Quality of Bio-diesel (FAME) and Use of FAME-blended Diesel

JAMA, Fuels & Lubricants Sub-committee

JAMA (Japan Automobile Manufacturers Association) has been, and is consistently in support of the use of bio-fuels complying with appropriate sustainability criteria as part of an integrated approach to the reduction of CO_2 emissions. FAME (fatty acid methyl ester), one of the bio-fuels, is renewable energy, and accordingly JAMA endorses automotive use of FAME-blended diesel from fossil fuel conservation and energy security points of view.

On the other hand, JAMA believes it imperative that FAME-blended diesel has equivalent quality to the conventional diesel fuel so as to achieve satisfactory safety and emission performance of vehicles. This in turn requires clear and harmonized fuel quality standards, which ensure vehicle and engine compatibility, and "fit-for-purpose" specifications for FAME and FAME-blended diesel. At the same time, appropriate handling rules to assure quality control in the distribution process and quality-monitoring scheme to eliminate improperly prepared FAME-blended diesel from the market are also necessary.

1. Blending Ratio (FAME Content) and Compatibility with Vehicles

For the use of FAME-blended diesel as conventional diesel fuel for vehicles, JAMA recommends blending ratio of maximum 5% (B5), provided that FAME before blending is added with oxidation stability enhancing additives to secure its quality.

JAMA cannot recommend the use of FAME-blended diesel of more than 5% FAME content except for the vehicles specially designed and operated by fleet users with special vehicle management qualification. Furthermore, the fueling pumps of high FAME content diesel should be provided with clear labeling (indicating specific FAME content) to prevent misfuelling of regular vehicles. In the case that high FAME content diesel is to be introduced widely as a policy, JAMA strongly recommends the use of HVO (hydro-treated vegetable oil) or BTL (biomass to liquid) as blendstocks for the production of FAME-blended diesel of more than 5% FAME content equivalent.

Introducing a new oxidation stability requirement (measurement by ***modified Rancimat*** method; induction period of 20 hours or longer) in the revised diesel fuel standard (EN 590:2009), Europe recently permitted blending ratio of up to 7% (B7). However, since there are not enough findings and market observations on the use of B7 so far, JAMA regards it necessary to wait for more market information to accumulate.

2. Appropriate Specifications for FAME and FAME-blended Diesel

JAMA strongly recommends the attached quality specification for FAME to be blended with diesel fuel; in other words, FAME before blending must satisfy the attached ***"JAMA Recommendation on FAME (B100) Specification for up to B5 Blends"*** to ensure safety and emission performance of the vehicles. In addition, the properties of FAME-blended diesel as final fuel must conform to quality standard of conventional diesel fuel, while proper oxidation stability requirement is introduced in it.

In this regard, the WWFC (World-wide Fuel Charter) ***"Guidelines for B100 Blendstock***

for use in up to B5 Blends" issued in March 2009 also gives a quality specification for FAME as automotive fuel, and complements the ***"World-wide Fuel Charter"***, which has been well recognized as guidelines for quality fuels. JAMA is an active formulator, and remains a faithful supporter of the WWFC since it is all the automotive manufacturers' will to seek desirable automotive fuels. Furthermore, JAMA is confident that the WWFC ***"Guidelines for B100 Blendstock for use in up to B5 Blends"*** will contribute towards the optimization and global harmonization of respective countries' FAME specifications.

3. Points of Quality Control for FAME-blended Diesel as Automotive Fuel

1) Materials compatibility

Metallic materials such as copper, brass, zinc and tin are widely used in the vehicle fuel-systems. According to the research results on compatibility of metals with poor-quality or deteriorated FAME-blended diesel, marked possibilities of corrosion were indicated. This is attributed to the fact that FAME generates acids through oxidation-induced deterioration (because of poor oxidation stability) and FAME-blended diesel has a tendency to hold more water, which is a promoter of corrosion, as compared with conventional diesel fuel. Similarly, rubber materials used in fuel hoses, sealing parts and so on are found to undergo degradation or deterioration of their properties, such as hardening and swelling. And this is attributed to the fact that due to the chemical affinity of FAME, a kind of ester compounds as polar solvent, rubber materials used in the vehicle fuel-systems are affected more. Therefore, in order to secure materials compatibility with FAME-blended diesel, its quality control (with regard to oxidation stability, total acid number and water content) is extremely important.

2) Oxidation stability

As mentioned above, FAME and FAME-blended diesel have poor oxidation stability, thus generated acids through oxidation-induced deterioration corrode metallic materials. In order to prevent such corrosion, it is imperative that oxidation stability requirement of European FAME quality standard, EN 14214 should be strengthened to "induction period of at least 10 hours" by ***Rancimat*** method. Additionally, to ensure sustainable stability of FAME and FAME-blended diesel, it is also mandatory to add oxidation stability enhancing additives like BHT.

Originally, it is necessary to introduce oxidation stability requirement for FAME-blended diesel as final fuel. In this case, the requirement is an increase of total acid number (ΔTAN) of not more than 0.12 mgKOH/g or induction period of 35 hours or longer by ***modified Rancimat*** method, however, equivalent effect can be obtained by securing above mentioned oxidation stability of FAME ("induction period of at least 10 hours" by ***Rancimat*** method).

3) Restriction of impurities

One of the classical problems associated with the use of FAME is infiltrated and remained impurities due to the shortcomings of the reaction and refining process. To ensure quality of FAME, it is essential to reduce total amount of impurities that adversely affect vehicle and engine operation to as little as possible.

In the case of insufficient refining, un-reacted tri-glyceride can remain in the products and induce defective operation of moving parts of the fuel injection systems and/or clogging of fuel filters. Recent findings indicate that fuel filters are also clogged by mono-glyceride and sterol glycoside. Metallic residues coming from reaction catalysts can promote deposits on the fuel injection systems and that is why control of these impurities is extremely important. In the case of insufficient washing, un-removed methanol may induce softening or swelling of rubber and plastic materials. As methanol is intensely corrosive, infiltration of methanol must be avoided as much as possible.

4. Summary (Requests from JAMA)

1) Adoption of ***"JAMA Recommendation on FAME (B100) Specification for up to B5 Blends"*** at the time of establishing or amending FAME quality standard.
2) Control of blending ratio of FAME as "maximum 5% (B5)". This is the most critical point of use of FAMA-blended diesel as conventional diesel fuel and in the case that FAME-blended diesel of more than 5% FAME content is to be introduced, use of HVO (hydro-treated vegetable oil) or BTL (biomass to liquid) as blendstocks is strongly recommended. Clear labeling of specific FAME content at the fueling pumps for FAME-blended diesel of more than 5% FAME content is required to prevent misfuelling of regular vehicles.
3) Introduction of oxidation stability requirement into FAME quality standard as "induction period of at least 10 hours" by ***Rancimat*** method. This can replace original requirements for FAME-blended diesel, which call for increase of total acid number (ΔTAN) of not more than 0.12 mgKOH/g or induction period of 35 hours or longer by ***modified Rancimat*** method.

(Writer; K. Furui, Overseas Affairs Taskforce、AKG Approved)

＜Attachment＞

"JAMA Recommendation on FAME (B100) Specification for up to B5 Blends"

Properties	Limit value	Units	Test Methods
Ester content	min. 96.5	% m/m	EN 14103 mod.
Linolenic acid methyl ester	max. 12.0	% m/m	EN 14103 mod.
Oxidation stability： Induction period	min. 10	hrs	pr EN 15751 or EN 14112 as an alternative
Iodine number	max. 120	$gI_2/100g$	EN 14111 JIS K0070
Total acid number	max. 0.50	mg KOH/g	ISO 6618 ASTM D664, D974 JIS K2501
Methanol	max. 0.20	% m/m	EN 14110 JIS K2536
Glycerides			
mono-glyceride	max. 0.80	% m/m	EN 14105 ASTM D6584
di- glyceride	max. 0.20	% m/m	EN 14105 ASTM D6584
tri- glyceride	max. 0.20	% m/m	EN 14105 ASTM D6584
Glycerin (Glycerol)			
Free glycerin	max. 0.02	% m/m	EN 14105/14106 ASTM D6584
Toatal glycerin	max. 0.25	% m/m	EN 14105 ASTM D6584
Density	Report	g/ml	EN ISO 3675 ASTM D4052 JIS K2249
Kinematic viscosity @40℃	2.0-5.0	mm^2/s	EN ISO 3104 ASTM D445 JIS K2283
Flush point	min. 100	℃	ISO 3679 ASTM D93 JIS K2265-3
Cetane number	min. 51		ISO 5165 ASTM D613 JIS K2280
Water	max. 500	mg/kg (ppm)	EN 12937 JIS K2275
Total contamination	max. 24	mg/kg (ppm)	EN 12662 ASTM D2276, D5452, D6217
Sulfated ash	max. 0.02	% m/m	ISO 3987 ASTM D874 JIS K2272
Carbon residue： Ramsbottom on 10% dist. residue 100% dist. residue	 max. 0.3 max. 0.05	 % m/m	 ASTM D4530 JIS K2270
Cupper corrosion	max. 1		JIS K2513
Sulfur	max. 10	mg/kg (ppm)	EN 20846/20884 ASTM D5453, D2622 JIS K3541-1,-2,-6 or -7
Phosphorus	max. 4 or 10 *1)	mg/kg (ppm)	EN 14107 ASTM D4951, D3231
Alkali metals（Na+K）	max. 5	mg/kg (ppm)	EN 14108/14109, EN 14538
Alkaline metals（Ca+Mg）	max. 5		EN 14538

*1) 4：Corresponds to Euro4 Emission Regulation, 10：Corresponds up to Euro3 Emission Regulation