drafts of any proposal may be obtained from the agency. *Id.*

b. Section 14.22: Notice of the proposed adoption of rules. The MAPA requires that if no public hearing is required, the agency must give notice that includes a statement advising the public that the public has 30 days in which to submit comments in support of or in opposition to the proposed rule and that comment is encouraged. *Id.* § 14.22. Additionally, the agency shall make "reasonable efforts to notify persons or classes of persons who may be significantly affected by the rule by giving notice of its intention in newsletters, newspapers, or other publications, or through other means of communication." *Id.*

c. Section 14.23: Statement of need and reasonableness. The MAPA requires that the agency must, by the date of the notice provided under Section 14.22, prepare a statement of need and reasonableness, which must be available to the public. *Id.* § 14.23. The statement of need and reasonableness must include the analysis required in Section 14.131 [which sets forth the requirements for the statement of need and reasonableness], including an assessment of "any differences between the proposed rule and existing federal regulations and a specific analysis of the need for an reasonableness of each difference." *Id.* The statement must also describe the agency's efforts to provide additional notification under Section 14.22 to persons or classes of persons who may be affected by the proposed rules or must explain why these efforts were not made. *Id.* For at least 30 days following the notice, the agency shall afford the public an opportunity to request a public hearing and to submit data and views on the proposed rule in writing. *Id.*

65. The Commissioner Defendants failed to comply with any of requirements set forth in the MAPA, including those in Sections 14.101, 14.22, and 14.23. The Commissioner Defendants did not provide notice of the intended rulemaking, did not provide the opportunity for public comment, and did not prepare or publish a statement of need and reasonableness. Moreover, there were no documented public hearings.

66. Plaintiffs are permitted to challenge this rule under the MAPA because they are citizens whose rights are impaired by the rule.

67. The Commissioner Defendants' rulemaking proceedings regarding the Minnesota Mandate were arbitrary and capricious, and therefore violate the MAPA. Minn. Stat. § 14.45; *Peterson v. Minnesota Dep't of Labor & Indus.*, 591 N.W.2d 76, 79 (Minn. Ct. App. 1999) ("This court applies the arbitrary and capricious standard when reviewing an agency's rulemaking proceedings."). First, the Commissioner Defendants did not establish an administrative record and otherwise did not present evidence or justification for its conclusions that the four statutory criteria were met. Second, the Commissioner Defendants failed to

consider important issues, including those that became apparent through the Minnesota Biodiesel Task Force meeting and from Minnesota Biodiesel Task Force member communication, such as the fact that not all vehicles are warranted to operate using more than B5. The Minnesota Mandate directly conflicts with established federally-required warranties by mandating the exclusive sale of B10, which prevents consumers from purchasing fuel that conforms to their vehicle/engine warranties.

68. The Commissioner Defendants purported to act within the scope of their authority under state law in adopting and implementing the Minnesota Mandate.

69. An actual, present and justiciable controversy has arisen between Plaintiffs and the Commissioner Defendants concerning whether the Defendant Commissioners violated the MAPA in promulgating the Minnesota Mandate.

70. Plaintiffs seek a declaratory judgment from this Court that the Defendant Commissioners violated the MAPA in promulgating the Minnesota Mandate, and the mandate cannot therefore be enforced.

COUNT THREE: PERMANENT INJUNCTION

71. The prior paragraphs are incorporated herein by reference.

72. The CAA preempts the Minnesota Mandate, and the Supremacy Clause prohibits enforcement of the Minnesota Mandate.

73. In the alternative, the proceedings employed by the Commissioner Defendants in adopting the Minnesota Mandate violate the MAPA, and the Minnesota Mandate may not be enforced under state law.

74. The Commissioner Defendants and those subject to their supervision, direction, and control are responsible for the rulemaking proceedings to adopt and implement the Minnesota Mandate and the B20 mandate as required by Minn. Stat. § 239.77(2)(b).

75. The Director Defendant and those subject to her supervision, direction, and control are responsible for the interpretation and enforcement of the illegal Minnesota Mandate.

76. The Director Defendant has enforced, currently is enforcing, and will continue to enforce the illegal Minnesota Mandate.

77. The Commissioner Defendants will implement the illegal B20 mandate as required by Minn. Stat. § 239.77 in 2018.

78. Defendants' wrongful conduct has caused and will continue to cause great and irreparable harm to Plaintiffs' members as described in the above paragraphs and in the attached Declarations, each of which are incorporated herein by reference.

79. Plaintiffs' members' rights will be permanently impaired, and Defendants will continue to implement and enforce the illegal Minnesota Mandate and the illegal B20 mandate, unless Defendants are enjoined and restrained by order of this Court.

80. Plaintiffs have no adequate remedy at law.

81. The harm to Plaintiffs' members outweighs any possible harm to Defendants. Accordingly, considering the balance of hardships between Plaintiffs and Defendants, a permanent injunction is warranted.

82. Granting a permanent injunction will not contravene or disserve the public interest.

PRAYER FOR RELIEF

WHEREFORE, Plaintiffs respectfully request the following relief:

a) A declaratory judgment, pursuant to 28 U.S.C. § 2201, that the Minnesota Mandate violates the Supremacy Clause of the United States Constitution and is preempted by federal law, together with permanent injunction enjoining Defendants from enforcing the Minnesota Mandate and implementing and enforcing a B20 mandate;

b) In the alternative, a declaratory judgment, pursuant to 28 U.S.C. § 2201, that the Minnesota Mandate violates the Minnesota Administrative Procedures Act, together with a permanent injunction enjoining Defendants from enforcing the Minnesota Mandate and implementing and enforcing a B20 mandate without first adhering to the requirements of the Minnesota Administrative Procedures Act;

c) Such other relief as the Court may deem just and proper.

BASSFORD REMELE
A Professional Association

Dated: April 17, 2015

By s/ Mark R. Bradford
Mark R. Bradford (MN #335940)
Steven M. Sitek (MN #300901)
Daniel R. Olson (MN #389235)
33 South Sixth Street, Suite 3800
Minneapolis, MN 55402-3707
Telephone: (612) 333-3000
Facsimile: (612) 333-8829
mbradford@bassford.com
ssitek@bassford.com
dolson@bassford.com

And

Of counsel:

William L. Wehrum, Esq.
Hunton & Williams LLP
2200 Pennsylvania Avenue, NW
Washington, D.C. 20037
Telephone: (202) 955-1500
Facsimile: (202) 778-2201
wwehrum@hunton.com

Nash E. Long, Esq.
Melissa A. Romanzo, Esq.
Hunton & Williams LLP
101 South Tyron Street
Charlotte, N.C. 28280
Telephone: (704) 378-4700
Facsimile: (704) 378-4890
nlong@hunton.com
mromanzo@hunton.com

Stacy Linden, Esq.
Erik Baptist, Esq.
American Petroleum Institute
1220 L Street NW
Washington, DC 20005-4070
Telephone: (202) 682-8250
linden@api.org
baptiste@api.org

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MINNESOTA

MINNESOTA TRUCKING ASSOCIATION, MINNESOTA AUTOMOBILE DEALERS ASSOCIATION, ALLIANCE OF AUTOMOBILE MANUFACTURERS, AMERICAN PETROLEUM INSTITUTE, and AMERICAN FUEL AND PETROCHEMICAL MANUFACTURERS,

Plaintiffs,

v.

JOHN LINC STINE, in his official capacity as Commissioner of the Minnesota Pollution Control Agency, DAVE FREDERICKSON, in his official capacity as Commissioner of the Minnesota Department of Agriculture, MICHAEL ROTHMAN, in his official capacity as Commissioner of the Minnesota Department of Commerce, and JULIE QUINN, in her official capacity as Director, Minnesota Department of Commerce's Weights and Measures Division,

Defendants.

DECLARATION OF JOHN HAUSLADEN

1. My name is John Hausladen. I am the President and Chief Executive Officer of the Minnesota Trucking Association ("MTA"). As the President and Chief Executive Officer, I am responsible for the overall operations of MTA, including oversight of its staff, programs and finances. I graduated from Bethel University with a Bachelor of Arts in Communications and Political Science.

2. MTA is a non-profit trade association representing the interests of the state's motor carrier industry since 1932. MTA has over 690 members. MTA serves as an advocate for the trucking industry on a variety of public policy issues and promotes highway safety, educating

EXHIBIT
1

policymakers and the public about the essential role that trucking plays in the economy, and promoting responsible policies that advance the trucking industry's environmental goals.

3. Individual members of MTA operate diesel-powered vehicles in Minnesota.

4. Minn. Stat. Ann. § 239.77 (the "Minnesota Mandate") has caused injury to these MTA members by requiring MTA members to pay higher prices for the diesel/biodiesel blends sold by fuel providers in Minnesota when compared to the diesel fuel sold by the same fuel providers outside of Minnesota.

5. Kottke Trucking has been a member of MTA since 1995. Kottke Trucking has been injured by the Minnesota Mandate as described above and in Kyle Kottke's declaration.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on March 23, 2015.

John Hausladen

UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MINNESOTA

AMERICAN PETROLEUM INSTITUTE, ALLIANCE OF AUTOMOBILE MANUFACTURERS, MINNESOTA TRUCKING ASSOCIATION, MINNESOTA AUTOMOBILE DEALERS ASSOCIATION, and AMERICAN FUEL & PETROCHEMICAL MANUFACTURERS	
Plaintiffs,	
v.	**No. __________**
MINNESOTA COMMISSIONER OF AGRICULTURE, *et al.*,	
Defendant.	

DECLARATION OF KYLE KOTTKE

1. My name is Kyle Kottke. I am the owner and general manager of Kottke Trucking, based in Buffalo Lake, Minnesota. Kottke Trucking is in the business of commercial transportation. Most of that business consists of transporting refrigerated and frozen food goods for delivery to retail businesses. Kottke Trucking has been a member of the Minnesota Trucking Association since 1995.

EXHIBIT
2

2. Although Kottke Trucking is based in Minnesota, it operates over a large portion of the lower 48 states, making deliveries in all areas with the exception of the northeast and the west coast. It does so with a fleet of 90 trucks—40 of which Kottke Trucking owns directly. The remaining 50 trucks are provided by individual owner-operators under contract with Kottke Trucking. All of these trucks were designed to operate on diesel fuel. Many of the trucks that Kottke Trucking owns (e.g., those manufactured by Peterbuilt or Kenworth) are warranted to run on diesel blends containing no more than 5% biodiesel (known in the industry as "B5").

3. Kottke Trucking does not have storage tanks for refueling the trucks that it operates for its transportation business. Instead, as is usually the case with trucking companies that operate across a number of state lines, Kottke Trucking has entered into contracts with fuel providers (for example, Pilot/Flying J and Love's) for the purchase of fuel to refuel its truck fleet. These fuel providers operate chains of fueling stations across the country, usually along the main interstate routes.

4. Under Kottke Trucking's contracts with both Pilot/Flying J and with Love's, Kottke Trucking buys fuel for its truck fleet at provider cost plus a fixed amount per gallon. Under this arrangement, I consistently see higher prices for the diesel/biodiesel blends sold by fuel providers in Minnesota when compared to the

diesel fuel sold by the same fuel provider outside of Minnesota. For the reasons set forth below, I attribute this price differential to Minnesota's mandate that each gallon of diesel fuel sold contain at least 10% biodiesel ("the B10 Mandate").

5. The cost data attached as Exhibits A and B to this declaration were compiled by Diesel Fuel Solutions, LLC, a fuels consultant under contract with Kottke Trucking. Kottke Trucking employs a fuels consultant because the cost of fuel consistently represents a significant portion of operating expenses for a trucking business such as ours. For example, the fuel costs for Kottke Trucking-owned trucks represents about 34% of Kottke Trucking's annual revenues. Paying close attention to fuel costs is therefore an imperative for my business.

6. The fuel cost data set forth in Exhibit A show that, after factoring out taxes, refueling Kottke Trucking's trucks in Minnesota under the B10 Mandate consistently costs more per gallon than it does to refill at the same owner's stations just across the state border in Wisconsin, Iowa or South Dakota. The price differential in July of this year (2014) was, on average, over $0.03 per gallon. Because the cost to Kottke Trucking under its contract with the owner is the same at either station (cost plus a fixed margin per gallon), I attribute the pre-tax price differential for fuel sold in Minnesota to Minnesota's B10 Mandate.

7. The fuel cost data set forth in Exhibit B show that, over time, the per gallon cost of B10 is consistently higher than B5, B2, or ultra-low sulfur diesel sold in the same location.

8. In an attempt to mitigate the price increase imposed on Kottke Trucking for fuel sold in Minnesota, I have asked Kottke Trucking drivers to refuel outside of Minnesota when possible. For certain routes, however, that type of cost avoidance is not feasible. For example, purely intra-state trips require Kottke Trucking vehicles to refuel in Minnesota, subjecting them to the increased costs produced by the B10 Mandate.

9. Kottke Trucking is at a competitive disadvantage as a result of the price differential created by Minnesota's B10 Mandate. The data show neighboring states which have no such mandate have lower fuel prices (after factoring out the impact of taxes). Kottke Trucking has therefore suffered economic losses as a result of Minnesota's B10 Mandate.

I declare under penalty of perjury that the foregoing is true and correct. Executed on September 25, 2014.

Kyle Kottke

Kyle Kottke

EXHIBIT A

Total Purchases	4445
Original Cost	14685.85
Original Average PPG	3.5888
Original Average PPG (Ex	3.3038
Gallons Moved	4445
New Cost	14547.83
New Average PPG	3.5406
New Average PPG (ExTa)	3.2727
Savings	138.02
Savings per Gallon	0.031
Gallons not Moved	0

Truck Stop Moved To Name	Location	City	State
Pilot Travel Centers #407	I-35 Exit 194 (2411 Hwy 18 E)	Clear Lake	IA
Flying J Travel Plaza #470	I-94 Exit 10 (1191 70th Ave)	Roberts	WI
Love's Travel Stops #353	I-29 Exit 62 (3220 39th St)	Fargo	ND
Totals			

Gallons	Cost
2338	7647.81
1950	6386.1
157	513.92
4445	14547.83

Truck Stop Moved From Name	Location
Love's Travel Stops #337	I-35 Exit 11 (2751 E Main St)
Love's Travel Stops #337	I-35 Exit 11 (2751 E Main St)
Love's Travel Stops #337	I-35 Exit 11 (2751 E Main St)
Love's Travel Stops #337	I-35 Exit 11 (2751 E Main St)
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Love's Travel Stops #337	I-35 Exit 11 (2751 E Main St)
Pilot Travel Centers #590	I-94 Exit 100 (3181 Evergreen Ln
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Pilot Travel Centers #581	Hwy 52 (11650 Court House Blv
Flying J Travel Plaza #576	I-35 Exit 69 (8051 Bagley Ave)
Flying J Travel Plaza #576	I-35 Exit 69 (8051 Bagley Ave)
Flying J Travel Plaza #576	I-35 Exit 69 (8051 Bagley Ave)
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Pilot Travel Centers #134	I-94 Exit 171 (4231 Clearwater R
Pilot Travel Centers #134	I-94 Exit 171 (4231 Clearwater R

City	State	Calc ex-tax	Cost
Albert Lea	MN	3.32	489.82
Albert Lea	MN	3.32	64.57
Albert Lea	MN	3.32	90.78
Albert Lea	MN	3.32	66.73
Albert Lea	MN	3.32	625.41
Albert Lea	MN	3.298	61.41
Albert Lea	MN	3.311	40.02
Albert Lea	MN	3.311	108.77
Albert Lea	MN	3.281	79.87
Albert Lea	MN	3.281	421.41
Albert Lea	MN	3.281	55.06
Albert Lea	MN	3.281	80.41
Albert Lea	MN	3.281	493.76
Albert Lea	MN	3.264	117.13
Albert Lea	MN	3.264	39.26
Albert Lea	MN	3.264	21.3
Albert Lea	MN	3.232	77.81
Albert Lea	MN	3.232	27.15
Albert Lea	MN	3.278	605.87
Albert Lea	MN	3.278	142.57
Albert Lea	MN	3.278	12.15
Albert Lea	MN	3.278	49.91
Albert Lea	MN	3.278	62.31
Albert Lea	MN	3.278	28.5
Albert Lea	MN	3.24	24.75
Albert Lea	MN	3.252	92.13
Albert Lea	MN	3.252	36.01
Albert Lea	MN	3.245	60
Albert Lea	MN	3.232	81.21
Albert Lea	MN	3.232	551.99
Albert Lea	MN	3.232	316.55
Albert Lea	MN	3.232	87.33
Albert Lea	MN	3.247	114.3
Albert Lea	MN	3.241	73.47
Albert Lea	MN	3.241	86.62
Albert Lea	MN	3.264	515.41
Albert Lea	MN	3.264	66.36
Albert Lea	MN	3.264	66.93
Albert Lea	MN	3.261	677.27
Albert Lea	MN	3.261	275.62
Albert Lea	MN	3.261	475.19
Albert Lea	MN	3.261	88.36
Albert Lea	MN	3.261	78.05
Albert Lea	MN	3.261	117.02
Albert Lea	MN	3.261	99.29
Albert Lea	MN	3.307	323.28
Albert Lea	MN	3.307	32.97
Albert Lea	MN	3.318	97.02
Albert Lea	MN	3.318	21.62
Alexandria	MN	3.398	21.1
Alexandria	MN	3.367	60.95

Alexandria	MN	3.318	90.07
Alexandria	MN	3.324	82.09
Alexandria	MN	3.313	25.19
Alexandria	MN	3.371	270.54
Alexandria	MN	3.371	21.94
Inver Grove Heights	MN	3.299	276.06
Inver Grove Heights	MN	3.299	68.17
Inver Grove Heights	MN	3.322	252.52
Inver Grove Heights	MN	3.322	25.25
Northfield	MN	3.355	43.68
Northfield	MN	3.332	52.89
Northfield	MN	3.281	118.26
Northfield	MN	3.292	279.54
Northfield	MN	3.292	89.43
Northfield	MN	3.293	114.5
Northfield	MN	3.293	39.43
Northfield	MN	3.293	407.9
Northfield	MN	3.293	572.5
Northfield	MN	3.313	39.58
Northfield	MN	3.313	41.02
Northfield	MN	3.313	579.34
Northfield	MN	3.356	54.65
Northfield	MN	3.356	36.41
Northfield	MN	3.356	582.6
Northfield	MN	3.341	456.91
Northfield	MN	3.367	69.64
Northfield	MN	3.367	120.52
Saint Cloud	MN	3.36	806.89
Saint Cloud	MN	3.341	133.43
Saint Cloud	MN	3.319	70.03
Saint Cloud	MN	3.332	55.3
Saint Cloud	MN	3.32	25.24
Saint Cloud	MN	3.31	242.21
Saint Cloud	MN	3.31	36.38
Saint Cloud	MN	3.342	70.11
Saint Cloud	MN	3.342	42.33
Saint Cloud	MN	3.383	550.22
Saint Cloud	MN	3.383	46.66
Saint Cloud	MN	3.394	660.47

Truck Stop Moved To Name	City	State	Gallons	Date	Calc ex-ta:	Cost
Pilot Travel Centers #407	Clear Lake	IA	135.86	07/01/2014	3.3011	448.49
Pilot Travel Centers #407	Clear Lake	IA	17.91	07/01/2014	3.3011	59.12
Pilot Travel Centers #407	Clear Lake	IA	25.18	07/01/2014	3.3011	83.12
Pilot Travel Centers #407	Clear Lake	IA	18.51	07/01/2014	3.3011	61.1
Pilot Travel Centers #407	Clear Lake	IA	173.47	07/01/2014	3.3011	572.64
Pilot Travel Centers #407	Clear Lake	IA	17.14	07/02/2014	3.3138	56.8
Pilot Travel Centers #407	Clear Lake	IA	11.13	07/03/2014	3.2893	36.61
Pilot Travel Centers #407	Clear Lake	IA	30.25	07/03/2014	3.2893	99.5
Pilot Travel Centers #407	Clear Lake	IA	22.4	07/05/2014	3.2869	73.63
Pilot Travel Centers #407	Clear Lake	IA	118.18	07/05/2014	3.2869	388.45
Pilot Travel Centers #407	Clear Lake	IA	15.44	07/06/2014	3.2869	50.75
Pilot Travel Centers #407	Clear Lake	IA	22.55	07/06/2014	3.2869	74.12
Pilot Travel Centers #407	Clear Lake	IA	138.47	07/07/2014	3.2863	455.05
Pilot Travel Centers #407	Clear Lake	IA	33	07/09/2014	3.2327	106.68
Pilot Travel Centers #407	Clear Lake	IA	11.06	07/09/2014	3.2327	35.75
Pilot Travel Centers #407	Clear Lake	IA	6	07/09/2014	3.2327	19.4
Pilot Travel Centers #407	Clear Lake	IA	22.12	07/10/2014	3.2345	71.55
Pilot Travel Centers #407	Clear Lake	IA	7.72	07/10/2014	3.2345	24.97
Pilot Travel Centers #407	Clear Lake	IA	170.07	07/12/2014	3.239	550.86
Pilot Travel Centers #407	Clear Lake	IA	40.02	07/12/2014	3.239	129.62
Pilot Travel Centers #407	Clear Lake	IA	3.41	07/12/2014	3.239	11.05
Pilot Travel Centers #407	Clear Lake	IA	14.01	07/12/2014	3.239	45.38
Pilot Travel Centers #407	Clear Lake	IA	17.49	07/12/2014	3.239	56.65
Pilot Travel Centers #407	Clear Lake	IA	8	07/12/2014	3.239	25.91
Pilot Travel Centers #407	Clear Lake	IA	7.02	07/15/2014	3.2451	22.78
Pilot Travel Centers #407	Clear Lake	IA	26.05	07/16/2014	3.23	84.14
Pilot Travel Centers #407	Clear Lake	IA	10.18	07/17/2014	3.2314	32.9
Pilot Travel Centers #407	Clear Lake	IA	17	07/19/2014	3.2276	54.87
Pilot Travel Centers #407	Clear Lake	IA	23.09	07/20/2014	3.2276	74.53
Pilot Travel Centers #407	Clear Lake	IA	156.94	07/21/2014	3.2276	506.54
Pilot Travel Centers #407	Clear Lake	IA	90	07/21/2014	3.2276	290.48
Pilot Travel Centers #407	Clear Lake	IA	24.83	07/21/2014	3.2276	80.14
Pilot Travel Centers #407	Clear Lake	IA	32.36	07/23/2014	3.2333	104.63
Pilot Travel Centers #407	Clear Lake	IA	20.84	07/24/2014	3.2539	67.81
Pilot Travel Centers #407	Clear Lake	IA	24.57	07/24/2014	3.2539	79.95
Pilot Travel Centers #407	Clear Lake	IA	145.23	07/25/2014	3.2503	472.04
Pilot Travel Centers #407	Clear Lake	IA	18.7	07/25/2014	3.2503	60.78
Pilot Travel Centers #407	Clear Lake	IA	18.86	07/25/2014	3.2503	61.3
Pilot Travel Centers #407	Clear Lake	IA	191	07/26/2014	3.2952	629.38
Pilot Travel Centers #407	Clear Lake	IA	77.73	07/26/2014	3.2952	256.14
Pilot Travel Centers #407	Clear Lake	IA	134.01	07/26/2014	3.2952	441.59
Pilot Travel Centers #407	Clear Lake	IA	24.92	07/26/2014	3.2952	82.12
Pilot Travel Centers #407	Clear Lake	IA	22.01	07/26/2014	3.2952	72.53
Pilot Travel Centers #407	Clear Lake	IA	33	07/26/2014	3.2952	108.74
Pilot Travel Centers #407	Clear Lake	IA	28	07/26/2014	3.2952	92.27
Pilot Travel Centers #407	Clear Lake	IA	90.01	07/28/2014	3.2952	296.6
Pilot Travel Centers #407	Clear Lake	IA	9.18	07/28/2014	3.2952	30.25
Pilot Travel Centers #407	Clear Lake	IA	26.93	07/31/2014	3.2827	88.4
Pilot Travel Centers #407	Clear Lake	IA	6	07/31/2014	3.2827	19.7
Love's Travel Stops #353	Fargo	ND	5.73	07/01/2014	3.2924	18.87
Love's Travel Stops #353	Fargo	ND	16.69	07/08/2014	3.271	54.59

Love's Travel Stops #353	Fargo	ND	25	07/15/2014	3.244	81.1
Love's Travel Stops #353	Fargo	ND	22.75	07/16/2014	3.2283	73.44
Love's Travel Stops #353	Fargo	ND	7	07/23/2014	3.23	22.61
Love's Travel Stops #353	Fargo	ND	74	07/28/2014	3.2927	243.66
Love's Travel Stops #353	Fargo	ND	6	07/29/2014	3.2758	19.65
Flying J Travel Plaza #470	Roberts	WI	77.02	07/24/2014	3.2669	251.62
Flying J Travel Plaza #470	Roberts	WI	19.02	07/24/2014	3.2669	62.14
Flying J Travel Plaza #470	Roberts	WI	70.01	07/25/2014	3.2667	228.7
Flying J Travel Plaza #470	Roberts	WI	7	07/25/2014	3.2667	22.87
Flying J Travel Plaza #470	Roberts	WI	12	07/03/2014	3.2788	39.35
Flying J Travel Plaza #470	Roberts	WI	14.62	07/07/2014	3.2878	48.07
Flying J Travel Plaza #470	Roberts	WI	33.16	07/10/2014	3.2348	107.27
Flying J Travel Plaza #470	Roberts	WI	78.15	07/14/2014	3.239	253.13
Flying J Travel Plaza #470	Roberts	WI	25	07/15/2014	3.2502	81.26
Flying J Travel Plaza #470	Roberts	WI	32	07/18/2014	3.2367	103.57
Flying J Travel Plaza #470	Roberts	WI	11.02	07/18/2014	3.2367	35.67
Flying J Travel Plaza #470	Roberts	WI	114	07/18/2014	3.2367	368.98
Flying J Travel Plaza #470	Roberts	WI	160	07/18/2014	3.2367	517.87
Flying J Travel Plaza #470	Roberts	WI	11	07/26/2014	3.3094	36.4
Flying J Travel Plaza #470	Roberts	WI	11.4	07/26/2014	3.3094	37.73
Flying J Travel Plaza #470	Roberts	WI	161	07/26/2014	3.3094	532.81
Flying J Travel Plaza #470	Roberts	WI	15.01	07/28/2014	3.3094	49.67
Flying J Travel Plaza #470	Roberts	WI	10	07/29/2014	3.2917	32.92
Flying J Travel Plaza #470	Roberts	WI	160.01	07/29/2014	3.2917	526.7
Flying J Travel Plaza #470	Roberts	WI	126.01	07/30/2014	3.3156	417.8
Flying J Travel Plaza #470	Roberts	WI	19.07	07/31/2014	3.2952	62.84
Flying J Travel Plaza #470	Roberts	WI	33	07/31/2014	3.2952	108.74
Flying J Travel Plaza #470	Roberts	WI	221.4	07/08/2014	3.2666	723.23
Flying J Travel Plaza #470	Roberts	WI	36.8	07/12/2014	3.239	119.2
Flying J Travel Plaza #470	Roberts	WI	19.43	07/14/2014	3.239	62.93
Flying J Travel Plaza #470	Roberts	WI	15.29	07/16/2014	3.2352	49.47
Flying J Travel Plaza #470	Roberts	WI	7	07/18/2014	3.2367	22.66
Flying J Travel Plaza #470	Roberts	WI	67.37	07/22/2014	3.2414	218.37
Flying J Travel Plaza #470	Roberts	WI	10.12	07/22/2014	3.2414	32.8
Flying J Travel Plaza #470	Roberts	WI	19.33	07/25/2014	3.2667	63.15
Flying J Travel Plaza #470	Roberts	WI	11.67	07/25/2014	3.2667	38.12
Flying J Travel Plaza #470	Roberts	WI	150	07/28/2014	3.3094	496.41
Flying J Travel Plaza #470	Roberts	WI	12.72	07/28/2014	3.3094	42.1
Flying J Travel Plaza #470	Roberts	WI	179.52	07/31/2014	3.2952	591.55

Savings	Dist Movec	Unit
2.57	35.79	566
0.34	35.79	566
0.48	35.79	584
0.35	35.79	4321
3.28	35.79	584
-0.27	35.79	4450
0.24	35.79	495
0.66	35.79	7980
-0.13	35.79	586
-0.7	35.79	586
-0.09	35.79	1022
-0.13	35.79	27
-0.73	35.79	2293
1.03	35.79	571
0.35	35.79	480
0.19	35.79	571
-0.06	35.79	7980
-0.02	35.79	4321
6.63	35.79	568
1.56	35.79	573
0.13	35.79	27
0.55	35.79	568
0.68	35.79	573
0.31	35.79	1179
-0.04	35.79	567
0.57	35.79	4321
0.21	35.79	27
0.3	35.79	1179
0.1	35.79	1077
0.69	35.79	2293
0.4	35.79	568
0.11	35.79	568
0.44	35.79	1226
-0.27	35.79	4321
-0.32	35.79	7980
1.99	35.79	2293
0.26	35.79	511
0.26	35.79	2293
-6.53	35.79	439
-2.66	35.79	566
-4.58	35.79	578
-0.85	35.79	566
-0.75	35.79	578
-1.13	35.79	1179
-0.96	35.79	439
1.06	35.79	568
0.11	35.79	568
0.95	35.79	7980
0.21	35.79	1179
0.61	95.48	2111
1.6	95.48	1016

1.85	95.48	2111
2.18	95.48	2111
0.58	95.48	567
5.79	95.48	2111
0.57	95.48	2111
2.47	26.35	578
0.61	26.35	578
3.87	26.35	585
0.39	26.35	585
0.91	49.63	2111
0.65	49.63	1010
1.53	49.63	1016
4.14	49.63	485
1.05	49.63	583
1.8	49.63	583
0.62	49.63	567
6.42	49.63	567
9.01	49.63	583
0.04	49.63	583
0.04	49.63	495
0.58	49.63	583
0.7	49.63	572
0.64	49.63	583
10.29	49.63	583
3.2	49.63	567
1.37	49.63	205
2.37	49.63	2111
20.68	85.77	486
3.75	85.77	555
1.55	85.77	1009
1.48	85.77	1563
0.58	85.77	4450
4.62	85.77	569
0.69	85.77	569
1.46	85.77	4450
0.88	85.77	584
11.04	85.77	571
0.94	85.77	571
17.74	85.77	569

EXHIBIT B

CPC Rack	OPIS Rack	City	State	Price	Product Ty	Date	7 Day Aver	30 Day Ave
354	345	Ft. Madisor	IA	2.939	Biodiesel B	03-Sep	2.98	2.993
354	345	Ft. Madisor	IA	2.9339	Ultra-Low D	03-Sep	2.98	2.992
354	345	Ft. Madisor	IA	2.9365	Biodiesel B	03-Sep	2.977	2.993
355	408	Le Mars	IA	2.9153	Ultra-Low D	03-Sep	2.966	2.976
356	437	Menard	IL	2.848	Ultra-Low D	03-Sep	2.878	2.886
356	437	Menard	IL	2.8636	Biodiesel B	03-Sep	2.892	2.901
0F61	574	Woodriver	IL	2.8769	Biodiesel B	03-Sep	2.913	2.896
0F61	574	Woodriver	IL	2.902	Ultra-Low D	03-Sep	2.931	2.918
0F61	574	Woodriver	IL	2.9332	Biodiesel B	03-Sep	2.965	2.949
0L23	293	Des Plaine	IL	2.8553	Ultra-Low D	03-Sep	2.88	2.888
0L23	293	Des Plaine	IL	2.8544	Biodiesel B	03-Sep	2.874	2.889
0L24	292	Blue Island	IL	2.8225	Ultra-Low D	03-Sep	2.844	2.847
0L25	291	Argo	IL	2.8297	Ultra-Low D	03-Sep	2.859	2.866
0L26	294	Lemont	IL	2.843	Biodiesel B	03-Sep	2.871	2.877
0L26	294	Lemont	IL	2.8507	Ultra-Low D	03-Sep	2.88	2.885
0L28	297	Mt. Prospe	IL	2.8338	Biodiesel B	03-Sep	2.864	2.87
0L28	297	Mt. Prospe	IL	2.8438	Biodiesel B	03-Sep	2.874	2.881
0L28	297	Mt. Prospe	IL	2.8237	Ultra-Low D	03-Sep	2.853	2.86
0L29	296	Lockport	IL	2.8544	Biodiesel B	03-Sep	2.874	2.889
0L29	296	Lockport	IL	2.8372	Ultra-Low D	03-Sep	2.852	2.861
136	250	Alexandria	MN	2.916	Biodiesel B	03-Sep	2.965	2.982
136	250	Alexandria	MN	2.9234	Biodiesel B	03-Sep	2.971	2.981
136	250	Alexandria	MN	2.9511	Biodiesel B	03-Sep	3.001	3.017
136	250	Alexandria	MN	2.9531	Biodiesel B	03-Sep	3	3.014
136	250	Alexandria	MN	2.9241	Ultra-Low D	03-Sep	2.973	2.985
137	334	Duluth	MN	2.9493	Biodiesel B	03-Sep	3.007	3.025
137	334	Duluth	MN	2.9812	Biodiesel B	03-Sep	3.029	3.045
137	334	Duluth	MN	3.027	Biodiesel B	03-Sep	3.068	3.073
137	334	Duluth	MN	2.9588	Ultra-Low D	03-Sep	3.007	3.021
137	334	Duluth	MN	2.9841	Biodiesel B	03-Sep	3.031	3.045
138	432	Marshall	MN	2.9278	Biodiesel B	03-Sep	2.979	2.996
138	432	Marshall	MN	2.9135	Ultra-Low D	03-Sep	2.963	2.979
138	432	Marshall	MN	2.9395	Biodiesel B	03-Sep	2.99	2.995
138	432	Marshall	MN	2.963	Biodiesel B	03-Sep	3.012	3.025
139	425	Mankato	MN	2.9055	Ultra-Low D	03-Sep	2.955	2.968
139	425	Mankato	MN	2.9258	Biodiesel B	03-Sep	2.977	2.992
139	425	Mankato	MN	2.9714	Biodiesel B	03-Sep	3.02	3.032
139	425	Mankato	MN	2.9236	Biodiesel B	03-Sep	2.972	2.988
140	448	Mpls./St. P	MN	2.9351	Ultra-Low D	03-Sep	2.983	2.994
140	448	Mpls./St. P	MN	2.9495	Biodiesel B	03-Sep	2.997	3.009
140	448	Mpls./St. P	MN	2.9236	Biodiesel B	03-Sep	2.972	2.983
140	448	Mpls./St. P	MN	2.9515	Biodiesel B	03-Sep	3	3.015
141	515	Rochester	MN	2.9121	Ultra-Low D	03-Sep	2.961	2.974
141	515	Rochester	MN	2.9357	Biodiesel B	03-Sep	2.983	2.999
141	515	Rochester	MN	2.9356	Biodiesel B	03-Sep	2.984	3.001
141	515	Rochester	MN	2.9689	Biodiesel B	03-Sep	3.017	3.031
143	449	Pine Bend	MN	2.92	Biodiesel B	03-Sep	2.963	2.971
143	449	Pine Bend	MN	2.9607	Biodiesel B	03-Sep	3.005	3.014
143	449	Pine Bend	MN	2.9421	Ultra-Low D	03-Sep	2.99	2.998
143	449	Pine Bend	MN	2.9569	Biodiesel B	03-Sep	3.001	3.013

552	451	Roseville/V	MN	2.9213	Biodiesel B	03-Sep	2.97	2.982
552	451	Roseville/V	MN	2.9614	Biodiesel B	03-Sep	3.011	3.024
552	451	Roseville/V	MN	2.9524	Biodiesel B	03-Sep	3	3.012
552	451	Roseville/V	MN	2.9344	Ultra-Low D	03-Sep	2.983	2.994
554	522	Sauk Centr	MN	2.932	Biodiesel B	03-Sep	2.982	3.005
554	522	Sauk Centr	MN	2.9299	Ultra-Low D	03-Sep	2.978	2.995
554	522	Sauk Centr	MN	2.8885	Biodiesel B	03-Sep	2.93	2.938
554	522	Sauk Centr	MN	2.9523	Biodiesel B	03-Sep	3	3.017
554	522	Sauk Centr	MN	2.9521	Biodiesel B	03-Sep	3	3.024
556	450	St.Paul/MA	MN	2.9123	Ultra-Low D	03-Sep	2.964	2.975
556	450	St.Paul/MA	MN	2.903	Biodiesel B	03-Sep	2.953	2.974
556	450	St.Paul/MA	MN	2.899	Biodiesel B	03-Sep	2.952	2.965
559	331	Duluth/Esk	MN	2.9493	Biodiesel B	03-Sep	3.007	3.025
559	331	Duluth/Esk	MN	2.9373	Biodiesel B	03-Sep	2.995	3.012
559	331	Duluth/Esk	MN	2.9252	Ultra-Low D	03-Sep	2.983	3
559	331	Duluth/Esk	MN	2.953	Biodiesel B	03-Sep	3.011	3.028
560	333	Duluth/Wre	MN	3.027	Biodiesel B	03-Sep	3.068	3.073
560	333	Duluth/Wre	MN	2.9909	Biodiesel B	03-Sep	3.036	3.051
560	333	Duluth/Wre	MN	2.9988	Biodiesel B	03-Sep	3.043	3.056
560	333	Duluth/Wre	MN	2.9675	Ultra-Low D	03-Sep	3.014	3.028
570	458	Moorhead	MN	2.9428	Ultra-Low D	03-Sep	2.994	3.009
570	458	Moorhead	MN	2.962	Biodiesel B	03-Sep	3.013	3.03
570	458	Moorhead	MN	2.9732	Biodiesel B	03-Sep	3.025	3.042
570	458	Moorhead	MN	2.957	Biodiesel B	03-Sep	3.008	3.024
0F52	453	Roseville/K	MN	2.9135	Biodiesel B	03-Sep	2.954	2.963
0F52	453	Roseville/K	MN	2.9427	Ultra-Low D	03-Sep	2.991	2.999
0F52	453	Roseville/K	MN	2.956	Biodiesel B	03-Sep	3	3.009
0F52	453	Roseville/K	MN	2.9444	Biodiesel B	03-Sep	2.99	3.003
219	341	Fargo	ND	2.9756	Biodiesel B	03-Sep	3.021	3.036
219	341	Fargo	ND	2.9466	Ultra-Low D	03-Sep	2.995	3.006
219	341	Fargo	ND	2.9777	Biodiesel B	03-Sep	3.025	3.033
219	341	Fargo	ND	2.9838	Biodiesel B	03-Sep	3.031	3.045
220	355	Grand Fork	ND	2.954	Biodiesel B	03-Sep	3.004	3.021
220	355	Grand Fork	ND	2.9432	Biodiesel B	03-Sep	2.996	3.016
220	355	Grand Fork	ND	2.9776	Biodiesel B	03-Sep	3.025	3.038
220	355	Grand Fork	ND	2.932	Ultra-Low D	03-Sep	2.982	2.996
221	390	Jamestowr	ND	2.9577	Ultra-Low D	03-Sep	3.01	3.022
222	273	Mandan	ND	3.0245	Ultra-Low D	03-Sep	3.076	3.078
223	452	Minot	ND	3.0494	Ultra-Low D	03-Sep	3.093	3.089
266	248	Aberdeen	SD	2.9464	Ultra-Low D	03-Sep	2.996	3.005
267	455	Mitchell	SD	2.9317	Ultra-Low D	03-Sep	2.982	2.994
268	506	Rapid City	SD	3.1651	Ultra-Low D	03-Sep	3.198	3.283
269	530	Sioux Falls	SD	2.9151	Ultra-Low D	03-Sep	2.965	2.979
270	571	Wolsey	SD	2.9463	Ultra-Low D	03-Sep	2.995	3.004
271	572	Yankton	SD	2.9215	Ultra-Low D	03-Sep	2.972	2.981
272	566	Watertown	SD	2.9251	Ultra-Low D	03-Sep	2.975	2.988
316	582	Waupun	WI	2.85	Ultra-Low D	03-Sep	2.896	2.905
317	295	Chippewa I	WI	2.9076	Ultra-Low D	03-Sep	2.966	2.972
318	360	Green Bay	WI	2.859	Ultra-Low D	03-Sep	2.894	2.905
319	395	Junction Ci	WI	2.8806	Ultra-Low D	03-Sep	2.92	2.923
320	420	Madison	WI	2.8595	Ultra-Low D	03-Sep	2.899	2.911

321	444	Milwaukee	WI	2.8488	Ultra-Low D	03-Sep	2.886	2.896
322	545	Superior	WI	2.9544	Biodiesel B	03-Sep	3.007	3.02
322	545	Superior	WI	2.9381	Ultra-Low D	03-Sep	2.993	3.009
322	545	Superior	WI	2.9831	Biodiesel B	03-Sep	3.036	3.051

60 Day Ave	90 Day Average
2.993	3.011
2.991	3.009
2.994	3.012
2.967	2.983
2.9	2.926
2.914	2.94
2.902	2.929
2.924	2.948
2.954	2.976
2.905	2.933
2.902	2.928
2.864	2.894
2.885	2.913
2.892	2.923
2.9	2.928
2.894	2.924
2.906	2.935
2.884	2.914
2.902	2.928
2.878	2.907
2.971	2.984
2.974	2.988
3.013	3.016
3.008	3.023
2.979	2.994
3.01	3.021
3.029	3.03
3.047	3.057
3.004	3.01
3.026	3.033
2.989	3.003
2.974	2.989
2.985	2.988
3.017	3.023
2.961	2.977
2.985	2.988
3.025	3.032
2.983	2.998
2.988	3
3.005	3.015
2.976	2.987
3.013	3.015
2.967	2.983
2.994	3.009
2.997	3.001
3.027	3.035
2.962	2.972
3.007	3.017
2.989	2.999
3.008	3.009

2.976	2.987
3.022	3.024
3.009	3.019
2.989	3.001
2.991	3.004
2.986	2.999
2.93	2.943
3.008	3.021
3.013	3.017
2.976	2.984
2.979	2.98
2.97	2.979
3.01	3.021
2.998	3.009
2.986	2.994
3.008	3.008
3.047	3.057
3.036	3.037
3.036	3.041
3.01	3.015
2.995	3.007
3.018	3.029
3.031	3.034
3.009	3.017
2.954	2.964
2.99	2.999
3.001	3.01
2.996	2.997
3.028	3.042
2.997	3.012
3.022	3.036
3.039	3.042
3.014	3.028
3.01	3.013
3.029	3.042
2.988	3.003
3.007	3.019
3.059	3.077
3.059	3.077
2.995	3.01
2.982	2.995
3.269	3.266
2.974	2.989
2.993	3.008
2.971	2.986
2.984	3.001
2.922	2.95
2.974	2.995
2.922	2.952
2.932	2.961
2.929	2.959

2.914	2.946
3.005	3.024
2.994	3.003
3.03	3.028

UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MINNESOTA

AMERICAN PETROLEUM INSTITUTE, ALLIANCE OF AUTOMOBILE MANUFACTURERS, MINNESOTA TRUCKING ASSOCIATION, MINNESOTA AUTOMOBILE DEALERS ASSOCIATION, and AMERICAN FUEL & PETROCHEMICAL MANUFACTURERS	
Plaintiffs,	
	No. __________
v.	
MINNESOTA COMMISSIONER OF AGRICULTURE, *et al.*,	
Defendant.	

DECLARATION OF SCOTT LAMBERT

1. My name is Scott Lambert. I am the Executive Vice President of the Minnesota Automobile Dealers Association ("MADA"). MADA is a statewide, non-profit, voluntary membership organization representing all 367 franchised new car and truck dealers in Minnesota. MADA was founded in 1927 and advocates the political, legal and regulatory interests of its members.

EXHIBIT
3

2. I am a native of St. Paul, Minnesota, where I attended St. Thomas Academy before earning my Bachelor of Arts degree in Political Science from Marquette University in Milwaukee in 1982.

3. I began working at MADA in 1989 with the government relations team. In 1994, I received the Award of Excellence in Government Relations from the American Society of Association Executives for my role in MADA's work in passing a Title Branding law in Minnesota. In 1995, I earned my Certified Association Executive Distinction, becoming one of only 2,000 nationally-certified executives. During my employment with MADA, I have managed the Government Affairs Department, the Political Action Committee, and the Association's Charitable Foundations. I was named MADA's Executive Vice President in November of 1999.

Background on Minnesota's Biodiesel Mandate

4. MADA has been concerned with Minn. Stat. Ann. § 239.77 since its passage. Under that statutory section, all diesel fuel offered for sale in the State of Minnesota beginning on September 29, 2005 was required to be 2% biodiesel in content, with the remainder of the blend being petroleum diesel. That blend is known in the industry as "B2." On May 1, 2009, the biodiesel content requirement for diesel fuel sold in Minnesota was increased to 5%, i.e., "B5."

5. Under the statute, the Commissioners of the Minnesota Department of Agriculture, Department of Commerce, and Pollution Control Agency ("Commissioners") could increase to 10% the required biodiesel content of diesel fuel (i.e., "B10") sold or offered for sale in Minnesota during certain months after May 1, 2012, provided the Commissioners made four findings.

6. Without soliciting formal public comment, the Commissioners published a conclusory notice on September 30, 2013 in the *Minnesota Register* indicating that the four findings had been met and that the biodiesel content mandate would be increased to 10% biodiesel, or "B10." That meant that effective July 1, 2014, the biodiesel content of all diesel fuel offered for sale or sold in Minnesota for use in internal combustion engines during the months of April through September would be B10 (the "B10 Mandate").

7. Many MADA members sell diesel-fueled vehicles that are only warrantied by original equipment manufacturers ("OEMs") to operate using diesel blends up to B5. For such vehicles, if a diesel blend containing more biodiesel than that authorized under the warranty is used, and such use causes equipment damage or failure, then the OEM's warranty will not cover such damage or failure. If the OEM denies warranty coverage, then the cost to repair such damage or failure would likely be borne by the consumer.

8. Engine damage or failure, emission control component damage, and vehicle stalling are likely to result from use of fuel with a greater biodiesel content than that authorized in the vehicle's warranty.

9. Because B10 is not an approved fuel for use in many diesel-fueled, light-duty vehicles offered for sale by MADA members, in November 2013 MADA recommended that its members selling diesel-fueled, light-duty vehicles provide a written disclosure to their customers prior to purchase of a new or used diesel-fueled, light-duty vehicles whose warranty only permitted biodiesel use up to B5. A true and correct copy of this disclosure is attached hereto as Exhibit A.

10. MADA developed this disclosure out of concern that failure to disclose information about the B10 Mandate to a purchaser of a new or used vehicle offered for sale (whose warranty coverage could be voided for B10 use) could result in lawsuits by consumers or the Minnesota Attorney General under the Minnesota consumer fraud statutes. Because (a) many vehicles are only warrantied for use of biodiesel blends as high as B5, (b) only B10 would be available for sale in Minnesota from April through September once the B10 Mandate went into effect, (c) that fuel blend is known to cause damage to the vehicle or engine, and (d) warranty coverage could be voided by the OEM upon use of B10 fuel, MADA believed that dealers should disclose these facts to consumers in writing and document that disclosure.

11. This concern arose in part from a letter that Volkswagen Group of America, Inc. ("VW") received from Lori Swanson, the Minnesota Attorney General, on September 25, 2013. A true and correct copy of that letter is attached hereto as Exhibit B. In that letter, Attorney General Swanson shared a complaint received from a consumer who said that he had purchased a new VW vehicle and an extended warranty without having been advised of Minnesota's biodiesel mandate. Attorney General Swanson requested that VW explain whether it "will warrant the engine if, in the future, Minnesota law requires a biodiesel blend in excess of 5 percent such that Mr. Winger has no choice but to use that higher percentage blend in car."

12. Initially, some affected MADA members provided a written disclosure such as Exhibit A to purchasers of diesel-powered vehicles. Many of those dealers later stopped providing the letter to customers for their review and signature. This is not surprising, as the only possible consumer reaction to such a disclosure is negative. If a Minnesota customer understands that their warranty might be voided if they fuel the car in that state, the customer will take one of two actions that are both harmful to the dealer. The customer could choose not to buy the car at all. Or, the customer could insist on buying the car for a lesser price given the risk that future engine and vehicle damage related to in-state fueling, not covered under the warranty, could result.

Even Dealers Able to Find Purchasers of Diesel-Fueled, Light-Duty Vehicles Not Warrantied for B10 Use Will Be Forced to Offer Those Vehicles at Reduced Price

13. Even if MADA members are able to sell new and used diesel-fueled, light-duty vehicles not warrantied to use B10, those vehicles will be devalued by the potential damage that the owner will incur if the vehicle or engine needs repair or replacement as a result of B10 usage that may not be covered by the OEM warranty.

14. Dealer-owned vehicles, often used as loaner cars or test vehicles, in stock prior to the mandate have diminished in value. Should the dealers now try to sell those vehicles, their value would reflect the potential that their warranties will be voided from damage caused by B10 usage.

Dealers Will Be Able to Offer Less for Future Trade-Ins

15. Because the value of a car that cannot use B10 without risk of voiding warranty coverage has diminished since July 1, 2014, dealers cannot offer as much for customer trade-ins as they did before July 1. The lowered trade-in value will hurt customer goodwill. Customers who look to a national valuation source (like Kelly Bluebook) will be disappointed when a Minnesota dealer cannot offer them a comparable amount. The customer might decide to forego the trade-in transaction, reducing dealer revenue.

16. Many customers choose to trade their current vehicle for value to a dealer, and receive a credit for the value of that used car against the purchase of a new car. A customer might decide not to purchase a new vehicle if they are not able to receive as much credit for their vehicle. The dealer would lose the new car sale and associated revenue and goodwill.

Dealers Face Harm of Violating Warranties on Dealer-Owned Vehicles, and Voiding Warranties on Those Vehicles

17. Dealers now also face the risk that they will void the warranty coverage of their own, dealer-owned vehicles if they fuel with B10 and that fuel use causes damage. If dealers wish to avoid the risk of impairing warranty coverage, they must drive outside of the state to fuel (which will come at additional expense of money and time). If they do not take that fueling precaution, they will have to pay for all damage to vehicles and engines caused by B10 use because they will have voided warranty coverage.

Dealers Will Be Burdened with the Administrative Costs of Processing Warranty Claims

18. Because B10 usage in cars not warrantied to use that fuel can result in vehicle and engine damage and failure, more customers who purchased vehicles will need repairs. Most OEMs provide dealers with the authority to decide the cause of vehicle or engine harm, and thus whether repairs will be covered under warranty. This increase in repair requests imposes an administrative burden on

dealers, who must assess if the damage was caused by B10 usage and then process claims.

19. That administrative time and effort will divert dealer employees from higher-revenue-generating activities, such as selling new vehicles. Any disputes with customers over whether repairs should be covered by a warranty could also damage the dealer's goodwill, and reduce future business.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on October 30, 2014.

Scott Lambert

EXHIBIT A

Non-Approved Fuel Disclosure

Dealership Name: ____________________________________ Date: ________________

Vehicle Description: ____

____

Almost all diesel cars and trucks currently sold in the United States are designed to run on fuel that contains 5% renewable biodiesel fuels. This fuel blend is called B5.

Effective July 1, 2014 Minnesota law requires that all motor vehicle diesel fuel sold in the state from April through October must be a minimum B10 blend and contain at least 10% renewable biodiesel.

Effective July 1, 2014: B5 will no longer be available for purchase in Minnesota during the warmer months of the year.

The diesel vehicle that you are purchasing is designed to operate on B5 diesel fuel.

However, B10 is not an approved fuel for your new vehicle.

Your new vehicle warranty may not cover damage to the vehicle which results from the use of this "non-approved" fuel.

The situation may change:

- The law prohibiting the sale of B5 may change between now and July 1, 2014.
- The manufacturer of the vehicle may change its criteria for approved fuels.
- There may be additional maintenance steps that you can take that will reduce the likelihood of damage from the B10 fuel blend.

However, the dealership wants you to be fully aware of the potential for non-approved fuel related problems with your new vehicle and new vehicle warranty.

Customer(s) Acknowledgment:

Signature: _______________________________ Date: _________________

Printed Name: ____________________________

Signature: _______________________________ Date: _________________

Printed Name: ____________________________

EXHIBIT B

STATE OF MINNESOTA

OFFICE OF THE ATTORNEY GENERAL

LORI SWANSON
ATTORNEY GENERAL

102 STATE CAPITOL
ST. PAUL, MN 55155
TELEPHONE: (651) 296-6196

September 25, 2013

Mr. Jonathan Browning, CEO
Volkswagen Group of America, Inc.
2200 Ferdinand Porsche Drive
Herndon, VA 20171

Dear Mr. Browning:

This Office was contacted by Chris W. Winger, whose address is 1649 Currie Street, Maplewood, Minnesota 55119.

Mr. Winger expressed concern about a Minnesota law, Minn. Stat. § 239.77, that requires all diesel sold in Minnesota to contain at least 5 percent biodiesel, and appears to mandate that the percentage blend may increase to 10 percent and 20 percent in the future. He explained that he recently purchased a new Volkswagen which runs on diesel, and he also purchased an extended warranty. Mr. Winger believes that Volkswagen should have told him about the Minnesota biodiesel mandate before selling him the vehicle and extended warranty. He also wants to know if Volkswagen will warrant the engine if, in the future, Minnesota law requires a biodiesel blend in excess of 5 percent such that Mr. Winger has no choice but to use that higher percentage blend in car. He stated that he has contacted Volkswagen about this issue, but it appears from his correspondence that Volkswagen may not yet have responded. He asks for any assistance this Office can provide.

I ask that you review this matter as quickly as possible and address Mr. Winger's concerns. In particular, please state whether Volkswagen will consider voiding the warranties of Minnesota Volkswagen owners if state law requires them to use B10 or B20 biodiesel in the future. Also please explain why Volkswagen did not tell Mr. Winger about Minnesota's biodiesel law before he purchased the car. I ask that you send a written response to this Office within ten (10) days of receiving this letter. Please provide a response to this Office at the following address:

Chuck Ferguson
Minnesota Attorney General's Office
1400 Bremer Tower
445 Minnesota Street
St. Paul, MN 55101-2131
Fax: (651) 282-2155

I thank you for your attention to this matter.

Sincerely,

LORI SWANSON
Attorney General

cc: Mr. Chris W. Winger
Mr. Chuck Ferguson, Manager of the Consumer Services Division

UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MINNESOTA

AMERICAN PETROLEUM INSTITUTE, ALLIANCE OF AUTOMOBILE MANUFACTURERS, MINNESOTA TRUCKING ASSOCIATION, MINNESOTA AUTOMOBILE DEALERS ASSOCIATION, and AMERICAN FUEL & PETROCHEMICAL MANUFACTURERS	)	
Plaintiffs,	)	
v.	)	**No. ___________**
MINNESOTA COMMISSIONER OF AGRICULTURE, *et al.*,	)	
Defendant.	)	

DECLARATION OF WILLIAM WOEBKENBERG

1. My name is William Woebkenberg. I am responsible for Fuels Technical and Regulatory Affairs in the United States for Mercedes-Benz Research & Development, North America ("MBRDNA"), an indirect, wholly owned subsidiary of Daimler AG ("Daimler"), the global manufacturer of Mercedes-Benz vehicles, and a leader in clean, efficient vehicle technology in the U.S. and the world. In that role, I have lead responsibility for all technical and regulatory affairs in the U.S. regarding light-duty vehicle fuels. During my almost 30 years in the auto

EXHIBIT

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industry, I have worked extensively on powertrain and vehicle development, as well as handled critical customer issues at the dealership level. I graduated from the University of Cincinnati with a Bachelor of Science Degree in Mechanical Engineering.

2. Among other things, MBRDNA provides technical and regulatory support to Mercedes-Benz USA, LLC ("MBUSA"), the exclusive importer and distributor of Mercedes-Benz vehicles in the United States. MBUSA is a member of the Alliance of Automobile Manufacturers (the "Alliance"). The Alliance is the leading advocacy group for the auto industry, and represents 77% of all car and light truck sales in the United States. Its members include MBUSA, BMW Group, Chrysler Group LLC, Ford Motor Company, General Motors Company, Jaguar Land Rover, Mazda, Mitsubishi Motors, Porsche, Toyota, Volkswagen Group of America, and Volvo Cars North America.

3. In order for original equipment manufacturers ("OEMs") to comply with fleet-wide greenhouse gas ("GHG") federal emissions regulations, many OEMs, including MBUSA and other Alliance members, depend on high customer acceptance of and demand for diesel-powered light-duty vehicles. MBUSA, which is also an indirect, wholly owned subsidiary of Daimler, has a particular interest in diesel passenger cars, which have been a part of Daimler's heritage dating back to 1936, with the introduction of the 260D. Mercedes-Benz diesel passenger cars

have been produced during every decade since. For MBUSA, diesel is not just a powertrain option, but a corporate tradition.

4. MBUSA distributes for sale numerous diesel-fueled light-duty vehicles in Minnesota each year. Because of the many popular vacation destinations in Minnesota and the major thoroughfares that cross the state, many other Mercedes-Benz vehicles purchased or leased in other states will refuel in Minnesota. For these reasons, MBUSA has a strong interest in any diesel fuel requirements in Minnesota.

5. In my corporate capacity at MBRDNA, I have extensively studied and evaluated the technical issues associated with the use of biodiesel in light-duty vehicles.

The Nature of Biodiesel and Its Use in Vehicles

6. Biodiesel, which belongs to a chemical family known as Fatty Acid Methyl Esters ("FAME"), is an oxygen-bearing substance produced from vegetable oils or animal fats. It can be produced from many different sources, including coconut oil, palm oil, soy, canola oil, jatropha, rapeseed, animal renderings, and used cooking oil.

7. The prevalence of biodiesel in the United States was spurred in large part by the federal Renewable Fuel Standard ("RFS"), instituted by Congress through section 211(o) of the Clean Air Act, 42 U.S.C. § 7545(o), and implemented by the

U.S. Environmental Protection Agency. Since the creation of the RFS, some states, including Minnesota, have attempted to incentivize biodiesel production and use.

8. Biodiesel can be used as a motor fuel in diesel-powered vehicles, including light-duty vehicles. Light-duty diesel vehicles are not designed to function on biodiesel in pure, non-blended form, also known as "neat" biodiesel ("B100"). Instead, pure biodiesel is generally blended with petroleum diesel to produce a petroleum diesel / biodiesel blend. When referring to such a blend, the notation "B" and then a number representing the maximum percentage of the blend that is biodiesel is used. For example, B5 means a blend that is up to 5% pure biodiesel and 95% pure petroleum diesel. The vast majority of new passenger car diesel vehicles are not designed to combust biodiesel blends containing more than 5% biodiesel.

9. Use of blends with higher biodiesel content is problematic for several reasons related to biodiesel's unique properties. Some of these problems are detailed below.

10. As a result of the problems associated with the use of higher biodiesel content in diesel fuel, most OEMs in the U.S. and Europe, including MBUSA, warrant diesel-fueled vehicles that use biodiesel blends only up to B5. These warranties state that the cost of repairing damage to vehicles that is attributable to

the use of fuel with a biodiesel blend containing more than 5% biodiesel will not be covered under the warranty. See Attachment 1.

11. This OEM warranty practice is consistent with the fifth edition of the Worldwide Fuel Charter, adopted by vehicle and engine manufacturers from around the world, including members of the Alliance, European Automobile Manufacturers Association (ACEA), Truck and Engine Manufacturers Association (EMA), and Japanese Automobile Manufacturers Association (JAMA). See Attachment 2. That charter endorses use of biodiesel blends only up to B5 in Category 4 diesel vehicles. Category 4 is the designation used for "[m]arkets with advanced requirements for emission control, for example markets requiring US Tier 2, US Tier 3 (pending), US 2007 / 2010 Heavy Duty On-Highway, US Non-Road Tier 4, California LEV II, EURO 4/IV, EURO 5/V, EURO 6/VI, JP 2009 or equivalent emission standards. Category 4 fuels enable sophisticated NOx and particulate matter after-treatment technologies."

Problems with Blends Greater than B5

12. There are two primary categories of problems associated with the use of higher level biodiesel blends, such as B10: (1) engine component damage caused by degraded or contaminated biodiesel; and (2) engine component damage caused by contamination of engine oil with biodiesel.

Degraded and Contaminated Biodiesel

13. Unlike pure petroleum diesel, pure biodiesel readily reacts with oxygen – i.e., it readily oxidizes. Biodiesel therefore has far less oxidation stability than petroleum diesel – that is, it has far less resistance to this oxidative degradation. The inherent instability of a biodiesel blend gets worse as the fraction of biodiesel in a blend increases.

14. Instability is a particular problem during periods of vehicle inactivity. During ideal operation, the fuel is combusted before it ages. If stored in an inactive vehicle, the biodiesel may significantly degrade in as little as two months.

15. High temperatures, contact with oxygen, and contact with catalytic surfaces (e.g., copper, brass) lead to increasing oxidation. For example, an increase in temperature of 10 degrees Celsius can reduce biodiesel's aging stability by a factor of two. Trace metals in bulk storage tanks and vehicle fuel tanks can also reduce oxidation stability.

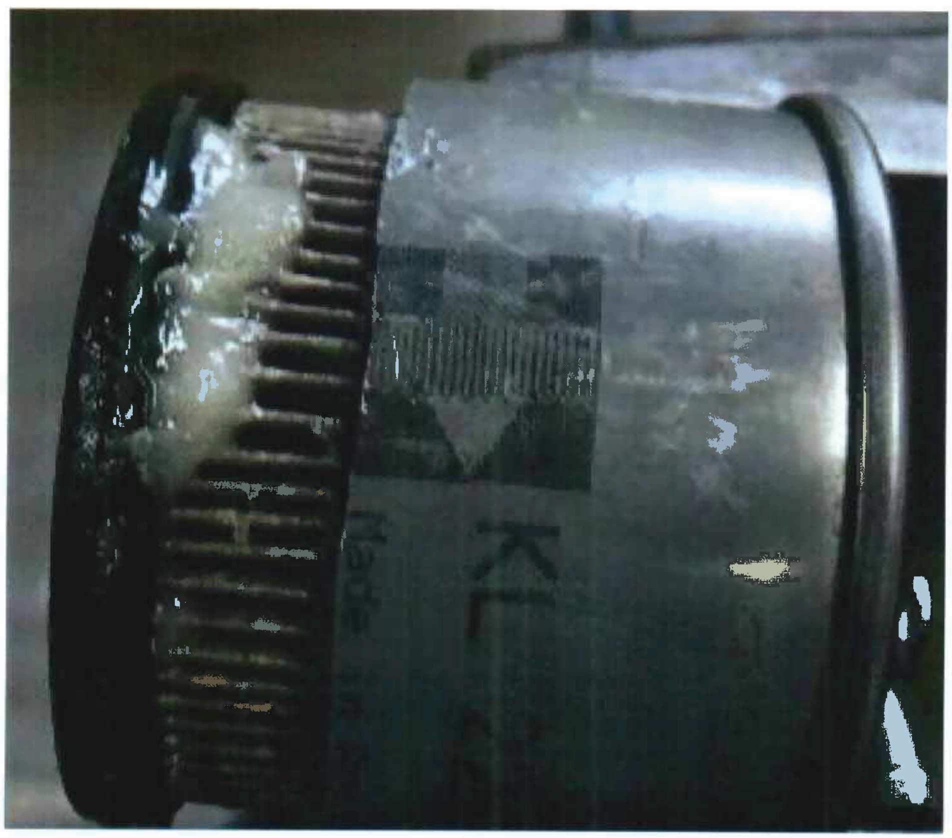
16. When biodiesel oxidizes, it generates peroxides, and then ultimately acids and polymers. The acids can degrade key engine components, which can impair vehicle operability and ultimately cause engine failures.

17. Polymers caused by biodiesel oxidation increase the viscosity of the fuel, which can lead to fuel system failures, such as plugged fuel pumps, fuel lines, fuel

filters, and fuel injectors. These failures can impair or prevent the delivery of fuel to the engine, which can impede engine performance and cause engine stalling.

18. Similarly, sodium, calcium, and other contaminants introduced through biodiesel production can combine with FAME to form soaps, which can deposit in fuel injectors and plug fuel filters. Moreover, metal soaps can cause injector nozzle coking.

Deposit Formation in Fuel Pressure Regulator Due to Degraded Biodiesel



Fuel Filter Clogging Due to Effects of Biodiesel Blends >B5

19. Lastly, biodiesel has a greater affinity for water than petroleum diesel. This means that biodiesel will absorb more water than petroleum diesel. And, like petroleum diesel, if sufficient water is present, a separate water layer can form in the bottom of vehicle or storage tanks. Also, to a much greater degree than petroleum diesel, biodiesel is a ready food source for various micro-organisms. These micro-organisms (bacteria and fungi) can survive and, in some cases, proliferate in the fuel /water boundary layer in a storage tank. Depending on the type of micro-organisms that are present, acids and/or sludge can form. When introduced into the fuel system of a vehicle, the acids and/or sludge can lead to heavy corrosion or plugging of the fuel filter and other fuel system components.

Example of Sludging Caused by Micro-organisms

Contamination of Engine Oil With Biodiesel

20. Modern clean diesel engines utilize so-called "diesel particulate filters" to control emissions of fine particles (e.g., soot). Diesel particulate filters are installed in the exhaust system of vehicles. As the name would suggest, diesel particulate filters function by trapping fine particles before they are emitted from the tailpipe of the vehicle. Periodically, diesel particulate filters must be regenerated so that they maintain their effectiveness. This typically is accomplished automatically by the vehicle's emissions control system, in which unburned fuel is injected into the cylinder during the exhaust portion of the combustion cycle. From there, unburned fuel mixes with the exhaust gas. This is called late in-cylinder injection. The unburned fuel begins to combust as it approaches the particulate filter, promoting the high temperatures needed to regenerate (i.e., "burn off") the diesel particulate filter.

21. Late in-cylinder injection invariably allows some amount of fuel to migrate into the engine oil system through a process known as "bore wash," whereby unburned fuel contacts the cylinder wall and migrates past the piston into the crankcase. Petroleum diesel has a low enough boiling point that it will typically evaporate out of the engine oil and exit the crankcase through crankcase vents. In contrast, biodiesel typically has a higher, more narrow range boiling point than

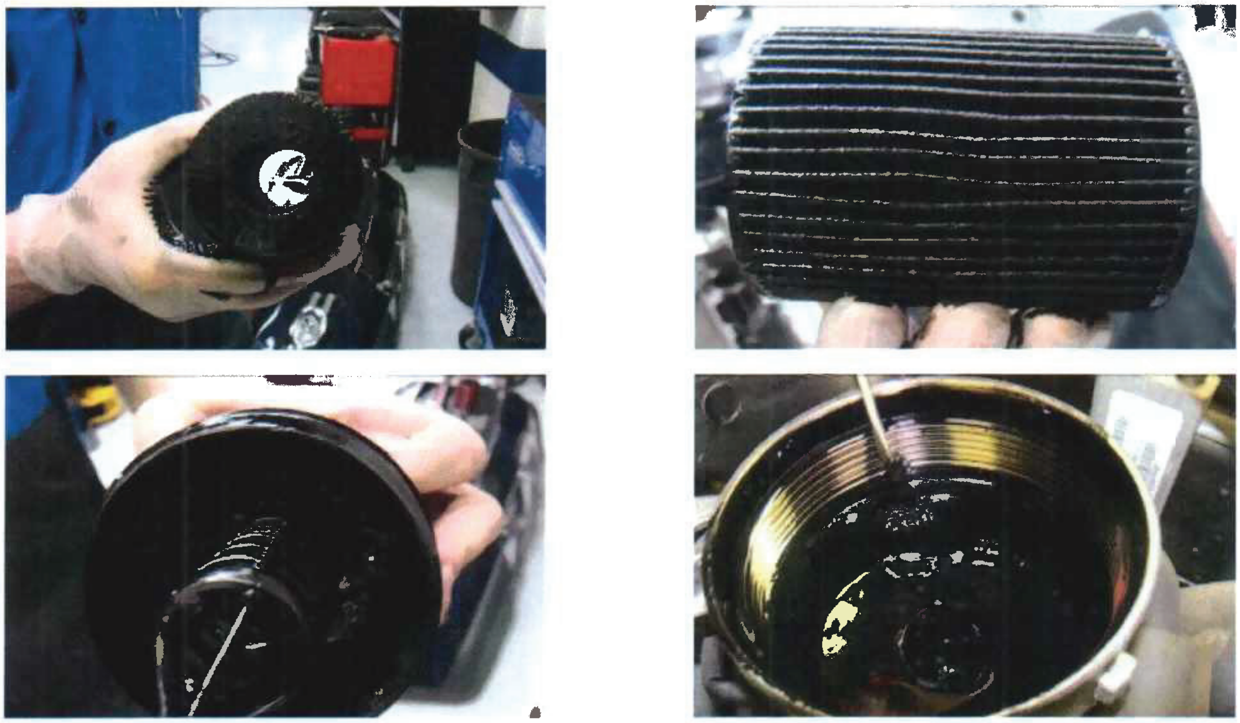
petroleum diesel and will not volatilize out of engine oil. As a result, biodiesel will accumulate in the engine oil.

22. Over time, as the biodiesel content in the oil increases, the viscosity of the oil changes: first it decreases, resulting in insufficient lubrication of bearings and other engine components, then, after oxidation has progressed, viscosity increases which promotes plugging of vital oil passageways, especially in the intricate channels in the engine assembly that feed oil to various rotating and reciprocating components in the engine. This can lead to failures of those engine components, such as crankshaft bearings, connecting rod bearings, camshaft bearings, turbocharger bearings and the like.

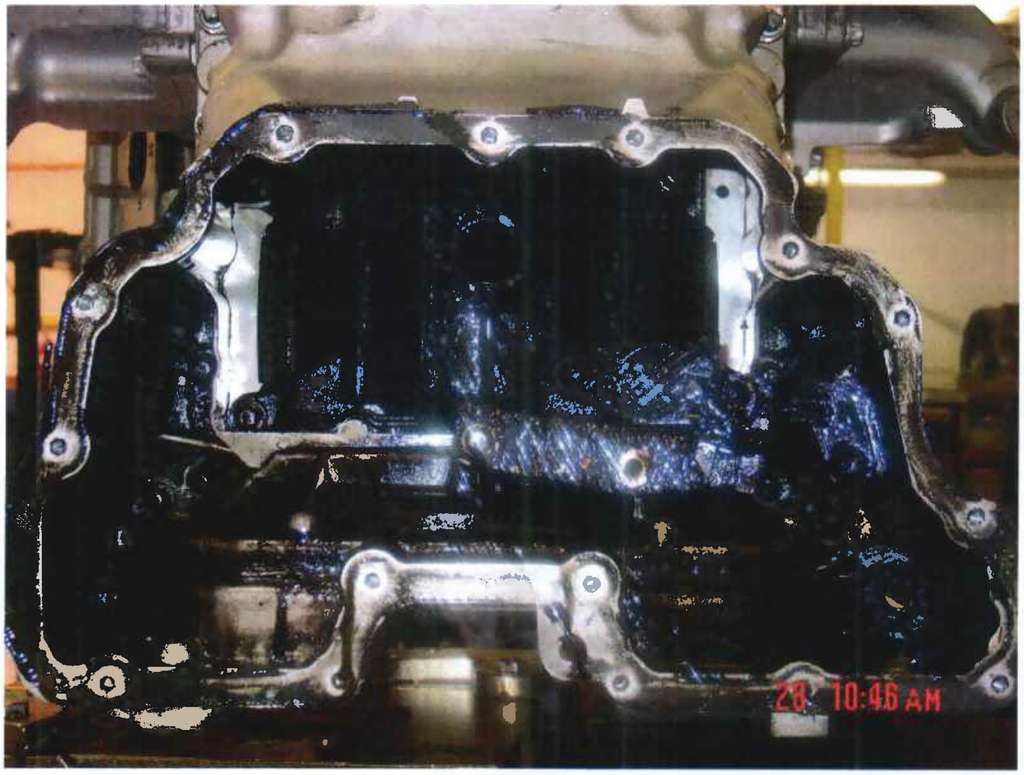
New **10K miles** **9K miles**

Biodiesel <= B5 **Biodiesel > B5**

Clogged Oil Filters Due to Biodiesel Degradation



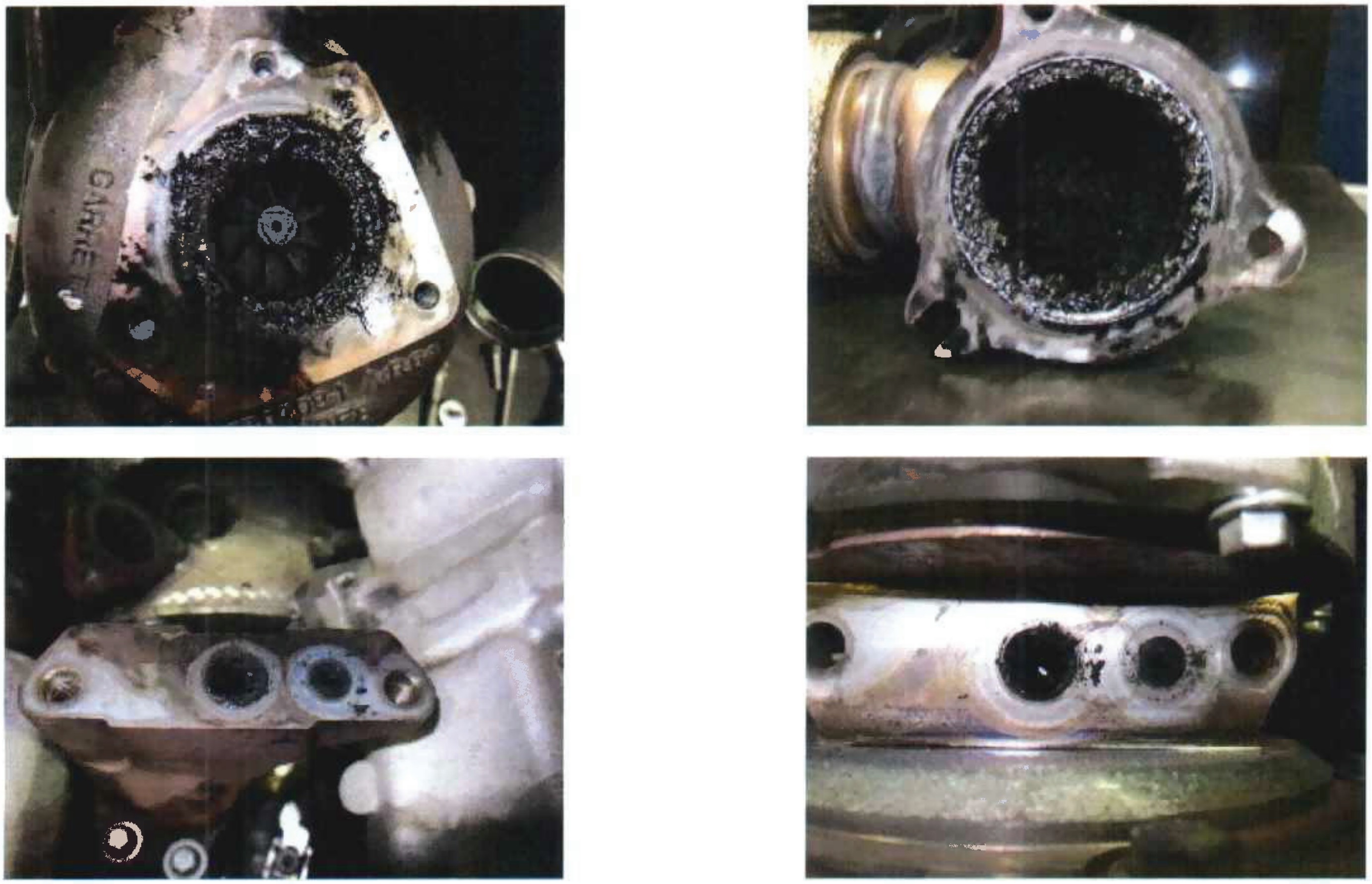
Oil Sludge Build Up in Oil Filter and Housing



Oil Sludging and Engine Failure Due to Biodiesel Contamination in Engine Oil

23. Other failure modes exist which are directly related to initial increases of biodiesel content in engine oil and the resultant reduction in engine oil viscosity. As engine oil viscosity decreases due to biodiesel presence, engine oil more readily bypasses seals and other barriers that are designed to segregate the oil to only particular parts of the engine. For example, biodiesel-contaminated engine oil will more readily migrate to the compressor side of turbochargers, which can cause fouling of the compressor and downstream components.

24. In addition, late in-cylinder injection of biodiesel results in combustion byproducts that can accumulate at various points in the exhaust system. For example, such byproducts will enter the exhaust gas recirculation ("EGR") system (which diverts a certain amount of engine exhaust back to the air intake, which helps control combustion temperature and, thus, lower emissions of nitrogen oxides), causing sticking and failure of the EGR valve. These effects can compromise engine performance, increase vehicle emissions, and in some cases result in engine failure.



Turbo and EGR Damage Due to Biodiesel

Experience with Blends Greater than B5 in Illinois

25. In 2003, Illinois adopted a 6.25% retail fuel tax rebate for sales of diesel blends containing greater than 10% biodiesel. MBUSA has extensively studied the effects of Illinois' biodiesel regulatory policy.

26. This tax incentive has led to the widespread availability of diesel fuel with greater than 10% biodiesel content (">B10") and associated limited availability of diesel fuel with lower biodiesel content. I understand that in Illinois most of the

diesel fuel sold in the state is >B10 and, most notably, in the Chicago metro area, most fueling stations dispense only blends of >B10. This makes it difficult for our customers to locate fuel that meets their vehicles' B5 warranty requirement.

27. Beginning in 2010, examples of low power and stalling due to the effects of >B10 usage were reported in Illinois by various OEMs. Those effects, including plugged fuel filters, sticky EGR valves, carbonated intake manifolds, and related issues, all increased in frequency of occurrence after the 6.25% retail fuel tax rebate was enacted.

28. Other, more expensive failures also occurred. I am aware of at least one manufacturer who reported engine failures in low mileage, well-maintained vehicles that suffered oil starvation due to extreme oil sludging in oil filters and housing, brought about by biodiesel dilution of engine oil. Examples of turbo damage and exhaust damage due to oil sludging were also reported.

29. These engine issues have led to a higher incidence of warranty repairs as well as catastrophic engine failure. Between 2010 and 2013, MBUSA found at least two cases of complete engine failure in diesel-powered vehicles, and determined that such failures were due to the chronic use of biodiesel blends >B10) from fuel dispensaries in Illinois. These engine failures occurred at only 15,000 miles and at 23,000 miles, respectively. Engine failures are rare. Multiple

engine failures in a single geographic area within a short period of time signals a problem.

30. The effect of the Illinois policy on Mercedes-Benz vehicles has been, and continues to be, of great concern to MBUSA. In 2011, MBUSA responded to the policy by suspending additional diesel vehicle allocations to Illinois dealerships, diminishing MBUSA's market share of diesel-powered light-duty vehicles in that state.

31. From 2011 through 2013, MBUSA customers in Illinois then complained about the lack of diesel models there, reflecting a loss in customer goodwill.

32. In late 2013, MBUSA disseminated a brochure to its customers there setting forth specific precautions for diesel-fueled vehicle owners to take if they were unable to access low-biodiesel content fuel. See Attachment 3. This brochure included recommendations about how to mitigate the effects of >B5. In addition, the brochure cautioned about the "engine performance degradation" and "engine mechanical damage" that could occur from use of >B5.

33. In addition to this customer outreach, MBUSA voiced its concern about the quality of the biodiesel blends offered for sale in Illinois through an August 2, 2013 letter to the Chief of the Illinois Department of Weights and Measures in the Illinois Department of Agriculture. As discussed in the letter, certain biodiesel producers were not compliant with the ASTM D975 Standard Specification for

Diesel Fuel Oils. The letter concluded that "in our view, fuels containing oxygenated materials other than 5% biodiesel, or additives in excess of 5000 ppm, do not meet ASTM D975. To reiterate, damage induced by fuel containing these products would not be covered by the Mercedes-Benz New Vehicle Limited Warranty or other OEM vehicle warranties." See Attachment 4.

34. In late 2013, in response to customer complaints about lack of vehicle availability, MBUSA resumed diesel vehicle allocations to Illinois dealerships, but to date, continues to monitor vehicle and engine issues reported.

35. The increase in warranty claims from customers of diesel-powered vehicles in Illinois associated with >B10 usage has compelled MBUSA to either pay for repairs, or to deny claims by asserting that customer use and maintenance was inconsistent with the warranty. Under either scenario, the damage caused by inappropriate fuel use undermines customer goodwill and increases administrative expense to MBUSA.

Impact on MBUSA from the Minnesota B10 Mandate

36. MBUSA is concerned that it will suffer injuries similar to those experienced in Illinois as a direct result of the Minnesota B10 mandate which went into effect on July 1, 2014. In fact, MBUSA expects the harm to be even worse in Minnesota than that experienced in Illinois.

37. Minnesota's B10 mandate could have more deleterious consequences than those in Illinois because the availability of lower biodiesel blends for purchase would not be merely reduced, but *outlawed* during the period when B10 is required to be sold. Therefore, no biodiesel blend compliant with MBUSA warranties will be available anywhere in the state when the B10 mandate is in effect.

38. The resulting damage to engines and other drivetrain components will require MBUSA either to service more claims at a significant cost – even those that should be denied because of out-of-warranty fueling – or to deny claims, which will negatively impact customer goodwill.

39. Moreover, the unavailability of warranty-compliant fuel is expected to decrease demand for new Mercedes-Benz diesel-fueled light duty vehicles in the State of Minnesota and is expected to adversely impact the Mercedes-Benz brand.

I declare under penalty of perjury that the foregoing is true and correct. Executed on September 15, 2014.

William Woebkenberg

ATTACHMENT 1

Biodiesel Cold Weather and Warranty Update for Minnesota Biodiesel Task Force
July 12, 2012

Steve Howell

MARC-IV/NBB

OEM Activity and Warranty Update

Engine and Vehicle Support for Biodiesel Blends

- All OEM's tell customers B5 meeting D975 is OK
- More than 75% of U.S. manufacturers now support B20 or higher biodiesel blends in at least some of their equipment
  - Over 95% of the U.S. medium duty truck market is at B20
  - Deutz recently approved B100 for underground mines
- For those OEM's who currently only recommend B5, use of biodiesel blends over B5 does not in an of itself void the manufacturers warranty
  - If there are problems CAUSED by higher levels of biodiesel, those will not be covered by the OEM warranty
  - Over 20 years of successful B20 use in many applications

OEM Support

OEMs Supporting B100	OEMs Supporting B20	OEMs Supporting B5
Case IH	**Arctic Cat**	**Audi ***
Deutz AG	**Buhler**	**BMW**
Fairbanks Morse	**Caterpillar**	**Mazda**
New Holland	**Chrysler** (in Dodge Ram for fleets)	**Mercedes Benz**
	Cummins	**Mitsubishi**
	Daimler Trucks - Including:	**PACCAR - Including:**
	- Detroit Diesel (upon request)	**- Kenworth**
	- Freightliner	**- Peterbilt**
	- Thomas Built Buses	**UD Trucks ***
	- Western Star	**Volkswagen ***
	Ferris	
	Ford (2011+ models)	
	General Motors (2011+ models)	
	HDT USA Motorcycles	
	Hino Trucks (2011+ models)	
	International / Navistar	
	Isuzu Commercial Trucks (2011+ models)	
	John Deere	
	Kubota	
	Mack	
	Perkins	
	Tomcar	
	Toro	*** = Currently completing B20 research**
	Volvo Trucks **Yanmar**	

BIODIESEL

New Diesel Engine NOx and PM Traps w/Biodiesel Blends

- One issue which remains un-resolved with some companies, i.e. light duty passenger cars:
  - Engine oil dilution of fuel when in-cylinder post injection is use for PM trap control.
  - This is an issue for petrodiesel as well
- Some OEMs have stated the presence of more biodiesel than B5 may cause problematic levels of fuel in engine oil dilution with new diesel cars:
  - More biodiesel hits the cylinder walls
  - What gets drug by the rings into the oil pan stays there and doesn’t evaporate like petrodiesel
- Other manufacturers with similar technology have approved B20

BIODIESEL

NBB Working with OEMs

- The National Biodiesel Board has an active program to work with all of the OEMs to secure B20 support in all diesel vehicles in the US
- Most US based diesel OEMs now support B20 in all their equipment moving forward
  - Foreign based manufacturers have been slower
- NBB has recently met with Daimler and others to encourage B20 support in new vehicles
  - And to investigate whether work-arounds for in-cylinder post injection engines are really needed with some of the newer diesel passenger cars in-cylinder post injection
  - If a work-around is needed, one possible solution discussed is simply to monitor the engine oil using the oil dipstick and change the oil if the level is significantly increasing

ATTACHMENT 2

Fifth Edition

WORLDWIDE FUEL CHARTER

SEPTEMBER 2013

ACEA
European Automobile
Manufacturers Association
Avenue des Nerviens 85
B-1040 Brussels, Belgium
Tel: +32 2 732 55 50
Fax: +32 2 738 73 10
www.acea.be

AUTO ALLIANCE
DRIVING INNOVATION
Alliance of
Automobile Manufacturers
803 7th Street, N.W., Suite 300
Washington D.C., 20001
Tel: +1 (202) 326-5500
Fax: +1 (202) 326-5567
www.autoalliance.org

ema
Truck and Engine
Manufacturers Association
333 West Wacker Drive, Suite 810
Chicago, IL 60606
Tel: +1 (312) 929-1970
Fax: +1 (312) 929-1975
www.truckandenginemanufacturers.org

JAMA
Japan Automobile
Manufacturers Association
Jidosha Kaikan
1-30, Shiba Daimon 1-Chome
Minato-ku, Tokyo 105-0012 Japan
Tel: +81-3-5405-6125
Fax: +81-3-5405-6136
www.japanauto.com

For copies, please contact ACEA, Alliance, EMA or JAMA or visit their websites.

The Worldwide Fuel Charter provides fuel quality recommendations published by the members of the Worldwide Fuel Charter Committee as a service to worldwide legislators, fuel users and producers. It contains information from sources believed to be reliable; however, the Committee makes no warranty, guarantee, or other representation, express or implied, with respect to the Charter's sufficiency or fitness for any particular purpose. The Charter imposes no obligation on any users or producers of fuel, and it does not prohibit use of any engine or vehicle technology or design, fuel, or fuel quality specification. It is not intended to, and does not, replace engine and vehicle manufacturers' fuelling recommendations.

ACEA	AUTO ALLIANCE DRIVING INNOVATION	ema	JAMA
European Automobile Manufacturers Association	Alliance of Automobile Manufacturers	Truck and Engine Manufacturers Association	Japan Automobile Manufacturers Association

September 2013

Subject: **Worldwide Fuels Harmonisation**

Dear Worldwide Fuel Charter Recipient:

On behalf of vehicle and engine manufacturers from around the world, the Worldwide Fuel Charter Committee is pleased to present the Fifth Edition of the Worldwide Fuel Charter. The Charter was first established in 1998 to increase understanding of the fuel quality needs of motor vehicle and engine technologies and to promote fuel quality harmonisation worldwide in accordance with those needs. Importantly, the Charter matches fuel specifications to the vehicle and engine specifications required to meet various customer needs around the world.

The Fifth Edition introduces Category 5 for markets with highly advanced requirements for emission control and fuel efficiency. As many countries take steps to require vehicles and engines to meet strict fuel economy standards in addition to stringent emission standards, Category 5, which raises the minimum research octane number (RON) to 95, will enable some gasoline technologies that can help increase vehicle and engine efficiency. For diesel fuel, this category establishes a high quality hydrocarbon-only specification that takes advantage of the characteristics of certain advanced biofuels, including hydrotreated vegetable oil (HVO) and Biomass-to-Liquid (BTL), provided all other specifications are respected and the resulting blend meets defined legislated limits.

Other changes from the previous edition include a new test method for trace metals and an updated gasoline volatility table. Significant changes relate to biodiesel: the Charter now allows up to 5% biodiesel by volume in Category 4 diesel fuel, has new diesel fuel oxidation stability limits and includes an alternative oxidation stability test method with correlations to other methods. The Charter also now references the E100 and B100 Guidelines published by the WWFC Committee in 2009.

As countries move toward more stringent vehicle and engine requirements, fuel quality's role in preserving the functionality of vehicles and engines continues to grow. Sulphur-free and metal-free fuels remain critical prerequisites for ultraclean, efficient and durable emission control systems. The most advanced vehicles and engines require the best fuel quality – as represented in Category 5 – to meet their design potential.

We appreciate the many comments submitted on this new edition of the Charter; they have helped make it a better document. We look forward to working with you to support harmonised specifications for the continued benefit of society.

Ivan Hodac	**Mitch Bainwol**	**Jed R. Mandel**	**Yoshiyasu Nao**
Secretary General	President & CEO	President	President
ACEA	Alliance	EMA	JAMA

ACEA member companies
BMW Group, DAF Trucks NV, Daimler AG, FIAT SpA, Ford of Europe, General Motors Europe, Hyundai Motor Europe, IVECO SpA, Jaguar Land Rover, PSA Peugeot Citroën, Renault SA, Toyota Motor Europe, Volkswagen Group, Volvo Car Corporation, Volvo Group.

Alliance member companies
BMW Group, Chrysler Group, Ford Motor Company, General Motors Company, Jaguar Land Rover, Mazda North America, Mercedes-Benz USA, Mitsubishi Motors, Porsche Cars North America, Toyota Motor North America, Inc., Volkswagen Group of America, Volvo Cars of North America.

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JAMA member companies
Daihatsu Motor Co. Ltd., Fuji Heavy Industries Ltd., Hino Motors Ltd., Honda Motor Co. Ltd., Isuzu Motors Limited, Kawasaki Heavy Industries Ltd., Mazda Motor Corporation, Mitsubishi Fuso Truck and Bus Corporation, Mitsubishi Motors Corporation, Nissan Diesel Motor Co. Ltd., Nissan Motor Co. Ltd., Suzuki Motor Corporation, Toyota Motor Corporation, UD Trucks Corporation, Yamaha Motor Co. Ltd.

Associate members
› Asociación de Fábricas de Automotores de Argentina (ADEFA)
› Associacion Mexicana de la Industria Automotriz, A.C. (AMIA)
› Brazilian Association of motor vehicle and motorised agricultural machinery manufacturers (ANFAVEA)
› Canadian Vehicle Manufacturers' Association (CVMA)
› Chamber of Automotive Manufacturers of the Philippines, Inc. (CAMPI)
› China Association of Automobile Manufacturers (CAAM)
› Global Automakers
› Global Automakers of Canada (GAC)
› Indonesia Automotive Federation (IAF)
› Korean Automobile Manufacturers Association (KAMA)
› National Association of Automobile Manufacturers of South Africa (NAAMSA)
› Malaysian Automotive Association (MAA)
› Society of Indian Automobile Manufacturers (SIAM)
› Thai Automotive Industry Association (TAIA)
› Vietnam Automobile Manufacturers Association (VAMA)

Supporting organisations:
› Organisation Internationale des Constructeurs d'Automobiles (OICA)

CONTENTS

AAMA	American Automobile Manufacturers Association, the U.S. trade association for Chrysler, Ford and GM from 1992 until 1998.
ACEA	Association des Constructeurs Européens d'Automobiles (European automobile manufacturers association)
AIAM	Association of International Automobil Manufacturers, the former name of Global Automakers
Alliance	Alliance of Automobile Manufacturers
AMA	Accelerated Mileage Accumulation
AQIRP	Air Quality Improvement Research Programme (part of the US Auto Oil programme, 1989-1992)
ASTM	ASTM International (formerly American Society for Testing and Materials)
Biofuel	Liquid transport fuel produced from biomass
Biomass	Biodegradable fraction of products, waste and residues from biological origin
BTL	Liquid fuel made from biomass ('Biomass to Liquid')
CCD	Combustion Chamber Deposits
CDPF	Catalysed Diesel Particulate Filter
CEC	Coordinating European Council for the Development of Performance Tests for Transportation Fuels, Lubricants and Other Fluids
CFPP	Cold Filter Plugging Point
CI	Cetane Index
CN	Cetane Number
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CP	Cloud Point
CRC	Coordinating Research Council (US)
CR-DPF	Continuously Regenerating Diesel Particulate Filter
DECSE	Diesel Emission Control – Sulfur Effects, research program of the US Department of Energy
DEF	Diesel Exhaust Fluid (for SCR systems)
DI	Distillation Index
DIN	Deutsches Institut für Normung (German Institute of Standardisation)
DPF	Diesel Particulate Filter
DVPE	Dry Vapour Pressure Equivalence
EMA	Truck and Engine Manufacturers Association
EN	European Norm
EPA	Environmental Protection Agency (US)
EPEFE	European Programme on Emissions, Fuels and Engine Technology (part of the European Auto-Oil 1 programme, 1993-1995)
EtBE	Ethyl tertiary-Butyl Ether
FAEE	Fatty Acid Ethyl Esters
FAME	Fatty Acid Methyl Esters
FBP	Final Boiling Point
FTP	(US) Federal Test Procedure
FLTM	Ford Laboratory Test Method
GHG	Greenhouse Gas
GTL	Liquid fuel typically made from methane gas using a gas-to-liquid/Fischer-Tropsch-type process
HC	Hydrocarbons
HFRR	High Frequency Reciprocating Rig
HVO	Hydrotreated Vegetable Oil
IDID	Internal Diesel Injector Deposits
ICP-AES	Inductively Coupled Plasma - Atomic Emission Spectrometry
IP	Energy Institute (formerly Institute of Petroleum)
ISO	International Organisation for Standardization
IVD	Intake Valve Deposits
JAMA	Japan Automobile Manufacturers Association
JARI	Japan Automobile Research Institute
JIS	Japanese Industrial Standards
LEV	Low Emission Vehicle
LTFT	Low Temperature Flow Test
MECA	Manufacturers of Emission Controls Association
METI	Ministry of Economy, Trade and Industry (Japan)
MMT	Methylcyclopentadienyl Manganese Tricarbonyl
MtBE	Methyl tertiary Butyl Ether
MON	Motor Octane Number
NF M	Norme Française - Industrie du Pétrole (French Norm - Petroleum Industry)
NF T	Norme Française - Industrie Chimique (French Norm - Chemical Industry)
NOx	Oxides of Nitrogen
OBD	On-Board Diagnostics
OFP	Ozone Forming Potential
Oxy	Oxygen
PAH	Polycyclic Aromatic Hydrocarbons
pHe	Acidity of ethanol
PM	Particulate Matter
ppm	Parts per million
PZEV	Partial Zero Emission Vehicle
RON	Research Octane Number
SCR	Selective Catalytic Reduction
SULEV	Super-Ultra-Low Emission Vehicle
TAN	Total Acid Number
TGA	Thermal Gravimetric Analysis
THC	Total Hydrocarbons
TLEV	Transitional Low Emission Vehicle
TWD	Total Weighted Demerits
ULEV	Ultra-Low Emission Vehicle
VDE	Vegetable Derived Esters

The objective of the global fuels harmonisation effort is to develop common, worldwide recommendations for quality fuels, taking into consideration customer requirements and the performance of vehicle and engine emission technologies. These recommendations allow vehicle and engine manufacturers to provide consistent fuel quality advice to policymakers who may want to control vehicle or engine emissions, whether for the first time or to expand already implemented legislation. Regardless of the legislative context, access to the recommended fuels will benefit consumers and their communities in all markets around the world.

Implementation of the recommendations will:

- Reduce the impact of motor vehicles on the environment by enabling reduced vehicle fleet emissions;
- Facilitate the delivery of optimised fuels for each emission control category, which will minimize vehicle equipment complexities and help reduce customer costs (purchase and operation); and,
- Increase customer satisfaction by maintaining vehicle performance for a longer period of time.

Five different categories of fuel quality, described below, have been established for unleaded gasoline and diesel fuel:

Category 1:
Markets with no or first level requirements for emission control; based primarily on fundamental vehicle/engine performance and protection of emission control systems, for example, markets requiring US Tier 0, EURO 1 or equivalent emission standards.

Category 2:
Markets with requirements for emission control or other market demands, for example, markets requiring US Tier 1, EURO 2/II, EURO 3/III or equivalent emission standards.

Category 3:
Markets with more stringent requirements for emission control or other market demands, for example, markets requiring US LEV, California LEV or ULEV, EURO 4/IV (except lean burn gasoline engines), JP 2005 or equivalent emission standards.

Category 4:
Markets with advanced requirements for emission control, for example, markets requiring US Tier 2, US Tier 3 (pending), US 2007 / 2010 Heavy Duty On-Highway, US Non-Road Tier 4, California LEV II, EURO 4/IV, EURO 5/V, EURO 6/VI, JP 2009 or equivalent emission standards. Category 4 fuels enable sophisticated NOx and particulate matter after-treatment technologies.

Category 5:
Markets with highly advanced requirements for emission control and fuel efficiency, for example, those markets that require US 2017 light duty fuel economy, US heavy duty fuel economy, California LEV III or equivalent emission control and fuel efficiency standards in addition to Category 4-level emission control standards.

Requirements for all markets:
Fuel in the market will meet the quality specifications only if blendstock quality is monitored and good management practices are used. The following requirements apply broadly to fuel systems in all markets:

- Additives must be compatible with engine oils, to prevent any increase in engine sludge or deposits of varnish.
- Ash-forming components must not be added.
- Good housekeeping practices must be used throughout distribution to minimize contamination from dust, water, different fuels and other sources of foreign matter.
- Pipeline corrosion inhibitors must not interfere with fuel quality, whether through formulation or reaction with sodium.

- Dispenser pumps must be labelled adequately to help customers identify the appropriate fuels for their vehicles.
- Fuel should be dispensed through nozzles meeting SAE J285, 'Dispenser Nozzle Spouts for Liquid Fuels Intended for Use with Spark Ignition and Compression Ignition Engines.'
- Ethanol used for blending with gasoline, and biodiesel (FAME) used for blending with diesel fuel, should adhere to the E100 Guidelines and the B100 Guidelines, respectively, published by the WWFC Committee.

Engine and vehicle technologies typically achieve improved performance and lower emissions with higher category fuels. These fuel quality recommendations are for the properties of the finished fuel as provided to the customer. Internal quality control methods are not dictated or restricted as long as the fuel meets these specifications. Where national requirements are more severe than these recommendations, those national limits have to be met.

To meet ongoing environmental, energy and customer challenges, vehicle and engine manufacturers will continue to develop and introduce advanced and innovative propulsion technologies that may require changes in fuel quality. Category revisions will occur as needed to reflect such changes in technology, as well as in petroleum refining, test methods and global market conditions.

Markets with no or first level requirements for emission controls; based primarily on fundamental vehicle/engine performance and protection of emission control system.

PROPERTIES		UNITS	LIMIT	
			Min.	Max.
'91 RON' (1)	Research Octane Number		91.0	
	Motor Octane Number		82.0	
'95 RON' (1)	Research Octane Number		95.0	
	Motor Octane Number		85.0	
'98 RON' (1)	Research Octane Number		98.0	
	Motor Octane Number		88.0	
Oxidation stability		minutes	360	
Sulphur		mg/kg (2)		1000
Trace metal (3)		mg/kg		1 or non-detectable, whichever is lower
Oxygen (4)		% m/m		2.7 (5)
Aromatics		% v/v		50.0
Benzene		% v/v		5.0
Volatility				See Tables, page 8
Unwashed gums		mg/100 ml		70
Washed gums		mg/100 ml		5
Density		kg/m3	715	780
Copper corrosion		rating		Class 1
Appearance			Clear and bright; no free water or particulates	
Carburettor cleanliness		merit	8.0 (6)	
Fuel injector cleanliness, Method 1, or		% flow loss		10 (6)
Fuel injector cleanliness, Method 2		% flow loss		10 (6)
Intake valve cleanliness		merit	9.0 (6)	

Footnotes:

(1) Three octane grades are defined for maximum market flexibility; availability of all three is not needed.

(2) The unit mg/kg is often expressed as ppm. Lower sulphur content preferred for catalyst-equipped vehicles.

(3) Examples of trace metals include, but are not limited to, Cu, Fe, Mn, Na, P, Pb, Si and Zn. Another undesirable element is Cl.. Metal-containing additives are acceptable only for valve seat protection in non-catalyst cars; in this case, potassium-based additives are recommended. No intentional addition of metal-based additives is allowed.

(4) Where oxygenates are used, ethers are preferred. Methanol is not permitted.

(5) By exception, up to 10% by volume ethanol content is allowed if permitted by existing regulation. Blendstock ethanol should meet the E100 Guidelines published by the WWFC Committee. Fuel pump labelling is recommended for gasoline-ethanol blends to enable customers to determine if their vehicles can use the fuel.

(6) Compliance with this requirement can be demonstrated by the use of proper detergent additives in comparable-base gasolines.

Markets with requirements for emission controls or other market demands.

PROPERTIES		UNITS	LIMIT Min.	Max.
'91 RON' [1]	Research Octane Number		91.0	
	Motor Octane Number		82.5	
'95 RON' [1]	Research Octane Number		95.0	
	Motor Octane Number		85.0	
'98 RON' [1]	Research Octane Number		98.0	
	Motor Octane Number		88.0	
Oxidation stability		minutes	480	
Sulphur		mg/kg [2]		150
Trace metal [3]		mg/kg		1 or non-detectable, whichever is lower
Oxygen [4]		% m/m		2.7 [5]
Olefins		% v/v		18.0
Aromatics		% v/v		40.0
Benzene		% v/v		2.5
Volatility				See Tables, page 8
Sediment (total particulate)		mg/l		1
Unwashed gums [6]		mg/100 ml		70
Washed gums		mg/100 ml		5
Density		kg/m3	715	770
Copper corrosion		rating		Class 1
Appearance			Clear and bright; no free water or particulates	
Fuel injector cleanliness, Method 1, or		% flow loss		5
Fuel injector cleanliness, Method 2		% flow loss		10
Intake-valve sticking		pass/fail	Pass	
Intake valve cleanliness II				
Method 1 (CEC F-05-A-93), or		avg. mg/valve		50
Method 2 (ASTM D5500), or		avg. mg/valve		100
Method 3 (ASTM D6201)		avg. mg/valve		90
Combustion chamber deposits [6]				
Method 1 (ASTM D6201), or		% of base fuel		140
Method 2 (CEC-F-20-A-98), or		mg/engine		3500
Method 3 (TGA - FLTM BZ154-01)		% mass.@ 450°C		20

Footnotes:

(1) Three octane grades are defined for maximum market flexibility; availability of all three is not needed.
(2) The unit mg/kg is often expressed as ppm.
(3) Examples of trace metals include, but are not limited to, Cu, Fe, Mn, Na, P, Pb, Si and Zn. Another undesirable element is Cl. No trace metal should exceed 1 mg/kg. No intentional addition of metal-based additives is allowed.
(4) Where oxygenates are used, ethers are preferred. Methanol is not permitted.
(5) By exception, up to 10% by volume ethanol content is allowed if permitted by existing regulation. Blendstock ethanol should meet the E100 Guidelines published by the WWFC Committee. Fuel pump labelling is recommended for gasoline-ethanol blends to enable customers to determine if their vehicles can use the fuel.
(6) To provide flexibility (for example, to enable the use of detergency additives that increase unwashed gum levels), the fuel may comply with either the Unwashed Gum limit or the Combustion Chamber Deposits limit.

Markets with more stringent requirements for emission controls or other market demands.

PROPERTIES		UNITS	LIMIT Min.	Max.
'91 RON' [1]	Research Octane Number		91.0	
	Motor Octane Number		82.5	
'95 RON' [1]	Research Octane Number		95.0	
	Motor Octane Number		85.0	
'98 RON' [1]	Research Octane Number		98.0	
	Motor Octane Number		88.0	
Oxidation stability		minutes	480	
Sulphur		mg/kg [2]		30
Trace metal [3]		mg/kg		1 or non-detectable, whichever is lower
Oxygen [4]		% m/m		2.7 [5]
Olefins		% v/v		10.0
Aromatics		% v/v		35.0
Benzene		% v/v		1.0
Volatility				See Tables, page 8
Sediment (total particulate)		mg/l		1
Unwashed gums [6]		mg/100 ml		30
Washed gums		mg/100 ml		5
Density		kg/m3	715	770
Copper corrosion		rating		Class 1
Appearance			Clear and bright; no free water or particulates	
Fuel injector cleanliness, Method 1, or		% flow loss		5
Fuel injector cleanliness, Method 2		% flow loss		10
Particulate contamination, size distribution		Code rating		18/16/13 per ISO 4406
Intake-valve sticking		pass/fail	Pass	
Intake valve cleanliness II				
Method 1 (CEC F-05-A-93), or		avg. mg/valve		30
Method 2 (ASTM D5500), or		avg. mg/valve		50
Method 3 (ASTM D6201)		avg. mg/valve		50
Combustion chamber deposits [6]				
Method 1 (ASTM D6201), or		% of base fuel		140
Method 2 (CEC-F-20-A-98), or		mg/engine		2500
Method 3 (TGA FLTM BZ154-01)		% mass @ 450°C		20

Footnotes:

(1) Three octane grades are defined for maximum market flexibility; availability of all three is not needed.
(2) The unit mg/kg is often expressed as ppm.
(3) Examples of trace metals include, but are not limited to, Cu, Fe, Mn, Na, P, Pb, Si and Zn. Another undesirable element is Cl. No trace metal should exceed 1 mg/kg. No intentional addition of metal-based additives is allowed.
(4) Where oxygenates are used, ethers are preferred. Methanol is not permitted.
(5) By exception, up to 10% by volume ethanol content is allowed if permitted by existing regulation. Blendstock ethanol should meet the E100 Guidelines published by the WWFC Committee. Fuel pump labelling is recommended for gasoline-ethanol blends to enable customers to determine if their vehicles can use the fuel.
(6) To provide flexibility (for example, to enable the use of detergency additives that increase unwashed gum levels), the fuel may comply with either the Unwashed Gum limit or the Combustion Chamber Deposits limit.

Markets with highly advanced requirements for emission control; enables sophisticated NOx and particulate matter after-treatment technologies.

PROPERTIES		UNITS	LIMIT Min.	Max.
'91 RON' [1]	Research Octane Number		91.0	
	Motor Octane Number		82.5	
'95 RON' [1]	Research Octane Number		95.0	
	Motor Octane Number		85.0	
'98 RON' [1]	Research Octane Number		98.0	
	Motor Octane Number		88.0	
Oxidation stability		minutes	480	
Sulphur		mg/kg [2]		10
Trace metal [3]		mg/kg		1 or non-detectable, whichever is lower
Oxygen [4]		% m/m		2.7 [5]
Olefins		% v/v		10.0
Aromatics		% v/v		35.0
Benzene		% v/v		1.0
Volatility			See Tables, page 8	
Sediment (total particulate)		mg/l		1
Unwashed gums [6]		mg/100 ml		30
Washed gums		mg/100 ml		5
Density		kg/m3	715	770
Copper corrosion	rating			Class 1
Silver corrosion	rating			Class 1
Appearance			Clear and bright; no free water or particulates	
Fuel injector cleanliness, Method 1, or		% flow loss		5
Fuel injector cleanliness, Method 2		% flow loss		10
Particulate contamination, size distribution		Code rating		18/16/13 per ISO 4406
Intake-valve sticking		pass/fail	Pass	
Intake valve cleanliness II				
Method 1 (CEC F-05-A-93), or		avg. mg/valve		30
Method 2 (ASTM D5500), or		avg. mg/valve		50
Method 3 (ASTM D6201)		avg. mg/valve		50
Combustion chamber deposits [6]				
Method 1 (ASTM D6201), or		% of base fuel		140
Method 2 (CEC-F-20-A-98), or		mg/engine		2500
Method 3 (TGA FLTM BZ154-01)		% mass @ 450°C		20

Footnotes:

[1] Three octane grades are defined for maximum market flexibility; availability of all three is not needed.
[2] The unit mg/kg is often expressed as ppm.
[3] Examples of trace metals include, but are not limited to, Cu, Fe, Mn, Na, P, Pb, Si and Zn. Another undesirable element is Cl. No trace metal should exceed 1 mg/kg. No intentional addition of metal-based additives is allowed.
[4] Where oxygenates are used, ethers are preferred. Methanol is not permitted.
[5] By exception, up to 10% by volume ethanol is allowed if permitted by existing regulation. Blendstock ethanol should meet the E100 Guidelines published by the WWFC Committee. Fuel pump labelling is recommended for gasoline-ethanol blends to enable customers to determine if their vehicles can use the fuel.
[6]: To provide flexibility (for example, to enable the use of detergency additives that increase unwashed gum levels), the fuel may comply with either the Unwashed Gum limit or the Combustion Chamber Deposits limit.

Markets with highly advanced requirements for emission control and fuel efficiency. Enables technologies that can help increase vehicle and engine efficiency, in addition to enabling sophisticated NOx and particulate matter after-treatment technologies.

PROPERTIES		UNITS	LIMIT Min.	Max.
'95 RON'	Research Octane Number		95.0	
	Motor Octane Number		85.0	
'98 RON'	Research Octane Number		98.0	
	Motor Octane Number		88.0	
Oxidation stability		minutes	480	
Sulphur		mg/kg (1)		10
Trace metal (2)		mg/kg		1 or non-detectable, whichever is lower
Oxygen (3)		% m/m		2.7 (4)
Olefins		% v/v		10.0
Aromatics		% v/v		35.0
Benzene		% v/v		1.0
Volatility			See Tables, page 8	
Sediment (total particulate)		mg/l		1
Unwashed gums (5)		mg/100 ml		30
Washed gums		mg/100 ml		5
Density		kg/m3	720	775
Copper corrosion		rating		Class 1
Sulphur corrosion		rating		Class 1
Appearance			Clear and bright; no free water or particulates	
Fuel injector cleanliness, Method 1, or		% flow loss		5
Fuel injector cleanliness, Method 2		% flow loss		10
Particulate contamination, size distribution		Code rating		18/16/13 per ISO 4406
Intake-valve sticking		pass/fail	Pass	
Intake valve cleanliness II				
Method 1 (CEC F-05-A-93), or		avg. mg/valve		30
Method 2 (ASTM D5500), or		avg. mg/valve		50
Method 3 (ASTM D6201)		avg. mg/valve		50
Combustion chamber deposits (5)				
Method 1 (ASTM D6201), or		% of base fuel		140
Method 2 (CEC-F-20-A-98), or		mg/engine		2500
Method 3 (TGA FLTM BZ154-01)		% mass. @ 450°C		20

Footnotes:

[1] The unit mg/kg is often expressed as ppm.
[2] Examples of trace metals include, but are not limited to, Cu, Fe, Mn, Na, P, Pb, Si and Zn. Another undesirable element is Cl. No trace metal should exceed 1 mg/kg. No intentional addition of metal-based additives is allowed.
[3] Where oxygenates are used, ethers are preferred. Methanol is not permitted.
[4] By exception, up to 10% ethanol by volume is allowed where permitted by existing regulation. Blendstock ethanol should meet the E100 Guidelines published by the WWFC Committee. Fuel pump labelling is recommended for gasoline-ethanol blends to enable customers to determine if their vehicles can use the fuel.
[5] To provide flexibility (for example, to enable the use of detergency additives that increase unwashed gum levels), the fuel may comply with either the Unwashed Gum limit or the Combustion Chamber Deposits limit.

ALL CATEGORIES

Class *	A	B	C	D	E
Ambient Temp. Range, °C	> 15	5 to 15	-5 to +5	-5 to -15	< -15
Vapour Pressure, kPa	45 - 60	55 - 70	65 - 80	75 - 90	85 - 105
T10, °C, max	65	60	55	50	45
T50, °C	77 - 100	77 - 100	75 - 100	70 - 100	65 - 100
T90, °C	130 - 175	130 - 175	130 - 175	130 - 175	130 - 175
EP, °C max.	205	205	205	205	205
E70, %	20 - 45	20 - 45	25 - 47	25 - 50	25 -50
E100, %	50 - 65	50 - 65	50 - 65	55 - 70	55 - 70
E180, % min	90	90	90	90	90
D.I., max	570	565	560	555	550

* 'Class' is based on the minimum expected ambient temperatures of the market and will vary by season.

Notes:

Ambient temperature ranges listed represent the condition the vehicle operator will encounter. Local regulations/standards may define classes based on expected temperatures from varying historical or statistical information sources applicable to their locale.
D.I. (Distillation Index) = (1.5 * T10) + (3 * T50) + T90 + (11 * mass % of oxygen); temperatures are in degrees Celsius.
The D.I. oxygenate correction does not apply to ethers, but limited data on LEV/ULEV vehicles suggest that ethers may require a similar oxygenate correction. The need for and the magnitude of the correction will be determined as more data become available. Preliminary data indicate that vehicles may need further volatility controls beyond what is currently specified.

VAPOUR / LIQUID RATIO (V/L), T V/L=20

ALL CATEGORIES

Class	Test Temperature, °C, min.	Applicable Temperature, °C
1	60	≥43
2	56	< 43
3	51	< 36
4	47	< 29
5	41	< 21
6	35	< 14

Vapour lock class is based on the 90th percentile maximum (applicable) daily temperature. The minimum test temperature of the gasoline for V/L=20 is provided for each vapour lock class. Limits to TV/L=20 are required to prevent hot fuel handling problems such as vapour lock, as discussed in the gasoline technical background under 'Volatility.' Additional information is provided in ASTM D4814.

The latest test methods should be used unless otherwise indicated by specific method year. On those parameters where 'non-detectable' is listed, the lowest possible levels are expected with no intentional additions of the additive or contaminant. Where multiple methods are indicated, the manufacturer should assure the product conforms to the most precise method listed.

PROPERTIES	UNITS	ISO	ASTM	JIS	OTHER
Research Octane Number		EN 5164	D2699	K 2280	
Motor Octane Number		EN 5163	D2700	K 2280-96	
Oxidation stability [(1)]	minutes	7536	D525	K 2287	
Sulphur content	mg/kg		D2622	K 2541	
		20846	D5453		
		20884			
Lead content	mg/l		D3237	K 2255	EN 237
Potassium (K) content	mg/l				NF M 07065 EN 14538
Trace metal content	mg/kg				ICP; ASTM D7111 modified
Phosphorus content	mg/l		D 3231		
Silicon content	mg/kg				ICP-AES (Reference in-house methods with detection limit = 1 mg/kg)
Chlorine content	mg/kg		D7359 or D7536		
Oxygen content	% m/m		D4815	K 2536	EN 13132
Olefin content [(2)]	% v/v	3837	D1319	K 2536	
Aromatic content [(2)]	% v/v	3837	D1319	K 2536	EN 14517
Benzene content	% v/v		D5580	K 2536	EN 238
			D3606		EN 14517
Vapour Pressure	kPa		D5191	K 2258	EN 13016/1 DVPE
Distillation: T10/T50/T90, E70/E100/E180, End Point, residue		3405	D86	K 2254	
Vapour/liquid ratio (V/L)	°C		D5188		
Sediment (total particulate)	mg/l		D5452		
Unwashed gums	mg/100 ml	6246	D381	K 2261	May be replaced with CCD test
Washed gums	mg/100 ml	6246	D381	K 2261	
Density	kg/m3	3675	D4052	K 2249	
		12185			
Copper corrosion	rating	2160	D130	K 2513	
Silver corrosion	rating		D7671		
Appearance			D4176		Visual inspection
Carburettor cleanliness	merit				CEC F-03-T
Fuel injector cleanliness, Method 1	% flow loss		D5598		
Fuel injector cleanliness, Method 2	% flow loss		D6421		
Particulate contamination, size	code rating	4406			
distribution	no. of particles/ml	4407 & 11500			
Intake-valve sticking	pass/fail				CEC F-16-T
Intake valve cleanliness I	merit				CEC F-04-A
Intake valve cleanliness II	avg. mg/valve				
Method 1, 4 valve avg.					CEC F-05-A
Method 2, BMW test			D5500		
Method 3, Ford 2.3L			D6201		
Combustion chamber deposits					
Method 1	% of base fuel		D6201		
Method 2	mg/engine				CEC F-20-A
Method 3	% mass @ 450°C				FLTM-BZ154 [(3)]

(1) Updated procedures are needed to better measure oxygenated blends.
(2) Some methods for olefin and aromatic content are used in legal documents; more precise methods are available and may be used.
(3) This method is available at http://global.ihs.com.

Markets with no or first level requirements for emission controls; based primarily on fundamental vehicle/engine performance and protection of emission control systems.

PROPERTIES	UNITS	LIMIT Min.	Max.
Cetane Number		48.0	
Cetane Index [(1)]		48.0 (45.0) [(1)]	
Density @ 15°C	kg/m3	820 [(2)]	860
Viscosity @ 40°C	mm2/s	2.0 [(3)]	4.5
Sulphur	mg/kg [(4)]		2000
T95	°C		370
Flash point	°C	55 [(5)]	
Carbon residue	% m/m		0.30
CFPP or LTFT or CP	°C		Equal to or lower than the lowest expected ambient temperature [(6)]
Water	mg/kg		500
Oxidation stablity			
Method 1	g/m3		25
Method 2a (Rancimat, modified) [(7)], or	hours	30	
Method 2b (Delta TAN) [(7)], or	mg KOH/g		0.12
Method 2c (PetroOxy) [(7)]	minutes	60	
FAME [(8)]	% v/v		5%
Other biofuels [(9)]	% v/v		[(9)]
Copper corrosion	rating		Class 1
Ethanol/Methanol	% v/v	Non-detectable [(10)]	
Ash	% m/m		0.01
Particulate contamination, total	see test method		10
Appearance		Clear and bright; no free water or particulates	
Lubricity (HFRR wear scar dia. @ 60°C)	micron		460

Footnotes:

(1) Cetane Index is acceptable instead of Cetane Number if a standardized engine to determine the Cetane Number is unavailable and cetane improvers are not used. When cetane improvers are used, the estimated Cetane Number must be greater than or equal to the specified value and the Cetane Index must be greater than or equal to the number in parenthesis.
(2) May relax the minimum limit to 800 kg/m3 when ambient temperatures are below -30°C.
(3) May relax the minimum limit to 1.5 mm2/s when ambient temperatures are below -30°C or to 1.3 mm2/s when ambient temperatures are below -40°C.
(4) The unit mg/kg is often expressed as ppm.
(5) The minimum limit can be relaxed to 38°C when ambient temperatures are below -30°C.
(6) If compliance is demonstrated by meeting CFPP, then the maximum must be no more than 10°C less than cloud point.
(7) Methods 2a and 2b must be used with fuels containing FAME. Method 2c correlation data are based on fuels containing FAME.
(8) For FAME, both EN14214 and ASTM D6751, or equivalent standards, should be considered. Where FAME is used, the blendstock should meet the B100 Guidelines published by the WWFC Committee, and fuel pumps should be labelled accordingly.
(9) Other biofuels include HVO and BTL. Blending level must allow the finished fuel to meet all the required specifications.
(10) At or below detection limit of the test method used.

Markets with requirements for emission controls or other market demands.

PROPERTIES	UNITS	LIMIT Min.	Max.
Cetane Number		51.0	
Cetane Index [(1)]		51.0 (48.0)[(1)]	
Density @ 15°C	kg/m3	820 [(2)]	850
Viscosity @ 40°C	mm2/s	2.0 [(3)]	4.0
Sulphur	mg/kg [(4)]		300
Trace metal [(5)]	mg/kg		1 or non-detectable, whichever is lower
Total aromatics	% m/m		25
PAH (di+, tri+)	% m/m		5
T90 [(6)]	°C		340
T95 [(6)]	°C		355
Final Boiling Point	°C		365
Flash point	°C	55	
Carbon residue	% m/m		0.30
CFPP or LTFT or CP	°C		Equal to or lower than the lowest expected ambient temperature [(7)]
Water	mg/kg		200
Oxidation stability			
Method 1	g/m3		25
Method 2a (Rancimat, modified) [(8)], or	hours	35	
Method 2b (Delta TAN) [(8)], or	mg KOH/g	0.12	
Method 2c (PetroOxy) [(8)]	minutes	65	
Biological growth [(9)]		no growth	
FAME [(10)]	% v/v		5
Other biofuels [(11)]	% v/v		[(11)]
Ethanol/Methanol	% v/v	Non-detectable [(12)]	
Total acid number	mg KOH/g		0.08
Ferrous corrosion			Light rusting
Copper corrosion	rating		Class 1
Ash	% m/m		0.01
Particulate contamination, total	see test method		10
Particulate contamination, size distribution	code rating		18/16/13 per ISO 4406
Appearance		Clear and bright; no free water or particulates	
Injector cleanliness (Method 1)	% air flow loss		85
Lubricity (HFRR wear scar dia. @ 60°C)	micron		460

Footnotes:

(1) Cetane Index is acceptable instead of Cetane Number if a standardized engine to determine the Cetane Number is unavailable and cetane improvers are not used. When cetane improvers are used, the estimated Cetane Number must be greater than or equal to the specified value and the Cetane Index must be greater than or equal to the number in parentheses.
(2) May relax the minimum limit to 800 kg/m3 when ambient temperatures are below -30°C. For environmental purposes, a minimum of 815 kg/m3 can be adopted.
(3) May relax the minimum limit to 1.5 mm2/s when ambient temperatures are below -30°C or to 1.3 mm2/s when ambient temperatures are below -40°C.
(4) The unit mg/kg is often expressed as ppm.
(5) Examples of trace metals include, but are not limited to, Cu, Fe, Mn, Na, P, Pb, Si and Zn. Another undesirable element is Cl. No trace metal should exceed 1 mg/kg. No intentional addition of metal-based additives is allowed.
(6) Compliance with either T90 or T95 is required.
(7) If compliance is demonstrated by meeting CFPP, then the maximum must be no more than 10°C less than cloud point.
(8) Methods 2a and 2b must be used with fuels containing FAME. Method 2c correlation data are based on fuels containing FAME.
(9) Alternative test methods, with appropriate limits for no biological growth, can be used.
(10) For FAME, both EN14214 and ASTM D6751, or equivalent standards, should be considered. Where FAME is used, the blendstock should meet the B100 Guidelines published by the WWFC Committee, and fuel pumps should be labelled accordingly.
(11) Other biofuels include HVO and BTL. Blending level must allow the finished fuel to meet all the required specifications.
(12) At or below detection limit of the test method used.

Markets with more stringent requirements for emission controls or other market demands.

PROPERTIES	UNITS	LIMIT Min.	Max.
Cetane Number		53.0	
Cetane Index (1)		53.0 (50.0)(1)	
Density @ 15°C	kg/m3	820 (2)	840
Viscosity @ 40°C	mm2/s	2.0 (3)	4.0
Sulphur	mg/kg (4)		50
Trace metal (5)	mg/kg		1 or non-detectable, whichever is lower
Total aromatics	% m/m		20
PAH (di+, tri+)	% m/m		3.0
T90 (6)	°C		320
T95 (6)	°C		340
Final Boiling Point	°C		350
Flash point	°C	55	
Carbon residue	% m/m		0.20
CFPP or LTFT or CP (7)	°C		Equal to or lower than the lowest expected ambient temperature
Water	mg/kg		200
Oxidation Stability			
Method 1	g/m3		25
Method 2a (Rancimat, modified) (8), or	hours	35	
Method 2b (Delta TAN) (8), or	mg KOH/g		0.12
Method 2c (PetroOxy) (8)	minutes	65	
Foam volume	ml		100
Foam vanishing time	sec.		15
Biological growth (9)		no growth	
FAME (10)	% v/v		5
Other Biofuels (11)	% v/v		(11)
Ethanol/Methanol	% v/v	Non-detectable (12)	
Total acid number	mg KOH/g		0.08
Ferrous corrosion			Light rusting
Copper corrosion	rating		Class 1
Ash	% m/m		0.01
Particulate contamination, total	see test method		10
Particulate contamination, size distribution	code rating		18/16/13 per ISO 4406
Appearance		Clear and bright; no free water or particulates	
Injector cleanliness (Method 1)	% air flow loss		85
Lubricity (HFRR wear scar dia. @ 60°C)	micron		460

Footnotes:

(1) Cetane Index is acceptable instead of Cetane Number if a standardized engine to determine the Cetane Number is unavailable and cetane improvers are not used. When cetane improvers are used, the estimated Cetane Number must be greater than or equal to the specified value and the Cetane Index must be greater than or equal to the number in parenthesis.
(2) May relax minimum limit to 800 kg/m3 when ambient temperatures are below -30°C. For environmental purposes, a minimum of 815 kg/m3 can be adopted.
(3) May relax minimum limit to 1.5 mm2/s when ambient temperatures are below -30°C or to 1.3 mm2/s when ambient temperatures are below -40°C.
(4) The unit mg/kg is often expressed as ppm.
(5) Examples of trace metals include, but are not limited to, Cu, Fe, Mn, Na, P, Pb, Si and Zn. Another undesirable element is Cl. No trace metal should exceed 1 mg/kg. No intentional addition of metal-based additives is allowed.
(6) Compliance with either T90 or T95 is required.
(7) If compliance is demonstrated by meeting CFPP, then it must be no more than 10°C less than cloud point.
(8) Methods 2a and 2b must be used with fuels containing FAME. Method 2c correlation data are based on fuels containing FAME.
(9) Alternative test methods, with appropriate limits for "no biological growth," can be used.
(10) For FAME, both EN14214 and ASTM D6751, or equivalent standards, should be considered. Where FAME is used, the blendstock should meet the B100 Guidelines published by the WWFC Committee, and fuel pumps should be labelled accordingly.
(11) Other biofuels include HVO and BTL. Blending level must allow the finished fuel to meet all the required specifications.
(12) At or below detection limit of the test method used.

Markets with advanced requirements for emission control. Enables sophisticated NOx and PM after-treatment technologies.

PROPERTIES	UNITS	LIMIT Min.	Max.
Cetane Number		55.0	
Cetane Index (1)		55.0 (52.0) (1)	
Density @ 15°C	kg/m3	820 (2)	840
Viscosity @ 40°C	mm2/s	2.0 (3)	4.0
Sulphur	mg/kg (4)		10
Trace metal (5)	mg/kg		1 or non-detectable, whichever is lower
Total aromatics	% m/m		15
PAH (di+, tri+)	% m/m		2.0
T90 (6)	°C		320
T95 (6)	°C		340
Final Boiling Point	°C		350
Flash point	°C	55	--
Carbon residue	% m/m		0.20
CFPP or LTFT or CP (7)	°C		Equal to or lower than the lowest expected ambient temperature
Water	mg/kg		200
Oxidation Stability			
Method 1	g/m3		25
Method 2a (Rancimat, modified) (8), or	hours	35	
Method 2b (Delta TAN) (8), or	mg KOH/g		0.12
Method 2c (PetroOxy) (8)	minutes	65	
Foam volume	ml		100
Foam vanishing time	sec.		15
Biological growth (9)		no growth	
FAME (10)	% v/v		5 (10)
Other biofuels (11)	% v/v		(11)
Ethanol/Methanol	% v/v	Non-detectable (12)	
Total acid number	mg KOH/g		0.08
Ferrous corrosion			Light rusting
Copper corrosion	rating		Class 1
Ash	% m/m		0.001 (13)
Particulate contamination, total	see test method		10
Particulate contamination, size distribution	code rating		18/16/13 per ISO 4406
Appearance		Clear and bright; no free water or particulates	
Injector cleanliness (Method 1)	% air flow loss		85
Injector cleanliness (Method 2)	% power loss		2
Lubricity (HFRR wear scar dia. @ 60°C)	micron		400

Footnotes:

(1) Cetane Index is acceptable instead of Cetane Number if a standardized engine to determine the Cetane Number is unavailable and Cetane improvers are not used. When Cetane improvers are used, the estimated Cetane Number must be greater than or equal to the specified value and the Cetane Index must be greater than or equal to the number in parenthesis.
(2) May relax the minimum limit to 800 kg/m3 when ambient temperatures are below -30°C. For environmental purposes, a minimum of 815 kg/m3 can be adopted.
(3) May relax the minimum limit to 1.5 mm2/s when ambient temperatures are below -30°C or to 1.3 mm2/s when ambient temperatures are below -40°C.
(4) The unit mg/kg is often expressed as ppm.
(5) Examples of trace metals include, but are not limited to, Cu, Fe, Mn, Na, P, Pb, Si and Zn. Another undesirable element is Cl. No trace metal should exceed 1 mg/kg. No intentional addition of metal-based additives is allowed.
(6) Compliance with either T90 or T95 is required.
(7) If compliance is demonstrated by meeting CFPP, then it must be no more than 10°C less than cloud point.
(8) Methods 2a and 2b must be used with fuels containing FAME. Method 2c correlation data are based on fuels containing FAME.
(9) Alternative test methods, with appropriate limits for "no biological growth," can be used.
(10) For FAME, both EN14214 and ASTM D6751, or equivalent standards, should be considered. Where FAME is used, the blendstock should meet the B100 Guidelines published by the WWFC Committee, and fuel pumps should be labelled accordingly.
(11) Other biofuels include HVO and BTL. Blending level must allow the finished fuel to meet all the required specifications.
(12) At or below detection limit of the test method used.
(13) Limit and test method are under review to assure DPF endurance.

Markets with highly advanced requirements for emission control and fuel efficiency. Enables sophisticated NOx and PM after-treatment technologies.

PROPERTIES	UNITS	LIMIT Min.	Max.
Cetane Number		55.0	
Cetane Index [1]		55.0 (52.0) [1]	
Density @ 15°C	kg/m3	820 [2]	840
Viscosity @ 40°C	mm2/s	2.0 [3]	4.0
Sulphur	mg/kg [4]		10
Trace metal [5]	mg/kg		1 or non-detectable, whichever is lower
Total aromatics	% m/m		15
PAH (di+, tri+)	% m/m		2.0
T90 [6]	°C		320
T95 [6]	°C		340
Final Boiling Point	°C		350
Flash point	°C	55	--
Carbon residue	% m/m		0.20
CFPP or LTFT or CP	°C		Equal to or lower than the lowest expected ambient temperature [7]
Water	mg/kg		200
Oxidation stability, Method 1	g/m3		25
Foam volume	ml		100
Foam vanishing time	sec.		15
Biological growth [8]		no growth	
FAME		Non-detectable	
Other Biofuels [9]			[9]
Ethanol/Methanol	% v/v	Non-detectable [10]	
Total acid number	mg KOH/g		0.08
Ferrous corrosion			Light rusting
Copper corrosion	rating		Class 1
Ash	% m/m		0.001 [11]
Particulate contamination, total	see test method		10
Particulate contamination, size distribution	code rating		18/16/13 per ISO 4406
Appearance		Clear and bright; no free water or particulates	
Injector cleanliness (Method 1)	% air flow loss		85
Injector cleanliness (Method 2)	% power loss		2
Lubricity (HFRR wear scar dia. @ 60°C)	micron		400

Footnotes:

[1] Cetane Index is acceptable instead of Cetane Number if a standardized engine to determine the Cetane Number is unavailable and cetane improvers are not used. When cetane improvers are used, the estimated Cetane Number must be greater than or equal to the specified value and the Cetane Index must be greater than or equal to the number in parenthesis.
[2] May relax the minimum limit to 800 kg/m3 when ambient temperatures are below -30°C. For environmental purposes, a minimum of 815 kg/m3 can be adopted.
[3] May relax the minimum to 1.5 mm2/s when ambient temperatures are below -30°C or to 1.3 mm2/s when ambient temperatures are below -40°C.
[4] The unit mg/kg is often expressed as ppm.
[5] Examples of trace metals include, but are not limited to, Cu, Fe, Mn, Na, P, Pb, Si and Zn. Another undesirable element is Cl. No trace metal should exceed 1 mg/kg. No intentional addition of metal-based additives is allowed.
[6] Compliance with either T90 or T95 is required.
[7] If compliance is demonstrated by meeting CFPP, then it must be no more than 10°C less than cloud point.
[8] Alternative test methods, with appropriate limits for "no biological growth," can be used.
[9] Other biofuels include HVO and BTL. Blending level must allow the finished fuel to meet all the required specifications.
[10] At or below detection limit of the test method used.
[11] Limit and test method are under review to assure DPF endurance.

The latest test methods should be used unless otherwise indicated by specific method year. On those parameters where 'no detectable' is listed, the lowest possible levels are expected with no intentional additions of this additive or contaminant. Where multiple methods are indicated, the manufacturer should assure the product conforms to the most precise method listed.

PROPERTIES	UNITS	ISO	ASTM	JIS	OTHER
Cetane Number		5165	D613	K 2280	D6890, D7170 [1]
Cetane Index		4264	D4737	K 2280	
Density @ 15°C	kg/m3	3675 12185	D4052	K 2249	
Viscosity @ 40°C	mm2/s	3104	D445	K 2283	
Sulphur content	mg/kg	20846	D5453	K 2541	
		20884	D2622		
Total aromatic content	% m/m		D5186		EN 12916
PAH content (di+, tri+)	% m/m		D5186		EN 12916, D2425
T90, T95, FBP	°C	3405, 3924	D86	K 2254	D2887
Flash point	°C	2719	D93	K 2265	D56
Carbon residue	% m/m	10370	D4530	K 2270	
Cold Filter Plugging Point (CFPP)	°C		D6371	K 2288	EN 116, IP 309
Low Temperature Flow Test (LTFT)	°C		D4539		
Cloud Point (CP)	°C	3015	D2500	K 2269	D5771, D5772, D5773
Water content	mg/kg	12937	D6304	K 2275	
Oxidation stability					
Method 1	g/m3	12205	D2274		
Method 2a (Rancimat, modified)	induction time (hours)				EN 15751
Method 2b (Delta TAN) [2]	mg KOH/g		D664 & D2274 (modified)		
Method 2c (PetroOxy)	minutes				EN 16091
Foam volume	ml				NF M 07-075
Foam vanishing time	sec.				NF M 07-075
Biological growth					NF M 07-070, IP385
FAME content	% v/v		D7371		EN 14078
Ethanol/Methanol content	% v/v		D4815 (modified)		
Total acid number (TAN)	mg KOH/g	6618	D664		
Ferrous corrosion			D665 [3]		
Copper corrosion	merit	2160	D130	K 2513	
Appearance			D4176		Visual inspection
Ash content	% m/m	6245	D482 [4]	K 2272	
Particulate contamination, total	see test method		D6217 FAME-free (mg/l) D7321 with FAME (mg/l)		EN 12662 (mg/kg)
Particulate contamination, size distribution	code rating no. of particles/ml	4406 4407 & 11500	D7619		
Injector cleanliness, Method 1	% air flow loss				CEC (PF-023) TBA
Injector cleanliness, Method 2	% power loss				CEC-F-098 [5]
Lubricity (HFRR wear scar diameter @ 60°C)	micron	12156-1.3	D6079		CEC F-06-A, D7688
Trace metal content					ICP, D7111 modified

[1] ASTM D6890 and D7170 measure Derived Cetane Number (DCN) and are being widely used as alternatives to D613.
[2] Measure Acid Number using D664 before and after aging fuel per D2274 (modified – 115°C).
[3] Procedure A.
[4] Minimum 100 g sample size.
[5] CEC has initiated test development for Internal Diesel Injector Deposits (IDID).

TECHNICAL BACKGROUND GASOLINE

OCTANE NUMBER

Octane number is a measure of a gasoline's ability to resist auto-ignition; auto-ignition can cause engine knock, which can severely damage engines. Two laboratory test methods are used to measure octane: one determines the Research Octane Number (RON) and the other determines the Motor Octane Number (MON). RON correlates best with low speed, mild-knocking conditions and MON correlates with high-temperature knocking conditions and with part-throttle operation. RON values are typically higher than MON, and the difference between these values is the sensitivity, which should not exceed 10. In North America, (RON + MON)/2 is typically used to specify the octane rating, while many other markets typically specify RON.

Vehicles are designed and calibrated for a certain octane rating. When a customer uses gasoline with an octane rating lower than required, knocking may result. Engines equipped with knock sensors can handle lower octane ratings by retarding the spark timing, but this will increase fuel consumption, impair driveability and reduce power, and knock may still occur. Using gasoline with an octane rating higher than recommended will not cause problems.

Gasoline sold at higher altitudes should have the same octane ratings as gasoline sold at lower altitudes. Historically, for older model engines, lower octanes provided the same anti-knock performance at high altitudes as higher octanes provided at sea level. Since 1984, however, most vehicles have been equipped with sophisticated electronic control systems that adjust to changes in air temperature and barometric pressure, and these vehicles require the same octane levels at all altitudes.

This Charter specifies three octane grades in Categories 1-4 for market flexibility, but not all markets need to carry all three grades. Similarly, while Category 5 specifies only two grades, marketers may provide additional grades as long as the minimum RON remains 95 in Category 5 markets. Importantly, fuel providers should make available the octane grades needed by the local market.

Ash-forming (metal-containing) additives sometimes used for boosting octane are not recommended (see Ash-Forming Additives discussion, page 22). Certain oxygenates, on the other hand, also can boost octane but can do so more safely.

Increasing the minimum octane rating available in the marketplace has the potential to help vehicles significantly improve fuel economy and, consequently, reduce vehicle CO_2 emissions. While the improvement will vary by powertrain design, load factor and calibration strategy, among other factors, vehicles currently designed for 91 RON gasoline could improve their efficiency by up to three percent if manufacturers could design them for 95 RON instead. Octane rating is becoming an especially important limiting factor in future efficiency improvements because new, more efficient engine designs, such as smaller displacement turbo-charged engines, are approaching their theoretical knock limits when using lower octane rated gasoline. Raising the minimum market octane to 95 RON will enable manufacturers to optimize powertrain hardware and calibrations for thermal efficiency and CO_2 emissions. All of these technologies and actions will be needed to meet the highly challenging fuel economy and CO_2 requirements emerging in many countries.

SULPHUR

Sulphur naturally occurs in crude oil. If the sulphur is not removed during the refining process it will remain in the vehicle fuel. Cross-contamination also can occur in the fuel distribution system. Sulphur has a significant impact on vehicle emissions by reducing the efficiency of catalysts. Sulphur also adversely affects heated exhaust gas oxygen sensors. Reductions in sulphur will provide immediate reductions of emissions from all catalyst-equipped vehicles on the road.

There has been extensive testing done on the impact of sulphur on vehicle emissions. The following studies (see Table 1) indicate the emission reductions that occur with different vehicle technologies as sulphur is reduced from the 'high' sulphur gasoline to the 'low':

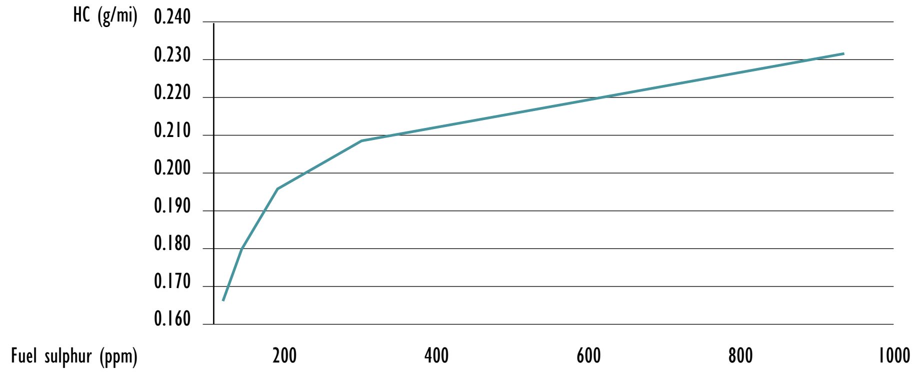
Table 1: Impact of Sulphur on Emissions

Study	Vehicle Technology	Sulphur Range (ppm)		Emission Reduction, % (high to low sulphur)		
		high	low	HC	CO	NOx
AQIRP	Tier 0	450	50	18	19	8
EPEFE	EURO 2+	382	18	9 (43*)	9 (52*)	10 (20*)
AAMA/AIAM	LEV & ULEV	600	30	32	55	48
CRC	LEV	630	30	32	46	61
JARI	1978 Regulations	197	21	55	51	77
Alliance/AIAM	LEV/ULEV	100	30	21	34	27
	LEV/ULEV	30	1	7	12	16
JCAP	DI/NOx cat.	25	2			37

* Reduction achieved during hot EUDC (extra-urban) portion of test.

Figure 1, which depicts the HC reductions from the US AQIRP study, indicates the typical emission reduction for the different studies as the sulphur level changes, including the significant reduction when sulphur is reduced from about 100 ppm to 'low' sulphur fuel. The data illustrate the importance of a very low sulphur limit for advanced technology vehicles.

Figure 1: Sulphur Effects on Tier 0 Technology



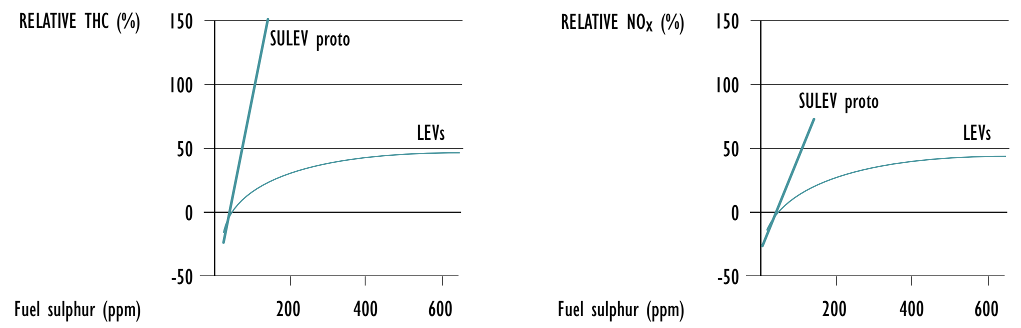
In addition, laboratory research of catalysts has demonstrated delays in light-off time, increases in light-off temperature and reductions in efficiency resulting from higher sulphur fuels across a full range of air/fuel ratios. Studies have also demonstrated that sulphur slows the rich to lean transition, thereby introducing an unintended rich bias into the emission calibration.

Stringent Emission Standard Challenges

Stringent emission requirements, combined with long-life compliance, demand extremely efficient, and durable, after-treatment systems. For example, it is generally recognised that catalyst hydrocarbon efficiency at 100,000 miles must be at least 93% for a vehicle meeting Low Emission Vehicle (LEV)/EURO 3 standards, and about 97% for a vehicle meeting Ultra-LEV/EURO 4 standards. Studies on LEVs indicate that warmed-up catalyst HC efficiency (i.e., excluding the start-up portion) must be 98% or better for 120,000 miles to ensure that new US Tier 2 emission limits are met. These standards represent significant technological hurdles, even in markets with high quality (Category 3) gasoline.

Figure 2 indicates the significant HC and NOx sensitivity to sulphur content. Advanced technologies indicate an even higher response to sulphur.

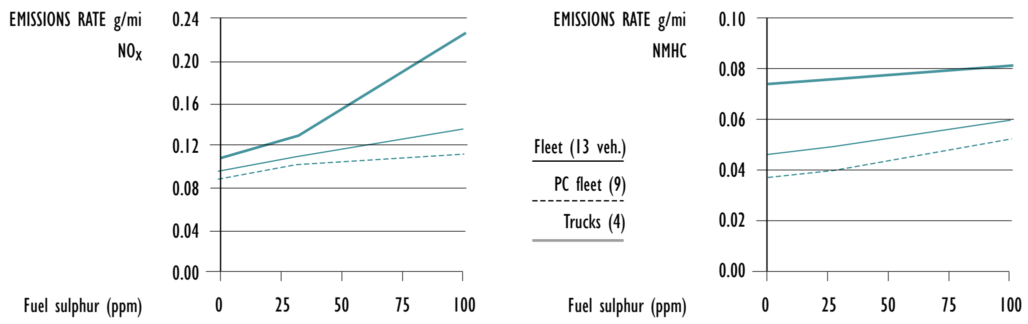
Figure 2: Effects of Fuel Sulphur on Emissions (relative to 30 ppm Sulphur Fuels)



In 2001, the Alliance and AIAM completed a joint test program to evaluate the emission effects of decreasing fuel sulphur levels ranging from 100 to 30 to 1 ppm S in a California Phase 2 reformulated gasoline containing 11% MtBE. The test fleet consisted of 13 vehicles with LEV and ULEV technology, including nine passenger cars and four light trucks. Vehicles were tested using the U.S. EPA Federal Test Procedure (FTP). The relative rate of emissions reduction in the 30 to 1 ppm S range may have been due to a sulphur contribution from the engine lubricant.

Figure 3 shows how the emissions of NOx and non-methane hydrocarbons (NMHC) continue to decline significantly at ultra-low sulphur levels for advanced technology vehicles.

Figure 3: Effects of Ultra-Low Sulphur Levels on Emissions of NOx and NMHC



Sulphur also will affect the feasibility of advanced on-board diagnostic system requirements. Existing California on-board diagnostic (OBD II) regulations require vehicles to be equipped with catalyst monitors that determine when catalyst efficiency changes and tailpipe emissions increase by 1.5 times the standard. The loss of catalyst efficiency resulting from high sulphur fuels could cause some catalyst monitors to indicate a problem code resulting in the illumination of a malfunction indicator light to signal the driver. Similarly, some LEV data demonstrate that the catalysts monitor could fail to identify when a catalyst operated on high sulphur fuel is no longer able to function.

Advanced and Future Technology

NOx emission control to the limits required by emission standards associated with Category 4 and 5 fuels—considering the concurrent needs of maintaining the control for the life of the vehicle and operating under very lean conditions—is among the biggest challenges for emerging emission control technologies, especially when sulphur is present in the fuel. Three way catalysts and lean NOx adsorbers are both highly sensitive to sulphur, albeit to different degrees, and the reversibility of the impact remains a concern for both types of emission control systems. Publicly available data are just beginning to emerge as vehicles with these technologies are becoming more widely available.

One study published in 2011 documented the effect of sulphur on a 2009 Model Year mid-sized sedan with three-way catalyst technology meeting California's PZEV standards (see SAE 2011-01-0300) The study compared the effects of a 3 ppm sulphur gasoline with those of a 33 ppm sulphur gasoline. One of the objectives was to determine whether 3 ppm fuel would cause NOx emission control to deteriorate during repeated testing, similar to the test-to-test deterioration seen with 33 ppm fuel ('NOx creep'). The study first confirmed that, at the low level of emissions being measured from PZEV technology, sulphur levels as low as 33 ppm can indeed contaminate the emission control system and affect test-to-test NOx stability during compliance (FTP) testing. Special procedures not typically found during real world driving can be applied prior to testing to nearly recover the original emission system efficiency, but the contamination and emission system degradation do not occur when 3 ppm sulphur fuel is used. The study also found that using a 3 ppm sulphur fuel can reduce tailpipe NOx emissions by 40% over the emissions produced when the vehicle is operated using a 33 ppm sulphur fuel.

A different type of emission control technology (lean-NOx adsorbers or traps) is required for lean-burn engines to meet emission standards for NOx that are associated with Category 4 and 5 fuels. Manufacturers are working toward ambitious goals for improved fuel consumption/reduced CO_2 emissions, and operation at lean air-fuel ratio is one of the most promising means to achieve these reductions in gasoline-powered vehicles. Manufacturers estimate lean-burn engines have the potential to reduce fuel consumption by up to 10 to 15%, but lean operation introduces a new challenge: while three-way catalysts effectively remove unburned HC and CO during lean operation, they can remove NOx only during stoichiometric or rich operation. Lean-NOx traps can operate in a lean exhaust environment, but they are highly sensitive to sulphur.

Lean NOx adsorber catalysts function by trapping NOx chemically during lean engine operation. NOx can then be released and destroyed over a catalyst by a few seconds of rich operation. However, sulphur oxides are more strongly trapped, and as a competitor to NOx, they reduce the NOx capacity of the adsorber. Sulphur removal requires prolonged rich operating conditions, but the original NOx reduction efficiency level can never be fully recovered. Also, allowing any rich engine operation significantly negates the fuel efficiency benefits of the lean burn engine technologies used with these catalysts. Sulphur-free gasoline is therefore necessary to maximise the benefits of lean-burn, fuel-efficient technology.

Figure 4 and Figure 5 provide examples of the adverse effect of sulphur on storage-type NOx reduction catalysts. With increased exposure time, the lower sulphur gasolines allow the catalysts to retain a higher NOx conversion efficiency. Further tests in vehicles (Figure 6 and Figure 7) confirm the critical need for very low sulphur gasolines. Maintaining a high level of NOx conversion efficiency over a long period of time—e.g., for the life of the vehicle—is another major concern due to sulphur's cumulative impact in the field. Figure 8 shows how ultra-low sulphur gasoline can maintain much higher NOx conversion efficiencies over time compared with higher sulphur levels. Thus, ultra-low or sulphur-free gasoline is required to achieve and maintain high NOx conversion efficiencies over years of vehicle use.

Figure 4: Sulphur Effect on Low Emission Vehicles – Direct Fuel Injection Engines (Japan Clean Air Program)

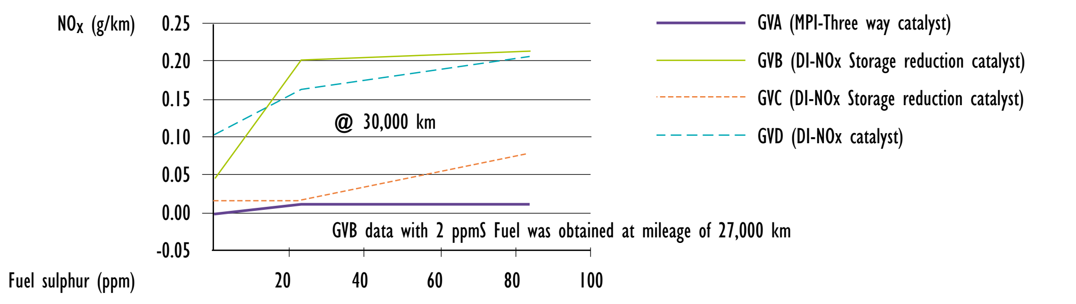


Figure 5: Effect of Fuel Sulphur on Lean NOx Traps Flow Reactor Study

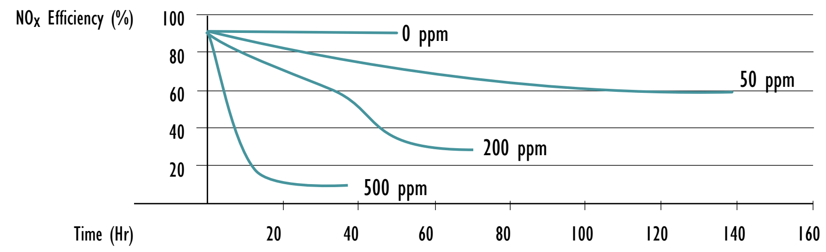


Figure 6: Influence of Sulphur Concentration in Gasoline on Vehicle Aftertreatment System Durability

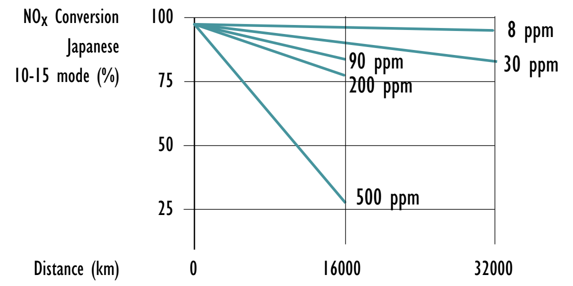


Figure 7: Lean NOx Adsorber Catalyst Data – Catalyst NOx Breakthrough vs. Fuel Consumed & Fuel Sulphur Content

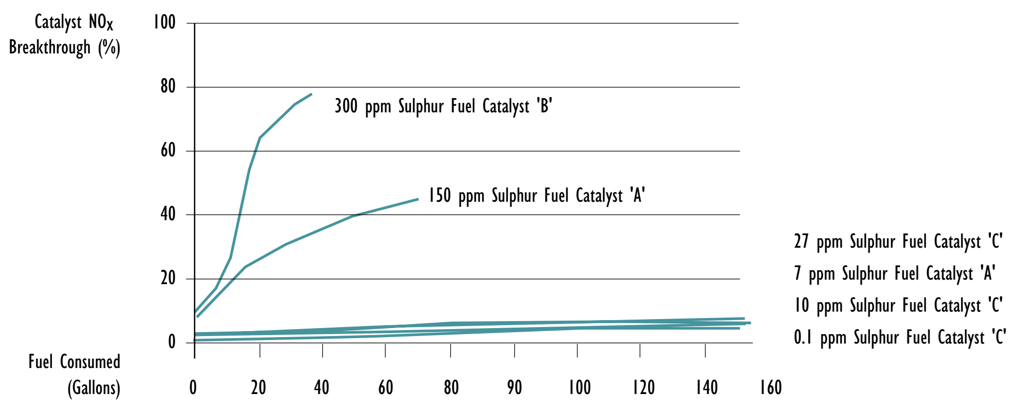
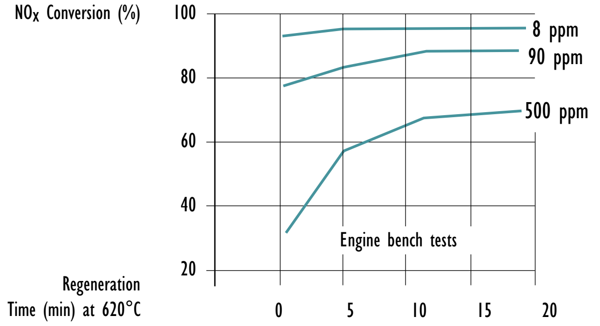


Figure 8: Regeneration of Sulphur Poisoning



ASH-FORMING (METAL-CONTAINING) ADDITIVES

Today's vehicles employ sophisticated exhaust emission control equipment and strategies, such as close-coupled high cell density three-way catalysts, ceramic oxygen sensors and computerized engine control modules that provide precise closed-loop control. These systems must be kept in optimal condition to maintain the vehicle's low emissions capability. Ash-forming fuel additives, such as organo-metallic compounds, and metallic contaminants, such as calcium, copper, phosphorous, sodium and zinc, can adversely affect the operation of these systems in an irreversible way that increases emissions. Thus, high-quality gasoline should be used and ash-forming additives and contaminants must be avoided.

Lead

Tetra-ethyl lead has been used historically as an inexpensive octane enhancer for gasoline, but it will poison vehicle emission control systems. The lead binds to active sites within the catalyst and oxygen sensor, greatly reducing their effectiveness. The tolerance to lead contamination has steadily declined as catalyst efficiencies and sensors have improved, so even a slight amount of lead in the fuel will irreversibly disable the emission control system. As a result, vehicle hydrocarbon and NOx emissions will increase even when the vehicle returns to using lead-free gasoline. Unleaded gasoline must be available wherever catalyst-equipped vehicles refuel; increasingly, this means every market around the world. A global lead-free market also is essential for public health, given lead's well-known adverse health effects. These concerns have led most countries to require lead-free gasoline; the few that have not yet done so should eliminate the use of this fuel additive as soon as possible.

Manganese (MMT)

Manganese is a key component of methylcyclopentadienyl manganese tricarbonyl (MMT), which also is marketed as an octane-enhancing fuel additive for gasoline. Like lead, manganese in the fuel will irreversibly reduce the efficiency of exhaust emission control systems.

Studies have shown that most of the MMT-derived manganese in the fuel remains within the engine, catalyst and exhaust system. The oxidized manganese coats exposed surfaces throughout the system, including spark plugs, oxygen sensors and inside the cells of the catalytic converter. These effects result in higher emissions and lower fuel economy. The effect is irreversible and cumulative.

- The coating of internal engine components, such as spark plugs, can cause in-cylinder combustion misfire, which leads to increased HC and CO emissions, increased fuel consumption, poor vehicle driveability and possible physical damage to the catalyst. These conditions result in increased owner dissatisfaction and expensive repairs for consumers and vehicle manufacturers.
- MMT's combustion products also accumulate on the catalyst. In some cases, the front face of the catalyst an become plugged with deposits, causing increased back pressure, poor vehicle operation and increased fuel consumption in addition to reduced emission control.

In 2002, automobile manufacturers jointly completed a multi-year study of the real-world impact of MMT on Low Emission Vehicles (LEVs). After 100,000 miles of driving with fuel containing 1/32 g Mn/gal, the test fleet showed significantly increased non-methane organic gases (NMOG), CO and NOx emissions. MMT also significantly decreased fuel economy; on average, on-road (highway) fuel economy was about 0.5 miles per gallon (mpg) lower than with a clear test gasoline (Figure 9). Similar results were found in another part of the study with earlier model vehicles equipped with Tier 1 emission control technology, where HC emissions increased after 50,000 miles of driving. Figure 10 provides visual evidence of MMT's impact on parts used in some Tier 1 and LEV vehicles. The spark plug and oxygen sensor came from vehicles used in the 2002 joint automaker study, and the catalytic converters came from market vehicles, one driven in Canada when MMT was in widespread use and the other driven in California where MMT is not allowed. The reddish-brown deposits were identified as oxidized manganese.

Figure 9: Emission and Fuel Economy Effect of MMT – 1998-99 LEVs

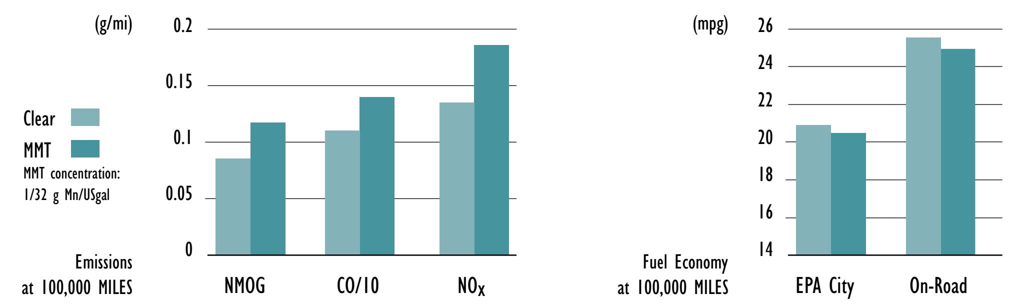
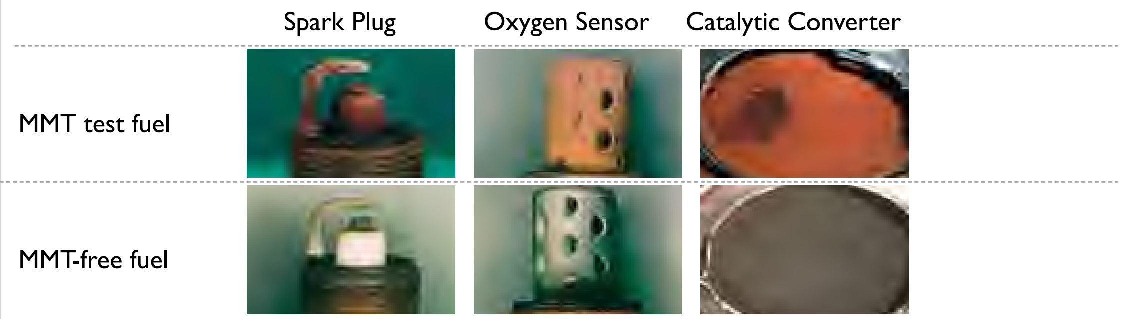


Figure 10: Impact of MMT on Tier 1/LEV Parts at 50,000 Miles



Around the time when this study was released (2002), North American automakers began to notice increased warranty claims in Canada, where MMT was in widespread use, compared to claims in the U.S., where MMT was not in widespread use. The growth in claims was occurring just as new emission control technologies were being introduced. Beginning in the late 1990s, automakers had been introducing vehicles with high cell density catalysts, close-coupled catalysts, catalysts with new washcoats, more sophisticated computerized engine-control systems and engine design modifications, in anticipation of more stringent emission standards. By the early 2000s, the newer technologies were penetrating the Canadian fleet at increasing rates, varying by manufacturer and model. Today, in the EU, Japan, North America and many other developed markets, these highly advanced technologies now dominate the fleets because they are needed to meet stringent emission standards.

Sierra Research, Inc., compiled and analysed these observations in Sierra Report SR2008-08-01, Impacts of MMT Use in Unleaded Gasoline on Engines, Emission Control Systems and Emissions (available at www.autoalliance.org). The report revealed cases of severe catalyst plugging, driveability problems, illumination of the dashboard engine malfunction indicator light (MIL) and increased tailpipe emissions, among other adverse effects (Table 2). The automakers conducted laboratory tests to confirm the in-use findings, investigated causative factors and measured the emission impacts. The data confirmed their suspicions: MMT had adversely affected at least 25 different models, including both advanced and older technologies of 1999-2003 model year vintage produced by nine different manufacturers and accounting for about 85% of Canadian light-duty vehicle sales in 2006. The magnitude of this statistic fails to reflect the full potential impact, however, due to unknowns and varying conditions such as changing vehicle technologies, fuel quality, vehicle mileage, MMT concentrations and actual use of MMT-containing gasoline. The report's Executive Summary includes the following statement:

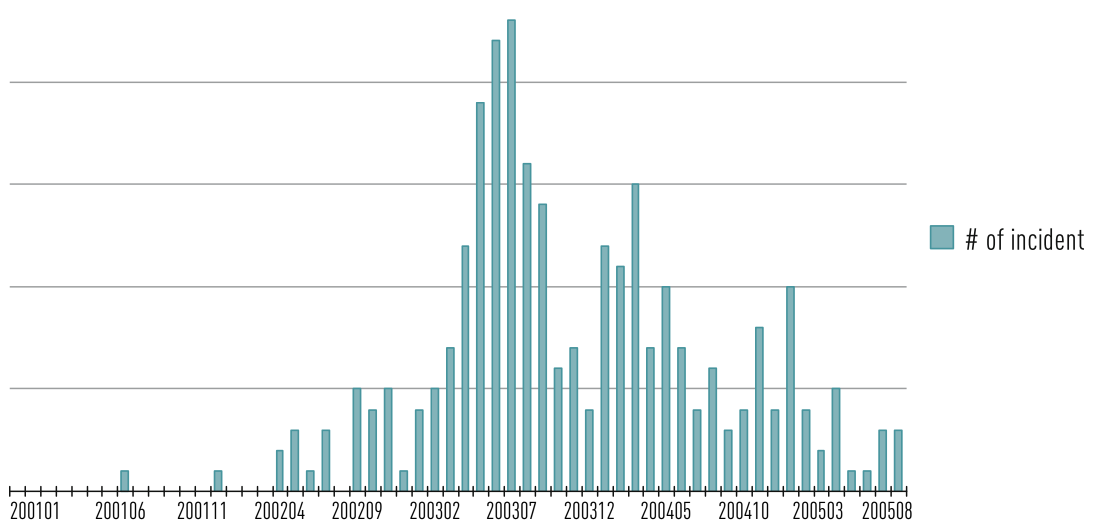
There is no demonstrated method, other than eliminating MMT® from the fuel, to ensure that an emission control system that allows a vehicle to comply with the requirements of the Tier 2/LEV II regulations will not experience catalyst plugging caused by manganese oxides as well as one or more of the observed problems of degraded driveability, MIL illumination, and increased emissions.

Table 2. Source of Evidence of Adverse MMT® Impacts on Exhaust Emissions, Operation and Performance of In-Use Canadian Vehicles with Advanced Emission Control Technologies and Systems

MFR	Warranty Claims	In-Use Vehicle Inspection	Laboratory Testing	Emissions Testing	Number of Models Impacted by MMT® Identified	Model Years
A	YES	YES	NO	NO	1	1999
C	YES	YES	YES	YES	4	2000-2002
D	YES	YES	YES	YES	2	2003
I	NO	YES	NO	NO	1	2002
J	YES	YES	YES	YES	7	2002-2003
K	YES	YES	YES	YES	1	2003
L	NO	YES	YES	YES	3	2001
M	YES	YES	YES	YES	5	2001-2003
O	NO	NO	YES	NO	1	2001

After Canadian refiners voluntarily halted MMT use between 2003 and 2005 (most use had ended by the summer of 2004), automakers then observed a rapid decline in the incidence of catalyst plugging. Figure 11 shows one manufacturer's month-by-month warranty analysis for the period between 2001 and 2005. Other manufacturers found similar impacts, including the reversal of the monitored effect as MMT was phased out in most of Canada.

Figure 11. Warranty Analysis: Number of Catalyst Replacement Incidences per Month due to MMT Plugging (Manufacturer C)

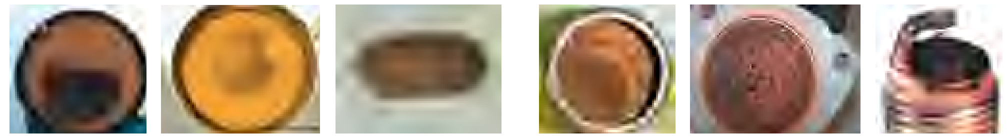


Automakers consider the above statistics to be very conservative and believe the true vehicle impact was actually greater than recorded. Since the vehicle impairment also meant the emission control systems were functioning poorly, automakers conservatively estimate that VOC, CO and NOx emissions would have increased by 77%, 51% and 12%, respectively, by 2020, if MMT had been reintroduced into Canada in 2008. The reader is referred to the Sierra Report for more detail concerning this analysis.

The real-world evidence of adverse impacts continues to grow. In addition to the above studies and experience in North America, several major companies have reported failed emission components in China, South Africa, parts of Eastern Europe, parts of Asia, and/or Argentina. South African vehicles, which have less advanced control systems than in Canada but use fuel with higher levels of MMT, also have been adversely affected (Figure 12). Given this overwhelming body of information, automobile manufacturers remain

extremely concerned about MMT's impact, especially on the highly sensitive technologies that are being or will be used in markets around the world. Most major auto manufacturers state in their Owner Guides that they recommend against the use of MMT, advising further that any damage caused by MMT may not be covered by the warranty.

Figure 12: Evidence of MMT's Impact on Canadian and South African Vehicles



A: Canada *B: South Africa*

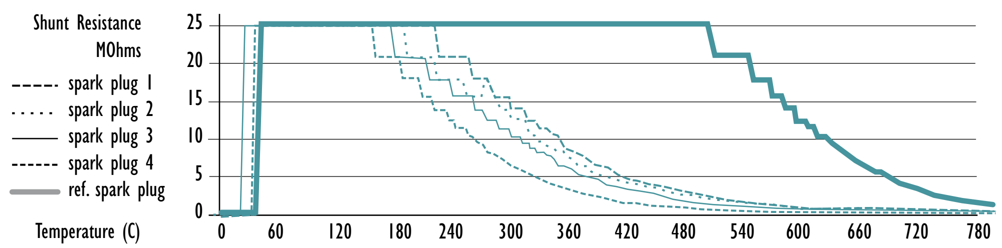
Information on the amount of MMT consumed worldwide is not publicly available, although fuel surveys suggest frequent use in several countries outside of Europe, Japan and North America. In other markets, surveys show that manganese is virtually absent from market gasoline, either as a result of regulation or voluntary action by fuel providers. U.S. law, for example, prohibits MMT use in federal reformulated gasoline (RFG), which constitutes more than one third of the U.S. gasoline pool, and the State of California also bans use in that state. Even outside RFG and regulated areas, the fuel is voluntarily MMT-free. Fuel providers in Canada, India, Indonesia and Japan also are voluntarily providing MMT-free gasoline. In 2009, the European Parliament adopted market restrictions on MMT that were upheld in 2011 against a legal challenge. South Africa adopted a dual fuel approach where gasoline with MMT may legally be sold for use in older vehicles (as Lead Replacement Petrol), but that market has been declining. China is among the regions where MMT use has been growing. In 2011, however, the government adopted a rule imposing tight limits nationwide beginning in 2014. For markets where at least some gasoline contains MMT, appropriate pump labelling is imperative to inform the consumer.

Iron (Ferrocene)

Ferrocene has been used to replace lead as an octane enhancer for unleaded fuels in some markets. It contains iron, which deposits on spark plugs, catalysts and other exhaust system parts as iron oxide, and may also affect other engine components. The deposits will cause premature failure of the spark plugs, with plug life being reduced by up to 90% compared to normal service expectations. Failing spark plugs will short-circuit and cause misfiring when hot, such as under high load condition. This may cause thermal damage to the exhaust catalyst.

Figure 13 shows the reduction in spark plug insulator resistance as a function of temperature. The results compare plugs using fuel with a ferrocene additive after only 32 hours of testing, with a reference plug using conventional gasoline after 300 hours of testing.

Figure 13: Insulator Resistance at Temperature Test Results for Spark Plugs Taken from Test Engine after 32 Hours



Iron oxide also acts as a physical barrier between the catalyst/oxygen sensor and the exhaust gases, and also leads to erosion and plugging of the catalyst. As a result, the emission control system is not able to function as designed, causing emissions to increase. Additionally, premature wear of critical engine components such as the pistons and rings can occur due to the presence of iron oxide in the vehicle lubrication system.

CONTAMINANTS

Contaminants, including some from additives, whether intentionally or inadvertently added during fuel production or distribution, can cause significant harm to the powertrain, fuel, exhaust or emission control systems. Good housekeeping practices can help minimize or prevent inadvertent contamination. No detectable levels of the elements listed below should exist in gasoline, nor should they be used as components of any fuel additive package intended to improve gasoline and engine performance. These elements should be strictly controlled, and it may prove necessary to check and control the fuel quality at the pump.

- Phosphorus, which is sometimes used as a valve recession additive, can foul spark plugs and will deactivate catalytic converters.
- Silicon is not a natural component of gasoline but has been found in commercial gasoline in several instances. The source usually is silicon-containing waste solvents added to the gasoline after the fuel has left the refinery. Such contamination has significant adverse effects on the engine and emission control systems. Silicon, even in low concentrations, can cause failure of the oxygen sensors and high levels of deposits in engines and catalytic converters. These impacts can lead to catastrophic engine failures in less than one tankful of contaminated fuel.
- Chlorine, which is not naturally contained in petroleum, has been found in gasoline in both inorganic and organic forms. Inorganic chlorine usually enters the fuel as a result of contamination by sea water ballast during shipping or from salt water intrusion during storage. Such contamination occurs more readily in gasoline-ethanol blends than in E0 due to the blends' ability to dissolve more water. Organic chlorine may enter the fuel through adulteration with chemical or waste solvents. Chlorine forms highly corrosive acids during combustion, which can reduce significantly the durability of the engine, fuel system and emission control system. In the worst case, the presence of chlorine may lead to catastrophic engine failure as injectors fail to operate or operate improperly after various periods and levels of exposure.

OXYGENATES

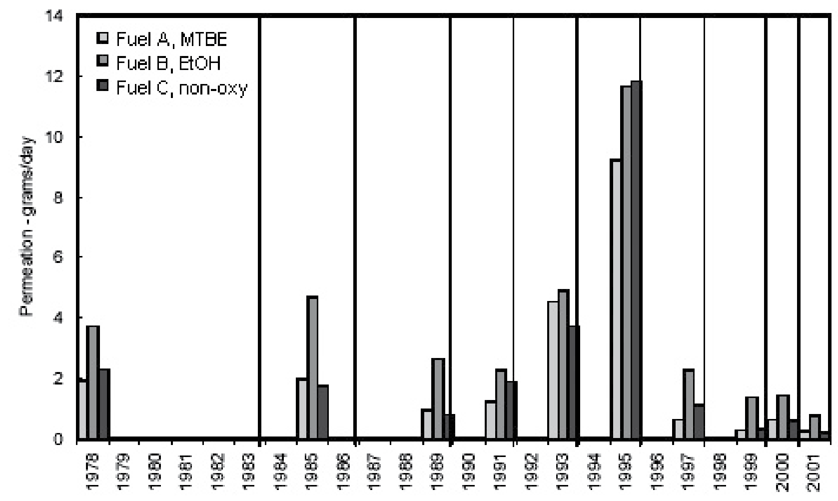
Oxygenated organic compounds, such as MtBE and ethanol, often are added to gasoline to increase octane or extend gasoline supplies. Oxygenating the fuel also may affect vehicle emissions (tailpipe, evaporative or both), performance and/or durability. Adding ethanol also affects the distillation of the gasoline blend. See Volatility, below.

Adding oxygenates to gasoline will induce a lean shift in engine stoichiometry, which, in turn, will reduce carbon monoxide (CO) emissions, especially from carburetted vehicles without electronic feedback-controlled fuel systems. These emission benefits are smaller in modern electronic feedback-controlled vehicles, however, because the leaning effect only occurs during cold operation or during rapid accelerations. In fact, fuel-leaning caused by oxygenates can cause tailpipe emissions to increase, depending on the leanness of the engine's base calibration with non-oxygenated gasoline. The California Air Resources Board (CARB) found in emission tests on 14 1990-1995 model year vehicles that a gasoline containing 10% ethanol by volume decreased toxic emissions by 2% and CO by 10% but increased NOx by 14%, total HC by 10% and ozone-forming potential by 9%, relative to a gasoline containing 11% MtBE by volume. More recent testing by the Coordinating Research Council (CRC) on newer vehicles has produced similar results (CRC E-67).

This over-leaning also can degrade driveability, and it is well documented that ethanol-blended gasoline, in particular, can cause an offset in driveability performance. Increased exhaust hydrocarbon emissions are likely to accompany this offset in driveability performance. Because ethanol has a higher heat of vaporisation than

ethers, some of the driveability and emissions degradation of gasoline-ethanol blends can be attributed to the additional heat needed to vaporise the gasoline.
The use of ethanol-blended gasoline also may affect evaporative emissions. LEV vehicles, for example, have been found to emit approximately 12 percent more evaporative emissions when using 10% ethanol-blended gasoline than when using a hydrocarbon-only fuel (General Motors, 2000). This emissions impact may be due, in part, to the permeation of fuel molecules through elastomeric materials (rubber and plastic parts) used in the vehicle's fuel and fuel vapor handling systems. In a study conducted from January 2003 to June 2004, the CRC in cooperation with CARB found that permeation emissions increased on all 10 vehicle-fuel systems in the study when ethanol replaced MtBE as the test fuel oxygenate (both oxygenated fuels contained 2% oxygen by weight). The ethanol-blended fuel increased the average diurnal permeation emissions by 1.4 g/day compared to the MtBE fuel, and by 1.1 g/day compared to the non-oxygenated fuel (see Figure 14). The study also confirmed previous estimates that permeation of these gasoline-ethanol blends doubles for each 10°C rise in temperature.

Figure 14: Average Diurnal Permeation of Day 1 & Day 2 (CRC E65 Fleet)



The study further examined specific ozone reactivity and found the non-oxygenated fuel to have a statistically higher reactivity than either the MtBE- or ethanol-containing fuels. The average specific reactivities of the two oxygenated fuel permeates were not statistically different. The data support the hypothesis that ethanol-blends tend to increase the permeation of other hydrocarbon species in addition to ethanol. The study is continuing with 2004 model year vehicles, which have to meet more stringent emission standards than those used in the first part of the study.

Based on past experience with impurities in ethanol that have led to degradation of fuel systems, fuel ethanol must have a specification to control pHe and its blending properties (ASTM D 4806). Also, the limits and restriction on the oxygenates permitted in each Category were developed on the basis of emission benefits, vehicle performance and existing regulations. Based on these criteria, when oxygenates are used, ethers are preferred. Also, the use of ethanol-blended gasoline may require other fuel changes to mitigate evaporative and exhaust emission impacts. Maintaining the availability of protection-grade fuel (up to E5) may be necessary in some markets to protect older vehicles designed for ethanol-free gasoline.

Methanol is not permitted. Methanol is an aggressive material that can cause corrosion of metallic com-ponents of fuel systems and the degradation of plastics and elastomers.

OLEFINS

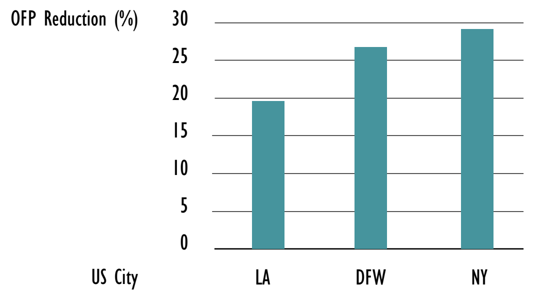
Olefins are unsaturated hydrocarbons and, in many cases, are also good octane components of gasoline. However, olefins in gasoline can lead to deposit formation and increased emissions of reactive (i.e., ozone-forming) hydrocarbons and toxic compounds.

Effect of Olefins on Emissions

Olefins are thermally unstable and may lead to gum formation and deposits in an engine's intake system. Furthermore, their evaporation into the atmosphere as chemically reactive species contributes to ozone formation and their combustion products form toxic dienes.

The effect on ozone-forming potential was clearly demonstrated by the US Auto/Oil programme. The programme concluded that reducing total olefins from 20% to 5% would significantly decrease ozone-forming potential in three critical cities: Los Angeles, Dallas-Fort Worth, and New York City (Figure 15).

Figure 15: Reduction in Ozone-Forming Potential with Reduction in Fuel Olefins (20%-5%)



The model also showed that the same reduction in gasoline olefin level would reduce the light-duty vehicle contribution to peak ozone by 13% to 25% in future years for the cities shown in Figure 15. About 70% of this effect was due to reducing low molecular weight olefins.

AROMATICS

Aromatics are fuel molecules that contain at least one benzene ring. In general, aromatics are good octane components of gasoline and high-energy density fuel molecules. Fuel aromatic content can increase engine deposits and increase tailpipe emissions, including CO_2.

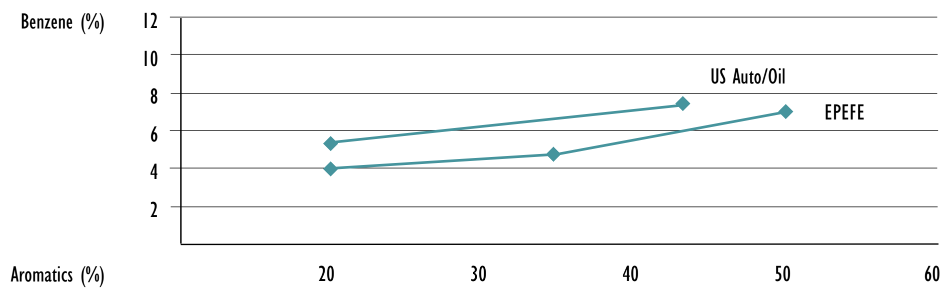
Influence of Aromatics on Engine Deposits

Heavy aromatics, and other high molecular weight compounds, have been linked to engine deposit for¬mation, particularly combustion chamber deposits. As discussed below ('Deposit Control Additives'), these deposits increase tailpipe emissions, including HC and NOx. Since it is not feasible to specify limits for individual hydrocarbon compounds in the fuel, the total aromatic limit in Category 1 and the final boil-ing point limits in Categories 2 and 3 provide the best means to limit heavy aromatics.

Influence of Aromatics on Tailpipe Emissions

Combustion of aromatics can lead to the formation of carcinogenic benzene in exhaust gas and increased combustion chamber deposits which can increase tailpipe emissions. Lowering aromatic levels in gasoline significantly reduces toxic benzene emissions in exhaust from vehicles as shown in both the US AQIRP and the European EPEFE studies. (Figure 16).

Figure 16: Fuel Aromatics Effect on Benzene Exhaust Emissions



Findings from the US AQIRP programme showed that, of all the fuel properties tested, aromatic level had the largest effect on total toxics, largely due to its effect on exhaust benzene emissions as shown in the above figure. Reducing total aromatics from 45% to 20% caused a reduction in total exhaust air toxics of 28% (74% of the total toxic emissions was benzene).

Influence of Aromatics on CO_2 Emissions

Gasoline aromatic content also has a direct effect on tailpipe CO_2 emissions. The European EPEFE programme demonstrated a linear relationship between CO_2 emissions and aromatic content. The reduction of aromatics from 50 to 20% was found to decrease CO_2 emissions by 5%.

BENZENE

Benzene is a naturally occurring constituent of crude oil and a product of catalytic reforming that produces high octane gasoline streams. It is also a known human carcinogen.

The control of benzene levels in gasoline is the most direct way to limit evaporative and exhaust emissions of benzene from automobiles. The control of benzene in gasoline has been recognised by regulators in many countries as an effective way to reduce human exposure to benzene. These gasoline recommendations recognise the increasing need for benzene control as emission standards become more stringent.

VOLATILITY

Proper volatility of gasoline is critical to the operation of spark ignition engines with respect to both perfor-mance and emissions. Volatility may be characterised by various measurements, the most common of which are vapour pressure, distillation and the vapour/liquid ratio. The presence of ethanol or other oxygenates may affect these properties and, as a result, performance and emissions as well.

Vapour Pressure

The vapour pressure of gasoline should be controlled seasonally to allow for the differing volatility needs of vehicles at different ambient temperatures. The vapour pressure must be tightly controlled at high temperatures to reduce the possibility of hot fuel handling problems, such as vapour lock or excessive evaporative emissions due to carbon canister overloading, especially at higher temperatures. At lower temperatures, a sufficiently high vapour pressure is needed to allow ease of starting and good warm-up performance. Therefore, both minimum and maximum vapour pressures are specified.

New data have become available on the effects of vapour pressure. Figures 17 and 18 provide the hydrocarbon slip from canisters for two sample vehicles tested during study of the effects of 48, 62 and 69 kPa E10 (10% ethanol gasoline blend) fuels on canister breakthrough emissions over 14 days of SHED testing using the temperature profile from the U.S. Federal Diurnal Cycle. The data collected throughout the testing provides a correlation between the hydrocarbon slip from the vehicle canister and the fuel vapour pressure. The data indicate that the lower vapour pressure fuels, such as 48 kPa, are imperative during warm ambient temperatures for achieving very low evaporative emissions. The full report, with additional data, can be found at SAE 2013-01-1057. The study provided additional empirical evidence to a previous SAE study (Clontz, SAE Technical Paper No. 2007-01-1929) that showed the most important property of the fuel blend for canister performance is the vapour pressure. More importantly, the vapour pressure, not ethanol concentration, is the determining factor for vapour generation in the fuel tank.

Figure 17: Effect of Vapour Pressure on LEV II PZEV Vehicle Canister During 14-day Diurnal

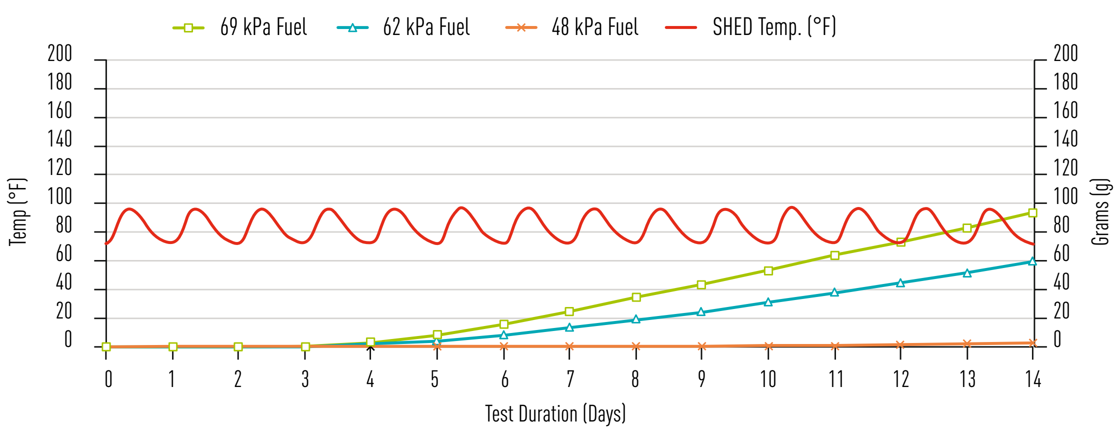
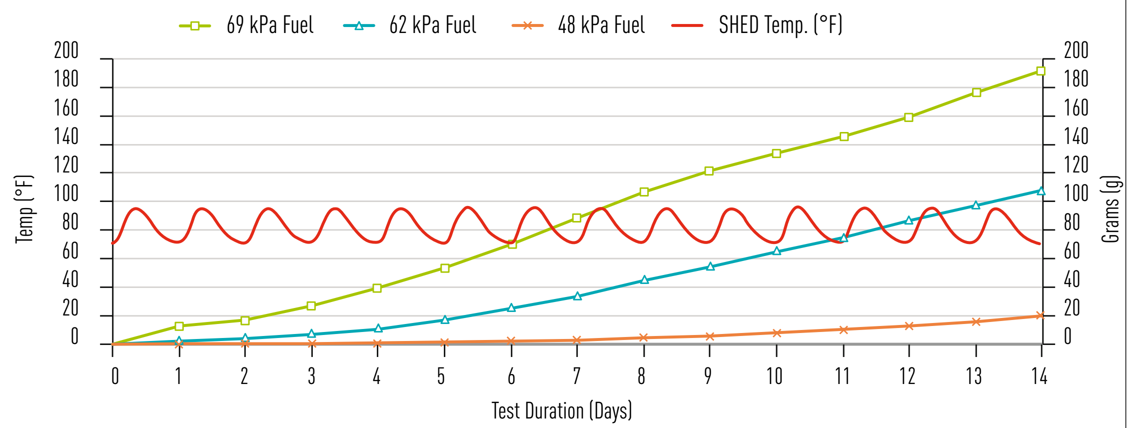


Figure 18: Effect of Vapour Pressure on Tier 2 Vehicle Canister During 14-day Diurnal

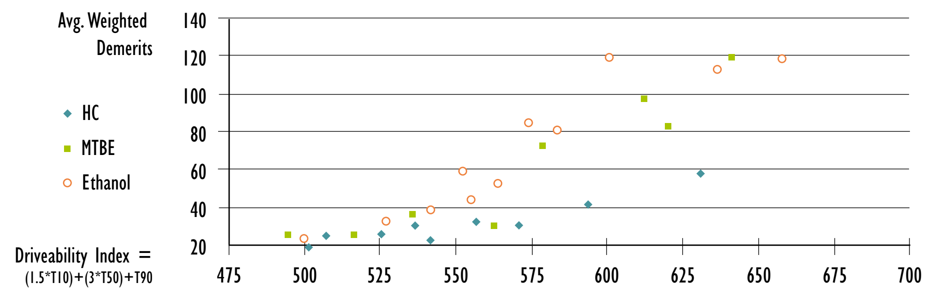


Distillation

Distillation of gasoline yields either a set of 'T' points (T50 is the temperature at which 50% of the gasoline distils) or 'E' points (E100 is the percentage of a gasoline distilled at 100 degrees). Excessively high T50 (low E100) can lead to poor starting and warm-up performance at moderate ambient temperatures. Control of the Distillation Index (DI), derived from T10, T50, T90, and oxygen content, also can be used to assure good cold start and warm-up performance.

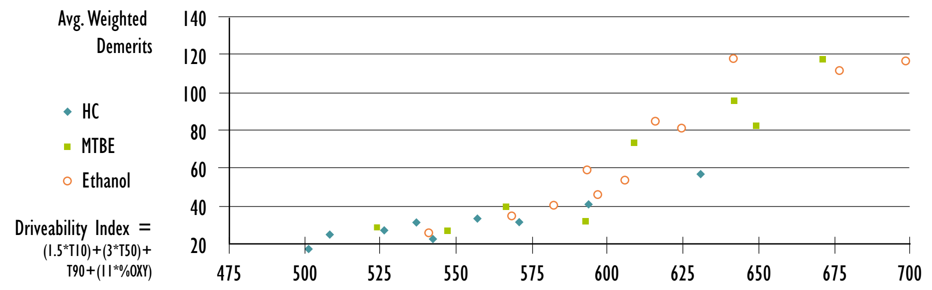
Driveability concerns are measured as demerits. Figure 19 provides the test results from one CRC study of the impact of the Driveability Index on driveability. This study tested 29 fuels: 9 all hydrocarbon, 11 with 10% ethanol and 9 with 15% MtBE. The data indicate that driveability problems increase for all fuel types as the Driveability Index increases. At Driveability Index levels higher than those specified in this Charter, driveability concerns increase dramatically.

Figure 19: Effect of Driveability Index on Driveability



An oxygen correction factor is required to correct for higher driveability demerits for oxygenated fuels as compared to all-HC gasoline. Figure 20 indicates how the correction factor smoothes the data presented in Figure 19.

Figure 20: Effect of DI on Driveability (Oxygen Corrected)



DI also is directly related to tailpipe HC emissions, as shown in Figure 21. As with driveability demerits, HC emissions increase significantly at DI levels higher than those specified in this Charter.

Figure 21: Effect of DI on Driveability and Exhaust Emissions

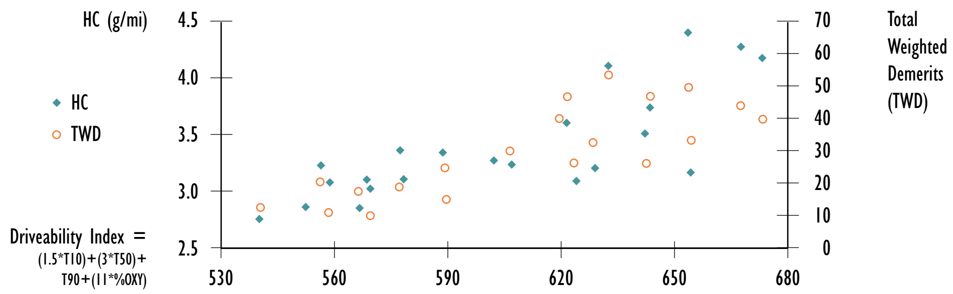
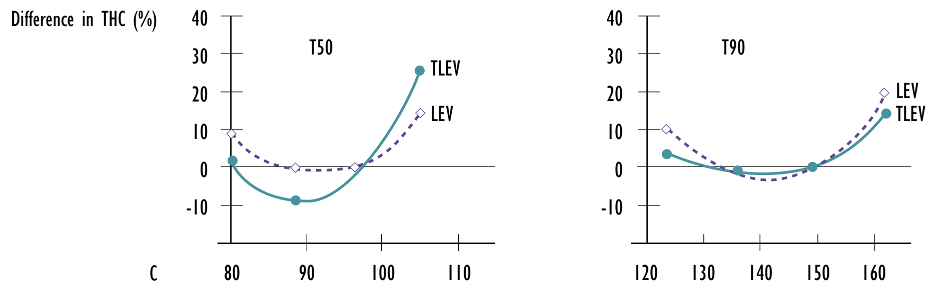


Figure 22 indicates that optimum values for T50 and T90 exist to achieve lower exhaust THC emissions.

Figure 22: Effect of T50/T90 on Exhaust Emissions Comparison of LEV and TLEV



Vapour/Liquid Ratio

Excessively high gasoline volatility can cause hot fuel handling problems such as vapour lock, canister overloading, and higher emissions. Vapour lock occurs when too much vapour forms in the fuel system and decreases or blocks fuel flow to the engine. This can result in loss of power, rough engine operation or engine stalls. Since controls on vapour pressure and distillation properties are insufficient to prevent this problem, a Vapour/Liquid Ratio specification is necessary.

Ethanol's Impact on Volatility

As a pure compound, ethanol exhibits straightforward behaviour regarding vapour pressure and distillation. When added to a base gasoline, however, the behaviour of the mixture is anything but straightforward. As a result, the vapour pressure and distillation of ethanol-gasoline blends, at a minimum, must be carefully regulated to ensure proper vehicle operation and emissions control. Ethanol also will make vapour lock more likely, so controlling the vapour-liquid ratio is even more important when ethanol is present.

Ethanol by itself has a very low vapour pressure, but adding it to gasoline has a non-linear and synergistic effect. Importantly, the final vapour pressure of the blend could be either higher or lower than the base gasoline, depending on temperature and ethanol concentration. At lower ethanol concentrations (below about 10% by volume) and typical temperatures, ethanol will cause the blend's vapour pressure to exceed that of the base gasoline. To prevent excess evaporative emissions, the vapour pressure of the finished blend, not just the base gasoline, must be controlled. Figure 23 illustrates this effect.

Figure 23: Impact of Ethanol Level on Vapour Pressure at 37.8 °C

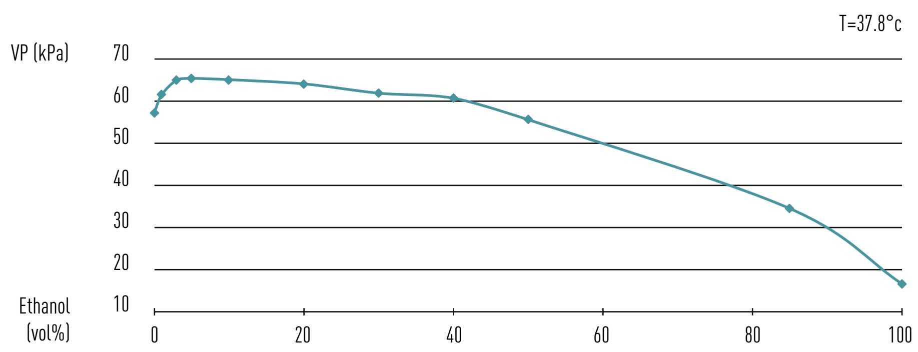
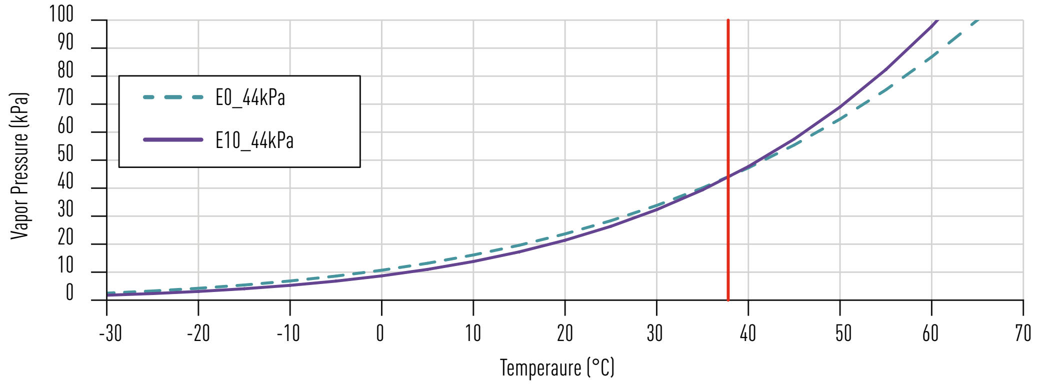
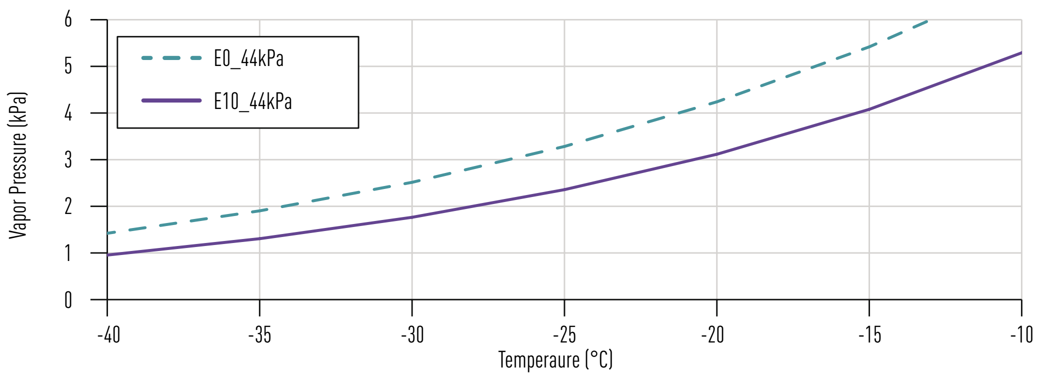


Figure 24, below, looks more closely at the variation for an E10 and its base gasoline (E0), showing the impact for a wider range of temperatures. Importantly, at temperatures above 37.8°C, the E10 has a higher vapour pressure relative to E0, but at lower temperatures, the vapour pressure goes below that of E0. The effect could be significant and prevent an engine from starting at very cold temperatures. Therefore, a higher minimum vapour pressure is required for ethanol-gasoline blends than would be needed for the base gasoline alone at these very low temperatures.

Figure 24: Comparison of E0 and E10 Vapour Pressures at Various Temperatures

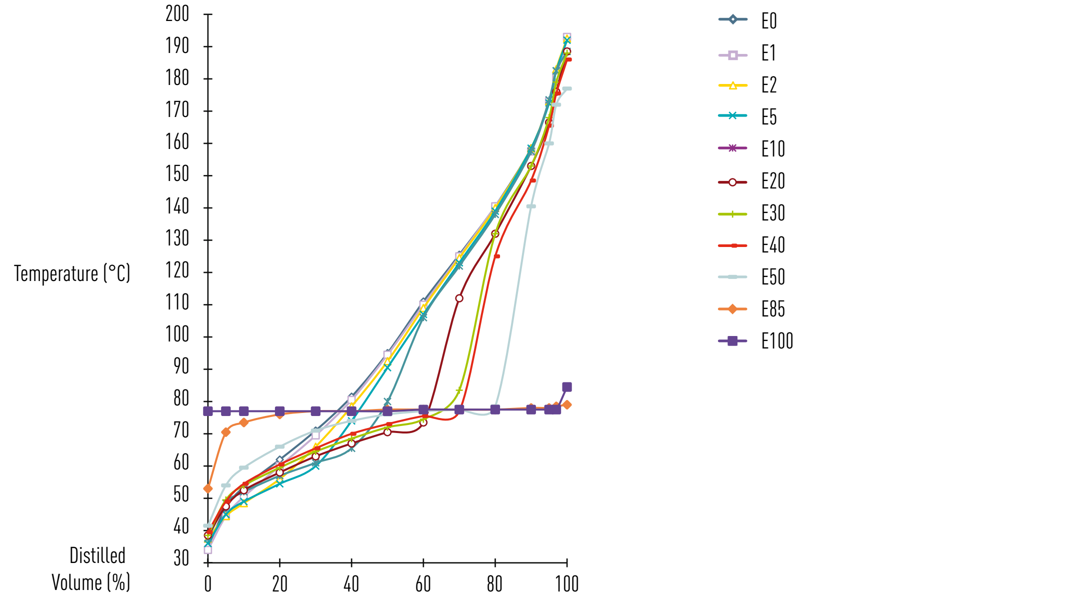


Magnification of Figure 24 at Temperatures Below Freezing



Ethanol's impact on the distillation curve is just as complex, if not more so. Figure 25 shows how different ethanol levels in gasoline can cause dramatic changes in distillation, especially as the ethanol concentration goes above 10% by volume and near the middle of the distillation curve. The distillation measurement must be adjusted to account for the impact, and the blend's distillation must be well-controlled.

Figure 25: Influence of Ethanol on Gasoline Distillation



DEPOSIT CONTROL ADDITIVES

Combustion of even good quality gasoline can lead to deposit formation. Such deposits will increase engine-out emissions and affect vehicle performance. High quality fuel contains sufficient deposit control additives to reduce deposit formation to acceptable rates.

Carburettors

First generation additives based on amine chemistry were developed in the early 1950's and are still used in some countries at levels of 50 parts per million treat rate. Many of these additives were multifunctional, providing anti-icing protection, corrosion inhibition and carburettor detergency performance.

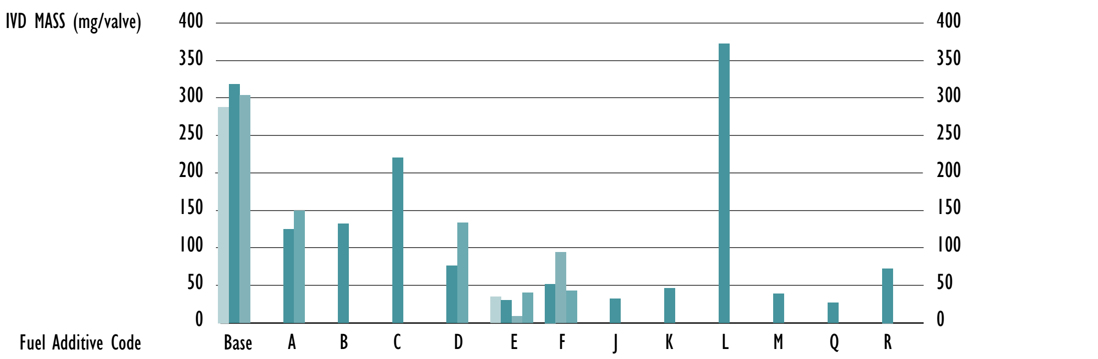
Port Fuel Injectors

US gasoline marketers introduced port fuel injector deposit control additives around 1985 to overcome problems with fuel injector fouling that led to driveability problems. However, treat rates were nearly double those for carburettor detergents resulting in increased intake valve deposits in many cases. Detergent technology and test procedures must be developed to protect the more advanced injectors being introduced in direct injection engines.

Intake Valves

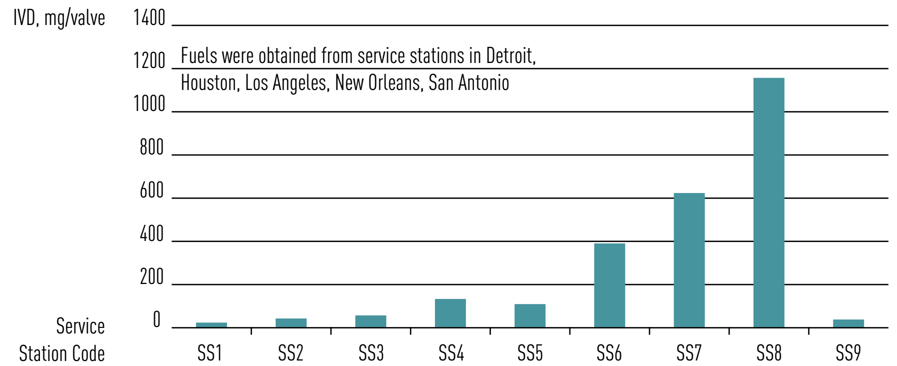
Various tests are available to evaluate the gasoline's capability of maintaining acceptable intake valve cleanliness. Figure 26 shows the performance of base fuel without detergent additives and fuels with various detergent additive chemistries in the Ford 2.3L IVD test (ASTM D6201). Moderate additive treat rates combined with effective carrier fluids help avoid intake valve sticking. Passing the VW Wasserboxer Intake Valve Sticking Test minimises the likelihood of this problem occurring.

Figure 26: IVD Performance of Gasolines With and Without Detergents, Using the Ford 2.3L Dynamometer Test



The impact of intake valve deposits on driveability in both North America and Europe has been severe enough in recent years to prompt vehicle manufacturers to steer customers to gasoline known to contain adequate detergency for minimizing and reducing intake valve deposits. Figure 27 shows the results of a Ford study of US market gasoline performance regarding intake valve deposits conducted in 1999-2000 and presented to ASTM in 2003. One third of the fuel samples caused unacceptable IVD rates ranging from 392 mg/valve to 1157 mg/valve. This problem is continuing to cause concern in 2012.

Figure 27: IVD Performance of Service Station Gasolines, using the Ford 2.3L Dynamometer Test



Combustion Chambers

As combustion chamber deposits (CCDs) form, they reduce the space available in the chamber for combustion while adding small crevices that increase the surface area of the chamber. This phenomenon has three undesirable effects: 1) higher compression ratios and end gas temperatures that increase the octane requirements higher than the engine was designed for, 2) increased exhaust emissions, and 3) mechanical interference between the piston top and cylinder head called 'carbon knock'.

Methods for measuring CCD could be improved. CEC F-20-A (Method 2), for example, produces technically relevant results when the engine operator has detailed knowledge about the measurement precision of the particular test stand, but in general, the method lacks precision data and cannot produce statistically valid CEC results for chamber deposits.

Engine Dynamometer Results

Detergent additives usually increase the level of CCDs relative to base fuel as shown in Figure 28 and Figure 29. Detergent packages with higher ratios of mineral oil carriers tend to increase CCDs, while detergent packages with optimised high-quality synthetic carrier fluids and compounds like polyether amines (PEA) minimise CCD build-up. Additive packages should be optimised to minimise CCDs, which will allow engine designers to improve combustion chamber designs further for lower emissions and fuel consumption.

Figure 28: Engine Dynamometer Results

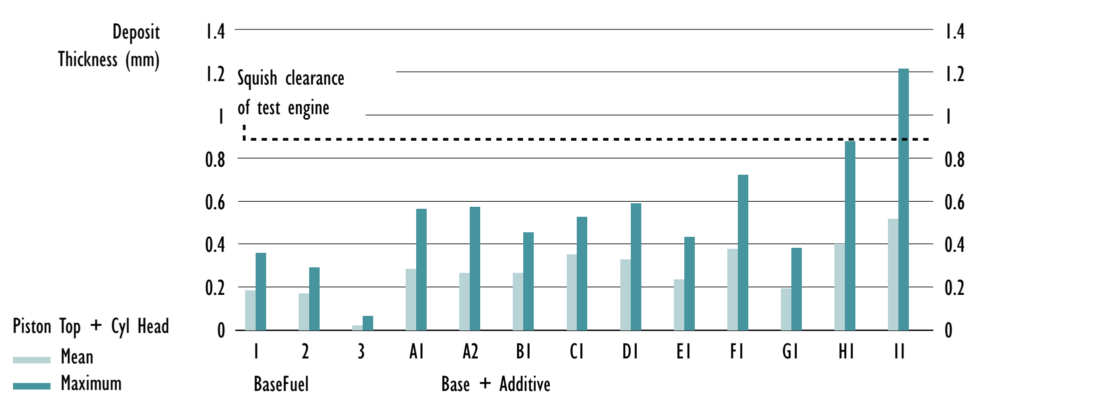
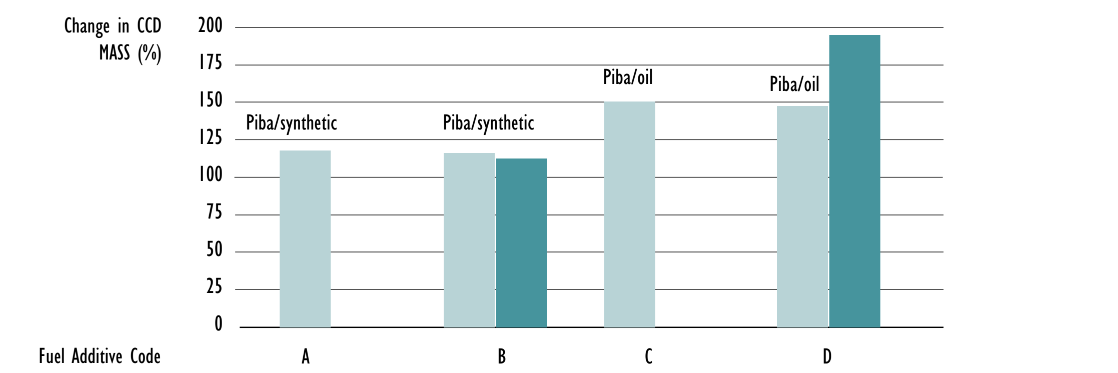


Figure 29: CCD Performance of Gasolines Using the Ford 2.3L Dynamometer Test (ASTM D6201)

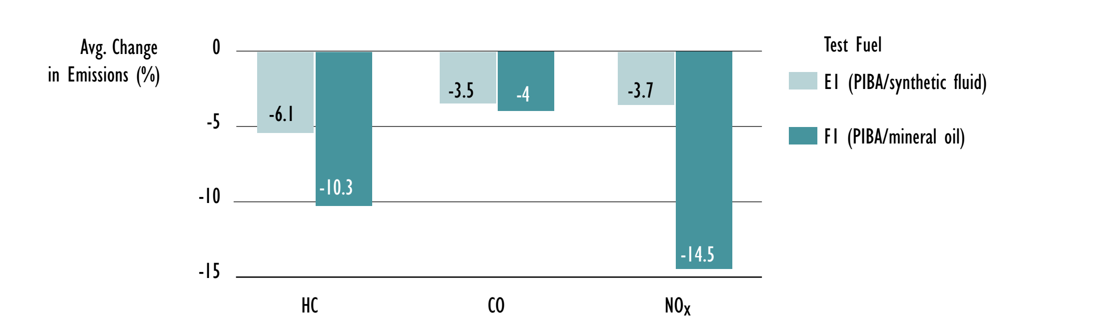


Note: Piba/Synthetic - polyisobutene amine/synthetic oil
Piba/Oil - polyisobutene amine/mineral oil

Effect of CCD Removal on Engine-Out Emissions

The removal of CCDs can reduce engine out HC emissions by up to 10%, CO by 4%, and NOx by 15% as shown in Figure 30 for fleet vehicles after accumulating 50,000 miles.

Figure 30: Effect of CCD Removal on Engine-Out Emissions



Carbon knock in modern engines did not occur even at high mileages in Japan. When these same engines were sold in the US, customers began objecting to the engine noise after only a few thousand miles in some cases. Some customers required replacement of the cylinder heads because of the damage caused by the piston hitting the deposits. Other customers switched brands of gasoline or used after-market deposit control additives to help remove deposits causing carbon knock. The problem in the US was attributed to high-additive treat rates being used for IVD control.

Relationship of CCDs to TGA Test

A test procedure with the Mercedes M111 E engine is being developed to evaluate the CCD-forming tendency of gasolines. A thermogravimetric analysis (TGA) bench test method has been developed that provides a good correlation with CCDs in a dynamometer-based multicylinder engine test as shown in Figure 31 and Figure 32.

Figure 31: Correlation of CCD and TGA Results of Commercial Fuels in Ford 2.3L IVD Test (ASTM D6201)

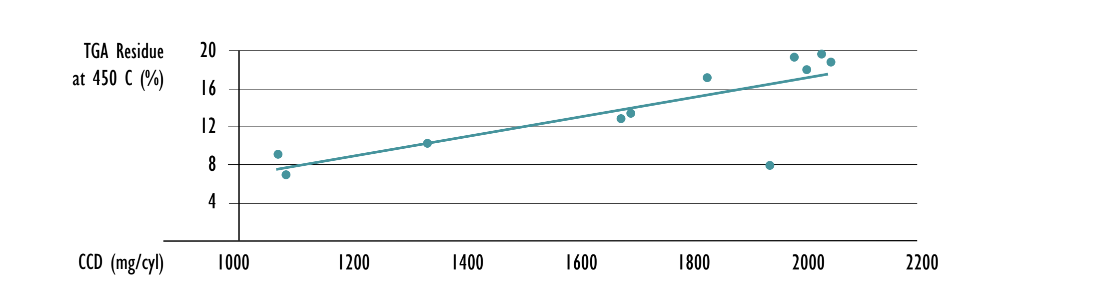
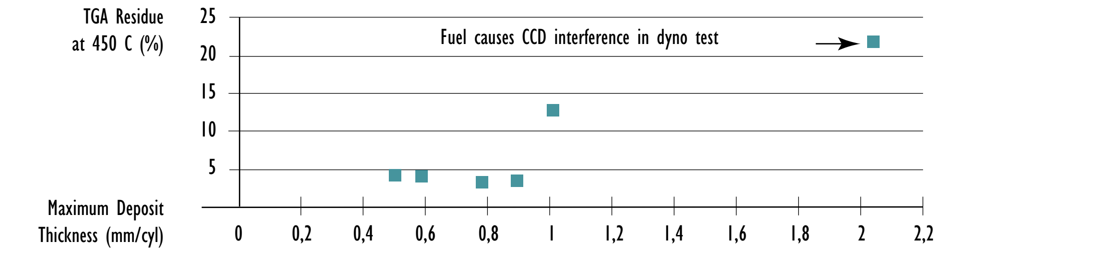


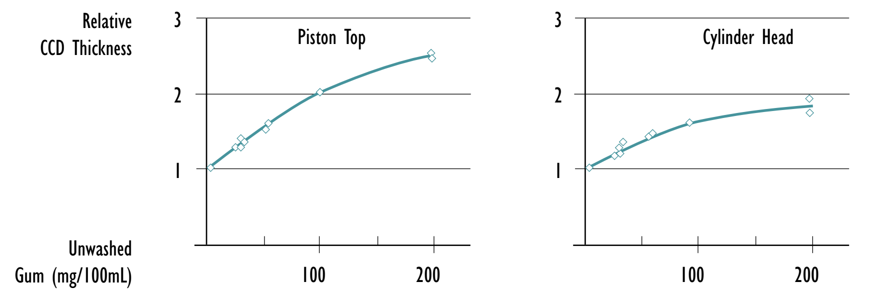
Figure 32: TGA Proposed Pass/Fail Limit - 4.0L Dynamometer Test Results



Relationship between Unwashed Gum and CCD Thickness

Figure 33 indicates the correlation between unwashed gums and CCD formation as compared to base gasoline without detergent. Thus, the Charter allows compliance to either an unwashed gum limit or a CCD requirement.

Figure 33: Relationship between Unwashed Gum and CCD Thickness



As emission standards become more stringent, it is critical for fuel quality to support improvements in emission control technology to meet these limits. Detergent additives that prevent the formation of CCDs have the benefit of helping meet environmental standards while improving vehicle performance.

GOOD HOUSEKEEPING PRACTICES

The problems encountered by vehicles from poor quality fuel often are caused by adulteration that occurs in the fuel distribution system, after the fuel has left the refinery gate. Failure to invest in adequate pipeline and storage facilities and failure to maintain the equipment can lead to volatility losses, fuel leakage and contamination by particulates and water that, in turn, can lead to a host of vehicle problems. Poor operating practices at the service station, such as too infrequent replacement of fuel dispenser filters or 'dipping' of tanks to check for water, can magnify these problems. Appropriate steps should be taken to minimize contamination by harmful elements such as copper, zinc and sodium. Helpful guidance to good housekeeping practices may be found in CEN/TR 15367-2, Petroleum products.

CORROSIVE (ACTIVE) SULPHUR

Certain fuel sulphur compounds, including elemental sulphur, hydrogen sulphide (H_2S), mercaptans and other sulphur-containing molecules, can tarnish silver- and copper-containing metals that are widely used in fuel system parts such as fuel level sender units and fuel pump bearings. Active sulphur compounds may be present in the fuel due to problems during gasoline production, such as improper operation of a refinery's desulphurization process or through accidental events. These compounds are highly reactive, and their presence even at very small levels (a few ppm) can cause harm. The sulphur compounds react with the metal parts to form silver or copper sulphides. In the case of fuel level sender units, which measure the amount of fuel in a fuel tank, the formation of silver sulphide on the electrical contacts interrupts the flow of current to the fuel gauge and causes the gauge to display erratic readings. In the case of fuel pump bearings, which enable the pump to operate smoothly, the formation of copper sulphide on the bearing surface causes the pump shaft to stick, interrupting the pump's smooth operation and potentially causing pump failure and vehicle stalling. To prevent the presence of these compounds in fuel, strict and continuous quality control is required.

TECHNICAL BACKGROUND DIESEL FUEL

CETANE

Cetane is a measure of the compression ignition behaviour of a diesel fuel; higher cetane levels enable quicker ignition. Cetane influences cold startability, exhaust emissions and combustion noise. Higher cetane generally enables improved control of ignition delay and combustion stability, especially with modern diesels which use high amounts of exhaust gas recirculation (EGR). It does this by providing room for engine calibrators to tailor combustion for the best calibration compromise among combustion noise, emissions and fuel consumption goals across the engine operating range. Additives can enhance a fuel's cetane level; natural cetane refers to the cetane level when the fuel contains no additives, and artificial cetane refers to the cetane level in an additized fuel. Cetane levels achieved through additives affect vehicle performance differently than natural cetane levels, and sometimes they produce inconsistent results.

Cetane is measured or derived in various ways. The cetane number is produced by testing the fuel in a test engine (ASTM D613). When the fuel does not contain any cetane improver, the cetane number is the same as the fuel's natural cetane. The derived cetane number, which is produced using a combustion tester (see ASTM D6890 and D7170), is an indirect measure of combustion ignition behaviour that is equated to the cetane number. The cetane index (ASTM D4737) is calculated from certain measured fuel properties (fuel density and distillation temperatures); it is designed to approximate the natural cetane. Since the cetane number and the derived cetane number are measured by combusting the fuel, both may reflect the effects of cetane improver additives; by contrast, the cetane index does not. To avoid excessive additive dosage, the difference between the cetane index and the cetane number must be maintained as specified in the various categories.

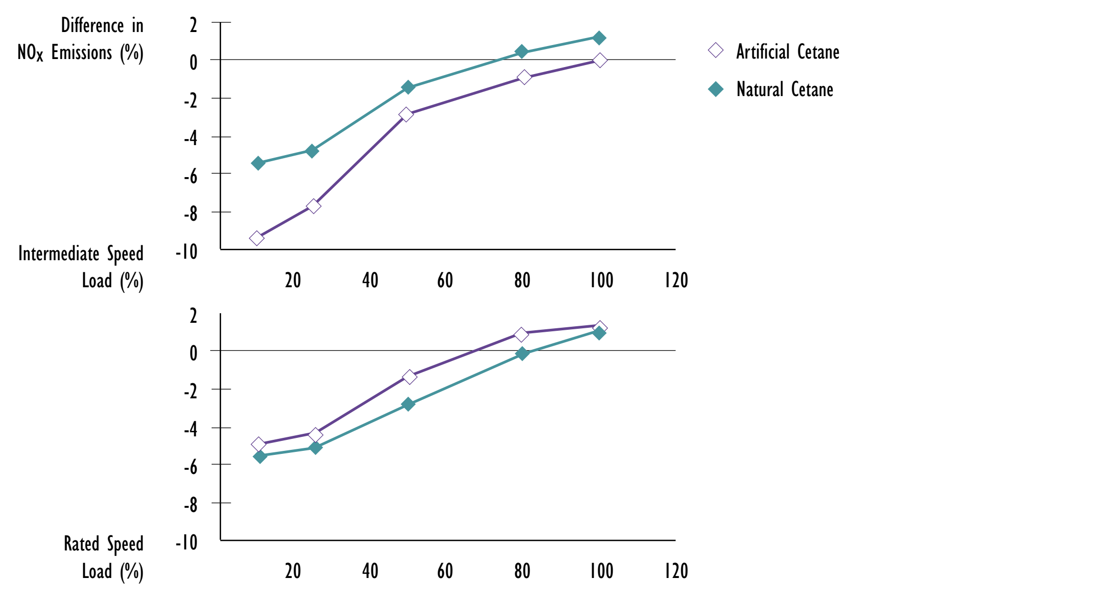
Influence of Cetane on Cold Startability

Increasing the cetane number will decrease engine crank time (the time before the engine reaches 'starter off") at a given engine speed. The ACEA EPEFE follow-up programme, which looked at the influence of diesel fuel quality on heavy-duty diesel engine emissions, demonstrated a significant (up to 40%) reduction in crank time for an increase in cetane number from 50 to 58. A shorter cranking cycle means fewer cycles with incomplete or partial combustion during 'crank to run' operation, and this leads to improved combustion stability and lower noise, vibration and harshness (NVH).

Influence of Cetane on Exhaust Emissions

The following figures show the influence of cetane on NOx emissions as a function of engine load in heavy-duty engines (88/77/EEC 13-mode cycle). Cetane's influence on NOx is very significant (Figure 1), particularly at low loads where reductions of up to 9% are achieved. (Note that each point in the graphs shows the NOx reduction achieved for cetane increase at a given load.) The cetane increase also reduced HC emissions by 30-40%. For light-duty vehicles, EPEFE found that increasing the cetane number from 50 to 58 would reduce HC and CO each by 26%.

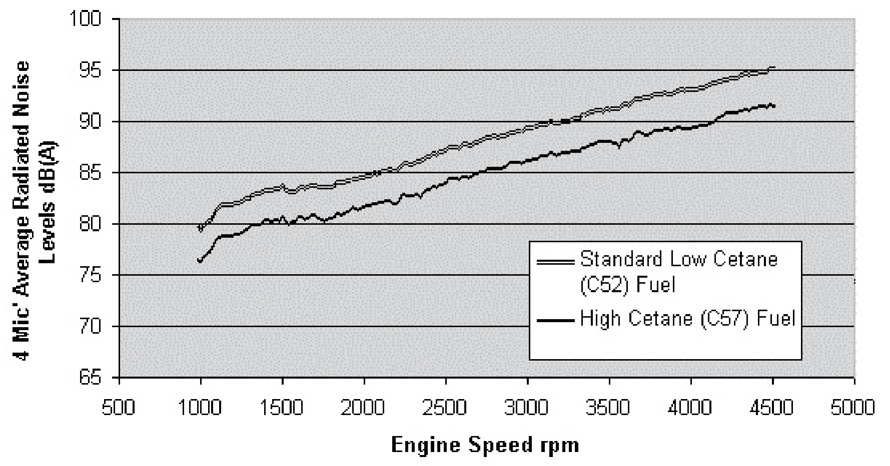
Figure 1: Effect of Cetane on NOx Emissions 50 to 58 CN



Cetane Influence on Combustion Noise

Increased cetane will also reduce noise, as demonstrated by the results shown here (Figure 2). In this case, natural and artificial cetane have similar effects.

Figure 2: Effect of Cetane on Engine Noise, 52 to 57 CN

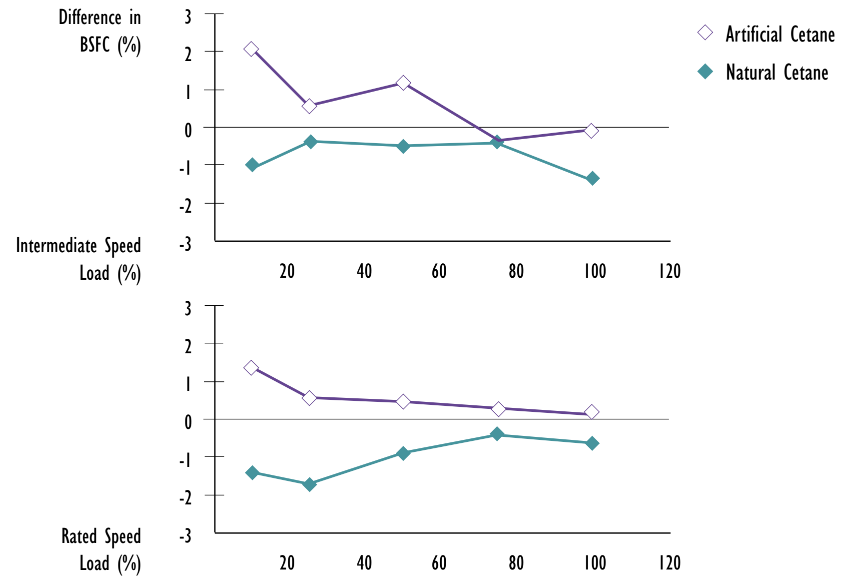


Influence of Cetane on Fuel Consumption

Existing data on the influence of cetane on fuel consumption in older technology heavy-duty engines are inconsistent. Figure 3 demonstrates this inconsistency through measurements of heavy-duty brake specific fuel consumption (BSFC): increasing natural cetane from 50 to 58 generally improved BSFC, but increasing artificial cetane had the opposite effect. Ongoing research may help resolve this uncertainty as well as provide better data for the impacts on more advanced heavy-duty and light-duty engines and vehicles.

TECHNICAL BACKGROUND DIESEL FUEL

Figure 3: Effect of Cetane on Fuel Consumption 50 to 58 CN



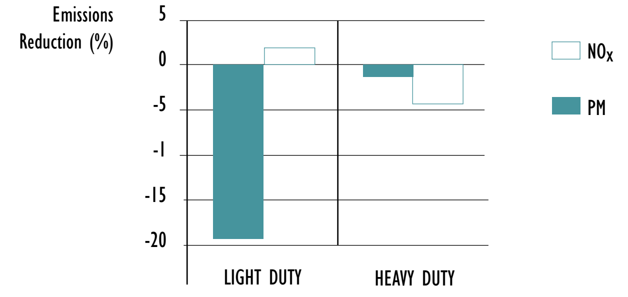
DENSITY and VISCOSITY

The diesel fuel injection is controlled volumetrically or by timing of the solenoid valve. Variations in fuel density (and viscosity) result in variations in engine power and, consequently, in engine emissions and fuel consumption. The European EPEFE programme found that fuel density also influences injection timing of mechanically controlled injection equipment, which also affects emissions and fuel consumption. Therefore, in order to optimise engine performance and tailpipe emissions, both minimum and maximum density limits must be defined in a fairly narrow range.

Effect of Density on Emissions and Engine Power

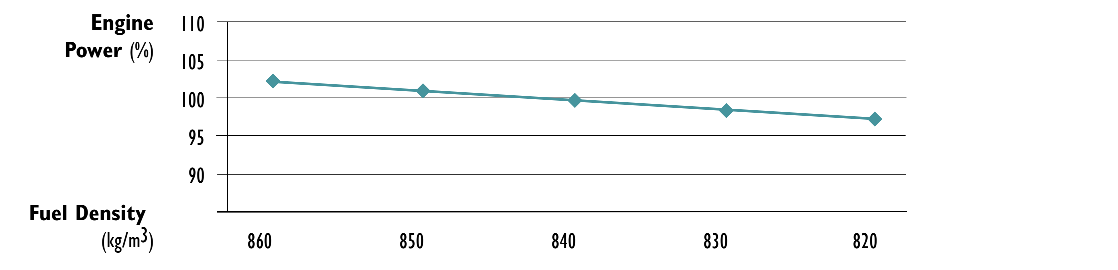
Emissions' testing has demonstrated that reduced density will reduce PM emissions from all diesel vehicles, and NOx emissions from heavy-duty vehicles (Figure 4).

Figure 4: Effect of Density on Exhaust Emissions 855 to 828 kg/m3



However, due to the volumetric fuel injection of diesel engines, reduced density will also increase fuel consumption and reduce power output. EPEFE testing has shown that lowering fuel density decreases engine power output (Figure 5) and increases volumetric fuel consumption. Variations in fuel viscosity (i.e., reduced density generally reduces viscosity) may accentuate the density effects on power (not necessarily fuel consumption), particularly in combination with distributor-type injection pumps.

Figure 5: Effect of Density on Engine Power 855 - 828 kg/m3



Influence of Fuel Density on Emission Control Systems

Production diesel engines are set to a standard density, which determines the amount of fuel injected. The (volumetric) injection quantity is a control parameter for other emission control systems like exhaust gas recirculation (EGR). Variations in fuel density therefore result in non-optimal EGR-rates for a given load and speed point in the engine map and, as a consequence, influence the exhaust emission characteristics.

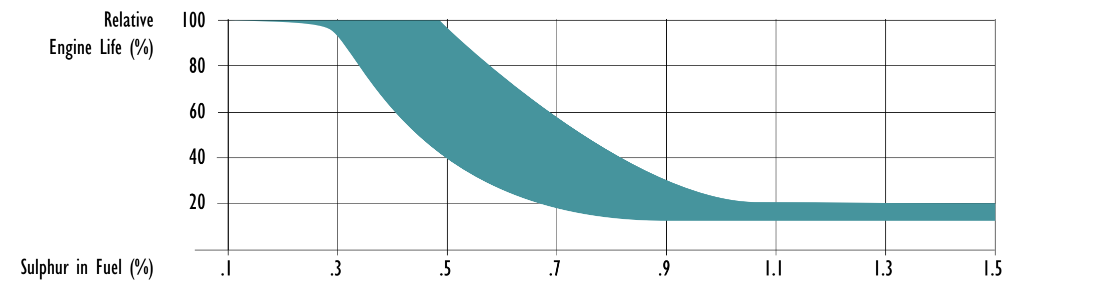
Influence of Fuel Viscosity on Injection System Performance

Fuelling and injection timing are also dependent on fuel viscosity. High viscosity can reduce fuel flow rates, resulting in inadequate fuelling. A very high viscosity may actually result in pump distortion. Low viscosity, on the other hand, will increase leakage from the pumping elements, and in worse cases (low viscosity, high temperature) can result in total leakage. As viscosity is impacted by ambient temperature, it is important to minimise the range between minimum and maximum viscosity limits to allow optimisation of engine performance.

SULPHUR

Sulphur naturally occurs in crude oil. If the sulphur is not removed during the refining process, it will remain in the vehicle fuel. Cross-contamination also can occur in the fuel distribution system. Sulphur can have a significant effect on engine life by leading to corrosion and wear of engine systems. As shown in Figure 6, relative engine life decreases as the sulphur level increases.

Figure 6: Effect of Sulphur on Engine Life



Diesel fuel sulphur also contributes significantly to fine particulate matter (PM) emissions, through the formation of sulphates both in the exhaust stream and later in the atmosphere. Furthermore, the efficiency of some exhaust after-treatment systems is reduced as fuel sulphur content increases, while others are rendered permanently ineffective through sulphur poisoning.

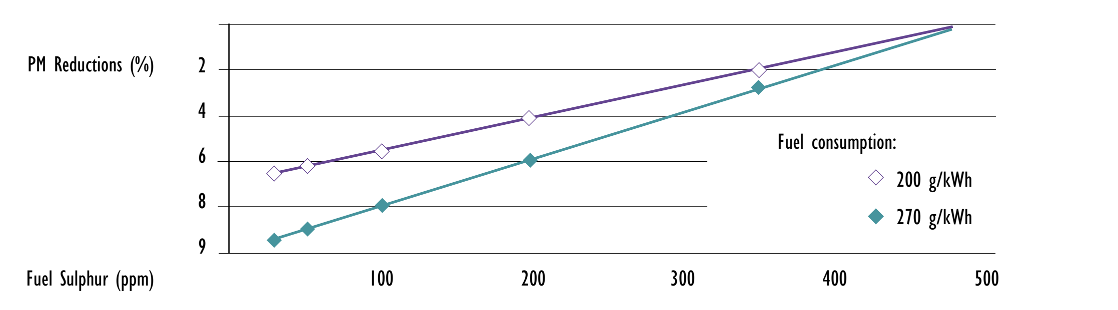
As sulphur levels are reduced, fuel stability requires special attention. The industry has developed a 'Standard Test Method for High Temperature Stability of Distillate Fuels' (ASTM D 6468) for thermal oxidative

stability. Inadequate thermal stability can result in fuel filter plugging by oxidised products (sludge). As fuel injection system pressures and temperatures increase, it may be more appropriate to measure the thermal oxidative stability of diesel fuel rather than only long-term storage stability.

Effect of Sulphur on Particulate Emissions

The impact of sulphur on particulate emissions is widely understood and known to be significant. In the European Auto Oil programme, it was predicted that a reduction in sulphur from 500 ppm to 30 ppm would result in PM emission reductions of 7% from light-duty vehicles and 4% from heavy-duty trucks. However, the predictive equations do not take into account the absolute PM level or the fuel consumption. A correction factor has been developed by European heavy-duty manufacturers to better reflect the relationship between PM emissions and fuel sulphur levels. This correction suggests that the real benefit from sulphur reductions will be more significant, as shown here (Figure 7) for heavy-duty trucks. Reductions in fuel sulphur will also provide particulate emission reductions in all engines, regardless of emission calibration.

Figure 7: Effect of Diesel Fuel Sulphur Level on PM Emissions Heavy-Duty Engines (PM = 0,10 g/kWh)



Testing performed on heavy-duty vehicles using the Japanese diesel 13 mode cycle have shown significant PM emission reductions can be achieved with both catalyst and non-catalyst equipped vehicles. The testing showed that PM emissions from a non-catalyst equipped truck running on 400 ppm sulphur fuel were about double the emissions when operating on 2 ppm fuel. (JSAE 9831171)

Sulphur Contribution to Aerosols and Fine Particulate Emissions

When sulphur is oxidised during combustion, it forms SO_2, which is the primary sulphur compound emitted from the engine. Some of the SO_2 is further oxidised—in the engine, exhaust, catalyst or atmosphere—to sulphate (SO_4). The sulphate and nearby water molecules often coalesce to form aerosols or engulf nearby carbon to form heavier particulates that have a significant influence on both fine and total PM. Without oxidation catalyst systems, the conversion rate from sulphur to sulphate is very low, typically around 1%, so the historical sulphate contribution to engine-out PM has been negligible. However, oxidation catalysts dramatically increase the conversion rate to as much as 100%, depending on catalyst efficiency. Therefore, for modern vehicle systems, most of which include oxidation catalysts, a large proportion of the engine-out SO_2 will be oxidized to SO_4, increasing the amount of PM emitted from the vehicle. Thus, fuel sulphur will have a significant impact on fine particulate emissions in direct proportion to the amount of sulphur in the fuel.

The mass of sulphates emitted from the engine depends on the following parameters:

- The fuel consumption of the engine
- The fuel sulphur content
- The S to SO_4 conversion rate

Both the fuel sulphur content and fuel consumption are measurable parameters; the conversion rate is predicted based on engine variability and the use of an oxidation catalyst. The following formula can provide an estimate of the impact:

$BSSO_4 = BSFC * FSC/100 * PCSC/100 * 7$ where

- **$BSSO_4$** = Brake specific sulphate in mass/brake power-hour
- **BSFC** = brake specific fuel consumption in g/kWh
- **FSC** = fuel sulphur content in % mass
- **PCSC** = Percent sulphur conversion (to SO_4)
- **7** = S to (SO_4 + water) weight increase factor

Overview of Sulphur's Effect on Highly Advanced Diesel Emission Control Systems

No single device can simultaneously reduce NOx, PM, HC and other emissions from diesel engines. Furthermore, tradeoffs historically have been required between and among emissions and fuel economy, especially for markets with higher sulphur diesel fuel. To meet the requirements of many new regulations, highly advanced emission control systems have been developed around combinations of engine and aftertreatment devices. Sulphur has a particularly strong impact on these newer NOx controls, and many will stop working if the sulphur level becomes too high. Thus, these new systems require low or ultra-low sulphur fuels to maintain their operational capability.

The most advanced of these technologies includes De-NOx catalyst systems, such as Lean NOx traps (LNT) (also known as NOx adsorbers,) and Selective Catalytic Reduction (SCR) devices, which can remove a greater amount of NOx emissions from the diesel's oxygen-rich exhaust than previously possible. Highly advanced particulate filters also have been developed to reduce PM emissions. Many of these devices are combined in various configurations to enable the vehicle to meet specific emission standards and to minimize impacts on fuel efficiency. Diesel oxidation catalysts (DOC), which reduce HC and CO emissions, and exhaust gas recirculation (EGR) systems, which reduce NOx, are among the proven technologies that may be used in conjunction with newer technologies. More importantly, all emission control systems perform better and last longer with sulphur-free fuel.

The Diesel Emission Control-Sulphur Effects (DECSE) project, a collaborative program conducted by the US Department of Energy (DOE), Engine Manufacturers Association (EMA) and Manufacturers of Emission Controls Association (MECA), studied the impact of diesel fuel sulphur levels of 3, 16, 30, 150 and 350 ppm on a number of these technologies on both heavy-duty and light-duty engines. Reference: www.ott.doe.gov/decse.

The Advanced Petroleum Based Fuels - Diesel Emission Control (APBF-DEC) Program, another collaborative effort, has identified optimal combinations of low-sulphur diesel fuels, lubricants, diesel engines and emission control systems to meet projected emission standards for the 2001 to 2010 time period. Reference: http://www.ott.doe.gov/apbf.shtml. Research and development are continuing to refine and improve the systems now entering Category 4 and Category 5 markets.

NOx Adsorber

NOx adsorbers are poisoned and rendered ineffective by the presence of sulphur. These devices can be up to 90% efficient in NOx removal if operated on sulphur-free fuel. The SO2 formed during combustion and released in the exhaust undergoes reactions in these devices that are similar to those of NOx, but the oxidized sulphur compounds adsorb more strongly to the catalyst surface than the NOx, thereby poisoning the catalyst.

The effect of fuel sulphur content on NOx adsorber conversion efficiency is shown in Figure 8 below. The figure illustrates the effect of fuel sulphur on relative NOx conversion efficiencies. Compared to 3 ppm sulphur fuel, both 16 and 30 ppm sulphur fuels resulted in a significant decline in performance.

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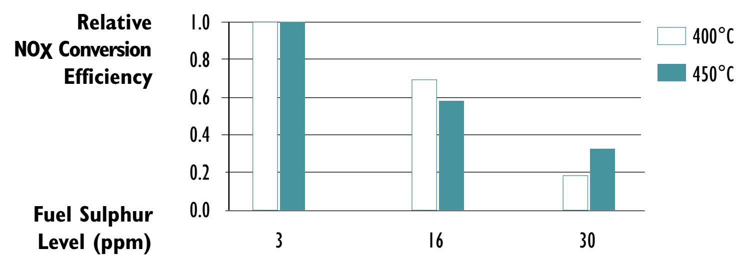
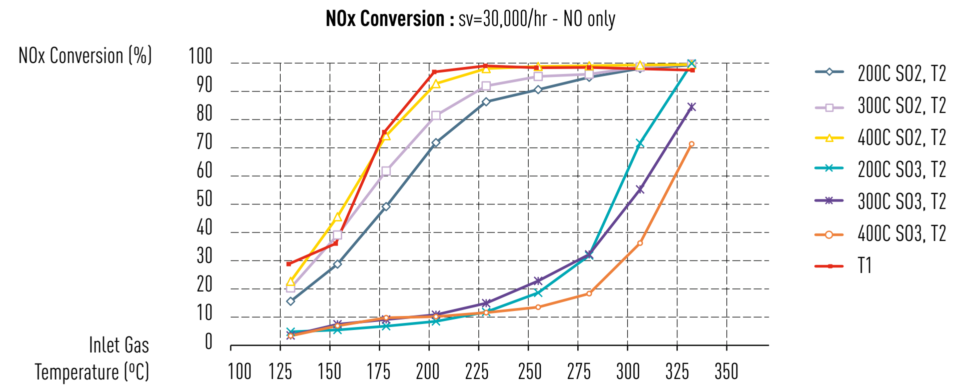
Figure 8: Effect of Fuel Sulphur Level on NOx Conversion Efficiency (150 Hours Aging)



Selective Catalytic Reduction

Selective Catalytic Reduction (SCR) emission control devices, which are being used on both light-duty and heavy-duty vehicles, are catalysts that work in conjunction with a specially formulated reactant (called Diesel Exhaust Fluid (DEF) in the U.S.) to convert NOx into nitrogen and water vapour. Like other catalysts, the effectiveness and durability of SCR systems can be adversely affected by fuel sulphur. The impact is exacerbated by the use of a diesel oxidation catalyst (DOC) in front of the SCR because DOCs convert much of the SO2 to SO3. While both SO2 and SO3 poison the SCR, research has shown SO3 to have a stronger impact on SCR conversion efficiency. Figure 9 shows how SO2 and SO3 affect NOx conversion in SCRs at different temperatures (also see SAE 2009-01-0898).

Figure 9: Impact of SOx on SCR Activity



Diesel Particulate Filter

The Diesel Particulate Filter (DPF), which first appeared in the market on production vehicles in mid-2000, allows vehicles to achieve extremely low particulate emissions. The filtration of exhaust gas particulates has been possible for many years, but the disposal of the accumulated particulate has remained a difficult problem to solve. Apart from removing the filter frequently for cleaning (which is not allowed in the U.S.), a reliable and cost-effective system of on-board filter regeneration by combustion of the particulate was previously not available. The latest generation of common rail engines opened possibilities through electronic injection strategies for increasing exhaust gas temperatures, however, and this has enabled the combustion of the trapped particulate. A different strategy for regenerating filters uses a combination of catalytic additive mixed on-board with the fuel, or post-combustion fuel injection into the exhaust and an oxidation catalyst pre-filter.

The latest generation of common rail direct injection diesel engines emits 60% less particulate matter than its immediate prechamber predecessors, and when combined with a DPF system, these engines can reduce the number of particulate in the exhaust gas to the level of ambient air, which completely eliminates black smoke. What is more, this 10^3 - 10^4 reduction magnitude in particulate emissions is constant over the whole

range of particulate size. Thus, using DPF systems further enhances the potential of the diesel engine as a low-polluting power unit.
The sulphur contained in diesel fuel is likely to be transformed into gaseous sulphur compounds in the oxidation catalyst included with the emission control system, and these compounds may be transformed through secondary reactions into sulphate particulates in the atmosphere. Therefore, the use of sulphur-free fuels in vehicles with DPF systems is highly recommended to avoid this phenomenon.

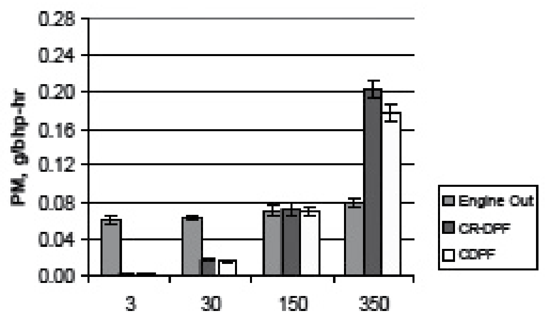
Continuously Regenerating and Catalysed Diesel Particulate Filters
The Continuously Regenerating Diesel Particulate Filter (CR-DPF) and Catalysed Diesel Particulate Filter (CDPF) represent two different approaches to DPF regeneration.

The CR-DPF regenerates by continuously generating NO2 from engine-emitted NO over a diesel oxidation catalyst placed upstream of the DPF. Proper vehicle calibration is necessary to ensure that sufficient NO2 is generated for this purpose. NO2 has been established as a more effective low-temperature oxidizing agent for diesel PM than oxygen. Sulphur in the exhaust is oxidised over the CR-DPF, however, forming sulphates that contribute to PM emissions. Sulphur oxides also compete for the critical NO and NO2 reaction sites on the DPF, making trap regeneration less effective.

The CDPF regenerates by using a catalyst coating on the DPF element to promote oxidation of the collected PM using available oxygen in the diesel exhaust. Sulphur in the exhaust is oxidised over the CDPF to form sulphates. Exhaust-gas temperature and fuel-sulphur level are critical factors that affect the performance of both types of DPF (CR-DPF and CDPF).

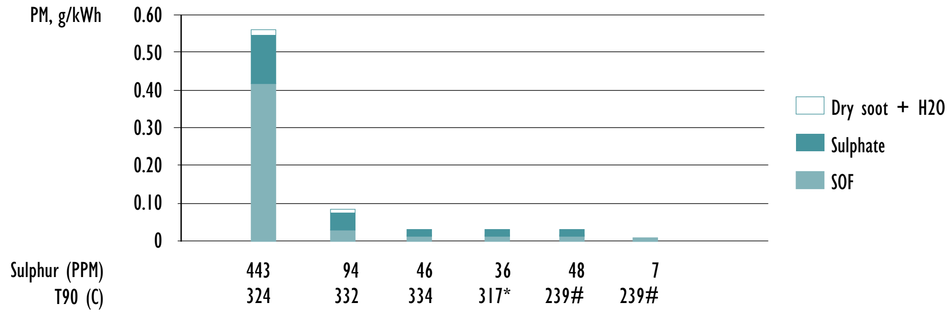
Fuel sulphur has a significant effect on PM emissions from these emission control devices. Both types of DPF effectively reduce PM emissions when fuel sulphur is very low, but when fuel sulphur increases, so do sulphate levels, which affects the amount of PM emitted. In one study, PM was reduced by 95% over the OICA cycle when the tested DPFs were used with 3-ppm sulphur fuel (Figure 10a), but with 30-ppm sulphur fuel, the PM reduction efficiencies dropped to 72 and 74% for the CR-DPF and CDPF, respectively. At the 150-ppm sulphur test point, the sulphur content of the measured mass completely masked the reduction in carbonaceous particles, so that the measured total PM reductions were near zero. A similar outcome was seen in Japanese DPF testing (Figure 10b).

Figure 10a: Effect of Fuel Sulphur Level on PM Emissions – OICA Cycle



Engine tested: Caterpillar 3126, 7.2 litre, Inline 6 cylinder, 205 kW @2200 rpm

Figure 10b: Fuel effect on Diesel Particulate – CR (Continuous Regeneration) - DPF Japan Diesel 13 Mode



*Blend of diesel fuel and kerosene.
#Kerosene.

ASH

Fuel and lubricant derived ash can contribute to coking on injector nozzles (see Figure 16) and will have a significant effect on the life of diesel particulate filters. Ash-forming metals can be present in fuel additives, lubricant additives or as a byproduct of the refining process.

Metallic ash constituents are incombustible, so when they are present in the fuel, they remain in the exhaust and become trapped within the DPF. Thus, the presence of ash-forming materials in the fuel will lead to a premature build-up of backpressure and other vehicle operability problems. Non-fuel solutions have been found unsatisfactory. Larger filters can reduce backpressure build-up but otherwise would be unnecessary and may be infeasible (for example, in smaller vehicles). Increased in-use maintenance or, in extreme cases, DPF replacement would help, but these steps may not be allowed in some markets. Therefore, keeping ash-forming compounds out of the fuel to the extent possible provides the best solution.

Ash-forming compounds may be present in fuel in four forms:
- Abrasive solids, such as suspended solids and organometallic compounds that contribute to injector, fuel pump, piston and ring wear and to the formation of engine deposits.
- Soluble metallic soaps, which have little effect on wear but may contribute to engine deposits.
- Soluble metals, which may be present in vegetable-derived fuels as a result of absorption by the plant source and inadequate removal during processing. Biodiesel fuel, for example, may contain metals that were left in the residue resulting from common catalytic production methods.
- Metals that originate in water entrained in the fuel.

Industry standards limiting ash to less than 0.01%, which were intended to protect close tolerance fuel injection equipment and reduce piston ring zone deposits, have addressed the first form of ash-forming compounds. Fuel surveys have confirmed that the ash content in most fuels has been near the detection limit of the currently available test procedure (0.001%). The remaining forms of metallic ash, however, may enter fuel during the distribution process and must be controlled before dispensing the fuel to the engine or vehicle.

Diesel fuel containing ash at the current detection limit (0.001%) may require the DPF to be serviced during the vehicle's useful life, but many jurisdictions do not allow this for Category 4 or Category 5 engines or vehicles. Therefore, ash-forming metals must be controlled to very low levels to enable these emission control devices to operate properly over the lifetime of the vehicle. To allow the appropriate level for these ash compounds, a new test procedure capable of measuring lower levels of ash in diesel fuel should be developed.

AROMATICS

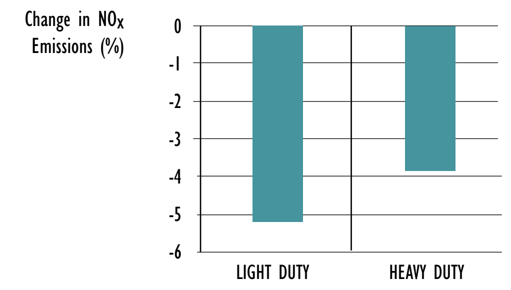
Aromatics are molecules that contain at least one benzene ring. The fuel aromatic content will affect combustion and the formation of particulate and polycyclic aromatic hydrocarbons (PAH) emissions.

The diesel fuel aromatics content influences flame temperature, and therefore, NOx emissions during the combustion. PAH in the fuel affect the formation of particulates and PAH emissions from a diesel engine.

Influence of Total Aromatics Content on NOx Emissions

A higher aromatic content in the fuel will increase the flame temperature during combustion, which results in increased NOx emissions. Testing in Europe (ACEA follow-up programme to EPEFE) demonstrated that a reduction of the total aromatic content from 30 to 10% yields significantly lower NOx emissions as shown in Figure 11.

Figure 11: Effect of Total Aromatics on NOx Emissions (30 to 10% Aromatics)

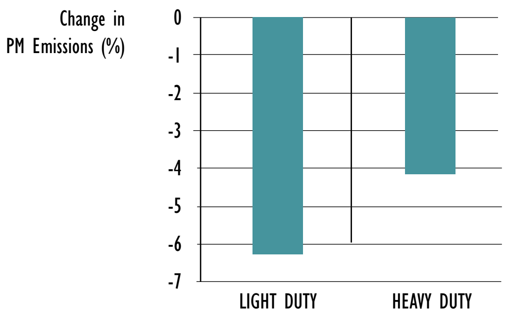


The light-duty data are based on the combined ECE/EUDC cycle, the heavy-duty on the 88/77/EEC 13-mode cycle.

Influence of Polyaromatic Content on Particulate Emissions

The influence of polyaromatic (di+, tri+) content on PM emissions was also investigated in the EPEFE programme. Figure 12 shows the reductions of PM emissions that were measured when the polyaromatic content was reduced from 9 to 1 %.

Figure 12: Effect of Polyaromatics on PM Emissions (from 9 to 1% di+ Polyaromatics)



Influence of PAH Content on PAH Emissions

PAH (tri+) content in diesel fuel has been shown to directly correlate to PAH emissions in diesel engine exhaust. The PAH emissions of a truck diesel engine on the US transient cycle using fuels with different PAH contents were measured in a Swedish study. The results shown in Figure 13 demonstrate this direct correlation.

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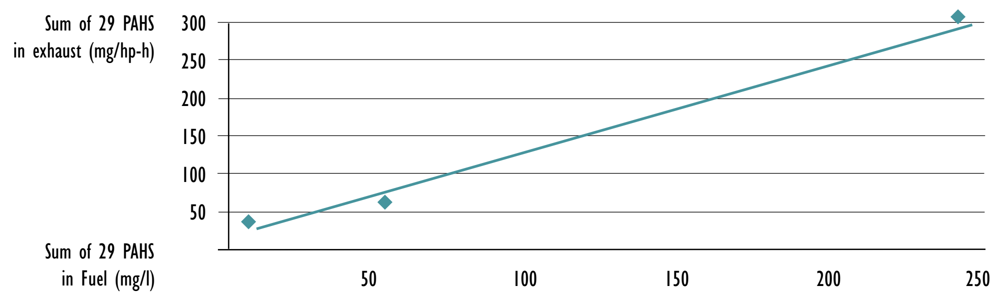
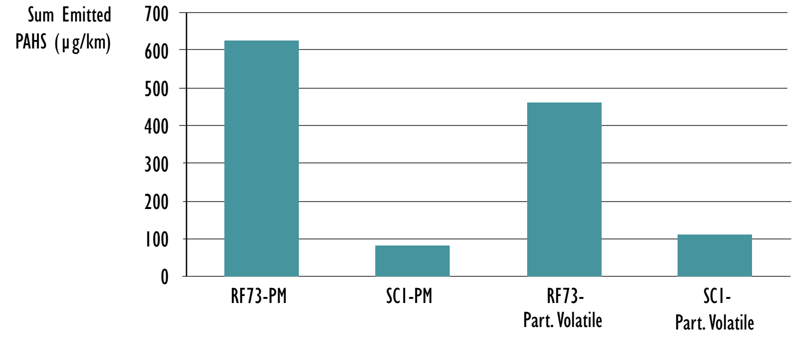
Figure 13: Effect of Fuel PAH on Emissions of PAH



The Swedish EPA also tested a Euro 2 diesel engine on the 88/77/EEC and the transient 'Braunschweig'-cycle on Sweden Class I fuel (SC1, PAH =24 mg/l) and European reference fuel (RF73; PAH=2100 mg/l). Figure 14 shows the sum of emitted PAH's collected on the filter (PM) and the emissions of partly volatile PAH's (average of four cycles).

Figure 14: Effect of Fuel PAH on Emissions of PAH



DISTILLATION CHARACTERISTICS

The distillation curve of diesel fuel indicates the amount of fuel that will boil off at a given temperature. The curve can be divided into three parts:

- The light end, which affects startability;
- The region around the 50% evaporated point, which is linked to other fuel parameters such as viscosity and density; and,
- The heavy end, characterised by the T90, T95 and final boiling points.

The heavy end has been the most thoroughly studied with respect to its effect on tailpipe emissions.

Influence of Heavy End on PM Emissions

In most new studies, only the influence of the upper boiling range has been investigated with respect to exhaust gas emissions, whereas the lower boiling range varied widely. Conclusions concerning the whole boiling range and distillation influence are therefore not possible. However, it is clear that too much fuel in the heavy end will result in coking and increased tailpipe emissions of soot/smoke/particulate matter.

Influence of T95 on Tailpipe Emissions

The effect of T95 on vehicle emissions was examined in the European EPEFE programme. The testing indicated that exhaust gas emissions from heavy-duty diesel engines were not significantly influenced by T95-variations between 375°C and 320°C. However, a tendency for lower NOx and higher HC with lower T95 was observed.
In the case of light-duty diesel engines, the same reduction in T95 resulted in a 7% reduction in PM and 4.6% increase in NOx emissions.

COLD FLOW

Diesel fuel can have a high content (up to 20%) of paraffinic hydrocarbons which have a limited solubility in the fuel and, if cooled sufficiently, will come out of solution as wax. Adequate cold flow performance, therefore, is one of the most fundamental quality criteria for diesel fuels.
The cold flow characteristics are primarily dictated by:

- Fuel distillation range, mainly the back-end volatility;
- Hydrocarbon composition: content of paraffins, naphthenes, aromatics;
- Use of cold flow additives.

Measures of Cold Flow Performance

Diesel cold flow properties must be specified according to the seasonal and climatic needs in the region where the fuel is to be used. Wax in vehicle fuel systems is a potential source of operating problems; the low-temperature properties of diesel fuels are therefore defined by wax-related tests:

- **Cloud Point, CP (ISO 3015, ASTM D2500)**: The temperature at which the heaviest paraffins start to precipitate and form wax crystals; the fuel becomes 'cloudy'.
- **Cold Filter Plugging Point, CFPP (EN116)**: The lowest temperature at which the fuel can pass through the filter in a standardised filtration test. The CFPP test was developed from vehicle operability data and demonstrates an acceptable correlation for fuels and vehicles in the market. For North American fuels however, CFPP is not a good predictor of cold flow operability. CFPP can be influenced by cold flow additives.
- **Low Temperature Flow Test, LTFT (ASTM D4539)**: The LTFT was developed to predict how diesel fuels in the United States and Canada will perform at low temperatures, in the diesel vehicles present in these markets. LTFT is a slow cooling test and therefore more severe than CFPP. LTFT temperature can be influenced by cold flow additives.

Cold Flow Limits

The diesel fuel cold flow performance can be specified by Cloud Point, by CFPP (with maximum delta between CFPP and Cloud Point), or by LTFT (in USA and Canada).

- If Cloud Point (only) or LTFT is used, the maximum allowed temperature should be set no higher than the lowest expected ambient temperature.
- If CFPP is used to predict cold flow, the maximum allowed CFPP temperature should be set equal to, or lower than, the lowest expected ambient temperature. In this case, the Cloud Point should be no more than 10°C above the CFPP specified.

Example:

- Lowest expected ambient temperature (statistical): -32°C
- Maximum allowed CFPP temperature: -32°C
- Maximum allowed Cloud Point: -22°C

FOAM

Diesel fuel has a tendency to generate foam during tank filling, which slows the process and risks an overflow. Anti-foamants are sometimes added to diesel fuel, often as a component of a multifunctional additive package, to help speed up or to allow more complete filling of vehicle tanks. Their use also minimises the likelihood of fuel splashing on the ground, which, in turn, reduces the risk of spills polluting the ground, the atmosphere and the consumer.

Foam Control

Silicon surfactant additives are effective in suppressing the foaming tendency of diesel fuels, the choice of silicon and co-solvent depending on the characteristics of the fuel to be treated. Selection of a diesel anti-foamant is

generally decided by the speed at which the foam collapses after vigorous manual agitation to simulate the effect of air entrainment during tank filling. It is important that the eventual additive chosen should not pose any problems for the long-term durability of the emission post-treatment control systems.

BIOFUELS and ALTERNATIVE SYNTHETIC FUEL COMPONENTS

Fatty Acid Methyl Esters

Fatty Acid Methyl Esters (FAME), also known as biodiesel, increasingly are being used to extend or replace diesel fuel. Such use has been driven largely by efforts in many nations to exploit agricultural produce and/or to reduce dependency on petroleum-based products.

Several different oils may be used to make biodiesel, for example, rapeseed, sunflower, palm, soy, cooking oils, animal fats and others. These oils must be reacted with an alcohol to form ester compounds before they can be used as biodiesel fuel. Unprocessed vegetable oils, animal fats and non-esterified fatty acids are not acceptable as transportation fuels due to their very low cetane, inappropriate cold flow properties, high injector fouling tendency and high kinematics viscosity level. Historically, methanol has been the alcohol most used to esterify the fatty acids, and the resultant product is called fatty acid methyl ester (FAME). Research is underway to enable use of ethanol as the reactant alcohol, in which case the product is called fatty acid ethyl ester (FAEE).

The European standards organization, CEN, has published a FAME standard (EN 14214) that establishes specifications for biodiesel use as either: (i) a final fuel in engines designed or adapted for biodiesel use; or (ii) a blendstock for conventional diesel fuel. Similarly, ASTM International has established specifications for neat biodiesel (ASTM D 6751) but only for use as a blending component, not as a final fuel.

Generally, biodiesel is believed to enhance the lubricity of conventional diesel fuel and reduce exhaust gas particulate matter. Also, the production and use of biodiesel fuel is reported to lower carbon dioxide emissions on a source to wheel basis, compared to conventional diesel fuel.

At the same time, engine and vehicle manufacturers have concerns about introducing biodiesel into the marketplace, especially at higher levels. Specifically:

- Biodiesel may be less stable than conventional diesel fuel, so precautions are needed to avoid problems linked to the presence of oxidation products in the fuel. Some fuel injection equipment data suggest such problems may be exacerbated when biodiesel is blended with ultra-low sulphur diesel fuels.
- Biodiesel requires special care at low temperatures to avoid an excessive rise in viscosity and loss of fluidity. Additives may be required to alleviate these problems.
- Being hygroscopic, biodiesel fuels require special handling to prevent high water content and the consequent risk of corrosion and microbial growth.
- Deposit formation in the fuel injection system may be higher with biodiesel blends than with conventional diesel fuel, so detergent additive treatments are advised.
- At low ambient temperatures, FAME may produce precipitated solids above the cloud point, which can cause filterability problems.
- Biodiesel may negatively impact natural and nitrile rubber seals in fuel systems. Also, metals such as brass, bronze, copper, lead and zinc may oxidize from contact with biodiesel, thereby creating sediments. Transitioning from conventional diesel fuel to biodiesel blends may significantly increase tank sediments due to biodiesel's higher polarity, and these sediments may plug fuel filters. Thus, fuel system parts must be specially chosen for their compatibility with biodiesel.
- Neat (100%) biodiesel fuel and high concentration biodiesel blends have demonstrated an increase in NOx exhaust emission levels.
- Biodiesel fuel that comes into contact with the vehicle's shell may be able to dissolve the paint coatings used to protect external surfaces.

In view of the high level of interest in this fuel, including among vehicle and engine manufacturers, biodiesel specifications and test methods will continue to be investigated.

Biodiesel (FAME) inherently has poor oxidation stability due to the nature of its chemical composition. Most FAME contains carbon-to-carbon double bonds in its chemical construction that are easily oxidized after production and during the storage and use of the fuel. Such oxidation reactions are why precautions must be taken, such as the use of oxidation stability enhancing additives like BHT, when blending and distributing biodiesel fuels.

To secure the quality of biodiesel blended fuel, additional oxidation stability criteria are being introduced into finished fuel specifications in some regions. The European standard for B7 requires a 20 hour minimum induction period by the modified Rancimat method (See EN 590). As part of a compulsory standard for B5, Japan requires either a delta TAN maximum of 0.12 mg KOH/g or a minimum 65 minutes by the PetroOXY method. (The delta TAN method measures acid value before and after aging per ASTM D2274 (@ 115°C)); the growth in acid value is reported as delta TAN. The current European limit is believed to be inadequate to prevent corrosion in metal parts such as vehicle fuel tanks, however. Given ongoing questions about the adequacy of various methods and limits, Europe and Japan are working to harmonize the oxidation stability test method by introducing the PetroOXY method. The goal of the investigation is to shorten the test duration and improve repeatability of the results. This research may lead to future revisions in the oxidation criterion and test method for biodiesel blended fuels. Figure 15a shows that a 35 hour minimum induction period by the modified Rancimat method is comparable to a delta TAN maximum of 0.12 mg KOH/g. Figure 15b shows the correlation between the PetroOxy and Delta TAN test methods for different FAME feedstocks and levels of antioxidant additive in B5 blends. Figure 15c shows the correlation between the PetroOxy and Rancimat methods for different diesel fuels, FAMEs and blend rates. It should be noted that the Rancimat and Delta TAN methods must be used with fuels containing FAME. All three of the correlations are based on fuels containing FAME.

Figure 15a : Correlation between Modified Rancimat Method and Delta TAN Method

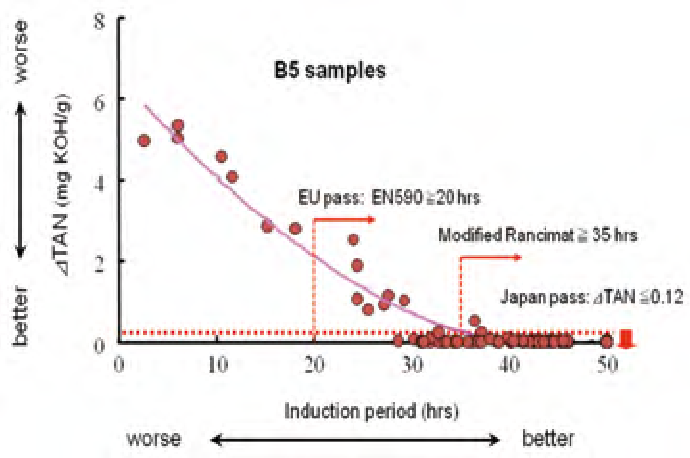


Figure 15b: Correlation between PetroOxy and Delta TAN Methods

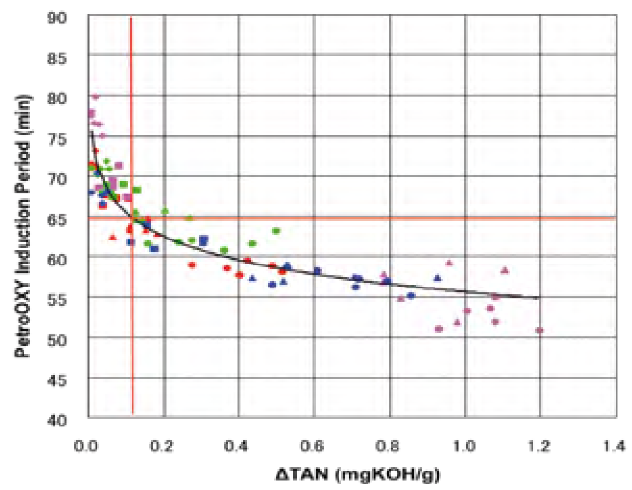
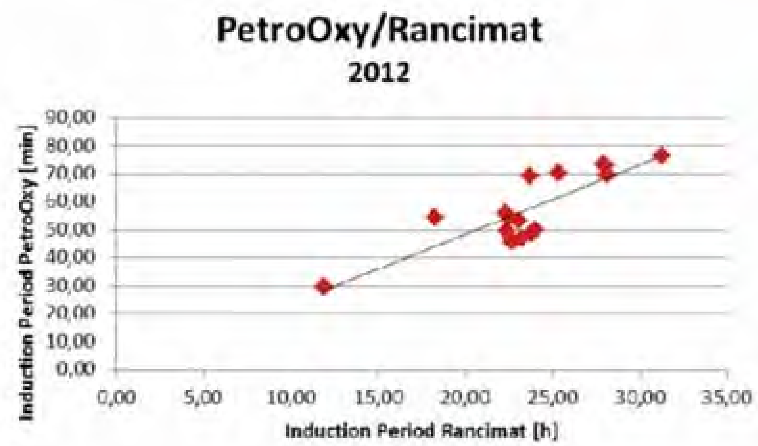


Figure 15c: Correlation between PetroOxy and Rancimat Methods



Synthetic Fuels

In recent years, various types of alternative and renewable diesel fuels have emerged that also can help extend or replace diesel fuel. The Fischer-Tropsch process, which was invented in the 1920s but today represents a variety of similar processes, converts feedstocks of biomass, methane (natural gas) or coal into paraffinic diesel fuels, commonly referred to as BTL ('biomass-to-liquid'), GTL ('gas-to-liquid') or CTL ('coal-to-liquid'), as the case may be. Regardless of feedstock, the process requires gasification and then synthesis to a liquid with the desired properties. BTL should not be confused with biodiesel (FAME), which is fundamentally a different fuel. Some of these blendstocks, particularly BTL, have relatively low well-to-wheel GHG emissions, and these are preferred over other synthetic fuels that are not considered to be low carbon fuels. CEN TS15940 may be used as a production guideline for GTL and HVO quality; additional engine validation may be needed to ensure the fuel ultimately works well in vehicles and engines.

These fuels are usable in any diesel engine either in pure form or blended with conventional diesel fuel, although they generally have poor lubricity, which requires the addition of appropriate additives to enable the fuel to meet or exceed requirements. The fuels are very clean-burning because they have virtually no sulphur or aromatics. They also have very high cetane levels, which enable more efficient engine operation. Their distillation profile differs from petroleum diesel fuel, and they have a lower density than the Charter's diesel fuel specification, however, and these factors may reduce fuel economy, compared to an equivalent volume of diesel fuel meeting the Charter's specification. CEN TS15940 may be used as a production guideline for GTL and HVO quality; additional engine validation may be needed to ensure the fuel ultimately works well in vehicles and engines.

Hydrotreated Vegetable Oils

Renewable feedstocks such as vegetable oils may be processed by variations of conventional petroleum refining, including hydrotreatment. These refining methods produce saturated paraffinic hydrocarbon molecules with extremely low aromatic levels and a very narrow distillation range, and properly processed, they can provide the required cold flow properties. Some HVO production processes may yield non-paraffinic hydrocarbons in addition to paraffins, however, so additional controls may be needed to ensure acceptable quality fuel. CEN TS15940 may be used as a production guideline for GTL and HVO quality; additional engine validation may be needed to ensure the fuel ultimately works well in vehicles and engines.

Unlike FAME, the paraffinic middle distillate fuel oils produced by these methods are indistinguishable from conventional paraffinic fuel oils derived from petroleum and lack the residual process elements typical of biodiesel. Thus, they are highly suited as a blendstock for diesel fuel. Engine and vehicle manufacturers widely support the development of HVO fuels as a way to increase diesel fuel's renewable, low carbon content without the concerns associated with methyl ester fuels.

E-Diesel

Adding ethanol to diesel fuel (E-diesel) has been considered as a way to extend the volume of diesel fuel, reduce dependency on imported oil products or exploit agricultural produce and waste. E-diesel fuel typically has an extremely low flashpoint of about 13°C (55°F), which is well below the minimum limit set by various organisations: ASTM D975 standard of 52°C (126°F), EN590 standard of 55°C min (131°F), JIS K2204 standard of 45°C (113°F). Such flashpoint levels raise serious safety concerns (such as explosions), for fuel handling, storage and use. Vehicle and engine manufacturers are concerned that e-diesel may damage vehicle parts, especially fuel injectors, and cause other types of vehicle failure due to low lubricity. The fuel's compatibility with the vehicle in other ways, its impact on vehicle emissions and its health effects remain unknown. Since ethanol has lower energy content than diesel fuel, its presence in the fuel will reduce fuel economy. Therefore, until the many safety, performance and health concerns are resolved and sufficient peer-reviewed research is conducted in these important areas, manufacturers do not support adding ethanol to any category of diesel fuel.

INJECTOR CLEANLINESS

The fuel injector, which is designed to meter fuel to a high degree of accuracy, is a component of very high precision. The correct behaviour of the engine depends on the injector doing its job properly; otherwise there will be repercussions in terms of noise, smoke and emissions.

Effect of Injector Fouling

The tip of the injector is subject to a very harsh environment as it is in direct contact with the combustion process, both in pre-chamber and in direct injection engines. The solid matter products of combustion are deposited on the tip and can result either in partial or complete hole blockage, with partial blockage the more common effect. Either effect will alter significantly the operation of the injector by reducing fuel flow and affecting power and emissions.. For pre-chamber engines, the combustion products partially block the progressive delivery of the fuel at part load, and the combustion can become violent and disorganised. Likewise in direct injection engines,

a partial or complete blockage of one of the fine spray holes will perturb the atomisation of the fuel jet, and the engine no longer functions as designed. Where pre-chamber engines are concerned, some coking is inevitable due to the type of injector used, and the choice of injector takes this into account. However, the coking level depends on the quality of the fuel, and excessive coking cannot be tolerated. The injectors of direct injection engines are initially more resistant to coking, but poor fuel quality can eventually block a spray hole.

Internal Diesel Injector Deposits

Engine and vehicle manufacturers recently have detected a new type of injector deposit that has been labeled Internal Diesel Injector Deposits (IDID). These deposits differ from injector nozzle (tip) coking deposits both in their location and their effects. The engine impacts range from increased noise and rough running to power loss and inability to start. Associated impacts include oil dilution, EGR line fouling, increased emissions and reductions in the efficiency and durability of emission control systems.

IDID have been found in several regions across a broad range of engine technologies, including both light and heavy duty vehicles, as well as non-road equipment. The rate of incidents has increased with the growth of common rail engines and their increasingly high fuel injection pressures, which are thought to be a contributing factor. Sub-ppm levels of metallic contaminants in the fuel, primarily Na and Zn, have been associated with IDID problems.

Two main types of IDID have been observed:

1. Lacquer or amide type deposits. Amine fuel constituents are thought to play a role, but the underlying mechanism, the types of constituents involved and the possibility of other co-contributors are open questions.
2. Carboxylate salt deposits. These deposits are thought to derive from reactions of sodium with organic acids present in FAME or in corrosion inhibitors used for pipeline protection.

Engineering solutions are unavailable to fully protect injectors from IDID risk. Some diesel fuel deposit control additives may mitigate the effects.

Currently, no standardized test is available to identify a fuel's risk of causing IDID. To improve this situation, CEC has initiated test development work to evaluate the IDID performance of fuels.

Influence of Detergent Additives

Detergent additives can remedy many of the concerns associated with injector cleanliness. High doses of these additives can partially clean an already heavily coked injector, while smaller doses can maintain injectors at an acceptably clean state, which ensures correct operation. Additive producers and fuel suppliers should check through field trials the extent to which their formulations may contribute to undesirable internal deposit formation at various treat rates. Many fuel distributors include these additives in commercial diesel fuels as quality features to obtain a 'keep clean' effect.

Cleanliness of the injectors has become an even higher priority at present as high-pressure injection systems are increasingly used on both heavy-duty and light-duty direct injection engines. The conformity of modern engines with their specified performance in terms of power, fuel consumption and emissions over time will depend largely on the cleanliness of their injectors. It has been observed in service and by many laboratories, both in manufacturing facilities and independently, that small quantities of metals such as zinc, copper, lead, sodium and potassium in diesel fuel can lead to significant injector fouling with subsequent engine power loss and increased exhaust gas PM. Figure 16 shows pictures of a nozzle with coking caused by metallic impurities.

Figure 16: Examples of Increased Nozzle Coking due to Metal Ion Impurities

Metals can pollute the fuel during the distribution process, even if the fuel is clear when leaving the refinery. Ideally, a standardized engine test on a direct injection diesel engine would permit the setting of an acceptable limit value for injector fouling due either to metals being present in the fuel or to the fuel composition. At present, such a standardized test procedure has not been established, but candidate procedures are being considered. Until an engine performance test is established, therefore, it is prudent to require diesel fuel delivered at the filling station to respect the specific limits for each metal in the fuel, to reduce the risk of severe injector fouling in modern direct injection diesel engines. The technique for measuring the metals should be by inductively coupled plasma, such as with the ASTM D 5185 method (direct measurement improves the detection limit).

LUBRICITY

Lubrication at component boundaries is critical for protecting engines and fuel handling systems. The components of the diesel fuel that provide boundary lubrication are believed to be the heavier hydrocarbons and polar fuel compounds. Diesel fuel pumps without an external lubrication system rely on the lubricating properties of diesel fuel to ensure proper operation.

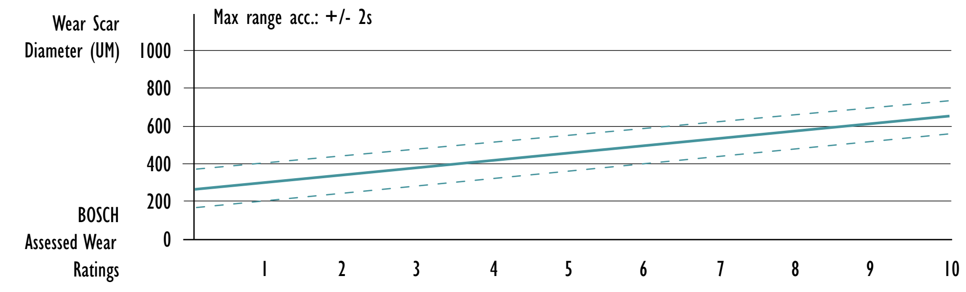
Refining processes to remove sulphur tend to simultaneously reduce diesel fuel components that provide natural lubricity. As diesel fuel sulphur levels decrease, the risk of inadequate lubricity also increases; however, poor lubricity has been observed even in diesel fuels with very high sulphur levels. Inexpensive additives can be used instead of changing the refining process to achieve the desired lubricity level.

Influence of Lubricity on Pump Wear

Inadequate lubricity can result in increased tailpipe emissions, excessive pump wear and, in some cases, catastrophic failure. Concerns over problems experienced with fuels with poor lubricity led to a significant international collaboration between oil companies, OEMs, additive companies and pump manufacturers to develop a test method and performance limit for fuel lubricity. The resultant method, the High Frequency Reciprocating Rig (HFRR) procedure, is a bench test that provides good correlation to measured pump effects.

Figure 17 shows the correlation between actual pump wear (measured by Bosch) and HFRR measured wear scar diameter. Bosch's rating scale describes 'normal wear' as less than 3.5 (which corresponds to a nominal HFRR Wear Scar Diameter of 400 mm). With a Bosch wear rating of 4, the pump will have decreased endurance, and ratings above 7 indicate potential fatal breakdown.

Figure 17: Assessed Pump Wear Rating vs. HFRR Results



PARTICULATE CONTAMINATION

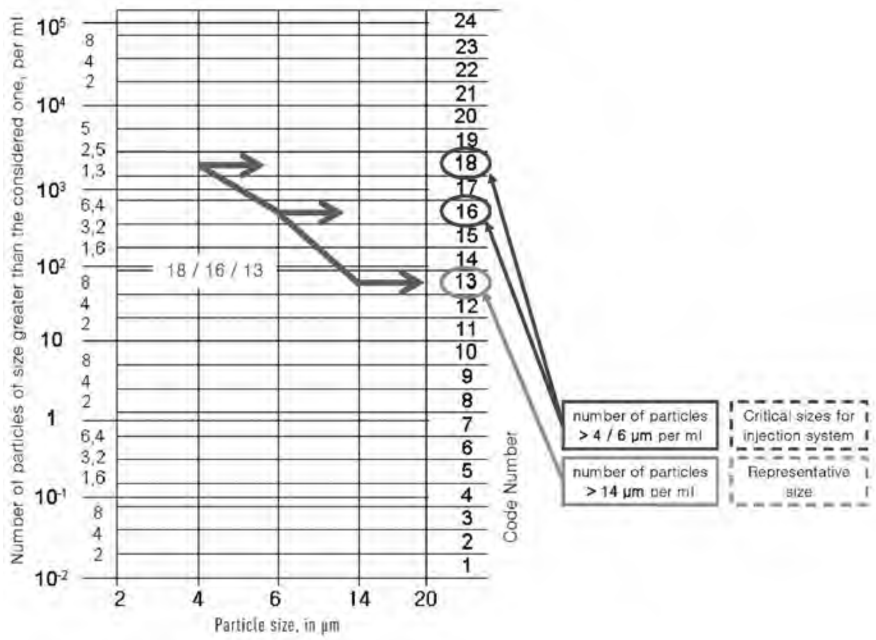
Fuel injection equipment manufacturers continue to develop fuel injection systems to reduce emissions and fuel consumption and to improve performance. Injection pressures have been increasing; currently, they have reached more than 2000 bars. Such levels of injection pressure demand reduced orifice sizes and component clearances, typically from 2 to 5 µm in injectors. Small, hard particles, which may be carried into these engine parts, are potential sources of engine failure.

Excessive diesel fuel contamination can cause premature clogging of diesel fuel filters, depending on the level of both hard and organic particles, and premature wear of modern fuel injection system parts. These impacts, depending on the size and the nature of the particles, will lead to:

- Reduced part lifetimes;
- Part malfunction;
- Engine failure; and
- Increased exhaust emissions.

Measuring fuel particle contamination necessarily considers both the size and number of particles per size class contained in the fuel, i.e. the particle size distribution. The ISO 4406 protocol provides a means of expressing the level of contamination by coding the size distribution. Three code numbers, corresponding to the numbers of particles of size greater than 4, 6 and 14 µm per millilitre, respectively, are reported. Figure 18 shows how to use the ISO 4406 coding method.

Figure 18: ISO 4406 Particulate Size Distribution Coding Chart



Engine and vehicle manufacturers recommend applying the Worldwide Fuel Charter's particulate contamination specification at the fuel station nozzle to prevent particles originating from fuel transport, storage and logistics from reaching the engine.

CONTAMINANTS

Contaminants, including some from additives, whether intentionally or inadvertently added during fuel production or distribution, also can cause significant harm to the powertrain, fuel, exhaust or emission control systems. Good housekeeping practices can help minimize or prevent inadvertent contamination. No detectable levels of the elements listed below should exist in diesel fuel, nor should they be used as components of any fuel additive package intended to improve diesel fuel and engine performance. These elements should be strictly controlled, and it may prove necessary to check and control the fuel quality at the pump.

- Calcium, copper, sodium, manganese, potassium, phosphorus and zinc, even at levels as low as 0.1 ppm, can contribute to the formation of deposits in fuel injector internal surfaces and nozzles. Injector deposits reduce combustion efficiency and increase emissions. Concern about injector deposits is increasing as the latest nozzle technology with tighter clearances and higher pressures becomes more widely used in the marketplace.
- Chlorine, which is not naturally contained in petroleum, has been found in diesel fuel in both inorganic and organic forms. Inorganic chlorine usually enters the fuel as a result of contamination by sea water ballast during shipping or from the use of salt dryers during refining. Organic chlorine may enter the fuel through adulteration with chemical or waste solvents. Chlorine forms highly corrosive acids during combustion, which can reduce significantly the durability of the engine, fuel system and emission control system. In the worst case, the presence of chlorine may lead to catastrophic engine failure as injectors fail to operate or operate improperly after various periods and levels of exposure.

GOOD HOUSEKEEPING PRACTICES

The problems encountered by vehicles from poor quality fuel often are caused by adulteration that occurs in the fuel distribution system, after the fuel has left the refinery gate. Failure to invest in adequate pipeline and storage facilities and failure to maintain the equipment can lead to volatility losses, fuel leakage and contamination by particulates and water that, in turn, can lead to a host of vehicle problems. Excess levels of water, for example, will lead to corrosion, as shown in Figure 19. Poor operating practices at the service station, such as too infrequent replacement of fuel dispenser filters or 'dipping' of tanks to check for water, can magnify these problems. Adding used engine oil to fuel is unacceptable unless expressly allowed by the manufacturer. Appropriate steps should be taken to minimize contamination by harmful elements such as copper, zinc and sodium. Helpful guidance to good housekeeping practices may be found in CEN/TR 15367-2, Petroleum Products.

Figure 19: Example of Corrosion in Field Pump Caused by Free Water in Diesel Fuel

GASOLINE

Table 1 US AQIRP, EPEFE, AAMA/AIAM, SAE 982726, JSAE 9838985
Table 2 SIERRA REPORT, 2008

Figure 1 US AQIRP
Figure 2 TOYOTA, 1999
Figure 3 ALLIANCE/AIAM LOW SULFUR EMISSIONS STUDY, 2001
Figure 4 JAPAN CLEAR AIR PROGRAM
Figure 5 SAE 962051
Figure 6 TOYOTA, 1999
Figure 7 GENERAL MOTORS, 1999
Figure 8 TOYOTA, 1999
Figure 9 SAE 2002-01-2894
Figure 10 ALLIANCE, AIAM AND CVMA, 2002
Figure 11 SIERRA REPORT, 2008
Figure 12 HONDA, BMW AND FORD
Figure 13 FORD 2000
Figure 14 CRC REPORT, NO. E65
Figure 15 US AQIRP
Figure 16 US AQIRP, EPEFE REPORT
Figure 17 SAE 2013-01-1057
Figure 18 SAE 2013-01-1057
Figure 19 CRC REPORT, NO. 605
Figure 20 CRC REPORT, NO. 605
Figure 21 GM/SAE 962023
Figure 22 TOYOTA/SAE 972851
Figure 23 TOYOTA, 2005
Figure 24 HONDA, 2010
Figure 25 TOYOTA, 2005
Figure 26 FORD, 1996
Figure 27 FORD/ASTM 2003
Figure 28 FORD/SAE 962012
Figure 29 FORD, 1996
Figure 30 FORD/SAE 962012
Figure 31 FORD/ASTM 2003
Figure 32 FORD/SAE 962012
Figure 33 TOYOTA/SAE 941893

DIESEL

Figure 1, 3 ACEA REPORT: INFLUENCE OF DIESEL FUEL QUALITY ON HEAVY DUTY DIESEL ENGINE EMISSIONS, MARCH 1997
Figure 2 FORD, 2004
Figure 4, 5 EPEFE REPORT
Figure 6 DETROIT DIESEL, EFFECT OF SULFUR ON ENGINE LIFE
Figure 7 ACEA REPORT: INFLUENCE OF DIESEL FUEL QUALITY ON HEAVY DUTY DIESEL ENGINE EMISSIONS, MARCH 1997
Figure 8 DECSE PROGRAM, PHASE 1, NUMBER 2, OCTOBER 1999, US DOE/EMA
Figure 9 FORD & PACIFIC NORTHWEST NATIONAL LABORATORY, 2009
Figure 10a DECSE PROGRAM, PHASE 1, NUMBER 3, NOVEMBER 1999, US DOE/EMA
Figure 10b JAPAN CLEAN AIR PROGRAM
Figure 11 ACEA REPORT: INFLUENCE OF DIESEL FUEL QUALITY ON HEAVY-DUTY DIESEL ENGINE EMISSIONS, MARCH 1997
Figure 12 DATA FROM THE EPEFE REPORT
Figure 13 KARLSSON (SCANRAFF REFINERY) AND RÖJ (VOLVO): DIESEL FUEL QUALITY FOR REDUCED EMISSIONS, WORLD FUELS CONFERENCE SAN FRANCISCO, 1995
Figure 14 GRÄGG, AP SVENSK BILPROVNING/MOTORTESTCENTER, REPORT 9/1995 BOSCH, 1997
Figure 15a JAMA, 2007
Figure 15b METI, 2010
Figuer 15c CEN TC19/JWG1, 2012
Figure 16 BOSCH, 2004
Figure 17 BOSCH, 1997
Figure 18 ISO 4406, 1999
Figure 19 BOSCH, 2002

This brochure was printed on paper manufactured without chlorine or optical brightening agents

Eleven individuals and organizations submitted more than 100 comments on the Proposed 5th Edition of the Worldwide Fuel Charter (December 2012). The WWFC Committee appreciates this input and carefully reviewed each comment for response or action. For brevity, the Committee consolidated and condensed similar comments, and for confidentiality, it has not identified commenters. The consolidated comments and the Committee's responses are provided below, organized under general and multi-fuel, gasoline, and diesel fuel headings.

General Comments and Those Relating to Both Gasoline and Diesel Fuel Chapters

COMMENT: The WWFC should expand discussion of fuel cost and supply, refinery and blending flexibility, fuel producibility, well-to-wheel (WTW) energy impacts, WTW emission impacts and relative costs of controlling the fuel vs. the vehicle.

RESPONSE: We recognize the importance of these other factors, but they are outside the Charter's scope.

COMMENT: Many of the cited benefits derive from very old studies on vehicles in declining use, or they provide very little additional benefit over existing fuels, so they do not justify the fixed and arbitrary limits, many of which, such as for aromatics and olefins, can reduce fuel supply, increase fuel costs or represent fuels that may not be producible.

RESPONSE: We disagree that the benefits do not justify the limits in this new edition. The age of studies does not necessarily determine their validity, and older technologies remain relevant in many parts of the world. The range of categories presented here reflects the progress in both technologies and markets.

COMMENT: The WWFC correctly uses a forward-looking approach that is based on technical needs found from tests or field experience.

RESPONSE: We agree. Thank you.

COMMENT: Worldwide fuel harmonization is the wrong goal because requirements, infrastructure capabilities and preferences vary regionally.

RESPONSE: Global fuel quality harmonization is needed because vehicles and engines are global products. As countries seek to tighten vehicle and engine requirements, fuel quality becomes an increasingly critical factor for preserving the functionality of these products.

COMMENT: The WWFC should comment on the International Agency for Research on Cancer's (IARC) recent finding of carcinogenicity of vehicle exhaust, especially given the emergence of new vehicle technologies and improved fuels.

RESPONSE: This issue is outside the WWFC's scope.

COMMENT: The WWFC should endorse low carbon/carbon neutral/renewable fuels such as BTL, since tailpipe GHG standards are ineffective.

RESPONSE: The WWFC5 notes in the Technical Background for Diesel Fuel that some "blendstocks, particularly BTL, have relatively low well-to-wheel GHG emissions, and these are preferred over other synthetic fuels that are not considered to be low carbon fuels."

COMMENT: The WWFC relies on many test methods, such as engine tests, that are not widely available at reasonable cost. Also, proposed limits should be measureable and consider test method repeatability, reproducibility and safety.

RESPONSE: The Committee strives to reference test methods that reflect best practices.

COMMENT: The WWFC should include EtBE among the acronyms.

RESPONSE: The Committee accepts this suggestion.

COMMENT: The WWFC should consider creating a new category for GTL, BTL, HVO and other neat paraffinic fuels.
RESPONSE: The WWFC is designed to present performance requirements and does not define the processes by which fuels are made.

COMMENT: EN 228 and EN 590 are among the most advanced fuel standards in the world, and advanced vehicle technologies have successfully used them for years, but neither meets all of the WWFC5 specifications, implying European fuel quality is inadequate. The WWFC should support these standards, perhaps by defining a category that complies with them.
RESPONSE: The WWFC offers recommendations for optimum fuel quality for performance and emissions. Even well-formulated, advanced standards may have room for improvement.

COMMENT: The biofuel blends allowed in this proposal do not need additional pump labelling. The labelling requirement for up to 5% FAME in diesel fuel is contrary to US law.
RESPONSE: Pump labelling is useful for the consumer. Also, the WWFC represents recommendations for a global market, and as such, its specifications may differ from standards specific to any particular country or location.

COMMENT: Why does the WWFC5 recommend a particular fuel nozzle, and what relevance does the nozzle have to fuel quality?
RESPONSE: The recommendation helps address misfueling and represents best practice.

COMMENT: The WWFC should state that unprocessed vegetable oils, animal fats and non-esterified fatty acids are unacceptable as diesel fuels or as diesel fuel blend components.
RESPONSE: The WWFC5's Technical Background for Diesel Fuel states: "Unprocessed vegetable oils, animal fats and non-esterified fatty acids are not acceptable as transportation fuels due to their very low cetane, inappropriate cold flow properties, high injector fouling tendency and high kinematics viscosity level."

COMMENT: Sulphur does not "contaminate" fuel because it is not added and is naturally part of the crude oil.
RESPONSE: The Technical Background has been changed to clarify how sulphur gets into the fuel.

COMMENT: Regarding the discussions about Good Housekeeping: (1) They would be greatly improved by recommending appropriate steps be taken to minimize elemental contamination by harmful elements such as copper, zinc and sodium, and by stating that adding used engine oil to fuel is unacceptable (unless expressly allowed by the manufacturer); (2) The WWFC5 should cite some of CONCAWE's many reports on good housekeeping.
RESPONSE: The Committee appreciates the comment and has modified the Technical Background.

COMMENT: The WWFC5 should include zinc as a harmful trace metal in the specifications.
RESPONSE: The specifications do not exclude zinc as a harmful trace metal, but the Committee agrees it would be helpful to explicitly mention Zn and has added it to the list of harmful trace metals.

COMMENT: Some supply and distribution systems cannot easily measure, control or remove trace metals to the level required, and trace metal harm is not well characterised.
RESPONSE: It is important for the market to adopt best available practices to ensure good fuel quality control. Improved trace metal test methods are being developed and will be incorporated when available.

COMMENT: The ICP method cannot detect chlorine, but ASTM D7359 may.
RESPONSE: The Committee will consider this suggestion for future editions.

COMMENT: Various comments were submitted regarding other test methods.
RESPONSE: Some test methods were added and others were corrected, as suggested.

COMMENT: Various comments were submitted regarding terminology.
RESPONSE: The Committee reviewed the suggestions and made changes in some cases.

COMMENT: The most common source of chlorine (chloride) contamination is from salt water (sodium chloride), originating during refining (salt dryers), fuel shipping (sea water ballast) and/or storage (salt water intrusion), especially for gasoline-ethanol blends which dissolve water more readily than E0.
RESPONSE: The Committee appreciates the comment and has modified the Technical Background.

Comments Relating Specifically To Gasoline

COMMENT: Category 5 should keep 91 RON gasoline because eliminating that grade is unnecessary (with premium fuel widely available), costly, without emission or fuel efficiency benefits and will increase refinery GHG emissions. The WWFC5 should defer to ASTM and CRC which are both addressing this issue.
RESPONSE: Higher market octane is a key enabler of more fuel efficient vehicles and engines.

COMMENT: The WWFC5 should include the Antiknock Index ((R+M)/2), which US law requires.
RESPONSE: RON and MON are recognized globally.

COMMENT: The Category 4 and Category 5 sulphur limits for gasoline lack scientific justification and will cause octane loss, increase fuel cost and increase GHG emissions.
RESPONSE: The Committee disagrees. A 10 ppm maximum sulphur limit in gasoline enables the use of more advanced technologies for emissions reduction and fuel efficiency and, compared to higher sulphur levels, improves the emissions performance of existing technologies.

COMMENT: The WWFC5 should accept proper methanol blending in gasoline, as EN228 allows (up to 3% v/v). Also, what is the rationale for not addressing certain regional use of higher methanol blends, such as M15, M30 and even M85?
RESPONSE: Methanol increases the risk of corrosion and material incompatibility. Some manufacturers do not allow any methanol use in some products. Some markets allow a maximum of 0.3%, which means no intentional addition in practice. Regarding higher methanol blends, such blends are outside the scope of this document.

COMMENT: The WWFC5 should modify the oxygen footnote to treat all types of acceptable oxygen additives the same.
RESPONSE: Oxygen content is not the only factor in determining the recommended limits.

COMMENT: The WWFC5 should acknowledge that some manufacturers are allowing up to E15 in non-flexible-fuel vehicles.
RESPONSE: Individual manufacturers may have different approaches to the use of blending components such as ethanol and, therefore, differing compatibility limits.

COMMENT: The WWFC5 should clarify whether E10 is acceptable in older vehicles, i.e., whether protection grade ethanol blends should continue to be made available.
RESPONSE: The Committee agrees some regions may still require the availability of ethanol levels below E5 for their fleets and has slightly modified the existing Technical Background text: "Maintaining the availability of protection-grade fuel (up to E5) may be necessary in some markets to protect older vehicles designed for ethanol-free gasoline."

COMMENT: The WWFC5 should raise the gasoline sediment limit.
RESPONSE: The Committee reviewed the limit and believes it is correct. ASTM D5452 precision is adequate to support the limit.

COMMENT: The WWFC5 should increase the unwashed gum limit and provide more information about the trade-offs between gum-levels and the use of performance additives.
RESPONSE: The existing footnote to the unwashed gum and CCD limits already addresses this question. The Technical Background further explains the trade-offs.

COMMENT: The WWFC5 should use the same density range in both Category 4 and Category 5, in the absence of a rationale for different ranges.
RESPONSE: Density levels correspond to category octane levels.

COMMENT: The WWFC5 should drop the term "sulphur corrosion" and call it "silver corrosion" instead.
RESPONSE: The Committee agrees and has changed the document accordingly.

COMMENT: The WWFC5 should rely on detergent additives for fuel injector cleanliness and either stop requiring two poorly available methods or remove the requirement.
RESPONSE: The Committee agrees injector cleanliness does not require both methods and has changed the specifications accordingly.

COMMENT: The WWFC5 should recommend additives instead of combustion chamber deposit limits because the methods are not readily available, are inaccurate and additives work well.
RESPONSE: The WWFC recommends performance requirements instead of specific additive formulations and doses.

COMMENT: Some recommendations, such as some volatility limits, deviate from current national or European regulations.
RESPONSE: The Charter represents recommendations for a global market, and as such, its specifications may differ from standards specific to any particular country or location. More stringent local regulations would supersede Charter requirements.

COMMENT: The WWFC5 should include European parameters, limits and methods for the vapour-liquid ratio and update TV/L=20 limits to match ASTM.
RESPONSE: The Committee will consider these suggestions for future editions.

COMMENT: The test methods for determining oxidation stability (ISO 7536 and ASTM D525) cannot be used on ethanol blends. It would be helpful if WWFC5 would highlight the need for a new test method.
RESPONSE: The Committee agrees attention should be paid to this issue, since alternatives do not currently exist. New methods for ethanol blends will be considered when they become available.

COMMENT: ASTM D5452 should be checked for applicability to gasoline.
RESPONSE: While this method applies to aviation fuel, it can be used and is useful for motor gasoline. The Committee welcomes and will consider alternative methods if/when available.

COMMENT: Octane rating at altitude need not be equal to the octane rating at sea level, and we are unaware of data that suggest otherwise.
RESPONSE: The Committee disagrees. Many published studies support the need for a common octane rating at all altitudes with modern fuel injected engines since the mid-1980s.

COMMENT: The WWFC5 should inform readers about the dramatic elimination of leaded gasoline over the past decade, especially in African countries, through the combined efforts of the Partnership for Clean Fuels and Vehicles (PCFV) and its automotive and oil industry partners.
RESPONSE: Thank you for mentioning this successful cooperative effort involving the auto, engine and oil industries to educate markets about how leaded gasoline harms vehicles and increases emissions. We would welcome similar efforts directed at additives containing other metals.

COMMENT: The WWFC5 should mention contaminants such as sulphates, water and inorganic chloride that often derive from ethanol blendstocks.
RESPONSE: Ethanol blends should use ethanol blendstocks that meet the WWFC Committee's Ethanol Guidelines, published in 2009.

Comments Relating Specifically To Diesel Fuel

COMMENT: Categories 4 and 5 limits likely can only be met with high levels of additives, which can be difficult to manage and often lead to vehicle performance problems and engine fouling.
RESPONSE: The Committee disagrees that these Categories can only be met with excessive additive levels; rather, this is mainly a base fuel issue. Even so, the Committee always welcomes additional data regarding additive usage and management.

COMMENT: Several commenters recommended alternatives to the proposed non-detectable FAME limit in Category 5: 0.2% v/v, since "non-detectable" is impractical where distribution systems supply both FAME-containing and FAME-free fuels; 7% as in Europe; or FAME-free fuel only during extended parking or fuel storage. One asked why 5% FAME would prevent the use of "highly advanced emission requirements," considering that FAME helps reduce many types of emissions.
RESPONSE: Not all technical issues involving FAME have been identified or resolved, and the intent is to minimize risks to the most advanced technologies. In addition, the introduction of FAME can affect fuel efficiency.

COMMENT: Higher cetane provides no benefits, but the proposed limits could restrict fuel supply.
RESPONSE: The Committee disagrees.

COMMENT: The minimum density limits would restrict the use of low carbon components such as GTL, HVO and low PNA and also could restrict fuel supply.
RESPONSE: As these blending components become more available and experience with them grows, the Committee will re-evaluate the specifications.

COMMENT: The WWFC5 should reduce the sodium limit to 0.1 mg/kg max to minimize internal deposits.
RESPONSE: The Committee agrees, but currently available test methods do not support lower limits. As new test methods become available, the Committee will re-evaluate the limits.

COMMENT: The WWFC5 should include an overall maximum for trace metal content and reduce the acceptable limit for each element to 0.1 mg/kg to restrict the maximum ash load, as the technical background already reasons.
RESPONSE: The Committee agrees, but currently available test methods do not support lower limits. As new test methods become available, the Committee will re-evaluate the limits.

COMMENT: It is unclear why the trace metal limits differ in Categories 2-5 vs Category 1.
RESPONSE: The trace metal limits differ because the engine technologies used in Category 1 markets are less sensitive to metal content than those in the higher categories.

COMMENT: The proposed aromatics cap is unjustified and could significantly restrict refinery operations, cause impacts downstream and limit fuel supply. Similarly, the WWFC fails to justify the very low PAH limits, which also are impractical given current refining processes and normal test method variability.
RESPONSE: The recommended aromatics and PAH limits are intended to optimize emissions performance.

COMMENT: The WWFC5 should require a minimum Initial Boiling Point (IBP) to minimize a potential increase in volatility components in Europe's imported fuel supply. Such components can increase the incidence of cavitation.
RESPONSE: The Committee will consider this topic for future WWFC editions and welcomes any available data.

COMMENT: The WWFC5 should set the CFPP to be below the lowest expected ambient temperature and the CP to below the lowest long term storage temperature, with the CP specification not more than 10°C above the CFPP spec (as described well in the background).
RESPONSE: The Committee has clarified the limit. We note the specification can be met by any of the three cold flow properties.

COMMENT: The biological growth test method is not well-known, and its "zero" limit is difficult to interpret. The Committee should consider using IP 385 with a max limit 1000 –3000 cfu/l. The Committee also might consider using modified IATA (aviation) methods and limits. Good housekeeping (with references to CEN or CONCAWE reports) should help avoid problems.
RESPONSE: The Committee has added the IP test method, will allow alternatives and added a reference on good housekeeping. It will consider additional changes for future WWFC editions and welcomes any available data.

COMMENT: The proposed Rancimat limits are excessively severe, lack sufficient justification and are inconsistent with European market experience. Also, the WWFC5 should re-examine the oxidation stability methods and limits for diesel fuel, especially the Rancimat limits, the Delta TAN method and the PetrOxy method. WWFC5 should clarify which methods can be used with fuels containing FAME.
RESPONSE: The Committee appreciates the comments on this subject, has modified these references and clarified their applicability to fuels containing FAME.

COMMENT: The WWFC should clarify why it includes a TAN limit and should reduce the limit to 0.03 mg/kg for FAME-free fuel to prevent acidified fuels. It also should explain that additives can affect TAN, and that effect should be taken into account when evaluating TAN results.
RESPONSE: The Committee appreciates the comment, will consider this topic for future WWFC editions and welcomes any available data.

COMMENT: For clarity and consistency, the WWFC5 should include GTL and "next generation fuels" in the footnote reference to "Other Biofuels," as well as indicating which biofuels are preferred.
RESPONSE: The Committee recognizes GTL as a high quality fuel component, but GTL is not bio-based. The WWFC represents a performance specification so that any fuel that meets the recommendation is acceptable.

COMMENT: The Total Particulate Contamination limit may be unattainable, given the repeatability of the test method. The WWFC5 should relax the limit to 12-15 mg/kg.
RESPONSE: The Committee reviewed the relevant test methods, changed one of the methods and retained the limit.

COMMENT: Regarding the particle count cleanliness test and limit: (1) The ISO fuel cleanliness approach is very difficult to implement in practice. (2) A particle count cleanliness limit is very desirable, but the selected limit is too severe and should be relaxed to 19/17/14, especially for Category 2 and 3 markets. Also, please clarify whether the limit means "up to and including" or "better than."
RESPONSE: The Committee reviewed the limit and test and believe they are appropriate for Categories 2 to 5. The code rating limit, shown as a maximum, means "up to and including" the stated limit.

COMMENT: The injector cleanliness tests are both engine tests, which are very expensive for monitoring market fuel quality. It is unclear whether the WWFC5 intends to require both tests.
RESPONSE: In Categories 4 and 5, the Committee believes both methods are justified and have appropriate limits. The Committee will consider new methods if/when they become available.

COMMENT: The Internal Injector Deposit limit for Method 1 is premature, since the method remains under discussion.
RESPONSE: The Committee agrees and notes that the limit does not address internal injector deposits. Work on methods to measure these types of deposits is proceeding.

COMMENT: The WWFC5 should tighten the Injector Cleanliness (Method 1) limit to 50% max, at least for Categories 4 and 5.
RESPONSE: The Committee will consider this suggestion for future editions.

COMMENT: The footnote referencing the development of a new method for internal diesel injector deposits (IDID) should be moved to a more relevant location to avoid confusion.
RESPONSE: The Committee agrees and, for clarity, has removed the footnote from the specification tables.

COMMENT: What new performance data support the HFRR relaxation (from 400 to 460 in Categories 1-3) since the publication of the 4th Edition of the WWFC?
RESPONSE: The limits are appropriate for the technologies in those categories.

COMMENT: The WWFC5 should clarify the method used to measure Delta TAN.
RESPONSE: The test method has been clarified.

COMMENT: The WWFC5 should update its discussion of density, viscosity and heating value effects on modern common rail fuel injection systems.
RESPONSE: The Committee appreciates the comment and will consider this suggestion for future editions.

COMMENT: Linking diesel cold flow performance to a lowest expected ambient temperature is impractical.
RESPONSE: The Committee believes the limit adds an additional margin of safety and is justified. We note the specification can be met by using any of the three cold flow test methods.

COMMENT: The WWFC5 should add a new, dedicated discussion of fuel stability, with attention to the distinction between long term storage at reasonable temperatures and thermal stability at the high temperatures found in fuel injection systems.
RESPONSE: The Committee appreciates the comment and will consider the suggestion for future editions.

COMMENT: As some GTL, HVO and other synthetic fuels may require additional controls to ensure acceptability, the WWFC5 should add the CEN TS 15940 specification as a guideline for GTL and HVO quality. Further, such fuels may need additional engine validation.
RESPONSE: The Committee appreciates the suggestion and has modified the Technical Background.

COMMENT: The WWFC5 should mention that high additive treat rates, for example, of some poly isobutylene succinimides (PIBSIs), can cause internal diesel injector deposit (IDID) formation, and should advise additive producers and fuel suppliers to check the extent to which their formulations contribute to such undesirable effects.

RESPONSE: The Committee appreciates the suggestion and has modified the Technical Background.

COMMENT: In addition to nozzle hole coking, the WWFC5 also should discuss internal injector deposits, to which fuel contaminants may contribute. The omission of this topic is a serious defect. Also, the WWFC5 should mention that partial nozzle blockage due to deposits is much more common than complete blockage and will just as significantly reduce fuel flow and affect power and emissions.

RESPONSE: The Committee appreciates the suggestions and has modified the Technical Background.

COMMENT: The discussion about lubricity should be edited to focus on boundary lubrication. The effect of fuel viscosity on friction and wear, under hydrodynamic and elasto-hydrodynamic conditions, also should be discussed.

RESPONSE: The Committee appreciates the suggestions, has modified the Technical Background and will consider additional changes in future editions.

ATTACHMENT 3

You can own and drive a Mercedes-Benz Diesel in the state of *Illinois*

Visit your local Mercedes-Benz dealership to learn more.

Should you have any questions or concerns, please contact your Mercedes-Benz dealer or the Customer Assistance Center at 1-800-FOR-MERCEDES (1-800-367-6372).

Please keep this pamphlet with your Warranty Booklet for future reference.

We hope you are enjoying the exceptional performance and fuel economy of your Mercedes-Benz diesel vehicle and wish you many miles of driving pleasure. Thank you for driving a Mercedes-Benz.

Mercedes-Benz USA, LLC
One Mercedes Drive, Montvale, NJ 07645
1-800-FOR-MERCEDES
MBUSA.com

PSMKG-13-BIODIESEL (10/13)

Mercedes-Benz

Congratulations on your selection of one of the most advanced diesel automobiles in the world.

Your Mercedes-Benz was developed by a company steeped in engineering tradition, and we continuously monitor market conditions to help you foster a long-lasting and gratifying experience with your vehicle. We have found one such development that warrants your attention.

Some states offer certain incentives to blend biodiesel into highway diesel fuel. Biodiesel is produced from various sources such as vegetable oil and used cooking oil, which is processed with methanol to be used as a bio substitute for conventional diesel fuel. As biodiesel is a domestic product it improves energy independence and supports the US economy.

The percentage of biodiesel in highway diesel fuel varies throughout the United States, particularly in Illinois. **Diesel fuel with biodiesel contents up to 5% will generally be labeled "Ultra Low Sulfur Diesel" or ULSD, while fuels with biodiesel contents between 5% and 20% will generally be labeled "B20".**

The fuel station dispenser labels are shown below:

ULTRA-LOW SULFUR HIGHWAY DIESEL FUEL
(15 ppm Sulfur Maximum)

Required for use in all highway diesel vehicles and engines.

Recommended for use in all diesel vehicles and engines.

B-20 Biodiesel Blend

Contains biomass-based diesel or biodiesel in quantities between 5 percent and 20 percent.





Continuous use of B20 fuel can lead to fuel filter clogging and injector deposits, and can cause the engine oil level to rise due to unburned fuel washing into the oil pan. A clogged fuel filter as well as injector deposits can cause engine performance degradation while increased engine oil levels due to dilution by unburned fuel can cause engine mechanical damage.

With these risks in mind, here are some things you can do to help mitigate the effects of B20 fuel:

- Fill up with ULSD (**B5 or less**) whenever possible, from a name brand fuel station.
- Regularly monitor your engine oil level if you use B20 fuel on a regular basis.
- Strictly follow the oil change intervals quoted in the instrument cluster and within your maintenance booklet, and **use ONLY engine oils and filters approved by Mercedes-Benz for use in your vehicle.**
- If you do not plan to drive your vehicle for several weeks, fill your vehicle's fuel tank in advance with ULSD fuel.

ATTACHMENT 4

Mercedes-Benz

August 2, 2013

Mercedes-Benz USA, LLC
A Daimler Company

Mr. Doug Rathbun, Chief
Illinois Bureau of Weights and Measures
Illinois Department of Agriculture
Illinois State Fairgrounds
801 E. Sangamon Ave.
Springfield, IL 62702

Dear Mr. Rathbun:

It has come to our attention that certain producers are inappropriately claiming compliance with the ASTM D975 Standard Specification for Diesel Fuel Oils. Recent warranty data reveals component failures due to the presence of fuel constituents not supported by the D975 specification.

This memo provides a brief explanation of the background of the ASTM D975 standard, the recent changes that have been implemented to it, and a clarification of the Mercedes-Benz and other OEM fuel injection supplier and trade association positions on materials which do not fall under the D975 standard.

The ASTM D975 specification, developed over the last 50 years, is based on the use of crude petroleum refined in conventional petroleum refineries. Fuels produced in this manner have certain inherent properties that make them suitable for use in diesel engines including, but not limited to: BTU content, fuel stability, and bulk modules of elasticity. Such properties are not controlled or measured in the ASTM D975 fuel specification. It is the combination of meeting the ASTM D975 fuel specification–and the inherent properties of fuel produced from traditional petroleum refineries--that provides a "fit for purpose" fuel for diesel engines.

Mercedes-Benz USA, in conjunction with General Motors Company, Truck and Engine Manufacturers Association (EMA), Robert Bosch GmbH and other stakeholders support the development of renewable fuels. These companies are actively working with the fuels industry and regulators to ensure these new fuels have appropriate specifications and quality controls. Such safeguards ensure that the renewable fuels will provide the performance customers expect from their vehicles, like those equipped with BlueTEC clean diesel technology. The first step in achieving this goal is the development and approval of ASTM consensus standards for these new fuels and additives.

Currently, the predominant new fuel for diesel engines is biodiesel, also known in the US as FAME (fatty acid methyl ester). The biodiesel industry has worked with petroleum and OEM stakeholders at ASTM to:

- secure ASTM standards for B100 (ASTM D6751 biodiesel-blendstock) used in blending with diesel fuel
- modify ASTM D975 to include up to 5% biodiesel meeting D6751
- develop a separate stand-alone standard for B6-B20 blends, ASTM D7467

The efforts of the biodiesel industry to work with OEMs, fuel refiners and fuel marketers to secure appropriate ASTM specifications serve as a model for other new fuels.

Mercedes-Benz USA, LLC
One Mercedes Drive
P.O. Box 350
Montvale, NJ 07645-0350
Phone (201) 573-0600
Fax (201) 573-0117
www.MBUSA.com

As new *fuels and* components have come into the market, some unscrupulous marketers have begun blending non-petroleum and non-hydrocarbon materials into petroleum-based diesel fuel, claiming that the finished fuel meets the D975 standard. Many of these new materials have not been well studied or tested to ensure they will provide a "fit for purpose" fuel. Some of these materials, such as alcohols, ethers, water emulsions, and raw vegetable oils or fats, are known to promote fuel injection and other engine concerns. It is important to note that any resultant damage associated with their use will not be covered by the Mercedes-Benz or other OEM New Vehicle Limited warranties. Consequently, ASTM modified the D975 standard in 2011 to more clearly specify which constituents are covered by ASTM D975 and which will need further study prior to D975 adoption via the ASTM consensus balloting process. The present revision of D975 includes a definition of the term 'hydrocarbon oil' to more clearly describe what the specification pertains to, both from a historic and current viewpoint (see ASTM D975 section 3.2 Definitions of Terms Specific to this Standard, available at http://www.astm.org/search/site-search.html?query=D975&cartname=mystore).

The materials noted above, such as alcohols, ethers, water emulsions, and raw vegetable oils or fats are not hydrocarbons and do not fall under the ASTM D975 standard unless they have been specifically balloted into the standard. Again, the leading example here is biodiesel (which is an ester, not a hydrocarbon), now permitted in blends up to 5% biodiesel, which meets its ASTM D6751 B100 blendstock standard under ASTM D975 through its incorporation under Section 7.3 of the standard.

This background is important when considering that certain companies are blending into base petroleum diesel fuel, oxygenated materials in levels up to 5% and claiming they 'meet D975' even though ASTM has incorporated the definitions above to strictly prohibit such materials from being considered D975 compliant fuel. We understand these companies are claiming they are 'additives' which are mentioned in D975 Note 5 as generally included in finished diesel fuel to improve performance properties (e.g. Cetane Number, lubricity, etc.).

Diesel fuel additives are typically added in extremely small levels (commonly between 3 -200 ppm). Such additive levels are considered beneficial and are supported by OEMs in general when professionally administered prior to retail sale. While ASTM does not specifically limit the amount of allowable additives, Mercedes-Benz *et al.* maintain that the maximum allowable additive concentration in D975 diesel fuel is 5000 ppm or 0.5% v/v.

Furthermore, the Truck and Engine Manufacturers Association issued a position statement in July 2012 stating that the use of unprocessed fats, greases or oils can reduce engine life and result in increased maintenance costs and should therefore be avoided. Referenced in that EMA guidance letter is the US Department of Energy's "Biodiesel Handling and Use Guide, 4th Edition" which advises that "raw or refined plant oil, or recycled greases that have not been processed into biodiesel, are not biodiesel and should be avoided." Similarly, the Diesel Fuel Injection Equipment Manufacturers, consisting of Bosch, Continental, Delphi, Denso, and Stanadyne issued "Common Position Statement 2012", available at http://www.globaldenso.com/en/topics/files/120730common_position_paper.pdf, which explicitly states that "the FIE manufacturers note that their high pressure fuel injection equipment is not designed to run on unesterified plant oil...".

Thus, in our view, fuels containing oxygenated materials other than 5% biodiesel, or additives in excess of 5000 ppm, do not meet ASTM D975. To reiterate, damage induced by fuel containing these products would not be covered by the Mercedes-Benz New Vehicle Limited Warranty or other OEM vehicle warranties.

Clean diesel technology is an integral part of the Daimler GHG Compliance Plan and customer acceptance of clean diesel technology is critical to the success of C02 reduction. We are extremely concerned that companies which produce or blend in low quality, non-ASTM covered alternative, renewable or oxygenated materials into US diesel fuel have caused and will cause both short- and long-term problems in these vehicles, adversely affecting the customer perception and acceptance of clean diesel technology in the US.

We encourage your support in enforcing the ASTM D975 specification as it was intended, and welcome the opportunity to discuss this with you and assist in this effort.

If you have any questions, please feel free to contact me or William Woebkenberg, Fuels Technical and Regulatory Affairs, Mercedes-Benz Research & Development North America.

Sincerely,

R. Thomas Brunner
Department Manager,
Vehicle Compliance and Analysis
Product Technical Support

Shaun Roopnarine
Environmental Compliance Engineer
Vehicle Compliance and Analysis

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MINNESOTA

MINNESOTA TRUCKING ASSOCIATION, MINNESOTA AUTOMOBILE DEALERS ASSOCIATION, ALLIANCE OF AUTOMOBILE MANUFACTURERS, AMERICAN PETROLEUM INSTITUTE, and AMERICAN FUEL AND PETROCHEMICAL MANUFACTURERS,

Plaintiffs,

v.

JOHN LINC STINE, in his official capacity as Commissioner of the Minnesota Pollution Control Agency, DAVE FREDERICKSON, in his official capacity as Commissioner of the Minnesota Department of Agriculture, MICHAEL ROTHMAN, in his official capacity as Commissioner of the Minnesota Department of Commerce, and JULIE QUINN, in her official capacity as Director, Minnesota Department of Commerce's Weights and Measures Division,

Defendants.

DECLARATION OF VALERIE UGHETTA

1. My name is Valerie Ughetta. I am the Director, Automotive Fuels (Environmental Affairs) for the Alliance of Automobile Manufacturers (the "Alliance"). As the Director, Automotive Fuels (Environmental Affairs), I manage Alliance activity on environmental issues with regard to automotive fuels and fuel quality, and staff the Alliance Fuels Workgroup. I graduated *cum laude* from Mount Holyoke College with a Bachelor of Arts degree in English, and I received a Juris Doctor degree from Catholic University of America School of Law. I am a member of the District of Columbia Bar (active) and the Maryland Bar (inactive); however, at my workplace, I am not engaged in the practice of law.

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2. The Alliance is a non-profit trade association comprised of twelve (12) member companies: BMW Group, FCA US LLC, Ford Motor Company, General Motors LLC, Jaguar Land Rover, Mazda Motor of America, Inc., Mercedes-Benz USA, LLC, Mitsubishi Motors North America, Inc., Porsche Cars North America, Inc., Toyota Motor Sales, Inc., Volkswagen Group of America, Inc., and Volvo Car Corporation.

3. The Alliance is the leading advocacy group for the auto industry and its members represent 77% of all cars and light truck sales in the United States. The Alliance operates for the purpose of promoting the general commercial, professional, legislative, regulatory and other common interests of its members. In this regard, the Alliance advocates on behalf of the auto industry to the public, Congress and the Executive Branch, state governments and the media. The Alliance represents the auto industry in legal proceedings, participates in coalitions and works in partnership with other associations to achieve its members' public policy goals. The Alliance regularly appears in litigation as a party where the issues raised are of widespread importance and concern to the industry.

4. Individual members of the Alliance have sold and continue to sell diesel-powered vehicles into the Minnesota market or may do so in the near future. Diesel-powered vehicles sold in other states are also driven to and operated in Minnesota.

5. By resolution of the Alliance Board of Directors, Mercedes-Benz USA, LLC ("MBUSA") became a member of the Alliance in 2007 and remains a member today.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on March 18, 2015.

Valerie Ughetta

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MINNESOTA

MINNESOTA TRUCKING ASSOCIATION, MINNESOTA AUTOMOBILE DEALERS ASSOCIATION, ALLIANCE OF AUTOMOBILE MANUFACTURERS, AMERICAN PETROLEUM INSTITUTE, and AMERICAN FUEL AND PETROCHEMICAL MANUFACTURERS,

Plaintiffs,

v.

JOHN LINC STINE, in his official capacity as Commissioner of the Minnesota Pollution Control Agency, DAVE FREDERICKSON, in his official capacity as Commissioner of the Minnesota Department of Agriculture, MICHAEL ROTHMAN, in his official capacity as Commissioner of the Minnesota Department of Commerce, and JULIE QUINN, in her official capacity as Director, Minnesota Department of Commerce's Weights and Measures Division,

Defendants.

DECLARATION OF ROBERT L. GRECO, III

1. My name is Robert L. Greco, III. I am the Group Director of Downstream and Industry Operations for the American Petroleum Institute ("API"). API is a national trade association representing over 625 companies involved in all aspects of America's oil and natural gas industry. API's members include producers, refiners, blenders, pipeline operators and marine transporters, as well as service and supply companies that support all segments of the industry ("Members").

EXHIBIT
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2. I currently reside in Vienna, Virginia. I received my Bachelor of Arts degree in Biology from Colgate University in 1981 and my Master of Science degree in Environmental Engineering from Cornell University in 1984.

3. I began working at API in 1990 with the Health and Environmental Affairs Department. During my employment with API, I have served in several capacities, including as the Director for Policy Analysis, Director of Global Climate Programs, and Refining Issues Manager. Over my 25 year career with API, I have managed issues such as refining, the production of gasoline and jet fuels, and the implementation of the Clean Air Act. Before joining API, I was an environmental engineer with the U.S. Environmental Protection Agency ("EPA"), with expertise in fuels and automotive emission control technologies. I was named API's Group Director of Downstream and Industry Operations in 2007.

Background on Minnesota's Biodiesel Mandate

4. API has been concerned with Minn. Stat. Ann. § 239.77 since its passage. Under that statutory section, all diesel fuel offered for sale in the State of Minnesota beginning on September 29, 2005 was required to be 2% biodiesel in content, with the remainder of the blend being petroleum diesel. That blend is known in the industry as "B2." On May 1, 2009, the biodiesel content requirement for diesel fuel sold in Minnesota was increased to 5%, i.e., "B5."

5. Under the statute, the Commissioners of the Minnesota Department of Agriculture, Department of Commerce, and Pollution Control Agency ("Commissioners") could increase to 10% the required biodiesel content of diesel fuel (i.e., "B10") sold or offered for sale in Minnesota during certain months after May 1, 2012, provided the Commissioners made four findings.

6. Without soliciting formal public comment, the Commissioners published a conclusory notice on September 30, 2013 in the *Minnesota Register* indicating that the four findings had been met and that the biodiesel content mandate would be increased to 10% biodiesel, or "B10." That meant that effective July 1, 2014, the biodiesel content of all diesel fuel offered for sale or sold in Minnesota for use in internal combustion engines during the months of April through September would be B10 (the "Minnesota Mandate").

Members Will Be Burdened with the Costs of Complying with the Minnesota Mandate

7. Members of API are injured by the Minnesota Mandate because they will incur more costs to sell diesel fuel in Minnesota than would be the case in the absence of the mandate. For example, by being subject to the Minnesota Mandate, Members of API must acquire biodiesel to blend with petroleum diesel to ensure that the diesel fuel sold at retail in Minnesota achieves the mandated 10% biodiesel content. Absent the Minnesota Mandate, the Members would not blend each gallon of diesel fuel they sell in Minnesota to at least 10% biodiesel. Thus, because of the mandate, those Members will expend additional effort and incur additional costs associated with acquiring the amount of biodiesel needed to meet the Minnesota Mandate, blending that biodiesel into petroleum diesel and delivering the B10 blend to the Members' retail stations in Minnesota, and implementing the internal administrative procedures necessary to assure compliance with the state mandate.

8. Further, as a result of blending biodiesel with petroleum diesel to achieve the required 10% biodiesel content, Members will sell proportionally less petroleum diesel in Minnesota.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on April 16, 2015.

Robert L. Greco, III

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MINNESOTA

MINNESOTA TRUCKING ASSOCIATION, MINNESOTA AUTOMOBILE DEALERS ASSOCIATION, ALLIANCE OF AUTOMOBILE MANUFACTURERS, AMERICAN PETROLEUM INSTITUTE, and AMERICAN FUEL AND PETROCHEMICAL MANUFACTURERS,

Plaintiffs,

v.

JOHN LINC STINE, in his official capacity as Commissioner of the Minnesota Pollution Control Agency, DAVE FREDERICKSON, in his official capacity as Commissioner of the Minnesota Department of Agriculture, MICHAEL ROTHMAN, in his official capacity as Commissioner of the Minnesota Department of Commerce, and JULIE QUINN, in her official capacity as Director, Minnesota Department of Commerce's Weights and Measures Division,

Defendants.

DECLARATION OF TIMOTHY HOGAN

1. My name is Timothy Hogan. I am the Director, Motor Fuels for the American Fuel & Petrochemical Manufacturers ("AFPM"). AFPM is a non-profit national trade association representing more than 400 companies, including a majority of all United States refiners and petrochemical manufacturers. AFPM members operate 120 U.S. refineries comprising more than 95% of U.S. refining capacity.

2. I currently reside in Clifton, Virginia. I received my Bachelor of Science degree in Mathematics from the University of Dayton in 1973 and my Master of Operations Research degree from George Washington University in 1979.

EXHIBIT
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3. I began working at AFPM in 1998. I represent AFPM members before federal regulatory agencies and the Executive Branch. I develop AFPM positions on fuels issues with AFPM leadership and members. Before joining AFPM, I worked on fuels issues for the American Petroleum Institute, was a consultant for Energy and Environmental Analysis, and collected and reported data for the American Gas Association.

Background on Minnesota's Biodiesel Mandate

4. AFPM has been concerned with Minn. Stat. Ann. § 239.77 since its passage. Under that statutory section, all diesel fuel offered for sale in the State of Minnesota beginning on September 29, 2005 was required to be 2% biodiesel in content, with the remainder of the blend being petroleum diesel. That blend is known in the industry as "B2." On May 1, 2009, the biodiesel content requirement for diesel fuel sold in Minnesota was increased to 5%, i.e., "B5."

5. Under the statute, the Commissioners of the Minnesota Department of Agriculture, Department of Commerce, and Pollution Control Agency ("Commissioners") could increase to 10% the required biodiesel content of diesel fuel (i.e., "B10") sold or offered for sale in Minnesota during certain months after May 1, 2012, provided the Commissioners made four findings.

6. Without soliciting formal public comment, the Commissioners published a conclusory notice on September 30, 2013 in the *Minnesota Register* indicating that the four findings had been met and that the biodiesel content mandate would be increased to 10% biodiesel, or "B10." That meant that effective July 1, 2014, the biodiesel content of all diesel fuel offered for sale or sold in Minnesota during the months of April through September would be B10 (the "Minnesota B10 Mandate").

7. Individual members of AFPM sell diesel in Minnesota and are therefore subject to the Minnesota B10 Mandate.

Members Will Be Burdened with the Costs of Complying with the Minnesota B10 Mandate

8. Members of AFPM are injured by the Minnesota B10 Mandate because they will incur more costs to sell diesel fuel in Minnesota than would be the case in the absence of the mandate. For example, by being subject to the Minnesota B10 Mandate, certain Members of AFPM must acquire biodiesel to blend with petroleum diesel to ensure that the diesel fuel sold at retail in Minnesota achieves the mandated 10% biodiesel content. Absent the Minnesota B10 Mandate, those Members would not blend each gallon of diesel fuel they sell in Minnesota to at least 10% biodiesel. Thus, because of the mandate, those Members will expend additional effort and incur additional costs associated with acquiring the amount of biodiesel needed to meet the Minnesota B10 Mandate, blending that biodiesel into petroleum diesel and delivering the B10 blend in Minnesota, and implementing the internal administrative procedures necessary to assure compliance with the state mandate.

9. Further, as a result of blending biodiesel with petroleum diesel to achieve the required 10% biodiesel content, Members will sell less petroleum diesel in Minnesota.

Members Will Experience Increased Costs of Complying with the Federal Renewable Fuel Standard

10. Because some of AFPM's Members produce diesel fuel and/or gasoline in the United States, those Members are obligated parties under the federal Renewable Fuel Standard ("RFS"). The RFS, established by Section 211(o) of the Clean Air Act, established minimum national biofuel blending requirements, which must be met on an average annual basis, and directed EPA to promulgate regulations to ensure that these requirements were met. The RFS

was amended in 2007 to increase substantially the minimum volumes of renewable fuels that refiners must blend with gasoline, and effectively imposes a biodiesel national blending requirement.

11. The RFS has four requirements: total RFS, advanced biofuels, biomass-based diesel, and cellulosic biofuel. Biomass-based diesel includes biodiesel and renewable diesel. Biodiesel is the primary compliance option to meet the biomass-based diesel requirement.

12. The regulations promulgated by EPA establish a credit trading program under which each gallon of renewable fuel is assigned a unique Renewable Identification Number ("RIN"). Refiners and importers satisfy their obligations under the RFS by conveying RINs on an annual basis to EPA. EPA specifies in its regulations the number of biomass-based diesel RINs that must be submitted for each gallon of petroleum diesel and gasoline produced by domestic manufacturers each year. Thus, the number of RINs that Members must submit to EPA for a given year is determined by how much petroleum diesel and gasoline those Members produce in the United States that year and by the RIN obligation adopted by EPA in its rules.

13. Refiners or importers may purchase biodiesel RINs from a biodiesel manufacturer or importer, or may acquire biodiesel RINs by purchasing them from other entities that have generated or acquired biodiesel RINs. Because it is implemented using an allowance-based approach, the RFS does not require obligated parties or any other entity to blend biodiesel into petroleum diesel fuel at any specified proportion.

14. Members of AFPM have established programs to ensure compliance with the RFS that rely on the RFS credit trading program.

15. Members of AFPM are injured by the Minnesota B10 Mandate because the mandate limits Members' compliance flexibility under the RFS. For example, as noted above,

Members are not required by the RFS to blend any particular amount of biodiesel into the diesel fuel they sell in Minnesota, or in any other location in the United States. Therefore, Members are free in any given year to purchase RINs, as they see fit, to satisfy their obligations under the RFS. Absent the Minnesota B10 Mandate, Members would not blend each gallon of diesel fuel they sell in Minnesota to at least 10% biodiesel. That would not be part of Members' least-cost compliance strategy under the RFS. As a result, the Minnesota B10 Mandate interferes with the compliance strategy that AFPM's Members otherwise would implement to satisfy the federal program.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on April 15, 2015.

Timothy Hogan

Timothy Hogan