

Comments were received from 14 companies and individuals on the June 2002 proposed World-Wide Fuel Charter (WWFC). All comments were carefully reviewed for appropriate action. In many cases several individuals or organizations, in essence, made the same comment. For brevity, the following discussion has been organized by the concept behind the comment rather than repetitively responding to many similar comments. Several helpful editorial corrections were suggested and adopted, but are not described in this document. For reasons of confidentiality, the individual commenters are not identified. It should be noted that the WWFC represents recommendations for a global market, and as such, its specifications will differ in some regards from standards specific for any particular country or location.

## GENERAL COMMENTS ON THE WORLD-WIDE FUEL CHARTER

- Comment:* Specific limits should be stated for the parameters instead of "non-detectable." It is not clear what procedure should be used or what the detection limits would be.
- Action & rationale:* "Non-detectable" represents a specification of "0," however, test method detectability limits should be used. It is the Committee's objective to minimize these contaminants to the lowest possible levels, and it expects no intentional additions. Test methods have been added where omitted, and the fuel manufacturer should assure the product would conform to the most precise and/or accurate method listed.
- Comment:* Temperature ranges in the volatility tables are confusing. It is not clear if min./max. ambient or other temperatures should be followed (i.e. 10%-ile/90%-ile).
- Action & rationale:* A note clarifying intended use of the classes has been added to the volatility tables. Minimum ambient temperatures, however, are defined differently in various markets or regions. The agency or organization utilizing the WWFC should define how to use temperature ranges based on its desired confidence and robustness levels.
- Comment:* The WWFC does not consider the relative environmental CO<sub>2</sub> emissions from vehicle and refinery energy effects. Reduced aromatics will lead to increased energy requirements at the refinery leading to overall higher CO<sub>2</sub> emissions.
- Action & rationale:* The overall environmental emissions from a vehicle can be split into "well to tank" (from oil well to vehicle fuel tank) and "tank to wheel" (vehicle operation). "Well to tank" includes refinery emissions, distribution and drilling or production emissions and accounts for only approximately 15% of the total lifecycle CO<sub>2</sub> emissions. Although refinery changes to produce more environmentally friendly fuels could in some cases result in higher energy use, the overall environmental benefits far outweigh these concerns. In many parts of the world, refiners and their technology suppliers have consistently been able to produce the "cleaner fuels" with less impact on the environment.
- Comment:* The phrase "integrated emission control technology" should be used in place of "aftertreatment."
- Action & rationale:* A review of the current WWFC text has determined that a similar phrase ("emission control system" and "aftertreatment") is used, each in their most appropriate contexts.
- Comment:* What are the compliance rules with respect to test precision?
- Action & rationale:* Unless otherwise defined by the controlling organization (e.g. government agency), the average of all test results should conform to the specification limits.
- Comment:* There is no need for world fuel standards.
- Action & rationale:* Charter members believe that defining the fuel quality deemed necessary for durability and emissions control systems is of value to customers and governments world-wide and can help promote harmonization, which lowers costs to consumers.
- Comment:* The petroleum industry did not participate in drafting the WWFC. The OEM's are being selective in developing specs rather than working with the petroleum industry.
- Action & rationale:* We believe issuing a proposal and reviewing comments from all interested parties, including the petroleum industry, is the most efficient approach to defining global specifications.
- Comment:* The WWFC is not needed. EU 2005 standards are sufficient.
- Action & rationale:* The WWFC is intended, in part, to help harmonize vehicle technology across regions. It is the only document

that transcends government borders and the needs of different markets around the world. In 2005, the European Union will introduce sulfur free diesel fuel and gasoline with sulfur content of 10 ppm or less to enable new technology to meet lower emissions and improved fuel economy. At the same time, many other areas of the world have different vehicle technology requirements and market needs.

*Comment:* Specifications should be based on engine performance tests, not indirect methods.

*Action & rationale:* Where practical, engine tests are specified. In some cases, less expensive alternatives are offered to accommodate the financial realities in some markets.

*Comment:* Various comments were submitted regarding test methods and detection limits.

*Action & rationale:* Some test methods were added and others were corrected as suggested. The year was retained on some methods so that control over the content of the Charter was maintained. Units and detection limits were updated as needed.

*Comment:* Can local or regional test methods be used?

*Action & rationale:* Other procedures can be used, however, the methods listed are considered appropriate and are the "referee" methods.

## COMMENTS RELATED SPECIFICALLY TO GASOLINE SPECIFICATIONS

*Comment:* The RON and MON levels defined by the WWFC do not correlate to U.S. anti-knock index practice.

*Action & rationale:* The WWFC specifications represent the minimum octane requirements as defined by vehicle manufacturers for use in all world-wide markets.

*Comment:* Due to changing engine designs, RON has become a much more meaningful measure of knock resistance than MON. Recent studies on modern European vehicles indicate that the best knock resistance is provided by fuels with lower MON at a given RON. This means better knock resistance with higher olefins and aromatics at the same RON and argues against the requirement of a minimum MON.

*Action & rationale:* The Committee continues to believe both RON and MON are needed for all operating conditions.

*Comment:* The "98 RON" gasoline should allow for a higher than 10 number sensitivity matching commercial practice.

*Action & rationale:* Minimum MON is required for proper engine operation. Commercial practice does not always necessarily represent vehicle operating needs.

*Comment:* There is a need for an 80 octane grade in developing countries, many of which use leaded fuels with RON in the low 80s.

*Action & rationale:* Developing countries need the benefits of modern fuels and vehicles too. WWFC members do not endorse the continued use of low octane fuels below specifications.

*Comment:* A test that requires longer than industry standard oxidation requirements will delay product delivery.

*Action & rationale:* Test length should have no bearing on product delivery. These tests define the minimum acceptable performance of the end product. Quality control tests may be different as long as the products conform to the specification. There are no specified frequencies defined for specification conformance. It is expected that the fuel delivered to the customer will conform to the specification. Each company determines its needed process control/quality control frequencies and procedures necessary to assure product conformance.

*Comment:* Sulfur has no effect on OBD function, and reference to this should be removed from the Technical Background section.

*Action & rationale:* While many current OBD system indicators are not activated when exposed to high sulfur fuels, it is clear that sulfur affects catalyst efficiency, and future OBD systems may not tolerate high sulfur fuels.

## RESPONSE TO COMMENTS ON WORLD-WIDE FUEL CHARTER — DECEMBER 2002

- Comment:* The non-linear effect of sulfur is seen only in AQIRP and is an artifact of nickel in U.S. catalysts.
- Action & rationale:* The non-linear effect is also evident in other programs, including the CRC study. Nickel is used to limit hydrogen sulfide formation. It does not fundamentally make the catalyst less tolerant of sulfur.
- Comment:* Advanced NO<sub>x</sub> technology is not yet durable. NO<sub>x</sub> reduction technology encounters trouble at 50 ppm sulfur.
- Action & rationale:* Fuel changes are most important when they enable new technology. Advanced NO<sub>x</sub> technology, for which research is rapidly advancing, makes possible large gains in pollution control. Sulfur reduction as defined in Category 4 is necessary in facilitating this new technology.
- Comment:* The change in emissions due to sulfur reductions is small in absolute terms.
- Action & rationale:* As emissions regulations become more stringent, small improvements in vehicle technology become much more difficult and fuel quality changes become much more important. Up to 21% emission reduction translates to tons of pollutants fleet-wide, which is very meaningful to the environment.
- Comment:* There should be a transition limit for lead of 13 mg/L instead of non-detectable.
- Action & rationale:* The detection limit of the current test method ASTM D 3237 is 2.6 mg/L. Lower levels of lead are necessary to protect catalyst technology.
- Comment:* The use of MMT should be allowed since it can help improved octane and reduce emissions.
- Action & rationale:* The Committee disagrees. Previous studies as well as the most recent study conducted by the Alliance and AIAM prove the detrimental effects of MMT. Charter members continue to believe any potential benefits from the use of MMT are outweighed by its known disadvantages.
- Comment:* The use of a "complex model," which would allow refiners to trade and offset various parameters with equivalent emissions impact, is preferred to individual parameter requirements.
- Action & rationale:* The use of individual parameter limits representing min./max. requirements for proper vehicle performance is preferred for ease of use in all world markets.
- Comment:* The WWFC should increase the gasoline maximum oxygen content to 3.5% (by mass) to allow the use of 10% (by volume) ethanol blends.
- Action & rationale:* The Committee selected the general mass oxygen limit of 2.7% to assure proper engine operation. A footnote, however, indicates the Committee accepts the use of 10% ethanol where the fuel conforms with all other distillation/volatility requirements and is permitted by pre-existing regulation.
- Comment:* The 3.5% oxygen content level for ethanol is too high. There is agreement with WWFC requirement of using co-solvents and corrosion inhibitors when methanol is used.
- Action & rationale:* The use of ethanol up to 10% by volume has been determined acceptable if the fuel conforms with all other distillation/volatility requirements and is permitted by pre-existing regulation. The Committee agrees with the methanol use comments.
- Comment:* Due to a maximum oxygen content cap, the WWFC does not allow the addition of 10% ethanol on top of base gasoline that may contain up to 2% MTBE, which is allowed by U.S. EPA.
- Action & rationale:* The WWFC specifications represent the max./min. requirements for proper vehicle performance. The Committee does not agree with EPA practice.
- Comment:* Limits on total olefins restricts the use of "good" olefins that could help meet octane requirements. Exhaust olefins are due mostly from light olefins and can originate from paraffins converted during combustion.
- Action & rationale:* There isn't enough information at this time to specify types of olefins, but the Committee will consider this comment in future WWFC editions.
- Comment:* The olefin limit of 10% is too restrictive and should be 20% max. Additives can compensate for the negative effects of olefins.
- Action & rationale:* While olefins are also produced by partial combustion, increases in olefin content directly increase the contribution from unburned hydrocarbons.

- Comment:* The proper pH levels for ethanol are now defined in ASTM D 4806-01a specification (6.5-9.0) for ethanol and do not need to be referenced in WWFC (currently 7.0-9.0).
- Action & rationale:* Though the ASTM specification allows a wider range of pH, it has been now also incorporated in the WWFC.
- Comment:* The latest CRC volatility program results suggest DI is no longer an issue in newer, less sensitive vehicle technology.
- Action & rationale:* The test temperature and duty cycles used in the CRC program do not properly represent reported customer concerns. Also, newer technology vehicles will be calibrated very lean to meet stringent emission standards and will require good volatility within the specified distillation limits.
- Comment:* The abbreviated term for "DI" is confusing. Does it represent ASTM driveability index or distillation index?
- Action & rationale:* DI, as defined in the WWFC document, represents the Distillation Index, which includes the necessary oxygenate correction factor. In those sections where ASTM Driveability Index is referenced, this term is spelled out as "Driveability Index."
- Comment:* A DI specification is not needed since other distillation parameters are defined. T50 and E100 are sufficient.
- Action & rationale:* While single distillation parameters are very useful for pure hydrocarbon fuels, they are insufficient for oxygenated fuels. Also, the full distillation properties of gasoline have an effect on vehicle performance, which thereby requires the DI limit.
- Comment:* Minimum E100 limits of 50/55 in the varied volatility classes are too restrictive.
- Action & rationale:* These values have been determined necessary for adequate vehicle driveability performance.
- Comment:* Why are there 6 V/L categories and only 5 DI categories?
- Action & rationale:* These categories represent standard industry practice.
- Comment:* Why is there is no spec on VLI?
- Action & rationale:* VLI is no longer considered necessary for pressurized fuel systems in fuel-injected vehicles.
- Comment:* The RVP range is too narrow.
- Action & rationale:* Given that more than one volatility class will apply in most locations during the seasonal changeover, we believe these classes are sufficient as stated.
- Comment:* Many comments were received on the volatility limits. Suggestions were received on the T10, T50, T90 and end-point limits. Some commenters suggested relaxing the specs while others suggested making them more stringent.
- Action & rationale:* All of these values were established to reduce emissions, achieve good driveability in cold starts and hot starts and yet not go past the limits that are supported by the literature.
- Comment:* Lower DI levels than currently specified have the potential to reduce emissions.
- Action & rationale:* More stringent DI requirements will be considered in future editions as more data become available.
- Comment:* FBP limits are too stringent and do not correlate with CCD.
- Action & rationale:* While not a perfect measure, FBP limits together with the other CCD measuring test procedures will help prevent CCD.
- Comment:* Unwashed gums correlate poorly with CCD levels; the same is true for mass and thickness. Engine performance tests should be run rather than just relying on bench test results.
- Action & rationale:* Unwashed gum requirements are offered as alternatives when CCD test results are not available. The unwashed gums limits represent a maximum for worst case fuel.
- Comment:* Unwashed gum limits may restrict additives that would help reduce deposits. Engine tests are the only acceptable ones, but engine tests take too long.
- Action & rationale:* Both engine tests and the newly added TGA test procedure are available to qualify a fuel with deposit-preventing additives that would fail the unwashed gum test. Implementation of quality control measures to ensure compliance is at the producer's discretion, as long as all fuels meet or conform to the limits.

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- Comment:* The density range is too stringent and does not allow the quality of gasolines that are available in some markets.
- Action & rationale:* The range of gasolines available in some of the current world markets needs to be narrower and as well as upgraded for proper vehicle operation and optimum customer satisfaction.
- Comment:* Since there are adequate checks by fuel manufacturers, no sediment limit is needed. ASTM is working on a new method.
- Action & rationale:* The limits will provide the motoring public with fuel that gives trouble free and low emission performance. All fuel should meet or outperform these limits. As new methods are developed, future WWFC requirements will be updated as appropriate.
- Comment:* Injector cleanliness tests are not reliable.
- Action & rationale:* The best methods available are listed in the Charter. As more effective tests become available, they will replace the current ones.
- Comment:* The IVD specification limit of 90 mg using ASTM D6201 should be 135 mg. Also, the 50 mg limit in Category 4 is not justified.
- Action & rationale:* The 90 mg IVD limit is directly correlated to the 100 mg pass limit in ASTM D 5500 (BMW test) using all pertinent correlation data. Completely clean intake valves offer additional driveability robustness and thereby improved emissions. The 50 mg limit was selected to help reduce exhaust emissions based on findings in SAE papers 922259, 941870, 962023 and 2002-01-1639.
- Comment:* The TGA procedure does not correlate to engine deposits. The procedure was developed as a test to measure IVD control and is not validated for measuring an additized gasoline's contribution to CCD.
- Action & rationale:* The TGA procedure in the WWFC has been shown to correlate with engine deposits as well as discriminate between varying gasolines.
- Comment:* The Ford TGA procedure is not available on the Web.
- Action & rationale:* The procedure can be ordered from the list of Ford test method distribution centers located around the world. Information about ordering also can be found at [www.autoalliance.org/fuel\\_charter.htm](http://www.autoalliance.org/fuel_charter.htm).
- Comment:* It is not clear what 140% max. specification represents under the combustion chamber deposit requirement.
- Action & rationale:* A correction to more clearly specify the wt. % increase as compared to base gasoline without detergent additive has been made.
- Comment:* CCD's may be good; they might reduce CO and hydrocarbon emissions in some cases.
- Action & rationale:* To the extent this occurs, it is not a uniform reduction. The increase in NO<sub>x</sub> and, in the extreme case, physical interference require the need to restrict deposit formation.

**COMMENTS RELATED SPECIFICALLY TO DIESEL SPECIFICATIONS**

- Comment:* Increasing cetane index number will cost fuel economy and power. It would also require refineries to add new plant equipment and would reduce fuel lubricity.
- Action & rationale:* Diesel fuels meeting all Charter requirements need to be optimized to match vehicle requirements.
- Comment:* Observed differences in natural vs. additized cetane are due to C/H ratio differences, not to cetane per se.
- Action & rationale:* Specifying maximum C/H ratio may be considered in the future when more data are available.
- Comment:* Why is the cetane requirement reduced as weather gets colder?
- Action & rationale:* Refiners produce light volatile fuels to improve cold start operation in extreme conditions. This can reduce the cetane number, but as a practical matter, to enable starting in extremely cold weather takes precedence over cetane number under these special conditions.
- Comment:* Emission changes with higher cetane limits are small in terms of g/km.
- Action & rationale:* As emission regulations become more stringent, small improvements in vehicle technology become much more difficult and fuel quality changes become much more important. Numerically small improvements translate to tons of pollutants, which is meaningful to the environment.
- Comment:* Adopting a cetane index (CI) is redundant and inappropriate
- Action & rationale:* Natural cetane (number) is pertinent to performance. Cetane Index limits cetane improver additives to reasonable levels.
- Comment:* As shown in the Technical Background graph, is the effect of density vs. emissions data due to aromatics, by addition of kerosene in lighter fuel, or only to the fuel's density?
- Action & rationale:* The chart presented in the WWFC is derived from the results of the European test programme, EPEFE. The effect of density was calculated from regression equations. Those equations were statistically derived from the results of vehicle's emission tests performed with a variety of diesel fuels, blended with the aim of having the density and the poly-aromatics uncorrelated. The effect pictured in the WWFC, therefore, represents the density effect only.
- Comment:* Density sensor or calibration changes would preclude the need for density limits and 30 kg/m<sup>3</sup> is needed for refinery flexibility.
- Action & rationale:* Existing engines require listed density limits. A range of allowed density is noted in footnote 3.
- Comment:* What is the rationale for reducing Category I sulfur to a 3000 mg/Kg max. limit?
- Action & rationale:* The maximum sulfur limit for Category I diesel has been reduced from 0.5% (5000 ppm) to 0.3% (3000 ppm) noting the significant increase in engine wear resulting from sulfur related acid formation encountered at sulfur levels above 0.3% and to lend support to moves made in developing markets to reduce the sulfur content of diesel fuel.
- Comment:* The aromatic limit of 10% max. is too severe. 20% together with a 50 cetane min. limit is more cost effective for attaining similar emission benefits.
- Action & rationale:* The aromatic limit listed in the WWFC is 15% max., not 10%, and is considered an acceptable compromise.
- Comment:* ASTM D6591 should be specified for aromatics instead of the methods listed in WWFC.
- Action & rationale:* While method D6591 measures more parameters, ASTM D 5186 provides better repeatability and reproducibility and should be the only procedure used.
- Comment:* The altered ACEA equation regarding aromatics is not justified and will have less effect of aromatics on new technology.
- Action & rationale:* The proposed ACEA equations will predict the relationship between fuel parameters and regulated emissions more accurately. Currently, there is no clear indication that this would be the case.

- Comment:* Poly-aromatics are the problem, not total aromatics.
- Action & rationale:* Poly-aromatics are certainly a problem, and the Charter addresses this issue separately. Total aromatics also have been shown to influence exhaust emissions, particularly NO<sub>x</sub> emissions from heavy-duty diesel engines.
- Comment:* Future technology may reduce the impact of cetane number, and it is too early to conclude poly-aromatics in the fuel contribute to PAH in the exhaust.
- Action & rationale:* Turnover in the diesel fleet is slow, and emission improvements are needed now. Should revised cetane limits become appropriate in the future, they will be considered. There is evidence that PAHs contribute to PM and exhaust PAH.
- Comment:* T95 is a better distillation parameter than FBP due to test precision.
- Action & rationale:* FBP limits prevent fuel from containing too much heavy material which adds to particulate matter emissions.
- Comment:* Lower carbon content in fuel will lead to higher carbon content in other refined products.
- Action & rationale:* The Charter is focused on automotive fuels and does not attempt to improve the CO<sub>2</sub> emissions of other industries.
- Comment:* The Charter should add a note that the carbon residue is on the 10% distillation residue.
- Action & rationale:* This note is not needed. Limits on carbon residue apply to the whole fuel or the distillation residue.
- Comment:* There is no need for a CP or CP-CFPP limit.
- Action & rationale:* CFPP alone will not fully describe the cold flow performance. Cloud point is needed in support, for adequate correlation between measured CFPP value and real vehicle operability.
- Comment:* Why is there no discussion in the Technical Background on oxidation stability?
- Action & rationale:* The intention of the Technical Background is to present key recent information related to durability and emissions. Many of the parameters are well understood, such as oxidation stability, so that additional information is not believed necessary.
- Comment:* The Charter should include a limit for thermal stability using ASTM D6468-99 instead of the oxidation stability requirement.
- Action & rationale:* The Committee agrees that the ASTM thermal stability test is an interesting procedure and will consider including it in future editions.
- Comment:* Silicon additives should not be used since they may cross-contaminate gasoline and jet fuel.
- Action & rationale:* The use of silicon in diesel fuel in Europe and other markets is a necessary common practice to reduce foaming and consequential spillage and customer dissatisfaction. These antifoam additives are an integral part of the diesel multifunctional additive package, which is added to the fuel post-refinery and pipeline at the "rack" or distribution point. At this late stage in the distribution process, the Committee does not think cross contamination should be an issue if normal good handling practices are in operation. For the future, limits on silicon in diesel fuel may be required to protect the diesel particulate filter from excessive ash accumulation as a result of antifoam overdosing and therefore may be a requirement in future editions.
- Comment:* The biological growth requirement of "Zero Content" has no meaning since all fuels have some.
- Action & rationale:* The French test method NF M 07-070 (January 1993) is used to detect the level of biological contamination of liquid fuels. In principle, the micro-organisms present in the water (contained in the diesel fuel) are placed in a nutritious environment, and the colonies that develop are then counted, by comparison to standards pictures. As a result of the test, the following levels of contamination may be identified: absence (zero), low, middle and high. As a consequence, the specification will be corrected to indicate "zero level" instead of "zero content" in diesel fuel categories 2, 3 and 4.
- Comment:* FAME is allowed up to 5% in Categories 1 – 3 but not in Category 4, which is inconsistent with EN 590.
- Action & rationale:* There are still some unresolved technical concerns with the use of FAME, and therefore, it is not included in Category 4 fuels at this time.

- Comment:* ASTM D6751 should not be used in specifying requirements for FAME. Instead, only EN 14214 should be specified for FAME.
- Action & rationale:* For bio-diesel fuels, both ASTM D6751 and EN14214 should be considered.
- Comment:* Bio-diesel content should be allowed to exceed 5%. Seals will not be affected for up to 30% content.
- Action & rationale:* The 5% limits were set to assure adequate engine and fuel system durability.
- Comment:* There are several negative references regarding bio-diesel fuels related to low temperature properties, water retention, deposit formation and corrosion. It is requested that these negative references to bio-diesel fuels in the Technical Background be removed.
- Action & rationale:* The Committee continues to believe bio-diesel fuels require special care when blending with diesel fuels, and therefore, these cautions remain valid.
- Comment:* The WWFC should delete the beginning of the E-diesel paragraph, "As with FAME" since this fuel should not be associated with bio-diesel fuels.
- Action & rationale:* The Committee agrees and has removed the reference.
- Comment:* E-diesel fuels should be encouraged to extend energy resources.
- Action & rationale:* The Committee disagrees for the reasons already outlined in the WWFC.
- Comment:* Committee should wait to reduce particulate limits from 24 mg to 10 mg until particulate limits and "clear and bright" requirements are developed by WG 31 – 24.
- Action & rationale:* The current WWFC specifications were based on data available in the literature. As new information is developed, future WWFC requirements will be updated as appropriate.
- Comment:* More justification is required to support injector cleanliness requirements.
- Action & rationale:* The Committee believes there is sufficient justification for injector cleanliness already available.
- Comment:* The lubricity requirement should be 460 microns as agreed by a joint industry group, instead of the 400 microns limit. A higher level is sufficient for fuel containing lubricity additives to protect pumps and injectors.
- Action & rationale:* The 400 micron maximum limit defines high quality diesel fuel, as the Committee believes appropriate.
- Comment:* Meeting the lubricity requirements using the HFRR test procedure may result in using excess lubricity additives.
- Action & rationale:* The HFRR procedure is the best available test method at this time. While new procedures can be investigated for future applications, the fuels must be compatible with the existing fleet, thus the need for a lubricity specification. As new procedures are developed, the WWFC requirements will be updated as appropriate.