Items to be considered in establishing to Guidelines of High-FAME Blends

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Japan Automobile Manufacturers Association
JAMA
1. Introduction

2. Conditions to be considered

3. Properties/specifications

4. Others

5. Summary
1. Introduction

- In the 1st APEC WS, the AAF recommendation was proposed to be used as a base specification for a discussion toward high FAME blends (up to B20) guidelines in APEC countries.
- AAF recommendation is established focusing on the market conditions in East-South Asian regions. However, it may not be suitable in the other APEC counties.
- There are several restrictions and conditions in the AAF recommendation in order to be utilized high FAME blends securely and safely. Because automobile manufacturers do not want to see any issues or problems on vehicles in the market.
- It is very important to recognize real world conditions of each country in APEC region and it may need to set the conditions or restrictions in the guideline.
2. Conditions to be Considered

- Emission Requirements
- Climate Conditions
- Feed Stock
- Base Diesel Fuel
2-1. Emission Requirements (1/2)

✓ AAF recommendation is specified the use of up to B20 in the regions implemented Euro 2/3/4 regulations.

**Conditions**

"Presupposed Conditions"
- Warm/Hot Climate
- PME
- Up to Euro4/IV emission requirement

"Recommendations"
- Oxidation Stability
- Precipitate
- Solubility

Material Compatibility

Concerned very much!

Concerned but, Conditionally Acceptable

Acceptable < Experienced in EU market >

Impact on EGR, After Treatment, & Sophisticated Fuel System

AAF
For vehicles compliant to more stringent emission regulations, need to consider the impact on sophisticated emission control systems by high FAME blends.

APEC Guideline

- B20: Concerned but Conditionally Acceptable
- B7: Acceptable

Material Compatibility

Concerned very much!

Impact on EGR, After Treatment, & Sophisticated Fuel System
Variation in ambient temperature is large in APEC countries. Ambient temperature would be an important factor to determine characteristics of FAME blends in the real world.

Source: NASA Earth Observatory
Composition of FAME is vary depending on feed stock.
Amount of saturated ME and polyunsaturated ME are key components to determine characteristics of FAME.

Composition of various biodiesel feedstocks

Source: JAMA/JARI report
Variuos feedstocks are utilized in APEC countries depending on its circumstances.

**Difference in composition by biodiesel feedstocks**

2-4. Base Diesel Fuel

- Properties of base diesel are vary and would effect to characteristics of FAME blends.
- Aniline point (Solubility) is changed by content of aromatics in diesel fuels.

(Aromatics Content%)

IL: Indonesia B0

Source: JAMA/JARI report

Aromatics content in Base Diesel >>> A10: 10%, A20: 20%, A30: 30%, A40: 40%
3. Properties/Specifications

These items have to be considered as well......

- Oxidation Stability
- Mono-glyceride Content
- Cold Properties: CP/CFPP/FBT
- Metallic Content
- Others - Uncontrollable Properties
3-1. Oxidation Stability (1/4)

- OS is vary based on distribution of composition in feed stocks.
- Generally, feed stocks having polyunsaturated ME are poor in OS.

Source: JAMA/JARI report

Comparison in Oxidation Stability (B100)

<table>
<thead>
<tr>
<th>Source</th>
<th>F/Stock</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP</td>
<td>Thailand</td>
<td>Palm</td>
</tr>
<tr>
<td>TH</td>
<td>Thailand</td>
<td>H-FAME</td>
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<tr>
<td>IP1</td>
<td>Indonesia</td>
<td>Palm</td>
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<tr>
<td>IP2</td>
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<td>Palm</td>
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<td>Soybean</td>
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<tr>
<td>AS2</td>
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<td>Soybean</td>
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<tr>
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<td>Coconut</td>
</tr>
<tr>
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</tbody>
</table>
3-1. Oxidation Stability (2/4)

✓ Oxidation stability of FAME blends is getting worse when FAME content is increased.
✓ Polyunsaturated ME is increased by increasing in FAME content.

Source: JATOP
3-1. Oxidation Stability (3/4)

✓ FAME containing much polyunsaturated ME will be deteriorated very much and generate polymers (sediment).

Source: JAMA/JARI report

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Conditions for Deterioration:
@ 130 Celsius, for 20 hrs
3-1. Oxidation Stability (4/4)

- Trend in sediment generation is different by feedstock.
- Aromatics content in diesel effects on sediment generation.

Source: JAMA/JARI report

Aromatics content in Base Diesel >>> A10: 10%, A20: 20%, A30: 30%, A40: 40%
3-2. Mono-glyceride Content (1/5)

- MG in FAME turns to solid from liquid at below room temperature.
- MG Content in B100 has to be specified in considering to the lowest temperature in the real world.

**Source**: JAMA/JARI report

### (5 °C Constant)

- **MG**: 0.5 mass%
- **PME Content** vs. **Precipitate**

### (15 °C Constant)

- **MG**: 0.5 mass%
- **PME Content** vs. **Precipitate**

### (25 °C Constant)

- **MG**: 0.5 mass%
- **PME Content** vs. **Precipitate**

- **Note**: No precipitate was observed with 0.13 mass % MG in PME.

![Precipitate](image-url)
✓ Tendency is similar regardless source of PME.
✓ Different trend would be seen with different temperature.

Source: JAMA/JARI report

Storage Temp: 5°C const. for 2 weeks
3-2. Mono-glyceride Content (3/5)

✓ Tendencies in precipitate amount are different by feed stock.

Source: JAMA/JARI report

Trends in Precipitate by Feed Stock

- Aromatics: 10%, 5 °C
- Aromatics: 10%, 10 °C

Distribution of SMG in Precipitate

- B20 PME @ 5 °C
- B20 CME @ 5 °C
3-2. Mono-glyceride Content (4/5)

Properties of base diesel would effect on characteristics in FAME blends because of its variation of solubility.

Source: JAMA/JARI report

Aromatics content in Base Diesel >>> A10: 10%, A20: 20%, A30: 30%, A40: 40%
Higher amount of precipitate was generated when base diesel contained lower aromatics was used.

Source: JAMA/JARI report
3-3. Cold Properties

- Cold properties such as CP, CFPP, and PP have to be specified in the guidelines of FAME Blends.
- The lowest temperature in some APEC countries would be below freezing point.

**Cold Properties (B100)**

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Source: JAMA/JARI report
3-4. Metallic Content

✓ Metallic content in FAME would become a source of ash in DPF.
✓ Accumulation of ash in DPF would be accelerated by FAME blends containing high metallic components.
✓ Generally, left over metallic components used in the production process of B100, are containing in FAME.
✓ Key metallic components need to be specified in B100 standard would be Ca, Zn, P, Mg, Fe, and so forth.
4. Others – Uncontrollable Properties

- There are some uncontrollable properties in FAME and in FAME blends which may impact on engine/vehicle operations.
- Typical properties to be considered are distillation and heating value (LHV).

Further Concerns - Expected Impacts (3/3)

- High FAME blends would be expected to impact on newly employed systems and components.

<table>
<thead>
<tr>
<th>Key Characteristics</th>
<th>Factor</th>
<th>Expected Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distillation &lt; High Boiling Point &gt;</td>
<td>Unburned FAME in Exhaust</td>
<td>Fouling, clogging EGR system components, Clogging DOC, DPF, Oil dilution by FAME (by DPF regeneration) - Drop of engine oil pressure</td>
</tr>
<tr>
<td>LHV &lt; Low Calories &gt;</td>
<td>Lower Exh. Gas Temperature</td>
<td>Drop of DPF regeneration performance, Decline in emission conversion rate</td>
</tr>
<tr>
<td>Oxidation Stability</td>
<td>Oxidized Degradation</td>
<td>Sludge formed in engine oil, Injector deposits, - In-cylinder injector, - Exhaust pipe injector (for DPF regeneration)</td>
</tr>
</tbody>
</table>
4. Summary – What to do next

✓ Need to recognize circumstances including restrictions in FQ by law (i.e. LCFS in Calif.) of real world in all APEC countries.
✓ Need to think about specification for important properties both in B100 and BXX based on the all circumstances in APEC countries.

➢ Priority (Proposal)

<table>
<thead>
<tr>
<th>Priority</th>
<th>B100</th>
<th>BXX</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Ester Content</td>
<td>FAME Content</td>
</tr>
<tr>
<td>2</td>
<td>Oxidation Stability</td>
<td>Oxidation Stability</td>
</tr>
<tr>
<td>3</td>
<td>Mono-glyceride</td>
<td>Water Content</td>
</tr>
<tr>
<td>4</td>
<td>Metallic components</td>
<td>CP/CFPP/PP/FBT</td>
</tr>
<tr>
<td>5</td>
<td>Water Content</td>
<td></td>
</tr>
</tbody>
</table>

...... and more!!
Thank you very much for your attention

JAMA
JAPAN AUTOMOBILE MANUFACTURERS ASSOCIATION, INC.