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Biodiesel Fuel Standard in Japan

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DME Vehicle

BDF Mini Bus

Collab. Res. Center

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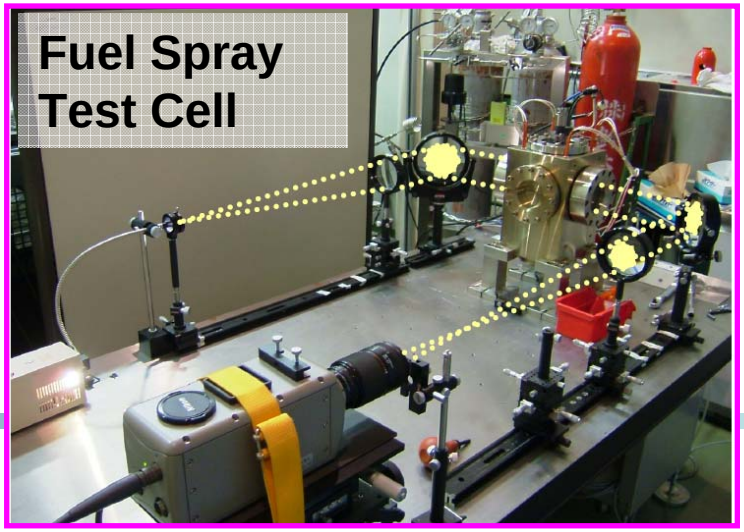
Engine Test Facilities in AIST

Vehicle Test Circuit

Fuel Spray Test Cell



Engine Test Cell

Fuel and Exhaust Gas Test Equip.

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Major Materials of Biodiesel Fuel

	Palm oil	Soybean oil	Rapeseed oil
Area	Asia	U.S.	Europa
Major component	Palmitic acid	Linoleic acid	Oleic acid
Production (kton)	33,328	32,857	15,734
Oil Yield at1ha (kg)	5,000	375	1,000

Source : http://www.oil.or.jp/seisan/seisan02_01.html

Palm

Soybean

Rapeseed

Waste cooking oil

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Introduction of Biodiesel Fuel (Europe and America)

'5th Eco Fuel Use Promotion Meeting', Document 2-2, Ministry of the Environment

	Country	Mixing rate	Material	Goals / Strategy
Europe	EU	-	-	Bio fuel usage 2% into transportation fuel in 2005 Bio fuel usage 5.75% into transportation fuel in 2010 (EUBD)
	Germany	5% 100%	Rapeseed	Bio fuel usage 3.8% in 2005
	France	5% 30%	Rapeseed	Bio fuel usage 1% in 2005 Make bio fuel usage 2% compulsory from 2005
	Italia	5% 30%	Rapeseed Sunflower	Bio fuel usage 2% in 2005 Apply B20 and B100 standard from 2007
	Poland	5% 20% 100%	Rapeseed	Bio fuel usage 0.48% in 2005 Apply B20 and B100 standard from 2007
North America	U.S.	2-5% 20% 100%	Soybean Waste cooking oil	Make bio fuel usage compulsory by Energy Policy Act of 2005 (4 billion gallon in 2006, 7 billion gallon in 2007)
	Canada	2-5%	Soybean Waste cooking oil	Introduction of B2 in 2010
Latin America	Brazil	2%	Soybean	Make BDF blend compulsory

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Introduction of Biodiesel Fuel (Asia and Oceania)

'5th Eco Fuel Use Promotion Meeting', Document 2-2, Ministry of the Environment

	Country	Mixing rate	Material	Goals / Strategy
Asia	Malaysia	2-5%	Palm	National Biofuel Policy, 2006 B5
	Indonesia	-	Palm	National Energy Program BDF usage 47 million kL in 2025
	Thailand	2%	Palm	Biodiesel Development and Promotion Strategy B5 in 2007, B10 in 2012
	Philippines	1% 100%	Coconut	Bio fuel Strategy 2006 BDF mixing rate 1% in 3 months, 2% in 2 years
	India	5%	Jatropha	Jatropha BDF demonstration 2005-2007 Jatropha BDF introduction2011-2012
	China	5% 2%	Waste cooking oil Jatropha	now under consideration in BDF standardization
Oceania	Australia	5% 20% 100%	Palm Soybean	Bio fuel introduction 35 million kL in 2010 Under consideration in B5 and B20 standardization
	New Zealand	5%	Animal fat Waste cooking oil	Bio fuel introduction 2PJ in 2012

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Biodiesel Fuel Program in Japan

Kyoto City (Waste cooking oil)

Source : Kyoto city

Shizuoka Truck Association (Rapeseed oil)

Source : NEPS
(New Energy Partnership)

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Japanese Biodiesel Fuel Applications

NPO juridical person biomass industrial society network, http://www.npobin.net/hakusho/2005/

Area	Raw Materials		Application
	Rapeseed Oil	Waste Cooking Oil	
Nagano-ken	○	○	Food Center Car, Machine for Agriculture, Tourist Facility
Joetsu-shi, Niigata	–	○	Public Car, Garbage Collection Car
Chiba-ken	○	○	Soap, BDF
Shizuoka Trucking Association	○	–	BDF for Diesel Truck, Demonstration Bus
Shiga-ken	–	–	Eco Bus crossing Biwako
Shinasahi-machi, Shiga	○	○	Circulation Type Recycling System
Aito-machi, Shiga	○	–	Circulation Type Foothold Institution
Kyoto-shi	–	○	Garbage Collection Car, Municipal Bus
Oasa-machi, Hiroshima	○	○	School Bus, Municipal Bus
Zentsuji-shi, Kagawa	–	○	Garbage Collection Car
Soo-gun, Kagoshima	–	○	Garbage Collection Car

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Fatty Acid Components of Raw Materials

		Palm	Jatropha	Coconut	Rapeseed	Soybean	Sunflower
Caprylic acid	(C8:0)	—	—	8.3	—	—	—
Capric acid	(C10:0)	—	—	5.8	—	—	—
Lauric acid	(C12:0)	—	—	48.7	—	—	—
Myristic acid	(C14:0)	1.0	—	18.0	—	—	—
Palmitic acid	(C16:0)	44.2	14.0	8.6	4.0	10.3	6.7
Stearic acid	(C18:0)	4.5	8.0	2.6	1.7	3.8	3.7
Oleic acid	(C18:1)	39.3	34.0	6.5	58.6	24.3	19.0
Linoleic acid	(C18:2)	9.6	43.0	—	21.8	52.7	69.9
Linolenic acid	(C18:3)	0.3	—	—	10.8	7.9	0.7

Source : http://www.suncarefuels.com/bdfoil.html

(Cxx:x)

Carbon number

Number of double bond

Influence of double bond

Low ←	Number of double dond	→ **High**
Good ←	Oxidation stability	→ **Poor**
Poor ←	Low temperature performance	→ **Good**

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Properties of FAMEs

Items	Unit	Palm oil methyl ester (PME)	Rapeseed oil methyl ester (RME)	Soybean oil methyl ester (SME)
Oxidation stability	Hours	6.65	4.5	1.28
Iodine number		50.2	110	128
Methyl Linoleniate	mass%	0.3	7.7	7.2
CFPP	℃	12	-11	-3

Fuel properties depend on material oil

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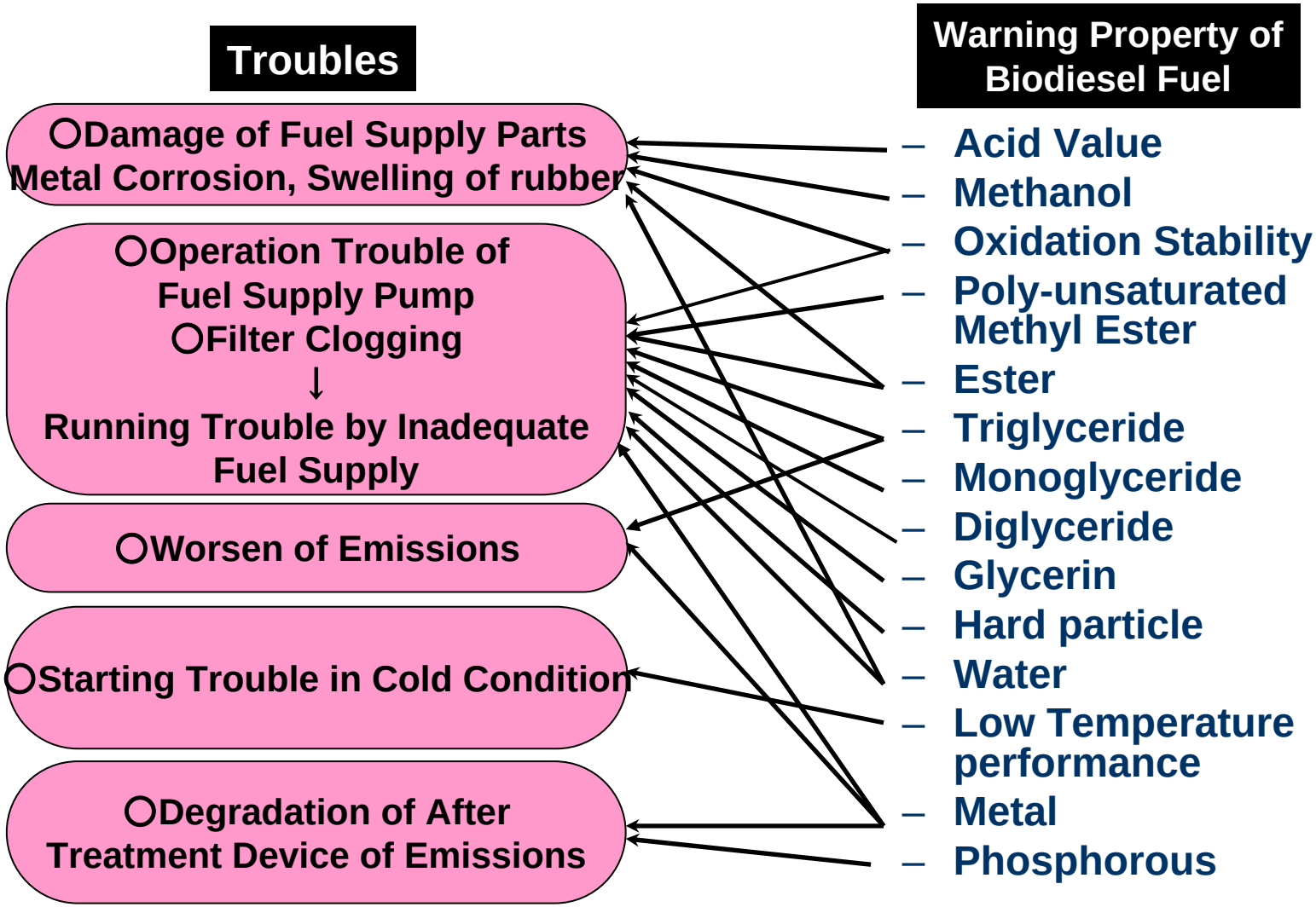
Envisioned Troubles by Biodiesel Fuel



21st Fuel Policy Subcommittee, the Petroleum Committee, and Advisory Committee for Natural Resources and Energy, METI

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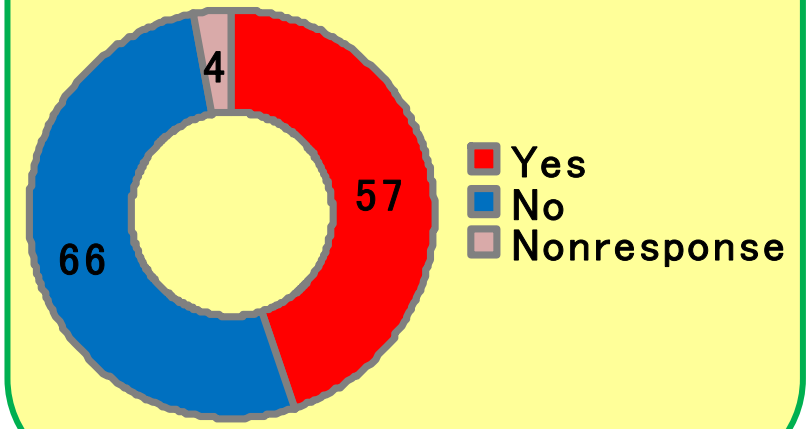
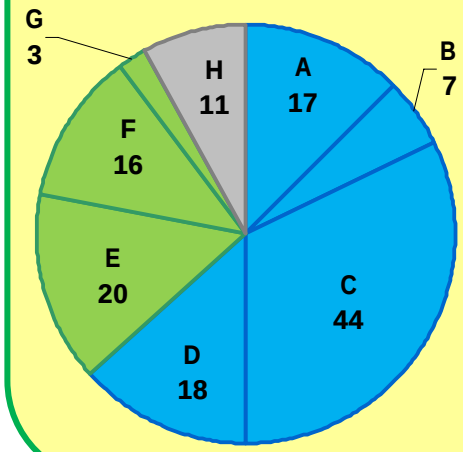
Trouble Case Derived from Biodiesel Fuel (1)

Existence of trouble



Source : MLIT

Contents of trouble report by using BDF in Japan



A : Deterioration or swelling of elastomer
B : Fuel leakage from elastomer parts
C : Fuel filter clogging
D : Fuel supply pump clogging
E : Deterioration of engine start-up
F : Instability of engine speed
G : Engine seizing
H : Others

Fuel supply system
Engine

Source : MLIT

Fuel filter clogging (by FAME solidification)

Source : MLIT

Coating detachment

Source : MLIT

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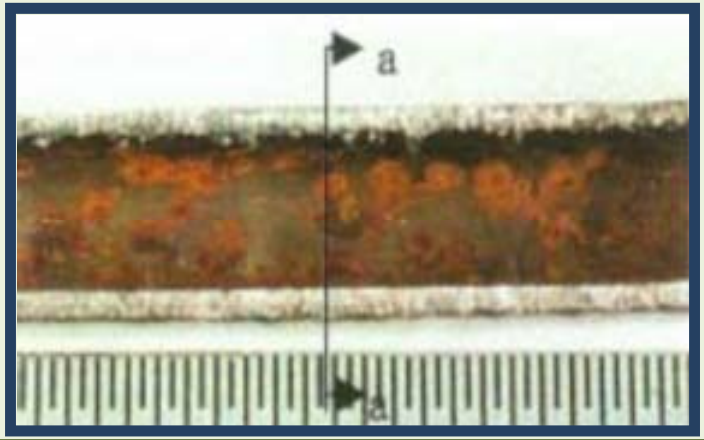
Trouble Case Derived from Biodiesel Fuel (2)

Fuel filter clogging (by impurity)

Source : Kyoto

Fuel pipe corrosion



Source : Kyoto

Nozzle coking

Source : JAMA

Soap formation

Source : JAMA

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Terne Sheet Corrosion by Biodiesel Fuel

Terne sheet : steel plate coated with Pb-Sn alloy

Diesel oil

FAME5%

	TAN	Pb (ppm)	Sn (ppm)
Diesel fuel	0.05	2	1>
FAME 1 %	0.05	8	1>
FAME 2 %	0.06	460	1>
FAME 3 %	0.06	40	1>
FAME 4 %	0.07	88	1>
FAME 5 %	0.07	1800	12

Takehiro Tsuchiya et al., “Japanese Standards for Diesel fuel containing 5% FAME: Investigation of Acid Generation in FAME Blended Diesel Fuels and its Impact on Corrosion, SAE paper 2006-01-3303

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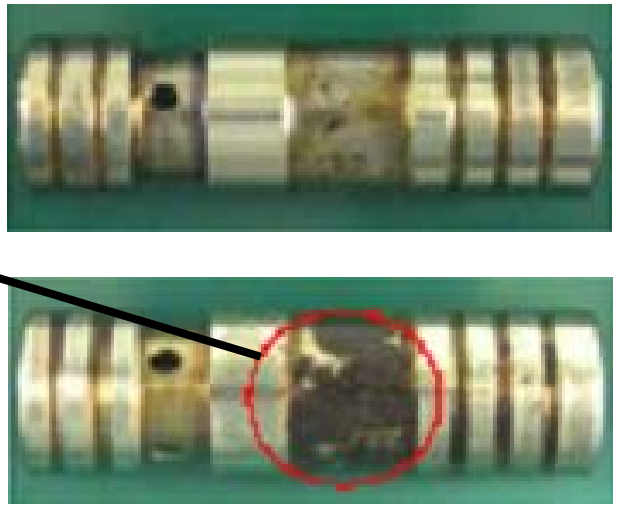
Influence of Oxidation Degradation

Fuel tank corrosion by organic acid

Sludge production Risk of poor sliding



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Influence of Organic Acid and Oxidation Stability on Fuel Tank Corrosion

	FAME5%+Organic acid	FAME5%+Antioxidant
Lower		
Upper		

Takehiro Tsuchiya et al., “Japanese Standards for Diesel fuel containing 5% FAME: Investigation of Acid Generation in FAME Blended Diesel Fuels and its Impact on Corrosion, SAE paper 2006-01-3303

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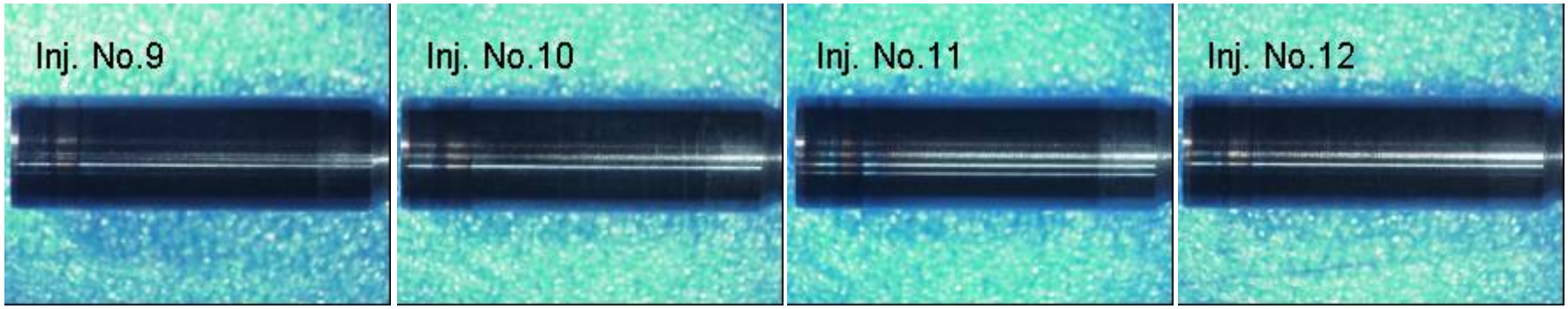
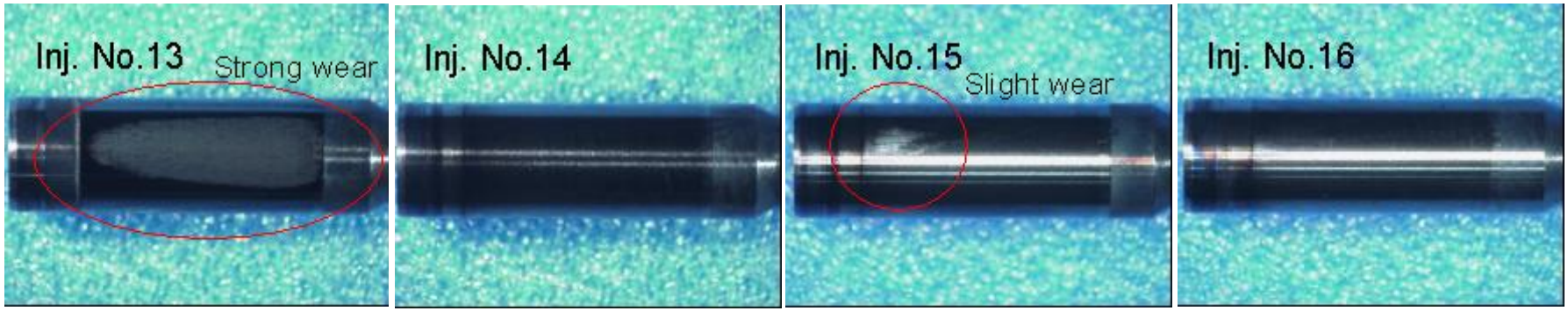
Injector Abrasion

Sliding part of nozzle needle

Diesel oil



FAME5%



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Biodiesel Fuel Standards in Other Countries

		U.S.	EU	Australia	Brazil
Ester content	mass%	—	96.5 min.	96.5 min.	—
Density	kg/m^3	—	0.86-0.9	0.86-0.89	equal to diesel oil
Kinetic viscosity	mm^2/s	1.9-6.0	3.5-5.0	3.5-5.0	equal to diesel oil
Flash point	℃	130 min.	120 min.	120 min.	100 min.
Sulfur content	mg/kg	0.0015 max.	0.001 max.	0.005 /0.001 max.	0.001 max.
Distillation (95%)	℃	360 max. (90%)	—	360 max.	360 max.
Carbon residue (100%)	mass%	0.05 max.	—	0.05 max.	0.05 max.
Carbon residue (10%)	mass%	—	0.3 max.	0.3 max.	—
Cetane number		47 min.	51 min.	51 min.	45 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.	0.05[vol%] max.	—
Total contamination	mg/kg	—	24 max.	24 max.	—
Copper corrosion		No.3	Class-1	No.3	No.1
Total acid number	mgKOH/g	0.50 max.	0.5 max.	0.80 max.	0.80 max.
Oxidation stability	hr.	3 min.	6 min.	6 min.	6 min.
Iodine number		—	120 max.	—	required report
Linolenic acid methyl ester	mass%	—	12 max.	—	—
poly unsaturated methyl ester	mass%	—	1 max.	—	—
Methanol content	mass%	0.2 max.	0.2 max.	0.2 max.	0.5 max.
Mono-glyceride	mass%	—	0.80 max.	—	1.0 max.
Di-glyceride	mass%	—	0.2 max.	—	0.25 max.
Tri-glyceride	mass%	—	0.2 max.	—	0.25 max.
Free glycerol	mass%	0.02 max.	0.02 max.	0.02 max.	0.02 max.
Total glycerol	mass%	0.24 max.	0.25 max.	0.25 max.	0.38 max.
Na+K	mg/kg	5 max.	5 max.	5 max.	10 max.
Ca+Mg	mg/kg	5 max.	5 max.	5 max.	—
Phosphorus	mg/kg	10 max.	10 max.	10 max.	10 max.
CFPP	℃	—	equal to diesel oil	suspension	—
Pour point	℃	—	0 max.	—	equal to diesel oil

Concept of FAME Blended Diesel Oil Regulation

①Maximum concentration

→swelling and deterioration of elastomer

②Purity

→sludge production by unreacted components
metal corrosion by methanol

③Freshness

→metal corrosion by lower organic acid

④Oxidation stability

→acid and sludge production by oxidation degradation

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Diesel Fuel Regulation in Japan

Items	FAME blended diesel oil	Diesel oil
Sulfur Contents	10ppm max	10ppm max
Cetane Index	45 min	45 min
T90	360℃ max	360℃ max
FAME content	5mass% max	0.1mass% max
Triglyceride	0.01mass% max	0.01mass% max
Methanol	0.01mass% max	—
Total Acid Number (TAN)	0.13mgKOH/g max	—
Total contents of Formic acid, Acetic acid and Propionic acid	30ppm max	—
Oxidation Stability (TAN Growth)	0.12mgKOH/g max	—

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JASO M360

Automotive fuel : FAME as blend stock

Items		Specification	
		Limit	Test method
Ester content	mass%	96.5 min	EN 14103
Density	g/ml	0.86 - 0.90	JIS K 2249
Kinematic Viscosity	mm2/s	3.5 - 5.0	JIS K 2283
Flash Point	Deg.C	120 min	JIS K 2265
Sulfur	ppm	10 max	JIS K 2541-1, -2, -6 or-7
10% Carbon Residue	mass%	0.3 max	JIS K 2270
Cetane number		51 min	JIS K 2280
Sulfated Ash	mass%	0.02 max	JIS K 2272
Water	ppm	500 max	JIS K 2275
Total contamination	ppm	24 max	EN 12662
Copper Corrosion		1 max	JIS K 2513
Total acid number	mgKOH/g	0.5 max	JIS K 2501, JIS K0070
Oxidation Stability		Agreement between producer and distributor	
Iodine Number	gI/100g	120 max	JIS K 0070
Methyl linolenate	mass%	12.0 max	EN 14103
Methanol	mass%	0.20 max	JIS K 2536, EN14110
Monoglyceride	mass%	0.80 max	EN 14105
Diglyceride	mass%	0.20 max	EN 14105
Triglyceride	mass%	0.20 max	EN 14105
Free glycerol	mass%	0.02max	EN 14105, EN14106
Total glycerol	mass%	0.25 max	EN 14105
Metals (Na + K)	ppm	5max	EN 14108, EN 14109
Metals (Ca + Mg)	ppm	5 max	EN 14538
Phosphorous	ppm	10 max	EN 14107
Pour point	Deg.C	Agreement between producer and distributor	
CFPP	Deg.C		

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Policy Relevance in Asia

- The importance of biofuels has been recognized in the Cebu Declaration on East Asian Energy Security on 15 January, 2007, in which the standardization was encouraged for practical use.

- On the same occasion, Japan announced four-pillar initiative entitled “Fueling Asia-Cooperation Initiative for Clean Energy and Sustainable Growth”, including the promotion of biomass energy. It was welcomed by all participating countries.

- Energy Cooperation Task Force (ECTF) will discuss the concrete measures, and then the results will be reported in the 3rd EAS to be held in Singapore.

2nd East Asia Summit

Source : The Ministry of Foreign Affairs of Japan

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Standardization of Biodiesel Fuel for Vehicles in East Asia

- Share the same recognition concerning the importance of ensuring BDF quality and the basic measurements for BDF standardization
- Study the characteristics of BDF and current situation in each country, and gather necessary information to formulate BDF standards
- Focus on Japanese standards (B5) as a typical example

- Working group

  Information sharing, promoting standardization
- Research and Survey

  Establishment of database

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WG members

Country	Name	Title/Institute
Australia	Dr. Lesley Dowling	Director, Fuel and Used Oil Policy, Department of Environment and Water Resources
China	Associate Prof. Wugao Zhang	Institute of Internal Combustion Engine School of Mechanical & Power Engineering, Shanghai Jiao Tong University
India	Dr. O.S. Tyagi	Senior Researcher Indian Institute of Petroleum (IIP), Council of Scientific & Industrial Research (CSIR)
Indonesia	Dr. Tatang Hernas Soerawidjaja	Chairman, Indonesian Biodiesel Forum / Head, Center for Research on Natural Resource Utilization, Institut Teknologi Bandung
Japan	Dr. Shinichi Goto	WG Leader Director, Research Center for New Fuels and Vehicle Technology (NFV), AIST
	Mr. Yasunori Takei	Japan Automobile Manufacturers Association (JAMA) / Toyota Motor Corporation
	Dr. Takashi Hoshino	Japan Automobile Manufacturers Association (JAMA) / Isuzu Motors Limited
	Prof. Koji Yamane	Unicersity of Shiga Prefecture
	Mr. Akio Imai	Petroleum Association of Japan (PAJ) / Showa Shell Sekiyu K.K.
Malaysia	Mr. Harrison Lau Lik Nang	Research Officer, Engineering and Processing Research Division, Malaysia Palm Oil Board (MPOB)
New Zealand	Mr. Andrew Saunders	Senior Policy Analyst Fuels & Crown Resources Group, Ministry of Economic Development
Philippins	Ms. Zenaida Ygnacio Monsada	Director, Oil Industry Management Bureau, Department of Energy
South Korea	Dr. Young Jae Lee	Leader, Transportation Energy Research Center, Korea Institute of Energy Research
Thailand	Ms. Peesamai Jenvanitpanjakul	Deputy Governor (R&D), Thailand Institute of Scientific and Technological Research (TISTR)
Vietnam	Ms. Hoang Thi Tinh	, Vietnam Certification Services, Directorate for Standards and Quality (STAMEQ)

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Recommendation Value in WG (tentative)

Items	Unit	JASO M 360	Recommendation in ERIA WG	Check items at plant
Ester content	mass%	96.5 min.	96.5 min.	
Density	g/cm^3	0.860 - 0.900	0.860 - 0.900	
Viscosity	mm^2/s	3.50 - 5.00	Equal to Diesel oil	
Flash point	℃	120 min.	Equal to Diesel oil	
Sulfur content	mass%	0.0010 max.	0.0010 max.	
Carbon residue (10%)	mass%	0.3 max.	0.3 max.	
Cetane number		51.0 min.	51.0 min.	
Sulfated ash	mass%	0.02 max.	0.02 max.	
Water content	**mg/kg**	**500 max.**	**500 max.**	**O**
Total contamination	mg/kg	24 max.	24 max.	
Copper strip corrosion		1	1	
Oxidation stability	**hr.**	**(*)**	**10 min.**	**O**
Total acid number	**mgKOH/g**	**0.50 max.**	**0.50 max.**	**O**
Iodine number		120 max.	130 max.	
Methyl linolenate	mass%	12.0 max.	12.0 max.	
Methanol content	**mass%**	**0.20 max.**	**0.20 max.**	**O**
Monoglyceride	mass%	0.80 max.	0.80 max.	
Diglyceride	mass%	0.20 max.	0.20 max.	
Triglyceride	**mass%**	**0.20 max.**	**0.20 max.**	**O**
Free glycerol	mass%	0.02 max.	0.02 max.	
Total glycerol	**mass%**	**0.25 max.**	**0.25 max.**	**O**
Na+K	mg/kg	5.0 max.	5.0 max.	
Ca+Mg	mg/kg	5.0 max.	5.0 max.	
Phosphorous	mg/kg	10.0 max.	10.0 max.	
Pout point	℃	(*)	(*)	
CFPP	℃	(*)	(*)	

(*) Agreement between producer and distributor

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Summry

- The Japanese standard was examined considering the European standard as a starting point.
- FAME content, triglyceride content, methanol content, TAN, individual acid content and oxidation stability are mainly regulated.
- The regulations of acid and oxidation stability had to be improved from European standard.
- In acid content, regulation of lower acid content is needed.
- WG which supports the standardization of biodiesel fuel in East Asia is ongoing.