# Fatty Acid Methyl Ester Fuels
# as a Replacement or Extender for Diesel Fuels

# Diesel Fuel Injection Equipment Manufacturers
# Common Position Statement

## Background:

Diesel Fuel Injection Equipment (FIE) manufacturers fully support the development of alternative sources of fuel for compression ignition engines.

In Europe and in the United States, fuel resources such as Rape Methyl Ester (RME) and Soybean Methyl Ester (SOME), collectively known as Fatty Acid Methyl Esters (FAME) are being used as alternatives & extenders for mineral oil derived fuels.

The introduction of any change in fuel composition needs to be fully assessed by those responsible, before these fuels are made available to the public. The need for thorough evaluation has been highlighted in recent years with the changes made to remove sulphur from mineral oil diesel fuels, which caused excessive wear and failure of rotary fuel injection equipment. In this case, release of the fuels took place before a suitable lubricity standard was in place to protect end-users from product failures.

The FIE manufacturers are aware of issues peculiar to fatty acid methyl ester fuels and are active in the generation of Standards for these fuels to protect the end-users of their products from potential premature failure. Biodiesels must conform to such Standards to be of acceptable quality, just as mineral oils do at present.

To date, experience in Europe has been mainly associated with the methyl esters of Rapeseed oil and in the US with Soybean derived fuels. Whether or not the service experience with these fuels will apply/ extend to all fatty acid methyl esters (including such as Tallow ME and Used Frying Oil ME) has yet to be determined. FAMEs tested so far appear to have good lubricity and cetane numbers.

## FIE Manufacturers Concerns:

FAMEs are derived from a wide range of base stocks, resulting in a similarly wide range of finished fuel characteristics.

Amongst the concerns of the FIE manufacturers are the following fuel characteristics:-

***- Free methanol*** ***- Dissolved and free water*** ***- Free glycerin***

***- Mono and di glycerides*** ***- Free fatty acids*** ***- Total solid impurity levels***

***- Alkaline metal compounds in solution.*** ***Oxidation and thermal stability***

As currently manufactured, these fuels are less stable than mineral oil derived fuels. FAME fuels readily "bio-degrade" in the event of accidental spillage or leakage - this is claimed as a marketing advantage- The degradation propensity is, however, of major concern to the FIE manufacturers as the products of this natural process can be potentially harmful to the fuel system.

Our tests have shown that fuel degradation can take place in the fuel supply chain and in the vehicle fuel system; it is accelerated by the presence of oxygen, water, heat and impurities. The products of bio-degradation have been shown to be corrosive (e.g. formic, acetic and organic acids, water and methanol) and polymerisation products drop out within mixes with mineral fuels.

During extensive field trials conducted by the FIE Manufacturers in collaboration with end-users, the following injection equipment and engine problems have been identified as being caused by these fuel characteristics:-

***- Corrosion of FIE components.*** ***- Elastomeric seal failures***
***- Low pressure fuel system blockage*** ***- Fuel injector spray hole blockage***
***- Increased dilution and polymerisation of engine sump oil***
***- Pump seizures due to high fuel viscosity at low temperatures***
***- Increased injection pressure***

The incidence of these effects is likely to be increased when the engine is in irregular use, in applications such as stand-by generator units, automatic plant and seasonally used vehicles. ( A list of potential problems is attached at the end of this document)

## Fuel Quality Control Requirements:

Several initiatives are currently underway, to define Standards for fatty acid methyl ester fuels. For vegetable oil methyl esters (VOME), Austrian, Italian, German and French Standards already exist as well as a draft European Standard, but it is recognised that these do not fully specify the fuel requirements to a sufficient level to protect the end-user. In particular the fuel ageing propensity is poorly defined and few controls are implemented.

Within the European Community, CEN technical committee TC19 has been given the responsibility to evolve Standards of FAME for diesel engine use, viz.,

a) 100% FAME as a complete replacement for diesel fuel
b) FAME fuel as a blending component for use with mineral diesel fuel to comply with EuroNorme EN590 with up to 5%(vol) FAME.

International Standards Organisation committee TC28 will liaise with this group with regard to an eventual world-wide standard. ASTM in the U.S. is involved in similar work.

The latest proposed draft German specification from DIN for FAME (E-DIN51606) contains most of the items proposed by the FIE manufacturers for inclusion in an acceptable standard. Uppermost in these requirements are the following:-

***- Oxidation Stability*** ***- Thermal Stability*** ***- Total Acid Number*** ***- Iodine Number***

***- Water Content*** ***- Content of methanol, free glycerine & glycerides*** ***Flash Point***

***- Low Temperature Operability parameters such as viscosity, CFPP & pour point.***

It is anticipated that, to reach acceptable levels for these parameters the development and inclusion of suitable fuel additives and appropriate test methods will be required.

For determination of oxidation stability, it is being proposed to use a modified IP306 procedure. Current experience suggests that the best of the FAME fuels tested cannot better an “induction period” of four hours. Fuels without additives to improve this characteristic are of concern to the FIE manufacturers

DELPHI Automotive Systems STANADYNE Automotive DENSO BOSCH

## Diesel Fuel Injection Equipment Manufacturers

# Common Position Statement on Fatty Acid Methyl Ester (FAME) Fuels as a Replacement or Extender for Diesel Fuels

## The FIE Manufacturers Position:

FIE manufacturers encourage the development of renewable compression ignition fuels. Experience to date with Rapeseed Methyl Ester fuels in Europe suggests that with fuels conforming to the existing national FAME standards at the point of sale in mixtures containing up to 5% volume RME, in mineral diesel fuel complying with currently accepted quality Standards, should not give end-users any serious problems.

Certain vehicle models have been adapted by their makers to use blends of 5% and above of good quality RME fuels in mineral diesel fuel. Other vehicles are adapted for using 100% good quality RME. The FIE manufacturers can supply equipment suitable for these applications.

The original quality of the FAME fuel is defined in draft National Standards which cover all relevant impurities and tramp chemicals from the processing. Suppliers of FAME fuels must be able to demonstrate compliance to these draft Standards at the point of delivery to the vehicle or plant.

International Standards are based on experience gained with the National Standards being developed to specify the original quality and long term stability of FAMEs. For the FIE manufacturers a key part of these Standards is resistance to oxidation. Aged or poor quality FAME contains organic acids, free water, peroxides and products of polymerisation which attack many components thereby drastically reducing the service life of the FIE. A full list of issues which have been witnessed in service is in the Attachment.

Even if these fuels comply with a suitable Standard as delivered, the enhanced care and attention required to maintain the fuels in vehicle or other tanks may entail a high risk of non-compliance to the Standard during use.

The FIE manufacturers can accept no legal liability for failure attributable to operating their products with fuels for which the products were not designed, and no warranties or representations are made as to the possible effects of running these products with such fuels.

Non-compliance of the fuel to Standards agreed by the FIE manufacturers, whether being evident by appearance of the known degradation products of these fuels, or their known effects within the fuel injection equipment, (see attached list of known issues) will render the FIE Manufacturers' guarantee null & void.

DELPHI Automotive Systems STANADYNE Automotive DENSO BOSCH

**Attachment**

# Fuel injection equipment - potential problems with FAME

**(non exhaustive list)**

| Fuel Characteristic | Effect | Failure Mode |
|---|---|---|
| Fatty acid methyl esters (general) | -Causes some elastomers including Nitrile rubbers to soften, swell, or harden and crack | Fuel Leakage |
| Free methanol in FAME | -Corrodes aluminium & zinc<br>-Low flash point | Corrosion of FIE |
| FAME process chemicals | Potassium and sodium compounds<br>Solid particles | Blocked Nozzles |
| Dissolved water in FAME | Reversion of FAME to fatty acid | Filter Plugging |
| Free water in mixtures | Corrosion<br>Sustains bacteria<br>Increases the electrical conductivity of fuel | Corrosion of FIE<br>Sludging |
| Free glycerine | Corrodes non ferrous metals<br>Soaks cellulose filters<br>Sediments on moving parts and Lacquering | Filter clogging<br><br>Injector Coking |
| Mono- & di-glyceride | Similar to glycerine | |
| Free fatty acid | Provides an electrolyte and hastens the corrosion of zinc<br>Salts of organic acids<br>Organic compounds formed | Corrosion of FIE<br>Filter plugging<br>Sediments on parts |
| Higher modulus of elasticity | Increases injection pressure | Potential of reduced service life |
| High viscosity at low temperature | Generates excessive heat locally in rotary distributor pumps<br>Higher stressed components | Pump seizures<br>Early life failures<br>Poor nozzle spray atomisation |
| Solid impurities | Potential lubricity problems | Reduced service life |
| **Ageing products** | | |
| Corrosive acids (formic & acetic) | Corrodes all metallic parts may form simple cell | Corrosion of FIE |
| Higher molecular organic acids | Similar to fatty acid | |
| Polymerisation products | Deposits especially from fuel mixes | Filter plugging<br>Lacquering formation in hot areas |

DELPHI Automotive Systems  STANADYNE Automotive  DENSO  BOSCH

**The views contained in this Common Position Statement are those of the FIE Manufacturers, which comprise the following:-**

**Signed on behalf of**
**Delphi Diesel Systems**

.....

**Dr M Norman**
**Technical Director**
**Delphi Diesel Systems**

**Signed on behalf of**
**Stanadyne Automotive Corp.**

.....

**Mr William Kelly**
**Vice President & General Manager**
**Fuel Injection Pumps**
**Diesel Systems Group**

**Signed on behalf of**
**DENSO CORPORATION**

.....

**Mr Masami Manabe**
**Director**
**Diesel Injection Product Division**

**Signed on behalf of**
**Robert Bosch GmbH**

.....

**Mr K Krieger**
**Senior Vice President Engineering**
**Automotive Equipment Group Systems**
**Diesel FIE Division.K5**