Chapter 3

Biodiesel Fuel Standardization Activities

Benchmarking of Biodiesel Fuel Standardization in East Asia Working Group

July 2010

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3. BIODIESEL FUEL STANDARDIZATION ACTIVITIES

3.1 EAS-ERIA Biodiesel Fuel Standard: 2008

3.1.1 Background

The Kyoto Protocol emphasized the concept of "carbon neutral" Biofuels can have climate change benefits as they are produced from renewable sources. Asian countries are actively promoting the introduction of biofuels due to soaring oil prices and increased energy consumption. The utilization of biofuels is also important from the viewpoint of energy security and diversification of transport fuels. However, the low-quality biodiesel fuel raises serious concerns regarding the effect on engine performance caused by fuel impurities and the oxidation. Therefore, biodiesel fuel standards have been established in many countries with national standards and characterization methodologies, as shown in Table 2 and Table 3, respectively. Harmonization of standards within the East Asia region will facilitate the use and trading of good quality biodiesel**.**

At the 2nd East Asia Summit (EAS) held in January, 2007, the Cebu Declaration on East Asian Energy Security was signed. At the Energy Cooperation Task Force (ECTF) working-level meeting of persons in charge of energy policies of the EAS participating countries, it was decided that issues toward unified specification/ standardization of biodiesel would be examined. In view of this, a study group of these issues was established within the specialist meeting of the Economic Research Institute for ASEAN and East Asia (ERIA) held in May, 2007.

As part of this ERIA "Standardization of Biodiesel Fuel in East Asia" study group, a working group was established with specialist of East Asian countries as members for the commercialization of good quality biodiesel fuel in the East Asian region, and a benchmark was set on the quality of diesel fuel-mixed biodiesel fuel with harmonized specification as a goal.

Table 2 Comparison of existing biodiesel fuel standards

Items	Units	U.S.	EU	Australia	Japan	Rep. of Korea	Thailand	Vietnam
		ASTM D6751-07b	EN14214:2003		JIS K2390:2008	PPAFB Act	DOEB: 2009	TCVN 7717:2007
Ester content	mass%	-	96.5 min.	96.5 min.	96.5 min.	96.5 min.	96.5	96.5 min.
Density	kg/m3	-	860-900	860-900	860-900	860-900	860-900	860-900
Viscosity	mm2/s	1.9-6.0	3.50-5.00	3.5 - 5.0	3.50-5.00	1.9-5.0	3.5-5.0	1.90-6.00
Flashpoint	deg. C	93 min.	120 min.	120.0 min.	120 min.	120 min.	120 min	130 min.
Sulfur content	mass%	0.0015 max.	0.0010 max.	0.0010 max.	0.0010 max.	0.0010 max.	0.0010 max	0.05 max.
Distillation, T90	deg. C	360 max.	-	360 max.	-	-	-	360 max.
Carbon residue (100%) or Carbon residue (10%)	mass%	0.05 max. -	- 0.30 max.	- 0.30 max.	- 0.3 max.	- 0.10 max.	- 0.30 max.	0.050 max. -
Cetane number		47 min.	51.0 min.	51.0 min.	51.0 min.	-	51.0 min	47.0 min.
Sulfated ash	mass%	0.02 max.	0.02 max.	0.02 max.	0.02 max.	0.01 max.	0.02 max	0.020 max.
Water content	mg/kg	0.05[vol%] max.	500 max.	0.050 [vol%] max.(1)	500 max.	500 max.	0.05[Wt%] max	0.05[vol%] max.
Total contamination	mg/kg	-	24 max.	24 max.	24 max.	24 max.	24 max.	-
Copper corrosion		No.3	Class-1	Class-1	Class-1	Class-1	Class-1	No.1
Acid value	mgKOH/g	0.50 max.	0.50 max.	0.80 max.	0.50 max.	0.50 max.	0.50 max.	0.50 max.
Oxidation stability	hrs.	3 min.	6.0 min.	6 min.	(**)	6.0 min.	10.0 min.	6.0 min.
Iodine value		-	120 max.	-	120 max.	-	120 max.	120 max.
Methyl Linolenate	mass%	-	12.0 max.	-	12.0 max.	-	12.0 max.	-
Polyunsaturated FAME (more than 4 double bonds)	mass%	-	1 max.	-	N.D.	-	-	-
Methanol content	mass%	0.2 max. (*)	0.20 max.	0.20 max.	0.20 max.	0.20 max.	0.20 max.	-
Monoglyceride content	mass%	-	0.80 max.	-	0.80 max.	0.80 max.	0.80 max.	-
Diglyceride content	mass%	-	0.20 max.	-	0.20 max.	0.20 max.	0.20 max.	-
Triglyceride content	mass%	-	0.20 max.	-	0.20 max.	0.20 max.	0.20 max.	-
Free glycerol content	mass%	0.020 max.	0.02 max.	0.020 max.	0.02 max.	0.02 max.	0.02 max.	0.020 max.
Total glycerol content	mass%	0.240 max.	0.25 max.	0.250 max.	0.25 max.	0.24 max.	0.25 max.	0.240 max.
Na+K	mg/kg	5 max.	5.0 max.	5 max.	5.0 max.	5.0 max.	5.0 max.	5.0 max.
Ca+Mg	mg/kg	5 max.	5.0 max.	5 max.	5.0 max.	5.0 max.	5.0 max.	-
Phosphorous content	mg/kg	10 max.	10.0 max.	10 max.	10.0 max.	10.0 max.	10.0 max.	10.0 max.

(*) 130 deg.C of flashpoint is available instead of measuring methanol content (**) Meet diesel oil specification

Table 3 Comparison of existing methods for biodiesel fuel characterization

Item	Test methods								
	Japan JIS K2390:2008	Australia	Indonesia SNI-04-7182-2006	Malaysia MS 2007:2007	New Zealand NZS 7500 (2005)	Philippines PNS/DOE QS 002:2007	South Korea PPAFB Act	Thailand DOEB-2007	Vietnam TCVN 7717
Ester content	EN 14103	EN 14103		EN 14103	EN 14103	PNS EN 14103 modified	EN 14103 (KS M2413)	EN 14103	TCVN (EN 14103)
Density	JIS K2249	ASTM D1298 or EN ISO 3675	ASTM D1298	ISO 3675 ISO 12185 ASTM D4052	ASTM D1298	PNS ASTM D1298 or PNS ASTM D4052 or PNS ISO 3675	ISO 3675 (KS M2002) ISO 12185	ASTM D1298	ASTM D1298
Kinematic Viscosity	JIS K2283	ASTM D445	ASTM D445	ISO 3104 MS 1831	ASTM D445	PNS ASTM D445	ISO 3104 (KS M 2014)	ASTM D445	ASTM D445
Flash point	JIS K2265	ASTM D93	ASTM D93	ISO 3679 MS 1831	ASTM D93	PNS ASTM D93	ISO 3679 (KS M2010)	ASTM D93	ASTM D93
Cloud point			ASTM D2500			PNS ASTM D2500			
Sulfur content	JIS K2541-1, -2, -6 or -7	ASTM D5453	ASTM D5453	ISO 20846 ISO 20884 ASTM D5453	IP 497 or ASTM D5453	PNS ASTM D2622/ PNS ASTM D5453/ PNS ASTM D4294	ISO 20846, ISO 20884 (KS M2027)	ASTM D2622	ASTM D5453
10% carbon residue	JIS K2270	EN ISO 10370 ASTM D4530	ASTM D4530	ISO 10370 ASTM D4530	ASTM D4530 ISO 10370	PNS ASTM D4530 or PNS ISO 10370	KS M ISO 10370	ASTM D4530	ASTM D4530
Cetane number	JIS K2280	EN ISO5165 ASTM D613 ASTM D6890 IP 498/03	ASTM D613	ISO 5165 MS 1895	ASTM D613 ASTM D6890	PNS ASTM D613 or PNS ASTM D6890 or PNS ISO 5165 or PNS IP 498/03		ASTM D613	ASTM D613
Distillation T90		ASTM D1160	ASTM D1160			PNS ASTM D1160 or PNS ASTM D86			ASTM D1160
Sulfated ash content	JIS K 2272	ASTM D874	ASTM D874	ISO 3987 ASTM D874	ASTM D874	PNS ASTM D874	KS M ISO 6245	ASTM D874	ASTM D874
Water content	JIS K 2275	ASTM D2709	ASTM D2709	ISO 12937 ASTM E203 ASTM D1160	IP 438	PNS ASTM D6304 or PNS ISO 12937 or PNS ASTM E203	(KS M2115)	EN ISO12937	ASTM D2709
Total contamination	EN 12662	EN 12662 ASTM D5452		EN 12662 ASTM D5452	IP440			EN 12662	
Copper corrosion	JIS K 2513	EN ISO2160 ASTM D130	ASTM D130	ISO 2160 MS 787	ASTM D130	PNS ASTM D130 or PNS ISO 2160	ISO 2160 (KS M 2018)	ASTM D130	ASTM D130
Oxidation stability		EN 14112 or ASTM D2274 (as relevant for biodiesel)		EN 14112	EN 14112	PNS EN 14112	EN 14112	EN 14112	EN 14112
Acid value	JIS K 2501 or JIS K 0070	ASTM D664	AOCS Cd3-63	EN 14104 MS 2011	ASTM D664	PNS ASTM D664/ PNS ASTM D974/ PNS EN 14104	KS M ISO 6618	ASTM D664	ASTM D664
Iodine value	JIS K 0070		AOCS Cd1-25	EN 14111	EN 14111			EN 14111	EN 14111
Methyl linolenate	EN 14103			EN 14103	EN 14103	PNS EN 14331 modified or PNS EN 14103 modified		EN 14103	
Methanol content	EN 14110	EN 14110		EN 14110	EN 14110	PNS EN 14110	EN 14110	EN 14110	
Monoglyceride content Diglyceride content Triglyceride content	EN 14105			EN 14105 ASTM D6584	ASTM D6584	PNS EN 14105 modified or PNS ASTM D6584		EN 14105	
Free glycerol content	EN 14105 or EN 14106	ASTM D6584	AOCS Ca14-56	EN 14105 EN 14106 ASTM D6584	ASTM D6584	PNS AOCS Ea 6-94 (1997)/ PNS ASTM D 6584 modified or PNS EN 14105 modified		EN 14105	ASTM D6584
Total glycerol content	EN 14105	ASTM D6584	AOCS Ca14-56		ASTM D6584	PNS AOCS Ca 14-56 (1997)/ PNS ASTM D 6584 modified or PNS EN 14105 modified	EN 14105 (KS M2412)	EN 14105	ASTM D6584
Alkyl ester content			Cakculated						
Metals (Na+K)	EN 14108 EN 14109	EN 14108 EN 14109		EN 14108 EN 14109	EN 14108 EN 14109	PNS EN 14108 PNS EN 14109	EN 14108 EN 14109	EN 14108 EN 14109	EN 14108 EN 14109
Metals (Ca+Mg)	EN 14538	EN 14538		EN 14538	EN 14538	PNS EN 14538	EN 14538	EN 14538	
Phosporous	EN 14107	ASTM D4951	AOCS Ca12-55	EN 14107 ASTM D4951	ASTM D4951	PNS ASTM D4951	EN 14107	ASTM D4951	ASTM D4951
Pour point									
CFPP				EN 116			KS M2411		
Halphen test			AOCS Cb1-25						
Additives									

3.1.2 Concepts of Harmonized Specification

To harmonize the specification of biodiesel fuel, the concepts were discussed as follows.

(1) Based on European standard (EN14214)

The subject of this WG is only focused on FAME (Fatty Acid Methyl Ester) as a biodiesel fuel. EN14214 is recognized as a comprehensive specification for FAME, and so this WG discussed the harmonized specification based on EN14214.

(2) Consideration of various oils

EN14214 is set for rapeseed oil only. There is a need to consider other feedstocks used in the East region, such as:

Coconut: low viscosity and flashpoint

Soybean: Iodine number

(3) Oxidation stability

Oxidation stability has critical impact on fuel tanks made of metals. In Europe, fuel tanks of vehicle are mainly made of plastics or resin. However in Asia, metal tanks are popular for vehicles. Oxidation stability value of “10 hours”, which was recommended by Japan Automobile Manufacturers Association, Inc. (JAMA), is based to prevent metal tank corrosion.

(4) Polyunsaturated FAME

Polyunsaturated FAME was mainly included in fish oil. It accelerates oxidation degradation and sludge production, however, the measurement method has not been developed. Polyunsaturated (more than 4 double bonds) FAME need to be excluded.

3.1.3 EAS-ERIA Biodiesel Fuel Standard: 2008

WG for Standardization of Biodiesel Fuel for Vehicles in East Asia made an “EAS-ERIA Biodiesel Fuel Benchmark Standard”. Table 4 shows the specification compared to other existing standards. This is a benchmark standard suggested for member countries for the purpose of harmonizing biodiesel standards in East-Asia.

Table 4 EAS-ERIA Biodiesel Fuel Standard: 2008 compared to other existing standards

Items	Units	U.S.	EU	Japan	EAS-ERIA Biodiesel Fuel
		ASTM D6751-07b	EN14214:2003	JIS K2390:2008	Standard:2008
Ester content	mass%	-	96.5 min.	96.5 min.	96.5 min.
Density	kg/m3	-	860-900	860-900	860-900
Viscosity	mm2/s	1.9-6.0	3.50-5.00	3.50-5.00	2.00-5.00
Flashpoint	deg. C	93 min.	120 min.	120 min.	100 min.
Sulfur content	mass%	0.0015 max.	0.0010 max.	0.0010 max.	0.0010 max.
Distillation, T90	deg. C	360 max.	-	-	-
Carbon residue (100%) or Carbon residue (10%)	mass%	0.05 max. -	- 0.30 max.	- 0.3 max.	0.05 max. 0.3 max.
Cetane number		47 min.	51.0 min.	51.0 min.	51.0 min.
Sulfated ash	mass%	0.02 max.	0.02 max.	0.02 max.	0.02 max.
Water content	mg/kg	0.05[vol%] max	500 max.	500 max.	500 max.
Total contamination	mg/kg	-	24 max.	24 max.	24 max.
Copper corrosion		No.3	Class-1	Class-1	Class-1
Acid value	mgKOH/g	0.50 max.	0.50 max.	0.50 max.	0.50 max.
Oxidation stability	hrs.	3 min.	6.0 min.	(**)	10.0 min. (****)
Iodine value		-	120 max.	120 max.	Reported (***)
Methyl Linolenate	mass%	-	12.0 max.	12.0 max.	12.0 max.
Polyunsaturated FAME (more than 4 double bonds)	mass%	-	1 max.	N.D.	N.D. (***)
Methanol content	mass%	0.2 max. (*)	0.20 max.	0.20 max.	0.20 max.
Monoglyceride content	mass%	-	0.80 max.	0.80 max.	0.80 max.
Diglyceride content	mass%	-	0.20 max.	0.20 max.	0.20 max.
Triglyceride content	mass%	-	0.20 max.	0.20 max.	0.20 max.
Free glycerol content	mass%	0.020 max.	0.02 max.	0.02 max.	0.02 max.
Total glycerol content	mass%	0.240 max.	0.25 max.	0.25 max.	0.25 max.
Na+K	mg/kg	5 max.	5.0 max.	5.0 max.	5.0 max.
Ca+Mg	mg/kg	5 max.	5.0 max.	5.0 max.	5.0 max.
Phosphorous content	mg/kg	10 max.	10.0 max.	10.0 max.	10.0 max.

(*) 130 deg.C of flashpoint is available instead of measuring methanol content (**) Meet diesel oil specification
(***) Need data check and further discussion (****) Need more data & discussion from 6 to 10 hours

This standard is for B100 aimed for low level blending with diesel fuel. In case of the use as a final fuel, further considerations are necessary, especially in regards to oxidation stability.

In the Second EAS Energy Ministers Meeting which was held on 7 August 2008 in Bangkok, this standard was welcomed from the Ministers as a valuable benchmark reference in developing respective national standards of EAS countries.

3.2 World Wide Fuel Charter - Biodiesel (B100) Guidelines

3.2.1 World Wide Fuel Charter

(1) Background

Fuel quality plays an important role in order that the latest low emission vehicles and their emission control systems may function properly. Especially in Japan, USA and Europe, nearly same levels of stringent emission regulations are scheduled to be introduced, and it is a common recognition of vehicle manufacturers that the supply of globally harmonized clean fuels is essential to achieve the target of cleaner air quality

and environment protections worldwide.

On the other hand, there are large varieties of fuels in many regions of the world, especially in the developing countries and districts (most of them have insufficient quality). This situation is one of the obstacles to prevent quick introduction of the latest low emission vehicles, and it is strongly required to improve fuel quality in the corresponded markets.

(2) Its History

In the beginning of 1990s, former CCMC in Europe released "CCMC Fuel Charter" and established an approval system of quality fuels in the market. Even after the organization change as ACEA, this system was taken over and "The ACEA Fuel Charter" was published in 1994.

At the same period, AAMA in the USA also published "AAMA National Gasoline Specification" in 1994 and revised it in 1996. JAMA supported this activity throughout the information and opinion exchanges.

Finally, the automotive industries from Japan, USA and Europe decided to cooperate together and published the 1st edition of "World Wide Fuel Charter" in 1998. After the several times of revision, the 4th edition published in 2006 is the latest version at the moment.

(3) Contents of WWFC

The WWFC Committee consists of 4 major automotive industry organizations of Japan Automobile Manufacturers Association (JAMA), Alliance of Automobile Manufacturers (AAM), Engine Manufacturers Association (EMA) and European Automobile Manufacturers Association (ACEA), and also associates members of other country national organizations from all over the world. (see Figure 9)

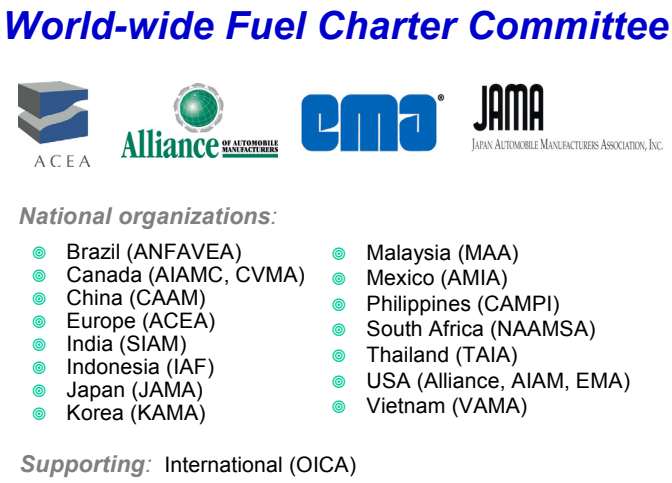


Figure 9 WWFC committee member organizations

"World Wide Fuel Charter" is an automotive industry's guiding document towards improved and harmonized market fuel quality. Gasoline and diesel fuel qualities for vehicles are classified into 4 quality levels (Category 1, 2, 3 and 4) to match emission requirements of up to Euro5/US10 or equivalent. (see Figure 10)

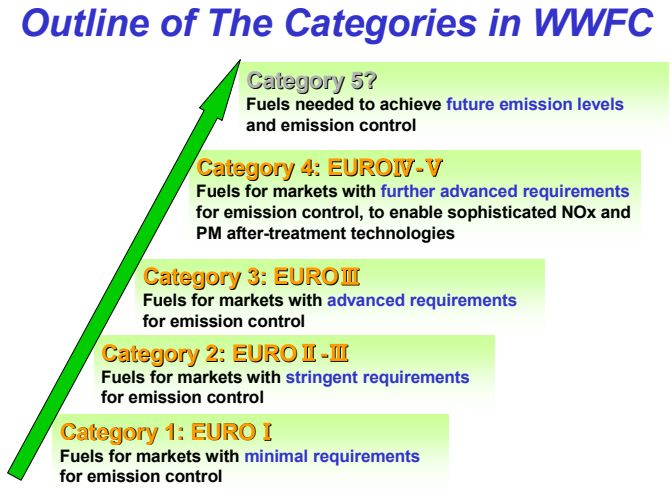


Figure 10 Outline of the fuel quality categories in WWFC

The Charter can be downloaded from each Committee member's website. Their URLs are as follows.

http://www.jama.or.jp/ or

http://www.autoalliance.org or

http://www.acea.be

3.2.2 WWFC Biofuel Guidelines

(1) Background

The use of bio-components like ethanol (and ETBE) and fatty acid methyl esters (FAME) in market fuels are increasing as from CO_2 reduction and energy security points of view. There only existed national/regional standards and specifications for bio-components so far. Their qualities were highly variable and not always fit for purpose. Bio-components can be inherently feedstock dependent (e.g. type and the nature of vegetable oils, their processing routes), and this represents additional challenges for the standardization activity.

On the other hands, as the automotive industry's activities are global, there also exists an increased need for international harmonization of market fuels including bio-components. However, bio-components are just mentioned as parts of the WWFC gasoline and diesel fuel specifications at the moment. As a consequence, the WWFC Committee concluded some 2 years ago that more uniform definition of ethanol and FAME quality is needed and decision was taken to develop "Biofuel Guidelines".

(2) Milestones of the Guideline Making

The WWFC Biofuel Guidelines drafts for comments were issued in July 2008 and the deadline for comments submission was October 1, 2008. The WWFC Committee held a meeting on October 7, 2008 in Chicago to review and discuss into details of the comments they received. After the continued work to finalize the Guidelines, the 1st editions of "World Wide Fuel Charter - Biofuel Guidelines" were published in March 2009 finally as E100 and B100 Guidelines for E10 and B5 blends. They are performance-based requirements and defined as feedstock neutral. Test methods for each property parameters are also described.

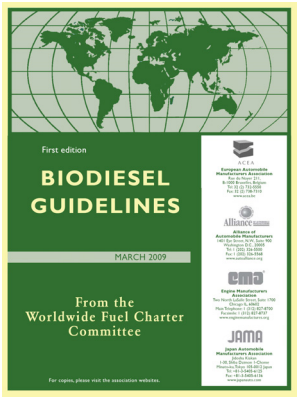
The target audiences are biofuel producers, fuel distributors, legislators and end-users. It is noted in the Guidelines that "World Wide Fuel Charter" still applies to retail gasoline and diesel fuel quality (i.e. the Guidelines supplement Category 1, 2, 3 and 4 requirements), and the fuel suppliers are responsible for final product quality. The Guidelines can be downloaded from each Committee member's website same as the Charter.

(3) The B100 Guidelines

The specification tables of the B100 Guidelines are shown in Figure 11.

Biodiesel (B100) Guidelines

* for up to B5 Blend



(a)

B100
Specs & Test Methods

Property	Value	Units	Test Methods
Ester content	96.5 min	% m/m	EN 14103 mod Other: ABNT NBR 15342
Linolenic Acid Methyl Ester	12.0 max	% m/m	EN 14103 mod
Polyunsaturated acid methyl ester (?4 double bonds)	1 max	% m/m	prEN 15799
Oxidation Stability Induction Period	10 min	hr	prEN 15751 or EN 14112 as alternative
Iodine Number	130 max*		EN 14111
Total Acid Number	0.5 max	mg KOH/g	ISO 6618 ASTM D664, D974 JIS K 2501 Other: ABNT NBR 14448
Methanol	0.20 max	% m/m	EN 14110 JIS K 2536 Other: ABNT NBR 15343
Glycerides			EN 14105
Mono-glyceride	0.80 max	% m/m	EN 14105 ASTM D6584 Other: ABNT NBR 15342
Di-glyceride	0.20 max	% m/m	- " -
Tri-glyceride	0.20 max	% m/m	- " -
Glycerin (glycerol)			EN 14105/14106 ASTM D6584 Other: ABNT NBR 15341
Free glycerin	0.02 max	% m/m	EN 14105 ASTM D6584 Other: ABNT NBR 15344
Total glycerin	0.25 max	% m/m	

(*) This limit may unnecessary preclude certain feed stocks.
Some engine technologies may need more stringent limit.

(b)

B100
Specs & Test Methods (cont'd)

Property	Value	Units	Test Methods
Density	report	g/ml @15° C	EN ISO 3675 ASTM D4052 JIS K 2249 Other: EN ISO 12185, ABNT NBR 7148/14065
Kinematic Viscosity	2.0 - 5.0	mm^2/s @40° C	EN ISO 3104 ASTM D445 JIS K2283 Other: ABNT NBR 10441
Flash Point	100 min	° C	ISO 3679 ASTM D93
Cetane Number	51 min		ISO 5165 ASTM D613 JIS: K2280
Water	500 max	mg/kg	EN 12937
Water and Sediment	0.05 max	% v/v	ASTM D2709
Total Contamination	24 max	mg/kg	EN 12662 ASTM D2276, D5452, D6217
Ash Content	0.001 max	% m/m	ISO EN 6245 ASTM D482 JIS K2272
Sulfated Ash	0.005 max	% m/m	ISO 3987 ASTM D874 Other: ABNT NBR 984
Carbon Residue: Ramsbottom, on 100% distillation residue	0.05 max	% m/m	ASTM D4530
Corrosion: Ferrous	light rusting, max	Rating	ASTM: D665, Procedure A
Sulfur	10 max	mg/kg	ISO: EN 20846/20884 ASTM: D5453/D2622 JIS K3541-1, -2, -6 or -7
Phosphorus	4 max	mg/kg	EN 14107 ASTM D4951, D3231
Alkali metals (Na+K)	5 max	mg/kg	EN 14108/14109, EN 14538
Alkaline metals (Ca+Mg)	5 max	mg/kg	EN 14538
Trace Metals	no addition		ASTM D7111

(c)

Figure 11 B100 specifications and test methods

Comparison of the limit values for each property between the B100 Guidelines and each national FAME specification of Japan, USA and Europe are summarized in Table 5. The properties shown in red and blue letters indicate rather important properties to prevent unnecessary vehicle problems in the market. In case of limit values shown in red letters, the Guidelines require more stringent control than the other national specification (ref. the limit for iodine number was decide as a compromise with more stringent limit for oxidation stability).

Table 5 Comparison with each national FAME spec. of Japan, USA and Europe

Items	Units	Japan JIS K 2390	USA ASTM D6751	EU EN14214	WWFC Biofuel Guidelines B100 for up
Ester content	mass%	96.5 min.	-	96.5 min.	96.5 min.
Density	kg/m3	860-900	-	860-900	Report
Viscosity	mm2/s	3.50-5.00	1.9-6.0	3.50-5.00	2.00-5.00
Flashpoint	deg C	120 min.	93 min.	120 min.	100 min.
Sulfur content	mass%	0.0010 max.	0.0015 max.	0.0010 max.	0.0010 max.
Distillation, T90	deg C	-	360 max.	-	-
Carbon residue (100%) or Carbon residue (10%)	mass%	- 0.30 max.	0.05 max. -	- 0.30 max.	0.05 max. -
Cetane number		51.0 min.	47 min.	51.0 min.	51.0 min.
Sulfated ash	mass%	0.02 max.	0.02 max.	0.02 max.	0.005 max.
Water content	mg/kg	500 max.	0.05[vol%] max.	500 max.	500 max.
Total contamination	mg/kg	24 max.	-	24 max.	24 max.
Copper corrosion		Class-1	No.3	Class-1	-
Acid value	mgKOH/g	0.50 max.	0.50 max.	0.50 max.	0.50 max.
Oxidation stability	hrs	(*)	3 min.	6.0 min.	10.0 min.
Iodine number		120 max.	-	120 max.	130 max.
Methyl Linolenate	mass%	12.0 max.	-	12.0 max.	12.0 max.
Polyunsaturated FAME (more than 4 double bonds)	mass%	N.D.	-	1 max.	1 max.
Methanol content	mass%	0.20 max.	0.2 max. (**)	0.20 max.	0.20 max.
Monoglyceride content	mass%	0.80 max.	-	0.80 max.	0.80 max.
Diglyceride content	mass%	0.20 max.	-	0.20 max.	0.20 max.
Triglyceride content	mass%	0.20 max.	-	0.20 max.	0.20 max.
Free glycerol content	mass%	0.02 max.	0.02 max.	0.02 max.	0.02 max.
Total glycerol content	mass%	0.25 max.	0.24 max.	0.25 max.	0.25 max.
Na+K	mg/kg	5.0 max.	5 max.	5.0 max.	5.0 max.
Ca+Mg	mg/kg	5.0 max.	5 max.	5.0 max.	5.0 max.
Phosphorous content	mg/kg	10.0 max.	10 max.	10.0 max.	4.0 max.

(*) Decided by both party's agreement, (**) Equivalent to diesel fuel

The points of discussion on important properties of FAME and some technical issues are as follows;

(i) Methyl ester purity: Low level of methyl ester indicates high levels of un-reacted materials or contaminations with non-FAME products. In the Guidelines, specific limits for linolenic acid methyl ester and poly-unsaturated acid methyl esters that have 4 or more double bonds are also regulated respectively because they are easily oxidized and the main cause of poor oxidation stability.

(ii) Oxidation stability is one of the most important properties. Oxidized products can disturb functioning of engine/vehicle and even create hardware damage. Poor oxidation stability increases risk of formation of gums, sludge and other

insoluble compounds.

(iii) Iodine number indicates total of double bonds (level of unsaturation), and can provide information about fuel's tendency to form sludge, also affect lubricant quality and/or cause corrosion.

(iv) Glycerides, glycerol (total and free) can cause filter plugging (especially at low temperature) and injector/engine deposits.

(v) Sulfated ash measure of amount of metals and other inorganic contaminants in the fuel. Sulfated ash content is linked to fuel injector deposits and PM filter plugging.

(vi) Phosphorus, sulfur cause catalyst poison, will cause increased exhaust emissions.

(vii) Alkali (Na, K) and alkaline earth (Ca, Mg) metals: KOH and NaOH are process chemical, which should not present in final product. Their presences can form deposits in injection systems and poison emission control systems, as well as injectors stick via soap formation.

(viii) Good house-keeping practices: In the Guidelines, good management practices are strongly recommended. CEN technical report CEN/TR 15367 gives good handling guidance.

(ix) Labeling: The Guidelines apply for up to B5 blend only. Clear labeling is also required in case of higher FAME concentration blend beyond B5.