



Technical Circular

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Alternative fuels

Due to the developments on the oil market, the interest in alternative fuels has grown strongly as the frequent inquiries confirm.

Operation with biodiesel (Fatty Acid Methyl Ester -FAME- according to the standard EN 14214) is no problem for most DEUTZ compact engines under consideration of some basic conditions (see TR 0199-99-3005).

The use of pure vegetable oils is possible for some engines with restrictions. DEUTZ can provide no guarantee however. The requirements for rape seed oil fuels are described in the the DIN draft E DIN 51605 (fuels for vegetable oil capable engines - rape seed oil fuel - requirements). Close attention must be paid to the quality of the rape seed oil fuel used.

The enclosed brochure

Alternative fuels: Biodiesel and rape seed oil, how things stand

provides helpful arguments for the use of alternative fuels for DEUTZ compact engines.

The brochure is available in German and English and can be ordered under the following part number from your responsible DEUTZ Service.

German TN 0031 1371
English TN 0031 1372

Service Information

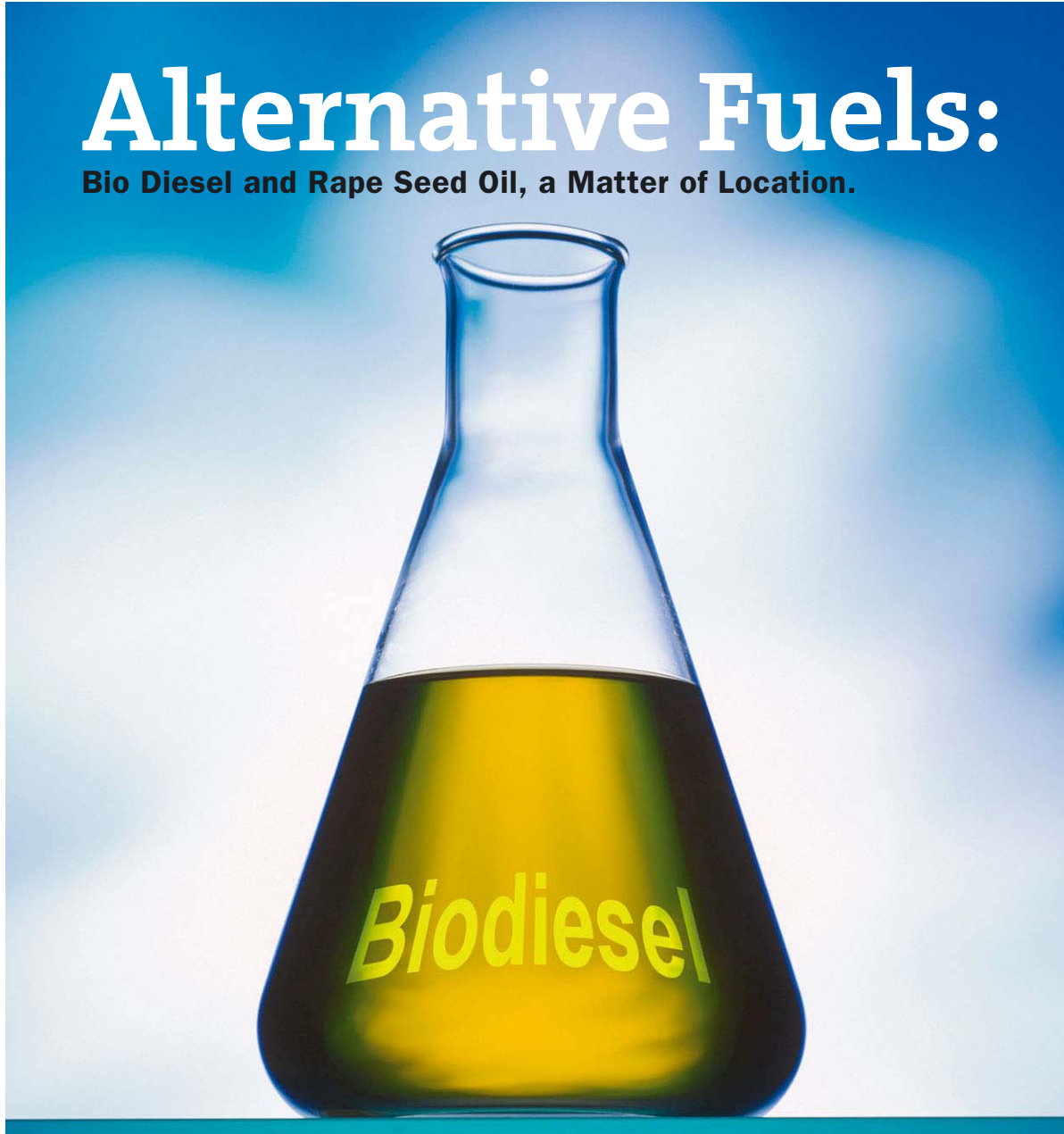
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Note:
The part numbers indicated in this document are not subject to updating.
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- TR KM
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Alternative Fuels:

Bio Diesel and Rape Seed Oil, a Matter of Location.



The engine company.



Suitability of rape seed oil methyl ester

In order to explain the fuel properties of vegetable oils (such as rape seed oil) which are important as regards application in diesel engines, reference should first be made to the chemical composition of vegetable oils. Vegetable oils are esters in which three long-chain fatty acids are bound to a trivalent alcohol (glycerol).

Certain of the characteristics of pure vegetable oils are problematic for use in diesel engine operation, primarily as a result of their very large molecules, which are approx. 60 C atoms in size. By means of interesterification with methanol, it is possible to convert the large glycerol esters, each of which has three fatty acids, into vegetable oil methyl esters with just one fatty acid per molecule. These molecules are similar in size to those of diesel fuel, and are therefore able to extensively substitute diesel fuel without problems.

The most common vegetable oil methyl ester in Europe is rape seed oil methyl ester (RME), also sold as »bio diesel«.

The following, only partially synonymous, terms are commonly used:

- Rape seed oil methyl ester (RME).
- Vegetable oil methyl ester (more general, also contains soya bean oil methyl ester, used in the USA as bio diesel).

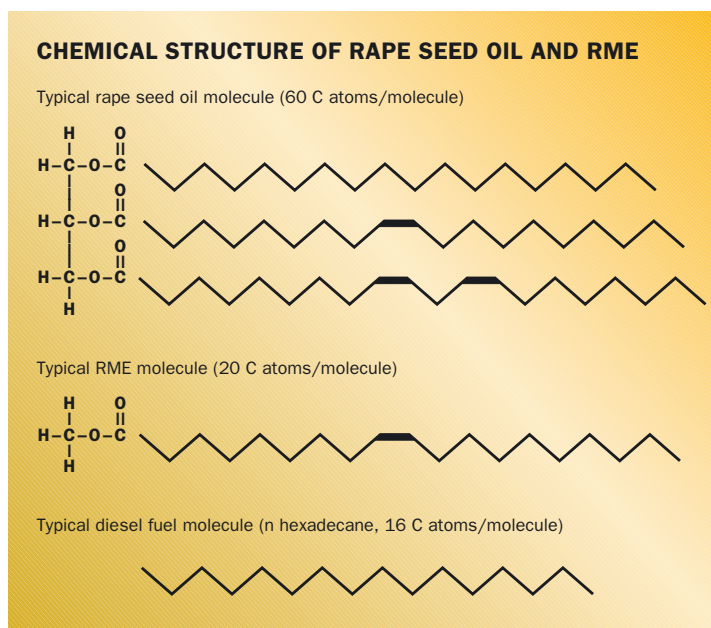
The EN 14214 standard »Fatty acid methyl esters (FAME) for diesel engines« has been in existence for several years. This has replaced DIN V 51606, which is now invalid.

The bio diesel quality management study group (registered association, AGQM), in which many German RME suppliers are amalgamated, has set down specifications which exceed those of EN 14214. Bio diesel suppliers which bear the AGQM badge are therefore particularly recommended to DEUTZ customers.

Operation with bio diesel is permissible for the majority of DEUTZ engines (912, 913, 914, 1011, 2011, 1012, 2012, 1013, 2013, 413 and 513) in accordance with the following

boundary conditions (according to DEUTZ technical circular TR 0199-99-3005):

- Only engines as of year of construction 1993 are approved.
 - Use of fuels with specifications according to EN 14214.
 - Applications with engine loads >80% (mean output >80% of rated output) are not approved for turbo-charged engines.
 - Possible loss of output of 5–7% must not be compensated by upfuelling.
 - The lube oil change interval must be halved in comparison with operation with diesel fuel according to EN 590.
 - Long downtimes must be avoided with bio diesel (e.g. winter break for equipments used in agricultural applications). Instead, the engine must be operated and shut down with diesel fuel before laying up.
 - The fuel hoses and diaphragm fuel pumps in series production engines are not permanently resistant to bio diesel, and must be replaced annually. Service kits containing the parts for annual replacement, and further service kits with bio diesel-resistant materials, which render annual replacement superfluous, are in preparation.
- Release tests have not yet been completed for the exhaust emission level III model series to be launched in 2006 (TCD 2012, TCD 2013).
- The advantages of bio diesel versus diesel fuel are listed in the following:
- Renewable fuel (high reduction of CO₂ accumulation in the atmosphere).
 - Lower soot emission (40–60% reduction) due to oxygen contained in the fuel.
 - Lower particulate emission (20–50% reduction).



- Lower sulphur content, lower SO₂ emission, therefore better exhaust gas aftertreatment prerequisites.
- Lower emission of polycyclic aromatics (PAH).
- Lower price (due to tax exemption, despite higher production costs).

These are countered by the following disadvantages:

- Restrictions (oil change intervals halved, annual replacement of fuel hoses...).
- Reduced output (5–7%).
- Increased fuel consumption (7–10%).
- Raised nitrogen oxide emissions (naturally-aspirated engines: 3–5%, turbocharged engines: up to 20%).
- Increased fuel storage effort. Due to bio diesel's ability to absorb more water, the water limit value (500 mg/kg according to EN 14214) may be exceeded easily. A higher water content also promotes bacterial growth, resulting in the total contamination limit value's (24 mg/kg) possibly being exceeded. The user is therefore recommended to consult his fuel supplier regarding the fuel storage system.
- Possible fuel filter clogging following the switch from diesel fuel to bio diesel due to the dissolution of deposits. This is perceived via a clear reduction in output approx. 100 hours following the switch. However, the problem can be permanently eliminated by a one-off filter change.

Reference is made to the results of a forestry RME vehicle fleet test (Doberlug-Kirchheim Forestry Department, Brandenburg, 1999) to demonstrate DEUTZ engines' suitability for operation with RME over long operating periods.

The following DEUTZ engines successfully took part in the test:

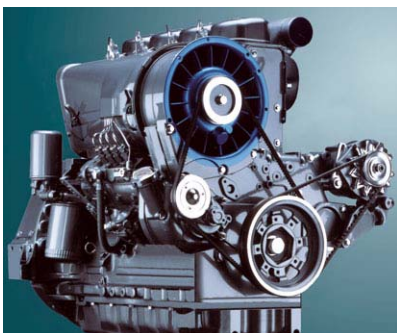
- F 3L 913 in a DEUTZ-FAHR tractor over a period of 1736 hours.
- BF 4M 1013 in forestry equipment (harvester) over a period of 5462 hours.
- BF 4M 1012 in forestry equipment (forwarder) over a period of 8764 hours.

Future use of bio diesel will depend on the future crude oil and diesel fuel price trend and on legal constraints.

Suitability of pure vegetable oils

The following, problematic fuel characteristics are attributable to the molecule size of pure vegetable oil:

- Lack of evaporability. That it is at all possible for combustion to occur in a diesel engine is due to the occurrence of chemical decomposition at the prevailing temperature, i. e. break-down into smaller fuel fractions takes place.
- Very high viscosity (10 times higher than RME and 20 times higher than



diesel fuel). The consequences are poor atomisation and air/fuel mixture formation.

- A low cetane number of 40–42, i. e. poor ignition quality. This is a consequence of the lack of evaporability and poor air/fuel mixture formation.
- High carbon residue (Conradson test). On hot surfaces, vegetable oil leads to high carbon build-up. This undesirable characteristic is attributable to the lack of evaporability (rapid escape from hot surfaces is prevented) and also to the double bonds, which may lead to polymerisation (= bonding of several molecules to form even larger units).
- Unfavourable low-temperature characteristics (problems are to be anticipated just below 0° C).

Despite the unfavourable fuel properties of pure rape seed oil, certain DEUTZ engines can be operated with this fuel: Swirl chamber engines 912

W and 413 FW. These engines employ a two-stage combustion process. In the first combustion stage, the swirl chamber, the fuel is extensively broken down, with the inclusion of air, into small fragments and gaseous fuels such as carbon monoxide and hydrogen. A second, largely complete combustion stage takes place in the main combustion chamber. Due to extensive cracking of the fuel in the swirl chamber, the rape seed oil's problematic, giant molecules no longer enter the critical regions of the engine (piston rings, lube oil).

The F6L 912 W was also used in the BMFT research project «Experimental investigation into the use of vegetable oils in diesel engines» (carried out at Porsche, concluded in 1991).

Neither the direct injection engines nor the passenger car swirl chamber engine survived the endurance test, but failed after 150–250 hours. Only the two divided-chamber engines with higher swept volumes, including the DEUTZ F6L 912 W, proved durable



and revealed no deterioration in their operating data.

The causes of the direct injection engines' failure included coking in the combustion chamber, in the piston ring grooves and at the fuel injection nozzles. Coking in the piston ring grooves resulted in piston ring sticking and piston seizure. Extremely viscous lube oil was also observed, caused by excessive entrainment of rape seed oil into the lube oil.

As has already been explained above, these coking phenomena are attributable to non-evaporability and the polymerisation tendency (double bonds), and are therefore causally connected to the basic chemical structure of vegetable oil. The phenomena which have been observed in engines can therefore be theoretically underpinned.

Due to the rise in diesel fuel prices and the reduction of agricultural diesel subsidisation, crude rape seed oil has become increasingly attractive to many users, particularly in the agricultural sector. In view of limited crude oil resources, political instances are also striving to introduce regenerative fuels. The conversion of 111 tractors to rape seed oil has been promoted by

BMVEL as part of the 100 tractors programme (running from 2001 to 2005). All conversions were carried out by small companies specialised in this field. Engine manufacturers, including DEUTZ AG, regard the risk involved in rape seed oil engines to be excessively high, and also consider the effort involved in development for a limited market to be too high.

The university of Rostock is documenting the farmers' experience with these rape seed oil tractors. Whilst the concluding report has not yet been published, interim reports have been given at several status seminars.

Up to May 2004, only 65 of the 111 tractors ran without, or with only minor, disturbances. All of the others suffered damage, up to and including total failure, primarily due to:

- Defective fuel injection pumps and nozzles,
- Seizing exhaust valves,
- In individual cases, piston seizure.

In comparison with the BMFT project from 1991, it must be stated that the more modern engines used in

the 100 tractor programme exhibit better rape seed oil suitability. The robust pump-line-nozzle systems fitted in the DEUTZ engines, in particular, proved relatively durable. Nevertheless, the incidence of damage is still far too high, and customers can hardly be expected to accept the risk of failure.

Farmers who still wish to have a tractor converted to operation with rape seed oil, despite the known risks, should demand warranty certificates from the converters.

In view of these results and the problems posed by the basic chemistry, we must expressly warn operators not to independently use vegetable oils in non-approved engines. All engines will run for a certain length of time without any conspicuous occurrences, but problems may occur after a certain period of time, and may lead to piston seizure in the worst-case scenario. Needless to say, customers cannot rely on warranty cover in such cases.

The negative assessment of pure vegetable oil also applies to use in combination with diesel fuel. The tendency to coke is merely reduced according to the mixture ratio, and remains a critical parameter.

Source:

VDBUM Information No. 6/2000 ; updated: 10/2005

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