Technical Bulletin

0199 - 99 - 1218/0 EN

This Circular supersedes: TR 0199-99-3005/9

Date: 21.05.2012
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DEUTZ engines

- All DEUTZ engines
- Assemblies:

  99

Fuels

Replacement is made because of:

- introduction of engines with new emission stages Tier 4 interim and stage IIIB.
- Extension of biodiesel releases
- Revision of fuel standards and legal regulations

General

This bulletin defines for which compact engines of the DEUTZ brand the following fuels are approved:

- Diesel fuels
- MDF distillate fuels
- Light heating oils
- Jet fuels
- Biofuels

For general data on fuels, see section:

- Synthetic fuels
- Biological contamination in fuels
- Fuel additives
- Fuel filters

Note:
The part numbers indicated in this document are not subject to updating.
Binding for the identification of spare parts is exclusively the spare parts documentation.

- General information on fuel properties, exhaust gas after-treatment systems and emission regulations

This Technical Bulletin applies for all air-cooled and liquid-cooled compact engines of the DEUTZ brand. For engines which are no longer in production, this TB applies accordingly. This TB only applies up to year of production 2000 for engines of the 226 series.

Fuels must be used as regulated in the respective national regulations (e.g. in Germany in the 10th BImSchV). No fuels which deviate from these national regulations may be used (e.g. no fuel may be used in Europe if it only meets the limit values of the US standard purely by chance).

The certification measurements for compliance with the legal emission limit values are carried out with the test fuels specified in the laws. These correspond with the diesel fuels according to EN 590 and ASTM D 975 described in the following section. No emission values are guaranteed with the other fuels described in this bulletin. The owner is obliged to check the permission for the use of fuels according to the regional regulations.

Engines which are equipped with exhaust gas after-treatment by particle filters (DPF), diesel oxidation catalytic converters (DOC), particle oxidation catalytic converters or an SCR system (Selective Catalytic Reduction) may only be operated with sulphur-free diesel fuels (EN 590, ASTM D975 Grade 2-D S15, ASTM D975 Grade 1-D S15 or heating oil in EN 590 quality). Otherwise compliance with the emission requirements and durability is not guaranteed.

In a warranty case the customer must prove by a certificate from the fuel supplier that a released fuel was used.

The following list specifies the released fuels for the different series and emission stages, the following text contains further data about these releases:

List of released fuels

	413 513 912 913 914 up to Tier 3 Stage IIIA	1008 2008 2009 226 909 910 up to Tier 3 Stage IIIA	1011 2011 up to Tier 3 Stage IIIA	1012 1013 2012 2013 up to Tier 2 Stage II EURO 3	1015 up to Tier 2 Stage II	413 513 912 913 1013M 1015M 2015M 914M Marine engines
Diesel fuels in accordance with EN 590, ASTM D975 or JIS K 2204 [8]	✓	✓	✓	✓	✓	✓
Distillate fuels for marine engines	✓	-	-	-	-	✓
Non-road fuels (light heating oils)	✓	✓	✓	✓	✓	✓
Jet fuels	✓	-	✓	✓	✓[7]	-
Biodiesel (up to 100 % EN14214, up to 20 % ASTM D7467)	✓	-	✓	✓	-	✓[6]
Diesel fuel world-wide according to appendix 11	✓	✓	✓	✓	✓	✓

	TCD 2012 2V 2012 4V Tier 3 Stage IIIA	TCD 2013 2V 2013 4V Tier 3 Stage IIIA	TCD 2013 4V Com-mercial vehicles up to Euro III	TCD 2013 4V Com-mercial vehicles from Euro IV	TCD 2015 Tier 3 Stage IIIA	DEUTZ Natural Fuel En-gine ® Stage IIIA
Diesel fuels in accordance with EN 590, ASTM D975 or JIS K 2204 [8]	✓	✓	✓	✓	✓[10]	✓
Distillate fuels for marine engines	-	-	-	-	-	-
Non-road fuels (light heating oils)	✓	✓	-	-	✓	✓[1]
Jet fuels	✓[7]	✓[7]	-	-	-	-
Biodiesel (up to 100 % EN14214, up to 20 % ASTM D7467)	✓	✓	✓	✓[3]	✓[4]	✓
Vegetable oil (DIN 51605)	-	-	-	-	-	✓
Diesel fuel world-wide according to appendix 11	✓	✓	✓	-	✓	-

	D/TD/ TCD 2.9 L4 TD/TDC 3.6 L4 up to Tier 3	D/TD/ TCD 2.9 L4 TD/TDC 3.6 L4 from Tier 4 in-terim Stage IIIB	TCD 4.1 L4 TCD 6.1 L6 TCD 7.8 L6 up to Tier 3	TCD 4.1 L4 TCD 6.1 L6 TCD 7.8 L6 from Tier 4 in-terim Stage IIIB	TCD 12.0 V6 TCD 16.0 V8 from Tier 4 in-terim Stage IIIB
Diesel fuels in accordance with EN 590, ASTM D975 or JIS K 2204 [8]	✓	✓ [5]	✓	✓ [5]	✓ [5]
Distillate fuels for marine engines	-	-	-	-	-
Non-road fuels (light heating oils)	-	✓[2]	-	✓[2]	✓[2]
Jet fuels	-	-	-	-	-
Biodiesel (up to 100 % EN14214, up to 20 % ASTM D7467)	-	-	-	✓[1]	-
Diesel fuel world-wide according to appendix 11	✓[9]	-	✓[9]	-	-

Restrictions	
✓[1]	Release only for Agri Power engines (Stage IIIB) with SCR exhaust gas after-treatment system
✓[2]	Release only for heating oils with EN 590 quality, see chapter Non-road fuels and light heating oils.
✓[3]	Release up to 30 %(V/V) EN14214 at replacement interval of the SCR catalytic converter of 200,000 km, see chapter Biofuels.
✓[4]	Release for engines as of 01.07.2010, retrofitting possible in earlier engines. US biodiesel release up to 50 % (V/V) for mine engines (MSHA)
✓[5]	Release for US diesel fuel according to ASTM D975 S15 only
✓[6]	Does not apply for the 1015M series
✓[7]	Only with magnet valve injection (MV system)
[8]	HFRR maximum 460 µm
✓[9]	Sulphur content maximum 2,000 mg/kg
✓[10]	Also applies for EURO 3

Diesel fuels

DEUTZ vehicle engines are designed for diesel fuels with a cetane number of at least 51. DEUTZ engines for mobile work machinery are designed for a cetane number of at least 45. When using fuels with a low cetane number, a disturbing formation of white smoke and ignition stutter is to be expected under some circumstances.

A cetane number of at least 40 is approved for the US market, therefore special engine versions were developed to avoid starting difficulties, extreme white smoke or increased hydrocarbon emissions. If the use of fuels with a very low cetane number is also known in advance in other countries, we recommend ordering the engines in EPA versions. It is generally recommened to use fuels with a higher cetane number than the minimum requirement of 40 in winter.

Diesel fuels are released and can be used according to the following specifications:

Fuel		Specifications
DIN EN 590	Biodiesel content max. 7 %(V/V)	Appendix 2
ASTM D 975 Grade 1-D S15	Biodiesel content max. 5 %(V/V)	Appendix 3
ASTM D 975 Grade 1-D S500		
ASTM D 975 Grade 2-D S15		
ASTM D 975 Grade 2-D S500		
JIS K 2204 No. 1, No. 2, No. 3		Appendix 4
NATO F-54		on request

US fuels in accordance with ASTM D 975 1-D S500 and ASTM D 975 2-D S500 are not released for engines from Tier 4 interim or Stage IIIB.

Japanese diesel fuels according to JIS K 2204 Grade 1 Fuel und Grade 2 Fuel are only released if the lubricating properties correspond with diesel fuel EN 590 (HFRR max. 460 micrometer according to EN ISO 12156-1).

The EN 590 standard has the status of a national standard in the countries of the EU, e.g. DIN EN 590. The NATO fuel F-54 is equivalent to diesel fuel in accordance with EN 590 but with max. 50 mg/kg sulphur.

Diesel fuels in other countries

The table in appendix 11 contains the requirements for diesel fuels for the countries in which none of the released fuels named in this bulletin exist.

Lubricating capacity for low-sulphur and sulphur-free fuels

Insufficient lubricating capacity can lead to serious wear problems, especially in common rail injection systems. Too low a lubricating capacity is particularly a problem in fuels with a low sulphur content (and in this respect sulphur contents ≤500 mg/kg can already be considered low). An adequate lubricating capacity is guaranteed by the appropriate additives at the refinery in low-sulphur (≤50 mg/kg) or sulphur-free (≤10 mg/kg or ≤15 mg/kg) diesel fuels according to EN 590 and ASTM D 975. In low-sulphur and sulphur-free diesel fuels which do not comply with this standard, the lubricating capacity may have to be guaranteed by additives. The parameter for sufficient lubricating capacity is a maximum wear spot of 460 micrometers in the HFRR test (EN ISO 12156-1).

High sulphur content in the fuel

Fuels with a sulphur content > 0.5 %(m/m) (5,000 mg/kg) demand a shorter lubricating oil change interval (see Technical Bulletin 0199-99-1217). These fuels with a high sulphur content may not be used in engines with exhaust gas after-treatment (Tier 4 interim or Stage IIIB). Fuels with a sulphur content > 1.0 %(m/m) are not permissible due to high corrosion and considerable shortening of the engine life. Low-ash / low SAPS engine lubricating oils (sulphate ash max. 1.0 %(m/m)) may only be used in engines without exhaust after-treatment systems if the sulphur content in the fuel does not exceed 50 mg/kg. However, low-ash lubricating oils may be used in engines without exhaust gas after-treatment systems up to sulphur contents of 500 mg/kg if the base number (TBN) is at least 9 mg KOH/g. A corresponding note regarding suitable lubricating oils is published in the DEUTZ lubricating oil release list.

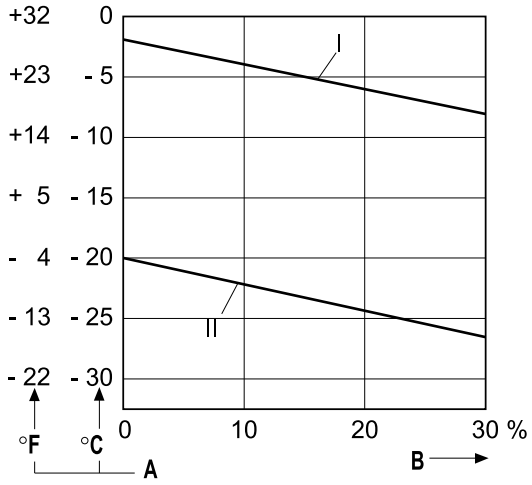
Winter operation with diesel fuel

Special demands are placed on the cold behaviour (temperature limit value of the filtrability) for winter operation. Suitable fuels are available at filling stations in winter.

Mixing with petrol is not permissible for safety and technical reasons (cavitation in the injection system).

Diesel fuels up to -44 °C are available for an Arctic climate. The addition of flow improvers to the diesel fuel is ony allowed in exceptional cases. The choice of a suitable additive and the necessary dosing and mixing procedure must be discussed with the fuel supplier.

If only summer diesel fuel is available, petroleum or kerosene can be added to the diesel fuel up to 30 % (V/V) at low temperatures as shown in the diagram below.



A 1 Mixing petroleum with summer diesel fuel

The mixing should take place in the engine tank. First pour in the necessary amount of petroleum or kerosene, and then add the diesel fuel.

For engines with common rail injection, the mixing of petroleum or kerosene and adding of extra low additives is not permissible. Fuels in accordance with ASTM D 975 Grade 1-D or DIN EN 590 - Arctic-Diesel may have no petroleum or kerosene added.

Marine distillate fuels

This includes distillate fuels which are used in shipping. Only marine distillate fuels which contain no residue oils (residue from the distillation process) may be used. The releases apply exclusively for DEUTZ marine engines of the 413/513/912/913/914M/1013M/1015M/2015M series.

The following marine fuels may be used:

Fuel	Specifications
DIN ISO 8217 DMX	Appendix 5
DIN ISO 8217 DMA (restriction: sulphur content max. 1.0 %(m/m))	Appendix 5
NATO F-75	Specifications available on request
NATO F-76	

- The cetane number must be at least 40, otherwise starting difficulties, extreme white smoke or increased hydrocarbon emission may occur.
- At a density of > 0.869g/cm^3, a return blocking in the injection pump is necessary (may only be carried out by authorised DEUTZ personnel).
- The possible high sulphur content ≥ 0.5 %(m/m) requires a shorter lubricating oil change interval. Fuels with a sulphur content > 1.0 %(m/m) are not permissible due to higher corrosion and considerable shortening of the engine life. It must also be pointed out that fuels in accordance with ISO 8217 DMA are only permissible when the maximum sulphur content is 1.0 %(m/m).
- Low-ash oils (low SAPS) are not permissible at sulphur contents > 50 mg/kg or > 500 mg/kg (see Technical Bulletin 0199-99-1217), i.e. generally not suitable for marine fuels.
- Because of the possible heavy contamination, great emphasis must be placed on fuel cleaning and possibly the installation of an additional fuel filter with a water trap to avoid biological contamination especially.

Non-road fuels and light heating oils

In some European countries, non-road fuels are defined with the same properties as heating oil but are taxed differently to diesel fuels. Systems which allow the use of heating oils and are subject to tax relief in Germany are described in the Energy Taxation Act (§3). The user must always abide by the pertient tax regulations. These are not part of this bulletin. With regard to use in the engine (warranty rights), no differences are to be made between the appropriate non-road fuels and light heating oils.

- For engines up to Tier 2 / Stage II and engines up to Tier 3 / Stage IIIA with mechanical injection, the following light heating oil may be used:

Fuel	Specifications
DIN 51603-1	Appendix 6

- For all non-road engines operated in Europe except Germany, light heating oils or non-road fuels may only be used if all the limits of EN 590 are complied with.

Jet fuels

The following jet fuels can be used:

Fuel	Specifications
F 34 (kerosene, NATO designation)	Specifications available on request
F 35 (kerosene, NATO designation)	
F-44 (kerosene, NATO designation)	
F-63 (kerosene, NATO designation, equivalent to F-34/F-35 with additives)	
F-65 (kerosene, NATO designation, 1:1 mixture of F-54 and F-34/F-35)	
JP-8 (kerosene, US military designation)	
JP-5 (kerosene, US military designation)	
Jet A (kerosene for civil aviation)	
Jet A1 (kerosene for civil aviation)	

- Released for engine series 413/513/912/913/914/1011/1012/1013/2011/2012/2013/1015 up to Tier 2 / Stage II and Euro III (Exception: Common Rail engines). These series are also released for Tier 3 / Stage IIIA where engines with mechanical injection are concerned. The TCD 2012/2013 series with solenoid valve injection (MV-system) Tier 3 / Stage IIIA are also released.

- Individual series which already have Common Rail injection systems in Tier 2 / Stage II and all other engines with electronic injection are not released for jet fuels. All engines with exhaust gas after-treatment are not released for jet fuels either.
- The cetane number must be at least 40, otherwise starting difficulties, extreme white smoke or increased hydrocarbon emission may occur.
- Because of the lower density and the greater leak fuel volume due to lower viscosity, depending on the engine speed and torque, a power loss up to 10 % is possible.

Increasing of injection fuel quantity to compensate the lack of power is not allowed!

- There are some problematical fuel properties amongst the listed jet fuels (viscosity, lubricating capacities and low boiling point). A slight increase in wear in the injection system is to be expected which can lead to a statistically shorter life of these components. The engine guarantee is maintained when these fuels are used.
- Jet fuels can be mixed with each other.

Bio fuels

The generic term biofuels includes biodiesel and pure vegetable oils.

Bio-diesel

Biodiesel is Fatty Acid Methyl Ester (FAM) of vegetable oil. It is produced on a large scale by re-estering vegetable oil and methanol to glycerine and fatty acid methly ester. It is possible to use different vegetable oils such as soya oil, palm oil, rape seed oil, sunflower seed oil or old fats.

In Europe biodiesel must comply with the EN 14214 standard. Because the biodiesel qualities available on the market do not always meet the requirements, DEUTZ customers in Germany are recommended to ensure the quality by buying biodiesel with an AGQM certificate (Association for Biodiesel Quality Management). The customers should also have compliance with the quality demands confirmed by the supplier by submission of a current analysis certificate of an ISO 17025 certified laboratory.

A 2 Biodiesel

The use of US biodiesel, based on soya oil methly ester, is only permissible in mixtures with diesel fuel with a maximum biodiesel content of 20 %(V/V) in accordance with the ASTM D7467 standard.. The US biodioesel greater than 20 %(V/V) used for the mixture must comply with the ASTM D6751 standard. Users are recommended to use biodiesel qualities with a quality certified in accordance with BQ 9000.

Fuel	Specifications
Biodiesel according to EN 14214	Appendix 7
US biodiesel blends according to ASTM D7467 (only for biodiesel blends with diesel fuel of 6-20 %(V/V))	Appendix 8
US biodiesel according to ASTM D6751 (B100) (only for blends with diesel fuel of 20-50 %(V/V))	Appendix 9

Released engines

- The series 413/513/912/913/914/1011/1012/1013/2011/2012 and 2013 are released if compliant with the basic conditions specified in the text below as of the year of manufacture 1993 for biodiesel according to EN 14214 as well as B20-blend according to ASTM D7467.
- The TCD 2012 2V/4V and TCD 2013 2V/4V series for mobile work machinery up to Stage IIIA/Tier 3 are released for 100 %(V/V) biodiesel according to EN 14214 as well as B20 blend according to ASTM D7467.
- For TCD 2013 EURO III/IV/V commercial vehicles, the addition of up to 30 %(V/V) biodiesel in accordance with EN 14214 is released as of October 2009 on the condition that the SCR catalytic converter is replaced every 200,000 km. The engines prior to this date are not all equipped with biodiesel-resistant pipes.
  The head office can provide further information here. Engines in which an additional diesel particle filter (DPF) is installed are excluded from the release.
- Engines of the 2015 series with MV injection system are released for operation with biodiesel from production date 01.07.2010.
  The release applies for biodiesel according to EN 14214 as well as B20-Blend according to ASTM D7467. For engines operated within the area of application of the Mine Safety and Health Administration (MSHA), mixing up to 50 %(V/V) US biodiesel is permissible according to ASTM D6751.
  Mixtures of US biodiesel with diesel fuel are not very suitable for cold weather and are not recommended for the winter.
  Engines with an earlier production date can be retrofitted. The head office can provide information about the scope of the retrofit.
- Agri Power engines with SCR exhaust gas after-treatment systems of stage IIIB of the TCD 6.1 L6 and TCD 7.8 L6 series (2000 bar Common Rail injection system) are released for 100 % (V/V) biodiesel according to EN 14214.

  The Agri Power engines of the TCD 4.1 L4 and TCD 6.1 L6 series (1600 bar Common Rail injection system) are currently on trial pending release.

  In Agri Power engines, the SCR catalytic converter must be changed every 3,000 oh or after 2 years at the latest.

New customers must ensure that all the necessary basic conditions are satisfied and release by the head office is available before using biodiesel. Here too, DEUTZ customers are recommended to only use biodiesel with an AGQM certificate.

- Turbocharged engines are excepted from the release for applications which are normally operated with a high load above 80% nominal power; these are, for example, engines in block type heating power stations.

Basic conditions to be observed

- Because of the low heating value, a power loss of 5-9 % and an extra fuel consumption of 7-8 % in comparison with diesel fuel according to EN 590 is possible. Increasing of injection fuel quantity to compensate the lack of power is not allowed.
- The lubricating oil change interval must be halved in comparison with operation with diesel fuel according to EN 590.
- Standstill times of longer than 4 weeks must be avoided with biodiesel. Otherwise the engine must be started and shut down with diesel fuel.
- Engines with a low annual running time, e.g. emergency generators, are excluded from operation with bio-diesel.
- In series engines, the fuel pipes, the fuel manual supply pumps, and the LDA diaphragms (series 1012/1013/2012/2013/TCD 2012 2V mechanical and TCD 2013 2V mechanical) are not resistant to biodiesel and must be changed annually. To avoid annual replacement of the fuel hand supply pumps, a piston with an LDA diaphragm resistant to biodiesel fuel was introduced. Since the fuel pipes can dissolve prematurely at increasing fuel temperature and high running performance, they may have to be replaced before one year is up. The fuel pipes must be checked for damage (swelling) in the course of daily maintenance E 20. The use of biodiesel-resistant fuel pipes (Viton) is recommended; in this case, the annual replacement can be dispensed with.
- Biodiesel can be mixed with normal diesel fuel but the basic conditions described in this section apply for mixtures. Mixtures containing up to 7 %(V/V) biodiesel (B7) as they are permitted in EU countries according to national laws are excepted. However, the biodiesel mixtures must comply with EN 14214 in any case.
- Approx. 30-50 oh after changing over from diesel fuel to bio-diesel, the fuel filter should be changed as a precaution to avoid a drop in performance due to clogged fuel filters. Deposited fuel ageing products are dissolved by bio-diesel and transported into the fuel filter. They should not be changed immediately, but after approx. 30 to 50 hours, because the dissolving of dirt takes a certain amount of time.
- All parts carrying fuel which are installed later (by OEM or end customers, e.g. fuel prefilter and fuel pipes) must be suitable for operation with biodiesel.

- To increase the oxidation stability of the used biodiesel and to improve the storability and reduce deposits and clogging in the injection system, it is recommended to use the DEUTZ additive "DEUTZ Clean-Diesel InSyPro" in the recommended concentration (see Technical Bulletin 0199-99-1210).

Plant oil

Pure plant oils (e.g. rape seed oil, soy oil, palm oil) are not classified as bio-diesel and exhibit problematic properties for engines which were not designed for operation with plant oils (strong tendency to coke, risk of piston seizure, extremely high viscosity, poor evaporation behaviour).

DEUTZ NATURAL FUEL ENGINE®

DEUTZ has developed the first series engine based on the TCD 2012 2V/4V series with the DEUTZ Common Rail System ® (DCR) for use with rape seed oil.

These engines are released for use of 100 %(V/V) rapeseed oil (refined or cold pressed) according to DIN 51605 (appendix 10) and biodiesel according to EN 14214 (appendix 7).

Basic conditions to be observed

- Because of the lower heating value, a power loss of 5-10 % and an extra fuel consumption of 4-5 % in comparison with diesel fuel according to EN 590 is possible. Blocking up of the injection pump is not allowed.
- The engine is a two-tank system with switching between diesel fuel and rape seed oil. Alternatively biodiesel can be used instead of rape seed oil or diesel fuel.
- At temperatures below 5 °C, rape seed oil should be replaced by diesel fuel or biodiesel.
- Shutdown periods of longer than 4 to 6 weeks must be avoided with bio-diesel and rape seed oil. Otherwise the engine must be started and stopped with diesel fuel.
- The lubricating oil change interval must be halved in comparison with operation with diesel fuel according to EN 590.
- Important fuel properties such as water content, oxidation stability, calcium, magnesium and phosphorus content and the total contamination are influenced especially by the harvest time, the pressing process in the oil mill, the storage of the rape seed oil and the further logistics chain. Because of the frequent exceeding of the limit values at distributed oil mills, the user is recommended to have the quality of the rape seed fuel delivery confirmed by an analysis certificate. In cases of doubt, the quality can be certified by an analysis carried out by a laboratory accredited according to ISO 17025, (e.g. ASG Analytik GmbH, D-86356 Neusäß, Tel. ++49 (0)821-450-423-0).

- Mixtures with other vegetable oils such as sunflower seed oil, soya oil or palm oil are not permissible because these vegetable oils can have problematic properties (strong coking tendency, danger of piston seizure, poorer cold properties, increased oxidation tendency).
- To increase the oxidation stability of the used rape seed oil and to improve the storability and reduce deposits and clogging in the injection system, it is recommended to use the DEUTZ additive "DEUTZ Clean-Diesel InSyPro" in the recommended concentration (see Technical Bulletin 0199-99-1210).

Notes for the storage of rape seed oil in fuel stations for own use:

- To be stored in dark places at constant low temperatures (maximum 20 °C, optimal in ground tanks at 5 – 10 °C). Storage temperatures below freezing point should be avoided, ground tanks are also optimal in this respect. The tanks may not be permeable to light (no polythene tanks).
- The storage time for rapeseed oil should be limited to a maximum of 6 months at storage temperatures up to 20 °C, for ground tanks < 10 °C maximum 12 months).
- Due to the hygrosopic (attracting water) properties of rape seed oil, works fuel stations should if possible be fitted with dehumidification on the air exchange system.
- Minimise contact with air with the use of thick locks.
- Contact with metals with a catalytic effect, above all copper or brass, must absolutely be avoided. These materials must not be used at all in the storage system (e.g. pipes, screws, pumps, etc).
- Avoidance of gathering of sediments by removal approx. 10cm above the tank floor.
- The tanks should be regularly cleaned, if a bacterial infestation occurs the bactericide Grotamar 71 or 82 should be used by a specialised firm.

Series diesel engines

The conversion of other DEUTZ engines to operation with pure plant oil with conversion kits and modified tanks systems of various manufacturers is not allowed and leads to loss of the guarantee rights.

Only engines of the 912W/913W/413FW/413W series with the 2-tank system from Henkelhausen, D-47809 Krefeld, Fax no. ++49 (0)2151 574 112, can be operated with rapeseed oil fuel according to DIN 51605, see appendix 10.

Synthetic fuels (GTL, CTL, BTL and HVO)

These fuels are produced synthetically from natural gas (Gas-to-Liquid), coal (Coal-to-Liquid) or biomass (Biomass-to-Liquid). At BTL one also refers to so-called biogenic fuels of the 2nd generation.

They differ from diesel fuel as follows:

- Chemical composition: pure paraffins, no aromates
- High centane number
- Positive influences on emissions (nitric oxides and particles)
- Lower density, this results in a lower engine performance

DEUTZ has tested such fuels and confirmed the positive influences on the emissions. However, it is a well known fact that engines which are operated for longer periods with conventional diesel fuel and then converted to synthetic fuels suffer shrinkage of polymer seals in the injection system and thus from fuel leaks. The reason for this behaviour is that the aromate-free synthetic fuels can lead to a change in the swelling behaviour of polymer seals. Therefore, conversion from diesel fuel to synthetic fuel should only take place after changing the critical seals. The problem of swelling does not occur when an engine is operated with synthetic fuel from the start.

Hydrogenated or hydrotreated vegetable oils (HVO) defines vegetable oils which are converted into hydrocarbons by a catalytic hydrogenation. Paraffins produced from the vegetable oils by this process consist of mixtures of saturated hydrocarbon chains of different lengths.
The density of these hydrogenated vegetable oils is approximately 700 kg/m^3 and is therefore much lower than mineral diesel fuel; the cetane value is much higher than that of diesel fuel with values of 80 to 90. This fuel is also free from sulphur and aromatic compounds.

Because of their very positive influences with regard to the cetane number and emission behaviour, these synthetic fuels are blended partly in small percentages in the so-called premium diesel fuels and in this case have no negative influences on the polymer compatibility.

Biological contamination in fuels

Symptoms

The following symptoms may indicate that a fuel tank is contaminated by micro-organisms:

- Corrosion of inside of tank
- Filter blockage and associated loss of power due to gel-like deposits on the fuel filter (especially after longer standstill times)

Cause

Micro-organisms (bacteria, yeast, fungi) can multiply into biosludge under favourable conditions (especially favoured by heat and water).

The water entry is usually caused by condensation of the water contained in the air. Water dissolves poorly in fuel so that the water which enters sinks to the bottom of the tank. The bacteria and fungi grow in the watery phase at the boundary with the fuel phase from which they draw their nutrition. There is an increased risk especially with biogenic fuels or biodiesel-diesel blends.

Remedial measures

- Keep storage tanks clean, regular tank cleaning (including the fuel line) by specialist companies.
- Installation of fuel pre-filters with water traps, especially in countries with frequently fluctuating fuel qualities and high percentage of water (e.g. Separ-filter or RACOR filter).
- Use of biocide GrotaMar 71 or GrotaMar 82 of

  Schülke & Mayr GmbH,
  D-22840 Norderstedt,
  Tel.: +49 (0)4052 100-0,
  e-mail: info@schuelke.com

  if fuel system and storage tank are already contaminated by micro-organisms. The biocide must be dosed according to the manufacturer's specifications.
  The use is restricted exclusively to eliminating microbe contamination. Prophylactic use is not permissible.
- In suspicious cases, biological contamination according to DIN 51441 (determination of the number of colonies in mineral oil products in the boiling range below 400 °C) can be analysed by laboratories certified according to ISO 17025 (e.g. Petrolab GmbH, D-67346 Speyer, Tel.: ++49 (0) 6232-33011).
- Avoid direct radiation of sunlight on the storage tank.
- Use of smaller storage tanks with correspondingly short dwell times of the stored fuel.
- Equip the fuel tank with a drying cartridge on the air exchange system.
- The tank must be cleaned before adding the biocide if there is a clearly visible biofilm in the tank or on the tank walls.
- Appropriate quick check kits are also available from the biocide suppliers.

Fuel additives

The **DEUTZ Clean-Diesel InSyPro** additive is released exclusively for use in DEUTZ engines. See Technical Bulletin 0199-99-1210 for notes on use and dosing.

The previously mentioned flow improvers (not for DEUTZ Common Rail engines) are an exception. The use of other fuel additives is prohibited. Voiding of the warranty is to be expected when unsuitable additives are used which haven't been released.

Fuel filters

Modern diesel engines, especially with high-pressure injection and common rail injection system make very high demands on the fuel quality. The **DEUTZ original fuel filters** are adapted and tested for these demands. Continuous, trouble-free operation of the engines is only guaranteed when the original filters are used. In case of damage to the injection system within the warranty period and proof that no original filters were used, the warranty will be voided.

Please contact the following persons if you have any questions about the listed topics.

Contact:
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This document has been created digitally and is valid without a signature.

Appendix 1

General information on fuel properties, exhaust gas after-treatment systems and emission regulations

Exhaust gas after-treatment systems

The introduction of new, stricter exhaust emission regulations demands the use of exhaust gas after-treatment systems such as the SCR technique (selective catalytic reduction), the diesel oxidation catalytic converter (DOC), and the diesel particle filter (DPF). For the trouble-free use of fuels, it is necessary to reduce ash and deposit formaing elements, as well as elements which damage the catalytic converter, such as sulphur, as much as possible. Therefore, these engines may only be operated with sulphur-free diesel fuels (EN 590, ASTM D975 Grade 2-D S15, ASTM D975 Grade 1-D S15 or heating oil or non-road fuels in EN 590 quality (sulphur content max. 10 mg/kg)). Other elements such as phosphorus, calcium, magnesium, sodium and potassium, which especially biogenic fuels may contain, should also be minimised. Otherwise, compliance with the emission requirements and durability of the exhaust gas after-treatment systems is not guaranteed.

Ash

Ash is carbon-free combustion residue which can lead to wear due to deposits in the engine and turbocharger.

Bio-diesel

Biodiesel is made by re-estering of greases or oils (triglyceride) with methanol. The correct chemical name is fatty acid methyl ester, often abbreviated to FAME. In Europe it is usually produced by re-estering of rape seed oil (rape seed oil methyl ester = RME). In the USA, biodiesel comes almost exclusively from soya oil (soya methyl ester = SME). Other vegetable oils (sunflower seed oil, palm oil, jatropha oil) or animal fats are also possible.

Due to national and EU regulations biodiesel (FAME) percentages are now possible or prescribed in most diesel fuels. In the new EN 590 max. 7 %(V/V) are permissible for example, in the US-ASTM D975 max. 5 %(V/V). According to the biofuel quota law, at least 5 %(V/V) FAME must be mixed with the normal, commercially available diesel in Germany.

Cetane number/cetane index

The cetane number indicates the fuel's willingness to ignite. Too low a cetane number may lead to starting difficulties, formation of white smoke, increased carbon emission and thermal and mechanical overloading of the engine. The cetane number is determined on a test engine. The cetane index can be substituted as a value calculated from density and boiling behaviour. The cetane index serves for estimating the cetane number for the basic fuel but it does not usually take the effect of willingness to ignite improvers when the cetane number of finished fuels is determined.

Density

The density is usually specified in g/cm^3 or kg/m^3 at 15 °C and is important for converting the fuel consumption from volume ? to weight ? unit. The higher the density, the greater the weight of the injected fuel.

Flashpoint

The flashpoint has no significance for the engine operation. It applies as a value for the fire hazard and is important for classification in one of the hazard classes (decisive for storage, transport and insurance).

Heating value

The lower heating value (H_l) indicates the amount of heat which is released when burning 1 kg of fuel.

Behaviour in cold

The following parameters indicate the suitability of the fuel for low temperatures:

- The solidification point indicates at what temperature the fuel no longer flows under its own weight.
- The pour point is approx. 3 °C above the solidification point.
- The cloud point indicates at what temperature solid emissions (paraffin) are visible.
- The limit of filtrability (CFPP) indicates at what temperature filters and pipes may be blocked.

Coke residue

The coke residue serves as a reference value for the tendency for residue to form in the combustion chamber.

Copper corrosion

Diesel fuel can be corrosive, especially during prolonged storage with fluctuating temperature and formation of condensation on the tank walls. To check the limit value defined in DIN EN 590, a polished copper strip is immersed in diesel fuel at 50 °C for 3 hours. Appropriate additives ensure protection of the metals which come into contact with the fuel even under difficult conditions.

Neutralisation number

The neutralisation number is a measure of the content of free acids in the diesel fuel or biodiesel fuel. It describes the amount of potassium lye required for neutralising the acids. Acid compounds in the fuel lead to corrosion, wear and formation of residue in the engine.

Oxidation resistance

Fuels may oxidise and polymerise partly during long storage. This can lead to the formation of insoluble (varnish like) components and the associated filter blockage. Biofuel parts are more sensitive to oxidation and also impair oxidation resistance.

Lubricity

The lubricity decreases with the degree of desulphurisation and can drop to a level that leads to considerable wear in the distributor injection pumps and common rail systems. Extremely desulphurised fuels contain special lubricity additives. The HFRR test (High Frequency Reciprocating Wear Rig) was developed for evaluating the fuels (EN ISO 12156-1). This test simulates the sliding wear in the injection pump by rubbing a ball on a polished steel plate with constant contact force. The flattening of the ball after 75 minutes is measured as an average wear diameter (limit value: max. 460 µm).

Sulfur content

High sulfur content and low component temperature can cause increased wear due to corrosion. The sulfur content influences the lubricating oil change intervals. Too low a sulfur content may impair the lubricity of the fuel if this has not had lubricity improvers added.

Sediments/total contamination

Sediments are solids (dust, rust, scale) which can cause wear in the injection system and combustion chamber as well as leaks in the valves.

Boiling curve

The boiling curve indicates how much volume% of the fuel is overdistilled at a certain temperature. The greater the boiling residue (amount remaining after evaporation), the more combustion residue may occur in the engine, especially in partial load operation.

Trace elements in the fuel (zinc, lead, copper)

Even small traces of zinc, lead and copper can lead to deposits in the injection nozzles, especially in the modern common rail injection systems.

Zinc and lead coatings are therefore not permitted in tank systems (especially in fuel stations for own use) and fuel pipes. Materials containing copper (copper pipes, brass parts) must also be avoided because they can lead to catalytic reactions in the fuel with subsequent deposits in the injection system.

Conversion ppm

The term parts per million (ppm) is often used in fuel analyses.

The term ppm alone is not a unit of measure. It usually describes the weight concentration (1 ppm (m/m) = 1 mg/kg). 1 ppm = 10^{-6} = parts per million = 0,0001 %

Viscosity

The kinematic viscosity in mm^2/s at a certain temperature (1 mm^2/s = 1 cSt [centistoke]) is specified. The viscosity must be within certain limits for engine operation. Too high viscosity requires pre-heating because otherwise a lower engine performance is to be expected.

Water

Too high a water content leads to corrosion and, in connection with corrosion products and sediments, to sludge. Disturbances in the fuel and injection system are the result.

Fuel quality and exhaust gas legislation

The fuel qualities to be used are closely related to the used engine and exhaust gas after-treatment technologies and these are selected in turn with regard to the emission limits of the exhaust laws of the countries in which the engines are used. Since the bulletin frequently refers to the exhaust gas law stages, these are explained below.

Emission laws for mobile work machinery (including building machinery, tractors, compressors, mobile electricity units)

Europe and the USA have largely similar emission legislations so that the stages specified for EU and the USA in one line in the following table are both satisfied by an engine developed for this. The dates for introduction and limit values differ for different performance categories. The dates for the category > 130 kW are the first respectively for a certain stage.

Designation of the emission stage		Introduction date for engines 130 - 560 kW	
EU	USA	EU	USA
Stage I	Tier 1	01.01.1999	01.01.1996
Stage II	Tier 2	01.01.2001	01.01.2001 up to 01.01.2003
Stage IIIA	Tier 3	01.01.2006	
Stage IIIB	Tier 4 interim	01.01.2011	
Stage IV	Tier 4 final	01.01.2014	

Emission laws for commercial vehicles in the EU

The emission stages EURO I to Euro VI were introduced on the following dates:

Designation of the emission stage	Introduction date for engines
EURO I	01.01.1993
EURO II	01.01.1996
EURO III	01.01.2001
EURO IV	01.01.2006
EURO V	01.01.2009
EURO VI	01.01.2014

Fuel laws have also been introduced appropriate to the emission laws. For the work machinery, the limit values from stage IIIB or Tier 4 interim are so low that exhaust gas after-treatment systems such as particle filters or SCR have to be introduced in most cases. Sulphur-free fuels are largely required for this and these are legally prescribed for the specified dates. Exhaust gas after-treatment has been introduced for commercial vehicle engines as of EURO IV.

Appendix 2

Fuel specification (requirements and test methods):
Diesel fuel according to DIN EN 590 **
May 2010 edition

Properties	Units	Limit values EN 590	Test method
Cetane number		min. 51	EN ISO 5165 or EN 15195
Cetane index		min. 46	EN ISO 4264
Density at 15 °C	kg/m^3	820 - 845	EN ISO 3675 or EN ISO 12185
Polycyclic aromatic hydrocarbons	%(m/m)	max. 8	EN 12916
Sulphur content	mg/kg	max. 10	EN ISO 20846 or EN ISO 20884
Flashpoint	°C	min. 55	EN ISO 2719
Coke residue (from 10 % distillation residue)	%(m/m)	max. 0.30	EN ISO 10370
Ash content	%(m/m)	max. 0.01	EN ISO 6245
Water content	mg/kg	max. 200	EN ISO 12937
Total contamination	mg/kg	max. 24	EN 12662
Corrosion effect on copper (3 h at 50 °C)	Degree of corrosion	Class 1	EN ISO 2160
Oxidation stability	g/m^3	max. 25	EN ISO 12205
Oxidation stability	h	min. 20	EN ISO 15751
Lubricity, corrected "wear scar diameter" (wsd 1.4) at 60 °C	µm	max. 460	EN ISO 12156-1
Viscosity at 40 °C	mm^2/s	2,00 - 4,50	EN ISO 3104
Distillation			EN ISO 3405
– collected at 250 °C	%(V/V)	max. 65	
– collected at 350 °C	%(V/V)	min. 85	
– 95 vol.% starting at	°C	360	
Fatty acid methyl ester (FAME)	%(V/V)	7,0	EN 14078
Limit of filtrability *			EN 116
– 15.04. - 30.09.	°C	max. 0	
– 01.10. - 15.11.	°C	max. - 10	
– 16.11. - 28.02. (in leap years 29.02.)	°C	max. - 20	
– 01.03. - 14.04.	°C	max. - 10	
* Specifications apply for Germany. National regulations may deviate.			
** Speification also applies for NATO fuel F-54 (except sulphur content max. 50 mg/kg)			

Appendix 3

Fuel specification (minimum requirement)
US diesel fuel according to ASTM Designation D 975-11

Properties	Units	Limit values		Test method
		Grade No. 1-D S500 Grade No. 1-D S15	Grade No. 2-D S500 Grade No. 2-D S15	
Density at 15 °C	kg/m^3	max. 860 *	max. 860 *	
Flashpoint	°C	min. 38	min. 52	ASTM D 93
Water and sediments	%(V/V)	max. 0.05	max. 0.05	ASTM D 2709
Boiling curve at 90 vol. %	°C °C	– max. 288	min. 282 max. 338	ASTM D 86
Kinematic viscosity at 40 °C	mm^2/s	1,3 - 2,4		ASTM D 445
Ash content	%(m/m)	max. 0.01	max. 0.01	ASTM D 482
Sulphur content – Grade No. 1/2-D S500 – Grade Low Sulfur No. 1/2-D S15	 %(m/m) %(m/m)	 max. 0.05 max. 0.0015	 max. 0.05 max. 0.0015	 ASTM D 2622 ASTM 5453
Corrosion effect on copper (3 h at 50 °C)	Degree of corrosion	No. 3	No. 3	ASTM D 130
Cetane number		min. 40	min. 40	ASTM D 613
Coke residue (from 10 % distillation residue) according to Ramsbottom	%(m/m)	0,15	0,35	ASTM D 524
Limit of filtrability	°C	**	**	
* minimum requirement DEUTZ				
** depending on the season and region				

Appendix 4

Fuel specification (minimum requirement)
Japan diesel fuel according to JIS K 2204:2007

Properties	Units	Limit values					Test method
		Special No. 1	No. 1	No. 2	No. 3	Special No. 3	
Flashpoint	°C	min. 50				min. 50	JIS K 2266-3
Boiling curve at 90 vol. %	°C	max. 360		max. 350	max. 330	max. 330	JIS K 2254
Pour point	°C	max.+5	max.-2.5	max.-7.5	max.-20	max.-30	JIS K 2269
Limit of filtrability	°C	-	max.-1	max.-5	max.-12	max.-19	JIS K 2288
Coke residue (from 10 % distillation residue)	%(m/m)	max. 0.1					JIS K 2270
Cetane index		min. 50		min. 45			JIS K 2280
Kinematic viscosity at 30 °C	%(V/V)	min. 2.7		min. 2.5	min. 2.0	min. 1.7	JIS K 2283
Sulphur content	mg/kg	max. 10 *					JIS K 2254-1, -2, -6, -7
Density at 15 °C	kg/m^3	max. 860					JIS K 2249

Appendix 5

Fuel specification (minimum requirement)
Distillate fuel (requirements for marine fuels) according to DIN ISO 8217
August 2009 edition

Properties	Units	Limit values Category ISO-F		Test method
		DMX	DMA	
Density at 15 °C	kg/m^3	/	max. 890	ISO 3675 / ISO 12185
Viscosity at 40 °C	mm^2/s	1,4 - 5,5	1,5 - 6,0	ISO 3104
Flashpoint	°C	min. 43	min. 60	ISO 2719
Pour point				
– Winter quality	°C	–	max. -6	ISO 3016
– Summer quality	°C	–	max. 0	ISO 3106
Cloud point	°C	max. -16	–	ISO 3015
Sulphur content	%(m/m)	max. 1.0 **	max. 1.0 */**	ISO 8754
Cetane number		min. 45	min. 40	ISO 5165
Coke residue (from 10 % distillation residue)	%(m/m)	max. 0.30	max. 0.30	ISO 10370
Ash content	%(m/m)	max. 0.01	max. 0.01	ISO 6245
Visual inspection clear and glossy (for DMX and DMA)				
* minimum requirement DEUTZ				
** observe shorter lubricating oil maintenance interval				

Appendix 6

Fuel specification (minimum requirement)
Light heating oil EL according to DIN 51603-1
September 2011 edition

Properties	Units	Limit values DIN 51603-1	Test method
Density at 15 °C	kg/m^3	max. 860	DIN 51757 or EN ISO 12185
Combustion point	MJ/kg	min. 45.4	DIN 51900-1 and DIN 51900-2 or DIN 51900-3 or Calculation
Flashpoint in closed pot according to Pensky-Martens	°C	more than 55	EN 2719
Kinematic viscosity at 20 °C	mm^2/s	max. 6.0	DIN 51562-1
Distillation curve total evaporated volume parts			EN ISO 3405
– up to 250 °C	%(V/V)	max. 65	
– up to 350 °C	%(V/V)	min. 85	
Cloud point	°C	max. 3	EN 23015
Temperature limit of filtrability (CFPP) depending on the cloud point			EN 116
– at cloud point = 3 °C	°C	max. -12	
– at cloud point = 2 °C	°C	max. -11	
– at cloud point <1 °C	°C	max. -10	
Coke residue (from 10 % distillation residue) according to Conradson	%(m/m)	max. 0.3	EN ISO 10370 or DIN 51551-1
Sulphur content – for heating oil EL-1 standard	%(m/m)	max. 0.10	EN 24260 or EN ISO 8754 or EN ISO 14596
Sulphur content – for heating oil EL-1 low sulphur	mg/kg	max. 50	EN ISO 20884 or EN ISO 20846
Water content	mg/kg	max. 200	DIN 51777-1 or EN ISO 12937
Total contamination	mg/kg	max. 24	EN 12662
Ash content	%(m/m)	max. 0.01	EN ISO 6245
Thermal stability (sediment)	mg/kg	max. 140	DIN 51371
Storage stability	mg/kg	to be specified	DIN 51471

Note:

Low-sulphur heating oil according to DIN 51603-1 has sufficient lubricity (according to EN ISO 12156 - 1) of 460 µm.

Appendix 7

Fuel specification (minimum requirement)
Fatty acid methyl ester (FAME) for diesel engines (biodiesel) according to EN 14214
April 2010 edition

Properties	Units	Limit values DIN EN 14214	Test method
Fatty acid methyl ester (FAME)	%(m/m)	min. 96.5	EN 14103
Density at 15 °C	kg/m^3	860 - 900	EN ISO 3675 EN ISO 12185
Viscosity at 40 °C	mm^2/s	3,5 - 5,0	EN ISO 3104
Flashpoint	°C	min. 101	EN ISO 2719/EN ISO 3679
Sulphur content	mg/kg	max. 10	EN ISO 20846/EN ISO 20884
Coke residue (from 10 % distillation residue)	%(m/m)	max. 0.30	EN ISO 10370
Cetane number		min. 51	EN ISO 5165
Ash content (Sulphate ash)	%(m/m)	max. 0.02	ISO 3987
Water content	mg/kg	max. 500	EN ISO 12937
Total contamination	mg/kg	max. 24	EN 12662
Corrosion effect on copper (3 h at 50 °C)	Degree of corrosion	Class 1	EN ISO 2160
Oxidation stability 110 °C	hours	min. 6	EN 15751/EN 14112
Acid number	mg KOH/g	max. 0.50	EN 14104
Iodine number	g Iodine/100g	max. 120	EN 14111
content of linolenic acid methylester	%(m/m)	max. 12.0	EN 14103
Content of polyunsaturated fatty acid methylesters with ≥ 4 double bonds	%(m/m)	max. 1.00	EN 15779
methanol content	%(m/m)	max. 0.20	EN 14110
Monoglyceride content	%(m/m)	max. 0.80	EN 14105
Diglyceride content	%(m/m)	max. 0.20	EN 14105
triglyceride content	%(m/m)	max. 0.20	EN 14105
content of free glycerine	%(m/m)	max. 0.02	EN 14105 EN 14106
content of total glycerine	%(m/m)	max. 0.25	EN 14105
Content of alkaline-metals (Na + K)	mg/kg	max. 5.0	EN 14108 EN 14109 EN 14538
Content of earth alkaline-metals (Ca + Mg)	mg/kg	max. 5.0	EN 14538

Properties	Units	Limit values DIN EN 14214	Test method
phosphor content	mg/kg	max. 4.0	EN 14107
Limit of filtrability			EN 116
– 15.04. - 30.09.	°C	max. 0	
– 01.10. - 15.11.	°C	max. - 10	
– 16.11. - 28.02.	°C	max. - 20	
– 01.03. - 14.04.	°C	max. - 10	
* Specifications apply for Germany. National regulations may deviate.			

Appendix 8

Fuel specification (minimum requirement)
US biodiesel blends according to ASTM D 7467-10 (B6-B20)

Properties	Units	Limit values ASTM D 7467	Test method
Biodiesel content	%(V/V)	6-20	ASTM D 7371
Flashpoint	°C	min. 52	ASTM D 93
Water and sediments	%(V/V)	max. 0.05	ASTM D 2709
Kinematic viscosity at 40 °C	mm^2/s	1,9 - 4,1	ASTM D 445
Ash content (oxide ash)	%(m/m)	max. 0.01	ASTM D 482
Sulphur content	%(m/m)	max. 0.0015 * max. 0.05 **	ASTM D 5453
Corrosion effect on copper	Degree of corrosion	No. 3	ASTM D 130
Cetane number		min. 40	ASTM D 613
Cloud point	°C	Report	ASTM D 2500
Coke residue	%(m/m)	max. 0.35	ASTM D 524
Acid number	mg KOH/g	max. 0.30	ASTM D 664
Boiling curve at 90 vol. %	°C	max. 343	ASTM D 86
Lubricity, HFRR at 60 °C	µm	max. 520	ASTM D 6079
Oxidation stability 110 °C	hours	min. 6	EN 14112
* ASTM D 7467-09a Grade S 15			
** ASTM D 7467-09a Grade S 500			

Appendix 9

Fuel specification (minimum requirement)
US biodiesel according to ASTM D6751-11a (B100)

Properties	Units	Limit values ASTM D 6751	Test method
Calcium and Magnesium (together)	mg/kg	max. 5	EN 14538
Flashpoint	°C	min. 93	ASTM D 93
Water and sediments	%(V/V)	max. 0.05	ASTM D 2709
Kinematic viscosity at 40 °C	mm^2/s	1,9 - 6,0	ASTM D 445
Ash content (oxide ash)	%(m/m)	max. 0.02	ASTM D 874
Sulphur content	%(m/m)	max. 0.0015 * max. 0.05 **	ASTM D 5453
Corrosion effect on copper	Degree of corro-sion	No. 3	ASTM D 130
Cetane number		min. 47	ASTM D 613
Cloud point	°C	Report	ASTM D 2500
Coke residue	%(m/m)	max. 0.050	ASTM D 4530
Acid number	mg KOH/g	max. 0.50	ASTM D 664
content of free glycerine	%(m/m)	0,020	ASTM D 6584
content of total glycerine	%(m/m)	0,240	ASTM D 6584
phosphor content	%(m/m)	max. 0.001	ASTM D 4951
Boiling curve at 90 vol. %	°C	max. 360	ASTM D 1160
Sodium and potassium (together)	mg/kg	max. 5	EN 14538
Oxidation stability 110 °C	hours	min. 3	EN 14112
* ASTM D 6751-09a Grade S 15			
** ASTM D 6751-09a Grade S 500			

Appendix 10

Fuel specification (requirements, test methods and limit values)
Rapeseed oil fuel according to DIN 51605
September 2010 edition

Properties	Units	Limit values DIN 51605	Test method
Visual assessment		Free from visible contamination and sediments and free water	
Density at 15 °C	kg/m^3	min. 900.0 max. 930.0	EN ISO 3675 EN ISO 12185/C1
Flashpoint according to Pensky-Martens	°C	min.101	EN ISO 2719
Kinematic viscosity at 40 °C	mm^2/s	max. 36.0	EN ISO 3104/C2
Heating value	kJ/kg	min. 36,000	DIN 51900-1, -2, -3
Willingness to ignite		min. 40	
Coke residue	%(m/m)	max. 0.40	EN ISO 10370
Iodine number	g Iodine/100g	max. 125	EN 14111
Sulphur content	mg/kg	max. 10	EN ISO 20884 EN ISO 20846
Total contamination	mg/kg	max. 24	EN 12662
Acid number	mg KOH/g	max. 2.0	EN 14104
Oxidation stability 110 °C	hours	min. 6	EN 14112
phosphor content	mg/kg	max. 3	DIN 51627-6
Calcium content	mg/kg	max. 1	DIN 51627-6
Magnesium content	mg/kg	max. 3	DIN 51627-6
Ash content (oxide ash)	%(m/m)	max. 0.01	EN ISO 6245
Water content	%(m/m)	max. 0.075	EN ISO 12937

Appendix 11

Minimum requirements for fuels in countries in which none of the named diesel fuels released by DEUTZ exist

Parameter	Basic condition	Test method	Units	DEUTZ requirement	
				min.	max.
Density at 15 °C	-	ISO 3675 / ISO 12185	kg/m^3	820[1]	876[2]
Cetane number	Ambient temperatures > 0 °C	ISO 5156 / ISO 15195 / ASTM D613 / ASTM D6890	-	40,0	-
	Ambient temperatures < 0 °C			45,0	-
Kinematic viscosity at 40 °C	Ambient temperatures > 0 °C	ISO 3104 / ASTM D44	mm^2/s	1,8	5,0
	Ambient temperatures < 0 °C			1,2	4,0
Cloud point	-	-	-	Not higher than the ambient temperature	
Pour point	-	ISO 3016 / ASTM D97	-	At least 6 °C lower than the ambient temperature	
Sulphur content	Engines without exhaust gas after-treatment	ISO 20846 / ISO 20847 / ASTM D 3605 / ASTM D1552	%(m/m)	-	1,0
	Engines without exhaust gas after-treatment [6]		mg/kg	-	2000
	Engines with exhaust gas after-treatment		mg/kg	-	15
Lubricity, corrected "wear scar diameter" (wsd 1.4) at 60 °C		ISO 12156-1 / ASTM D6079	µm	-	460
50 %V/V boiling temperature		ISO 3405 / ASTM D86	°C	-	282
90 %V/V boiling temperature				-	360
Coke residue (from 10 % distillation residue)		ASTM D524	%(m/m)	-	0,35
Ash content	Engines without exhaust gas after-treatment	ISO 6245 / ASTM D482	%(m/m)	-	0,01
Inorganic elements (Ca+Mg+Na+K)	Engines with exhaust gas after-treatment	EN 14108 / EN 14109 / EN 14538	mg/kg	-	5
Water content		ISO 12937	mg/kg	-	200[4]
Total contamination		EN 12662	mg/kg	-	24[5]

Parameter	Basic condition	Test method	Units	DEUTZ requirement	
				min.	max.
Alternative to water content and total contamination: Water and sediment		ASTM D473	%(V/V)	-	0,05
Corrosion effect on copper (3 h at 50 °C)		ISO 2160 / ASTM D130	Degree of corrosion	-	1
[1] For Arctic diesel fuels the lower density limit is 800 kg/m^3 at 15 °C.					
[2] At densities >860 kg/m^3 at 15 °C return blocking of the engine power by authorised DEUTZ dealers is necessary.					
[3] At sulphur contents >5000 mg/kg the oil change intervals must be halved.					
[4] Water contents up to 1000 mg/kg are possible when water trapping fuel filters are used.					
[5] At dirt contents >24 mg/kg fuel filters with a higher dirt capacity and very high efficiency must be used.					
[6] D/TD/TCD 2.9 L4; TD/TCD 3.6 L4; TCD 4.1 L4; TCD 6.1 L6; TCD 7.8 L6					