Fuel Requirements for Diesel Fuel Injection Systems
Diesel Fuel Injection Equipment Manufacturers
Common Position Statement 2012

Please note that this statement supersedes all previous joint statements

Background

The continuous world-wide tendency to increase engine performance and reduce emissions has necessitated the development of new generations of enhanced diesel fuel injection equipment, supporting the achievement of stringent legislation targets. Rising injection pressures and multiple injections result in higher operating temperatures, increased contact pressures and reduced clearances. Minimum standards of fuel quality are essential to maintain durability and emission compliance over a longer duration.

International standards have been established defining fuel quality and continue to be revised on an as needed basis. Alterations to fuel quality, e.g. by increasingly severe refinery hydro-processing being introduced to remove sulphur also reduce the content of aromatics and destroy surface active compounds and antioxidants. Removal of these beneficial compounds effects boundary lubrication, commonly known as lubricity, and inherent oxidation stability and must be compensated for. Fuel parameters such as cetane number, viscosity, density, lubricity, oxidation stability, sulphur and aromatic content together with the absence of free water and dirt contamination are key parameters required to ensure performance of equipment in the field.

Biofuels are becoming increasingly available to end-users. In Europe (EU) and in the United States of America (USA), as well as in other countries, fuel sources such as rapeseed methyl ester (RME), soybean methyl ester (SME), palm oil methyl ester (PME) and others, collectively known as fatty acid methyl esters (FAME), are being used as alternatives and extenders for mineral oil derived fuels. Furthermore, the EU Biofuels Directive 2003/30/EC requires member states to ensure that a minimum proportion of biofuels is placed on the market. It must be recognized that the physical and chemical characteristics of bio components are significantly different to conventional fuels and that care must be taken in their specification and use.

Diesel fuel injection equipment (FIE) manufacturers fully support the development of alternative sources of fuel. Where possible, compatible components were provided and validated. However, many vehicles, engines and equipment are not designed to run on them. It is recommended to refer to the vehicle and engine manufacturers ‘Limitations of Use’ documents for guidance. Prior to use, users should also check whether appropriate biofuel quality is guaranteed.

General Diesel Fuel Quality

Standards: The European fuel standard EN 590:2009 embodies the latest fuel quality requirements. Fuel injection equipment manufacturers' products might not meet the expected lifetime performance and emissions targets if EN 590:2009 fuel or fuel with similar properties to the EN 590:2009 specification is not used. The responsibility therefore must fall to the equipment user and/or the fuel supplier to ensure that the fuels used are compatible with the fuel system and objectives of the emissions legislation.

Users of diesel engines are reminded that fuel standards apply only to the point of delivery from the distribution network, generally from the pump nozzle of the filling station. From this point on it is the user's responsibility to protect the fuel from free water and dirt contamination to enable engines to achieve their designed performance, emission, and durability targets. Engine/vehicle manufacturers should provide appropriate fuel conditioning depending on application, duty cycle, territory, and climate.

Additives: Fuel standards are performance based. Meeting the standard specifications is a minimum requirement. In order to further improve fuel quality, the use of additives in the appropriate amount is helpful provided that harmful side-effects can be excluded (e.g. internal injector deposits). Additives demonstrated to have harmful effects that result in field issues must not be used, even if the blended fuel meets the performance standard. It is the responsibility of the fuel provider to exclude harmful side-effects.

Lubricity: It is essential that the lubricity of the fuel as measured by the HFRR test specified in ISO 12156-1 meets the requirement of a wear scar diameter not greater than 460 microns. In addition, it is recommended by the Diesel FIE manufacturers, that "first fill" of the fuel tank should be with fuel with good lubricity characteristics (HFRR < 400 µm) in order to guarantee good "run-in" of the injection system components. The US diesel specification (ASTM D975-11) and others includes a lubricity value of 520 µm maximum (according to ASTM D6079-11). Fuel with a lubricity exceeding 460 µm can adversely affect the lifetime of some fuel lubricated injection system components.

Cleanliness: The fine tolerances needed to produce high injection pressures demand good fuel cleanliness, with increasing emphasis on small particle sizes. The fuel injection equipment manufacturers encourage the standardization bodies in the EU and US to elaborate a precise test method for the determination of total contamination and for particle counting required to ensure the demand for improved fuel cleanliness of future FIE systems is met.

Deposits: Local and temporary deviations in fuel composition, additivation and/or contamination are responsible for in-system deposits, which impede the precise dynamics of the high pressure injection equipment. Such deposits affect vehicle performance, leading to complaints by the end customer. Two predominant types of deposits have been identified: metal-based salts and soaps as well as polymeric organic material with specific additive-related structural elements.

Among the metal containing deposits sodium is prevalent; with even trace contamination having an effect. Sodium contamination can be involuntarily transferred from refinery, pipeline transportation, fuel drying, storage and distribution.

Deposits on the internal surfaces can also be formed by chemical reaction/polymerisation of additives with acidic fuel components. Nitrogen functionalised additives, e.g. detergents of the polyisobutylene succinimide (PIBSI) type were identified to form conversion products of higher molecular weight.

EN590:2009 section 5.4.3 states "Diesel fuel shall be free from any adulterant or contaminant that may render the fuel unacceptable for use in diesel engine vehicles". It is the task and responsibility of the fuel industry (refineries, additive producers, pipeline operators, transport sector and fuel storage facilities) to apply increased diligence and protective measures to prevent deposit related incidents and ensure the fuel is suitable for use in modern high pressure fuel injection systems.

It should be noted that exposure of fuel to surfaces containing copper (Cu), zinc (Zn) or lead (Pb) can adversely affect fuel quality and should be minimised.

Fatty Acid Methyl Ester (FAME)

Standards: The European FAME standard EN 14214:2009 provides minimum quality requirements and limits relevant side products and tramp chemicals from FAME processing. In order to reduce the risk of premature failure of the fuel system, FAME must conform to EN 14214:2009, regardless whether used as 100 % fuel (B100) or as a blending component.

The European diesel fuel standard EN 590:2009 includes diesel blends with up to 7 % FAME (B7). All injection equipment is released for admixtures up to a maximum of 7 % FAME (meeting EN 14214:2009) with the resulting blend meeting the EN 590:2009 standard.

A more extensive revision of EN 14214:2009 is ongoing to facilitate blending of up to 10 % FAME (B10). The FIE manufacturers support the development of a European B10 standard rather than individual norms of the member states, and do not approve national decrees. The discussion about introducing higher blends is dominated by compatibility concerns with the existing fleet, consequently limiting release of higher blend rates to special vehicle applications only.

CEN is working on a feasibility study and preliminary specification for B30. B30 is intended for use in captive fleets only, as already practised in France for some years. An approval for the use of any blend with a high FAME content or of B100 requires a customised validation for the intended application(s).

The FIE manufacturers registered that the use of fatty acid ethyl esters (FAEE) is proposed in France. Knowledge about the characteristics of FAEE is still very limited, and testing with FAEE or FAEE blends in fuel systems has only been performed exemplarily. Progress in the normalisation of FAEE on the European level under CEN is required in order to create a reference basis for validation.

In the US, the quality of fatty acid esters is defined in the ASTM D6751-11b standard provided for different fatty acid alkyl esters (FAAE) intended for use in blends at concentrations of up to 20 %. Two additional standards have been developed to describe qualities of the blended fuels up to B5 (ASTM D975-11) and from B6 to B20 (ASTM D7467-10), respectively.

The use of B5 according to ASTM D975-11 is tolerated by the FIE manufacturers, although the absence of a stability requirement is seen as a large risk that should be reduced as soon as possible. Blends containing in excess of 5 % (V/V) FAAE (ASTM D6751-11b) require positive validation of specific issues associated with higher concentrations of low stability FAME (also in view of the fact that ASTM D6751-11b allows the use of fatty acid alkyl esters [other than methyl esters], which are not yet successfully evaluated).

FAME Stability: The reduced stability of FAME is of particular concern. Aged or poor quality FAME contains organic acids like formic acid and polymerisation products. The acids attack many components, and the polymers can lead to plugged filters, sediments and sticking moving parts drastically reducing the service life of the FIE. Long standstill periods bear the risk of reaching the point when the ageing reserve of the fuel inside the tank and FIE is depleted. Extra measures are recommended like well-timed monitoring of fuel stability or precautionary fuel exchange, followed by an idling operation when such extended periods of inactivity are anticipated. This also affects seasonally operated equipment such as harvesters or emergency generators and vehicles to be exported overseas. For this reason FAME-free EN 590 fuel is highly recommended for “first fill” or extended inactive periods.

Fuel stability is best described by the parameter ‘ageing reserve’, determined as induction period (IP) according to the EN 15751:2009 test method. B5 and B7 with an IP of ≥ 20 h has been demonstrated to be sufficiently stable for standard usage conditions in Europe. The stakeholders of CEN/TC19/WG24 considered it essential to maintain the fuel stability level of B5 and B7 also for B10 and B30 and agreed to adapt future fuel standards accordingly.

In the US, ASTM D975-11 standard for diesel (B0 to B5) does not contain any mandatory stability requirement; the standards for B6 to B20 blends (ASTM D7467-10) and for pure FAME (ASTM D6751-11b) do not include sufficient stability safeguards present in both the EN 590:2009 and EN 14214:2009 standards. ASTM D6751-11b for FAME requires a minimum IP of 3 hrs, which is half of that required by EN 14214:2009, and for B6 to B20 blends an induction period of 6 hrs is fixed in ASTM D7467-10, compared to 20 hrs in EN 590:2009. It is expected that the operating performance and lifetime of fuel injection systems will be adversely affected by using fuels with reduced stability. To secure sufficient stability of diesel/FAME blends world-wide the FIE manufacturers request comparable regulations for every diesel fuel specification that allows blending of FAME. FIE manufacturers are powerless to prevent issues originating from the use of insufficiently stable fuel. Fuel suppliers need to take appropriate measures for stabilising fuels and are responsible for ensuring that the level of oxidation stability is sufficient to prevent damage due to depletion of oxidation reserve during use.

FAME Impurities: As FAME is being produced from an increasing number of new feedstock uncertainties are associated with additional impurities that might not become evident until vehicle operation. Further concerns are minor components of FAME with high molecular weight like steryl glycosides leading to filter plugging and use of diesel or FAME additives with interacting chemistries. There are also several possible risks associated with fuel delivery and supply chain, such as accumulated metal ion impurities affecting the quality of the final blend at the point of sale.

FAME Compatibility: Material issues may occur on older vehicles, designed before the use of FAME was considered. As FAME concentrations increase, compatibility issues become more likely with filters, hoses and seals being the most likely components affected.

Other Biofuels: The FIE manufacturers support the use of bioparaffins obtained by hydro-treatment or co-processing of plant oil. Due to their paraffinic nature and high fuel and transport system compatibility, bioparaffins are also well-suited for blends with biogenic portions above 7 %. High blend rates of (bio-) paraffins or use in their pure form require extra validation. The necessary validation extent will depend on the parameters and limits defined in the CEN Workshop Agreement CWA 15940:2009 and in the future CEN Technical Specification of paraffinic diesel fuel and FAME blending.

The FIE manufacturers note that their high pressure injection equipment is not designed to run on unesterified plant oil, even if such fuel meets all requirements defined in the CEN Workshop Agreement CEN/TC WS 56 or in existing national standards such as DIN V 51605.

The views contained in this Common Position Statement are those of the FIE Manufacturers comprising the following companies:

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